

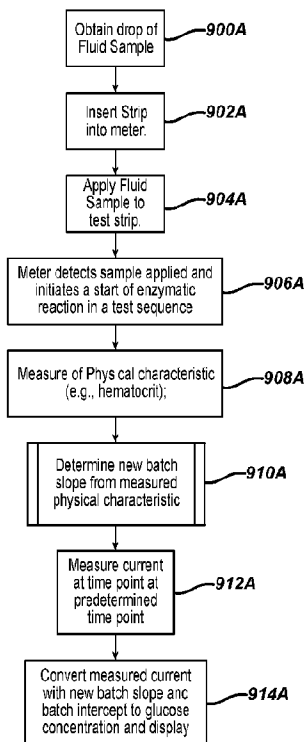


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(54) Titre : MESURES PRECISES D'UNE SUBSTANCE A ANALYSER POUR BANDE DE TEST ELECTROCHIMIQUE BASEES SUR UNE OU PLUSIEURS CARACTERISTIQUES PHYSIQUES DETECTEES DE L'ECHANTILLON CONTENANT LA SUBSTANCE A ANALYSER

(54) Title: ACCURATE ANALYTE MEASUREMENTS FOR ELECTROCHEMICAL TEST STRIP BASED ON SENSED PHYSICAL CHARACTERISTIC(S) OF THE SAMPLE CONTAINING THE ANALYTE



(57) Abrégé/Abstract:

Glucose concentration determination with a biosensor by determining at least one physical characteristic of the blood sample, typically hematocrit percentage, and deriving one of a batch slope, a sampling time, or combinations thereof to attain glucose concentration.

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(54) Title: ACCURATE ANALYTE MEASUREMENTS FOR ELECTROCHEMICAL TEST STRIP BASED ON SENSED PHYSICAL CHARACTERISTIC(S) OF THE SAMPLE CONTAINING THE ANALYTE

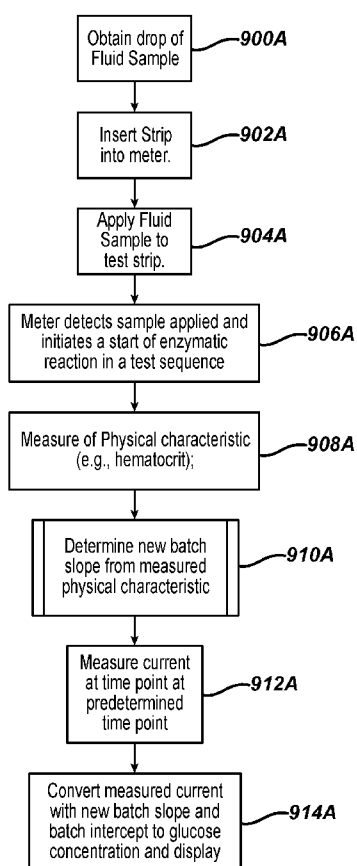


FIG. 6A(1)

(57) Abstract: Glucose concentration determination with a biosensor by determining at least one physical characteristic of the blood sample, typically hematocrit percentage, and deriving one of a batch slope, a sampling time, or combinations thereof to attain glucose concentration.

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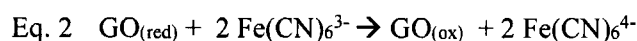
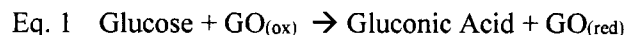
see Notice of 31 October 2013

# **Accurate Analyte Measurements for Electrochemical Test Strip Based on Sensed Physical Characteristic(s) of the Sample Containing the Analyte**

[0001]

## **BACKGROUND**

[0002] Electrochemical glucose test strips, such as those used in the OneTouch® Ultra® whole blood testing kit, which is available from LifeScan, Inc., are designed to measure the concentration of glucose in a physiological fluid sample from patients with diabetes. The measurement of glucose can be based on the selective oxidation of glucose by the enzyme glucose oxidase (GO). The reactions that can occur in a glucose test strip are summarized below in Equations 1 and 2.



[0003] As illustrated in Equation 1, glucose is oxidized to gluconic acid by the oxidized form of glucose oxidase ( $\text{GO}_{(\text{ox})}$ ). It should be noted that  $\text{GO}_{(\text{ox})}$  may also be referred to as an “oxidized enzyme.” During the reaction in Equation 1, the oxidized enzyme  $\text{GO}_{(\text{ox})}$  is converted to its reduced state, which is denoted as  $\text{GO}_{(\text{red})}$  (i.e., “reduced enzyme”). Next, the reduced enzyme  $\text{GO}_{(\text{red})}$  is re-oxidized back to  $\text{GO}_{(\text{ox})}$  by

reaction with  $\text{Fe}(\text{CN})_6^{3-}$  (referred to as either the oxidized mediator or ferricyanide) as illustrated in Equation 2. During the re-generation of  $\text{GO}_{(\text{red})}$  back to its oxidized state  $\text{GO}_{(\text{ox})}$ ,  $\text{Fe}(\text{CN})_6^{3-}$  is reduced to  $\text{Fe}(\text{CN})_6^{4-}$  (referred to as either reduced mediator or ferrocyanide).

**[0004]** When the reactions set forth above are conducted with a test signal applied between two electrodes, a test current can be created by the electrochemical re-oxidation of the reduced mediator at the electrode surface. Thus, since, in an ideal environment, the amount of ferrocyanide created during the chemical reaction described above is directly proportional to the amount of glucose in the sample positioned between the electrodes, the test current generated would be proportional to the glucose content of the sample. A mediator, such as ferricyanide, is a compound that accepts electrons from an enzyme such as glucose oxidase and then donates the electrons to an electrode. As the concentration of glucose in the sample increases, the amount of reduced mediator formed also increases; hence, there is a direct relationship between the test current, resulting from the re-oxidation of reduced mediator, and glucose concentration. In particular, the transfer of electrons across the electrical interface results in the flow of a test current (2 moles of electrons for every mole of glucose that is oxidized). The test current resulting from the introduction of glucose can, therefore, be referred to as a glucose signal.

**[0005]** Electrochemical biosensors may be adversely affected by the presence of certain blood components that may undesirably affect the measurement and lead to inaccuracies in the detected signal. This inaccuracy may result in an inaccurate glucose reading, leaving the patient unaware of a potentially dangerous blood sugar level, for example. As one example, the blood hematocrit level (i.e. the percentage of the amount of blood that is occupied by red blood cells) can erroneously affect a resulting analyte concentration measurement.

**[0006]** Variations in a volume of red blood cells within blood can cause variations in glucose readings measured with disposable electrochemical test strips. Typically, a negative bias (i.e., lower calculated analyte concentration) is observed at high hematocrit, while a positive bias (i.e., higher calculated analyte concentration) is observed at low hematocrit. At high hematocrit, for example, the red blood cells may impede the reaction of enzymes and electrochemical mediators, reduce the rate of chemistry dissolution since there is less plasma volume to solvate the chemical

reactants, and slow diffusion of the mediator. These factors can result in a lower than expected glucose reading as less signal is produced during the electrochemical process. Conversely, at low hematocrit, fewer red blood cells may affect the electrochemical reaction than expected, and a higher measured signal can result. In addition, the physiological fluid sample resistance is also hematocrit dependent, which can affect voltage and/or current measurements.

[0007] Several strategies have been used to reduce or avoid hematocrit based variations on blood glucose. For example, test strips have been designed to incorporate meshes to remove red blood cells from the samples, or have included various compounds or formulations designed to increase the viscosity of red blood cells and attenuate the effect of low hematocrit on concentration determinations. Other test strips have included lysis agents and systems configured to determine hemoglobin concentration in an attempt to correct hematocrit. Further, biosensors have been configured to measure hematocrit by measuring an electrical response of the fluid sample via alternating current signals or change in optical variations after irradiating the physiological fluid sample with light, or measuring hematocrit based on a function of sample chamber fill time. These sensors have certain disadvantages. A common technique of the strategies involving detection of hematocrit is to use the measured hematocrit value to correct or change the measured analyte concentration, which technique is generally shown and described in the following respective US Patent Application Publication Nos. 2010/0283488; 2010/0206749; 2009/0236237; 2010/0276303; 2010/0206749; 2009/0223834; 2008/0083618; 2004/0079652; 2010/0283488; 2010/0206749; 2009/0194432; or US Patent Nos., 7,972,861 and 7,258,769.

## **SUMMARY OF THE DISCLOSURE**

[0008] Applicants have provided various embodiments of a technique to allow for improved glucose measurement using a relationship between batch slope and physical characteristic (e.g., hematocrit) to derive a new batch slope that can be used to determine the analyte concentration based on this derived batch slope of an electrochemical biosensor. Advantageously, this new technique does not rely on correction(s) or modification(s) to be made to an analyte measurement, thereby reducing test time while at the same time improving accuracy.

[0009] In a first aspect of applicants' disclosure, a method of determining an analyte concentration from a fluid sample (which may be a physiological sample) with a biosensor (which may be in the form of a test strip but is not limited to a test strip) is provided. The biosensor has at least two electrodes and a reagent disposed on at least one of the electrodes. The method can be achieved by: depositing a fluid sample (which may be a physiological sample) on the at least two electrodes to start an analyte test sequence; applying a first signal to the sample to measure or estimate a physical characteristic of the sample; deriving a batch slope for the biosensor based on the measured or estimated physical characteristic from an equation of the form:

$$x = aH^2 + bH + c$$

where

$x$  represents a derived batch slope;

$H$  is measured or estimated physical characteristic;

$a$  represents about  $1.4\text{e-}6$ , or is equal to  $1.4\text{e-}6$ , or is equal to  $1.4\text{e-}6 \pm 10\%$ ,  $5\%$  or  $1\%$  of  $1.4\text{e-}6$ ;

$b$  represents about  $-3.8\text{e-}4$ , or is equal to  $-3.8\text{e-}4$ , or is equal to  $-3.8\text{e-}4 \pm 10\%$ ,  $5\%$  or  $1\%$  of  $-3.8\text{e-}4$ ;

$c$  represents about  $3.6\text{e-}2$ , or is equal to  $3.6\text{e-}2$ , or is equal to  $3.6\text{e-}2 \pm 10\%$ ,  $5\%$  or  $1\%$  of  $3.6\text{e-}2$ ;

driving a second signal to the sample; and measuring an output signal from at least one of the at least two electrodes; calculating an analyte concentration based on the measured output signal and derived batch slope with an equation of the form:

$$G_0 = \left[ \frac{I_E - \text{Intercept}}{x} \right]$$

where

$G_0$  represents an analyte concentration

$I_E$  represents, or is, a signal (value or measurement; proportional to analyte concentration) measured at a predetermined or specified sampling time, which may be the total signal measured at the predetermined or specified sampling time;

Intercept represents a calibration parameter for a batch of biosensors;

$x$  represents, or is, the derived batch slope from the deriving step.

[0010] In a second aspect of applicants' disclosure, a method of determining an analyte concentration from a fluid sample (which may be a physiological sample) with a biosensor (which may be in the form of a test strip but is not limited to a test strip) is provided. The biosensor has at least two electrodes and a reagent disposed on at least one of the electrodes. The method can be achieved by: depositing a fluid sample (which may be a physiological sample) on the at least two electrodes to start an analyte test sequence; applying a first signal to the sample to measure a physical characteristic of the sample; deriving a batch slope for the biosensor based on the measured or estimated physical characteristic; driving a second signal to the sample; and measuring an output signal from at least one of the at least two electrodes; calculating an analyte concentration based on the measured output signal and derived batch slope from the measured or estimated physical characteristic of the sample.

[0011] In any of the aspects described herein the following features may also be utilized in various combinations with the previously disclosed aspects: the applying of the first signal and the driving of the second signal may be in sequential order; the applying of the first signal may overlap with the driving of the second signal; the applying of the first signal may include directing an alternating signal to the sample so that a physical characteristic of the sample is determined from an output of the alternating signal; the applying of the first signal may include directing an optical signal to the sample so that a physical characteristic of the sample is determined from an output of the optical signal; the physical characteristic may include hematocrit and the analyte may include glucose; the physical characteristic may include at least one of viscosity, hematocrit, temperature and density of the sample; the directing may include driving first and second alternating signals at different respective frequencies in which a first frequency is lower than the second frequency; the first frequency may be at least one order of magnitude lower than the second frequency; and/or the first frequency may include any frequency in the range of about 10kHz to about 250kHz, or about 10kHz to about 90kHz.

[0012] In these aspects, the deriving may include calculating a batch slope from an equation of the form:

$$x = aH^2 + bH + c$$

where

x represents, or is, a derived batch slope from the deriving step;

H represents, or is, measured or estimated physical characteristic (e.g. hematocrit);

a represents about 1.4e-6, or is equal to 1.4e-6, or is equal to 1.4e-6 +/- 10%, 5% or 1% of the numerical value provided hereof;

b represents about -3.8e-4, or is equal to -3.8e-4, or is equal to -3.8e-4 +/- 10%, 5% or 1% of the numerical value provided hereof;

c represents about 3.6e-2, or is equal to 3.6e-2, or is equal to -3.6e-2 +/- 10%, 5% or 1% of the numerical value provided hereof;

[0013] Furthermore, the calculating of the analyte concentration may include utilizing an equation of the form:

$$G_0 = \left[ \frac{I_E - \text{Intercept}}{x} \right]$$

where

$G_0$  represents, or is, an analyte concentration

$I_E$  represents, or is, a signal (proportional to analyte concentration) which may be the total signal measured at a predetermined time, for example at least one of 2.5 seconds or 5 seconds, or at one of 2.5 seconds or 5 seconds (about or exactly) after a start of the test sequence; and wherein the total signal means one signal from each electrode summed or the signal from one electrode being doubled;

Intercept represents, or is, a calibration parameter for a batch of biosensors;

x represents, or is, a derived batch slope from the deriving step.

[0014] In a third aspect of applicants' disclosure, an analyte measurement system is provided that includes a test strip and an analyte meter. The test strip includes a substrate with a plurality of electrodes connected to respective electrode connectors. The analyte meter includes a housing, a test strip port, and a processor. The strip port connector is configured to connect to the respective electrode connectors of the test strip. The microprocessor is in electrical communication with the test strip port

connector to apply electrical signals or sense electrical signals from the plurality of electrodes during a test sequence. The microprocessor is configured to, during the test sequence: (a) apply a first signal to the plurality of electrodes so that a batch slope defined by a physical characteristic of a physiological fluid sample is derived and (b) apply a second signal to the plurality of electrodes so that an analyte concentration is determined based on the derived batch slope.

[0015] And for these aspects, the following features may also be utilized in various combinations with these previously disclosed aspects: the plurality of electrodes may include at least two electrodes to measure the physical characteristic and at least two other electrodes to measure the analyte concentration; the at least two electrodes and the at least two other electrodes may be disposed in the same chamber provided on the substrate; the at least two electrodes and the at least two other electrodes may be disposed in different chambers provided on the substrate; the at least two electrodes may include two electrodes to measure the physical characteristic and the analyte concentration; the plurality of electrodes may include two electrodes to measure the physical characteristic and the analyte concentration; alternatively, all of the electrodes are disposed on the same plane defined by the substrate; a reagent is disposed proximate the at least two other electrodes and no reagent is disposed on the at least two electrodes; and/or the batch slope may be calculated from an equation of the form:

$$x = aH^2 + bH + c$$

where

x represents, or is, a derived batch slope from the deriving step;

H represents, or is, measured or estimated physical characteristic (e.g. hematocrit);

a represents about 1.4e-6, or is equal to 1.4e-6, or is equal to 1.4e-6 +/- 10%, 5% or 1% of the numerical value provided hereof;

b represents about -3.8e-4, or is equal to -3.8e-4, or is equal to -3.8e-4 +/- 10%, 5% or 1% of the numerical value provided hereof;

c represents about 3.6e-2, or is equal to 3.6e-2, or is equal to -3.6e-2 +/- 10%, 5% or 1% of the numerical value provided herein.

[0016] Furthermore, in these aspects, the analyte concentration may be determined from an equation of the form:

$$G_0 = \left[ \frac{I_E - \text{Intercept}}{x} \right]$$

where

$G_0$  represents, or is, an analyte concentration

$I_E$  represents, or is, a signal (proportional to analyte concentration) measured at a predetermined or specified sampling time, which may be the total signal measured at the predetermined or specified sampling time;

Intercept represents, or is, the calibration parameter for a batch of test strips;

$x$  represents, or is, the derived batch slope from the deriving step.

[0017] In a fourth aspect of applicants' disclosure, an analyte measurement system is provided that includes a test strip and an analyte meter. The test strip includes a substrate with a plurality of electrodes connected to respective electrode connectors. The analyte meter includes a housing, a test strip port, and a processor. The strip port connector is configured to connect to the respective electrode connectors of the test strip. The microprocessor is in electrical communication with the test strip port connector to apply electrical signals or sense electrical signals from the plurality of electrodes during a test sequence. The microprocessor is configured to, during a test sequence: (a) apply a first signal to the plurality of electrodes so that a batch slope defined by a physical characteristic of a physiological fluid sample is derived and (b) apply a second signal to the plurality of electrodes so that an analyte concentration is determined based on the derived batch slope obtained from the physical characteristic of the sample within about 10 seconds of a start of the test sequence.

[0018] And for these aspects, the following features may also be utilized in various combinations with these previously disclosed aspects: the plurality of electrodes may include at least two electrodes to measure the physical characteristic and at least two other electrodes to measure the analyte concentration; the at least two electrodes and the at least two other electrodes may be disposed in the same chamber provided on the substrate; the at least two electrodes and the at least two other electrodes may be disposed in different chambers provided on the substrate; the at least two electrodes

may include two electrodes to measure the physical characteristic and the analyte concentration; the plurality of electrodes may include two electrodes to measure the physical characteristic and the analyte concentration; all of the electrodes may be disposed on the same plane defined by the substrate; a reagent is disposed proximate the at least two other electrodes and no reagent disposed on the at least two electrodes; and/or the batch slope may be calculated from an equation of the form:

$$x = aH^2 + bH + c$$

where

x represents, or is, a derived batch slope from the deriving step;

H represents, or is, measured or estimated physical characteristic (e.g. hematocrit);

a represents about 1.4e-6, or is equal to 1.4e-6, or is equal to 1.4e-6 +/- 10%, 5% or 1% of the numerical value provided hereof;

b represents about -3.8e-4, or is equal to -3.8e-4, or is equal to -3.8e-4 +/- 10%, 5% or 1% of the numerical value provided hereof;;

c represents about 3.6e-2, or is equal to 3.6e-2, or is equal to -3.6e-2 +/- 10%, 5% or 1% of the numerical value provided hereof.

[0019] In these aspects, the analyte concentration may be calculated from an equation of the form:

$$G_0 = \left[ \frac{I_E - \text{Intercept}}{x} \right]$$

where

G<sub>0</sub> represents, or is, an analyte concentration

I<sub>E</sub> represents, or is, a signal (value or measurement; proportional to analyte concentration) measured at a predetermined or specified sampling time, which may be the total signal measured at the predetermined or specified sampling time;

Intercept represents, or is, a calibration parameter for a batch of test strips;

x represents, or is, a derived batch slope from the deriving step.

**[0020]** In a fifth aspect of applicants' disclosure, a method of demonstrating increased accuracy of a test strip is provided. The method can be achieved by: providing a batch of test strips; introducing a referential sample containing a referential concentration of an analyte to each test strip of the batch of test strips to initiate a test sequence; reacting the analyte with a reagent on each test strip to cause a physical transformation of the analyte proximate the two electrodes (which may be between the two electrodes); determining a physical characteristic of the referential sample; deriving a batch slope for the batch of test strips based on the determined physical characteristic of the referential sample; sampling an electrical output of the referential sample at a predetermined time point during the test sequence; calculating an analyte concentration based on the defined batch slope and sampled electrical output to provide for a final analyte concentration value for each test strip of the batch of test strips such that at least 95% of the final analyte concentration values of the batch of test strips are within  $\pm 15\%$  of the referential analyte concentration.

**[0021]** And for these aspects, the following features may also be utilized in various combinations with these previously disclosed aspects: the determining may include applying a first signal to the sample to measure a physical characteristic of the sample; the sampling may include driving a second signal to the sample; the applying of the first signal and the driving of the second signal may be in sequential order; the applying of the first signal may overlap with the driving of the second signal; the applying of the first signal may include directing an alternating signal to the sample so that a physical characteristic of the sample is determined from an output of the alternating signal; the applying of the first signal may include directing an optical signal to the sample so that a physical characteristic of the sample is determined from an output of the optical signal; the physical characteristic may include hematocrit and the analyte may include glucose; the physical characteristic may include at least one of viscosity, hematocrit, temperature and density; the directing may include driving first and second alternating signals at different respective frequencies in which a first frequency is lower than the second frequency; the first frequency may be at least one order of magnitude lower than the second frequency; the first frequency may include any frequency in the range of about 10kHz to about 250kHz, or about 10kHz to about 90kHz; and/or the deriving may include calculating a batch slope from an equation of the form:

$$x = aH^2 + bH + c$$

where

x represents, or is, a derived batch slope from the deriving step;

H represents, or is, measured, determined or estimated physical characteristic (e.g. hematocrit);

a represents about 1.4e-6, or is equal to 1.4e-6, or is equal to 1.4e-6 +/- 10%, 5% or 1% of the numerical value provided hereof;

b represents about -3.8e-4, or is equal to -3.8e-4, or is equal to -3.8e-4 +/- 10%, 5% or 1% of the numerical value provided hereof;

c represents about 3.6e-2, or is equal to 3.6e-2, or is equal to -3.6e-2 +/- 10%, 5% or 1% of the numerical value provided hereof;

**[0022]** In these aspects, the calculating of the analyte concentration may include utilizing an equation of the form:

$$G_0 = \left[ \frac{I_E - \text{Intercept}}{x} \right]$$

where

$G_0$  represents, or is, an analyte concentration

$I_E$  represents, or is, a signal (value or measurement; proportional to analyte concentration) measured at a predetermined or specified sampling time, which may be the total signal measured at the predetermined or specified sampling time;

Intercept represents, or is, a calibration parameter for a batch of test strips;

x represents, or is, a derived batch slope from the deriving step.

**[0023]** In a sixth aspect of applicants' disclosure, a method of determining an analyte concentration from a fluid sample (which may be a physiological sample) is provided. The method can be achieved by: depositing a fluid sample (which may be a physiological sample) on a biosensor; applying signals to the sample to transform the analyte into a different material; measuring or estimating a physical characteristic of the sample; evaluating signal output from the sample; deriving a parameter of the biosensor from the measured or estimated physical characteristic; and determining an analyte

concentration based on the derived parameter of the biosensor and the signal output of the sample.

**[0024]** And for these aspects, the following features may also be utilized in various combinations with these previously disclosed aspects: the measuring may include applying a first signal to the sample to measure a physical characteristic of the sample; the evaluating may include driving a second signal to the sample; the applying of the first signal and the driving of the second signal may be in sequential order; the applying of the first signal may overlap with the driving of the second signal; the applying of the first signal may include directing an alternating signal to the sample so that a physical characteristic of the sample is determined from an output of the alternating signal; the applying of the first signal may include directing an optical signal to the sample so that a physical characteristic of the sample is determined from an output of the optical signal; the physical characteristic may include hematocrit and the analyte may include glucose; the physical characteristic may include at least one of viscosity, hematocrit, temperature and density; the directing may include driving first and second alternating signals at different respective frequencies in which a first frequency is lower than the second frequency; the first frequency may be at least one order of magnitude lower than the second frequency; the first frequency may include any frequency in the range of about 10kHz to about 250kHz, or about 10kHz to about 90kHz; the derived parameter may be a batch slope; and/or the deriving may include calculating a batch slope from an equation of the form:

$$x = aH^2 + bH + c$$

where

x represents, or is, a derived batch slope from the deriving step;

H represents, or is, measured or estimated physical characteristic (e.g. hematocrit);

a represents about 1.4e-6, or is equal to 1.4e-6, or is equal to 1.4e-6 +/- 10%, 5% or 1% of the numerical value provided hereof;

b represents about -3.8e-4, or is equal to -3.8e-4, or is equal to -3.8e-4 +/- 10%, 5% or 1% of the numerical value provided hereof;

c represents about 3.6e-2, or is equal to 3.6e-2, or is equal to -3.6e-2 +/- 10%, 5% or 1% of the numerical value provided herein.

[0025] In these aspects, the calculating of the analyte concentration may include utilizing an equation of the form:

$$G_0 = \left[ \frac{I_E - \text{Intercept}}{x} \right]$$

where

$G_0$  represents, or is, an analyte concentration

$I_E$  represents, or is, a signal (value or measurement; proportional to analyte concentration) measured at a predetermined or specified sampling time, which may be the total signal measured at the predetermined or specified sampling time;

Intercept represents, or is, a calibration parameter for a batch of test strips;

$x$  represents a derived batch slope from the deriving step.

[0026] In a seventh aspect of applicants' disclosure, a method of determining an analyte concentration from a fluid sample (which may be a physiological sample) with a biosensor (*e.g.* a test strip) is provided. The biosensor has at least two electrodes and a reagent disposed on at least one electrode of the electrodes. The method can be achieved by: depositing a fluid sample (which may be a physiological sample) on the at least two electrodes to start an analyte test sequence; applying a first signal to the sample to derive a physical characteristic of the sample; obtaining a physical characteristic of the sample; specifying a sampling time based on the obtained physical characteristic; driving a second signal to the sample; and measuring an output signal at the specified sampling time from at least one electrode of the at least two electrodes; and calculating an analyte concentration based on the measured output signal.

[0027] For the seventh aspect of applicants' disclosure, the following features may also be utilized in various combinations: the applying of the first signal and the driving of the second signal may be in sequential order; the applying of the first signal may overlap with the driving of the second signal; the applying of the first signal may include directing an alternating signal to the sample so that a physical characteristic of the sample is determined from an output of the alternating signal; the applying of the first signal may include directing an optical signal to the sample so that a physical characteristic of the sample is determined from an output of the optical signal; the physical characteristic may include hematocrit and the analyte may include glucose; the

physical characteristic may include at least one of viscosity, hematocrit, temperature and density of the sample; the directing may include driving first and second alternating signals at different respective frequencies in which a first frequency is lower than the second frequency; the first frequency may be at least one order of magnitude lower than the second frequency; the first frequency may include any frequency in the range of about 10kHz to about 250kHz, or about 10kHz to about 90kHz; and/or the specified sampling time may be calculated using an equation of the form:

$$\text{SpecifiedSamplingTime} = x_1 H^{x_2} + x_3$$

where

“*SpecifiedSamplingTime*” is designated as a time point from the start of the test sequence at which to sample or measure the output signal (e.g. output signal) of the test strip,

*H* represents the physical characteristic of the sample;

$x_1$  is about 4.3e5, or is equal to 4.3e5, or is equal to 4.3e5 +/- 10%, 5% or 1% of the numerical value provided hereof;

$x_2$  is about -3.9, or is equal to -3.9, or is equal to -3.9 +/- 10%, 5% or 1% of the numerical value provided hereof; and

$x_3$  is about 4.8, or is equal to 4.8, or is equal to 4.8 +/- 10%, 5% or 1% of the numerical value provided herein.

**[0028]** Additionally, in the seventh aspect of applicants’ disclosure, the calculating of the analyte concentration may be computed with an equation of the form:

$$G_0 = \left[ \frac{I_E - \text{Intercept}}{\text{Slope}} \right]$$

where

$G_0$  represents, or is, an analyte concentration

$I_E$  represents, or is, a signal (proportional to analyte concentration) measured at the *SpecifiedSamplingTime*, which may be the total signal measured at the *SpecifiedSamplingTime*;

Slope represents, or is, the value obtained from calibration testing of a batch of test strips of which this particular strip comes from; and

Intercept represents, or is, the value obtained from calibration testing of a batch of test strips from which this particular strip comes.

[0029] In an eighth aspect of applicants' disclosure, an analyte measurement system is provided that includes a test strip and a test meter. The test strip includes a substrate and a plurality of electrodes connected to respective electrode connectors. The analyte meter includes a housing, a test strip port connector configured to connect to the respective electrode connectors of the test strip and a microprocessor. The microprocessor is in electrical communication with the test strip port connector to apply electrical signals or sense electrical signals from the plurality of electrodes during a test sequence. The microprocessor is configured to, during the test sequence: (a) apply a first signal to the plurality of electrodes so that a specific sampling time point determined from a physical characteristic of a physiological fluid sample is derived, (b) apply a second signal to the plurality of electrodes, and (c) measure a signal output from one of the plurality of electrodes at the specified sampling time point so that an analyte concentration is determined.

[0030] And for these aspects, the following features may also be utilized in various combinations with these previously disclosed aspects: the plurality of electrodes may include at least two electrodes to measure the physical characteristic and at least two other electrodes to measure the analyte concentration; the at least two electrodes and the at least two other electrodes may be disposed in the same chamber provided on the substrate; the at least two electrodes and the at least two other electrodes may be disposed in different chambers provided on the substrate; the at least two electrodes may comprise two electrodes to measure the physical characteristic and the analyte concentration; the plurality of electrodes may comprise two electrodes to measure the physical characteristic and the analyte concentration; all of the electrodes may be disposed on the same plane defined by the substrate; a reagent may be disposed proximate the at least two other electrodes and no reagent disposed on the at least two electrodes; and/or the specified sampling time may be calculated using an equation of the form:

$$\text{SpecifiedSamplingTime} = x_1 H^{x_2} + x_3$$

where

"SpecifiedSamplingTime" is designated as a time point from the start of the test sequence at which to sample the output signal (e.g. output signal) of the test strip,

*H represents the physical characteristic of the sample;*

$x_1$  is about 4.3e5, or is equal to 4.3e5, or is equal to 4.3e5 +/- 10%, 5% or 1% of the numerical value provided hereof;

$x_2$  is about -3.9, or is equal to -3.9, or is equal to -3.9 +/- 10%, 5% or 1% of the numerical value provided hereof; and

$x_3$  is about 4.8, or is equal to 4.8, or is equal to 4.8 +/- 10%, 5% or 1% of the numerical value provided herein.

[0031] Additionally, in these aspects, the analyte concentration is determined from an

equation of the form: 
$$G_0 = \left[ \frac{I_E - \text{Intercept}}{\text{Slope}} \right]$$

where

$G_0$  represents, or is, an analyte concentration

$I_E$  represents, or is, a signal (value or measurement; proportional to analyte concentration) measured at the *SpecifiedSamplingTime*, which may be the total signal measured at the *SpecifiedSamplingTime*;

Slope represents, or is, the value obtained from calibration testing of a batch of test strips of which this particular strip comes from; and

Intercept represents, or is, the value obtained from calibration testing of a batch of test strips from which this particular strip comes from.

[0032] In a ninth aspect of applicants' disclosure, an analyte measurement system is provided that includes a test strip and a test meter. The test strip includes a substrate and a plurality of electrodes connected to respective electrode connectors. The analyte meter includes a housing, a test strip port connector configured to connect to the respective electrode connectors of the test strip and a microprocessor. The microprocessor is in electrical communication with the test strip port connector to apply electrical signals or sense electrical signals from the plurality of electrodes. The microprocessor is configured to, during a test sequence: (a) apply a first signal to the plurality of electrodes so that a specific sampling time point determined from a physical characteristic of a physiological fluid sample is derived, (b) apply a second signal to the plurality of electrodes, and (c) measure a signal output from one of the plurality of

electrodes at the specified sampling time point so that an analyte concentration of the sample is determined based on the specific sampling time point within about 10 seconds of a start of the test sequence.

**[0033]** And for these aspects, the following features may also be utilized in various combinations with these previously disclosed aspects: the plurality of electrodes may include at least two electrodes to measure the physical characteristic and at least two other electrodes to measure the analyte concentration; the at least two electrodes and the at least two other electrodes may be disposed in the same chamber provided on the substrate; the at least two electrodes and the at least two other electrodes may be disposed in different chambers provided on the substrate; the at least two electrodes may comprise two electrodes to measure the physical characteristic and the analyte concentration; all of the electrodes may be disposed on the same plane defined by the substrate; a reagent may be disposed proximate the at least two other electrodes and no reagent disposed on the at least two electrodes; and/or the specified sampling time may be calculated using an equation of the form:

$$\text{SpecifiedSamplingTime} = x_1 H^{x_2} + x_3$$

where

“*SpecifiedSamplingTime*” is designated as a time point from the start of the test sequence at which to sample the output signal (e.g. output signal) of the test strip,

*H* represents, or is, the physical characteristic of the sample;

$x_1$  is about 4.3e5, or is equal to 4.3e5, or is equal to 4.3e5 +/- 10%, 5% or 1% of the numerical value provided hereof;

$x_2$  is about -3.9, or is equal to -3.9, or is equal to -3.9 +/- 10%, 5% or 1% of the numerical value provided hereof; and

$x_3$  is about 4.8, or is equal to 4.8, or is equal to 4.8 +/- 10%, 5% or 1% of the numerical value provided herein.

**[0034]** Additionally, for these aspects, an analyte concentration may be calculated from

an equation of the form: 
$$G_0 = \left[ \frac{I_E - \text{Intercept}}{\text{Slope}} \right]$$

where

$G_0$  represents, or is, an analyte concentration

$I_E$  represents, or is, a signal (proportional to analyte concentration) measured at the *SpecifiedSamplingTime*, which may be the total signal measured at the *SpecifiedSamplingTime*;

Slope represents, or is, the value obtained from calibration testing of a batch of test strips of which this particular strip comes from; and

Intercept represents, or is, the value obtained from calibration testing of a batch of test strips of which this particular strip comes from.

[0035] In a tenth aspect of applicants' disclosure, a method of determining an analyte concentration from a fluid sample (which may be a physiological sample) is provided. The method can be achieved by: depositing a fluid sample (which may be a physiological sample) on a biosensor (*e.g.* a test strip) having a reagent deposited thereon; applying signals to the sample and the reagent to transform the analyte into a different material; obtaining a physical characteristic of the sample; specifying a time point for sampling of signal output based on the obtained physical characteristic; measuring signal output at the specified sampling time point; and determining an analyte concentration based on the measured signal output of the sample.

[0036] And for these aspects, the following features may also be utilized in various combinations with these previously disclosed aspects: the obtaining may include driving a second signal to the sample to derive a physical characteristic of the sample; the applying may include applying a first signal to the sample to derive a physical characteristic of the sample, and the applying of the first signal and the driving of the second signal may be in sequential order; the applying of the first signal may overlap with the driving of the second signal; the applying may comprise applying a first signal to the sample to derive a physical characteristic of the sample, and the applying of the first signal may overlap with the driving of the second signal; the applying of the first signal may include directing an alternating signal to the sample so that a physical characteristic of the sample is determined from an output of the alternating signal; the applying of the first signal may include directing an optical signal to the sample so that a physical characteristic of the sample is determined from an output of the optical signal; the physical characteristic may include hematocrit and the analyte may include glucose; the physical characteristic may include at least one of viscosity, hematocrit,

temperature and density; the directing may include driving first and second alternating signal at different respective frequencies in which a first frequency is lower than the second frequency; the first frequency may be at least one order of magnitude lower than the second frequency; the first frequency may include any frequency in the range of about 10kHz to about 250kHz, or about 10kHz to about 90kHz; and/or the specified sampling time may be calculated using an equation of the form:

$$SpecifiedSamplingTime = x_1 H^{x_2} + x_3$$

where

“*SpecifiedSamplingTime*” is designated as a time point from the start of the test sequence at which to sample the output signal (e.g. output signal) of the test strip,

$H$  represents, or is physical characteristic of the sample;

$x_1$  is about 4.3e5, or is equal to 4.3e5, or is equal to 4.3e5 +/- 10%, 5% or 1% of the numerical value provided hereof;

$x_2$  is about -3.9, or is equal to -3.9, or is equal to -3.9 +/- 10%, 5% or 1% of the numerical value provided hereof; and

$x_3$  is about 4.8, or is equal to 4.8, or is equal to 4.8 +/- 10%, 5% or 1% of the numerical value provided herein.

[0037] Additionally, the calculating of the analyte concentration may include utilizing

an equation of the form: 
$$G_0 = \left[ \frac{I_E - Intercept}{Slope} \right]$$

where

$G_0$  represents, or is, an analyte concentration

$I_E$  represents, or is, a signal (value or measurement; proportional to analyte concentration) measured at the *SpecifiedSamplingTime*, which may be the total signal measured at the *SpecifiedSamplingTime*;

Slope represents, or is, the value obtained from calibration testing of a batch of test strips of which this particular strip comes from; and

Intercept represents, or is, the value obtained from calibration testing of a batch of test strips of which this particular strip comes from.

**[0038]** In addition to the above, applicants have provided various embodiments of a technique to allow for improved glucose measurement using two somewhat related relationships: (a) a relationship between sampling time point and hematocrit to derive or calculate a specific sampling time point at which a measurement of the output from the biosensor is to be taken; and (b) a relationship between batch slope and physical characteristic (e.g., hematocrit) that allows derivation of a new batch slope. Both relationships are utilized to determine a more accurate analyte concentration (i.e., based on the specified sampling time and the derived batch slope). This new technique does not rely on correction(s) or modification(s) to be made to an analyte measurement, thereby reducing test time while at the same time improving accuracy.

**[0039]** In an eleventh aspect of applicants' disclosure, a method of determining an analyte concentration from a fluid sample (which may be a physiological sample) with a biosensor is provided. The biosensor has at least two electrodes and a reagent disposed on at least one electrode of the electrodes. The method can be achieved by: depositing a fluid sample (which may be a physiological sample) on the at least two electrodes to start an analyte test sequence; applying a first signal to the sample to derive a physical characteristic of the sample; obtaining a physical characteristic of the sample; specifying a sampling time based on the physical characteristic from the obtaining step; deriving a batch slope for the biosensor based on the physical characteristic from the obtaining step; driving a second signal to the sample; and measuring an output signal at the specified sampling time from at least one electrode of the at least two electrodes; and calculating an analyte concentration based on the measured output signal at the specified sampling time and the derived batch slope.

**[0040]** And for these aspects, the following features may also be utilized in various combinations with these previously disclosed aspects: the applying of the first signal and the driving of the second signal may be in sequential order; the applying of the first signal may overlap with the driving of the second signal; the applying of the first signal may include directing an alternating signal to the sample so that a physical characteristic of the sample is determined from an output of the alternating signal; the applying of the first signal may include directing an optical signal to the sample so that a physical characteristic of the sample is determined from an output of the optical signal; the physical characteristic may include hematocrit and the analyte may include glucose; the physical characteristic may include at least one of viscosity, hematocrit,

temperature and density of the sample; the directing may include driving first and second alternating signal at different respective frequencies in which a first frequency is lower than the second frequency; the first frequency may be at least one order of magnitude lower than the second frequency; the first frequency may include any frequency in the range of about 10kHz to about 250kHz, or about 10kHz to about 90kHz; and/or the specified sampling time may be calculated using an equation of the form:

$$\text{SpecifiedSamplingTime} = x_1 H^{x_2} + x_3$$

where

“SpecifiedSamplingTime” is designated as a time point from the start of the test sequence at which to sample the output signal of the test strip,

$H$  represents physical characteristic of the sample;

$x_1$  is about  $4.3e5$ , or is equal to  $4.3e5$ , or is equal to  $4.3e5 \pm 10\%$ ,  $5\%$  or  $1\%$  of the numerical value provided hereof;

$x_2$  is about  $-3.9$ , or is equal to  $-3.9$ , or is equal to  $-3.9 \pm 10\%$ ,  $5\%$  or  $1\%$  of the numerical value provided hereof; and

$x_3$  is about  $4.8$ , or is equal to  $4.8$ , or is equal to  $4.8 \pm 10\%$ ,  $5\%$  or  $1\%$  of the numerical value provided herein.

[0041] Additionally, for these aspects noted above, the derived slope may be determined from an equation of the form:

$$\text{NewSlope} = aH^2 + bH + c$$

where

$H$  is a measured or estimated physical characteristic (e.g., hematocrit);

$a$  represents about  $1.4e-6$ , or is equal to  $1.35e-6$ , or is equal to  $1.4e-6 \pm 10\%$ ,  $5\%$  or  $1\%$  of the numerical value provided hereof;

$b$  represents about  $-3.8e-4$ , or is equal to  $-3.79e-4$ , or is equal to  $-3.8e-4 \pm 10\%$ ,  $5\%$  or  $1\%$  of the numerical value provided hereof;;

$c$  represents about  $3.6e-2$ , or is equal to  $3.56e-2$ , or is equal to  $-3.6e-2 \pm 10\%$ ,  $5\%$  or  $1\%$  of the numerical value provided herein.

[0042] Furthermore, the calculating of the analyte concentration is computed with an

$$\text{equation of the form: } G_0 = \left[ \frac{I_E - \text{Intercept}}{\text{NewSlope}} \right]$$

where

$G_0$  represents, or is, an analyte concentration

$I_E$  represents, or is, a signal (proportional to analyte concentration) measured at the *SpecifiedSamplingTime*, which may be the total signal measured at the *SpecifiedSamplingTime*;

*NewSlope* represents, or is, the value derived from the measured or estimated physical characteristic; and

Intercept represents, or is, the value obtained from calibration testing of a batch of test strips of which this particular strip comes from.

[0043] In a twelfth aspect of applicants' disclosure, an analyte measurement system is provided that includes a test strip and an analyte meter. The test strip includes a substrate and a plurality of electrodes connected to respective electrode connectors. The analyte meter includes a housing, a test strip port connector configured to connect to the respective electrode connectors of the test strip, and a microprocessor in electrical communication with the test strip port connector to apply electrical signals or sense electrical signals from the plurality of electrodes during a test sequence. The microprocessor is configured to, during the test sequence: (a) apply a first signal to the plurality of electrodes so that a specific sampling time point and a batch slope determined from a physical characteristic of a physiological fluid sample are derived, (b) apply a second signal to the plurality of electrodes, and (c) measure a signal output from one of the plurality of electrodes at the specified sampling time point so that an analyte concentration is determined based on the measured signal at the specified time point and the batch slope.

[0044] And for these aspects, the following features may also be utilized in various combinations with these previously disclosed aspects: the plurality of electrodes may include at least two electrodes to measure the physical characteristic and at least two other electrodes to measure the analyte concentration; the at least two electrodes and the at least two other electrodes may be disposed in the same chamber provided on the substrate; the at least two electrodes and the at least two other electrodes may be

disposed in different chambers provided on the substrate; the at least two electrodes may comprise two electrodes to measure the physical characteristic and the analyte concentration; the plurality of electrodes may comprise two electrodes to measure the physical characteristic and the analyte concentration; all of the electrodes may be disposed on the same plane defined by the substrate; a reagent may be disposed proximate the at least two other electrodes and no reagent disposed on the at least two electrodes; and/or the specified sampling time may be calculated using an equation of the form:

$$\text{SpecifiedSamplingTime} = x_1 H^{x_2} + x_3$$

where

“SpecifiedSamplingTime” is designated as a time point from the start of the test sequence at which to sample the output signal of the test strip,

$H$  represents, or is, a physical characteristic of the sample;

$x_1$  is about 4.3e5, or is equal to 4.3e5, or is equal to 4.3e5 +/- 10%, 5% or 1% of the numerical value provided hereof;

$x_2$  is about -3.9, or is equal to -3.9, or is equal to -3.9 +/- 10%, 5% or 1% of the numerical value provided hereof; and

$x_3$  is about 4.8, or is equal to 4.8, or is equal to 4.8 +/- 10%, 5% or 1% of the numerical value provided herein.

[0045] In these aspects previously noted above, the derived slope is determined from an equation of the form:

$$\text{NewSlope} = aH^2 + bH + c$$

where

$H$  is measured or estimated physical characteristic (e.g., hematocrit);

$a$  represents about 1.4e-6, or is equal to 1.35e-6, or is equal to 1.4e-6 +/- 10%, 5% or 1% of the numerical value provided hereof;

$b$  represents about -3.8e-4, or is equal to -3.79e-4, or is equal to -3.8e-4 +/- 10%, 5% or 1% of the numerical value provided hereof;

$c$  represents about 3.6e-2, or is equal to 3.56e-2, or is equal to -3.6e-2 +/- 10%, 5% or 1% of the numerical value provided herein.

[0046] Furthermore, for these aspects, the calculating of the analyte concentration is

computed with an equation of the form:  $G_0 = \left[ \frac{I_E - \text{Intercept}}{\text{NewSlope}} \right]$

where

$G_0$  represents, or is, an analyte concentration

$I_E$  represents, or is, a signal (proportional to analyte concentration) measured at the *SpecifiedSamplingTime*, which may be the total signal measured at the *SpecifiedSamplingTime*;

*NewSlope* represents, or is, the value derived from the measured or estimated physical characteristic; and

Intercept represents, or is, the value obtained from calibration testing of a batch of test strips of which this particular strip comes from.

[0047] In a thirteenth aspect of applicants' disclosure, an analyte measurement system is provided that includes a test strip and an analyte meter. The test strip includes a substrate and a plurality of electrodes connected to respective electrode connectors. The analyte meter includes a housing, a test strip port connector configured to connect to the respective electrode connectors of the test strip, and a microprocessor in electrical communication with the test strip port connector to apply electrical signals or sense electrical signals from the plurality of electrodes during a test sequence. The microprocessor is configured to, during a test sequence: (a) apply a first signal to the plurality of electrodes so that a specific sampling time point and a batch slope of the test strip determined from a physical characteristic of a physiological fluid sample are derived, (b) apply a second signal to the plurality of electrodes, and (c) measure a signal output from one of the plurality of electrodes at the specified sampling time point so that an analyte concentration of the sample is determined based on the specific sampling time point and batch slope within about 10 seconds of a start of the test sequence.

[0048] And for these aspects, the following features may also be utilized in various combinations with these previously disclosed aspects: the plurality of electrodes may include at least two electrodes to measure the physical characteristic and at least two other electrodes to measure the analyte concentration; the at least two electrodes and the at least two other electrodes may be disposed in the same chamber provided on the

substrate; the at least two electrodes and the at least two other electrodes may be disposed in different chambers provided on the substrate; the at least two electrodes may comprise two electrodes to measure the physical characteristic and the analyte concentration; the plurality of electrodes may comprise two electrodes to measure the physical characteristic and the analyte concentration; all of the electrodes may be disposed on the same plane defined by the substrate; a reagent may be disposed proximate the at least two other electrodes and no reagent disposed on the at least two electrodes; the specified sampling time may be calculated using an equation of the form:

$$\text{SpecifiedSamplingTime} = x_1 H^{x_2} + x_3$$

where

“*SpecifiedSamplingTime*” is designated as a time point from the start of the test sequence at which to sample the output signal of the test strip,

*H* represents, or is, a physical characteristic of the sample;

$x_1$  is about 4.3e5, or is equal to 4.3e5, or is equal to 4.3e5 +/- 10%, 5% or 1% of the numerical value provided hereof;

$x_2$  is about -3.9, or is equal to -3.9, or is equal to -3.9 +/- 10%, 5% or 1% of the numerical value provided hereof; and

$x_3$  is about 4.8, or is equal to 4.8, or is equal to 4.8 +/- 10%, 5% or 1% of the numerical value provided herein.

[0049] For these aspects previously noted, the derived slope may be determined from an equation of the form:

$$\text{NewSlope} = aH^2 + bH + c$$

where

*NewSlope* represents the derived slope;

*H* is measured or estimated physical characteristic (e.g., hematocrit);

*a* represents, or is, about 1.4e-6, or is equal to 1.35e-6, or is equal to 1.4e-6 +/- 10%, 5% or 1% of the numerical value provided hereof;

*b* represents, or is, about -3.8e-4, or is equal to -3.79e-4, or is equal to -3.8e-4 +/- 10%, 5% or 1% of the numerical value provided hereof;

*c* represents, or is, about 3.6e-2, or is equal to 3.56e-2, or is

equal to  $-3.6\text{e-}2 \pm 10\%$ ,  $5\%$  or  $1\%$  of the numerical value provided hereof

[0050] Furthermore, for these aspects, the calculating of the analyte concentration is

computed with an equation of the form: 
$$G_0 = \left[ \frac{I_E - \text{Intercept}}{\text{NewSlope}} \right]$$

where  $G_0$  represents, or is, an analyte concentration

$I_E$  represents, or is, a signal (proportional to analyte concentration) measured at the *SpecifiedSamplingTime*, which may be the total signal measured at the *SpecifiedSamplingTime*;

*NewSlope* represents, or is, the value derived from the measured or estimated physical characteristic; and

Intercept represents, or is, the value obtained from calibration testing of a batch of test strips of which this particular strip comes from.

[0051] In a fourteenth aspect of applicants' disclosure, a method of demonstrating increased accuracy of a test strip is provided. The method can be achieved by: providing a batch of test strips; introducing a referential sample containing a referential concentration of an analyte to each of the batch of test strips to initiate a test sequence; reacting the analyte to cause a physical transformation of the analyte proximate the two electrodes (which may be between the two electrodes); determining a physical characteristic of the referential sample; deriving a batch slope of the batch of test strips based on the determined physical characteristic; sampling an electrical output of the referential sample at a specified time point during the test sequence defined by the measured or estimated physical characteristic; and calculating an analyte concentration based on the specified time point and the derived batch slope to provide for a final analyte concentration value for each of the batch of test strips such that at least 95% of the final analyte concentration values of the batch of test strips are within  $\pm 15\%$  of the referential analyte concentration.

[0052] And for these aspects, the following features may also be utilized in various combinations with these previously disclosed aspects: the reacting may include driving a second signal to the sample and the determining may include applying a first signal to the sample to derive a physical characteristic of the sample, and the applying of the first

signal and the driving of the second signal may be in sequential order; the applying of the first signal may overlap with the driving of the second signal; the reacting may comprise driving a second signal to the sample and the determining may comprise applying a first signal to the sample to derive a physical characteristic of the sample, and the applying of the first signal may overlap with the driving of the second signal; the applying of the first signal may include directing an alternating signal to the sample so that a physical characteristic of the sample is determined from an output of the alternating signal; the applying of the first signal may include directing an optical signal to the sample so that a physical characteristic of the sample is determined from an output of the optical signal; the physical characteristic may include hematocrit and the analyte may include glucose; the physical characteristic may include at least one of viscosity, hematocrit, temperature and density; the directing may include driving first and second alternating signal at different respective frequencies in which a first frequency is lower than the second frequency; the first frequency may be at least one order of magnitude lower than the second frequency; the first frequency may include any frequency in the range of about 10kHz to about 250kHz, or about 10kHz to about 90kHz; and/or the specified sampling time may be calculated using an equation of the form:

$$\text{SpecifiedSamplingTime} = x_1 H^{x_2} + x_3$$

where

“*SpecifiedSamplingTime*” is designated as a time point from the start of the test sequence at which to sample the output signal of the test strip,

*H* represents, or is, a physical characteristic of the sample;

$x_1$  is about 4.3e5, or is equal to 4.3e5, or is equal to 4.3e5 +/- 10%, 5% or 1% of the numerical value provided hereof;

$x_2$  is about -3.9, or is equal to -3.9, or is equal to -3.9 +/- 10%, 5% or 1% of the numerical value provided hereof; and

$x_3$  is about 4.8, or is equal to 4.8, or is equal to 4.8 +/- 10%, 5% or 1% of the numerical value provided hereof

[0053] Additionally, for these previously disclosed aspects, the derived slope may be determined from an equation of the form:

$$\text{NewSlope} = aH^2 + bH + c$$

where

H is measured or estimated physical characteristic (e.g., hematocrit);

a represents, or is, about  $1.4\text{e-}6$ , or is equal to  $1.35\text{e-}6$ , or is equal to  $1.4\text{e-}6 \pm 10\%$ ,  $5\%$  or  $1\%$  of the numerical value provided hereof;

b represents, or is, about  $-3.8\text{e-}4$ , or is equal to  $-3.79\text{e-}4$ , or is equal to  $-3.8\text{e-}4 \pm 10\%$ ,  $5\%$  or  $1\%$  of the numerical value provided hereof;

c represents, or is, about  $3.6\text{e-}2$ , or is equal to  $3.56\text{e-}2$ , or is equal to  $-3.6\text{e-}2 \pm 10\%$ ,  $5\%$  or  $1\%$  of the numerical value provided hereof.

**[0054]** Furthermore, for these aspects, the calculating of the analyte concentration is

computed with an equation of the form: 
$$G_0 = \left[ \frac{I_E - \text{Intercept}}{\text{NewSlope}} \right]$$

where

$G_0$  represents, or is, an analyte concentration

$I_E$  represents, or is, a signal (proportional to analyte concentration) or signals measured at the *SpecifiedSamplingTime*, which may be the total signal measured at the *SpecifiedSamplingTime*;

*NewSlope* represents, or is, the value derived from the measured or estimated physical characteristic; and

Intercept represents, or is, the value obtained from calibration testing of a batch of test strips of which this particular strip comes from.

**[0055]** In a fifteenth aspect of applicants' disclosure, a method of determining an analyte concentration from a fluid sample (which may be a physiological sample). The method can be achieved by: depositing a fluid sample (which may be a physiological sample) on a biosensor having a reagent deposited thereon; applying signals to the sample and the reagent to transform the analyte into a different material; obtaining a physical characteristic of the sample; specifying a time point for sampling of signal output based on the physical characteristic from the obtaining step; deriving a batch slope of the biosensor; measuring signal output at the specified sampling time point;

and determining an analyte concentration based on the measured signal output of the sample at the specified sampling time point and the derived batch slope.

[0056] And for these aspects, the following features may also be utilized in various combinations with these previously disclosed aspects: the obtaining may include driving a second signal to the sample to derive a physical characteristic of the sample; the applying may include applying a first signal to the sample to derive a physical characteristic of the sample, and the applying of the first signal and the driving of the second signal may be in sequential order; the applying of the first signal may overlap with the driving of the second signal; the applying may comprise applying a first signal to the sample to derive a physical characteristic of the sample, and the applying of the first signal may overlap with the driving of the second signal; the applying of the first signal may include directing an alternating signal to the sample so that a physical characteristic of the sample is determined from an output of the alternating signal; the applying of the first signal may include directing an optical signal to the sample so that a physical characteristic of the sample is determined from an output of the optical signal; the physical characteristic may include hematocrit and the analyte may include glucose; the physical characteristic may include at least one of viscosity, hematocrit, temperature and density; the directing may include driving first and second alternating signal at different respective frequencies in which a first frequency is lower than the second frequency; the first frequency may be at least one order of magnitude lower than the second frequency; the first frequency may include any frequency in the range of about 10kHz to about 250kHz, or about 10kHz to about 90kHz; and/or the specified sampling time may be calculated using an equation of the form:

$$SpecifiedSamplingTime = x_1 H^{x_2} + x_3$$

where

“*SpecifiedSamplingTime*” is designated as a time point from the start of the test sequence at which to sample the output signal of the test strip,

$H$  represents, or is, a physical characteristic of the sample;

$x_1$  is about 4.3e5, or is equal to 4.3e5, or is equal to 4.3e5 +/- 10%, 5% or 1% of the numerical value provided hereof,

$x_2$  is about -3.9, or is equal to -3.9, or is equal to -3.9 +/- 10%, 5% or 1% of the numerical value provided hereof; and

$x_3$  is about 4.8, or is equal to 4.8, or is equal to 4.8 +/- 10%, 5% or 1% of the numerical value provided hereof.

[0057] For these aspects previously disclosed, the derived slope may be determined from an equation of the form:

$$NewSlope = aH^2 + bH + c$$

where

H is measured or estimated physical characteristic (e.g., hematocrit);

a represents, or is, about 1.4e-6, or is equal to 1.35e-6, or is equal to 1.4e-6 +/- 10%, 5% or 1% of the numerical value provided hereof;

b represents, or is, about -3.8e-4, or is equal to -3.79e-4, or is equal to -3.8e-4 +/- 10%, 5% or 1% of the numerical value provided hereof;

c represents, or is, about 3.6e-2, or is equal to 3.56e-2, or is equal to -3.6e-2 +/- 10%, 5% or 1% of the numerical value provided hereof.

[0058] Furthermore, the calculating of the analyte concentration is computed with an

equation of the form: 
$$G_0 = \left[ \frac{I_E - Intercept}{NewSlope} \right]$$

where

$G_0$  represents, or is, an analyte concentration

$I_E$  represents, or is, a signal (proportional to analyte concentration) measured at the *SpecifiedSamplingTime*, which may be the total signal measured at the *SpecifiedSamplingTime*;

*NewSlope* represents, or is, the value derived from the measured or estimated physical characteristic; and

Intercept represents, or is, the value obtained from calibration testing of a batch of test strips of which this particular strip comes from.

[0059] In a sixteenth aspect of applicants' disclosure, a method of determining an analyte concentration from a fluid sample (which may be a physiological sample) with a biosensor is provided. The biosensor has at least two electrodes and a reagent disposed on at least one of the electrodes. The method can be achieved by: depositing a fluid sample (which may be a physiological sample) on the at least two electrodes to start an analyte test sequence; applying a first signal to the sample to measure a physical characteristic of the sample; driving a second signal to the sample to cause an enzymatic reaction of the analyte and the reagent; estimating an analyte concentration based on a predetermined sampling time point from the start of the test sequence; selecting a sampling time point from a look-up table that includes a matrix in which different qualitative categories of the estimated analyte are set forth in the leftmost column of the matrix and different qualitative categories of the measured or estimated physical characteristic are set forth in the topmost row of the matrix and the sampling times are provided in the remaining cells of the matrix; measuring signal output from the sample at the selected sampling time point from the look-up table; calculating an analyte concentration from measured output signal sampled at said selected sampling time point in accordance with an equation of the form:

$$G_0 = \left[ \frac{I_T - \text{Intercept}}{\text{Slope}} \right]$$

where

$G_0$  represents, or is, an analyte concentration;

$I_T$  represents, or is, a signal (proportional to analyte concentration) measured at a specified sampling time  $T$ , which may be the total signal measured at the specified sampling time  $T$ ;

Slope represents, or is the value obtained from calibration testing of a batch of test strips of which this particular strip comes from; and

Intercept represents, or is, the value obtained from calibration testing of a batch of test strips of which this particular strip comes from.

[0060] In a seventeenth aspect of applicants' disclosure, a method of determining an analyte concentration from a fluid sample (which may be a physiological sample) with a biosensor is provided. The biosensor has at least two electrodes and a reagent disposed on at least one of the electrodes. The method can be achieved by: depositing a

fluid sample (which may be a physiological sample) on the at least two electrodes to start an analyte test sequence; applying a first signal to the sample to measure or estimate a physical characteristic of the sample; driving a second signal to the sample to cause an enzymatic reaction of the analyte and the reagent; estimating an analyte concentration based on a predetermined sampling time point from the start of the test sequence; selecting a sampling time point from a look-up table that includes a matrix in which different qualitative categories of the estimated analyte are set forth in the leftmost column of the matrix and different qualitative categories of the measured or estimated physical characteristic are set forth in the topmost row of the matrix and the sampling times are provided in the remaining cells of the matrix; measuring signal output from the sample at the selected sampling time point; and calculating an analyte concentration from measured output signal sampled at said selected sampling time point.

**[0061]** And for these aspects, the following features may also be utilized in various combinations with these previously disclosed aspects: the applying of the first signal and the driving of the second signal may be sequential; the applying of the first signal may overlap with the driving of the second signal; the applying of the first signal may comprise directing an alternating signal to the sample so that a physical characteristic of the sample is determined from an output of the alternating signal; the physical characteristic may comprise hematocrit and the analyte may comprise glucose; the physical characteristic may comprise at least one of viscosity, hematocrit, temperature and density; the directing may comprise driving first and second alternating signals at different respective frequencies in which a first frequency is lower than the second frequency; the first frequency may be at least one order of magnitude lower than the second frequency; the first frequency may comprise any frequency in the range of about 10kHz to about 250kHz, or about 10kHz to about 90kHz; the measuring may comprise sampling the signal output continuously at the start of the test sequence until at least about 10 seconds after the start; which may further include the step of estimating an analyte concentration based on a measurement of the output signal at a predetermined time; the estimating may comprise comparing the estimated analyte concentration and the measured or estimated physical characteristic against a look-up table having different respective ranges of analyte concentration and physical characteristic of the sample indexed against different sample measurement times so that

the point in time for measurement of the output from the sample of the second signal is obtained for the calculating step; and/or the calculating step may comprise utilizing an equation of the form:

$$G_0 = \left[ \frac{I_T - \text{Intercept}}{\text{Slope}} \right]$$

where

$G_0$  represents, or is, an analyte concentration;

$I_T$  represents, or is, a signal (proportional to analyte concentration) measured at a specified sampling time  $T$ , which may be the total signal measured at the specified sampling time  $T$ ;

Slope represents, or is, the value obtained from calibration testing of a batch of test strips of which this particular strip comes from; and

Intercept represents, or is, the value obtained from calibration testing of a batch of test strips of which this particular strip comes from.

**[0062]** In an eighteenth aspect of applicants' disclosure, an analyte measurement system is provided that includes a test strip and an analyte meter. The test strip includes a substrate and a plurality of electrodes connected to respective electrode connectors. The analyte meter includes a housing, a test strip port connector configured to connect to the respective electrode connectors of the test strip, and a microprocessor in electrical communication with the test strip port connector to apply electrical signals or sense electrical signals from the plurality of electrodes. The microprocessor is configured to: (a) apply a first signal to the plurality of electrodes so that a physical characteristic of a physiological fluid sample is determined; (b) estimate an analyte concentration based on a predetermined sampling time point during a test sequence; and (c) apply a second signal to the plurality of electrodes at a sampling time point during the test sequence dictated by the determined physical characteristic so that an analyte concentration is calculated from the second signal.

**[0063]** And for these aspects, the following features may also be utilized in various combinations with these previously disclosed aspects: the plurality of electrodes may comprise at least two electrodes to measure the physical characteristic and at least two other electrodes to measure the analyte concentration; the at least two electrodes and the at least two other electrodes may be disposed in the same chamber provided on the

substrate; the at least two electrodes and the at least two other electrodes may be disposed in different chambers provided on the substrate; all of the electrodes may be disposed on the same plane defined by the substrate; and/or a reagent may be disposed proximate the at least two other electrodes and no reagent disposed on the at least two electrodes.

**[0064]** In a nineteenth aspect of applicants' disclosure, an analyte measurement system is provided that includes a test strip and an analyte meter. The test strip includes a substrate and a plurality of electrodes connected to respective electrode connectors. The analyte meter includes a housing, a test strip port connector configured to connect to the respective electrode connectors of the test strip, and a microprocessor in electrical communication with the test strip port connector to apply electrical signals or sense electrical signals from the plurality of electrodes. The microprocessor is configured to: (a) apply a first signal to the plurality of electrodes so that a physical characteristic of a physiological fluid sample is determined during a test sequence; (b) estimate an analyte concentration based on a predetermined sampling time point during a test sequence; and (c) apply a second signal to the plurality of electrodes at a sampling time point during the test sequence dictated by the determined physical characteristic so that so that an analyte concentration is determined from the second signal within about 10 seconds of a start of the test sequence.

**[0065]** And for these aspects, the following features may also be utilized in various combinations with these previously disclosed aspects: the plurality of electrodes may comprise at least two electrodes to measure the physical characteristic and at least two other electrodes to measure the analyte concentration; the at least two electrodes and the at least two other electrodes may be disposed in the same chamber provided on the substrate; the at least two electrodes and the at least two other electrodes may be disposed in different chambers provided on the substrate; all of the electrodes may be disposed on the same plane defined by the substrate; and/or a reagent may be disposed proximate on the at least two other electrodes and no reagent disposed on the at least two electrodes.

**[0066]** In a twentieth aspect of applicants' disclosure, a method of demonstrating increased accuracy of a test strip is provided. The method can be achieved by: providing a batch of test strips; introducing a referential sample containing a referential concentration of an analyte to each test strip of the batch of test strips to start a test

sequence; reacting the analyte with reagent disposed on each of the test strips to cause a physical transformation of the analyte proximate the two electrodes (which may be between the two electrodes); estimating an analyte concentration based on measured signal output of the sample at a predetermined time point from the start of the test sequence; determining a physical characteristic of the referential sample; sampling an electrical output of the referential sample at a dictated time point during the test sequence defined by the measured or estimated physical characteristic and the estimated analyte concentration; calculating an analyte concentration based on the dictated time point to provide for a final analyte concentration value for each test strip of the batch of test strips such that at least 95% of the final analyte concentration values of the batch of test strips are within  $\pm 10\%$  of the referential analyte concentration for a range of hematocrit of the sample from about 30% to about 55%.

[0067] And for these aspects, the following features may also be utilized in various combinations with these previously disclosed aspects: the determining may comprise applying a first signal to the sample to measure a physical characteristic of the sample; the reacting may comprise driving a second signal to the sample; the applying of the first signal and the driving of the second signal may be sequential; the applying of the first signal may overlap with the driving of the second signal; the applying of the first signal may comprise directing an alternating signal to the sample so that a physical characteristic of the sample is determined from an output of the alternating signal; the applying of the first signal may comprise directing an electromagnetic signal to the sample so that a physical characteristic of the sample is determined from an output of the electromagnetic signal; the physical characteristic may comprise hematocrit and the analyte may comprise glucose; the physical characteristic may comprise at least one of viscosity, hematocrit, temperature and density; the directing may comprise driving first and second alternating signals at different respective frequencies in which a first frequency is lower than the second frequency; the first frequency may be at least one order of magnitude lower than the second frequency; the first frequency may comprise any frequency in the range of about 10kHz to about 250kHz, or about 10kHz to about 90kHz; and/or the measuring may comprise sampling the signal output continuously at the start of the test sequence until at least about 10 seconds after the start; which may further include the step of estimating an analyte concentration based on a measurement of the output signal at a predetermined time; the estimating may comprise comparing

the estimated analyte concentration and the measured or estimated physical characteristic against a look-up table having different respective ranges of analyte concentration and physical characteristic of the sample indexed against different sample measurement times so that the point in time for measurement of the output from the sample of the second signal is obtained for the calculating step.

**[0068]** In a twenty-first aspect of applicants' disclosure, a method of determining an analyte concentration from a fluid sample (which may be a physiological sample) is provided. The method can be achieved by: depositing a fluid sample (which may be a physiological sample) on a biosensor to start a test sequence; causing the analyte in the sample to undergo an enzymatic reaction; estimating an analyte concentration in the sample; measuring at least one physical characteristic of the sample; defining a time point from the start of the test sequence to sample output signals of the biosensor based on the estimated analyte concentration and at least one physical characteristic from the measuring step; sampling output signals of the biosensor at the defined time point; determining an analyte concentration from sampled signals at the defined time point.

**[0069]** And for these aspects, the following features may also be utilized in various combinations with these previously disclosed aspects: the measuring may comprise applying a first signal to the sample to measure a physical characteristic of the sample; the causing step may comprise driving a second signal to the sample; the measuring may comprise evaluating an output signal from the at least two electrodes at a point in time after the start of the test sequence, in which the point in time is set as a function of at least the measured or estimated physical characteristic; the determining step may comprise calculating an analyte concentration from the measured output signal at said point in time; the applying of the first signal and the driving of the second signal may be sequential; the applying of the first signal may overlap with the driving of the second signal; the applying of the first signal may comprise directing an alternating signal to the sample so that a physical characteristic of the sample is determined from an output of the alternating signal; which may further include the step of estimating an analyte concentration based on a predetermined sampling time point from the start of the test sequence; the defining may comprise selecting a defined time point based on both the measured or estimated physical characteristic and the estimated analyte concentration; the physical characteristic may comprise hematocrit and the analyte may comprise glucose; the physical characteristic may comprise at least one of viscosity,

hematocrit, temperature and density; the directing may comprise driving first and second alternating signal at different respective frequencies in which a first frequency is lower than the second frequency; the first frequency may be at least one order of magnitude lower than the second frequency; the first frequency may comprise any frequency in the range of about 10kHz to about 250kHz, or about 10kHz to about 90kHz; the measuring may comprise sampling the signal output continuously at the start of the test sequence until at least about 10 seconds after the start; which may further include the step of estimating an analyte concentration based on a measurement of the output signal at a predetermined time; and/or the estimating may comprise comparing the estimated analyte concentration and the measured or estimated physical characteristic against a look-up table having different respective ranges of analyte concentration and physical characteristic of the sample indexed against different sample measurement times so that the point in time for measurement of the output from the sample of the second signal is obtained for the calculating step.

**[0070]** In the sixteenth to the twenty-first aspects, the sampling time point could be selected from a look-up table that includes a matrix in which different qualitative categories of the estimated analyte are set forth in the leftmost column of the matrix and different qualitative categories of the measured or estimated physical characteristic are set forth in the topmost row of the matrix and the sampling times are provided in the remaining cells of the matrix. In any of the above aspects, the fluid sample may be blood. In any of the above aspects, the physical characteristic may include at least one of viscosity, hematocrit, or density of the sample, or the physical characteristic may be hematocrit, wherein, optionally, the hematocrit level is between 30% and 55%. In any of the above aspects, where  $H$  represents, or is, the physical characteristic of the sample, it may be the measured, estimated or determined hematocrit, or may be in the form of hematocrit. In any of the above aspects, the physical characteristic may be determined from a measured characteristic, such as the impedance or phase angle of the sample. In any of the above aspects, the signal represented by  $I_E$  and/or  $I_T$  may be current.

**[0071]** In the aforementioned aspects of the disclosure, the steps of determining, estimating, calculating, computing, deriving and/or utilizing (possibly in conjunction with an equation) may be performed by an electronic circuit or a processor. These steps may also be implemented as executable instructions stored on a computer

readable medium; the instructions, when executed by a computer may perform the steps of any one of the aforementioned methods.

[0072] In additional aspects of the disclosure, there are computer readable media, each medium comprising executable instructions, which, when executed by a computer, perform the steps of any one of the aforementioned methods.

[0073] In additional aspects of the disclosure, there are devices, such as test meters or analyte testing devices, each device or meter comprising an electronic circuit or processor configured to perform the steps of any one of the aforementioned methods.

[0074] These and other embodiments, features and advantages will become apparent to those skilled in the art when taken with reference to the following more detailed description of the exemplary embodiments of the invention in conjunction with the accompanying drawings that are first briefly described.

#### **BRIEF DESCRIPTION OF THE DRAWINGS**

[0075] The accompanying drawings, which are incorporated herein and constitute part of this specification, illustrate presently preferred embodiments of the invention, and, together with the general description given above and the detailed description given below, serve to explain features of the invention (wherein like numerals represent like elements), in which:

[0076] Figure 1 illustrates an analyte measurement system.

[0077] Figure 2A illustrates in simplified schematic form the components of the meter 200.

[0078] Figure 2B illustrates in simplified schematic form a preferred implementation of a variation of meter 200.

[0079] Figure 3A(1) illustrates the test strip 100 of the system of Figure 1 in which there are two physical characteristic sensing electrodes upstream of the measurement electrodes.

[0080] Figure 3A(2) illustrates a variation of the test strip of Figure 3A(1) in which a shielding or grounding electrode is provided for proximate the entrance of the test chamber;

- [0081] Figure 3A(3) illustrates a variation of the test strip of Figure 3A(2) in which a reagent area has been extended upstream to cover at least one of the physical characteristic sensing electrodes;
- [0082] Figure 3A(4) illustrates a variation of test strip 100 of Figures 3A(1), 3A(2) and 3A(3) in which certain components of the test strip have been integrated together into a single unit;
- [0083] Figure 3B illustrates a variation of the test strip of Figure 3A(1), 3A(2), or 3A(3) in which one physical characteristic sensing electrode is disposed proximate the entrance and the other physical characteristic sensing electrode is at the terminal end of the test cell with the measurement electrodes disposed between the pair of physical characteristic sensing electrodes.
- [0084] Figures 3C and 3D illustrate variations of Figure 3A(1), 3A(2), or 3A(3) in which the physical characteristic sensing electrodes are disposed next to each other at the terminal end of the test chamber with the measurement electrodes upstream of the physical characteristic sensing electrodes.
- [0085] Figures 3E and 3F illustrates a physical characteristic sensing electrodes arrangement similar to that of Figure 3A(1), 3A(2), or 3A(3) in which the pair of physical characteristic sensing electrodes are proximate the entrance of the test chamber.
- [0086] Figure 3G is a simplified, perspective, exploded view of an analytical test strip according to an embodiment of the present disclosure;
- [0087] Figure 3H is a simplified top view of the analytical test strip of Figure 3G;
- [0088] Figure 3I is a simplified cross-sectional side view of the analytical test strip of Figure 3H taken along line A-A of Figure 3H;
- [0089] Figure 3J is a simplified cross-sectional end view of the analytical test strip of Figure 3H taken along line B-B of Figure 3H; and
- [0090] Figure 3K is a simplified, perspective exploded view of an analytical test strip according to an embodiment of the present disclosure;
- [0091] Figure 3L is a simplified top view of the electrically-insulating substrate and a portion of a first patterned conductor layer of an analytical test strip of Figure 3K;
- [0092] Figure 3M is a simplified top view of the first patterned spacer layer of the analytical test strip of Figure 3K;

- [0093] Figure 3N is a simplified top view of the second patterned spacer layer of the analytical test strip of Figure 3K;
- [0094] Figure 3O is a simplified cross-sectional side view of the analytical test strip of Figure 3K taken along line A-A of Figures 2A;
- [0095] Figure 3P is a simplified, perspective exploded view of an analytical test strip according to another embodiment of the present disclosure;
- [0096] Figure 3Q is a simplified top view of the electrically insulating substrate and first patterned conductor layer of the analytical test strip of Figure 3P;
- [0097] Figure 3R is a simplified top view of a portion of a second patterned spacer layer and second patterned conductor layer of the analytical test strip of Figure 3P;
- [0098] Figure 3S is a simplified top view of a third patterned spacer layer of the analytical test strip of Figure 3P;
- [0099] Figure 3T is a simplified cross-sectional side view of the analytical test strip of Figure 3P taken along line B-B of Figures 3Q.
- [00100] Figure 4A illustrates a graph of time over applied potential to the test strip of Figure 1.
- [00101] Figure 4B illustrates a graph of time over output current from the test strip of Figure 1.
- [00102] Figure 5 illustrates an exemplary waveform applied to the test chamber and a waveform as measured from the test chamber to show a time delay between the waveforms.
- [00103] Figure 6A1 illustrates a logic diagram of an exemplary method to achieve a more accurate analyte determination.
- [00104] Figure 6A2 illustrates one relationship between batch slope and physical characteristic (e.g., hematocrit).
- [00105] Figure 6A3 illustrates data from test measurements conducted with the exemplary technique herein such that the data show the bias of less than  $\pm 15\%$  for the hematocrit range of about 30% to about 55%.
- [00106] Figure 6B1 illustrates a logic diagram of an exemplary method to achieve a more accurate analyte determination.
- [00107] Figure 6B2 illustrates one relationship between sampling time point and hematocrits.

- [00108] Figure 6B3 illustrates data from test measurements conducted with the exemplary technique herein such that the data show the bias of less than  $\pm 25\%$  for the hematocrit range of about 30% to about 55%.
- [00109] Figure 6C1 illustrates a logic diagram of an exemplary method to achieve a more accurate analyte determination.
- [00110] Figure 6C2 illustrates one relationship between sampling time point and hematocrits.
- [00111] Figure 6C3 illustrates a relationship between slope and hematocrits.
- [00112] Figure 6C4 illustrates data from test measurements conducted with the exemplary technique herein such that the data show the bias of less than  $\pm 25\%$  for the hematocrit range of about 30% to about 55%.
- [00113] Figure 6D1 illustrates a logic diagram of an exemplary method to achieve a more accurate analyte determination.
- [00114] Figure 6D2 illustrates a signal output transient of the biosensor and the range of time point utilized for determination of the analyte, as well as the estimation of the analyte concentration.
- [00115] Figure 6D3 illustrates data from test measurements conducted with the exemplary technique herein such that the data show the bias of less than about  $\pm 10\%$  for the hematocrit range of about 30% to about 55%.
- [00116] Figure 7 illustrates a signal output transient of the biosensor and the range of time point utilized for determination of the analyte, as well as the estimation of the analyte concentration.

## MODES OF CARRYING OUT THE INVENTION

- [00117] The following detailed description should be read with reference to the drawings, in which like elements in different drawings are identically numbered. The drawings, which are not necessarily to scale, depict selected embodiments and are not intended to limit the scope of the invention. The detailed description illustrates by way of example, not by way of limitation, the principles of the invention. This description will clearly enable one skilled in the art to make and use the invention, and describes several embodiments, adaptations, variations, alternatives and uses of the invention, including what is presently believed to be the best mode of carrying out the invention.

**[00118]** As used herein, the terms “about” or “approximately” for any numerical values or ranges indicate a suitable dimensional tolerance that allows the part or collection of components to function for its intended purpose as described herein. More specifically, “about” or “approximately” may refer to the range of values  $\pm 10\%$  of the recited value, e.g. “about 90%” may refer to the range of values from 81% to 99%. In addition, as used herein, the terms “patient,” “host,” “user,” and “subject” refer to any human or animal subject and are not intended to limit the systems or methods to human use, although use of the subject invention in a human patient represents a preferred embodiment. As used herein, “oscillating signal” includes voltage signal(s) or current signal(s) that, respectively, change polarity or alternate direction of current or are multi-directional. Also used herein, the phrase “electrical signal” or “signal” is intended to include direct current signal, alternating signal or any signal within the electromagnetic spectrum. The terms “processor”; “microprocessor”; or “microcontroller” are intended to have the same meaning and are intended to be used interchangeably. Finally, the term “e” as used in each of the mathematical relationships described herein is intended to refer to exponential notation; e.g.,  $4.3e5 = 4.3 \times 10^5 = 430,000$ .

**[00119]** Figure 1 illustrates a test meter 200, for testing analyte (e.g., glucose) levels in the blood of an individual with a test strip produced by the methods and techniques illustrated and described herein. Test meter 200 may include user interface inputs (206, 210, 214), which can be in the form of buttons, for entry of data, navigation of menus, and execution of commands. Data can include values representative of analyte concentration, and/or information that are related to the everyday lifestyle of an individual. Information, which is related to the everyday lifestyle, can include food intake, medication use, the occurrence of health check-ups, general health condition and exercise levels of an individual. Test meter 200 can also include a display 204 that can be used to report measured glucose levels, and to facilitate entry of lifestyle related information.

**[00120]** Test meter 200 may include a first user interface input 206, a second user interface input 210, and a third user interface input 214. User interface inputs 206, 210, and 214 facilitate entry and analysis of data stored in the testing device, enabling a user to navigate through the user interface displayed on display 204. User interface inputs 206, 210, and 214 include a first marking 208, a second marking 212, and a third marking 216, which help in correlating user interface inputs to characters on display 204.

**[00121]** Test meter 200 can be turned on by inserting a test strip 100 (or its variants 400, 500, or 600) into a strip port connector 220, by pressing and briefly holding first user interface input 206, or by the detection of data traffic across a data port 218. Test meter 200 can be switched off by removing test strip 100 (or its variants 400, 500, or 600), pressing and briefly holding first user interface input 206, navigating to and selecting a meter off option from a main menu screen, or by not pressing any buttons for a predetermined time. Display 104 can optionally include a backlight.

**[00122]** In one embodiment, test meter 200 can be configured to not receive a calibration input for example, from any external source, when switching from a first test strip batch to a second test strip batch. Thus, in one exemplary embodiment, the meter is configured to not receive a calibration input from external sources, such as a user interface (such as inputs 206, 210, 214), an inserted test strip, a separate code key or a code strip, data port 218. Such a calibration input is not necessary when all of the test strip batches have a substantially uniform calibration characteristic. The calibration input can be a set of values ascribed to a particular test strip batch. For example, the calibration input can include a batch slope and a batch intercept value for a particular test strip batch. The calibrations input, such as batch slope and intercept values, may be preset within the meter as will be described below.

**[00123]** Referring to Figure 2A, an exemplary internal layout of test meter 200 is shown. Test meter 200 may include a processor 300, which in some embodiments described and illustrated herein is a 32-bit RISC microcontroller. In the preferred embodiments described and illustrated herein, processor 300 is preferably selected from the MSP 430 family of ultra-low power microcontrollers manufactured by Texas Instruments of Dallas, Texas. The processor can be bi-directionally connected via I/O ports 314 to a memory 302, which in some embodiments described and illustrated herein is an EEPROM. Also connected to processor 300 via I/O ports 214 are the data port 218, the user interface inputs 206, 210, and 214, and a display driver 320. Data port 218 can be connected to processor 300, thereby enabling transfer of data between memory 302 and an external device, such as a personal computer. User interface inputs 206, 210, and 214 are directly connected to processor 300. Processor 300 controls display 204 via display driver 320. Memory 302 may be pre-loaded with calibration information, such as batch slope and batch intercept values, during production of test meter 200. This pre-loaded calibration information can be accessed and used by

processor 300 upon receiving a suitable signal (such as current) from the strip via strip port connector 220 so as to calculate a corresponding analyte level (such as blood glucose concentration) using the signal and the calibration information without receiving calibration input from any external source.

**[00124]** In embodiments described and illustrated herein, test meter 200 may include an Application Specific Integrated Circuit (ASIC) 304, so as to provide electronic circuitry used in measurements of glucose level in blood that has been applied to a test strip 100 (or its variants 400, 500, or 600) inserted into strip port connector 220. Analog voltages can pass to and from ASIC 304 by way of an analog interface 306. Analog signals from analog interface 306 can be converted to digital signals by an A/D converter 316. Processor 300 further includes a core 308, a ROM 310 (containing computer code), a RAM 312, and a clock 318. In one embodiment, the processor 300 is configured (or programmed) to disable all of the user interface inputs except for a single input upon a display of an analyte value by the display unit such as, for example, during a time period after an analyte measurement. In an alternative embodiment, the processor 300 is configured (or programmed) to ignore any input from all of the user interface inputs except for a single input upon a display of an analyte value by the display unit. Detailed descriptions and illustrations of the meter 200 are shown and described in International Patent Application Publication No. WO2006070200.

**[00125]** Figure 3A(1) is an exemplary exploded perspective view of a test strip 100, which may include seven layers disposed on a substrate 5. The seven layers disposed on substrate 5 can be a first conductive layer 50 (which can also be referred to as electrode layer 50), an insulation layer 16, two overlapping reagent layers 22a and 22b, an adhesive layer 60 which includes adhesive portions 24, 26, and 28, a hydrophilic layer 70, and a top layer 80 which forms a cover 94 for the test strip 100. Test strip 100 may be manufactured in a series of steps where the conductive layer 50, insulation layer 16, reagent layers 22, and adhesive layer 60 are sequentially deposited on substrate 5 using, for example, a screen-printing process. Note that the electrodes 10, 12, and 14) are disposed for contact with the reagent layer 22a and 22b whereas the physical characteristic sensing electrodes 19a and 20a are spaced apart and not in contact with the reagent layer 22. Hydrophilic layer 70 and top layer 80 can be disposed from a roll stock and laminated onto substrate 5 as either an integrated

laminate or as separate layers. Test strip 100 has a distal portion 3 and a proximal portion 4 as shown in Figure 3A(1).

**[00126]** Test strip 100 may include a sample-receiving chamber 92 through which a physiological fluid sample 95 may be drawn through or deposited (Fig. 3A(2)). The physiological fluid sample discussed herein may be blood. Sample-receiving chamber 92 can include an inlet at a proximal end and an outlet at the side edges of test strip 100, as illustrated in Figure 3A(1). A fluid sample 95 can be applied to the inlet along axis L-L (Fig. 3A(2)) to fill a sample-receiving chamber 92 so that glucose can be measured. The side edges of a first adhesive pad 24 and a second adhesive pad 26 located adjacent to reagent layer 22 each define a wall of sample-receiving chamber 92, as illustrated in Figure 3A(1). A bottom portion or “floor” of sample-receiving chamber 92 may include a portion of substrate 5, conductive layer 50, and insulation layer 16, as illustrated in Figure 3A(1). A top portion or “roof” of sample-receiving chamber 92 may include distal hydrophilic portion 32, as illustrated in Figure 3A(1). For test strip 100, as illustrated in Figure 3A(1), substrate 5 can be used as a foundation for helping support subsequently applied layers. Substrate 5 can be in the form of a polyester sheet such as a polyethylene terephthalate (PET) material (Hostaphan PET supplied by Mitsubishi). Substrate 5 can be in a roll format, nominally 350 microns thick by 370 millimeters wide and approximately 60 meters in length.

**[00127]** A conductive layer is required for forming electrodes that can be used for the electrochemical measurement of glucose. First conductive layer 50 can be made from a carbon ink that is screen-printed onto substrate 5. In a screen-printing process, carbon ink is loaded onto a screen and then transferred through the screen using a squeegee. The printed carbon ink can be dried using hot air at about 140°C. The carbon ink can include VAGH resin, carbon black, graphite (KS15), and one or more solvents for the resin, carbon and graphite mixture. More particularly, the carbon ink may incorporate a ratio of carbon black: VAGH resin of about 2.90:1 and a ratio of graphite: carbon black of about 2.62:1 in the carbon ink.

**[00128]** For test strip 100, as illustrated in Figure 3A(1), first conductive layer 50 may include a reference electrode 10, a first working electrode 12, a second working electrode 14, third and fourth physical characteristic sensing electrodes 19a and 19b, a first contact pad 13, a second contact pad 15, a reference contact pad 11, a first working electrode track 8, a second working electrode track 9, a reference electrode track 7, and

a strip detection bar 17. The physical characteristic sensing electrodes 19a and 20a are provided with respective electrode tracks 19b and 20b. The conductive layer may be formed from carbon ink. First contact pad 13, second contact pad 15, and reference contact pad 11 may be adapted to electrically connect to a test meter. First working electrode track 8 provides an electrically continuous pathway from first working electrode 12 to first contact pad 13. Similarly, second working electrode track 9 provides an electrically continuous pathway from second working electrode 14 to second contact pad 15. Similarly, reference electrode track 7 provides an electrically continuous pathway from reference electrode 10 to reference contact pad 11. Strip detection bar 17 is electrically connected to reference contact pad 11. Third and fourth electrode tracks 19b and 20b connect to the respective electrodes 19a and 20a. A test meter can detect that test strip 100 has been properly inserted by measuring a continuity between reference contact pad 11 and strip detection bar 17, as illustrated in Figure 3A(1).

**[00129]** Variations of the test strip 100 (Figure 3A(1), 3A(2), 3A(3), or 3A(4)) are shown in Figures 3B-3T. Briefly, with regard to variations of test strip 100 (illustrated exemplarily in Figures 3A(2), 3A(2) and 3B through 3T), these test strips include an enzymatic reagent layer disposed on the working electrode, a patterned spacer layer disposed over the first patterned conductive layer and configured to define a sample chamber within the analytical test strip, and a second patterned conductive layer disposed above the first patterned conductive layer. The second patterned conductive layer includes a first phase-shift measurement electrode and a second phase-shift measurement electrode. Moreover, the first and second phase-shift measurement electrodes are disposed in the sample chamber and are configured to measure, along with the hand-held test meter, a phase shift of an electrical signal forced through a bodily fluid sample introduced into the sample chamber during use of the analytical test strip. Such phase-shift measurement electrodes are also referred to herein as bodily fluid phase-shift measurement electrodes. Analytical test strips of various embodiments described herein are believed to be advantageous in that, for example, the first and second phase-shift measurement electrodes are disposed above the working and reference electrodes, thus enabling a sample chamber of advantageously low volume. This is in contrast to a configuration wherein the first and second phase-shift measurement electrodes are disposed in a co-planar relationship with the working and

reference electrodes thus requiring a larger bodily fluid sample volume and sample chamber to enable the bodily fluid sample to cover the first and second phase-shift measurement electrodes as well as the working and reference electrodes.

**[00130]** In the embodiment of Figure 3A(2) which is a variation of the test strip of Figure 3A(1), an additional electrode 10a is provided as an extension of any of the plurality of electrodes 19a, 20a, 14, 12, and 10. It must be noted that the built-in shielding or grounding electrode 10a is used to reduce or eliminate any capacitance coupling between the finger or body of the user and the characteristic measurement electrodes 19a and 20a. The grounding electrode 10a allows for any capacitance to be directed away from the sensing electrodes 19a and 20a. To do this, the grounding electrode 10a can be connected any one of the other five electrodes or to its own separate contact pad (and track) for connection to ground on the meter instead of one or more of contact pads 15, 17, 13 via respective tracks 7, 8, and 9. In a preferred embodiment, the grounding electrode 10a is connected to one of the three electrodes that has reagent 22 disposed thereon. In a most preferred embodiment, the grounding electrode 10a is connected to electrode 10. Being the grounding electrode, it is advantageous to connect the grounding electrode to the reference electrode (10) so not to contribute any additional current to the working electrode measurements which may come from background interfering compounds in the sample. Further by connecting the shield or grounding electrode 10a to electrode 10 this is believed to effectively increase the size of the counter electrode 10 which can become limiting especially at high signals. In the embodiment of Figure 3A(2), the reagent are arranged so that they are not in contact with the measurement electrodes 19a and 20a. Alternatively, in the embodiment of Figure 3A(3), the reagent 22 is arranged so that the reagent 22 contacts at least one of the sensing electrodes 19a and 20a.

**[00131]** In alternate version of test strip 100, shown here in Figure 3A(4), the top layer 38, hydrophilic film layer 34 and spacer 29 have been combined together to form an integrated assembly for mounting to the substrate 5 with reagent layer 22' disposed proximate insulation layer 16'.

**[00132]** In the embodiment of Figure 3B, the analyte measurement electrodes 10, 12, and 14 are disposed in generally the same configuration as in Fig. 3A(1), 3A(2), or 3A(3). The electrodes 19a and 20a to sense physical characteristic (e.g., hematocrit) level, however, are disposed in a spaced apart configuration in which one electrode 19a

is proximate an entrance 92a to the test chamber 92 and another electrode 20a is at the opposite end of the test chamber 92. Electrodes 10, 12, and 14 are disposed to be in contact with a reagent layer 22.

**[00133]** In Figures 3C, 3D, 3E and 3F, the physical characteristic (e.g., hematocrit) sensing electrodes 19a and 20a are disposed adjacent each other and may be placed at the opposite end 92b of the entrance 92a to the test chamber 92 (Figs. 3C and 3D) or adjacent the entrance 92a (Figs. 3E and 3F). In all of these embodiments, the physical characteristic sensing electrodes are spaced apart from the reagent layer 22 so that these physical characteristic sensing electrodes are not impacted by the electrochemical reaction of the reagent in the presence of a fluid sample (e.g., blood or interstitial fluid) containing glucose.

**[00134]** Referring to Figures 3G through 3J, electrochemical-based analytical test strip 400 includes an electrically-insulating substrate layer 402, a first patterned conductive layer 404 disposed on the electrically-insulating substrate layer, an enzymatic reagent layer 406 (for clarity depicted in Figure 3G only), a patterned spacer layer 408, a second patterned conductive layer 410 disposed above first patterned conductive layer 404, and an electrically-insulating top layer 412. Patterned spacer layer 408 is configured such that electrochemical-based analytical test strip 400 also includes a sample chamber 414 formed therein with patterned spacer layer 408 defining outer walls of sample chamber 414.

**[00135]** First patterned conductive layer 404 includes three electrodes, a counter electrode 404a (also referred to as a reference electrode), a first working electrode 404b and a second working electrode 404c (see Figure 3G).

**[00136]** Second patterned conductive layer 410 includes a first phase-shift measurement electrode 411 and a second phase shift measurement electrode 413. Second patterned conductive layer 410 also includes a first phase-shift probe contact 416 and a second phase-shift probe contact 418.

**[00137]** During use of electrochemical-based analytical test strip 400 to determine an analyte in a bodily fluid sample (e.g., blood glucose concentration in a whole physiological fluid sample), electrodes 404a, 404b and 404c are employed by an associated meter (not shown) to monitor an electrochemical response of the electrochemical-based analytical test strip. The electrochemical response can be, for example, an electrochemical reaction induced current of interest. The magnitude of

such a current can then be correlated, taking into consideration the physical characteristic (e.g., hematocrit) of the bodily fluid sample as determined by the bodily fluid sample's phase shift, with the amount of analyte present in the bodily fluid sample under investigation. During such use, a bodily fluid sample is applied to electrochemical-based analytical test strip 400 and, thereby, received in sample chamber 414.

**[00138]** Electrically-insulating substrate layer 402 can be any suitable electrically-insulating substrate known to one skilled in the art including, for example, a nylon substrate, polycarbonate substrate, a polyimide substrate, a polyvinyl chloride substrate, a polyethylene substrate, a polypropylene substrate, a glycolated polyester (PETG) substrate, a polystyrene substrate, a silicon substrate, ceramic substrate, glass substrate or a polyester substrate (e.g., a 7 millimeters thick polyester substrate). The electrically-insulating substrate can have any suitable dimensions including, for example, a width dimension of about 5 mm, a length dimension of about 27 mm and a thickness dimension of about 0.5 mm.

**[00139]** First patterned conductive layer 404 can be formed of any suitable electrically conductive material such as, for example, gold, palladium, carbon, silver, platinum, tin oxide, iridium, indium, or combinations thereof (e.g., indium doped tin oxide). Moreover, any suitable technique or combination of techniques can be employed to form first patterned conductive layer 404 including, for example, sputtering, evaporation, electro-less plating, screen-printing, contact printing, laser ablation or gravure printing. A typical but non-limiting thickness for the patterned conductive layer is in the range of 5 nanometers to 400 nanometers.

**[00140]** As is known, conventional electrochemical-based analyte test strips employ a working electrode along with an associated counter/reference electrode and enzymatic reagent layer to facilitate an electrochemical reaction with an analyte of interest and, thereby, determine the presence and/or concentration of that analyte. For example, an electrochemical-based analyte test strip for the determination of glucose concentration in a fluid sample can employ an enzymatic reagent that includes the enzyme glucose oxidase and the mediator ferricyanide (which is reduced to the mediator ferrocyanide during the electrochemical reaction). Such conventional analyte test strips and enzymatic reagent layers are described in, for example, U.S. Patents 5,708,247; 5,951,836; 6,241,862; and 6,284,125. In this regard, the reagent layer employed in

various embodiments provided herein can include any suitable sample-soluble enzymatic reagents, with the selection of enzymatic reagents being dependent on the analyte to be determined and the bodily fluid sample. For example, if glucose is to be determined in a fluid sample, enzymatic reagent layer 406 can include glucose oxidase or glucose dehydrogenase along with other components necessary for functional operation.

**[00141]** In general, enzymatic reagent layer 406 includes at least an enzyme and a mediator. Examples of suitable mediators include, for example, ruthenium, Hexaammine Ruthenium (III) Chloride, ferricyanide, ferrocene, ferrocene derivatives, osmium bipyridyl complexes, and quinone derivatives. Examples of suitable enzymes include glucose oxidase, glucose dehydrogenase (GDH) using a pyrroloquinoline quinone (PQQ) co-factor, GDH using a nicotinamide adenine dinucleotide (NAD) co-factor, and GDH using a flavin adenine dinucleotide (FAD) co-factor. Enzymatic reagent layer 406 can be applied during manufacturing using any suitable technique including, for example, screen printing.

**[00142]** Applicants note that enzymatic reagent layer 406 may also contain suitable buffers (such as, for example, Tris HCl, Citraconate, Citrate and Phosphate), hydroxyethylcellulose [HEC], carboxymethylcellulose, ethycellulose and alginate, enzyme stabilizers and other additives as are known in the field.

**[00143]** Further details regarding the use of electrodes and enzymatic reagent layers for the determination of the concentrations of analytes in a bodily fluid sample, albeit in the absence of the phase-shift measurement electrodes, analytical test strips and related methods described herein, are in U.S. Patent No. 6,733,655.

**[00144]** Patterned spacer layer 408 can be formed of any suitable material including, for example, a 95micrometers thick, double-sided pressure sensitive adhesive layer, a heat activated adhesive layer, or a thermo-setting adhesive plastic layer. Patterned spacer layer 408 can have, for example, a thickness in the range of from about 1 micron to about 500 microns, preferably between about 10 microns and about 400 microns, and more preferably between about 40 microns and about 200 microns.

**[00145]** Second patterned conductive layer 410 can be formed of any suitable conductive material including, for example, copper, silver, palladium, gold and conductive carbon materials. Second patterned conductive layer 410 can be, for example, disposed on a lower surface of electrically-insulating top layer 412 (as depicted in Figures 3G-3J) or embedded in the lower surface of electrically-insulating top layer 412. Second patterned conductive layer 410 can have any suitable thickness including, for example, a thickness in the range of 20 microns to 400 microns.

**[00146]** First phase-shift measurement electrode 411 and second phase shift measurement electrode 413 of second patterned conductive layer 410 are separated within sample chamber 414 by a gap (in the horizontal direction of Figure 3J) that is suitable for phase-shift measurement. Such a gap can be, for example, in the range of 20 microns to 1,400 microns with a typical gap being 500 microns. Moreover, the surface area of first phase-shift measurement electrode 111 and second phase shift measurement electrode 113 that is exposed to a bodily fluid sample within sample chamber 414 is typically 0.5 mm<sup>2</sup> but can range, for example, from 0.1 mm<sup>2</sup> to 2.0 mm<sup>2</sup>.

**[00147]** Electrochemical-based analytical test strip 400 can be manufactured, for example, by the sequential aligned formation of first patterned conductive layer 404, enzymatic reagent layer 406, patterned spacer layer 408, second patterned conductive layer 410 and electrically insulating top layer 412 onto electrically-insulating substrate layer 402. Any suitable techniques known to one skilled in the art can be used to accomplish such sequential aligned formation, including, for example, screen printing, photolithography, photogravure, chemical vapour deposition, sputtering, tape lamination techniques and combinations thereof.

**[00148]** Analytical test strips according to embodiments can be configured, for example, for operable electrical connection (via, for example, first and second phase shift probe contacts 416 and 418) and use with the analytical test strip sample cell interface of a hand-held test meter as described in co-pending patent application 13/250,525 with a copy provided in the Appendix.

**[00149]** It has been determined that a relationship exists between the reactance of a whole fluid sample and the physical characteristic (e.g., hematocrit) of that sample.

Electrical modeling of a bodily fluid sample (e.g., a whole blood sample) as parallel capacitive and resistive components indicates that when an alternating current (AC) signal is forced through the bodily fluid sample, the phase shift of the alternating signal will be dependent on both the frequency of the alternating signal voltage and the physical characteristic (e.g., hematocrit) of the sample. Therefore, the physical characteristic (e.g., hematocrit) of a bodily fluid sample can be measured by, for example, driving alternating signals of a known frequency (or known frequencies) through the bodily fluid sample and detecting their phase shift. The phase-shift measurement electrodes of analytical test strips of various embodiments described herein are particularly suitable for use in such phase-shift measurements since the first and second phase shift measurement electrodes are in direct contact with a bodily fluid sample present in the sample chamber. Moreover, a bodily fluid sample physical characteristic (e.g., hematocrit) ascertained from a phase shift measurement(s) can be employed to compensate for the effect of physical characteristic (e.g., hematocrit) during analyte determination.

[00150] Applicants note that for various embodiments of analytical test strips (e.g., an electrochemical-based analytical test strip) described here for use with a hand-held test meter in the determination of an analyte (such as glucose) in a bodily fluid sample (for example, a whole blood sample) may include an electrically insulating substrate, a first patterned conductor layer disposed on the electrically insulating substrate and having a working electrode and a reference electrode. The analytical test strip may also include an enzymatic reagent layer disposed on the working electrode, a first patterned spacer layer disposed over the first patterned conductor layer and defining both a first sample-receiving channel and an analyte determination sample chamber within the analytical test strip, and a second patterned spacer layer disposed over the first patterned spacer layer and defining at least a second sample-receiving channel. In addition, the analytical test strip further includes a bodily fluid phase-shift sample chamber in fluidic communication with the second sample-receiving channel. Moreover, the first sample-receiving channel and analyte determination sample chamber of the analytical test strip are isolated from the second sample-receiving channel and bodily fluid phase-shift sample chamber of the analytical test strip.

[00151] Analytical test strips of various embodiments described herein are believed by applicants to be beneficial in that, for example, the isolation (fluidic and electrical)

between the analyte determination sample chamber and the bodily fluid phase-shift sample chamber prevents potential interference between the determination of the analyte in the bodily fluid sample and a phase-shift measurement of the bodily fluid. Applicants note that certain advantages are obtained by having the first sample-receiving channel and analyte determination chamber separated from the second sample-receiving channel and bodily fluid phase-shift sample chamber by portions of the first and/or second patterned spacer layers that can be thinner, thus providing for an analytical test strip with a small, yet mechanically stable, cross-section.

**[00152]** Referring to Figures 3K-3O, electrochemical-based analytical test strip 500 includes an electrically-insulating substrate 502, a first patterned conductor layer 504 disposed on the electrically-insulating substrate layer, an enzymatic reagent layer 506 (for clarity depicted in Figure 3K only), a first patterned spacer layer 508, a second patterned spacer layer 510, and a top cover 511. In the embodiment of Figure 3K, first patterned spacer layer 508 and second patterned spacer layer 510 are depicted as bi-layer structures. However, the first and second patterned spacer layers employed in various embodiments provided herein can be unitary layers or any other suitably formed layer.

**[00153]** First patterned spacer layer 508 is configured such that electrochemical-based analytical test strip 500 also includes a first sample-receiving channel 512 and an analyte determination sample chamber 514. First patterned spacer layer 508 is also configured to define a bodily fluid phase-shift sample chamber 516 and an analyte determination sample chamber vent 518 (for clarity not depicted in Figure 3K).

**[00154]** Second patterned spacer layer 510 is configured to define a second sample-receiving channel 520 and a bodily fluid phase-shift chamber vent 522 (for clarity not depicted in Figure 3K).

**[00155]** First patterned conductor layer 504 includes a first phase-shift measurement electrode 524, a second phase-shift measurement electrode 526, two working electrodes 528a and 528b and a reference electrode 530. For clarity, Figure 3L depicts only first phase-shift measurement electrode 524 and second phase-shift measurement electrode 526 and not the entirety of first patterned conductor layer 504.

**[00156]** First sample-receiving channel 512 and analyte determination sample chamber 514 are isolated, both fluidically and electrically, from second sample-receiving channel 520 and bodily fluid phase-shift sample chamber 516 (see Figure 3O in particular wherein the first and second patterned conductor layers are omitted for

clarity). Moreover, in the embodiment of Figure 3O, the bodily fluid phase-shift sample chamber is disposed in a side-by-side configuration with the analyte determination sample chamber.

**[00157]** During use of electrochemical-based analytical test strip 500 to determine an analyte in a bodily fluid sample (e.g., blood glucose concentration in a whole blood sample), working and reference electrodes are employed by an associated meter (not shown) to monitor an electrochemical response of the electrochemical-based analytical test strip. The electrochemical response can be, for example, an electrochemical reaction induced current of interest. The magnitude of such a signal can then be correlated, taking into consideration the haematocrit of the bodily fluid sample as determined by the bodily fluid sample's phase shift, with the amount of analyte present in the bodily fluid sample under investigation. During such use, a bodily fluid sample is applied to electrochemical-based analytical test strip 500 and, thereby, received in both analyte determination sample chamber 514 and bodily fluid phase-shift sample chamber 516.

**[00158]** Electrically-insulating substrate 502 can be any suitable electrically-insulating substrate known to one skilled in the art including, for example, a nylon substrate, polycarbonate substrate, a polyimide substrate, a polyvinyl chloride substrate, a polyethylene substrate, a polypropylene substrate, a glycolated polyester (PETG) substrate, a polystyrene substrate, a silicon substrate, ceramic substrate, glass substrate or a polyester substrate (e.g., a 7 millimeters thick polyester substrate). The electrically-insulating substrate can have any suitable dimensions including, for example, a width dimension of about 5 mm, a length dimension of about 27 mm and a thickness dimension of about 0.5 mm.

**[00159]** First patterned conductor layer 504 can be formed of any suitable electrically conductive material such as, for example, gold, palladium, carbon, silver, platinum, tin oxide, iridium, indium, or combinations thereof (e.g., indium doped tin oxide). Moreover, any suitable technique or combination of techniques can be employed to form first patterned conductor layer 504 including, for example, sputtering, evaporation, electro-less plating, screen-printing, contact printing, laser ablation or gravure printing. A typical but non-limiting thickness for the patterned conductor layer is in the range of 5nanometers to 500nanometers.

**[00160]** Applicants note that conventional electrochemical-based analyte test strips employ a working electrode along with an associated counter/reference electrode and enzymatic reagent layer to facilitate an electrochemical reaction with an analyte of interest and, thereby, determine the presence and/or concentration of that analyte. For example, an electrochemical-based analyte test strip for the determination of glucose concentration in a fluid sample can employ an enzymatic reagent that includes the enzyme glucose oxidase and the mediator ferricyanide (which is reduced to the mediator ferrocyanide during the electrochemical reaction). Such conventional analyte test strips and enzymatic reagent layers are described in, for example, U.S. Patents 5,708,247; 5,951,836; 6,241,862; and 6,284,125. In this regard, the reagent layer employed in various embodiments provided herein can include any suitable sample-soluble enzymatic reagents, with the selection of enzymatic reagents being dependent on the analyte to be determined and the bodily fluid sample. For example, if glucose is to be determined in a fluid sample, enzymatic reagent layer 506 can include glucose oxidase or glucose dehydrogenase along with other components necessary for functional operation.

**[00161]** In general, enzymatic reagent layer 506 includes at least an enzyme and a mediator. Examples of suitable mediators include, for example, ferricyanide, ferrocene, ferrocene derivatives, osmium bipyridyl complexes, and quinone derivatives. Examples of suitable enzymes include glucose oxidase, glucose dehydrogenase (GDH) using a pyrroloquinoline quinone (PQQ) co-factor, GDH using a nicotinamide adenine dinucleotide (NAD) co-factor, and GDH using a flavin adenine dinucleotide (FAD) co-factor. Enzymatic reagent layer 506 can be applied during manufacturing using any suitable technique including, for example, screen printing.

**[00162]** Applicants note that enzymatic reagent layer 506 may also contain suitable buffers (such as, for example, Tris HCl, Citraconate, Citrate and Phosphate), hydroxyethylcellulose [HEC], carboxymethylcellulose, ethylcellulose and alginate, enzyme stabilizers and other additives as are known in the field.

**[00163]** Further details regarding the use of electrodes and enzymatic reagent layers for the determination of the concentrations of analytes in a bodily fluid sample, albeit in the absence of the phase-shift measurement electrodes, bodily-fluid phase-shift sample chambers and second sample receiving channels analytical test strips and related methods described herein, are in U.S. Patent No. 6,733,655.

**[00164]** First and second patterned spacer layers 508 and 510 respectively can be formed of any suitable material including, for example, a 95micrometers thick, double-sided pressure sensitive adhesive layer, a heat activated adhesive layer, or a thermo-setting adhesive plastic layer. First patterned spacer layer 508 can have, for example, a thickness in the range of from about 1 micron to about 500 microns, preferably between about 10 microns and about 400 microns, and more preferably between about 40 microns and about 600 microns.

**[00165]** Electrochemical-based analytical test strip 500 can be manufactured, for example, by the sequential aligned formation of first patterned conductor layer 504, enzymatic reagent layer 506, first patterned spacer layer 508, and second patterned spacer layer 510 onto electrically-insulating substrate 502. Any suitable techniques known to one skilled in the art can be used to accomplish such sequential aligned formation, including, for example, screen printing, photolithography, photogravure, chemical vapour deposition, sputtering, tape lamination techniques and combinations thereof.

**[00166]** Analytical test strips according to embodiments can be configured, for example, for operable electrical connection and use with the analytical test strip sample cell interface of a hand-held test meter as described in co-pending patent application 13/250,525 with a copy provided in the Appendix.

**[00167]** It has been determined that a relationship exists between the reactance of a fluid sample and the physical characteristic (e.g., hematocrit) of that sample. Electrical modeling of a bodily fluid sample (e.g., a whole blood sample) as parallel capacitive and resistive components indicates that when an alternating signal such as, for example, alternating-current (AC) signal is forced through the bodily fluid sample, the phase shift of the alternating signal will be dependent on both the frequency of the alternating signal voltage and the physical characteristic (e.g., hematocrit) of the sample. Therefore, the physical characteristic (e.g., hematocrit) of a bodily fluid sample can be measured by, for example, driving alternating signals of known frequencies through the bodily fluid sample and detecting their phase shift. The phase-shift measurement

electrodes of analytical test strips of various embodiments described herein are particularly suitable for use in such phase-shift measurements since the first and second phase shift measurement electrodes are in direct contact with a bodily fluid sample present in the sample chamber. Moreover, a bodily fluid sample physical characteristic (e.g., hematocrit) ascertained from a phase shift measurement(s) can be employed to compensate for the effect of physical characteristic (e.g., hematocrit) during analyte determination.

- [00168]** Referring to Figures 3P-3T, electrochemical-based analytical test strip 600 includes an electrically-insulating substrate 602, a first patterned conductor layer 604 disposed on the electrically-insulating substrate layer, an enzymatic reagent layer 606 (for clarity depicted in Figure 3P only), a first patterned spacer layer 608, a second patterned conductor layer 609, a second patterned spacer layer 610, and a top cover 611. In the embodiment of Figure 3P, first patterned spacer layer 608 and second patterned spacer layer 610 are depicted as bi-layer structures. However, the first and second patterned spacer layers employed in various embodiments provided herein can be unitary layers or any other suitably formatted layer.
- [00169]** First patterned spacer layer 608 is configured such that electrochemical-based analytical test strip 600 also includes a first sample-receiving channel 612, an analyte determination sample chamber 614 and an analyte determination sample chamber vent 618 (not depicted in Figure 3P but depicted with dashed lines in Figure 3R). Analyte determination sample chamber vent 618 is configured to aid in the introduction of a bodily fluid sample into analyte determination sample chamber 614 via first sample-receiving channel 612.
- [00170]** Second patterned spacer layer 610 is configured to define a second sample-receiving channel 620, a bodily fluid phase-shift sample chamber 616 and a bodily fluid phase-shift chamber vent 622 (not depicted in Figure 3P but depicted with dashed lines in Figure 3S). Bodily fluid phase-shift chamber vent 622 is configured to aid in the introduction of a bodily fluid sample into bodily fluid phase-shift sample chamber 616 via second sample-receiving channel 620.
- [00171]** First patterned conductor layer 604 includes two working electrodes 628a and 628b (depicted in Figures 3P and 3Q) and a reference electrode 630 (also depicted in Figures 3P and 3Q). Second patterned conductor layer 609 includes a first phase-shift measurement electrode 624 and a second phase-shift measurement electrode 626 and is

disposed above first patterned spacer layer 608 and embedded in the bi-layer structure of second patterned spacer layer 610.

[00172] First sample-receiving channel 612 and analyte determination sample chamber 614 are isolated, both fluidically and electrically, from second sample-receiving channel 620 and bodily fluid phase-shift sample chamber 616 (see Figure 3T in particular wherein the first and second patterned conductor layers are not depicted for clarity).

[00173] In the various embodiments of the test strip, there are two measurements that are made to a fluid sample deposited on the test strip. One measurement is that of the concentration of the analyte (e.g. glucose) in the fluid sample while the other is that of physical characteristic (e.g., hematocrit) in the same sample. The measurement of the physical characteristic (e.g., hematocrit) is used to modify or correct the glucose measurement so as to remove or reduce the effect of red blood cells on the glucose measurements. Both measurements (glucose and hematocrit) can be performed in sequence, simultaneously or overlapping in duration. For example, the glucose measurement can be performed first then the physical characteristic (e.g., hematocrit); the physical characteristic (e.g., hematocrit) measurement first then the glucose measurement; both measurements at the same time; or a duration of one measurement may overlap a duration of the other measurement. Each measurement is discussed in detail as follow with respect to Figures 4A, 4B and 5.

[00174] Figure 4A is an exemplary chart of a test signal applied to test strip 100 and its variations shown here in Figures 3A-3T. Before a fluid sample is applied to test strip 100 (or its variants 400, 500, or 600), test meter 200 is in a fluid detection mode in which a first test signal of about 400 millivolts is applied between second working electrode and reference electrode. A second test signal of about 400 millivolts is preferably applied simultaneously between first working electrode (e.g., electrode 12 of strip 100) and reference electrode (e.g., electrode 10 of strip 100). Alternatively, the second test signal may also be applied contemporaneously such that a time interval of the application of the first test signal overlaps with a time interval in the application of the second test voltage. The test meter may be in a fluid detection mode during fluid detection time interval  $T_{FD}$  prior to the detection of physiological fluid at starting time at zero. In the fluid detection mode, test meter 200 determines when a fluid is applied to test strip 100 (or its variants 400, 500, or 600) such that the fluid wets either the first

working electrode 12 or second working electrode 14 (or both working electrodes) with respect to reference electrode 10. Once test meter 200 recognizes that the physiological fluid has been applied because of, for example, a sufficient increase in the measured test current at either or both of first working electrode 12 and second working electrode 14, test meter 200 assigns a zero second marker at zero time "0" and starts the test time interval  $T_s$ . Test meter 200 may sample the current transient output at a suitable sampling rate, such as, for example, every 1 milliseconds to every 100 milliseconds. Upon the completion of the test time interval  $T_s$ , the test signal is removed. For simplicity, Figure 4A only shows the first test signal applied to test strip 100 (or its variants 400, 500, or 600).

[00175] Hereafter, a description of how glucose concentration is determined from the known signal transients (e.g., the measured electrical signal response in nanoamperes as a function of time) that are measured when the test voltages of Figure 4A are applied to the test strip 100 (or its variants 400, 500, or 600).

[00176] In Figure 4A, the first and second test voltages applied to test strip 100 (or its variants described herein) are generally from about +100 millivolts to about +600 millivolts. In one embodiment in which the electrodes include carbon ink and the mediator includes ferricyanide, the test signal is about +400 millivolts. Other mediator and electrode material combinations will require different test voltages, as is known to those skilled in the art. The duration of the test voltages is generally from about 1 to about 5 seconds after a reaction period and is typically about 3 seconds after a reaction period. Typically, test sequence time  $T_s$  is measured relative to time  $t_0$ . As the voltage 401 is maintained in Figure 4A for the duration of  $T_s$ , output signals are generated, shown here in Figure 4B with the current transient 702 for the first working electrode 12 being generated starting at zero time and likewise the current transient 704 for the second working electrode 14 is also generated with respect to the zero time. It is noted that while the signal transients 702 and 704 have been placed on the same referential zero point for purposes of explaining the process, in physical term, there is a slight time differential between the two signals due to fluid flow in the chamber towards each of the working electrodes 12 and 14 along axis L-L. However, the current transients are sampled and configured in the microcontroller to have the same start time. In Figure 4B, the current transients build up to a peak proximate peak time  $T_p$  at which time, the current slowly drops off until approximately one of 2.5 seconds or 5 seconds after zero

time. At the point 706, approximately at 5 seconds, the output signal for each of the working electrodes 12 and 14 may be measured and added together. Alternatively, the signal from only one of the working electrodes 12 and 14 can be doubled.

[00177] Referring back to Fig. 2B, the system drives a signal to measure or sample the output signals  $I_E$  from at least one the working electrodes (12 and 14) at any one of a plurality of time points or positions  $T_1, T_2, T_3, \dots, T_N$ . As can be seen in Fig. 4B, the time position can be any time point or interval in the test sequence  $T_S$ . For example, the time position at which the output signal is measured can be a single time point  $T_{1.5}$  at 1.5 seconds or an interval 708 (e.g., interval~10 milliseconds or more depending on the sampling rate of the system) overlapping the time point  $T_{2.8}$  proximate 2.8 seconds.

[00178] From knowledge of the parameters of the test strip (e.g., batch calibration code offset and batch slope) for the particular test strip 100 and its variations, the analyte (e.g., glucose) concentration can be calculated. Output transient 702 and 704 can be sampled to derive signals  $I_E$  (by summation of each of the current  $I_{WE1}$  and  $I_{WE2}$  or doubling of one of  $I_{WE1}$  or  $I_{WE2}$ ) at various time positions during the test sequence. From knowledge of the batch calibration code offset and batch slope for the particular test strip 100 and its variations in Figures 3B-3T, the analyte (e.g., glucose) concentration can be calculated.

[00179] It is noted that “Intercept” and “Slope” are the values obtained by measuring calibration data from a batch of test strips. Typically around 1500 strips are selected at random from the lot or batch. Physiological fluid (e.g., blood) from donors is spiked to various analyte levels, typically six different glucose concentrations. Typically, blood from 12 different donors is spiked to each of the six levels. Eight strips are given blood from identical donors and levels so that a total of  $12 \times 6 \times 8 = 576$  tests are conducted for that lot. These are benchmarked against actual analyte level (e.g., blood glucose concentration) by measuring these using a standard laboratory analyzer such as Yellow Springs Instrument (YSI). A graph of measured glucose concentration is plotted against actual glucose concentration (or measured current versus YSI current) and a formula  $y = mx + c$  least squares fitted to the graph to give a value for batch slope  $m$  and batch intercept  $c$  for the remaining strips from the lot or batch. The applicants have also provided methods and systems in which the batch slope is derived during the

determination of an analyte concentration. The “batch slope”, or “Slope”, may therefore be defined as the measured or derived gradient of the line of best fit for a graph of measured glucose concentration plotted against actual glucose concentration (or measured current versus YSI current). The “batch intercept”, or “Intercept”, may therefore be defined as the point at which the line of best fit for a graph of measured glucose concentration plotted against actual glucose concentration (or measured current versus YSI current) meets the y axis.

[00180] It is worthwhile here to note that the various components, systems and procedures described earlier allow for applicants to provide an analyte measurement system that heretofore was not available in the art. In particular, this system includes a test strip that has a substrate and a plurality of electrodes connected to respective electrode connectors. The system further includes an analyte meter 200 that has a housing, a test strip port connector configured to connect to the respective electrode connectors of the test strip, and a microcontroller 300, shown here in Figure 2B. The microprocessor 300 is in electrical communication with the test strip port connector 220 to apply electrical signals or sense electrical signals from the plurality of electrodes.

[00181] Referring to Figure 2B, details of a preferred implementation of meter 200 where the same numerals in Figures 2A and 2B have a common description. In Figure 2B, a strip port connector 220 is connected to the analogue interface 306 by five lines including an impedance sensing line EIC to receive signals from physical characteristic sensing electrode(s), alternating signal line AC driving signals to the physical characteristic sensing electrode(s), reference line for a reference electrode, and signal sensing lines from respective working electrode 1 and working electrode 2. A strip detection line 221 can also be provided for the connector 220 to indicate insertion of a test strip. The analog interface 306 provides four inputs to the processor 300: (1) real impedance  $Z'$ ; (2) imaginary impedance  $Z''$ ; (3) signal sampled or measured from working electrode 1 of the biosensor or  $I_{we1}$ ; (4) signal sampled or measured from working electrode 2 of the biosensor or  $I_{we2}$ . There is one output from the processor 300 to the interface 306 to drive an oscillating signal AC of any value from 25kHz to about 250kHz or higher to the physical characteristic sensing electrodes. A phase differential  $P$  (in degrees) can be determined from the real impedance  $Z'$  and imaginary impedance  $Z''$  where:

$$P = \tan^{-1}\{Z''/Z'\} \quad \text{Eq. 3.1}$$

[00182] and magnitude  $M$  (in ohms and conventionally written as  $|Z|$ ) from line  $Z'$  and  $Z''$  of the interface 306 can be determined where

$$M = \sqrt{(Z')^2 + (Z'')^2} \quad \text{Eq. 3.2}$$

[00183] In this system, the microprocessor is configured to: (a) apply a first signal to the plurality of electrodes so that a batch slope defined by a physical characteristic of a fluid sample is derived and (b) apply a second signal to the plurality of electrodes so that an analyte concentration is determined based on the derived batch slope. For this system, the plurality of electrodes of the test strip or biosensor includes at least two electrodes to measure the physical characteristic and at least two other electrodes to measure the analyte concentration. For example, the at least two electrodes and the at least two other electrodes are disposed in the same chamber provided on the substrate. Alternatively, the at least two electrodes and the at least two other electrodes are disposed in different chambers provided on the substrate. It is noted that for some embodiments, all of the electrodes are disposed on the same plane defined by the substrate. In particular, in some of the embodiments described herein, a reagent is disposed proximate the at least two other electrodes and no reagent is disposed on the at least two electrodes. One feature of note in this system is the ability to provide for an accurate analyte measurement within about 10 seconds of deposition of a fluid sample (which may be a physiological sample) onto the biosensor as part of the test sequence.

[00184] As an example of an analyte calculation (e.g., glucose) for strip 100 (Fig. 3A(1), 3A(2), or 3A(3) and its variants in Figures 3B-3T), it is assumed in Fig. 4B that the sampled signal value at 706 for the first working electrode 12 is about 1600 nanoamperes whereas the signal value at 706 for the second working electrode 14 is about 1300 nanoamperes and the calibration code of the test strip indicates that the Intercept is about 500 nanoamperes and the Slope is about 18 nanoamperes/mg/dL. Glucose concentration  $G_0$  can be thereafter be determined from Equation 3.3 as follow:

$$G_0 = [(I_E) - \text{Intercept}] / \text{Slope} \quad \text{Eq. 3.3}$$

where

$I_E$  is a signal (proportional to analyte concentration) which is the total signal from all of the electrodes in the biosensor (e.g., for sensor 100, both electrodes 12 and 14 (or  $I_{we1} + I_{we2}$ ));

$I_{we1}$  is the signal measured for the first working electrode at the set sampling time;

$I_{we2}$  is the signal measured for the second working electrode at the set sampling time;

Slope is the value obtained from calibration testing of a batch of test strips of which this particular strip comes from;

Intercept is the value obtained from calibration testing of a batch of test strips of which this particular strip comes from.

[00185] From Eq. 3.3;  $G_0 = [(1600+1300)-500]/18$  and therefore,  $G_0 = 133.33$  nanoamp  $\sim$  133 mg/dL.

[00186] It is noted here that although the examples have been given in relation to a biosensor 100 which has two working electrodes (12 and 14 in Fig. 3A(1)) such that the measured currents from respective working electrodes have been added together to provide for a total measured current  $I_E$ , the signal resulting from only one of the two working electrodes can be multiplied by two in a variation of test strip 100 where there is only one working electrode (either electrode 12 or 14). Instead of a total signal, an average of the signal from each working electrode can be used as the total measured current  $I_E$  for Equations 3.3, 6, and 8-11 described herein, and of course, with appropriate modification to the operational coefficients (as known to those skilled in the art) to account for a lower total measured current  $I_E$  than as compared to an embodiment where the measured signals are added together. Alternatively, the average of the measured signals can be multiplied by two and used as  $I_E$  in Equations 3.3, 6, and 8-11 without the necessity of deriving the operational coefficients as in the prior example. It is noted that the analyte (e.g., glucose) concentration here is not corrected for any physical characteristic (e.g., hematocrit value) and that certain offsets may be provided to the signal values  $I_{we1}$  and  $I_{we2}$  to account for errors or delay time in the electrical circuit of the meter 200. Temperature compensation can also be utilized to ensure that the results are calibrated to a referential temperature such as for example room temperature of about 20 degrees Celsius.

**[00187]** Now that a glucose concentration ( $G_0$ ) can be determined from the signal  $I_E$ , a description of applicant's technique to determine the physical characteristic (e.g., hematocrit) of the fluid sample is provided in relation to Figure 5. In Figure 5, the system 200 (Fig. 2) applies a first oscillating input signal 800 at a first frequency (e.g., of about 25kilo-Hertz) to a pair of sensing electrodes. The system is also set up to measure or detect a first oscillating output signal 802 from the third and fourth electrodes, which in particular involve measuring a first time differential  $\Delta t_1$  between the first input and output oscillating signals. At the same time or during overlapping time durations, the system may also apply a second oscillating input signal (not shown for brevity) at a second frequency (e.g., about 100kilo-Hertz to about 1MegaHertz or higher, and preferably about 250 kilo Hertz) to a pair of electrodes and then measure or detect a second oscillating output signal from the third and fourth electrodes, which may involve measuring a second time differential  $\Delta t_2$  (not shown) between the first input and output oscillating signals. From these signals, the system estimates a physical characteristic (e.g., hematocrit) of the fluid sample based on the first and second time differentials  $\Delta t_1$  and  $\Delta t_2$ . Thereafter, the system is able to derive a glucose concentration. The estimate of the physical characteristic (e.g., hematocrit) can be done by applying an equation of the form

$$HCT_{EST} = \frac{(C_1 \Delta t_1 - C_2 \Delta t_2 - C_3)}{m_1} \quad \text{Eq. 4.1}$$

where

each of  $C_1$ ,  $C_2$ , and  $C_3$  is an operational constant for the test strip and  $m_1$  represent a parameter from regressions data.

**[00188]**

**[00189]** Another technique to determine physical characteristic (e.g., hematocrit) can be by two independent measurements of physical characteristic (e.g., hematocrit). This can be obtained by determining: (a) the impedance of the fluid sample at a first frequency and (b) the phase angle of the fluid sample at a second frequency

substantially higher than the first frequency. In this technique, the fluid sample is modeled as a circuit having unknown reactance and unknown resistance. With this model, an impedance (as signified by notation “ $|Z|$ ”) for measurement (a) can be determined from the applied voltage, the voltage across a known resistor (e.g., the intrinsic strip resistance), and the voltage across the unknown impedance  $V_z$ ; and similarly, for measurement (b) the phase angle can be measured from a time difference between the input and output signals by those skilled in the art. Other suitable techniques for determining the physical characteristic (e.g., hematocrit, viscosity, temperature or density) of the fluid sample can also be utilized such as, for example, US Patent No. 4,919,770, US Patent No. 7,972,861, US Patent Application Publication Nos. 2010/0206749, 2009/0223834, or “Electric Cell–Substrate Impedance Sensing (ECIS) as a Noninvasive Means to Monitor the Kinetics of Cell Spreading to Artificial Surfaces” by Joachim Wegener, Charles R. Keese, and Ivar Giaever and published by Experimental Cell Research 259, 158–166 (2000) doi:10.1006/excr.2000.4919, available online at <http://www.idealibrary.com!>; “Utilization of AC Impedance Measurements for Electrochemical Glucose Sensing Using Glucose Oxidase to Improve Detection Selectivity” by Takuya Kohma, Hidefumi Hasegawa, Daisuke Oyamatsu, and Susumu Kuwabata and published by Bull. Chem. Soc. Jpn. Vol. 80, No. 1, 158–165 (2007).

**[00190]** Another technique to determine the physical characteristic (e.g., hematorcrits, density, or temperature) can be obtained by knowing the phase difference (e.g., phase angle) and magnitude of the impedance of the sample. In one example, the following relationship is provided for the estimate of the physical characteristic or impedance characteristic of the sample (“IC”):

$$IC = M^2 * y_1 + M * y_2 + y_3 + P^2 * y_4 + P * y_5 \quad \text{Eq. 4.2}$$

where: M represents a magnitude  $|Z|$  of a measured impedance in ohms);

P represents a phase difference between the input and output signals (in degrees)

$y_1$  is about  $-3.2\text{e-}08$  and  $\pm 10\%$ ,  $5\%$  or  $1\%$  of the numerical value provided hereof (and depending on the frequency of the input signal, can be zero);

$y_2$  is about  $4.1\text{e-}03$  and  $\pm 10\%$ ,  $5\%$  or  $1\%$  of the numerical value provided hereof (and depending on the frequency of the input signal, can be zero);

$y_3$  is about  $-2.5\text{e+}01$  and  $\pm 10\%$ ,  $5\%$  or  $1\%$  of the numerical value provided hereof;

$y_4$  is about  $1.5\text{e-}01$  and  $\pm 10\%$ ,  $5\%$  or  $1\%$  of the numerical value provided hereof (and depending on the frequency of the input signal, can be zero); and

$y_5$  is about  $5.0$  and  $\pm 10\%$ ,  $5\%$  or  $1\%$  of the numerical value provided hereof (and depending on the frequency of the input signal, can be zero);

[00191] It is noted here that where the frequency of the input AC signal is high (e.g., greater than  $75\text{kHz}$ ) then the parametric terms  $y_1$  and  $y_2$  relating to the magnitude of impedance M may be  $\pm 200\%$  of the exemplary values given herein such that each of the parametric terms may include zero or even a negative value. On the other hand, where the frequency of the AC signal is low (e.g., less than  $75\text{ kHz}$ ), the parametric terms  $y_4$  and  $y_5$  relating to the phase angle P may be  $\pm 200\%$  of the exemplary values given herein such that each of the parametric terms may include zero or even a negative value. It is noted here that a magnitude of H or HCT, as used herein, is generally equal to the magnitude of IC. In one exemplary implementation, H or HCT is equal to IC as H or HCT is used herein this application.

[00192] In another alternative implementation, Equation 4.3 is provided. Equation 4.3 is the exact derivation of the quadratic relationship, without using phase angles as in Equation 4.2.

$$IC = \frac{-y_2 + \left| \sqrt{y_2^2 - (4y_3(y_1 - M))} \right|}{2y_1} \quad \text{Eq. 4.3}$$

where:

IC is the Impedance Characteristic [%];

M is the magnitude of impedance [Ohm];

$y_1$  is about 1.2292e1 and  $\pm 10\%$ , 5% or 1% of the numerical value provided hereof;

$y_2$  is about -4.3431e2 and  $\pm 10\%$ , 5% or 1% of the numerical value provided hereof;

$y_3$  is about 3.5260e4 and  $\pm 10\%$ , 5% or 1% of the numerical value provided hereof.

**[00193]** By virtue of the various components, systems and insights provided herein, at least four techniques of determining an analyte concentration from a fluid sample (which may be a physiological sample) (and variations of such method) are achieved by applicants.

**[00194]** With reference to Figure 6A1, the method involves depositing a fluid sample (which may be a physiological sample) on a biosensor at step 904A (e.g., in the form of a test strip as show in Figures 3A (1), 3A (2), or 3A (3)-3T) that has been inserted into a meter (step 902A). Once the meter 200 is turned on, a voltage is applied to the strip 100 (or its variants 400, 500, or 600) and when the sample is deposited onto the test chamber, the applied voltage physically transforms the analyte in the sample into a different form due to the enzymatic reaction of the analyte with the reagent in the test chamber. As the sample flows into the capillary channel of the test cell, at least one physical characteristic of the sample is obtained (step 908A). In particular, the step of obtaining the physical characteristic (step 908A) may include applying a first signal to the sample to measure a physical characteristic of the sample, while the step 906A of initiating an enzymatic reaction may involve driving a second signal to the sample, and the step of measuring (step 912A) may entail evaluating an output signal from the at least two electrodes at a point in time after the start of the test sequence, in which a new batch slope is set (at step 910A) as a function of at least the measured or estimated physical characteristic (step 908A).

**[00195]** The setting of a new batch slope to derive a more accurate analyte concentration measurement merits a discussion with reference to Figures 7 and 6A2. Applicants have found that the existing glucose test strip made by LifeScan (marketed under the Ultra brand) has variations in the signal output transients depending on the glucose concentration and hematocrit. These variations can be seen in Figure 7 in which at high level of glucose (“High G”) or mid-level of glucose (“Mid-G”), the signal transient varies distinctly as a function of the physical characteristic (e.g., hematocrit) level and at low glucose level (“Lo-G”) the signal transient does not vary as distinctly as in the High-G or Mid-G as a function of hematocrit. Specifically, at the High G, the signal transients 1000a, 1002a, and 1004a (for 30%, 42% and 55% Hct) maintain a generally consistent separation in signal output over time after the peak at about 1.5 seconds after the start of the test sequence. Similarly, at the Mid-G, the signal transients 1000b, 1002b, and 1004b (for 30%, 42%, and 55% Hct) maintains a consistent separation in signal output over time after the peak at about 1.5 seconds after the start of the test sequence. At the Low-G, the signal transients 1000c, 1002c, and 1004c (for 30%, 42%, and 55% Hct) generally converge together after the peak at about 1.5 seconds after the start of the test sequence.

**[00196]** Based on these observations, applicants have found that a relationship exists between the batch slope of these test strips tested at the Lo-G, Mid-G, and Hi-G levels with respect to 30%, 42%, and 55% hematocrit levels. In particular, applicants have found that the batch slope for these strips is generally curved with respect to hematocrit level, shown here in Figure 6A2. In Figure 6A2, the batch slope declines in a generally curved manner at low (e.g., 30%), medium (e.g., 42%), and high (e.g., 55%) hematocrits. As a consequence, by knowing the physical characteristic of the sample (e.g., hematocrit) from Equation 4 above, the relationship in Figure 6A2 can be exploited to allow the slope in Equation 3.3 to accommodate the different levels of physical characteristic (e.g., hematocrit) so as to achieve much more accurate glucose concentration measurements.

**[00197]** It should be noted that while slope “x” in Figure 6A2 appears to be a linear line, slope “x” is in fact a curved line and a curve has been fitted for the relationship between physical characteristic (e.g., hematocrit) and slope implicit in Figure 6A2. This fitted curve for Figure 6A2 is found by applicants to be a second order equation of the form:

$$NewSlope = aH^2 + bH + c \quad \text{Eq. 5}$$

where

*NewSlope* is the derived or calculated new batch slope;

H is measured or estimated physical characteristic (e.g., hematocrit);

a is about 1.35e-6,

b is about -3.79e-4,

c is about 3.56e-2.

[00198] Equation 5 can be used instead of plotting against Figure 6A2, depending on the available computing power of the processor. The viability of this approach can be seen here in Figure 6A3 which is a plot of a large number of test strips at different glucose ranges and hematocrit levels versus percent bias by use of Equations 5 and 6. In Figure 6A3, it can be seen that virtually all of the glucose concentration at different glucose ranges (low, medium, and high) across about 30%, 42%, and about 55% hematocrit have a bias of less than +10%.

[00199] Continuing on with the exemplary process of Figure 6A1, once the physical characteristic is known at step 908A from Equation 4, such as for example Hct ~55%, the graph of Figure 6A2 is utilized to determine the appropriate batch slope, designated here as “*NewSlope*” which is about 0.019. Alternatively, Equation 5 can be utilized to derive the *NewSlope* from the measured or estimated physical characteristic (e.g., hematocrit). This *NewSlope* (from Fig. 6A2 or Eq. 5) is used along with the batch intercept (Intercept) of the particular batch of test strip in Equation 3.3, as set forth below in Equation 6.

$$G_0 = \left[ \frac{I_E - \text{Intercept}}{x} \right] \quad \text{Eq. 6.}$$

where

$G_0$  represents an analyte concentration

$I_E$  is a signal (proportional to analyte concentration) as measured at the specified *SamplingTime* point;

$x$  or “*NewSlope*” is the value obtained from the relationship in Figure 6A2 or from Eq. 5;

Intercept is the value obtained from calibration testing of a batch of test strips of which this particular strip comes from.

**[00200]** Once the signal output  $I_E$  of the test chamber is measured at the designated time, typically at about 2.5 seconds or about 5 seconds, the signal  $I_E$  is thereafter used with the NewSlope (of the batch) and Intercept (of the batch) in the calculation of the analyte concentration (in this case glucose) with Eq. 6 above. It is noted here that  $I_E$  could be a current from only one working electrode where the biosensor has only one working electrode, a sum of current outputs from two working electrodes, a current from one working electrode multiplied by two or an average current from the two working electrodes. It should be noted that the step of applying the first signal and the driving of the second signal is in sequential order in that the order may be the first signal then the second signal or both signals overlapping in sequence; alternatively, the second signal first then the first signal or both signals overlapping in sequence. Alternatively, the applying of the first signal and the driving of the second signal may take place simultaneously.

**[00201]** In the method, the step of applying of the first signal involves directing an alternating signal provided by an appropriate power source (e.g., the meter 200) to the sample so that a physical characteristic of the sample is determined from an output of the alternating signal. The physical characteristic being detected may be one or more of viscosity, hematocrit, temperature or density. The directing step may include driving first and second alternating signals at different respective frequencies in which a first frequency is lower than the second frequency. Preferably, the first frequency is at least one order of magnitude lower than the second frequency. As an example, the first frequency may be any frequency in the range of about 10 kHz to about 100 kHz and the second frequency may be from about 250 kHz to about 1 MHz or more. As used herein, the phrase “alternating signal” can have some portions of the signal alternating in polarity or all alternating current signal or an alternating current with a direct current offset or even a multi-directional signal combined with a direct-current signal.

**[00202]** Although the method may specify only one sampling time point, the method may include sampling as many time points as required, such as, for example, sampling the signal output continuously (e.g., at specified sampling time such as, every 10 milliseconds to 100 milliseconds) from the start of the test sequence until at least about 10 seconds after the start and the results stored for processing near the end of the test sequence. Applicants note that the appropriate sampling time is measured from the

start of the test sequence but any appropriate datum may be utilized in order to determine when to sample the output signal. As a practical matter, the system can be programmed to sample the output signal at an appropriate time sampling interval during the entire test sequence such as for example, one sampling every 100 milliseconds or even as little as about 1 milliseconds. In this variation, the sampled signal output at the specified sampling time point is the value used to calculate the analyte concentration.

**[00203]** It is noted that in the preferred embodiments, the measure of a signal output for the glucose concentration is performed prior to the measurement or estimation of the hematocrit. Alternatively, the hematocrit level can be measured or estimated prior to the measurement of the glucose concentration.

**[00204]** Thus, as another benefit of the teaching provided herein, a method of demonstrating increased accuracy of a test strip than heretofore is achieved. This method involves providing a batch of test strips, typically in a batch of at least about 1500 test strips (and in some cases up to 1 million test strips per batch), introducing a referential sample containing a referential concentration of an analyte to each of the batch of test strips to initiate a test sequence (a “referential sample” contains a “referential” or “known” concentration of an analyte, e.g. glucose). The method involves, reacting the analyte with a reagent on the test strip to cause a physical transformation of the analyte proximate the two electrodes, determining a physical characteristic of the referential sample, deriving a biosensor parameter (e.g., a batch slope) for the batch of test strips based on the determined physical characteristics of the referential sample; sampling an electrical output of the referential sample at a predetermined time point during the test sequence, and calculating an analyte concentration based on the derived biosensor parameter and sampled electrical output to provide for a final analyte concentration value for each of the batch of test strips such that at least 95% of the analyte concentration values of the batch of test strips are within about  $\pm 15\%$  of the referential analyte concentration for the range of hematocrit from about 30% to about 55%, shown here in Figure 6A3 (an example of a “physical transformation”, specifically an “enzymatic reaction”, of an analyte to form a different material is the oxidation of glucose to D-glucono- $\delta$ -lactone and hydrogen peroxide by glucose oxidase (e.g. where the analyte is glucose and the reagent comprises glucose oxidase)).

[00205] In Figure 6A3, experiments were performed to quantify the improvement in the glucose measurements from the method noted above. The quantification of the improvement can be shown by the “bias” at different levels of hematocrit. The bias, which is an estimate of the relative error in the glucose measurement, was calculated for each glucose concentrations determined with the method described in this example. The bias for each glucose concentration was determined with equations of the form:

$$Bias_{abs} = G_{calculated} - G_{reference} \text{ for } G_{reference} \text{ less than } 100 \text{ mg/dL glucose and}$$

$$Bias_{\%} = \frac{G_{calculated} - G_{reference}}{G_{reference}} \text{ for } G_{reference} \text{ greater than or equal to } 100 \text{ mg/dL}$$

glucose

where

$Bias_{abs}$  is absolute bias,

$Bias_{\%}$  is percent bias,

$G_{calculated}$  is the glucose concentration determined by the method herein

and

$G_{reference}$  is the reference glucose concentration.

[00206] As can be seen in Figure 6A3, most or virtually all of the glucose concentration using this technique are within about  $\pm 15\%$  bias for hematocrit from about 30% hematocrit to about 55% hematocrit. Specifically, at region 1010A, only one glucose concentration greater than 100 mg/dL is outside the bias of -15%; at region 1012A of intermediate hematocrit, a few glucose concentrations are outside the bias range of -15% and at region 1014A of high hematocrit, more glucose concentrations are dispersed outside the bias of -15% as compared to regions 1010A and 1012A.

[00207] With reference to Figure 6B1, another technique involves depositing a fluid sample (which may be a physiological sample) on a biosensor at step 904B (e.g., in the form of a test strip as show in Figures 3A (1), 3A(2), or 3A(3)-3T) that has been inserted into a meter (step 902B). Once the meter 200 is turned on, a voltage is applied to the strip 100 (or its variants 400, 500, or 600) and when the sample is deposited onto the test chamber, the applied voltage physically transforms the analyte in the sample into a different form due to the enzymatic reaction of the analyte with the reagent in the test chamber. As the sample flows into the capillary channel of the test cell, at least one physical characteristic of the sample is obtained (step 908B). In particular, the step of

obtaining or measuring the physical characteristic (step 908B) may include applying a first signal to the sample to derive a physical characteristic of the sample, while the step 906B of initiating an enzymatic reaction (e.g., by applying electrical signals to the sample and reagent) may involve driving a second signal to the sample, and the step of measuring (step 912B) may entail measuring an output signal from the at least two electrodes at a point in time after the start of the test sequence, in which a sampling time point is specified (at step 910B) as a function of at least the measured or estimated physical characteristic (step 908B).

**[00208]** In a variation of the method, the step of applying of the first signal involves directing an alternating signal provided by an appropriate power source (e.g., the meter 200) to the sample so that a physical characteristic of the sample is determined from an output of the alternating signal. The physical characteristic being detected may be one or more of viscosity, hematocrit or density of the sample (which may not be physiological fluid such as, for example, calibration fluid). The directing step may include driving first and second alternating signals at different respective frequencies in which a first frequency is lower than the second frequency. Preferably, the first frequency is at least one order of magnitude lower than the second frequency. As an example, the first frequency may be any frequency in the range of about 10 kHz to about 100 kHz and the second frequency may be from about 250 kHz to about 1 MHz or more. As used herein, the phrase “alternating signal” can have some portions of the signal alternating in polarity or all alternating current signal or an alternating current with a direct current offset or even a multi-directional signal combined with a direct-current signal.

**[00209]** Once the physical characteristic of the sample is determined or obtained from a suitable technique, the physical characteristic can be used to specify a sampling time point at which point during the test sequence the output signal of the test chamber could be measured. In particular, applicants have found a relationship between the physical characteristic and the sampling time point, as shown here in Figure 7. This relationship has been further explored such that applicants were able to derive a direct relationship between the sampling time point of the sample and the physical characteristic of the sample (e.g., hematocrit), shown here in Figure 6B2. As a consequence, by knowing the physical characteristic of the sample (e.g., hematocrit) from Equation 4 above, the relationship in Figure 6B2 can be exploited to allow the sampling time point to be

specified to accommodate the different levels of physical characteristic (e.g., hematocrit) so as to achieve much more accurate glucose concentration measurements than heretofore.

[00210] Referring back to Figure 7, it can be seen that as the analyte concentration (proportional to the signal output) increases, the peak of the high glucose concentration (denoted by 1002a, 1004a, and 1006a) is shifted to the right as compared to the medium glucose concentration (denoted by 1002b, 1004b, and 1006b). Similarly, the peak of the medium glucose concentration is further to the right of Figure 7 as compared to low glucose concentration (denoted by 1002c, 1004c, and 1006c). It can also be seen here that the steady-state of the low glucose concentrations (1002c, 1004c, and 1006c) is reached earlier than the medium glucose concentrations (1002b, 1004b, and 1006b). This pattern is repeated for high glucose concentration (1002a, 1004a, and 1006b) as compared to medium glucose concentrations.

[00211] From data in Figure 7, applicants were able to derive a second degree relationship between the sensed physical characteristic and the sampling time, shown here in Figure 6B2. In Figure 6B2, a curve is fitted to hematocrit values at about 30%, 42% and about 55% and glucose values for these ranges of hematocrits (from Figure 7). This fitted curve is found by applicants to be an equation of the form:

[00212]

$$SamplingTime = x_1 H^{x_2} + x_3 \quad \text{Eq. 7}$$

where,

“Sampling Time” is designated (for convenience) as a time point from the start of the test sequence at which to sample the output signal of the test strip,

*H represents the physical characteristic of the sample;*

$x_1$  is about 4.3e5;

$x_2$  is about -3.9; and

$x_3$  is about 4.8.

[00213] Although the method may specify only one sampling time point, the method may include sampling as many time points as required, such as, for example, sampling the signal output continuously (e.g., at specified sampling time such as, every 10 milliseconds to 100 milliseconds) from the start of the test sequence until at least

about 10 seconds after the start and the results stored for processing near the end of the test sequence. Applicants note that the appropriate sampling time is measured from the start of the test sequence but any appropriate datum may be utilized in order to determine when to sample the output signal. As a practical matter, the system can be programmed to sample the output signal at an appropriate time sampling interval during the entire test sequence such as for example, one sampling every 100 milliseconds or even as little as about 1 milliseconds. In this variation, the sampled signal output at the specified sampling time point is the value used to calculate the analyte concentration.

**[00214]** Referring back to Figure 6B1, the method can now determine the analyte concentration (step 914B) based on the measured signal (step 912B) sampled at the specified time point, which specified time point is a function of the obtained or measured or estimated physical characteristic of the sample (e.g., from plot of Figure 6B2 or Equation 7). That is, once the sampling time T has been specified from Equation 7, the method provides for measuring the output signal from the test chamber (e.g., chamber 92) so that the sampled output can be utilized with Equation 3.3 to provide for an analyte (e.g., glucose) concentration.

**[00215]** Alternatively, a look-up table, represented exemplarily here with reference to Table 1 can also be utilized in place of Equation 7 or in addition to Equation 7 to specify an appropriate sampling time point. In Table 1, the value of the physical characteristic is used by the processor of the system to look up the appropriate time at which the signal output of the biosensor is sampled or measured to determine the analyte concentration. For example, once the physical characteristic has been determined, in this case about 33% hematocrit, the time at which the signal output of the biosensor 100 is utilized in determining the analyte concentration can be gleaned from Table 1, which shows that the time at which the system must sample the signal output is at approximately 5.32 seconds after the start of the test sequence.

**Table 1**

| <b>Physical Characteristic (e.g., Hematocrit %)</b> | <b>Sampling Time T (seconds)</b> |
|-----------------------------------------------------|----------------------------------|
| 30                                                  | 5.56                             |
| 31                                                  | 5.46                             |
| 32                                                  | 5.38                             |

| Physical Characteristic (e.g., Hematocrit %) | Sampling Time T (seconds) |
|----------------------------------------------|---------------------------|
| 33                                           | 5.32                      |
| 34                                           | 5.26                      |
| 35                                           | 5.2                       |
| 36                                           | 5.16                      |
| 37                                           | 5.12                      |
| 38                                           | 5.08                      |
| 39                                           | 5.06                      |
| 40                                           | 5.02                      |
| 41                                           | 5                         |
| 42                                           | 5                         |
| 43                                           | 4.98                      |
| 44                                           | 4.96                      |
| 45                                           | 4.96                      |
| 46                                           | 4.94                      |
| 47                                           | 4.92                      |
| 48                                           | 4.92                      |
| 49                                           | 4.9                       |
| 50                                           | 4.9                       |
| 51                                           | 4.9                       |
| 52                                           | 4.88                      |
| 53                                           | 4.88                      |
| 54                                           | 4.88                      |
| 55                                           | 4.86                      |

**[00216]** It should be noted that the step of applying the first signal and the driving of the second signal is in sequential order in that the order may be the first signal then the second signal or both signals overlapping in sequence; alternatively, the second signal first then the first signal or both signals overlapping in sequence. Alternatively, the applying of the first signal and the driving of the second signal may take place simultaneously.

**[00217]** It is noted that in the preferred embodiments, the measurement of a signal output for the glucose concentration is performed prior to the estimation of the physical

characteristic (e.g., hematocrit). Alternatively, the physical characteristic (e.g., hematocrit) level can be estimated, measured, or obtained prior to the measurement of the glucose concentration.

**[00218]** Thus, as another benefit of the teaching provided herein, a method of demonstrating increased accuracy of a test strip than heretofore is achieved. This method involves providing a batch of test strips, typically in a batch of at least about 1500 test strips (and in some cases up to 1 million test strips per batch), introducing a referential sample containing a referential concentration of an analyte to each of the batch of test strips to initiate a test sequence. The method involves reacting the analyte to cause a physical transformation of the analyte with the reagent between the two electrodes, determining a physical characteristic of the referential sample, estimating the analyte concentration, sampling an electrical output of the referential sample at a specified time point during the test sequence defined by the measured or estimated physical characteristic of the sample and the estimated analyte concentration, and calculating an analyte concentration based on the specified sampling time such that at least 95% of the analyte concentration values of the batch of test strips are within about 25% of the referential analyte concentration for the range of hematocrit from about 30% to about 55%, shown here in Figure 6B3.

**[00219]** As can be seen in Figure 6B3, most or virtually all of the glucose concentration using this technique are within about  $\pm 25\%$  bias for hematocrit from about 30% hematocrit to about 55% hematocrit. Specifically, at region 1010B, only one glucose concentration greater than 100 mg/dL is outside the bias of -15%; at region 1012B of intermediate hematocrit, a few glucose concentrations are outside the bias range of about -25% and at region 1014B of high hematocrit, more glucose concentrations are dispersed outside the bias of about -25% as compared to regions 1010B and 1012B.

**[00220]** Yet another technique can be understood with reference to Figure 6C1. This technique involves depositing a fluid sample (which may be a physiological sample) on a biosensor at step 904C (e.g., in the form of a test strip as show in Figures 3A (1), 3A(2), or 3A(3)-3T) that has been inserted into a meter (step 902C). Once the meter 200 is turned on, a voltage is applied to the strip 100 (or its variants 400, 500, or 600) and when the sample is deposited onto the test chamber, the applied voltage physically transforms the analyte in the sample into a different form due to the enzymatic reaction of the analyte with the reagent in the test chamber. As the sample flows into the

capillary channel of the test cell, at least one physical characteristic of the sample is obtained (step 908C). In particular, the step of obtaining or measuring the physical characteristic (step 908C) may include applying a first signal to the sample to derive a physical characteristic of the sample, while the step 906C of initiating an enzymatic reaction (e.g., by applying signals to the sample and reagent) may involve driving a second signal to the sample, and the step of measuring (step 912C) may entail measuring an output signal from the at least two electrodes at a point in time after the start of the test sequence, in which a sampling time point is specified (at step 909) and a batch slope (step 910C) is derived and as a function of at least the measured or estimated physical characteristic (step 908C).

**[00221]** In a variation of the method, the step of applying of the first signal involves directing an alternating signal provided by an appropriate power source (e.g., the meter 200) to the sample so that a physical characteristic of the sample is determined from an output of the alternating signal. The physical characteristic being detected may be one or more of viscosity, hematocrit or density. The directing step may include driving first and second alternating signal at different respective frequencies in which a first frequency is lower than the second frequency. Preferably, the first frequency is at least one order of magnitude lower than the second frequency. As an example, the first frequency may be any frequency in the range of about 10 kHz to about 100 kHz and the second frequency may be from about 250 kHz to about 1 MHz or more. As used herein, the phrase “alternating signal” can have some portions of the signal alternating in polarity or all alternating current signal or an alternating current with a direct current offset or even a multi-directional signal combined with a direct-current signal.

**[00222]** Once the physical characteristic of the sample is determined or obtained from a suitable technique, the physical characteristic can be used to specify a sampling time point (step 909) at which point during the test sequence the output signal of the test chamber could be measured. In particular, applicants have found a relationship between the physical characteristic and the sampling time point, as shown here in Figure 7. This relationship has been further explored such that applicants were able to derive a direct relationship between the sampling time point of the sample and the physical characteristic of the sample (e.g., hematocrit), shown here in Figure 6C2. As a consequence, by knowing the physical characteristic of the sample (e.g., hematocrit) from Equation 4 above, the relationship in Figure 6C2 can be exploited to allow the

sampling time point to be specified to accommodate the different levels of physical characteristic (e.g., hematocrit) so as to achieve much more accurate analyte (e.g., glucose) concentration measurements.

**[00223]** Referring back to Figure 7, it can be seen that as the analyte concentration (proportional to the signal output) increases, the peak of the high glucose concentration (denoted by 1002a, 1004a, and 1006a) is shifted to the right as compared to the medium glucose concentration (denoted by 1002b, 1004b, and 1006b). Similarly, the peak of the medium glucose concentration is further to the right of Fig. 7A as compared to low glucose concentration (denoted by 1002c, 1004c, and 1006c). It can also be seen here that the steady-state of the low glucose concentrations (1002c, 1004c, and 1006c) is reached earlier than the medium glucose concentrations (1002b, 1004b, and 1006b). This pattern is repeated for high glucose concentration (1002a, 1004a, and 1006b) as compared to medium glucose concentrations.

**[00224]** Although the method may specify only one sampling time point, the method may include sampling as many time points as required, such as, for example, sampling the signal output continuously (e.g., at specified sampling time such as, every one millisecond to 100 milliseconds) from the start of the test sequence until at least about 10 seconds after the start and the results stored for processing near the end of the test sequence. Applicants note that the appropriate sampling time is measured from the start of the test sequence but any appropriate datum may be utilized in order to determine when to sample the output signal. As a practical matter, the system can be programmed to sample the output signal at an appropriate time sampling interval during the entire test sequence such as for example, one sampling every 100 milliseconds or even as little as about 1 milliseconds. In this variation, the sampled signal output at the specified sampling time point T is the value used to calculate the analyte concentration.

**[00225]** Alternatively, a look-up table, represented exemplarily here with reference to Table 1 can also be utilized in place of Equation 7 or in addition to Equation 7 to determine the appropriate sampling time point T. In Table 1, the value of the physical characteristic is used by the processor of the system to look up the appropriate time at which the signal output of the biosensor is sampled or measured to determine the analyte concentration. For example, once the physical characteristic has been

determined, in this case about 33% hematocrit, the time at which the signal output of the biosensor 100 is utilized in determining the analyte concentration can be gleaned from Table 1, which shows that the time at which the system must sample the signal output is at approximately 5.32 seconds after the start of the test sequence.

**[00226]** To further improve the accuracy of the results, the method may entail evaluating an output signal from the at least two electrodes at a point in time after the start of the test sequence, in which a new batch slope is derived (at step 910C) as a function of at least the measured or estimated physical characteristic (step 908C).

**[00227]** The setting of a new batch slope (step 910C) to derive a more accurate analyte concentration measurement merits a discussion with reference to Figures 7 and 6C3. Applicants have further found that another relationship exists between the batch slope of these test strips tested at the Lo-G, Mid-G, and Hi-G levels with respect to 30%, 42%, and 55% hematocrit levels of Figure 7. In particular, applicants have found that the batch slope for these strips is generally curved with respect to hematocrit level, shown here in Figure 6C3. In Figure 6C3, the batch slope declines in a generally curved manner at low (e.g., 30%), medium (e.g., 42%), and high (e.g., 55%) hematocrits. As a consequence, by knowing the physical characteristic of the sample (e.g., hematocrit) from Equation 4 above, the relationship in Figure 6C3 can be exploited to allow the slope in Equation 3.3 to be calculated for the different levels of physical characteristic (e.g., hematocrit) so as to achieve much more accurate glucose concentration measurements.

**[00228]** It should be noted that while slope “x” in Figure 6C3 appears to be a linear line, slope “x” is in fact a curved line and a curve has been fitted for the relationship between physical characteristic (e.g., hematocrit) and slope implicit in Figure 6C3. This fitted curve for Figure 6C3 was found by applicants and defined in Equation 5 previously. It is noted that due to an adjustment at which the sampling time was taken for the embodiment described herein, Equation 5 is preferably used with the following coefficients: a is about  $-1.98\text{e-}6$ ; b is about  $-2.87\text{e-}5$ ; and c is about  $2.67\text{e-}2$  and  $\pm 10\%$  for each of the magnitudes provided. The adjustment stems from the fact that the new coefficients (a, b, and c) are calculated at different sampling time, whereas before, the sampling time was fixed at about 5 seconds. This will cause coefficients a, b and c to be different in order to maximise accuracy. If one skilled in the art were to use the same coefficients a, b and c as before, such skilled person can still obtain the analyte

concentration but the resulting estimates will deteriorate. The driver here is that slope of glucose relation to haematocrit is changing within the signal transient, so different slopes are needed as the sampling time is varied between about 3.5seconds to about 6 seconds.

[00229] It is noted that Equation 5 can be used instead of plotting against Figure 6C3, depending on the available computing power of the processor. Continuing on with the exemplary process of Figure 6C1, once the physical characteristic is known at step 908C from Equation 4, such as for example Hct ~55%, the graph of Figure 6C3 or Equation 5 is utilized to determine the appropriate batch slope, designated here as “*NewSlope*” which is about 0.019. Alternatively, Equation 5 can be utilized to derive the *NewSlope* from the measured or estimated physical characteristic (e.g., hematocrit). This *NewSlope* (from Fig. 6C3 or Eq. 5) is used along with the batch intercept (Intercept) with the sampling time relationship that applicants have found, as set forth previously with respect to Eq. 5.

[00230] Referring back to Figure 6C1, the method can now determine the analyte concentration (step 914C) based on a new batch slope (i.e., *NewSlope*) derived from the measured or estimated physical characteristic of the sample (at step 910C) along with the measured signal (step 912C) sampled at the specified time point (at step 909), which specified time point is a function of the obtained or measured or estimated physical characteristic of the sample (e.g., from plot of Figure 6C2 or Equation 5). That is, once the sampling time has been specified from Equation 5 and the *NewSlope* from Equation 6, the method provides for measuring the output signal from the test chamber (e.g., chamber 92) so that the sampled output can be utilized with Equation 3.3 to provide for an analyte (e.g., glucose) concentration.

[00231] In one embodiment the analyte (e.g., glucose) concentration is determined based on a modified form of Equation 3.3, delineated here as Equation 8:

$$G_0 = \left[ \frac{I_E - \text{Intercept}}{\text{NewSlope}} \right] \quad \text{Eq. 8}$$

where

$G_0$  represents an analyte concentration

$I_E$  is a signal (proportional to analyte concentration) as measured at the specified *SamplingTime* point;

“*NewSlope*” is the value obtained from the relationship in Figure 6C3 or from Eq. 5;

Intercept is the value obtained from calibration testing of a batch of test strips of which this particular strip comes from.

[00232] Once the signal output  $I_E$  of the test chamber is measured at the specified time (step 909) at any point between about 3 seconds to about 8 seconds, the signal  $I_E$  is thereafter used with the *NewSlope* (of the batch) and *Intercept* (of the batch) in the calculation of the analyte concentration (in this case glucose) with Eq. 8 above. Intercept comprises a manufacturing parameter for a batch of biosensors, and in the embodiments described herein, Intercept typically varies from about 0.7 to about 0.6. It should be noted that the step of applying the first signal and the driving of the second signal is in sequential order in that the order may be the first signal then the second signal or both signals overlapping in sequence; alternatively, the second signal first then the first signal or both signals overlapping in sequence. Alternatively, the applying of the first signal and the driving of the second signal may take place simultaneously.

[00233] It is noted that in the preferred embodiments, the measurement of a signal output for the analyte (e.g., glucose) concentration is performed prior to the estimation of the physical characteristic (e.g., hematocrit). Alternatively, the physical characteristic (e.g., hematocrit) level can be estimated, measured, or obtained prior to the measurement of the analyte (e.g., glucose) concentration.

[00234] Thus, as another benefit of the teaching provided herein, a method of demonstrating increased accuracy of a test strip is heretofore is achieved. This method involves providing for a batch of test strips, typically in a batch of at least about 1500 test strips (and in some cases up to 1 million test strips per batch), introducing a referential sample containing a referential concentration of an analyte to each of the batch of test strips to initiate a test sequence. The method involves reacting the analyte to cause a physical transformation of the analyte with the reagent between the two electrodes, determining a physical characteristic of the referential sample, deriving a batch slope for the test strip, sampling an electrical output of the referential sample at a specified time point during the test sequence defined by the measured or estimated physical characteristic of the sample, and calculating an analyte concentration based on

the dictated time and the derive batch slope such that at least 95% of the analyte concentration values of the batch of test strips are within about  $\pm 15\%$  of the referential analyte concentration for the range of hematocrit from about 30% to about 55%, shown here in Figure 6C4.

**[00235]** As can be seen in Figure 6C4, most or virtually all of the glucose concentration using this technique are within about  $\pm 15\%$  bias for hematocrit from about 30% hematocrit to about 55% hematocrit. Specifically, at region 1010C, none of the glucose concentration greater than 100 mg/dL is outside the bias of -15%; at region 1012C of intermediate hematocrit, a few glucose concentrations are outside the bias range of 15% and at region 1014C of high hematocrit, a few more glucose concentrations are dispersed outside the bias of 15% as compared to regions 1010C and 1012C.

**[00236]** Yet a further technique can be understood with reference to Figure 6D1. This technique involves depositing a fluid sample (which may be a physiological sample) on a biosensor at step 904 (e.g., in the form of a test strip as show in Figures 3A(1), 3A(2), or 3A(3)-3T) that has been inserted into a meter (step 902). Once the meter 200 is turned on, a voltage is applied to the strip 100 (or its variants 400, 500, or 600) and when the sample is deposited onto the test chamber, the applied signal physically transforms the analyte in the sample into a different form due to the enzymatic reaction of the analyte with the reagent in the test chamber. As the sample flows into the capillary channel of the test cell, at least one physical characteristic of the sample is obtained (step 908) along with estimate of the analyte concentration (step 910). From the obtained physical characteristic (step 908) and estimated analyte concentration (step 910), a sampling time point is defined at which the signal output from the sample during the test sequence is measured (at step 914) and used for calculating the analyte concentration in step 916. In particular, the step of obtaining the physical characteristic (step 908) may include applying a first signal to the sample to measure a physical characteristic of the sample, while the step 906 of initiating an enzymatic reaction may involve driving a second signal to the sample, and the step of measuring (step 914) may entail evaluating an output signal from the at least two electrodes at a point in time after the start of the test sequence, in which the point in time is set (at step 912) as a function of at least the measured or estimated physical characteristic (step 908) and estimated analyte concentration (step 910).

**[00237]** The determination of the appropriate point in time as a function of the measured or estimated physical characteristic(s) in step 912 can be determined by the use of a look-up table programmed into the microprocessor of the system. For example, a look-up table may be provided that allows for the system to select the appropriate sampling time for the analyte (e.g., glucose or ketone) with measured or known physical characteristic (e.g., hematocrit or viscosity) of the sample.

**[00238]** In particular, an appropriate sampling time point may be based on an early estimation of the analyte and the measured or known physical characteristic to arrive at the appropriate sampling time that gives the lowest error or bias as compared to referential values. In this technique, a look up table is provided in which the defined sampling time point is correlated to (a) the estimated analyte concentration and (b) the physical characteristic of the sample. For example, Table 2 may be programmed into the meter to provide a matrix in which qualitative categories (low, medium, and high glucose) of the estimated analyte form the main column and the qualitative categories (low, medium, and high) of the measured or estimated physical characteristic form the header row. In the second column,  $t/Hct$  is a value determined experimentally of the time shift per % hematocrit difference from nominal hematocrit of 42%. As one example, for 55% hematocrit at “Mid-Glucose” would indicate a time shift of  $(42 - 55) * 90 = -1170ms$ . The time of -1170 milliseconds is added to the original test time of about 5000 milliseconds giving  $(5000 - 1170 = 3830 \text{ milliseconds}) \sim 3.9\text{seconds}$ .

**Table 2**

| <b>Estimated Analyte</b> | <b>t/ Hct (in milliseconds)</b> | <b>Sampling Time Point T for Lo Hct (from start of test sequence, in seconds)</b> | <b>Sampling Time Point T for Mid Hct (from start of test sequence, in seconds)</b> | <b>Sampling Time Point T for High Hct (from start of test sequence, in seconds)</b> |
|--------------------------|---------------------------------|-----------------------------------------------------------------------------------|------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|
| Lo-Glucose               | 40                              | 5.5                                                                               | 5                                                                                  | 4.5                                                                                 |
| Mid-Glucose              | 90                              | 6.1                                                                               | 5                                                                                  | 3.9                                                                                 |
| Hi-Glucose               | 110                             | 6.3                                                                               | 5                                                                                  | 3.6                                                                                 |

**[00239]** The time T at which the system should be sampling the output signal of the biosensor is based on both the qualitative category of the estimated analyte and measured or estimated physical characteristic and is predetermined based on regression analysis of a large sample size of actual physiological fluid samples. Applicants note that the appropriate sampling time is measured from the start of the test sequence but any appropriate datum may be utilized in order to determine when to sample the output signal. As a practical matter, the system can be programmed to sample the output signal at an appropriate time sampling interval during the entire test sequence such as for example, one sampling every 100 milliseconds or even as little as about 1 milliseconds. By sampling the entire signal output transient during the test sequence, the system can perform all of the needed calculations near the end of the test sequence rather than attempting to synchronize the sampling time with the set time point, which may introduce timing errors due to system delay.

**[00240]** Applicants hereafter will discuss the look-up Table 2 in relation to the particular analyte of glucose in physiological fluid samples. Qualitative categories of blood glucose are defined in the first column of Table 2 in which low blood glucose concentrations of less than about 70 mg/dL are designated as “Lo-Glucose”; blood glucose concentrations of higher than about 70 mg/dL but less than about 250 mg/dL are designated as “Mid-Glucose”; and blood glucose concentrations of higher than about 250 mg/dL are designated as “Hi-Glucose”.

**[00241]** During a test sequence, an “Estimated Analyte” can be obtained by sampling the signal at a convenient time point, typically at five seconds during a typical 10 seconds test sequence. The measurement sampled at this five second time point allows for an accurate estimate of the analyte (in this case blood glucose). The system may then refer to a look-up table (e.g., Table 2) to determine when to measure the signal output from the test chamber at a specified sampling time T based on two criteria: (a) estimated analyte and (b) qualitative value of the physical characteristic of the sample. For criteria (b), the qualitative value of the physical characteristic is broken down into three sub-categories of Low Hct, Mid Hct and High Hct. Thus, in the event that the measured or estimated physical characteristic (e.g., hematocrit) is high (e.g., greater than 46%) and the estimated glucose is also high, then according to Table 2, the test time for the system to measure the signal output of test chamber would be about 3.6 seconds. On the other hand, if the measured hematocrit is low (e.g., less than 38%) and

the estimated glucose is low then according to Table 2, the test time T for the system to measure the signal output of test chamber would be about 5.5 seconds.

[00242] Once the signal output  $I_T$  of the test chamber is measured at the designated time (which is governed by the measured or estimated physical characteristic), the signal  $I_T$  is thereafter used in the calculation of the analyte concentration (in this case glucose) with Equation 9 below.

$$G_0 = \left[ \frac{I_T - \text{Intercept}}{\text{Slope}} \right] \quad \text{Eq. 9}$$

where

$G_0$  represents an analyte concentration;

$I_T$  represents a signal (proportional to analyte concentration) determined from the sum of the end signals measured at a specified sampling time T, which may be the total current measured at the specified sampling time T;

Slope represents the value obtained from calibration testing of a batch of test strips of which this particular strip comes from and is typically about 0.02; and

Intercept represents the value obtained from calibration testing of a batch of test strips of which this particular strip comes from and is typically from about 0.6 to about 0.7.

[00243] It should be noted that the step of applying the first signal and the driving of the second signal is sequential in that the order may be the first signal then the second signal or both signals overlapping in sequence; alternatively, the second signal first then the first signal or both signals overlapping in sequence. Alternatively, the applying of the first signal and the driving of the second signal may take place simultaneously.

[00244] In the method, the step of applying of the first signal involves directing an alternating signal provided by an appropriate power source (e.g., the meter 200) to the sample so that a physical characteristic of the sample is determined from an output of the alternating signal. The physical characteristic being detected may be one or more of viscosity, hematocrit or density. The directing step may include driving first and second alternating signal at different respective frequencies in which a first frequency is lower than the second frequency. Preferably, the first frequency is at least one order of magnitude lower than the second frequency. As an example, the first frequency may be

any frequency in the range of about 10 kHz to about 100 kHz and the second frequency may be from about 250 kHz to about 1 MHz or more. As used herein, the phrase “alternating signal” or “oscillating signal” can have some portions of the signal alternating in polarity or all alternating current signal or an alternating current with a direct current offset or even a multi-directional signal combined with a direct-current signal.

[00245] Further refinements of Table 2 based on additional investigations of the technique allowed applicants to devise Table 3, shown below.

**Table 3. Sampling Time S to Estimated G and Measured or Estimated Physical Characteristic**

| Estimated<br>G<br>[mg/dL] | Measured or Estimated Physical Characteristic (e.g., HCT [%]) |     |     |     |     |     |     |     |     |     |     |     |     |
|---------------------------|---------------------------------------------------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
|                           | 24                                                            | 27  | 30  | 33  | 36  | 39  | 42  | 45  | 48  | 51  | 54  | 57  | 60  |
| 25                        | 4.6                                                           | 4.6 | 4.5 | 4.4 | 4.4 | 4.4 | 4.3 | 4.3 | 4.3 | 4.2 | 4.1 | 4.1 | 4.1 |
| 50                        | 5                                                             | 4.9 | 4.8 | 4.7 | 4.7 | 4.6 | 4.5 | 4.4 | 4.3 | 4.2 | 4.1 | 4   | 4   |
| 75                        | 5.3                                                           | 5.3 | 5.2 | 5   | 4.9 | 4.8 | 4.7 | 4.5 | 4.4 | 4.3 | 4.1 | 4   | 3.8 |
| 100                       | 5.8                                                           | 5.6 | 5.4 | 5.3 | 5.1 | 5   | 4.8 | 4.6 | 4.4 | 4.3 | 4.1 | 3.9 | 3.7 |
| 125                       | 6.1                                                           | 5.9 | 5.7 | 5.5 | 5.3 | 5.1 | 4.9 | 4.7 | 4.5 | 4.3 | 4.1 | 3.8 | 3.6 |
| 150                       | 6.4                                                           | 6.2 | 5.9 | 5.7 | 5.5 | 5.3 | 5   | 4.8 | 4.6 | 4.3 | 4   | 3.8 | 3.5 |
| 175                       | 6.6                                                           | 6.4 | 6.2 | 5.9 | 5.6 | 5.4 | 5.2 | 4.9 | 4.6 | 4.3 | 4   | 3.7 | 3.4 |
| 200                       | 6.8                                                           | 6.6 | 6.4 | 6.1 | 5.8 | 5.5 | 5.2 | 4.9 | 4.6 | 4.3 | 4   | 3.7 | 3.4 |
| 225                       | 7.1                                                           | 6.8 | 6.5 | 6.2 | 5.9 | 5.6 | 5.3 | 5   | 4.7 | 4.3 | 4   | 3.6 | 3.2 |
| 250                       | 7.3                                                           | 7   | 6.7 | 6.4 | 6   | 5.7 | 5.3 | 5   | 4.7 | 4.3 | 4   | 3.6 | 3.2 |
| 275                       | 7.4                                                           | 7.1 | 6.8 | 6.4 | 6.1 | 5.8 | 5.4 | 5   | 4.7 | 4.3 | 4   | 3.5 | 3.2 |
| 300                       | 7.5                                                           | 7.1 | 6.8 | 6.5 | 6.2 | 5.8 | 5.5 | 5.1 | 4.7 | 4.3 | 4   | 3.5 | 3.1 |
| w325                      | 7.6                                                           | 7.3 | 6.9 | 6.5 | 6.2 | 5.8 | 5.5 | 5.1 | 4.7 | 4.3 | 3.9 | 3.5 | 3.1 |
| 350                       | 7.6                                                           | 7.3 | 7   | 6.6 | 6.2 | 5.8 | 5.5 | 5.1 | 4.7 | 4.3 | 3.9 | 3.5 | 3.1 |
| 375                       | 7.7                                                           | 7.3 | 7   | 6.6 | 6.2 | 5.8 | 5.5 | 5.1 | 4.7 | 4.3 | 3.9 | 3.5 | 3.1 |
| 400                       | 7.7                                                           | 7.3 | 6.9 | 6.5 | 6.2 | 5.8 | 5.4 | 5   | 4.7 | 4.3 | 3.9 | 3.5 | 3.1 |
| 425                       | 7.6                                                           | 7.3 | 6.9 | 6.5 | 6.2 | 5.8 | 5.4 | 5   | 4.6 | 4.3 | 3.8 | 3.5 | 3.1 |
| 450                       | 7.6                                                           | 7.2 | 6.8 | 6.4 | 6.1 | 5.7 | 5.3 | 5   | 4.6 | 4.3 | 3.8 | 3.5 | 3.1 |
| 475                       | 7.4                                                           | 7.1 | 6.7 | 6.4 | 6   | 5.6 | 5.3 | 4.9 | 4.6 | 4.2 | 3.8 | 3.5 | 3.1 |
| 500                       | 7.3                                                           | 7   | 6.6 | 6.2 | 5.9 | 5.5 | 5.2 | 4.9 | 4.5 | 4.1 | 3.8 | 3.5 | 3.2 |
| 525                       | 7.1                                                           | 6.8 | 6.5 | 6.1 | 5.8 | 5.5 | 5.1 | 4.8 | 4.4 | 4.1 | 3.8 | 3.5 | 3.2 |
| 550                       | 7                                                             | 6.7 | 6.3 | 5.9 | 5.6 | 5.3 | 5   | 4.7 | 4.4 | 4.1 | 3.8 | 3.5 | 3.2 |
| 575                       | 6.8                                                           | 6.4 | 6.1 | 5.8 | 5.5 | 5.2 | 4.9 | 4.6 | 4.3 | 4.1 | 3.8 | 3.5 | 3.4 |
| 600                       | 6.5                                                           | 6.2 | 5.9 | 5.6 | 5.3 | 5   | 4.7 | 4.5 | 4.3 | 4   | 3.8 | 3.6 | 3.4 |

[00246] As in Table 2, a measured or estimated physical characteristic is used in Table 3 along with an estimated analyte concentration to derive a time S at which the sample is to be measured. For example, if the measured characteristic is about 30% and the estimated glucose (e.g., by sampling at about 2.5 to 3 seconds) is about 350, the time at which the microcontroller should sample the fluid is about 7 seconds. In another example, where the estimated glucose is about 300 mg/dL and the measured or estimated physical characteristic is 60%, the specified sampling time point would be about 3.1 seconds.

[00247] For the embodiments utilized with Table 3, the estimated glucose concentration is provided with an equation:

$$G_{est} = \frac{(I_E - x_2)}{x_1} \quad \text{Eq. 10}$$

where  $G_{est}$  represents the estimated glucose concentration;  
 $I_E$  is the signal measured at about 2.5 seconds;  
 $x_1$  is the slope (e.g.,  $x_1=1.3e01$ );  
 $x_2$  is the intercept (e.g.,  $x_2=6.9e02$ )

[00248] From the estimated glucose, the glucose concentration can be determined from:

$$G_o = \frac{(I_s - x_4)}{x_3} \quad \text{Eq. 11}$$

where:  $G_o$  represents the glucose concentration;  
 $I_s$  is the signal measured at a specified sampling time point S from Table 3;  
 $x_3$  is the slope (e.g.,  $x_3=9.6$ ); and  
 $x_4$  is the intercept (e.g.,  $x_4=4.8e02$ ).

[00249] Although the method may specify only one sampling time point, the method may include sampling as many time points as required, such as, for example, sampling the signal output continuously (e.g., at specified sampling time such as, every 1 milliseconds to 100 milliseconds) from the start of the test sequence until at least about 10 seconds after the start and the results stored for processing near the end of the test

sequence. In this variation, the sampled signal output at the specified sampling time point (which may be different from the predetermined sampling time point) is the value used to calculate the analyte concentration.

**[00250]** It is noted that in the preferred embodiments, the measurement of a signal output for the value that is somewhat proportional to analyte (e.g., glucose) concentration is performed prior to the estimation of the hematocrit. Alternatively, the hematocrit level can be estimated prior to the measurement of the preliminary glucose concentration. In either case, the estimated glucose measurement  $G_E$  is obtained by Equation 3.3 with  $I_E$  sampled at about one of 2.5 seconds or 5 seconds, as in Figure 6D2, the physical characteristic (e.g., Hct) is obtained by Equation 4 and the glucose measurement  $G$  is obtained by using the measured signal output  $I_D$  at the designated sampling time point(s) (e.g., the measured signal output  $I_D$  being sampled at 3.5 seconds or 6.5 seconds) for the signal transient 1000.

**[00251]** Thus, as another benefit of the teaching provided herein, a method of demonstrating increased accuracy of a test strip is heretofore is achieved. This method involves providing for a batch of test strips, typically in a batch of at least about 1500 test strips (and up to a million or more test strips in certain cases), introducing a referential sample containing a referential concentration of an analyte to each of the batch of test strips to initiate a test sequence. The method involves, reacting the analyte to cause a physical transformation of the analyte with the reagent between the two electrodes, determining a physical characteristic of the referential sample, estimating the analyte concentration, sampling an electrical output of the referential sample at a dictated time point during the test sequence defined by the measured or estimated physical characteristic of the sample and the estimated analyte concentration, and calculating an analyte concentration based on the dictated time such that at least 95% of the analyte concentration values of the batch of test strips are within  $\pm 10\%$  of the referential analyte concentration for the range of hematocrit from about 30% to about 55%, shown here in Figure 6D3.

**[00252]** In Figure 6D3, experiments were performed to quantify the improvement in the glucose measurements from the method noted above. The quantification of the improvement can be shown by the “bias” at different levels of hematocrit. The bias, which is an estimate of the relative error in the glucose measurement, was calculated for each glucose concentration determined with the method described in this example.

**[00253]** As can be seen in Figure 6D3, most or virtually all of the glucose concentration using this technique are within about  $\pm 10\%$  bias for hematocrit from about 30% hematocrit to about 55% hematocrit. This is believed to be a breakthrough as the prior technique of sampling the output signal transient at a fixed time point (typically at about one of 2.5 seconds or 5 seconds from the start of test sequence) for this specific type of test strip generally fails to show any bias of less than  $\pm 20\%$ . By virtue of the descriptions and teachings provided herein, applicant was able to devise a glucose test strip that has a substrate, a plurality of electrodes disposed on the substrate and connected to respective electrode connectors. The test strip 100 includes at least a reagent disposed on at least one of the plurality of electrodes, in which at least one of the electrodes is configured to sense a physical characteristic of fluid sample deposited on the at least one electrode and at least another of the electrodes is configured to measure output signal from the sample upon application of input signal to the sample. Included with the test strip are instructions for use with a glucose meter. The instructions include indicia embedded in an appropriate communication medium (e.g., paper, computer, internet, audio or visual medium or the like) to a user to insert the electrode connectors of the test strip to a test strip port of the glucose meter. The meter indicated for use with the glucose test strip includes a test strip port connector configured to connect to respective electrode connectors of a test strip, and a microprocessor in electrical communication with the test strip port connector to apply electrical signals or sense electrical signals from a plurality of electrodes of the test strip connected to the respective electrode connectors of the test strip during a test sequence. The instructions further include indicia embedded in an appropriate communication medium (e.g., paper, computer, internet, audio or visual medium or the like) to the user to deposit a fluid sample proximate at least one of the plurality of electrodes so that the microprocessor 300 is operable to: (a) apply a first signal to the plurality of electrodes so that a physical characteristic of a fluid sample deposited on the plurality of electrodes is determined; (b) estimate an analyte concentration based on a predetermined sampling time point during a test sequence; and (c) apply a second signal to the plurality of electrodes at a sampling time point during the test sequence dictated by the determined physical characteristic so that an analyte concentration is calculated from the second signal.

**[00254]** Similarly, applicant was able to devise a glucose test strip 100 that has a substrate, a plurality of electrodes disposed on the substrate and connected to respective electrode connectors. The test strip includes at least a reagent disposed on at least one of the plurality of electrodes, in which at least one of the electrodes is configured to sense a physical characteristic of fluid sample deposited on the at least one electrode and at least another of the electrodes is configured to measure output signal from the sample upon application of input signal to the sample. Included with the test strip are instructions for use with a glucose meter. The instructions includes indicia embedded in an appropriate communication medium (e.g., paper, computer, internet, audio or visual means and the like) to a user to insert the electrode connectors of the test strip to a test strip port of the glucose meter. The meter indicated for use with the glucose test strip includes a test strip port connector configured to connect to respective electrode connectors of a test strip, and a microprocessor in electrical communication with the test strip port connector to apply electrical signals or sense electrical signals from a plurality of electrodes of the test strip connected to the respective electrode connectors of the test strip during a test sequence. The instructions further include indicia to the user to deposit a fluid sample proximate at least one of the plurality of electrodes so that the microprocessor is operable to: (a) apply a first signal to the plurality of electrodes so that a specific sampling time determined from a physical characteristic of a fluid sample is derived, (b) apply a second signal to the plurality of electrodes, and (c) measure a signal output from one of the plurality of electrodes at the specified sampling time so that an analyte concentration is determined.

**[00255]** Likewise, applicant was able to devise a glucose test strip that has a substrate, a plurality of electrodes disposed on the substrate and connected to respective electrode connectors. The test strip includes at least a reagent disposed on at least one of the plurality of electrodes, in which at least one of the electrodes is configured to sense a physical characteristic of fluid sample deposited on the at least one electrode and at least another of the electrodes is configured to measure output signal from the sample upon application of input signal to the sample. Included with the test strip are instructions for use with a glucose meter. The instructions includes indicia embedded in an appropriate communication medium (e.g., paper, computer, internet, audio or visual means and the like) to a user to insert the electrode connectors of the test strip to a test strip port of the glucose meter. The meter indicated for use with the glucose test

strip includes a test strip port connector configured to connect to respective electrode connectors of a test strip, and a microprocessor in electrical communication with the test strip port connector to apply electrical signals or sense electrical signals from a plurality of electrodes of the test strip connected to the respective electrode connectors of the test strip during a test sequence. The instructions further include indicia to the user to deposit a fluid sample proximate at least one of the plurality of electrodes so that the microprocessor is operable to: (a) apply a first signal to the plurality of electrodes so that a specific sampling time point and a batch slope determined from a physical characteristic of a fluid sample are derived, (b) apply a second signal to the plurality of electrodes, and (c) measure a signal output from one of the plurality of electrodes at the specified sampling time so that an analyte concentration is determined based on the measured signal at the specified sampling time and the batch slope.

[00256] Similarly, applicant was able to devise a glucose test strip that has a substrate, a plurality of electrodes disposed on the substrate and connected to respective electrode connectors. The test strip includes at least a reagent disposed on at least one of the plurality of electrodes, in which at least one of the electrodes is configured to sense a physical characteristic of fluid sample deposited on the at least one electrode and at least another of the electrodes is configured to measure output signal from the sample upon application of input signal to the sample. Included with the test strip are instructions for use with a glucose meter. The instructions include indicia embedded in an appropriate communication medium (e.g., paper, computer, internet, audio or visual means and the like) to a user to insert the electrode connectors of the test strip to a test strip port of the glucose meter. The meter indicated for use with the glucose test strip includes a test strip port connector configured to connect to respective electrode connectors of a test strip, and a microprocessor in electrical communication with the test strip port connector to apply electrical signals or sense electrical signals from a plurality of electrodes of the test strip connected to the respective electrode connectors of the test strip during a test sequence. The instructions further include indicia to the user to deposit a fluid sample proximate at least one of the plurality of electrodes so that the microprocessor is operable to: (a) apply a first signal to the plurality of electrodes so that a batch slope defined by a physical characteristic of a fluid sample is derived, and (b) apply a second signal to the plurality of electrodes so that an analyte concentration is determined based on the derived batch slope.

**[00257]** Although the techniques described herein have been directed to determination of glucose, the techniques can also be applied to other analytes (with appropriate modifications by those skilled in the art) that are affected by physical characteristic(s) of the fluid sample in which the analyte(s) is disposed in the fluid sample. For example, the physical characteristic (e.g., hematocrit, viscosity or density and the like) of a physiological fluid sample could be accounted for in determination of ketone or cholesterol in the fluid sample, which may be physiological fluid, calibration, or control fluid. Other biosensor configurations can also be utilized. For example, the biosensors shown and described in the following US Patents can be utilized with the various embodiments described herein: US Patent Nos. 6179979; 6193873; 6284125; 6413410; 6475372; 6716577; 6749887; 6863801; 6890421; 7045046; 7291256; 7498132.

**[00258]** As is known, the detection of the physical characteristic does not have to be done by alternating signals but can be done with other techniques. For example, a suitable sensor can be utilized (e.g., US Patent Application Publication No. 20100005865 or EP1804048 B1) to determine the viscosity or other physical characteristics. Alternatively, the viscosity can be determined and used to derive for hematocrits based on the known relationship between hematocrits and viscosity as described in "Blood Rheology and Hemodynamics" by Oguz K. Baskurt, M.D., Ph.D.,<sup>1</sup> and Herbert J. Meiselman, Sc.D., *Seminars in Thrombosis and Hemostasis*, volume 29, number 5, 2003.

**[00259]** As described earlier, the microcontroller or an equivalent microprocessor (and associated components that allow the microcontroller to function for its intended purpose in the intended environment such as, for example, the processor 300 in Figure 2B) can be utilized with computer codes or software instructions to carry out the methods and techniques described herein. Applicants note that the exemplary microcontroller 300 (along with suitable components for functional operation of the processor 300) in Figure 2B is embedded with firmware or loaded with computer software representative of the logic diagrams in Figures 6A(1), 6B(1); 6C(1); or 6D(1) and the microcontroller 300, along with associated connector 220 and interface 306 and equivalents thereof, are the means for: (a) determining a specified sampling time based on a sensed or estimated physical characteristic, the specified sampling time being at least one time point or interval referenced from a start of a test sequence upon

deposition of a sample on the test strip and (b) determining an analyte concentration based on the specified sampling time point. Alternatively, the means for determining may include means for applying a first signal to the plurality of electrodes so that a batch slope defined by a physical characteristic of a fluid sample is derived and for applying a second signal to the plurality of electrodes so that an analyte concentration is determined based on the derived batch slope and the specified sampling time.

Furthermore, the means for determining may include means for estimating an analyte concentration based on a predetermined sampling time point from the start of the test sequence and for selecting a specified sampling time point from a matrix of estimated analyte concentration and sensed or estimated physical characteristic. Yet further, the means for determining may include means for selecting a batch slope based on the sensed or estimated physical characteristic and for ascertaining the specified sampling time point from the batch slope.

**[00260]** Moreover, while the invention has been described in terms of particular variations and illustrative figures, those of ordinary skill in the art will recognize that the invention is not limited to the variations or figures described. In addition, where methods and steps described above indicate certain events occurring in certain order, it is intended that certain steps do not have to be performed in the order described but in any order as long as the steps allow the embodiments to function for their intended purposes. Therefore, to the extent there are variations of the invention, which are within the spirit of the disclosure or equivalent to the inventions found in the claims, it is the intent that this patent will cover those variations as well.

## EMBODIMENTS

*The following embodiments may or may not be claimed:*

1. A method of determining an analyte concentration from a fluid sample with a biosensor having at least two electrodes and a reagent disposed on at least one of the electrodes, the method comprising:

depositing a fluid sample on any one of the at least two electrodes to start an analyte test sequence;

applying a first signal to the sample to measure or estimate a physical characteristic of the sample;

deriving a batch slope for the biosensor based on the measured or estimated physical characteristic from an equation of the form:

$$x = aH^2 + bH + c$$

where

x represents a derived batch slope;

H represents the measured or estimated physical characteristic of the;

a represents about 1.4e-6,

b represents about 3.8e-4,

c represents about 3.6e-2;

driving a second signal to the sample; and

measuring an output signal from at least one of the at least two electrodes;

calculating an analyte concentration based on the measured output signal and derived batch slope with an equation of the form:

$$G_0 = \left[ \frac{I_E - \text{Intercept}}{x} \right]$$

where

G<sub>0</sub> represents an analyte concentration

I<sub>E</sub> represents, or is, a signal (value or measurement; proportional to analyte concentration) measured at a predetermined or specified sampling time;

Intercept represents a calibration parameter for a batch of biosensors;

x represents a derived batch slope from the deriving step.

2. A method of determining an analyte concentration from a fluid sample with a biosensor having at least two electrodes and a reagent disposed on at least one of the electrodes, the method comprising:

depositing a fluid sample on any one of the at least two electrodes to start an analyte test sequence;

applying a first signal to the sample to measure or estimate a physical characteristic of the sample;

deriving a batch slope for the biosensor based on the measured or estimated physical characteristic;

driving a second signal to the sample;

measuring an output signal from at least one of the at least two electrodes; and

calculating an analyte concentration based on the measured output signal and derived batch slope from the measured or estimated physical characteristic of the sample.

3. The method of embodiment 1 or embodiment 2, in which the applying of the first signal and the driving of the second signal is in sequential order.

4. The method of embodiment 1 or embodiment 2, in which the applying of the first signal overlaps with the driving of the second signal.

5. The method of embodiment 1 or embodiment 2, in which the applying of the first signal comprises directing an alternating signal to the sample so that a physical characteristic of the sample is determined from an output of the alternating signal.

6. The method of embodiment 1 or embodiment 2, in which the applying of the first signal comprises directing an optical signal to the sample so that a physical characteristic of the sample is determined from an output of the optical signal.

7. The method of embodiment 5 or embodiment 6, in which the physical characteristic comprises hematocrit and the analyte comprises glucose.

8. The method of embodiment 5 or embodiment 6, in which the physical characteristic comprises at least one of viscosity, hematocrit, temperature and density of the sample or combinations thereof.
9. The method of embodiment 5, in which the directing comprises driving first and second alternating signals at different respective frequencies in which a first frequency is lower than the second frequency.
10. The method of embodiment 9, in which the first frequency is at least one order of magnitude lower than the second frequency.
11. The method of embodiment 10, in which the first frequency comprises any frequency in the range of about 10kHz to about 250kHz.
12. The method of embodiment 2, in which the deriving comprises calculating a batch slope from an equation of the form:
- $$x = aH^2 + bH + c$$
- where
- x represents a derived batch slope from the deriving step;
  - H represents the measured or estimated physical characteristic of the sample;
  - a represents about  $1.4 \times 10^{-6}$ ,
  - b represents about  $3.8 \times 10^{-4}$ ,
  - c represents about  $3.6 \times 10^{-2}$ .

13. The method of embodiment 12, in which the calculating of the analyte concentration comprises utilizing an equation of the form:

$$G_0 = \left[ \frac{I_E - \text{Intercept}}{x} \right]$$

where

$G_0$  represents an analyte concentration

$I_E$  represents, or is, a signal (value or measurement; proportional to analyte concentration) measured at a predetermined or specified sampling time selected from one of about 2.5 seconds or about 5 seconds after a start of the test sequence;

Intercept represents calibration parameter for a batch of biosensors;

$x$  represents a derived batch slope from the deriving step.

14. An analyte measurement system comprising:
  - a test strip including:
    - a substrate;
    - a plurality of electrodes connected to respective electrode connectors; and
  - an analyte meter including:
    - a housing;
    - a test strip port connector configured to connect to the respective electrode connectors of the test strip; and
    - a microprocessor in electrical communication with the test strip port connector to apply electrical signals or sense electrical signals from the plurality of electrodes during a test sequence,
  - the microprocessor is configured to, during the test sequence:
    - (a) apply a first signal to the plurality of electrodes so that a batch slope defined by a physical characteristic of a fluid sample is derived and
    - (b) apply a second signal to the plurality of electrodes so that an analyte concentration is determined based on the derived batch slope.
15. The system of embodiment 14, in which the plurality of electrodes comprises at least two electrodes to measure the physical characteristic and at least two other electrodes to measure the analyte concentration.
16. The system of embodiment 15, in which the at least two electrodes and the at least two other electrodes are disposed in the same chamber provided on the substrate.
17. The system of embodiment 15, in which the at least two electrodes and the at least two other electrodes are disposed in different chambers provided on the substrate.

18. The system of embodiment 14, in which the plurality of electrodes comprises two electrodes to measure the physical characteristic and the analyte concentration.
19. The system of one of embodiments 15, 16, 17, or 18, in which all of the electrodes are disposed on the same plane defined by the substrate.
20. The system of one of embodiments 15, 16, or embodiment 17, in which a reagent is disposed proximate the at least two other electrodes and no reagent is disposed on the at least two electrodes.
21. The system of embodiment 14, in which the batch slope is calculated from an equation of the form:

$$x = aH^2 + bH + c$$

where

x represents a derived batch slope from the deriving step;

H represents the measured or estimated physical characteristic of the sample;

a represents about  $1.4 \times 10^{-6}$ ,

b represents about  $-3.8 \times 10^{-4}$ ,

c represents about  $3.6 \times 10^{-2}$ .

22. The system of embodiment 21, in which the analyte concentration is determined from an equation of the form:

$$G_0 = \left[ \frac{I_E - \text{Intercept}}{x} \right]$$

where

$G_0$  represents an analyte concentration

$I_E$  represents, or is, a signal (value or measurement; proportional to analyte concentration) measured at a predetermined or specified sampling time;

Intercept represents a calibration parameter for a batch of test strips;

x represents a derived batch slope from the deriving step.

23. An analyte measurement system comprising:
- a test strip including:
    - a substrate;
    - a plurality of electrodes connected to respective electrode connectors; and
  - an analyte meter including:
    - a housing;
    - a test strip port connector configured to connect to the respective electrode connectors of the test strip; and
    - a microprocessor in electrical communication with the test strip port connector to apply electrical signals or sense electrical signals from the plurality of electrodes,
  - the microprocessor is configured to, during a test sequence:
    - (a) apply a first signal to the plurality of electrodes so that a batch slope defined by a physical characteristic of a fluid sample is derived and
    - (b) apply a second signal to the plurality of electrodes so that an analyte concentration is determined based on the derived batch slope obtained from the physical characteristic of the sample within about 10 seconds of a start of the test sequence.
24. The system of embodiment 23, in which the plurality of electrodes comprises at least two electrodes to measure the physical characteristic and at least two other electrodes to measure the analyte concentration.
25. The system of embodiment 24, in which the at least two electrodes and the at least two other electrodes are disposed in the same chamber provided on the substrate.
26. The system of embodiment 24, in which the at least two electrodes and the at least two other electrodes are disposed in different chambers provided on the substrate.
27. The system of embodiment 23, in which the plurality of electrodes comprise two electrodes to measure the physical characteristic and the analyte concentration.

28. The system of one of embodiments 24, 25, 26 or 27, in which all of the electrodes are disposed on the same plane defined by the substrate.

29. The system of one of embodiments 24, 25, or 26 in which a reagent is disposed proximate the at least two other electrodes and no reagent is disposed on the at least two electrodes.

30. The system of embodiment 23, in which the batch slope is calculated from an equation of the form:

$$x = aH^2 + bH + c$$

where

x represents a derived batch slope from the deriving step;

H represents the measured or estimated physical characteristic of the sample;

a represents about  $1.4 \times 10^{-6}$ ,

b represents about  $-3.8 \times 10^{-4}$ ,

c represents about  $3.6 \times 10^{-2}$ .

31. The system of embodiment 30, in which analyte concentration is calculated from an equation of the form:

$$G_0 = \left[ \frac{I_E - \text{Intercept}}{x} \right]$$

where

$G_0$  represents an analyte concentration

$I_E$  represents, or is, a signal (value or measurement; proportional to analyte concentration) measured at a predetermined or specified sampling time;

Intercept represents a calibration parameter for a batch of test strips;

x represents a derived batch slope from the deriving step.

32. A method of demonstrating increased accuracy of a test strip, the method comprising: providing a batch of test strips;

introducing a referential sample containing a referential concentration of an analyte to each test strip of the batch of test strips to initiate a test sequence;  
reacting the analyte with a reagent on each test strip to cause a physical transformation of the analyte proximate the two electrodes;  
determining a physical characteristic of the referential sample;  
deriving a batch slope for the batch of test strips based on the determined physical characteristics of the referential sample;  
sampling an electrical output of the referential sample at a predetermined time point during the test sequence;  
calculating an analyte concentration based on the defined batch slope and sampled electrical output to provide for a final analyte concentration value for each test strip of the batch of test strips such that at least 95% of the final analyte concentration values of the batch of test strips are within  $\pm 15\%$  of the referential analyte concentration.

33. The method of embodiment 32, in which the determining comprises applying a first signal to the sample to measure a physical characteristic of the sample.

34. The method of embodiment 32 or embodiment 33, in which the sampling comprises driving a second signal to the sample.

35. The method of embodiment 34, in which the applying of the first signal and the driving of the second signal is in sequential order.

36. The method of embodiment 34, in which the applying of the first signal overlaps with the driving of the second signal.

37. The method of embodiment 34, in which the applying of the first signal comprises directing an alternating signal to the sample so that a physical characteristic of the sample is determined from an output of the alternating signal.

38. The method of embodiment 34, in which the applying of the first signal comprises directing an optical signal to the sample so that a physical characteristic of the sample is determined from an output of the optical signal.

39. The method of embodiment 37 or embodiment 38 in which the physical characteristic comprises hematocrit and the analyte comprises glucose.
40. The method of embodiment 37 or embodiment 38 in which the physical characteristic comprises at least one of viscosity, hematocrit, temperature density, temperature, or combinations thereof.
41. The method of embodiment 37, in which the directing comprises driving first and second alternating signal at different respective frequencies in which a first frequency is lower than the second frequency.
42. The method of embodiment 41, in which the first frequency is at least one order of magnitude lower than the second frequency.
43. The method of embodiment 42, in which the first frequency comprises any frequency in the range of about 10kHz to about 250kHz.
44. The method of embodiment 32, in which the deriving comprises calculating a batch slope from an equation of the form:

$$x = aH^2 + bH + c$$

where

- x represents a derived batch slope from the deriving step;
- H represents the determined or estimated physical characteristic of the sample;
- a represents about  $1.4 \times 10^{-6}$ ,
- b represents about  $-3.8 \times 10^{-4}$ ,
- c represents about  $3.6 \times 10^{-2}$ .

45. The method of embodiment 44, in which the calculating of the analyte concentration comprises utilizing an equation of the form:

$$G_0 = \left[ \frac{I_E - \text{Intercept}}{x} \right]$$

where

$G_0$  represents an analyte concentration

$I_E$  represents, or is, a signal (value or measurement; proportional to analyte concentration) measured at a predetermined or specified sampling time;

Intercept represents a calibration parameter for the batch of test strips;

$x$  represents a derived batch slope from the deriving step.

46. A method of determining an analyte concentration from a fluid sample, the method comprising:

depositing a fluid sample on a biosensor;

applying electrical signals to the sample to transform the analyte into a different material;

measuring or estimating a physical characteristic of the sample;

evaluating signal output from the sample;

deriving a parameter of the biosensor from the measured or estimated physical characteristic; and

determining an analyte concentration based on the derived parameter of the biosensor and the signal output of the sample.

47. The method of embodiment 46, in which the measuring comprises applying a first signal to the sample to measure a physical characteristic of the sample.

48. The method of embodiment 46 or embodiment 47, in which the evaluating comprises driving a second signal to the sample.

49. The method of embodiment 48, in which the applying of the first signal and the driving of the second signal is in sequential order.

50. The method of embodiment 48, in which the applying of the first signal overlaps with the driving of the second signal.

51. The method of embodiment 48, in which the applying of the first signal comprises

directing an alternating signal to the sample so that a physical characteristic of the sample is determined from an output of the alternating signal.

52. The method of embodiment 48, in which the measuring comprises directing an optical signal to the sample so that a physical characteristic of the sample is determined from an output of the optical signal.

53. The method of one of embodiment 51 or embodiment 52 in which the physical characteristic comprises hematocrit and the analyte comprises glucose.

54. The method of one of embodiment 51 or embodiment 52 in which the physical characteristic comprises at least one of viscosity, hematocrit, temperature and density or combinations thereof.

55. The method of embodiment 51, in which the directing comprises driving first and second alternating signal at different respective frequencies in which a first frequency is lower than the second frequency.

56. The method of embodiment 55, in which the first frequency is at least one order of magnitude lower than the second frequency.

57. The method of embodiment 56, in which the first frequency comprises any frequency in the range of about 10kHz to about 250kHz.

58. The method of embodiment 46, in which the deriving comprises calculating a batch slope from an equation of the form:

$$x = aH^2 + bH + c$$

where

x represents a derived batch slope from the deriving step;

H represents the measured or estimated physical characteristic of the sample;

a represents about  $1.4\text{e-}6$ ,

b represents about  $-3.8\text{e-}4$ ,

c represents about 3.6e-2.

59. The method of embodiment 57, in which the calculating of the analyte concentration comprises utilizing an equation of the form:

$$G_0 = \left[ \frac{I_E - \text{Intercept}}{x} \right]$$

where

$G_0$  represents an analyte concentration

$I_E$  represents, or is, a signal (value or measurement; proportional to analyte concentration) measured at a predetermined or specified sampling time;

Intercept represents a calibration parameter for a batch of test strips;

x represents a derived batch slope from the deriving step.

60. A method of determining an analyte concentration from a fluid sample with a biosensor having at least two electrodes and a reagent disposed on at least one electrode of the electrodes, the method comprising:

depositing a fluid sample on any one of the at least two electrodes to start an analyte test sequence;

applying a first signal to the sample to derive a physical characteristic of the sample;

obtaining a physical characteristic of the sample;

specifying a sampling time based on the obtained physical characteristic;

driving a second signal to the sample; and

measuring an output signal at the specified sampling time from at least one electrode of the at least two electrodes;

calculating an analyte concentration based on the measured output signal.

61. The method of embodiment 60, in which the applying of the first signal and the driving of the second signal is in sequential order.

62. The method of embodiment 60, in which the applying of the first signal overlaps with the driving of the second signal.

63. The method of embodiment 60, in which the applying of the first signal comprises directing an alternating signal to the sample so that a physical characteristic of the sample is determined from an output of the alternating signal.
64. The method of embodiment 60, in which the applying of the first signal comprises directing an optical signal to the sample so that a physical characteristic of the sample is determined from an output of the optical signal.
65. The method of one of embodiment 63 or embodiment 64 in which the physical characteristic comprises hematocrit and the analyte comprises glucose.
66. The method of embodiment 60, in which the physical characteristic comprises at least one of viscosity, hematocrit, temperature and density of the sample.
67. The method of embodiment 63, in which the directing comprises driving first and second alternating signal at different respective frequencies in which a first frequency is lower than the second frequency.
68. The method of embodiment 67, in which the first frequency is at least one order of magnitude lower than the second frequency.
69. The method of embodiment 68, in which the first frequency comprises any frequency in the range of about 10kHz to about 250kHz.
70. The method of embodiment 60, in which the biosensor is a test strip and the specified sampling time is calculated using an equation of the form:

$$\text{SpecifiedSamplingTime} = x_1 H^{x_2} + x_3$$

where

“*SpecifiedSamplingTime*” is designated as a time point from the start of the test sequence at which to sample the output signal of the test strip,

*H* represents the physical characteristic of the sample;

$x_1$  is about 4.3e5;

$x_2$  is about -3.9; and

$x_3$  is about 4.8.

71. The method of embodiment 70, in which the calculating of the analyte concentration is

computed with an equation of the form:  $G_0 = \left[ \frac{I_E - Intercept}{Slope} \right]$

where

$G_0$  represents an analyte concentration

$I_E$  represents a signal (proportional to analyte concentration) measured at the *SpecifiedSamplingTime*;

Slope represents the value obtained from calibration testing of a batch of test strips of which this particular strip comes from; and

Intercept represents the value obtained from calibration testing of a batch of test strips of which this particular strip comes from.

72. An analyte measurement system comprising:

a test strip including:

a substrate;

a plurality of electrodes connected to respective electrode connectors; and

an analyte meter including:

a housing;

a test strip port connector configured to connect to the respective electrode connectors of the test strip; and

a microprocessor in electrical communication with the test strip port connector to apply electrical signals or sense electrical signals from the plurality of electrodes during a test sequence,

the microprocessor is configured to, during the test sequence:

(a) apply a first signal to the plurality of electrodes so that a specific sampling time point determined from a physical characteristic of a fluid sample is derived,

(b) apply a second signal to the plurality of electrodes, and

(c) measure a signal output from one of the plurality of electrodes at the specified sampling time so that an analyte concentration is determined.

73. The system of embodiment 72, in which the plurality of electrodes comprises at least two electrodes to measure the physical characteristic and at least two other electrodes to measure the analyte concentration.

74. The system of embodiment 73, in which the at least two electrodes and the at least two other electrodes are disposed in the same chamber provided on the substrate.

75. The system of embodiment 73, in which the at least two electrodes and the at least two other electrodes are disposed in different chambers provided on the substrate.

76. The system of embodiment 72, in which the plurality of electrodes comprises two electrodes to measure the physical characteristic and the analyte concentration.

77. The system of one of embodiments 73, 74, 75, or 76 in which all of the electrodes are disposed on the same plane defined by the substrate.

78. The system of one of embodiments 73, 74, or 75 in which a reagent is disposed proximate the at least two other electrodes and no reagent is disposed on the at least two electrodes.

79. The system of embodiment 72, in which the specified sampling time is calculated using an equation of the form:

$$\text{SpecifiedSamplingTime} = x_1 H^{x_2} + x_3$$

where

“*SpecifiedSamplingTime*” is designated as a time point from the start of the test sequence at which to sample the output signal of the test strip,

*H* represents the physical characteristic of the sample;

$x_1$  represents about 4.3e5;

$x_2$  represents about -3.9; and

$x_3$  represents about 4.8.

80. The system of embodiment 79, in which the analyte concentration is determined from

an equation of the form:  $G_0 = \left[ \frac{I_E - Intercept}{Slope} \right]$

where

$G_0$  represents an analyte concentration

$I_E$  represents, or is, a signal (value or measurement; proportional to analyte concentration) measured at the *SpecifiedSamplingTime*;

Slope represents the value obtained from calibration testing of a batch of test strips of which this particular strip comes from; and

Intercept represents the value obtained from calibration testing of a batch of test strips of which this particular strip comes from.

81. An analyte measurement system comprising:

a test strip including:

a substrate;

a plurality of electrodes connected to respective electrode connectors; and

an analyte meter including:

a housing;

a test strip port connector configured to connect to the respective electrode connectors of the test strip; and

a microprocessor in electrical communication with the test strip port connector to apply electrical signals or sense electrical signals from the plurality of electrodes,

the microprocessor is configured to, during a test sequence:

(a) apply a first signal to the plurality of electrodes so that a specific sampling time point determined from a physical characteristic of a fluid sample is derived,

(b) apply a second signal to the plurality of electrodes, and

(c) measure a signal output from one of the plurality of electrodes at the specified sampling time so that an analyte concentration of the sample is determined based on the specified sampling time within about 10 seconds of a start of the test sequence.

82. The system of embodiment 81, in which the plurality of electrodes comprises at least

two electrodes to measure the physical characteristic and at least two other electrodes to measure the analyte concentration.

83. The system of embodiment 82, in which the at least two electrodes and the at least two other electrodes are disposed in the same chamber provided on the substrate.

84. The system of embodiment 82, in which the at least two electrodes and the at least two other electrodes are disposed in different chambers provided on the substrate.

85. The system of embodiment 81, in which the plurality of electrodes comprise two electrodes to measure the physical characteristic and the analyte concentration.

86. The system of one of embodiments 82, 83, 84, or 85, in which all of the electrodes are disposed on the same plane defined by the substrate.

87. The system of one of embodiments 82, 83 or 84 embodiment, in which a reagent is disposed proximate the at least two other electrodes and no reagent is disposed on the at least two electrodes.

88. The system of embodiment 81, in which the specified sampling time is calculated using an equation of the form:

$$\text{SpecifiedSamplingTime} = x_1 H^{x_2} + x_3$$

where

“*SpecifiedSamplingTime*” is designated as a time point from the start of the test sequence at which to sample the output signal of the test strip,

*H* represents the physical characteristic of the sample;

$x_1$  represents about 4.3e5;

$x_2$  represents about -3.9; and

$x_3$  represents about 4.8.

89. The system of embodiment 88, in which analyte concentration is calculated from an

equation of the form: 
$$G_0 = \left[ \frac{I_E - \text{Intercept}}{\text{Slope}} \right]$$

where

$G_0$  represents an analyte concentration

$I_E$  represents, or is, a signal (value or measurement; proportional to analyte concentration) measured at the *SpecifiedSamplingTime*;

Slope represents the value obtained from calibration testing of a batch of test strips of which this particular strip comes from; and

Intercept represents the value obtained from calibration testing of a batch of test strips of which this particular strip comes from.

90. A method of determining an analyte concentration from a fluid sample, the method comprising:

- depositing a fluid sample on a biosensor having a reagent deposited thereon;
- applying signals to the sample and the reagent to transform the analyte into a different material;
- obtaining a physical characteristic of the sample;
- specifying a time point for sampling of signal output based on the obtained physical characteristic;
- measuring signal output at the specified sampling time; and
- determining an analyte concentration based the measured signal output of the sample.

91. The method of embodiment 90, in which the applying comprises driving a second signal to the sample.

92. The method of embodiment 91, in which the obtaining comprises applying a first signal to the sample to derive a physical characteristic of the sample, and the applying of the first signal and the driving of the second signal is in sequential order.

93. The method of embodiment 91 in which the obtaining comprises applying a first signal to the sample to derive a physical characteristic of the sample, and the applying of the first signal overlaps with the driving of the second signal.

94. The method of embodiment 92 or embodiment 93, in which the applying of the first signal comprises directing an alternating signal to the sample so that a physical characteristic of the sample is determined from an output of the alternating signal.
95. The method of embodiment 92 or embodiment 93, in which the applying of the first signal comprises directing an optical signal to the sample so that a physical characteristic of the sample is determined from an output of the optical signal.
96. The method of embodiment 94 or embodiment 95 in which the physical characteristic comprises hematocrit and the analyte comprises glucose.
97. The method of embodiment 94 or embodiment 95 in which the physical characteristic comprises at least one of viscosity, hematocrit, temperature and density.
98. The method of embodiment 94, in which the directing comprises driving first and second alternating signal at different respective frequencies in which a first frequency is lower than the second frequency.
99. The method of embodiment 98, in which the first frequency is at least one order of magnitude lower than the second frequency.
100. The method of embodiment 99, in which the first frequency comprises any frequency in the range of about 10kHz to about 250kHz.
101. The method of embodiment 90, in which the specified sampling time is calculated using an equation of the form:

$$\text{SpecifiedSamplingTime} = x_1 H^{x_2} + x_3$$

where

“*SpecifiedSamplingTime*” is designated as a time point from the start of the test sequence at which to sample the output signal of the test strip,

*H* represents the physical characteristic of the sample;

$x_1$  represents about 4.3e5;

$x_2$  represents about -3.9; and

$x_3$  represents about 4.8.

102. The method of embodiment 101, in which the calculating of the analyte concentration

comprises utilizing an equation of the form:  $G_0 = \left[ \frac{I_E - \text{Intercept}}{\text{Slope}} \right]$

where

$G_0$  represents an analyte concentration

$I_E$  represents, or is, a signal (value or measurement; proportional to analyte concentration) measured at the *SpecifiedSamplingTime*;

Slope represents the value obtained from calibration testing of a batch of test strips of which this particular strip comes from; and

Intercept represents the value obtained from calibration testing of a batch of test strips of which this particular strip comes from.

103. A method of determining an analyte concentration from a fluid sample with a biosensor having at least two electrodes and a reagent disposed on at least one electrode of the electrodes, the method comprising:

depositing a fluid sample on any one of the at least two electrodes to start an analyte test sequence;

applying a first signal to the sample to derive a physical characteristic of the sample;

obtaining a physical characteristic of the sample;

specifying a sampling time based on the physical characteristic from the obtaining step;

deriving a batch slope for the biosensor based on the physical characteristic from the obtaining step;

driving a second signal to the sample; and

measuring an output signal at the specified sampling time from at least one electrode of the at least two electrodes;

calculating an analyte concentration based on the measured output signal at the specified sampling time and the derived batch slope.

104. The method of embodiment 103, in which the applying of the first signal and the driving of the second signal is in sequential order.

105. The method of embodiment 103, in which the applying of the first signal overlaps with the driving of the second signal.

106. The method of embodiment 103, in which the applying of the first signal comprises directing an alternating signal to the sample so that a physical characteristic of the sample is determined from an output of the alternating signal.

107. The method of embodiment 103, in which the applying of the first signal comprises directing an optical signal to the sample so that a physical characteristic of the sample is determined from an output of the optical signal.

108. The method of embodiment 106 or embodiment 107, in which the physical characteristic comprises hematocrit and the analyte comprises glucose.

109. The method of embodiment 103, in which the physical characteristic comprises at least one of viscosity, hematocrit, temperature and density of the sample.

110. The method of embodiment 106, in which the directing comprises driving first and second alternating signals at different respective frequencies in which a first frequency is lower than the second frequency.

111. The method of embodiment 110, in which the first frequency is at least one order of magnitude lower than the second frequency.

112. The method of embodiment 111, in which the first frequency comprises any frequency in the range of about 10kHz to about 250kHz.

113. The method of embodiment 103, in which the biosensor is a test strip and the specified sampling time is calculated using an equation of the form:

$$SpecifiedSamplingTime = x_1 H^{x_2} + x_3$$

where

“*SpecifiedSamplingTime*” is designated as a time point from the start of the test sequence at which to sample the output signal of the test strip,

*H represents the physical characteristic of the sample;*

*x<sub>1</sub> is about 4.3e5;*

*x<sub>2</sub> is about -3.9; and*

*x<sub>3</sub> is about 4.8.*

114. The method of embodiment 113, in which the derived slope is determined from an equation of the form:

$$NewSlope = aH^2 + bH + c$$

*where*

*NewSlope represents the derived slope;*

*H is measured or estimated physical characteristic;*

*a is about 1.35e-6,*

*b is about -3.79e-4,*

*c is about 3.56e-2.*

115. The method of embodiment 114, in which the calculating of the analyte concentration

is computed with an equation of the form:  $G_0 = \left[ \frac{I_E - Intercept}{NewSlope} \right]$

*where*

*G<sub>0</sub> represents an analyte concentration*

*I<sub>E</sub> represents a signal (proportional to analyte concentration) measured at the SpecifiedSamplingTime;*

*NewSlope represents the value derived from the measured or estimated physical characteristic; and*

*Intercept represents the value obtained from calibration testing of a batch of test strips of which this particular strip comes from.*

116. An analyte measurement system comprising:

a test strip including:

a substrate;

a plurality of electrodes connected to respective electrode connectors; and

an analyte meter including:

a housing;

a test strip port connector configured to connect to the respective electrode connectors of the test strip; and

a microprocessor in electrical communication with the test strip port connector to apply electrical signals or sense electrical signals from the plurality of electrodes during a test sequence,

the microprocessor is configured to, during the test sequence:

- (a) apply a first signal to the plurality of electrodes so that a specific sampling time point and a batch slope determined from a physical characteristic of a fluid sample are derived,
- (b) apply a second signal to the plurality of electrodes, and
- (c) measure a signal output from one of the plurality of electrodes at the specified sampling time so that an analyte concentration is determined based on the measured signal at the specified sampling time and the batch slope.

117. The system of embodiment 116, in which the plurality of electrodes comprises at least two electrodes to measure the physical characteristic and at least two other electrodes to measure the analyte concentration.

118. The system of embodiment 117, in which the at least two electrodes and the at least two other electrodes are disposed in the same chamber provided on the substrate.

119. The system of embodiment 117, in which the at least two electrodes and the at least two other electrodes are disposed in different chambers provided on the substrate.

120. The system of embodiment 116, in which the plurality of electrodes comprises two electrodes to measure the physical characteristic and the analyte concentration.

121. The system of one of embodiments 117, 118, 119, or 120, in which all of the electrodes are disposed on the same plane defined by the substrate.

122. The system of one of embodiments 117, 118 or 119, in which a reagent is disposed proximate the at least two other electrodes and no reagent is disposed on the at least two

electrodes.

123. The system of embodiment 116, in which the specified sampling time is calculated using an equation of the form:  $SpecifiedSamplingTime = x_1 H^{x_2} + x_3$

where

“*SpecifiedSamplingTime*” is designated as a time point from the start of the test sequence at which to sample the output signal of the test strip,  
*H* represents the physical characteristic of the sample;  
 $x_1$  represents about 4.3e5;  
 $x_2$  represents about -3.9; and  
 $x_3$  represents about 4.8.

124. The system of embodiment 123, in which the derived slope is determined from an equation of the form:

$$NewSlope = aH^2 + bH + c$$

where

*NewSlope* represents the derived slope;  
*H* is measured or estimated physical characteristic;  
*a* is about 1.35e-6,  
*b* is about -3.79e-4,  
*c* is about 3.56e-2.

125. The system of embodiment 124, in which the calculating of the analyte concentration is

computed with an equation of the form:  $G_0 = \left[ \frac{I_E - Intercept}{NewSlope} \right]$

where

$G_0$  represents an analyte concentration  
 $I_E$  represents a signal (proportional to analyte concentration) measured at the *SpecifiedSamplingTime*;  
*NewSlope* represents the value derived from the measured or estimated physical characteristic; and

Intercept represents the value obtained from calibration testing of a batch of test strips of which this particular strip comes from.

126. An analyte measurement system comprising:
- a test strip including:
    - a substrate;
    - a plurality of electrodes connected to respective electrode connectors; and
  - an analyte meter including:
    - a housing;
    - a test strip port connector configured to connect to the respective electrode connectors of the test strip; and
  - a microprocessor in electrical communication with the test strip port connector to apply electrical signals or sense electrical signals from the plurality of electrodes, the microprocessor is configured to, during a test sequence:
    - (a) apply a first signal to the plurality of electrodes so that a specific sampling time point and a batch slope of the test strip determined from a physical characteristic of a fluid sample are derived,
    - (b) apply a second signal to the plurality of electrodes, and
    - (c) measure a signal output from one of the plurality of electrodes at the specified sampling time so that an analyte concentration of the sample is determined based on the specified sampling time and batch slope within about 10 seconds of a start of the test sequence.

127. The system of embodiment 126, in which the plurality of electrodes comprises at least two electrodes to measure the physical characteristic and at least two other electrodes to measure the analyte concentration.

128. The system of embodiment 127, in which the at least two electrodes and the at least two other electrodes are disposed in the same chamber provided on the substrate.

129. The system of embodiment 127, in which the at least two electrodes and the at least two other electrodes are disposed in different chambers provided on the substrate.

130. The system of embodiment 126, in which the plurality of electrodes comprises two electrodes to measure the physical characteristic and the analyte concentration.

131. The system of one of embodiments 127, 128, 129, or 130, in which all of the electrodes are disposed on the same plane defined by the substrate.

132. The system of one of embodiments 127, 128 or 129, in which a reagent is disposed proximate the at least two other electrodes and no reagent is disposed on the at least two electrodes.

133. The system of embodiment 126, in which the specified sampling time is calculated using an equation of the form:  $SpecifiedSamplingTime = x_1 H^{x_2} + x_3$

where

*“SpecifiedSamplingTime”* is designated as a time point from the start of the test sequence at which to sample the output signal of the test strip,

*H* represents the physical characteristic of the sample;

$x_1$  represents about 4.3e5;

$x_2$  represents about -3.9; and

$x_3$  represents about 4.8.

134. The system of embodiment 133, in which the derived batch slope is determined from an equation of the form:

$$NewSlope = aH^2 + bH + c$$

where

*NewSlope* represents the derived slope;

*H* is measured or estimated physical characteristic;

*a* is about 1.35e-6,

*b* is about -3.79e-4,

*c* is about 3.56e-2.

135. The system of embodiment 134, in which the calculating of the analyte concentration is

computed with an equation of the form:  $G_0 = \left[ \frac{I_E - Intercept}{NewSlope} \right]$

where

$G_0$  represents an analyte concentration

$I_E$  represents a signal (proportional to analyte concentration) measured at the *SpecifiedSamplingTime*;

*NewSlope* represents the value derived from the measured or estimated physical characteristic; and

Intercept represents the value obtained from calibration testing of a batch of test strips of which this particular strip comes from.

136. A method of demonstrating increased accuracy of a test strip, the method comprising:
- providing a batch of test strips;
  - introducing a referential sample containing a referential concentration of an analyte to each test strip of the batch of test strips to initiate a test sequence;
  - reacting the analyte to cause a physical transformation of the analyte between the two electrodes;
  - determining a physical characteristic of the referential sample;
  - deriving a batch slope of the batch of test strips based on the determined physical characteristic;
  - sampling an electrical output of the referential sample at a specified sampling time during the test sequence defined by the measured or estimated physical characteristic;
  - calculating an analyte concentration based on the specified sampling time and the derived batch slope to provide for a final analyte concentration value for each test strip of the batch of test strips such that at least 95% of the final analyte concentration values of the batch of test strips are within  $\pm 15\%$  of the referential analyte concentration.

137. The method of embodiment 136, in which the reacting comprises driving a second signal to the sample and the determining comprises applying a first signal to the sample to derive a physical characteristic of the sample, and the applying of the first signal and the driving of the second signal is in sequential order.

138. The method of embodiment 136, in which the reacting comprises driving a second

signal to the sample and the determining comprises applying a first signal to the sample to derive a physical characteristic of the sample, and the applying of the first signal overlaps with the driving of the second signal.

139. The method of embodiment 137 or 138, in which the applying of the first signal comprises directing an alternating signal to the sample so that a physical characteristic of the sample is determined from an output of the alternating signal.

140. The method of embodiment 137 or embodiment 138, in which the applying of the first signal comprises directing an optical signal to the sample so that a physical characteristic of the sample is determined from an output of the optical signal.

141. The method of embodiment 139 or embodiment 140 in which the physical characteristic comprises hematocrit and the analyte comprises glucose.

142. The method of embodiment 139 or embodiment 140 in which the physical characteristic comprises at least one of viscosity, hematocrit, temperature and density.

143. The method of embodiment 139, in which the directing comprises driving first and second alternating signals at different respective frequencies in which a first frequency is lower than the second frequency.

144. The method of embodiment 143, in which the first frequency is at least one order of magnitude lower than the second frequency.

145. The method of embodiment 143, in which the first frequency comprises any frequency in the range of about 10kHz to about 250kHz.

146. The method of embodiment 136, in which the specified sampling time is calculated using an equation of the form:  $SpecifiedSamplingTime = x_1 H^{x_2} + x_3$

where

*SpecifiedSamplingTime* is designated as a time point from the start of the test sequence at which to sample the output signal of the test strip,

*H* represents the physical characteristic of the sample;

$x_1$  represents about 4.3e5;

$x_2$  represents about -3.9; and

$x_3$  represents about 4.8.

147. The method of embodiment 146, in which the derived slope is determined from an equation of the form:

$$NewSlope = aH^2 + bH + c$$

where

*NewSlope* represents the derived slope;

*H* is measured or estimated physical characteristic;

*a* is about 1.35e-6,

*b* is about -3.79e-4,

*c* is about 3.56e-2.

148. The method of embodiment 147, in which the calculating of the analyte concentration

is computed with an equation of the form:  $G_0 = \left[ \frac{I_E - Intercept}{NewSlope} \right]$

where

$G_0$  represents an analyte concentration

$I_E$  represents a signal (proportional to analyte concentration) measured at the *SpecifiedSamplingTime*;

*NewSlope* represents the value derived from the measured or estimated physical characteristic; and

Intercept represents the value obtained from calibration testing of a batch of test strips of which this particular strip comes from.

149. A method of determining an analyte concentration from a fluid sample, the method comprising:

depositing a fluid sample on a biosensor having a reagent deposited thereon;  
applying signals to the sample and the reagent to transform the analyte into a different material;  
obtaining a physical characteristic of the sample;  
specifying a time point for sampling of signal output based on the physical characteristic from the obtaining step;  
deriving a batch slope of the biosensor;  
measuring signal output at the specified sampling time; and  
determining an analyte concentration based on the measured signal output of the sample at the specified sampling time and the derived batch slope.

150. The method of embodiment 149, in which the applying comprises driving a second signal to the sample.

151. The method of embodiment 150, in which the obtaining comprises applying a first signal to the sample to derive a physical characteristic of the sample, and the applying of the first signal and the driving of the second signal is in sequential order.

152. The method of embodiment 150, in which the obtaining comprises applying a first signal to the sample to derive a physical characteristic of the sample, and the applying of the first signal overlaps with the driving of the second signal.

153. The method of embodiment 151 or embodiment 152, in which the applying of the first signal comprises directing an alternating signal to the sample so that a physical characteristic of the sample is determined from an output of the alternating signal.

154. The method of embodiment 151 or embodiment 152, in which the applying of the first signal comprises directing an optical signal to the sample so that a physical characteristic of the sample is determined from an output of the optical signal.

155. The method of embodiment 153 or embodiment 154 in which the physical characteristic comprises hematocrit and the analyte comprises glucose.

156. The method of embodiment 153 or embodiment 154 in which the physical characteristic comprises at least one of viscosity, hematocrit, temperature and density.

157. The method of embodiment 153, in which the directing comprises driving first and second alternating signals at different respective frequencies in which a first frequency is lower than the second frequency.

158. The method of embodiment 157, in which the first frequency is at least one order of magnitude lower than the second frequency.

159. The method of embodiment 158, in which the first frequency comprises any frequency in the range of about 10kHz to about 250kHz.

160. The method of embodiment 149, in which the biosensor is a test strip and the specified sampling time is calculated using an equation of the form:

$$\text{SpecifiedSamplingTime} = x_1 H^{x_2} + x_3$$

where

“*SpecifiedSamplingTime*” is designated as a time point from the start of the test sequence at which to sample the output signal of the test strip,

*H* represents the physical characteristic of the sample;

$x_1$  represents about 4.3e5;

$x_2$  represents about -3.9; and

$x_3$  represents about 4.8.

161. The method of embodiment 160, in which the derived slope is determined from an equation of the form:

$$\text{NewSlope} = aH^2 + bH + c$$

where

*NewSlope* represents the derived slope;

*H* is measured or estimated physical characteristic;

*a* is about 1.35e-6,

*b* is about -3.79e-4,

*c* is about 3.56e-2.

162. The method of embodiment 161, in which the calculating of the analyte concentration

is computed with an equation of the form: 
$$G_0 = \left[ \frac{I_E - Intercept}{NewSlope} \right]$$

where

$G_0$  represents an analyte concentration

$I_E$  represents a signal (proportional to analyte concentration) measured at the *SpecifiedSamplingTime*;

*NewSlope* represents the value derived from the measured or estimated physical characteristic; and

Intercept represents the value obtained from calibration testing of a batch of test strip of which this particular strip comes from.

163. The method or system of respective one of embodiments 114, 124, 134, 147, or 161, in which, instead of the values recited in the aforementioned embodiments,  $a$  is about  $-1.98e-6$ ;  $b$  is about  $-2.87e-5$ ; and  $c$  is about  $2.67e-2$ .

164. A method of determining an analyte concentration from a fluid sample with a biosensor having at least two electrodes and a reagent disposed on at least one of the electrodes, the method comprising:

depositing a fluid sample on any one of the at least two electrodes to start an analyte test sequence;

applying a first signal to the sample to measure a physical characteristic of the sample; driving a second signal to the sample to cause an enzymatic reaction of the analyte and the reagent;

estimating an analyte concentration based on a predetermined sampling time point from the start of the test sequence;

selecting a sampling time point from a look-up table having different qualitative categories of the estimated analyte and different qualitative categories of the measured or estimated physical characteristic indexed against different sampling time points;

measuring signal output from the sample at the selected sampling time point from the look-up table;

calculating an analyte concentration from measured output signal sampled at said

selected sampling time point in accordance with an equation of the form:

$$G_0 = \left[ \frac{I_T - \text{Intercept}}{\text{Slope}} \right]$$

where

$G_0$  represents an analyte concentration;

$I_T$  represents a signal (proportional to analyte concentration) measured at a selected sampling time  $T$ ;

Slope represents the value obtained from calibration testing of a batch of test strips of which this particular strip comes from; and

Intercept represents the value obtained from calibration testing of a batch of test strips of which this particular strip comes from.

165. A method of determining an analyte concentration from a fluid sample with a biosensor having at least two electrodes and a reagent disposed on at least one of the electrodes, the method comprising:

depositing a fluid sample on any one of the at least two electrodes to start an analyte test sequence;

applying a first signal to the sample to measure a physical characteristic of the sample; driving a second signal to the sample to cause an enzymatic reaction of the analyte and the reagent;

estimating an analyte concentration based on a predetermined sampling time point from the start of the test sequence;

selecting a sampling time point based on both the measured or estimated physical characteristic and the estimated analyte concentration;

measuring signal output from the sample at the selected sampling time point;

calculating an analyte concentration from measured output signal sampled at said selected sampling time point.

166. The method of embodiment 164 or embodiment 165, in which the applying of the first signal and the driving of the second signal is sequential.

167. The method of embodiment 164 or embodiment 165, in which the applying of the first signal overlaps with the driving of the second signal.

168. The method of embodiment 164 or embodiment 165, in which the applying of the first signal comprises directing an alternating signal to the sample so that a physical characteristic of the sample is determined from an output of the alternating signal.

169. The method of embodiment 168, in which the physical characteristic comprises hematocrit and the analyte comprises glucose.

170. The method of embodiment 168 embodiment in which the physical characteristic comprises at least one of viscosity, hematocrit, and density.

171. The method of embodiment 168, in which the directing comprises driving first and second alternating signal at different respective frequencies in which a first frequency is lower than the second frequency.

172. The method of embodiment 171, in which the first frequency is at least one order of magnitude lower than the second frequency.

173. The method of embodiment 171, in which the first frequency comprises any frequency in the range of about 10kHz to about 250kHz.

174. The method of embodiment 164 or embodiment 165, in which the measuring comprises sampling the signal output continuously at the start of the test sequence until at least about 10 seconds after the start.

175. The method of embodiment 165, in which the predetermined time comprises any time point less than ten seconds from the start of the test sequence.

176. The method of embodiment 165, in which the predetermined time comprises about 2.5 seconds from the start of the test sequence.

177. The method of embodiment 175, in which the estimating comprises comparing the estimated analyte concentration and the measured or estimated physical characteristic against a

look-up table having different respective ranges of analyte concentration and physical characteristic of the sample indexed against different sample measurement times so that the point in time for measurement of the output from the sample of the second signal is obtained for the calculating step.

178. The method of embodiment 165, in which the calculating step comprises utilizing an equation of the form:

$$G_0 = \left[ \frac{I_T - \text{Intercept}}{\text{Slope}} \right]$$

where

$G_0$  represents an analyte concentration;

$I_T$  represents a signal (proportional to analyte concentration) measured at a specified sampling time  $T$ ;

Slope represents the value obtained from calibration testing of a batch of test strips of which this particular strip comes from; and

Intercept represents the value obtained from calibration testing of a batch of test strips of which this particular strip comes from.

179. An analyte measurement system comprising:

a test strip including:

a substrate;

a plurality of electrodes connected to respective electrode connectors; and

an analyte meter including:

a housing;

a test strip port connector configured to connect to the respective electrode connectors of the test strip; and

a microprocessor in electrical communication with the test strip port connector to apply electrical signals or sense electrical signals from the plurality of electrodes,

the microprocessor is configured to:

(a) apply a first signal to the plurality of electrodes so that a physical characteristic of a fluid sample is determined;

(b) estimate an analyte concentration based on a predetermined sampling time

point during a test sequence; and

(c) apply a second signal to the plurality of electrodes at a sampling time point during the test sequence dictated by the determined physical characteristic so that an analyte concentration is calculated from the second signal.

180. The system of embodiment 179, in which the plurality of electrodes comprises at least two electrodes to measure the physical characteristic and at least two other electrodes to measure the analyte concentration.

181. The system of embodiment 180, in which the at least two electrodes and the at least two other electrodes are disposed in the same chamber provided on the substrate.

182. The system of embodiment 180, in which the at least two electrodes and the at least two other electrodes are disposed in different chambers provided on the substrate.

183. The system of embodiment 181 or embodiment 182, in which all of the electrodes are disposed on the same plane defined by the substrate.

184. The system of embodiment 181 or embodiment 182, in which a reagent is disposed proximate the at least two other electrodes and no reagent is disposed on the at least two electrodes.

185. An analyte measurement system comprising:

a test strip including:

a substrate;

a plurality of electrodes connected to respective electrode connectors; and

an analyte meter including:

a housing;

a test strip port connector configured to connect to the respective electrode connectors of the test strip; and

a microprocessor in electrical communication with the test strip port connector to apply electrical signals or sense electrical signals from the plurality of electrodes,

the microprocessor is configured to:

- (a) apply a first signal to the plurality of electrodes so that a physical characteristic of a fluid sample is determined during a test sequence;
- (b) estimate an analyte concentration based on a predetermined sampling time point during a test sequence; and
- (c) apply a second signal to the plurality of electrodes at a sampling time point during the test sequence dictated by the determined physical characteristic so that so that an analyte concentration is determined from the second signal within about 10 seconds of a start of the test sequence.

186. The system of embodiment 185, in which the plurality of electrodes comprises at least two electrodes to measure the physical characteristic and at least two other electrodes to measure the analyte concentration.

187. The system of embodiment 185, in which the at least two electrodes and the at least two other electrodes are disposed in the same chamber provided on the substrate.

188. The system of embodiment 185, in which the at least two electrodes and the at least two other electrodes are disposed in different chambers provided on the substrate.

189. The system of embodiment 187 or embodiment 188, in which all of the electrodes are disposed on the same plane defined by the substrate.

190. The system of embodiment 187 or embodiment 188, in which a reagent is disposed proximate the at least two other electrodes and no reagent is disposed on the at least two electrodes.

191. A method of demonstrating increased accuracy of a test strip, the method comprising:  
 providing a batch of test strips;  
 introducing a referential sample containing a referential concentration of an analyte to each test strip of the batch of test strips to start a test sequence;  
 reacting the analyte with reagent disposed on each of the test strips to cause a physical transformation of the analyte proximate the two electrodes;

estimating an analyte concentration based on a measured signal output of the sample at a predetermined time point from the start of the test sequence;  
determining a physical characteristic of the referential sample;  
sampling an electrical output of the referential sample at a dictated time point during the test sequence defined by the measured or estimated physical characteristic and the estimated analyte concentration;  
calculating an analyte concentration based on the dictated time point to provide for a final analyte concentration value for each test strip of the batch of test strips such that at least 95% of the final analyte concentration values of the batch of test strips are within  $\pm 10\%$  of the referential analyte concentration for a range of hematocrit of the sample from about 30% to about 55%.

192. The method of embodiment 191, in which the determining comprises applying a first signal to the sample to measure a physical characteristic of the sample.

193. The method of embodiment 191 or embodiment 192, in which the reacting comprises driving a second signal to the sample.

194. The method of embodiment 193, in which the applying of the first signal and the driving of the second signal is sequential.

195. The method of embodiment 193, in which the applying of the first signal overlaps with the driving of the second signal.

196. The method of embodiment 192 or embodiment 193, in which the applying of the first signal comprises directing an alternating signal to the sample so that a physical characteristic of the sample is determined from an output of the alternating signal.

197. The method of embodiment 189, in which the applying of the first signal comprises directing an electromagnetic signal to the sample so that a physical characteristic of the sample is determined from an output of the electromagnetic signal.

198. The method of embodiment 196 or embodiment 197, in which the physical

characteristic comprises hematocrit and the analyte comprises glucose.

199. The method of embodiment 196 or embodiment 197, in which the physical characteristic comprises at least one of viscosity, hematocrit, temperature and density.

200. The method of embodiment 196, in which the directing comprises driving first and second alternating signal at different respective frequencies in which a first frequency is lower than the second frequency.

201. The method of embodiment 200, in which the first frequency is at least one order of magnitude lower than the second frequency.

202. The method of embodiment 201, in which the first frequency comprises any frequency in the range of about 10kHz to about 250kHz.

203. The method of embodiment 191, in which the sampling comprises sampling the signal output continuously at the start of the test sequence until at least about 10 seconds after the start.

204. The method of embodiment 191, in which the predetermined time comprises any time point less than 10 seconds from the start of the test sequence.

205. The method of embodiment 204, in which the estimating comprises comparing the estimated analyte concentration and the measured or estimated physical characteristic against a look-up table having different respective ranges of analyte concentration and physical characteristic of the sample indexed against different sample measurement times so that the point in time for measurement of the output from the sample of the second signal is obtained for the calculating step.

206. A method of determining an analyte concentration from a fluid sample, the method comprising:

depositing a fluid sample on a biosensor to start a test sequence;

causing the analyte in the sample to undergo an enzymatic reaction;

estimating an analyte concentration in the sample;  
measuring at least one physical characteristic of the sample;  
defining a time point from the start of the test sequence to sample output signals of the biosensor based on the estimated analyte concentration and at least one physical characteristic from the measuring step;  
sampling output signals of the biosensor at the defined time point;  
determining an analyte concentration from sampled signals at the defined time point.

207. The method of embodiment 206, in which the measuring comprises applying a first signal to the sample to measure a physical characteristic of the sample; the causing step comprises driving a second signal to the sample; the sampling comprises evaluating an output signal from at least two electrodes of the biosensor at a point in time after the start of the test sequence, in which the point in time is set as a function of at least the measured or estimated physical characteristic; and the determining step comprises calculating an analyte concentration from the measured output signal at said point in time.

208. The method of embodiment 207, in which the applying of the first signal and the driving of the second signal is sequential.

209. The method of embodiment 207, in which the applying of the first signal overlaps with the driving of the second signal.

210. The method of embodiment 207, in which the applying of the first signal comprises directing an alternating signal to the sample so that a physical characteristic of the sample is determined from an output of the alternating signal.

211. The method of embodiment 206, further comprising estimating an analyte concentration based on a predetermined sampling time point from the start of the test sequence.

212. The method of embodiment 211, in which the defining comprises selecting a defined time point based on both the measured or estimated physical characteristic and the estimated analyte concentration.

213. The method of embodiment 210 or embodiment 211 in which the physical characteristic comprises hematocrit and the analyte comprises glucose.
214. The method of embodiment 209 or embodiment 210 in which the physical characteristic comprises at least one of viscosity, hematocrit, temperature and density.
215. The method of embodiment 210, in which the directing comprises driving first and second alternating signal at different respective frequencies in which a first frequency is lower than the second frequency.
216. The method of embodiment 215, in which the first frequency is at least one order of magnitude lower than the second frequency.
217. The method of embodiment 216, in which the first frequency comprises any frequency in the range of about 10kHz to about 250kHz.
218. The method of embodiment 206, in which the sampling comprises sampling the signal output continuously at the start of the test sequence until at least about 10 seconds after the start.
219. The method of embodiment 218, further comprising estimating an analyte concentration based on a measurement of the output signal at a predetermined time.
220. The method of embodiment 219, in which the estimating comprises comparing the estimated analyte concentration and the measured or estimated physical characteristic against a look-up table having different respective ranges of analyte concentration and physical characteristic of the sample indexed against different sample measurement times so that the point in time for sampling the output from the sample of the second signal is obtained for the calculating step.
221. The method or system of any one of embodiments 164 to 220, in which the sampling time point is selected from a look-up table that includes a matrix in which different qualitative categories of the estimated analyte are set forth in the leftmost column of the matrix and

different qualitative categories of the measured or estimated physical characteristic are set forth in the topmost row of the matrix and the sampling times are provided in the remaining cells of the matrix.

222. The method or system of any one of the embodiments from 1-221, in which the physical characteristic represented by H is generally equal to an impedance characteristic determined by an equation of the form:

$$IC = M^2 * y_1 + M * y_2 + y_3 + P^2 * y_4 + P * y_5$$

where:

- IC represents an impedance characteristic;
- M represents a magnitude  $|Z|$  of a measured impedance in ohms);
- P represents a phase difference between the input and output signals (in degrees)
- $y_1$  is about  $-3.2e-08$ ;
- $y_2$  is about  $4.1e-03$ ;
- $y_3$  is about  $-2.5e+01$ ;
- $y_4$  is about  $1.5e-01$ ; and
- $y_5$  is about  $5.0$ .

223. The method or system of any one of the embodiments from 1-221, in which the physical characteristic represented by H is generally equal to an impedance characteristic determined by an equation of the form:

$$IC = \frac{-y_2 + \sqrt{y_2^2 - (4y_3(y_1 - M))}}{2y_1}$$

where:

IC represents the Impedance Characteristic [%]

M represents the magnitude of impedance [Ohm]

$y_1$  is about  $1.2292e1$

$y_2$  is about  $-4.3431e2$

$y_3$  is about  $3.5260e4$ .

224. A glucose test strip comprising:

a substrate;

a plurality of electrodes disposed on the substrate and connected to respective electrode connectors;

at least a reagent disposed on at least one of the plurality of electrodes, wherein at least one of the electrodes is configured to sense a physical characteristic of fluid sample deposited on the at least one electrode and at least another of the electrodes is configured to measure output signal from the sample upon application of input signal to the sample; and

instructions for use with a glucose meter, the instructions including indicia to a user to insert the electrode connectors of the test strip to a test strip port of the glucose meter, wherein the meter includes a test strip port connector configured to connect to respective electrode connectors of a test strip, and a microprocessor in electrical communication with the test strip port connector to apply electrical signals or sense electrical signals from a plurality of electrodes of the test strip connected to the respective electrode connectors of the test strip during a test sequence, the instructions further including indicia to the user to deposit a fluid sample proximate at least one of the plurality of electrodes so that the microprocessor is operable to: (a) apply a first signal to the plurality of electrodes so that a physical characteristic of a fluid sample deposited on the plurality of electrodes is determined; (b) estimate an analyte concentration based on a predetermined sampling time point during a test sequence; and (c) apply a second signal to the plurality of electrodes at a sampling time point during the test sequence dictated by the determined physical characteristic so that an analyte concentration is calculated from the second signal.

225. A glucose test strip comprising:

a substrate;

a plurality of electrodes disposed on the substrate and connected to respective electrode connectors;

at least a reagent disposed on at least one of the plurality of electrodes, wherein at least

one of the electrodes is configured to sense a physical characteristic of fluid sample deposited on the at least one electrode and at least another of the electrodes is configured to measure output signal from the sample upon application of input signal to the sample; and

instructions for use with a glucose meter, the instructions including indicia to a user to insert the electrode connectors of the test strip to a test strip port of the glucose meter, wherein the meter includes a test strip port connector configured to connect to respective electrode connectors of a test strip, and a microprocessor in electrical communication with the test strip port connector to apply electrical signals or sense electrical signals from a plurality of electrodes of the test strip connected to the respective electrode connectors of the test strip during a test sequence, the instructions further including indicia to the user to deposit a fluid sample proximate at least one of the plurality of electrodes so that the microprocessor is operable to: (a) apply a first signal to the plurality of electrodes so that a specific sampling time determined from a physical characteristic of a fluid sample is derived, (b) apply a second signal to the plurality of electrodes, and (c) measure a signal output from one of the plurality of electrodes at the specified sampling time so that an analyte concentration is determined.

226. A glucose test strip comprising:

a substrate;

a plurality of electrodes disposed on the substrate and connected to respective electrode connectors;

at least a reagent disposed on at least one of the plurality of electrodes, wherein at least one of the electrodes is configured to sense a physical characteristic of fluid sample deposited on the at least one electrode and at least another of the electrodes is configured to measure output signal from the sample upon application of input signal to the sample; and

instructions for use with a glucose meter, the instructions including indicia to a user to insert the electrode connectors of the test strip to a test strip port of the glucose meter, wherein the meter includes a test strip port connector configured to connect to respective electrode connectors of a test strip, and a microprocessor in electrical communication with the test strip port connector to apply electrical signals or sense electrical signals from a plurality of electrodes of the test strip connected to the respective electrode connectors of the test strip during a test sequence, the instructions further including indicia to the user to deposit a fluid sample proximate at least one of the plurality of electrodes so that the microprocessor is operable to: (a) apply a first signal to the plurality of electrodes so that a specific sampling time

point and a batch slope determined from a physical characteristic of a fluid sample are derived, (b) apply a second signal to the plurality of electrodes, and (c) measure a signal output from one of the plurality of electrodes at the specified sampling time so that an analyte concentration is determined based on the measured signal at the specified sampling time and the batch slope.

227. A glucose test strip comprising:

a substrate;

a plurality of electrodes disposed on the substrate and connected to respective electrode connectors;

at least a reagent disposed on at least one of the plurality of electrodes, wherein at least one of the electrodes is configured to sense a physical characteristic of fluid sample deposited on the at least one electrode and at least another of the electrodes is configured to measure output signal from the sample upon application of input signal to the sample; and

instructions for use with a glucose meter, the instructions including indicia to a user to insert the electrode connectors of the test strip to a test strip port of the glucose meter, wherein the meter includes a test strip port connector configured to connect to respective electrode connectors of a test strip, and a microprocessor in electrical communication with the test strip port connector to apply electrical signals or sense electrical signals from a plurality of electrodes of the test strip connected to the respective electrode connectors of the test strip during a test sequence, the instructions further including indicia to the user to deposit a fluid sample proximate at least one of the plurality of electrodes so that the microprocessor is operable to: (a) apply a first signal to the plurality of electrodes so that a batch slope defined by a physical characteristic of a fluid sample is derived, and (b) apply a second signal to the plurality of electrodes so that an analyte concentration is determined based on the derived batch slope.

## ADDITIONAL ASPECTS OF THE DISCLOSURE

### Section “A”

The following aspects form part of the present disclosure:

1. A method of determining an analyte concentration from a physiological sample with a biosensor having at least two electrodes and a reagent disposed on at least one of the electrodes, the method comprising:

depositing a physiological sample on the at least two electrodes to start an analyte test sequence;

applying a first electrical signal to the sample to measure a physical characteristic of the sample;

deriving a batch slope for the reagent based on the measured physical characteristic from an equation of the form:

$$x = aH^2 + bH + c$$

where  $x$  represents a derived batch slope;

$H$  is measured or estimated hematocrit;

$a$  represents about  $1.4\text{e-}6$ ,

$b$  represents about  $-3.8\text{e-}4$ ,

$c$  represents about  $3.6\text{e-}2$ ;

driving a second electrical signal to the sample; and

measuring an output current from at least one of the at least two electrodes;

calculating an analyte concentration based on the measured output current and derived batch slope with an equation of the form:

$$G_0 = \left[ \frac{I_E - \text{Intercept}}{x} \right]$$

where

$G_0$  represents an analyte concentration

$I_E$  represents a current (proportional to analyte concentration) determined from the sum of the end currents measured at a predetermined time;

Intercept represents calibration parameter for a batch of biosensors;

$x$  represents a derived batch slope from the deriving step.

2. A method of determining an analyte concentration from a physiological sample with a biosensor having at least two electrodes and a reagent disposed on at least one of the electrodes, the method comprising:

depositing a physiological sample on the at least two electrodes to start an analyte test sequence;

applying a first electrical signal to the sample to measure a physical characteristic of the sample;

deriving a batch slope for the reagent based on the measured physical characteristic;

driving a second electrical signal to the sample; and

measuring an output current from at least one of the at least two electrodes;

calculating an analyte concentration based on the measured output current and derived batch slope from the measured physical characteristic of the sample.

3. The method of aspect A1 or aspect A2, in which the applying of the first signal and the driving of the second signal is in sequential order.

4. The method of aspect A1 or aspect A2, in which the applying of the first signal overlaps with the driving of the second signal.

5. The method of aspect A1 or aspect A2, in which the applying of the first signal comprises directing an alternating signal to the sample so that a physical characteristic of the sample is determined from an output of the alternating signal.

6. The method of aspect A1 or aspect A2, in which the applying of the first signal comprises directing an optical signal to the sample so that a physical characteristic of the sample is determined from an output of the optical signal.

7. The method of one of aspect A5 or aspect A6, in which the physical characteristic comprises hematocrit and the analyte comprises glucose.

8. The method of one of aspect A5 or aspect A6, in which the physical characteristic comprises at least one of viscosity, hematocrit, and density of the sample.
9. The method of aspect A5, in which the directing comprises driving first and second alternating signal at different respective frequencies in which a first frequency is lower than the second frequency.
10. The method of aspect A9, in which the first frequency is at least one order of magnitude lower than the second frequency.
11. The method of aspect A10, in which the first frequency comprises any frequency in the range of about 10kHz to about 90kHz.
12. The method of aspect A2, in which the deriving comprises calculating a batch slope from an equation of the form:

$$x = aH^2 + bH + c$$

where x represents a derived batch slope from the deriving step;

H is measured or estimated hematocrit; a represents about  $1.4 \times 10^{-6}$ , b represents about  $3.8 \times 10^{-4}$ , c represents about  $3.6 \times 10^{-2}$ .

13. The method of aspect A12, in which the calculating of the analyte concentration comprises utilizing an equation of the form:

$$G_0 = \left[ \frac{I_E - \text{Intercept}}{x} \right]$$

where

$G_0$  represents an analyte concentration

$I_E$  represents a current (proportional to analyte concentration) determined from the sum of the end currents measured at a predetermined time of about 5 seconds after a start of the test sequence;

Intercept represents calibration parameter for a batch of biosensors;

x represents a derived batch slope from the deriving step.

14. An analyte measurement system comprising:

a test strip including:

a substrate;

a plurality of electrodes connected to respective electrode connectors; and

an analyte meter including:

a housing;

a test strip port connector configured to connect to the respective electrode connectors of the test strip; and

a microprocessor in electrical communication with the test strip port connector to apply electrical signals or sense electrical signals from the plurality of electrodes during a test sequence, the microprocessor is configured to, during the test sequence, (a) apply a first electrical signal to the plurality of electrodes so that batch slope defined by a physical characteristic of a physiological fluid sample is derived and (b) apply a second electrical signal to the plurality of electrodes so that an analyte concentration is determined based on the derived batch slope.

15. The system of aspect A14, in which the plurality of electrodes comprises at least two electrodes to measure the physical characteristic and at least two other electrodes to measure the analyte concentration.

16. The system of aspect A14, in which the at least two electrodes and the at least two other electrodes are disposed in the same chamber provided on the substrate.

17. The system of aspect A14, in which the at least two electrodes and the at least two other electrodes are disposed in different chambers provided on the substrate.

18. The system of aspect A14, in which the at least two electrodes comprise two electrodes to measure the physical characteristic and the analyte concentration.

19. The system of one of aspects A16, A17, or A18, in which all of the electrodes are disposed on the same plane defined by the substrate.

20. The system of one of aspect A17 or aspect A18, in which a reagent is disposed proximate on the at least two other electrodes and no reagent is disposed on the at least two electrodes.

21. The system of aspect A14, in which the batch slope is calculated from an equation of the form:

$$x = aH^2 + bH + c$$

where x represents a derived batch slope from the deriving step;

H represents measured or estimated hematocrit; a represents about  $1.4\text{e-}6$ , b represents about  $-3.8\text{e-}4$ , c represents about  $3.6\text{e-}2$ .

22. The system of aspect A21, in which the analyte concentration is determined from an equation of the form:

$$G_0 = \left[ \frac{I_E - \text{Intercept}}{x} \right]$$

where

$G_0$  represents an analyte concentration

$I_E$  represents a current (proportional to analyte concentration) determined from the sum of the end currents measured at a predetermined time;

Intercept represents calibration parameter for a batch of test strips;

x represents a derived batch slope from the deriving step.

23. An analyte measurement system comprising:

a test strip including:

a substrate;

a plurality of electrodes connected to respective electrode connectors; and

an analyte meter including:

a housing;

a test strip port connector configured to connect to the respective electrode

connectors of the test strip; and

a microprocessor in electrical communication with the test strip port connector to apply electrical signals or sense electrical signals from the plurality of electrodes, the microprocessor is configured to, during a test sequence: (a) apply a first electrical signal to the plurality of electrodes so that batch slope defined by a physical characteristic of a physiological fluid sample is derived and (b) apply a second electrical signal to the plurality of electrodes so that an analyte concentration is determined based on the derived batch slope obtained from the physical characteristic of the sample within about 10 seconds of a start of the test sequence.

24. The system of aspect A23, in which the plurality of electrodes comprises at least two electrodes to measure the physical characteristic and at least two other electrodes to measure the analyte concentration.
25. The system of aspect A23, in which the at least two electrodes and the at least two other electrodes are disposed in the same chamber provided on the substrate.
26. The system of aspect A23, in which the at least two electrodes and the at least two other electrodes are disposed in different chambers provided on the substrate.
27. The system of aspect A23, in which the at least two electrodes comprise two electrodes to measure the physical characteristic and the analyte concentration.
28. The system of one of aspects A24, A25, or A26, in which all of the electrodes are disposed on the same plane defined by the substrate.
29. The system of one of aspect A23 or aspect A24, in which a reagent is disposed proximate on the at least two other electrodes and no reagent is disposed on the at least two electrodes.
30. The system of aspect A23, in which the batch slope is calculated from an equation of the form:

$$x = aH^2 + bH + c$$

where x represents a derived batch slope from the deriving step;

H represents measured or estimated hematocrit; a represents about  $1.4 \times 10^{-6}$ , b represents about  $-3.8 \times 10^{-4}$ , c represents about  $3.6 \times 10^{-2}$ .

31. The system of aspect A30, in which analyte concentration is calculated from an equation of the form:

$$G_0 = \left[ \frac{I_E - \text{Intercept}}{x} \right]$$

where

$G_0$  represents an analyte concentration

$I_E$  represents a current (proportional to analyte concentration) determined from the sum of the end currents measured at a predetermined time;

Intercept represents calibration parameter for a batch of test strips;

x represents a derived batch slope from the deriving step.

32. A method of obtaining increased accuracy of a test strip, the method comprising:
- providing for a batch of test strips;
  - introducing a referential sample containing a referential concentration of an analyte to each of the batch of test strips to initiate a test sequence;
  - reacting the analyte with a reagent on the test strip to cause a physical transformation of the analyte between the two electrodes;
  - determining a physical characteristic of the referential sample;
  - deriving a batch slope for the batch of test strips based on the determined physical characteristics of the referential sample;
  - sampling an electrical output of the referential sample at a predetermined time point during the test sequence;

calculating an analyte concentration based on the defined batch slope and sampled electrical output to provide for a final analyte concentration value for each of the batch of test strips such that at least 95% of the final analyte concentration values of the batch of test strips are within  $\pm 15\%$  of the referential analyte concentration.

33. The method of aspect A32, in which the applying of the first signal and the driving of the second signal is in sequential order.
34. The method of aspect A32, in which the applying of the first signal overlaps with the driving of the second signal.
35. The method of aspect A32, in which the applying of the first signal comprises directing an alternating signal to the sample so that a physical characteristic of the sample is determined from an output of the alternating signal.
36. The method of aspect A32, in which the applying of the first signal comprises directing an optical signal to the sample so that a physical characteristic of the sample is determined from an output of the optical signal.
37. The method of one of aspect A35 or aspect A36 in which the physical characteristic comprises hematocrit and the analyte comprises glucose.
38. The method of one of aspect A35 or aspect A36 in which the physical characteristic comprises at least one of viscosity, hematocrit, and density.
39. The method of aspect A34, in which the directing comprises driving first and second alternating signal at different respective frequencies in which a first frequency is lower than the second frequency.
40. The method of aspect A39, in which the first frequency is at least one order of magnitude lower than the second frequency.
41. The method of aspect A40, in which the first frequency comprises any frequency in the

range of about 10kHz to about 90kHz.

42. The method of aspect A32, in which the deriving comprises calculating a batch slope from an equation of the form:

$$x = aH^2 + bH + c$$

where x represents a derived batch slope from the deriving step;

H represents measured or estimated hematocrit; a represents about  $1.4 \times 10^{-6}$ , b represents about  $-3.8 \times 10^{-4}$ , c represents about  $3.6 \times 10^{-2}$ .

43. The method of aspect A42, in which the calculating of the analyte concentration comprises utilizing an equation of the form:

$$G_0 = \left[ \frac{I_E - \text{Intercept}}{x} \right]$$

where

$G_0$  represents an analyte concentration

$I_E$  represents a current (proportional to analyte concentration) determined from the sum of the end currents measured at a predetermined time;

Intercept represents calibration parameter for a batch of test strips;

x represents a derived batch slope from the deriving step.

44. A method of determining an analyte concentration from a physiological sample, the method comprising:

depositing a physiological sample on a biosensor;

applying electrical signals to the sample to transform the analyte into a different material;

measuring a physical characteristic of the sample;

evaluating signal output from the sample;

deriving a parameter of the biosensor from the measured physical characteristic; and

determining an analyte concentration based on the derived parameter of the biosensor and the signal output of the sample.

45. The method of aspect A44, in which the measuring comprises applying a first electrical signal to the sample to measure a physical characteristic of the sample.

46. The method of aspect A44, in which the evaluating comprises driving a second electrical signal to the sample.

47. The method of aspect A46, in which the applying of the first signal and the driving of the second signal is in sequential order.

48. The method of aspect A46, in which the applying of the first signal overlaps with the driving of the second signal.

49. The method of aspect A46, in which the applying of the first signal comprises directing an alternating signal to the sample so that a physical characteristic of the sample is determined from an output of the alternating signal.

50. The method of aspect A44, in which the applying of the first signal comprises directing an optical signal to the sample so that a physical characteristic of the sample is determined from an output of the optical signal.

51. The method of one of aspect A49 or aspect A50 in which the physical characteristic comprises hematocrit and the analyte comprises glucose.

52. The method of one of aspect A49 or aspect A50 in which the physical characteristic comprises at least one of viscosity, hematocrit, and density.

53. The method of aspect A49, in which the directing comprises driving first and second alternating signal at different respective frequencies in which a first frequency is lower than the second frequency.

54. The method of aspect A53, in which the first frequency is at least one order of magnitude lower than the second frequency.
55. The method of aspect A54, in which the first frequency comprises any frequency in the range of about 10kHz to about 90kHz.
56. The method of aspect A44, in which the deriving comprises calculating a batch slope from an equation of the form:

$$x = aH^2 + bH + c$$

where x represents a derived batch slope from the deriving step;  
H represents measured or estimated hematocrit; a represents about 1.4e-6, b represents about -3.8e-4, c represents about 3.6e-2.

57. The method of aspect A56, in which the calculating of the analyte concentration comprises utilizing an equation of the form:

$$G_0 = \left[ \frac{I_E - \text{Intercept}}{x} \right]$$

where

$G_0$  represents an analyte concentration  
 $I_E$  represents a current (proportional to analyte concentration) determined from the sum of the end currents measured at a predetermined time;  
Intercept represents calibration parameter for a batch of test strips;  
x represents a derived batch slope from the deriving step.

## Section "B"

The following aspects form part of the present disclosure:

1. A method of determining an analyte concentration from a physiological sample with a biosensor having at least two electrodes and a reagent disposed on at least one electrode of the electrodes, the method comprising:
  - depositing a physiological sample on the at least two electrodes to start an analyte test sequence;
  - applying a first electrical signal to the sample to derive a physical characteristic of the sample;
  - obtaining a physical characteristic of the sample;
  - specifying a sampling time based on the obtained physical characteristic;
  - driving a second electrical signal to the sample; and
  - measuring an output current at the specified sampling time from at least one electrode of the at least two electrodes;
  - calculating an analyte concentration based on the measured output current.
2. The method of aspect B1, in which the applying of the first signal and the driving of the second signal is in sequential order.
3. The method of aspect B1, in which the applying of the first signal overlaps with the driving of the second signal.
4. The method of aspect B1, in which the applying of the first signal comprises directing an alternating signal to the sample so that a physical characteristic of the sample is determined from an output of the alternating signal.
5. The method of aspect B1, in which the applying of the first signal comprises directing an optical signal to the sample so that a physical characteristic of the sample is determined from an output of the optical signal.
6. The method of one of aspect B4 or aspect B5 in which the physical characteristic comprises hematocrit and the analyte comprises glucose.

7. The method of aspect B1, in which the physical characteristic comprises at least one of viscosity, hematocrit, and density of the sample.
8. The method of aspect B4, in which the directing comprises driving first and second alternating signal at different respective frequencies in which a first frequency is lower than the second frequency.
9. The method of aspect B8, in which the first frequency is at least one order of magnitude lower than the second frequency.
10. The method of aspect B9, in which the first frequency comprises any frequency in the range of about 10kHz to about 90kHz.
11. The method of aspect B1, in which the specified sampling time is calculated using an equation of the form:

$$SpecifiedSamplingTime = x_1 H^{x_2} + x_3$$

where “*SpecifiedSamplingTime*” is designated as a time point from the start of the test sequence at which to sample the output signal of the test strip,

$H$  represents physical characteristic of the sample in the form of hematocrit;

$x_1$  is about  $4.3e5$ ;

$x_2$  is about  $-3.9$ ; and

$x_3$  is about  $4.8$ .

12. The method of aspect B11, in which the calculating of the analyte concentration is

computed with an equation of the form: 
$$G_0 = \left[ \frac{I_E - Intercept}{Slope} \right]$$

where

$G_0$  represents an analyte concentration

$I_E$  represents a current (proportional to analyte concentration) determined from the sum of the end currents measured at the *SpecifiedSamplingTime*;

Slope represents the value obtained from calibration testing of a batch of test strip of which this particular strip comes from; and

Intercept represents the value obtained from calibration testing of a batch of test strip of which this particular strip comes from.

13. An analyte measurement system comprising:
  - a test strip including:
    - a substrate;
    - a plurality of electrodes connected to respective electrode connectors; and
  - an analyte meter including:
    - a housing;
    - a test strip port connector configured to connect to the respective electrode connectors of the test strip; and
    - a microprocessor in electrical communication with the test strip port connector to apply electrical signals or sense electrical signals from the plurality of electrodes during a test sequence, the microprocessor is configured to, during the test sequence, (a) apply a first electrical signal to the plurality of electrodes so that a specific sampling time point is determined from a physical characteristic of a physiological fluid sample is derived, (b) apply a second electrical signal to the plurality of electrodes, and (c) measure a current output from one of the plurality of electrodes at the specified sampling time point so that an analyte concentration is determined.
14. The system of aspect B13, in which the plurality of electrodes comprises at least two electrodes to measure the physical characteristic and at least two other electrodes to measure the analyte concentration.
15. The system of aspect B14, in which the at least two electrodes and the at least two other electrodes are disposed in the same chamber provided on the substrate.
16. The system of aspect B14, in which the at least two electrodes and the at least two other electrodes are disposed in different chambers provided on the substrate.

17. The system of aspect B14, in which the at least two electrodes comprise two electrodes to measure the physical characteristic and the analyte concentration.
18. The system of one of aspects B15, B16, or B17, in which all of the electrodes are disposed on the same plane defined by the substrate.
19. The system of one of aspect B16 or aspect B17, in which a reagent is disposed proximate on the at least two other electrodes and no reagent is disposed on the at least two electrodes.
20. The system of aspect B13, in which the specified sampling time is calculated using an equation of the form:

$$\text{SpecifiedSamplingTime} = x_1 H^{x_2} + x_3$$

where “*SpecifiedSamplingTime*” is designated as a time point from the start of the test sequence at which to sample the output signal of the test strip,

*H* represents physical characteristic of the sample in the form of hematocrit;

$x_1$  represents about  $4.3e5$ ;

$x_2$  represents about  $-3.9$ ; and

$x_3$  represents about  $4.8$ .

21. The system of aspect B20, in which the analyte concentration is determined from an

equation of the form: 
$$G_0 = \left[ \frac{I_E - \text{Intercept}}{\text{Slope}} \right]$$

where

$G_0$  represents an analyte concentration

$I_E$  represents a current (proportional to analyte concentration) determined from the sum of the end currents measured at the *SpecifiedSamplingTime*;

Slope represents the value obtained from calibration testing of a batch of test strip of which this particular strip comes from; and

Intercept represents the value obtained from calibration testing of a batch of test strip of which this particular strip comes from.

22. An analyte measurement system comprising:
- a test strip including:
    - a substrate;
    - a plurality of electrodes connected to respective electrode connectors; and
  - an analyte meter including:
    - a housing;
    - a test strip port connector configured to connect to the respective electrode connectors of the test strip; and
    - a microprocessor in electrical communication with the test strip port connector to apply electrical signals or sense electrical signals from the plurality of electrodes, the microprocessor is configured to, during a test sequence: (a) apply a first electrical signal to the plurality of electrodes so that a specific sampling time point is determined from a physical characteristic of a physiological fluid sample is derived, (b) apply a second electrical signal to the plurality of electrodes, and (c) measure a current output from one of the plurality of electrodes at the specified sampling time point so that an analyte concentration of the sample is determined based on the specific sampling time point within about 10 seconds of a start of the test sequence.
23. The system of aspect B22, in which the plurality of electrodes comprises at least two electrodes to measure the physical characteristic and at least two other electrodes to measure the analyte concentration.
24. The system of aspect B23, in which the at least two electrodes and the at least two other electrodes are disposed in the same chamber provided on the substrate.
25. The system of aspect B23, in which the at least two electrodes and the at least two other electrodes are disposed in different chambers provided on the substrate.
26. The system of aspect B23, in which the at least two electrodes comprise two electrodes to measure the physical characteristic and the analyte concentration.

27. The system of one of aspects B23, B24, B25, or B26, in which all of the electrodes are disposed on the same plane defined by the substrate.

28. The system of one of aspect B22 or aspect B23, in which a reagent is disposed proximate on the at least two other electrodes and no reagent is disposed on the at least two electrodes.

29. The system of aspect B22, in which the specified sampling time is calculated using an equation of the form:

$$\text{SpecifiedSamplingTime} = x_1 H^{x_2} + x_3$$

where “*SpecifiedSamplingTime*” is designated as a time point from the start of the test sequence at which to sample the output signal of the test strip,

*H* represents physical characteristic of the sample in the form of hematocrit;

$x_1$  represents about  $4.3e5$ ;

$x_2$  represents about -3.9; and

$x_3$  represents about 4.8.

30. The system of aspect B29, in which analyte concentration is calculated from an

equation of the form: 
$$G_0 = \left[ \frac{I_E - \text{Intercept}}{\text{Slope}} \right]$$

where

$G_0$  represents an analyte concentration

$I_E$  represents a current (proportional to analyte concentration) determined from the sum of the end currents measured at the *SpecifiedSamplingTime*;

Slope represents the value obtained from calibration testing of a batch of test strip of which this particular strip comes from; and

Intercept represents the value obtained from calibration testing of a batch of test strip of which this particular strip comes from.

31. A method of determining an analyte concentration from a physiological sample, the method comprising:
- depositing a physiological sample on a biosensor having a reagent deposited thereon;
  - applying electrical signals to the sample and the reagent to transform the analyte into a different material;
  - obtaining a physical characteristic of the sample;
  - specifying a time point for sampling of current output based on the obtained physical characteristic;
  - measuring signal output at the specified sampling time point; and
  - determining an analyte concentration based the measured signal output of the sample.
32. The method of aspect B31, in which the obtaining comprises driving a second electrical signal to the sample to derive a physical characteristic of the sample.
33. The method of aspect B44, in which the applying comprises applying a first electrical signal to the sample to derive a physical characteristic of the sample, and the applying of the first signal and the driving of the second signal is in sequential order.
34. The method of aspect B33, in which the applying of the first signal overlaps with the driving of the second signal.
35. The method of aspect B33, in which the applying of the first signal comprises directing an alternating signal to the sample so that a physical characteristic of the sample is determined from an output of the alternating signal.
36. The method of aspect B33, in which the applying of the first signal comprises directing an optical signal to the sample so that a physical characteristic of the sample is determined from an output of the optical signal.
37. The method of one of aspect B35 or aspect B36 in which the physical characteristic comprises hematocrit and the analyte comprises glucose.

38. The method of one of aspect B36 or aspect B37 in which the physical characteristic comprises at least one of viscosity, hematocrit, and density.
39. The method of aspect B36, in which the directing comprises driving first and second alternating signal at different respective frequencies in which a first frequency is lower than the second frequency.
40. The method of aspect B39, in which the first frequency is at least one order of magnitude lower than the second frequency.
41. The method of aspect B40, in which the first frequency comprises any frequency in the range of about 10kHz to about 90kHz.
42. The method of aspect B31, in which the specified sampling time is calculated using an equation of the form:

$$\text{SpecifiedSamplingTime} = x_1 H^{x_2} + x_3$$

where “*SpecifiedSamplingTime*” is designated as a time point from the start of the test sequence at which to sample the output signal of the test strip,

$H$  represents physical characteristic of the sample in the form of hematocrit;

$x_1$  represents about 4.3e5;

$x_2$  represents about -3.9; and

$x_3$  represents about 4.8.

43. The method of aspect B42, in which the calculating of the analyte concentration

comprises utilizing an equation of the form:  $G_0 = \left[ \frac{I_E - \text{Intercept}}{\text{Slope}} \right]$

where

$G_0$  represents an analyte concentration

$I_E$  represents a current (proportional to analyte concentration) determined from the sum of the end currents measured at the *SpecifiedSamplingTime*;

Slope represents the value obtained from calibration testing of a batch of test strip of which this particular strip comes from; and

Intercept represents the value obtained from calibration testing of a batch of test strip of which this particular strip comes from.

## Section “C”

The following aspects form part of the present disclosure:

1. A method of determining an analyte concentration from a physiological sample with a biosensor having at least two electrodes and a reagent disposed on at least one electrode of the electrodes, the method comprising:

depositing a physiological sample on the at least two electrodes to start an analyte test sequence;

applying a first electrical signal to the sample to derive a physical characteristic of the sample;

obtaining a physical characteristic of the sample;

specifying a sampling time based on the physical characteristic from the obtaining step;

deriving a batch slope for the reagent based on the physical characteristic from the obtaining step;

driving a second electrical signal to the sample; and

measuring an output signal at the specified sampling time from at least one electrode of the at least two electrodes;

calculating an analyte concentration based on the measured output signal at the specified sampling time and the derived batch slope.

2. The method of aspect C1, in which the applying of the first signal and the driving of the second signal is in sequential order.

3. The method of aspect C1, in which the applying of the first signal overlaps with the

driving of the second signal.

4. The method of aspect C1, in which the applying of the first signal comprises directing an alternating signal to the sample so that a physical characteristic of the sample is determined from an output of the alternating signal.
5. The method of aspect C1, in which the applying of the first signal comprises directing an optical signal to the sample so that a physical characteristic of the sample is determined from an output of the optical signal.
6. The method of one of aspect C4 or aspect C5 in which the physical characteristic comprises hematocrit and the analyte comprises glucose.
7. The method of aspect C1, in which the physical characteristic comprises at least one of viscosity, hematocrit, and density of the sample.
8. The method of aspect C4, in which the directing comprises driving first and second alternating signal at different respective frequencies in which a first frequency is lower than the second frequency.
9. The method of aspect C8, in which the first frequency is at least one order of magnitude lower than the second frequency.
10. The method of aspect C9, in which the first frequency comprises any frequency in the range of about 10kHz to about 90kHz.
11. The method of aspect C1, in which the specified sampling time is calculated using an equation of the form:  $SpecifiedSamplingTime = x_1 H^{x_2} + x_3$

where “*SpecifiedSamplingTime*” is designated as a time point from the start of the test sequence at which to sample the output signal of the test strip,

$H$  represents physical characteristic of the sample in the form of hematocrit;

$x_1$  is about  $4.3e5$ ;

$x_2$  is about  $-3.9$ ; and

$x_3$  is about  $4.8$ .

12. The method of aspect C11, in which the derived slope is determined from an equation of the form:

$$NewSlope = aH^2 + bH + c$$

where  $H$  is measured or estimated physical characteristic (e.g., hematocrit);

$a$  is about  $1.35e-6$ ,

$b$  is about  $-3.79e-4$ ,

$c$  is about  $3.56e-2$ .

13. The method of aspect C12, in which the calculating of the analyte concentration is

computed with an equation of the form:  $G_0 = \left[ \frac{I_E - Intercept}{NewSlope} \right]$

where

$G_0$  represents an analyte concentration

$I_E$  represents a signal (proportional to analyte concentration) determined from the sum of the end signals measured at the *SpecifiedSamplingTime*;

*NewSlope* represents the value derived from the measured physical characteristic; and

Intercept represents the value obtained from calibration testing of a batch of test strip of which this particular strip comes from.

14. An analyte measurement system comprising:

a test strip including:

a substrate;

a plurality of electrodes connected to respective electrode connectors; and

an analyte meter including:

a housing;

a test strip port connector configured to connect to the respective electrode connectors of the test strip; and

a microprocessor in electrical communication with the test strip port connector to apply electrical signals or sense electrical signals from the plurality of electrodes during a test sequence, the microprocessor is configured to, during the test sequence, (a) apply a first electrical signal to the plurality of electrodes so that a specific sampling time point and a batch slope are determined from a physical characteristic of a physiological fluid sample are derived, (b) apply a second electrical signal to the plurality of electrodes, and (c) measure a signal output from one of the plurality of electrodes at the specified sampling time point so that an analyte concentration is determined based on the measured signal at the specified time point and the batch slope.

15. The system of aspect C14, in which the plurality of electrodes comprises at least two electrodes to measure the physical characteristic and at least two other electrodes to measure the analyte concentration.
16. The system of aspect C15, in which the at least two electrodes and the at least two other electrodes are disposed in the same chamber provided on the substrate.
17. The system of aspect C15, in which the at least two electrodes and the at least two other electrodes are disposed in different chambers provided on the substrate.
18. The system of aspect C15, in which the at least two electrodes comprise two electrodes to measure the physical characteristic and the analyte concentration.
19. The system of one of aspects C16, C17, or C18, in which all of the electrodes are disposed on the same plane defined by the substrate.
20. The system of one of aspect C17 or aspect C18, in which a reagent is disposed proximate on the at least two other electrodes and no reagent is disposed on the at least two electrodes.
21. The system of aspect C14, in which the specified sampling time is calculated using an equation of the form:  $SpecifiedSamplingTime = x_1 H^{x_2} + x_3$

where “*SpecifiedSamplingTime*” is designated as a time point from the start of the test sequence at which to sample the output signal of the test strip,  
*H* represents physical characteristic of the sample in the form of hematocrit;  
*x*<sub>1</sub> represents about 4.3e5;  
*x*<sub>2</sub> represents about -3.9; and  
*x*<sub>3</sub> represents about 4.8.

22. The method of aspect C21, in which the derived slope is determined from an equation of the form:

$$NewSlope = aH^2 + bH + c$$

where *H* is measured or estimated physical characteristic (e.g., hematocrit);

*a* is about 1.35e-6,

*b* is about -3.79e-4,

*c* is about 3.56e-2.

23. The method of aspect C22, in which the calculating of the analyte concentration is

computed with an equation of the form:  $G_0 = \left[ \frac{I_E - Intercept}{NewSlope} \right]$

where

*G*<sub>0</sub> represents an analyte concentration

*I*<sub>E</sub> represents a signal (proportional to analyte concentration) determined from the sum of the end signals measured at the *SpecifiedSamplingTime*;

*NewSlope* represents the value derived from the measured physical characteristic; and

Intercept represents the value obtained from calibration testing of a batch of test strip of which this particular strip comes from.

24. An analyte measurement system comprising:

a test strip including:

a substrate;

a plurality of electrodes connected to respective electrode connectors; and

an analyte meter including:

a housing;

a test strip port connector configured to connect to the respective electrode connectors of the test strip; and

a microprocessor in electrical communication with the test strip port connector to apply electrical signals or sense electrical signals from the plurality of electrodes, the microprocessor is configured to, during a test sequence:

- (a) apply a first electrical signal to the plurality of electrodes so that a specific sampling time point and a batch slope of the test strip are determined from a physical characteristic of a physiological fluid sample is derived,
- (b) apply a second electrical signal to the plurality of electrodes, and
- (c) measure a signal output from one of the plurality of electrodes at the specified sampling time point so that an analyte concentration of the sample is determined based on the specific sampling time point and batch slope within about 10 seconds of a start of the test sequence.

25. The system of aspect C24, in which the plurality of electrodes comprises at least two electrodes to measure the physical characteristic and at least two other electrodes to measure the analyte concentration.

26. The system of aspect C24, in which the at least two electrodes and the at least two other electrodes are disposed in the same chamber provided on the substrate.

27. The system of aspect C24, in which the at least two electrodes and the at least two other electrodes are disposed in different chambers provided on the substrate.

28. The system of aspect C24, in which the at least two electrodes comprise two electrodes to measure the physical characteristic and the analyte concentration.

29. The system of one of aspects C24, C25, C26, or C27, in which all of the electrodes are disposed on the same plane defined by the substrate.

30. The system of one of aspect C23 or aspect C24, in which a reagent is disposed proximate on the at least two other electrodes and no reagent is disposed on the at least two

electrodes.

31. The system of aspect C24, in which the specified sampling time is calculated using an equation of the form:  $SpecifiedSamplingTime = x_1 H^{x_2} + x_3$

where “*SpecifiedSamplingTime*” is designated as a time point from the start of the test sequence at which to sample the output signal of the test strip,

$H$  represents physical characteristic of the sample in the form of hematocrit;

$x_1$  represents about  $4.3e5$ ;

$x_2$  represents about  $-3.9$ ; and

$x_3$  represents about  $4.8$ .

32. The system of aspect C31, in which the derived slope is determined from an equation of the form:

$$NewSlope = aH^2 + bH + c$$

where *NewSlope* represents the derived slope;

$H$  is measured or estimated physical characteristic (e.g., hematocrit);

$a$  is about  $1.35e-6$ ,

$b$  is about  $-3.79e-4$ ,

$c$  is about  $3.56e-2$ .

33. The method of aspect C32, in which the calculating of the analyte concentration is

computed with an equation of the form:  $G_0 = \left[ \frac{I_E - Intercept}{NewSlope} \right]$

where

$G_0$  represents an analyte concentration

$I_E$  represents a signal (proportional to analyte concentration) determined from the sum of the end signals measured at the *SpecifiedSamplingTime*;

*NewSlope* represents the value derived from the measured physical characteristic; and

Intercept represents the value obtained from calibration testing of a batch of test strip of which this particular strip comes from.

34. A method of obtaining increased accuracy of a test strip, the method comprising:
- providing for a batch of test strips;
  - introducing a referential sample containing a referential concentration of an analyte to each of the batch of test strips to initiate a test sequence;
  - reacting the analyte to cause a physical transformation of the analyte between the two electrodes;
  - determining a physical characteristic of the referential sample;
  - deriving a batch slope of the batch of test strips based on the determined physical characteristic;
  - sampling an electrical output of the referential sample at a specified time point during the test sequence defined by the measured physical characteristic;
  - calculating an analyte concentration based on the specified time point and the derived batch slope to provide for a final analyte concentration value for each of the batch of test strips such that at least 95% of the final analyte concentration values of the batch of test strips are within  $\pm 15\%$  of the referential analyte concentration.
35. The method of aspect C34, in which the reacting comprises driving a second electrical signal to the sample and the determining comprises applying a first electrical signal to the sample to derive a physical characteristic of the sample, and the applying of the first signal and the driving of the second signal is in sequential order.
36. The method of aspect C35, in which the applying of the first signal overlaps with the driving of the second signal.
37. The method of aspect C34, in which the applying of the first signal comprises directing an alternating signal to the sample so that a physical characteristic of the sample is determined from an output of the alternating signal.
38. The method of aspect C34, in which the applying of the first signal comprises directing

an optical signal to the sample so that a physical characteristic of the sample is determined from an output of the optical signal.

39. The method of one of aspect C37 or aspect C38 in which the physical characteristic comprises hematocrit and the analyte comprises glucose.

40. The method of one of aspect C37 or aspect C38 in which the physical characteristic comprises at least one of viscosity, hematocrit, and density.

41. The method of aspect C37, in which the directing comprises driving first and second alternating signal at different respective frequencies in which a first frequency is lower than the second frequency.

42. The method of aspect C41, in which the first frequency is at least one order of magnitude lower than the second frequency.

43. The method of aspect C41, in which the first frequency comprises any frequency in the range of about 10kHz to about 90kHz.

44. The method of aspect C34, in which the specified sampling time is calculated using an equation of the form:  $SpecifiedSamplingTime = x_1 H^{x_2} + x_3$

where “*SpecifiedSamplingTime*” is designated as a time point from the start of the test sequence at which to sample the output signal of the test strip,

$H$  represents physical characteristic of the sample in the form of hematocrit;

$x_1$  represents about 4.3e5;

$x_2$  represents about -3.9; and

$x_3$  represents about 4.8.

45. The method of aspect C44, in which the derived slope is determined from an equation of the form:

$$NewSlope = aH^2 + bH + c$$

where  $H$  is measured or estimated physical characteristic (e.g., hematocrit);

$a$  is about  $1.35e-6$ ,

$b$  is about  $-3.79e-4$ ,

$c$  is about  $3.56e-2$ .

46. The method of aspect C45, in which the calculating of the analyte concentration is

computed with an equation of the form:  $G_0 = \left[ \frac{I_E - Intercept}{NewSlope} \right]$

where

$G_0$  represents an analyte concentration

$I_E$  represents a signal (proportional to analyte concentration) determined from the sum of the end signals measured at the *SpecifiedSamplingTime*;

*NewSlope* represents the value derived from the measured physical characteristic; and

Intercept represents the value obtained from calibration testing of a batch of test strip of which this particular strip comes from.

47. A method of determining an analyte concentration from a physiological sample, the method comprising:

depositing a physiological sample on a biosensor having a reagent deposited thereon;

applying electrical signals to the sample and the reagent to transform the analyte into a different material;

obtaining a physical characteristic of the sample;

specifying a time point for sampling of signal output based on the physical characteristic from the specifying step;

deriving a batch slope of the biosensor;

measuring signal output at the specified sampling time point; and

determining an analyte concentration based on the measured signal output of the sample at the specified sampling time point and the derived batch slope.

48. The method of aspect C47, in which the obtaining comprises driving a second electrical signal to the sample to derive a physical characteristic of the sample.

49. The method of aspect C48, in which the applying comprises applying a first electrical signal to the sample to derive a physical characteristic of the sample, and the applying of the first signal and the driving of the second signal is in sequential order.
50. The method of aspect C49, in which the applying of the first signal overlaps with the driving of the second signal.
51. The method of aspect C50, in which the applying of the first signal comprises directing an alternating signal to the sample so that a physical characteristic of the sample is determined from an output of the alternating signal.
52. The method of aspect C50, in which the applying of the first signal comprises directing an optical signal to the sample so that a physical characteristic of the sample is determined from an output of the optical signal.
53. The method of one of aspect C51 or aspect C52 in which the physical characteristic comprises hematocrit and the analyte comprises glucose.
54. The method of one of aspect C52 or aspect C53 in which the physical characteristic comprises at least one of viscosity, hematocrit, and density.
55. The method of aspect C53, in which the directing comprises driving first and second alternating signal at different respective frequencies in which a first frequency is lower than the second frequency.
56. The method of aspect C55, in which the first frequency is at least one order of magnitude lower than the second frequency.
57. The method of aspect C56, in which the first frequency comprises any frequency in the range of about 10kHz to about 90kHz.
58. The method of aspect C47, in which the specified sampling time is calculated using an

equation of the form:  $SpecifiedSamplingTime = x_1 H^{x_2} + x_3$

where “*SpecifiedSamplingTime*” is designated as a time point from the start of the test sequence at which to sample the output signal of the test strip,

*H* represents physical characteristic of the sample in the form of hematocrit;

$x_1$  represents about 4.3e5;

$x_2$  represents about -3.9; and

$x_3$  represents about 4.8.

59. The method of aspect C58, in which the derived slope is determined from an equation of the form:

$$NewSlope = aH^2 + bH + c$$

where *H* is measured or estimated physical characteristic (e.g., hematocrit);

*a* is about 1.35e-6,

*b* is about -3.79e-4,

*c* is about 3.56e-2.

60. The method of aspect C59, in which the calculating of the analyte concentration is

computed with an equation of the form:  $G_0 = \left[ \frac{I_E - Intercept}{NewSlope} \right]$

where

$G_0$  represents an analyte concentration

$I_E$  represents a signal (proportional to analyte concentration) determined from the sum of the end signals measured at the *SpecifiedSamplingTime*;

*NewSlope* represents the value derived from the measured physical characteristic; and

Intercept represents the value obtained from calibration testing of a batch of test strip of which this particular strip comes from.

61. The method or system of respective one of aspects C12, C22, C32, C44, or C59, in which *a* is about -1.98e-6; *b* is about -2.87e-5; and *c* is about 2.67e-2.

## Section “D”

The following aspects form part of the present disclosure:

1. A method of determining an analyte concentration from a physiological sample with a biosensor having at least two electrodes and a reagent disposed on at least one of the electrodes, the method comprising:

depositing a physiological sample on the at least two electrodes to start an analyte test sequence;

applying a first electrical signal to the sample to measure a physical characteristic of the sample;

driving a second electrical signal to the sample to cause an enzymatic reaction of the analyte and the reagent;

estimating an analyte concentration based on a predetermined sampling time point from the start of the test sequence;

selecting a sampling time point from a look-up table that includes a matrix in which different qualitative categories of the estimated analyte are set forth in the leftmost column of the matrix and different qualitative categories of the measured physical characteristic are set forth in the topmost row of the matrix and the sampling times are provided in the remaining cells of the matrix;

measuring signal output from the sample at the selected sampling time point from the look-up table;

calculating an analyte concentration from measured output signal sampled at said selected sampling time point in accordance with an equation of the form:

$$G_0 = \left[ \frac{I_T - \text{Intercept}}{\text{Slope}} \right]$$

where  $G_0$  represents an analyte concentration;

$I_T$  represents a signal (proportional to analyte concentration) determined from the sum of the end signals measured at a specified

sampling time T;

Slope represents the value obtained from calibration testing of a batch of test strip of which this particular strip comes from; and

Intercept represents the value obtained from calibration testing of a batch of test strip of which this particular strip comes from.

2. A method of determining an analyte concentration from a physiological sample with a biosensor having at least two electrodes and a reagent disposed on at least one of the electrodes, the method comprising:
  - depositing a physiological sample on the at least two electrodes to start an analyte test sequence;
  - applying a first electrical signal to the sample to measure a physical characteristic of the sample;
  - driving a second electrical signal to the sample to cause an enzymatic reaction of the analyte and the reagent;
  - estimating an analyte concentration based on a predetermined sampling time point from the start of the test sequence;
  - selecting a sampling time point based on both the measured physical characteristic and the estimated analyte concentration;
  - measuring signal output from the sample at the selected sampling time point;
  - calculating an analyte concentration from measured output signal sampled at said selected sampling time point.
3. The method of aspect D1 or aspect D2, in which the applying of the first signal and the driving of the second signal is sequential.
4. The method of aspect D1 or aspect D2, in which the applying of the first signal overlaps with the driving of the second signal.
5. The method of aspect D1 or aspect D2, in which the applying of the first signal comprises directing an alternating signal to the sample so that a physical characteristic of the sample is determined from an output of the alternating signal.

6. The method of aspect D5 in which the physical characteristic comprises hematocrit and the analyte comprises glucose.
7. The method of one of aspect D5 or aspect D6 in which the physical characteristic comprises at least one of viscosity, hematocrit, and density.
8. The method of aspect D5, in which the directing comprises driving first and second alternating signal at different respective frequencies in which a first frequency is lower than the second frequency.
9. The method of aspect D8, in which the first frequency is at least one order of magnitude lower than the second frequency.
10. The method of aspect D8, in which the first frequency comprises any frequency in the range of about 10kHz to about 90kHz.
11. The method of aspect D1 or aspect D2, in which the measuring comprises sampling the signal output continuously at the start of the test sequence until at least about 10 seconds after the start.
12. The method of aspect D2, further comprising estimating an analyte concentration based on a measurement of the output signal at a predetermined time.
13. The method of aspect D12, in which the predetermined time comprises about 5 seconds from the start of the test sequence.
14. The method of aspect D12, in which the estimating comprises comparing the estimated analyte concentration and the measured physical characteristic against a look-up table having different respective ranges of analyte concentration and physical characteristic of the sample indexed against different sample measurement times so that the point in time for measurement of the output from the sample of the second signal is obtained for the calculating step.
15. The method of aspect D2, in which the calculating step comprises utilizing an equation

of the form:

$$G_0 = \left[ \frac{I_T - \text{Intercept}}{\text{Slope}} \right]$$

where  $G_0$  represents an analyte concentration;

$I_T$  represents a signal (proportional to analyte concentration) determined from the sum of the end signals measured at a specified sampling time  $T$ ;

Slope represents the value obtained from calibration testing of a batch of test strip of which this particular strip comes from; and

Intercept represents the value obtained from calibration testing of a batch of test strip of which this particular strip comes from

16. An analyte measurement system comprising:

a test strip including:

a substrate;

a plurality of electrodes connected to respective electrode connectors; and

an analyte meter including:

a housing;

a test strip port connector configured to connect to the respective electrode connectors of the test strip; and

a microprocessor in electrical communication with the test strip port connector to apply electrical signals or sense electrical signals from the plurality of electrodes, the microprocessor is configured to: (a) apply a first electrical signal to the plurality of electrodes so that a physical characteristic of a physiological fluid sample is determined; (b) estimating an analyte concentration based on a predetermined sampling time point during a test sequence; and (c) apply a second electrical signal to the plurality of electrodes at a sampling time point during the test sequence dictated by the determined physical characteristic so that an analyte concentration is calculated from the second electrical signal.

17. The system of aspect D16, in which the plurality of electrodes comprises at least two electrodes to measure the physical characteristic and at least two other electrodes to measure the analyte concentration.

18. The system of aspect D17, in which the at least two electrodes and the at least two other electrodes are disposed in the same chamber provided on the substrate.
19. The system of aspect D17, in which the at least two electrodes and the at least two other electrodes are disposed in different chambers provided on the substrate.
20. The system of one of aspect D18 or aspect D19, in which all of the electrodes are disposed on the same plane defined by the substrate.
21. The system of one of aspect D18 or aspect D19, in which a reagent is disposed proximate on the at least two other electrodes and no reagent is disposed on the at least two electrodes.
22. An analyte measurement system comprising:
  - a test strip including:
    - a substrate;
    - a plurality of electrodes connected to respective electrode connectors; and
  - an analyte meter including:
    - a housing;
    - a test strip port connector configured to connect to the respective electrode connectors of the test strip; and
  - a microprocessor in electrical communication with the test strip port connector to apply electrical signals or sense electrical signals from the plurality of electrodes, the microprocessor is configured to: (a) apply a first electrical signal to the plurality of electrodes so that a physical characteristic of a physiological fluid sample is determined during a test sequence; (b) estimating an analyte concentration based on a predetermined sampling time point during a test sequence; and (c) apply a second electrical signal to the plurality of electrodes at a sampling time point during the test sequence dictated by the determined physical characteristic so that so that an analyte concentration is determined from the second electrical signal within about 10 seconds of a start of the test sequence.

23. The system of aspect D23, in which the plurality of electrodes comprises at least two electrodes to measure the physical characteristic and at least two other electrodes to measure the analyte concentration.
24. The system of aspect D23, in which the at least two electrodes and the at least two other electrodes are disposed in the same chamber provided on the substrate.
25. The system of aspect D23, in which the at least two electrodes and the at least two other electrodes are disposed in different chambers provided on the substrate.
26. The system of one of aspect D24 or aspect D25, in which all of the electrodes are disposed on the same plane defined by the substrate.
27. The system of one of aspect D24 or aspect D25, in which a reagent is disposed proximate on the at least two other electrodes and no reagent is disposed on the at least two electrodes.
28. A method of obtaining increased accuracy of a test strip, the method comprising:
- providing for a batch of test strips;
  - introducing a referential sample containing a referential concentration of an analyte to each of the batch of test strips to start a test sequence;
  - reacting the analyte with reagent disposed on each of the test strips to cause a physical transformation of the analyte between the two electrodes;
  - estimating an analyte concentration based on measured signal output of the sample at a predetermined time point from the start of the test sequence;
  - determining a physical characteristic of the referential sample;
  - sampling an electrical output of the referential sample at a dictated time point during the test sequence defined by the measured physical characteristic and the estimated analyte concentration;
  - calculating an analyte concentration based on the dictated time point to provide for a final analyte concentration value for each of the batch of test strips such that at

least 95% of the final analyte concentration values of the batch of test strips are within  $\pm 10\%$  of the referential analyte concentration for a range of hematocrit of the sample from about 30% to about 55%.

29. The method of aspect D28, in which the applying of the first signal and the driving of the second signal is sequential.

30. The method of aspect D28, in which the applying of the first signal overlaps with the driving of the second signal.

31. The method of aspect D28, in which the applying of the first signal comprises directing an alternating signal to the sample so that a physical characteristic of the sample is determined from an output of the alternating signal.

32. The method of aspect D28, in which the applying of the first signal comprises directing an electromagnetic signal to the sample so that a physical characteristic of the sample is determined from an output of the electromagnetic signal.

33. The method of one of aspect D31 or aspect D32, in which the physical characteristic comprises hematocrit and the analyte comprises glucose.

34. The method of one of aspect D31 or aspect D32, in which the physical characteristic comprises at least one of viscosity, hematocrit, and density.

35. The method of aspect D30, in which the directing comprises driving first and second alternating signal at different respective frequencies in which a first frequency is lower than the second frequency.

36. The method of aspect D35, in which the first frequency is at least one order of magnitude lower than the second frequency.

37. The method of aspect D36, in which the first frequency comprises any frequency in the range of about 10kHz to about 90kHz.

38. The method of aspect D29, in which the measuring comprises sampling the signal output continuously at the start of the test sequence until at least about 10 seconds after the start.
39. The method of aspect D29, further comprising estimating an analyte concentration based on a measurement of the output signal at a predetermined time.
40. The method of aspect D39, in which the estimating comprises comparing the estimated analyte concentration and the measured physical characteristic against a look-up table having different respective ranges of analyte concentration and physical characteristic of the sample indexed against different sample measurement times so that the point in time for measurement of the output from the sample of the second signal is obtained for the calculating step.
41. A method of determining an analyte concentration from a physiological sample, the method comprising:
- depositing a physiological sample on a biosensor to start a test sequence;
  - causing the analyte in the sample to undergo an enzymatic reaction;
  - estimating an analyte concentration in the sample;
  - measuring at least one physical characteristic of the sample;
  - defining a time point from the start of the test sequence to sample output signals of the biosensor based on the estimated analyte concentration and at least one physical characteristic from the measuring step;
  - sampling output signals of the biosensor at the defined time point;
  - determining an analyte concentration from sampled signals at the defined time point.
42. The method of aspect D41, in which the measuring comprises applying a first electrical signal to the sample to measure a physical characteristic of the sample; the causing step comprises driving a second electrical signal to the sample; the measuring comprises evaluating an output signal from the at least two electrodes at a point in time after the start of the test sequence, in which the point in time is set as a function of at least the measured physical characteristic; and

the determining step comprises calculating an analyte concentration from the measured output signal at said point in time.

43. The method of aspect D41, in which the applying of the first signal and the driving of the second signal is sequential.

44. The method of aspect D41, in which the applying of the first signal overlaps with the driving of the second signal.

45. The method of aspect D41, in which the applying of the first signal comprises directing an alternating signal to the sample so that a physical characteristic of the sample is determined from an output of the alternating signal.

46. The method of aspect D41, further comprising estimating an analyte concentration based on a predetermined sampling time point from the start of the test sequence.

47. The method of aspect D46, in which the defining comprises selecting a defined time point based on both the measured physical characteristic and the estimated analyte concentration.

48. The method of one of aspect D45 or aspect D46 in which the physical characteristic comprises hematocrit and the analyte comprises glucose.

49. The method of one of aspect D44 or aspect D45 in which the physical characteristic comprises at least one of viscosity, hematocrit, and density.

50. The method of aspect D46, in which the directing comprises driving first and second alternating signal at different respective frequencies in which a first frequency is lower than the second frequency.

51. The method of aspect D50, in which the first frequency is at least one order of magnitude lower than the second frequency.

52. The method of aspect D51, in which the first frequency comprises any frequency in the range of about 10kHz to about 90kHz.
53. The method of aspect D41, in which the measuring comprises sampling the signal output continuously at the start of the test sequence until at least about 10 seconds after the start.
54. The method of aspect D53, further comprising estimating an analyte concentration based on a measurement of the output signal at a predetermined time.
55. The method of aspect D54, in which the estimating comprises comparing the estimated analyte concentration and the measured physical characteristic against a look-up table having different respective ranges of analyte concentration and physical characteristic of the sample indexed against different sample measurement times so that the point in time for measurement of the output from the sample of the second signal is obtained for the calculating step.
56. The method or system of any one of aspects D1 to D55, in which the sampling time point is selected from a look-up table that includes a matrix in which different qualitative categories of the estimated analyte are set forth in the leftmost column of the matrix and different qualitative categories of the measured physical characteristic are set forth in the topmost row of the matrix and the sampling times are provided in the remaining cells of the matrix.

#### Section “E”

The following aspects form part of the present disclosure:

1. A method of determining an analyte concentration from a physiological sample with a biosensor having at least two electrodes and a reagent disposed on at least one electrode of the electrodes, the method comprising:

depositing a physiological sample on the at least two electrodes to start an analyte test sequence;

applying a first electrical signal to the sample to derive a physical characteristic of the sample;

driving a second electrical signal to the sample for a first sampling time duration that overlaps with the test sequence to obtain a first transient signal output from the sample, the first transient signal correlated to both time and magnitude during the first sampling time duration;

extracting a specific sampling time during the test sequence in the first sampling time duration based on the physical characteristic of the sample;

defining a second sampling time duration based on the specific sampling time such that the second sampling time duration overlaps the first sampling time duration;

obtaining from the first transient signal a second transient signal referenced with respect to the second sampling time duration;

dividing the second transient signal into discrete intervals with respect to the second sampling time duration;

deriving respective magnitudes of the second transient signal at discrete selected intervals in the second sampling time duration; and

determining an analyte concentration based on respective magnitudes of the second transient signal at the discrete selected time intervals.

2. A method of determining an analyte concentration from a physiological sample with a biosensor having at least two electrodes and a reagent disposed on at least one electrode of the electrodes, the method comprising:

depositing a physiological sample on the at least two electrodes to start an analyte test sequence;

applying a first electrical signal to the sample to derive a physical characteristic of the sample;

driving a second electrical signal to the sample for a first sampling time duration that

overlaps with the test sequence to obtain a first transient signal output from the sample, the first transient signal correlated to both time and magnitude during the first sampling time duration;

extracting a specific sampling time during the test sequence in the first sampling time duration based on the physical characteristic of the sample;

obtaining from the first transient signal a second transient signal over a second sampling time duration;

deriving respective magnitudes of the second transient signal at selected intervals in the second sampling time duration; and

determining an analyte concentration based on respective magnitudes of the second transient signal at the selected time intervals.

3. A method of determining an analyte concentration from a physiological sample with a biosensor having at least two electrodes and a reagent disposed on at least one electrode of the electrodes, the method comprising:

depositing a physiological sample on the at least two electrodes to start an analyte test sequence;

applying a first electrical signal to the sample to derive a physical characteristic of the sample;

extracting a specific sampling time in a first sampling time duration;

applying or driving a second signal into the sample for the first sampling time duration,

measuring or sampling a first transient signal output from the sample for the duration of the first sampling time duration;

defining a specific range of time that includes the specific sampling time in the first sampling time duration;

obtaining plural magnitudes of the first transient signal at respective discrete intervals within the specific range of time, and

determining the analyte concentration based on the magnitudes of the first transient signal from the obtaining step.

4. A method of determining an analyte concentration from a physiological sample with a biosensor having at least two electrodes and a reagent disposed on at least one electrode of the electrodes, the method comprising:

depositing a physiological sample on the at least two electrodes to start an analyte test sequence;

applying a first electrical signal to the sample to derive a physical characteristic of the sample;

extracting a specific sampling time in a first sampling time duration;

applying or driving a second signal into the sample for the first sampling time duration, measuring or sampling a first transient signal output from the sample for the duration of the first sampling time duration;

obtaining plural magnitudes of the first transient signal output at time intervals other than at about the specific sampling time; and

determining the analyte concentration based on the plural magnitudes of the first transient signal from the obtaining step.

5. A method of determining an analyte concentration from a physiological sample with a biosensor having at least two electrodes and a reagent disposed on at least one electrode of the electrodes, the method comprising:

depositing a physiological sample on the at least two electrodes to start an analyte test sequence for each of a plurality of the biosensors;

applying a first electrical signal to the sample to derive a physical characteristic of the sample for each of the plurality of the biosensors;

extracting a specific sampling time in a first sampling time duration for each of the plurality of the biosensors;

applying or driving a second signal into the sample for the first sampling time duration for each of a plurality of the biosensors;

measuring or sampling a first transient signal output from the sample for the duration of the first sampling time duration for each of the plurality of the biosensors;

defining a specific range of time that includes the specific sampling time in the first sampling time duration for each of the plurality of the biosensors;

obtaining plural magnitudes of the first transient signal at respective discrete intervals within the specific range of time for each of the plurality of the biosensors; and

determining the analyte concentration based on the magnitudes of the first transient signal from the obtaining step for each of the plurality of the biosensors such that an error between a plurality of analyte concentrations determined by the determining step for the plurality of the biosensors is less than  $\pm 15\%$  as compared to referential value at each of 30%, 42%, and 55% hematocrits.

6. The method of one of aspects E1, E2, or E3, in which the specific range of time include magnitudes of first transient signal measured before the specific sampling time.

7. The method of one of aspects E1, E2, E3, E4, or E5, in which the step of extracting the specific sampling time comprises calculating a defined specific sampling time in the first sampling time duration based on the physical characteristic of the sample.

8. The method of aspect E6, in which the calculating step for the defined specific sampling time comprises utilizing an equation of the form:

$$\text{SpecifiedSamplingTime} = x_1 H^{x_2} + x_3$$

where “*SpecifiedSamplingTime*” is designated as a time point from the start of the test sequence at which to sample the output signal of the biosensor,

$H$  represents physical characteristic of the sample in the form of hematocrit;

$x_1$  is about  $4.3e5$ ;

$x_2$  is about  $(-)$ 3.9; and

$x_3$  is about 4.8.

9. The method of aspect E8, in which the step of defining the second sampling time duration comprises obtaining an absolute value of a difference between the defined specific sampling time and a predetermined time point to define a start time (T1) and an end time (T2) approximately equal to the specified sampling time point, and the first sampling time duration comprises about 10 seconds or less from the step of depositing the sample.

10. The method of aspect E8, in which the step of obtaining further comprises defining a second sampling time duration that overlaps the first sampling time duration and includes a portion of the first transient signal and its magnitudes with respect to time of the second sampling time duration, wherein the portion is designated as a second transient signal.
11. The method of aspect E9, in which the step of obtaining the second transient signal comprises extracting from the first transient signal a portion of the first transient signal that is designated as a second transient signal that is within the second sampling time duration.
12. The method of aspect E11, in which the deriving of respective magnitudes of the second transient signal at discrete selected time intervals comprises calculating a magnitude of the second transient signal during each selected time intervals.
13. The method of aspect E12, in which the dividing comprises dividing the second transient signal into at least 22 intervals in sequence starting from interval one at about the start time to interval twenty-two at about the end time.
14. The method of aspect E13, in which the determination of analyte concentration is obtained by utilizing an equation of the form:

$$G = \frac{\left(\frac{|I_3|}{|I_4|}\right)^{x_1} \times \left(\frac{|I_2| + x_4 |I_5| - x_5 |I_1|}{|I_2| + x_4 |I_5|} |I_5|\right) - x_2}{x_3}$$

where:

G comprises analyte concentration;  $I_1 \approx$  magnitude of second transient signal at interval 17;  $I_2 \approx$  magnitude of second transient signal at interval 13;  $I_3 \approx$  magnitude of second transient signal at interval 5;  $I_4 \approx$  magnitude of second transient signal at interval 3;  $I_5 \approx$  magnitude of second transient signal at interval 22;  $x_1 \approx 0.75$ ;  $x_2 \approx 337.27$ ;  $x_3 \approx (-)16.81$ ;  $x_4 \approx 1.41$ ; and  $x_5 \approx 2.67$ .

15. The method of aspect E10, in which the determination of analyte concentration is obtained by utilizing an equation of the form:

$$G = \frac{x_1(|I_1|)\left(x_2 - \frac{x_3}{|I_2|}\right) - x_4}{x_5}$$

where:

G comprises analyte concentration;  $I_1 \approx$  magnitude of second transient signal at interval 11;  $I_2 \approx$  magnitude of second transient signal at interval 7;  $x_1 \approx 0.59$ ;  $x_2 \approx 2.51$ ;  $x_3 \approx (-)12.74$ ;  $x_4 \approx (-) 188.31$ ; and  $x_5 \approx 9.2$ .

16. The method of aspect E13, in which the determination of analyte concentration is obtained by utilizing an equation of the form:

$$G = \frac{x_1 \ln\left(x_2 \frac{|I_1|}{|I_2|}\right)^{x_3} |I_3|^{x_4} - x_5}{x_6}$$

where G comprises analyte concentration;  $I_1 \approx$  magnitude of second transient signal at interval 20;  $I_2 \approx$  magnitude of second transient signal at interval 22;  $I_3 \approx$  magnitude of second transient signal at interval 19;  $x_1 \approx 20.15$ ;  $x_2 \approx 1.0446$ ;  $x_3 \approx 0.95$ ;  $x_4 \approx 1.39$ ;  $x_5 \approx (-)0.71$ ;  $x_6 \approx 0.11$ .

17. The method of aspect E13, in which the determination of analyte concentration is obtained by utilizing an equation of the form:

$$G = \frac{x_3 \left| \frac{I_1}{I_2} \right|^{(x_1 - x_2 \left| \frac{I_3}{I_4} \right|)} \times |I_5| - x_5}{x_4}$$

where:

$I_1 \approx$  magnitude of second transient signal at interval 5;  $I_2 \approx$  magnitude of second transient signal at interval 1;  $I_3 \approx$  magnitude of second transient signal at interval 2;  $I_4 \approx$  magnitude of second transient signal at interval 10;  $I_5 \approx$  magnitude of second transient signal at interval 22;

$x_1 \approx 0.70$ ;  $x_2 \approx 0.49$ ,  $x_3 \approx 28.59$ ,  $x_4 \approx 0.7$ , and  $x_5 \approx 15.51$ .

18. The method of aspect E10, in which the determination of analyte concentration is obtained by utilizing an equation of the form:

$$G = \frac{\left( \left| \frac{I_1}{I_2} \right|^{x_1} \times \frac{x_2 |I_3|^2 + x_3 |I_3| + x_4}{x_5 |I_4| + x_6} \right) - x_7}{x_8}$$

where:

$G$  comprises glucose concentration;  $I_1 \approx$  magnitude of second transient signal at interval 19;  $I_2 \approx$  magnitude of second transient signal at interval 16;  $I_3 \approx$  magnitude of second transient signal at interval 11;  $I_4 \approx$  magnitude of second transient signal at interval 5;  $x_1 \approx (-)1.68$ ;  $x_2 \approx 0.95$ ;  $x_3 \approx (-)4.97$ ;  $x_4 \approx 6.29$ ;  $x_5 \approx 3.08$ ;  $x_6 \approx (-)5.84$ ;  $x_7 \approx (-)0.47$ ;  $x_8 \approx 0.01$ .

19. The method of aspect E10, in which the determination of analyte concentration is obtained by utilizing an equation of the form:

$$G = \frac{\left( \left| \frac{I_1}{I_2} \right|^{x_1} \times \frac{x_2 |I_3|^3 + x_3 |I_3|^2 + x_4 |I_3| + x_5}{x_6 |I_4|^2 + x_7 |I_4| + x_8} \right) - x_9}{x_{10}}$$

where:

$G$  comprises glucose concentration;  $I_1 \approx$  magnitude of second transient signal at interval 16;  $I_2 \approx$  magnitude of second transient signal at interval 5;  $I_3 \approx$  magnitude of second transient signal at interval 12;  $I_4 \approx$  magnitude of second transient signal at interval 14;  $x_1 \approx 1.18$ ;  $x_2 \approx 0.97$ ;  $x_3 \approx (-)11.32$ ;  $x_4 \approx 38.76$ ;  $x_5 \approx (-)39.32$ ;  $x_6 \approx 0.0928$ ;  $x_7 \approx (-)0.85$ ;  $x_8 \approx 1.75$ ;  $x_9 \approx (-)9.38$ ; and  $x_{10} \approx 0.25$ .

20. The method of any one of aspects E14-E19, in which the magnitude of the second transient signal at each of the plurality of discrete intervals comprises an average magnitude of measured magnitudes at each discrete interval.

21. The method of any one of aspect E1, aspect E2, or aspect E3, in which the applying of the first signal and the driving of the second signal is in sequential order.
22. The method of any one of aspect E1, aspect E2, or aspect E3, in which the applying of the first signal overlaps with the driving of the second signal.
23. The method of any one of aspect E1, aspect E2, or aspect E3, in which the applying of the first signal comprises directing an alternating signal to the sample so that a physical characteristic of the sample is determined from an output of the alternating signal.
24. The method of any one of aspect E1, aspect E2, or aspect E3, in which the applying of the first signal comprises directing an optical signal to the sample so that a physical characteristic of the sample is determined from an output of the optical signal.
25. The method of aspect E24, in which the physical characteristic comprises hematocrit and the analyte comprises glucose.
26. The method of any one of aspect E1, aspect E2, or aspect E3, in which the physical characteristic comprises at least one of viscosity, hematocrit, or density of the sample.
27. The method of aspect E24, in which the directing comprises driving first and second alternating signal at different respective frequencies in which a first frequency comprises a frequency than the second frequency.
28. The method of aspect E25, in which the first frequency is at least one order of magnitude lower than the second frequency.
29. The method of aspect E26, in which the first frequency comprises any frequency in the range of about 10kHz to about 90kHz.
30. The method of any one of aspect E1, aspect E2, or aspect E3, in which the obtaining comprises extracting from the first transient signal a second transient signal referenced with respect to the second sampling time duration

31. The method of any one of aspect E1, aspect E2, or aspect E3, in which the obtaining comprises removing signals from the first transient signals that are outside of the second sampling time duration to leave the second transient signal within the second sampling time duration.
32. The method of one of aspect E30 or aspect E31, in which the deriving comprises storing magnitudes of the second transient signal for each discrete intervals in the second sampling time duration.
33. An analyte measurement system comprising:  
a test strip including:  
a substrate;  
a plurality of electrodes disposed on the substrate and connected to respective electrode connectors; and  
an analyte meter including:  
a housing;  
a test strip port connector configured to connect to the respective electrode connectors of the test strip; and  
a microprocessor in electrical communication with the test strip port connector to apply electrical signals or sense electrical signals from the plurality of electrodes during a test sequence, the microprocessor is configured to: (a) apply a first electrical signal to the plurality of electrodes so that a physical characteristic of the sample is derived to provide a specific sampling time, (b) apply a second electrical signal to the plurality of electrodes, (c) measure a first transient output signal from the plurality of electrodes; (d) extract a second transient output signal from the first output signal; (e) determine a magnitude of the second transient output signal over at least 22 discrete time intervals; and (f) calculate the analyte concentration from the magnitudes of the second transient output signal at selected intervals of the at least 22 discrete time intervals.
34. An analyte measurement system comprising:  
a test strip including:

a substrate;

a plurality of electrodes disposed on the substrate and connected to respective electrode connectors; and

an analyte meter including:

a housing;

a test strip port connector configured to connect to the respective electrode connectors of the test strip; and

a microprocessor in electrical communication with the test strip port connector to apply electrical signals or sense electrical signals from the plurality of electrodes during a test sequence, the microprocessor is configured to: (a) apply a first electrical signal to the plurality of electrodes so that a physical characteristic of the sample is derived to provide a specific sampling time, (b) apply a second electrical signal to the plurality of electrodes, (c) measure a first transient output signal from the plurality of electrodes; (d) extract a second transient output signal from the first output signal; (e) determine a magnitude of the second transient output signal over at least 22 discrete time intervals; and (f) calculate the analyte concentration from the magnitudes of the second transient output signal at selected intervals of the at least 22 discrete time intervals to annunciate the analyte concentration within about 10 seconds of a start of the test sequence

35. The system of one of aspect E33 or aspect E34, in which the plurality of electrodes comprises at least two electrodes to measure the physical characteristic and at least two other electrodes to measure the analyte concentration.

36. The system of aspect E35, in which the at least two electrodes and the at least two other electrodes are disposed in the same chamber provided on the substrate.

37. The system of aspect E35, in which the at least two electrodes and the at least two other electrodes are disposed in different chambers provided on the substrate.

38. The system of aspect E37, in which the different chambers are disposed adjacent to each other on an edge of the substrate.

39. The system of aspect E35, in which the at least two electrodes and the other at least two

electrodes are disposed in a common chamber that receives a fluid sample.

40. The system of aspect E35, in which the at least two electrodes comprise two electrodes to measure the physical characteristic and the analyte concentration.

41. The system of one of aspects E33-40, in which all of the electrodes are disposed on the same plane defined by the substrate.

42. The system of one of aspects E33-40, in which a reagent is disposed proximate on the at least two other electrodes and no reagent is disposed on the at least two electrodes.

43. The system of aspect E33 or aspect E34, in which the specified sampling time is calculated using an equation of the form:

$$\text{SpecifiedSamplingTime} = x_1 H^{x_2} + x_3$$

where “*SpecifiedSamplingTime*” is designated as a time point from the start of the test sequence at which to sample the output signal of the test strip,

*H* represents physical characteristic of the sample in the form of hematocrit;

$x_1$  represents about  $4.3e5$ ;

$x_2$  represents about  $(- )3.9$ ; and

$x_3$  represents about 4.8.

44. The system of any one of aspects E33, E34, or E41, in which the microprocessor calculates the analyte concentration with an equation of the form:

$$G = \frac{\left(\frac{|I_3|}{|I_4|}\right)^{x_1} \times \left(\frac{|I_2| + x_4 |I_5| - x_5 |I_1|}{|I_2| + x_4 |I_5|} |I_5|\right) - x_2}{x_3}$$

where:

G comprises analyte concentration;  $I_1 \approx$  magnitude of second transient signal at interval 1;  $I_2$

$\approx$  magnitude of second transient signal at interval 13;  $I_3 \approx$  magnitude of second transient signal at interval 5;  $I_4 \approx$  magnitude of second transient signal at interval 3;  $I_5 \approx$  magnitude of second transient signal at interval 22;  $x_1 \approx 0.75$ ;  $x_2 \approx 337.27$ ;  $x_3 \approx (-)16.81$ ;  $x_4 \approx 1.41$ ; and  $x_5 \approx 2.67$ .

45. The system of any one of aspects E33, E34, or E44, in which the microprocessor calculates the analyte concentration with an equation of the form:

$$G = \frac{x_1(|I_1|)\left(x_2 - \frac{x_3}{|I_2|}\right) - x_4}{x_5}$$

where:

G comprises analyte concentration;  $I_1 \approx$  magnitude of second transient signal at interval 11;  $I_2 \approx$  magnitude of second transient signal at interval 7;  $x_1 \approx 0.59$ ;  $x_2 \approx 2.51$ ;  $x_3 \approx (-)12.74$ ;  $x_4 \approx (-)188.31$ ; and  $x_5 \approx 9.2$ .

46. The system of any one of aspects E33, E34, or E41, in which the microprocessor calculates the analyte concentration with an equation of the form:

$$G = \frac{x_1 \ln\left(x_2 \frac{|I_1|}{|I_2|}\right)^{x_3} |I_3|^{x_4} - x_5}{x_6}$$

where G comprises analyte concentration;  $I_1 \approx$  magnitude of second transient signal at interval 20;  $I_2 \approx$  magnitude of second transient signal at interval 22;  $I_3 \approx$  magnitude of second transient signal at interval 19;  $x_1 \approx 20.15$ ;  $x_2 \approx 1.0446$ ;  $x_3 \approx 0.95$ ;  $x_4 \approx 1.39$ ;  $x_5 \approx (-)0.71$ ;  $x_6 \approx 0.11$ .

47. The system of any one of aspects E33, E34, or E41, in which the microprocessor calculates the analyte concentration with an equation of the form:

$$G = \frac{x_3 \left| \frac{I_1}{I_2} \right|^{x_1 - x_2 \left| \frac{I_3}{I_4} \right|} \times |I_5| - x_5}{x_4}$$

where:

$I_1 \approx$  magnitude of second transient signal at interval 5;  $I_2 \approx$  magnitude of second transient signal at interval 1;  $I_3 \approx$  magnitude of second transient signal at interval 2;  $I_4 \approx$  magnitude of second transient signal at interval 10;  $I_5 \approx$  magnitude of second transient signal at interval 22;  $x_1 \approx 0.70$ ,  $x_2 \approx 0.49$ ,  $x_3 \approx 28.59$ ,  $x_4 \approx 0.7$ , and  $x_5 \approx 15.51$ .

48. The system of any one of aspects E33, E34, or E41, in which the microprocessor calculates the analyte concentration with an equation of the form:

$$G = \frac{\left( \left| \frac{I_1}{I_2} \right|^{x_1} \times \frac{x_2 |I_3|^2 + x_3 |I_3| + x_4}{x_5 |I_4| + x_6} \right) - x_7}{x_8}$$

where:

$G$  comprises glucose concentration;  $I_1 \approx$  magnitude of second transient signal at interval 19;  $I_2 \approx$  magnitude of second transient signal at interval 16;  $I_3 \approx$  magnitude of second transient signal at interval 11;  $I_4 \approx$  magnitude of second transient signal at interval 5;  $x_1 \approx (-)1.68$ ;  $x_2 \approx 0.95$ ;  $x_3 \approx (-)4.97$ ;  $x_4 \approx 6.29$ ;  $x_5 \approx 3.08$ ;  $x_6 \approx (-)5.84$ ;  $x_7 \approx (-)0.47$ ;  $x_8 \approx 0.01$ .

49. The system of any one of aspects E33, E34, or E41, in which the microprocessor calculates the analyte concentration with an equation of the form:

$$G = \frac{\left( \left| \frac{I_1}{I_2} \right|^{x_1} \times \frac{x_2 |I_3|^3 + x_3 |I_3|^2 + x_4 |I_3| + x_5}{x_6 |I_4|^2 + x_7 |I_4| + x_8} \right) - x_9}{x_{10}}$$

where:

$G$  comprises glucose concentration;  $I_1 \approx$  magnitude of second transient signal at interval 16;  $I_2$

$\approx$  magnitude of second transient signal at interval 5;  $I_3 \approx$  magnitude of second transient signal at interval 12;  $I_4 \approx$  magnitude of second transient signal at interval 14;  $x_1 \approx 1.18$ ;  $x_2 \approx 0.97$ ;  $x_3 \approx (-)11.32$ ;  $x_4 \approx 38.76$ ;  $x_5 \approx (-)39.32$ ;  $x_6 \approx 0.0928$ ;  $x_7 \approx (-)0.85$ ;  $x_8 \approx 1.75$ ;  $x_9 \approx (-)9.38$ ; and  $x_{10} \approx 0.25$ .

50. The system of any one of aspects E33, E34, or E41, in which the magnitude of the second transient signal at each of the plurality of discrete intervals comprises an average magnitude of the signal sampled throughout each interval.
51. The system of any one of aspects E33, E34, or E41, in which an error between a plurality of analyte concentrations calculated by the microprocessor is less than  $\pm 15\%$  as compared to referential value at 30% hematocrits.
52. The system of any one of aspects E33, E34, or E41, in which an error between the plurality of analyte concentrations calculated by the microprocessor is less than  $\pm 15\%$  as compared to referential value at 42% hematocrits.
53. The system of any one of aspects E33, E34, or E41, in which an error between a plurality of analyte concentrations calculated by the microprocessor is less than  $\pm 15\%$  as compared to referential value at 55% hematocrits.

#### Section "F"

The following aspects form part of the present disclosure:

1. A hand-held test meter for use with an analytical test strip in the determination of an analyte in a bodily fluid sample, the hand-held test meter comprising:  
a housing;

a microcontroller block disposed in the housing; and  
 a phase-shift-based hematocrit measurement block that includes:  
     a signal generation sub-block;  
     a low pass filter sub-block;  
     an analytical test strip sample cell interface sub-block;  
     a transimpedance amplifier sub-block; and  
     a phase detector sub-block,

wherein the phase-shift-based hematocrit measurement block and  
 microcontroller block are configured to measure the phase shift of a bodily fluid sample in a  
 sample cell of an analytical test strip inserted in the hand-held test meter, and

wherein the microcontroller block is configured to compute the hematocrit of  
 the bodily fluid based on the measured phase shift.

2. The hand-held test meter of aspect F1 wherein the phase-shift-based hematocrit  
 measurement block and microcontroller block are configured to measure the phase shift using  
 a signal of a first frequency and a second signal of a second frequency.

3. The hand-held test meter of aspect F2 wherein the bodily fluid sample is a  
 whole blood sample and wherein the first frequency is in the range of 10kHz to 25kHz and the  
 second frequency is in the range of 250kHz to 500kHz.

4. The hand-held test meter of aspect F1 wherein the phase detector sub-block is  
 configured as a rising edge capture phase detector.

5. The hand-held test meter of aspect F1 wherein the phase detector sub-block is  
 configured as a dual edge capture phase detector.

6. The hand-held test meter of aspect F1 wherein the phase detector sub-block is  
 configured as an XOR phase detector.

7. The hand-held test meter of aspect F1 wherein the phase detector sub-block is  
 configured as a synchronous modulation phase detector.

8. The hand-held test meter of aspect F1 further including a calibration load sub-block configured in parallel with the analytical test strip sample cell interface sub-block.
9. The hand-held test meter of aspect F1 wherein the signal generation sub-block is configured to generate at least a first electrical signal of a first frequency and a second electrical signal of a second frequency.
10. The hand-held test meter of aspect F1 wherein the phase-shift-based hematocrit measurement block and microcontroller block are configured to measure the phase shift of a bodily fluid sample in a sample cell of an analytical test strip inserted in the hand-held test meter by forcing a signal of known frequency through the bodily fluid sample and measuring the phase-shift of the signal.
11. The hand-held test meter of aspect F9 wherein the first frequency is in the range of 10kHz to 25kHz and the second frequency is in the range of 250kHz to 500kHz, and wherein the phase-shift-based hematocrit measurement block and microcontroller block are configured such that the signal of the first frequency is employed as a reference signal during the measurement of the phase shift of a bodily fluid sample.
12. The hand-held test meter of aspect F9 wherein the signal generation block is integrated with the microcontroller block.
13. The hand-held test meter of aspect F1 wherein the analytical test strip sample cell interface block is configured to operatively interface with the sample cell of the analytical test strip via a first electrode and as second electrode of the analytical test strip disposed in the sample cell.
14. The hand-held test meter of aspect F1 wherein the analytical test strip is an electrochemical-based analytical test strip configured for the determination of glucose in a whole blood sample.
15. The hand-held test meter of aspect F1 wherein the phase detector sub-block is configured as a Quadratur DEMUX phase detector.

16. A method for employing a hand-held test meter and analytical test strip, the method comprising:
- introducing a whole blood sample into a sample cell of an analytical test strip;
  - measuring a phase shift of the bodily fluid sample in the sample cell using a phase-shift-based measurement block and a microcontroller block of a hand-held test meter; and
  - computing the hematocrit of whole blood sample based on the measured phase shift using the microcontroller block.
17. The method of aspect F16 further including:
- determining an analyte in the introduced bodily fluid sample using the analytical test strip, hand-held test meter and computed hematocrit.
18. The method of aspect F17 wherein the analytical test strip is an electrochemical-based analytical test strip and the analyte is glucose.
19. The method of aspect F16 wherein the measuring step includes measuring the phase shift with a phase-shift based measurement circuit block that includes:
- a signal generation sub-block;
  - a low pass filter sub-block;
  - an analytical test strip sample cell interface sub-block;
  - a transimpedance amplifier sub-block; and
  - a phase detector sub-block.
20. The method of aspect F19 wherein the phase detector sub-block is configured as a rising edge capture phase detector.
21. The method of aspect F19 wherein the phase detector sub-block is configured as a dual edge capture phase detector.

22. The method of aspect F19 wherein the phase detector sub-block is configured as an XOR phase detector.
23. The method of aspect F19 wherein the phase detector sub-block is configured as a synchronous modulation phase detector.
24. The method of aspect F19 wherein the phase detector sub-block is configured as a Quadratur DEMUX phase detector.
25. The method of aspect F16 wherein the phase-shift-based hematocrit measurement block and microcontroller block are configured to measure the phase shift using a signal of a first frequency and a second signal of a second frequency.
26. The method of aspect F25 wherein the bodily fluid sample is a whole blood sample and wherein the first frequency is in the range of 10kHz to 25kHz and the second frequency is in the range of 250kHz to 500kHz.

## APPENDIX

The following appendix forms part of the present disclosure:

The disclosure below relates, in general, to medical devices and, in particular, to test meters and related methods.

The determination (e.g., detection and/or concentration measurement) of an analyte in a fluid sample is of particular interest in the medical field. For example, it can be desirable to determine glucose, ketone bodies, cholesterol, lipoproteins, triglycerides, acetaminophen and/or HbA1c concentrations in a sample of a bodily fluid such as urine, blood, plasma or interstitial fluid. Such determinations can be achieved using a hand-held test meter in combination with analytical test strips (e.g., electrochemical-based analytical test strips).

The novel features of the disclosure are set forth with particularity in aspects F. A better understanding of the features and advantages of the present disclosure will be obtained by reference to the following detailed description that sets forth illustrative embodiments, in which the principles of the disclosure are utilized, and the accompanying drawings, in which like numerals indicate like elements, of which:

FIG. 8 is a simplified depiction of a hand-held test meter according to an embodiment of the present disclosure;

FIG. 9 is a simplified block diagram of various blocks of the hand-held test meter of FIG. 8;

FIG. 10 is a simplified block diagram of a phase-shift-based hematocrit measurement block as can be employed in embodiments according to the present disclosure;

FIG. 11 is a simplified annotated schematic diagram of a dual low pass filter sub-block as can be employed in embodiments of the present disclosure;

FIG. 12 is a simplified annotated schematic diagram of a transimpedance amplifier (TIA) sub-block as can be employed in embodiments of the present disclosure;

FIG. 13 is a simplified annotated schematic block diagram depicting a dual low pass filter sub-block, a calibration load sub-block, an analytical test strip sample cell interface sub-block, a transimpedance amplifier sub-block, an XOR phase shift measurement sub-block and a Quadratur DEMUX phase-shift measurement sub-block as can be employed in a phase-shift-based hematocrit measurement block of embodiments of the present disclosure; and

FIG. 14 is a flow diagram depicting stages in a method for employing a hand-held test meter according to an embodiment of the present disclosure.

The following detailed description should be read with reference to the drawings, in which like elements in different drawings are identically numbered. The drawings, which are not necessarily to scale, depict exemplary embodiments for the purpose of explanation only and are not intended to limit the scope of the disclosure. The detailed description illustrates by way of example, not by way of limitation, the principles of the disclosure. This description will clearly enable one skilled in the art to make and use the disclosure, and describes several embodiments, adaptations, variations, alternatives and uses of the disclosure, including what is presently believed to be the best mode of carrying out the disclosure.

As used herein, the terms “about” or “approximately” for any numerical values or ranges indicate a suitable dimensional tolerance that allows the part or collection of components to function for its intended purpose as described herein.

In general, hand-held test meters for use with an analytical test strip in the determination of an analyte (such as glucose) in a bodily fluid sample (i.e., a whole blood sample) according to embodiments of the present disclosure include a housing, a microcontroller block disposed in the housing, and a phase-shift-based hematocrit measurement block (also referred to as a phase-shift-based hematocrit circuit). In such hand-held test meters, the phase-shift-based hematocrit measurement block includes a signal generation sub-block, a low pass filter sub-block, an analytical test strip sample cell interface sub-block, a transimpedance amplifier sub-block, and a phase detector sub-block. In addition, the phase-shift-based hematocrit measurement block and microcontroller block are configured

to measure the phase shift of a bodily fluid sample in a sample cell of an analytical test strip inserted in the hand-held test meter and the microcontroller block is also configured to compute the hematocrit of the bodily fluid sample based on the measured phase shift.

Hand-held test meters according to embodiments of the present disclosure are beneficial in that they provide improved accuracy of analyte determination (such as glucose determination) in whole blood samples by measuring the hematocrit of the whole blood sample and then employing the measured hematocrit during analyte determination.

Once one skilled in the art is apprised of the present disclosure, he or she will recognize that an example of a hand-held test meter that can be readily modified as a hand-held test meter according to the present disclosure is the commercially available OneTouch® Ultra® 2 glucose meter from LifeScan Inc. (Milpitas, California). Additional examples of hand-held test meters that can also be modified are found in U.S. Patent Application Publications No's. 2007/0084734 (published on April 19, 2007) and 2007/0087397 (published on April 19, 2007) and in International Publication Number WO2010/049669 (published on May 6, 2010).

FIG. 8 is a simplified depiction of a hand-held test meter 100 according to an embodiment of the present disclosure. FIG. 9 is a simplified block diagram of various blocks of hand-held test meter 100. FIG. 10 is a simplified combined block diagram of a phase-shift-based hematocrit measurement block of hand-held test meter 100. FIG. 11 is a simplified annotated schematic diagram of a dual low pass filter sub-block of hand-held test meter 100. FIG. 12 is a simplified annotated schematic diagram of a transimpedance amplifier sub-block of hand-held test meter 100. FIG. 13 is a simplified annotated schematic block diagram of portions of a phase-shift-based hematocrit measurement block of hand-held test meter 100.

Referring to FIGs. 8 through 13, hand-held test meter 100 includes a display 102, a plurality of user interface buttons 104, a strip port connector 106, a USB interface 108, and a housing 110 (see FIG. 8). Referring to FIG. 9 in particular, hand-held test meter 100 also includes a microcontroller block 112, a phase-shift-based hematocrit measurement block 114, a display control block 116, a memory block 118 and other electronic components (not shown) for applying a test voltage to analytical test strip (labeled TS in FIG. 8), and also for

measuring an electrochemical response (e.g., plurality of test current values) and determining an analyte based on the electrochemical response. To simplify the current descriptions, the figures do not depict all such electronic circuitry.

Display 102 can be, for example, a liquid crystal display or a bi-stable display configured to show a screen image. An example of a screen image may include a glucose concentration, a date and time, an error message, and a user interface for instructing an end user how to perform a test.

Strip port connector 106 is configured to operatively interface with an analytical test strip TS, such as an electrochemical-based analytical test strip configured for the determination of glucose in a whole blood sample. Therefore, the analytical test strip is configured for operative insertion into strip port connector 106 and to operatively interface with phase-shift-based hematocrit measurement block 114 via, for example, suitable electrical contacts.

USB Interface 108 can be any suitable interface known to one skilled in the art. USB Interface 108 is essentially a passive component that is configured to power and provide a data line to hand-held test meter 100.

Once an analytical test strip is interfaced with hand-held test meter 100, or prior thereto, a bodily fluid sample (e.g., a whole blood sample) is introduced into a sample chamber of the analytical test strip. The analytical test strip can include enzymatic reagents that selectively and quantitatively transform an analyte into another predetermined chemical form. For example, the analytical test strip can include an enzymatic reagent with ferricyanide and glucose oxidase so that glucose can be physically transformed into an oxidized form.

Memory block 118 of hand-held test meter 100 includes a suitable algorithm and can be configured, along with microcontroller block 112 to determine an analyte based on the electrochemical response of analytical test strip and the hematocrit of the introduced sample. For example, in the determination of the analyte blood glucose, the hematocrit can be used to compensate for the effect of hematocrit on electrochemically determined blood glucose concentrations.

Microcontroller block 112 is disposed within housing 110 and can include any suitable microcontroller and/or micro-processor known to those of skill in the art. One such suitable microcontroller is a microcontroller commercially available from Texas Instruments, Dallas, TX USA and part number MSP430F5138. This microcontroller can generate a square wave of 25 to 250kHz and a 90 degree phase-shifted wave of the same frequency and, thereby, function as a signal generation s-block described further below. MSP430F5138 also has Analog-to-Digital (A/D) processing capabilities suitable for measuring voltages generated by phase shift based hematocrit measurement blocks employed in embodiments of the present disclosure.

Referring in particular to FIG. 10, phase-shift-based hematocrit measurement block 114 includes a signal generation sub-block 120, a low pass filter sub-block 122, an analytical test strip sample cell interface sub-block 124, an optional calibration load block 126 (within the dashed lines of FIG. 10), a transimpedance amplifier sub-block 128, and a phase detector sub-block 130.

As described further below, phase-shift-based hematocrit measurement block 114 and microcontroller block 112 are configured to measure the phase shift of a bodily fluid sample in a sample cell of an analytical test strip inserted in the hand-held test meter by, for example, measuring the phase shift of one or more high frequency electrical signals driven through the bodily fluid sample. In addition, microcontroller block 112 is configured to compute the hematocrit of the bodily fluid based on the measured phase shift. Microcontroller 112 can compute the hematocrit by, for example, employing an A/D converter to measure voltages received from a phase-detector sub-block, convert the voltages into a phase-shift and then employing a suitable algorithm or look-up table to convert the phase-shift into a hematocrit value. Once apprised of the present disclosure, one skilled in the art will recognize that such an algorithm and/or look-up table will be configured to take into account various factors such as strip geometry (including electrode area and sample chamber volume) and signal frequency.

It has been determined that a relationship exists between the reactance of a whole blood sample and the hematocrit of that sample. Electrical modeling of a bodily fluid

sample (i.e., a whole blood sample) as parallel capacitive and resistive components indicates that when an alternating current (AC) signal is forced through the bodily fluid sample, the phase shift of the AC signal will be dependent on both the frequency of the AC voltage and the hematocrit of the sample. Moreover, modeling indicates that hematocrit has a relatively minor effect on the phase shift when the frequency of the signal is in the range of approximately 10kHz to 25kHz and a maximum effect on the phase shift when the frequency of the signal is in the range of approximately 250 kHz to 500kHz. Therefore, the hematocrit of a bodily fluid sample can be measured by, for example, driving AC signals of known frequency through the bodily fluid sample and detecting their phase shift. For example, the phase-shift of a signal with a frequency in the range of 10kHz to 25kHz can be used as a reference reading in such a hematocrit measurement while the phase shift of a signal with a frequency in the range of 250 kHz to 500kHz can be used as the primary measurement.

Referring to FIGs. 10 through 13 in particular, signal generation sub-block 120 can be any suitable signal generation block and is configured to generate a square wave (0V to Vref) of a desired frequency. Such a signal generation sub-block can, if desired, be integrated into microcontroller block 112.

The signal generated by signal generation sub-block 120 is communicated to dual low pass filter sub-block 122, which is configured to convert the square wave signal to a sine wave signal of a predetermined frequency. The dual LPF of FIG. 11 is configured to provide both a signal of a first frequency (such as a frequency in the range of 10kHz to 25kHz) and a signal of a second frequency (such as a frequency in the range of 250 kHz to 500kHz) to the analytical test strip sample cell interface sub-block and an analytical test strips' sample chamber (also referred to as the HCT measurement cell). Selection of the first and second frequency is accomplished using switch IC7 of FIG. 11. The dual LPF of FIG. 11 includes employs two suitable operational amplifiers (IC4 and IC5) such as the operational amplifier available from Texas Instruments, Dallas, Texas, USA as high-speed, voltage feedback, CMOS operational amplifier part number OPA354.

Referring to FIG. 11, F-DRV represents a square wave input of either a low or high frequency (e.g., 25kHz or 250 kHz) and is connected to both IC4 and IC5. Signal Fi-HIGH/LOW (from the microcontroller) selects the output of dual low pass filter sub-block 122

via switch IC7. C5 in FIG. 11 is configured to block the operating voltage of dual low pass filter sub-block 122 from the HCT measurement cell.

Although a specific dual LPF is depicted in FIG. 11, dual low pass filter sub-block 122 can be any suitable low pass filter sub-block known to one skilled in the art including, for example, any suitable multiple feedback low pass filter, or a Sallen and Key low pass filter.

The sine wave produced by low pass filter sub-block 122 is communicated to analytical test strip sample cell interface sub-block 124 where it is driven across the sample cell of the analytical test strip (also referred to as an HCT measurement cell). Analytical test strip sample cell interface block 124 can be any suitable sample cell interface block including, for example, an interface block configured to operatively interface with the sample cell of the analytical test strip via first electrode and second electrodes of the analytical test strip disposed in the sample cell. In such a configuration, the signal can be driven into the sample cell (from the low pass filter sub-block) via the first electrode and picked-up from the sample cell (by the transimpedance amplifier sub-block) via the second electrode as depicted in FIG. 13.

The current produced by driving the signal across the sample cell is picked-up by transimpedance amplifier sub-block 128 and converted into a voltage signal for communication to phase detector sub-block 130.

Transimpedance sub-block 128 can be any suitable transimpedance sub-block known to one skilled in the art. FIG. 12 is a simplified annotated schematic block diagram of one such transimpedance amplifier sub-block (based on two OPA354 operational amplifiers, IC3 and IC9). The first stage of TIA sub-block 128 operates at, for example, 400mV, which limits the AC amplitude to +/-400mV. The second stage of TIA sub-block 128 operates at  $V_{ref}/2$ , a configuration which enables the generation of an output of the full span of the microcontroller A/D inputs. C9 of TIA sub-block 128 serves as a blocking component that only allows an AC sine wave signal to pass.

Phase detector sub-block 130 can be any suitable phase detector sub-block that produces either a digital frequency that can be read back by microcontroller block 112 using a

capture function, or an analog voltage that can be read back by microcontroller block 112 using an analog to digital converter. FIG. 13 depicts a schematic that includes two such phase detector sub-blocks, namely an XOR phase detector (in the upper half of FIG. 13 and including IC22 and IC23) and a Quadrature DEMUX phase detector (in the lower half of FIG. 13 and including IC12 and IC13).

FIG. 13 also depicts a calibration load sub-block 126 that includes a switch (IC16) and a dummy load R7 and C6. Calibration load sub-block 126 is configured for the dynamic measurement of a phase offset for the known phase shift of zero degrees produced by resistor R7, thus providing a phase offset for use in calibration. C6 is configured to force a predetermined slight phase shift, e.g. to compensate for phase delays caused by parasitic capacities in the signal traces to the sample cell, or for phase delays in the electrical circuits (LPF and TIA).

The Quadrature DEMUX phase detector circuit of FIG. 13 includes two portions, one portion for a resistive part of the incoming AC signal and one portion for the reactive portion of the incoming AC signal. Use of such two portions enables the simultaneous measurement of both the resistive and reactive portion of the AC signal and a measurement range that covers 0 degrees to 360 degrees. The Quadrature DEMUX circuit of FIG. 13 generates two separate output voltages. One of these output voltages represents the “in phase measurement” and is proportional to the “resistive” part of the AC signal, the other output voltage represents the “Quadrature Measurement” and is proportional to the “reactive part of the signal. The phase shift is calculated as:

$$\Phi = \tan^{-1}(V_{\text{QUAD-PHASE}} / V_{\text{IN-PHASE}})$$

Such a Quadrature DEMUX phase detector circuit can also be employed to measure the impedance of a bodily fluid sample in the sample cell. It is hypothesized, without being bound, that the impedance could be employed along with the phase-shift, or independently thereof, to determine the hematocrit of the bodily sample. The amplitude of a signal forced through the sample cell can be calculated using the two voltage outputs of the Quadrature DEMUX circuit as follows :

$$\text{Amplitude} = \text{SQR} ((V_{\text{QUAD-PHASE}})^2 + (V_{\text{IN-PHASE}})^2)$$

This amplitude can then be compared to an amplitude measured for the known resistor of calibration load block 126 to determine the impedance.

The XOR phase detector portion has a measurement range of 0° to 180°, or alternatively a measurement range of -90° to +90°, depending whether the “Square wave input from  $\mu\text{C}$ ” is in phase to the sine wave or is set to a 90° phase shift. The XOR phase detector produces an output frequency that is always double the input frequency, however the duty cycle varies. If both inputs are perfectly in phase, the output is LOW, if both inputs are 180° shifted the output is always HIGH. By integrating the output signal (e.g. via a simple RC element) a voltage can be generated that is directly proportional to the phase shift between both inputs.

Once apprised of the present disclosure, one skilled in the art will recognize that phase detector sub-blocks employed in embodiments of the present disclosure can take any suitable form and include, for example, forms that employ rising edge capture techniques, dual edge capture techniques, XOR techniques and synchronous demodulation techniques.

Since low pass filter sub-block 122, transimpedance amplifier sub-block 128 and phase detector sub-block 130 can introduce a residual phase shift into phase-shift-based hematocrit measurement block 114, calibration load block 126 can be optionally included in the phase-shift-based hematocrit measurement block. Calibration load block 126 is configured to be essentially resistive in nature (for example a 33k-ohm load) and, therefore, induces no phase shift between excitation voltage and generated current. Calibration load block 126 is configured to be switched in across the circuit to give a “zero” calibration reading. Once calibrated, the hand-held test meter can measure the phase shift of a bodily fluid sample, subtract the “zero” reading to compute a corrected phase shift and subsequently compute the bodily sample hematocrit based on the corrected phase shift.

FIG. 14 is a flow diagram depicting stages in a method 200 for employing a hand-held test meter and analytical test strip (e.g., an electrochemical-based analytical test

strip). Method 200, at step 210, includes introducing a whole blood sample into a sample cell of the analytical test strip.

At step 220, a phase shift of the whole blood sample in the sample cell is measured using a phase-shift-based measurement block and a microcontroller block of a hand-held test meter. Method 200 further includes computing the hematocrit of whole blood sample based on the measured phase shift using the microcontroller block (see step 230 of FIG. 14).

Once apprised of the present disclosure, one skilled in the art will recognize that methods according to embodiments of the present disclosure, including method 200, can be readily modified to incorporate any of the techniques, benefits and characteristics of hand-held test meters according to embodiments of the present disclosure and described herein. For example, if desired, an analyte in the introduced bodily fluid sample using the analytical test strip, hand-held test meter and computed hematocrit.

## CLAIMS

1. A method of determining an analyte concentration from a fluid sample with a test strip having at least two electrodes and a reagent disposed on at least one electrode of the electrodes, the method comprising:

a) depositing a fluid sample on any one of the at least two electrodes to start an analyte test sequence;

b) applying a first signal to the sample to derive a physical characteristic of the sample;

c) obtaining a physical characteristic of the sample;

d) specifying a sampling time based on the obtained physical characteristic;

e) driving a second signal to the sample, wherein the second signal is applied from the start of the analyte test sequence; and

f) measuring an output signal at the specified sampling time from at least one electrode of the at least two electrodes;

g) calculating an analyte concentration based on the measured output signal, wherein

h) the specified sampling time is calculated using either:

i) an equation of the form:

$$\textit{SpecifiedSamplingTime} = x_1 H^{x_2} + x_3$$

where

"*SpecifiedSamplingTime*" is designated as a time point in seconds from the start of the test sequence at which to sample the output signal of the test strip, in which

*H* represents the physical characteristic of the sample, which is the hematocrit level of the sample expressed as whole percentages;

$x_1$  is  $4.3 \times 10^5(\text{s}) \pm 10\%$ ;

$x_2$  is  $-3.9 \pm 10\%$ ; and

$x_3$  is  $4.8 (\text{s}) \pm 10\%$ , or

ii) the specified sampling time is looked up in look-up Table 1,

wherein the specified sampling time is designated as a time point in seconds from the start of the test sequence at which to sample the output signal of the test strip:

Table 1

| Physical Characteristic | Sampling Time T (seconds) |
|-------------------------|---------------------------|
| 30                      | 5.56                      |
| 31                      | 5.46                      |
| 32                      | 5.38                      |
| 33                      | 5.32                      |
| 34                      | 5.26                      |
| 35                      | 5.2                       |
| 36                      | 5.16                      |
| 37                      | 5.12                      |
| 38                      | 5.08                      |
| 39                      | 5.06                      |
| 40                      | 5.02                      |
| 41                      | 5                         |
| 42                      | 5                         |
| 43                      | 4.98                      |
| 44                      | 4.96                      |
| 45                      | 4.96                      |
| 46                      | 4.94                      |
| 47                      | 4.92                      |
| 48                      | 4.92                      |
| 49                      | 4.9                       |
| 50                      | 4.9                       |
| 51                      | 4.9                       |
| 52                      | 4.88                      |
| 53                      | 4.88                      |
| 54                      | 4.88                      |
| 55                      | 4.86                      |

and wherein the physical characteristic comprises hematocrit and the analyte is glucose.

2. The method of claim 1, in which the applying of the first signal and the driving of the second signal is in sequential order.
3. The method of claim 1, in which the applying of the first signal overlaps with the driving of the second signal.

4. The method of claim 1, in which the applying of the first signal comprises directing an alternating signal to the sample so that the physical characteristic of the sample is determined from an output of the alternating signal.
5. The method of claim 1, in which the applying of the first signal comprises directing an optical signal to the sample so that the physical characteristic of the sample is determined from an output of the optical signal.
6. The method of claim 4, in which the directing comprises driving first and second alternating signal at different respective frequencies in which a first frequency is lower than a second frequency.
7. The method of claim 6, in which the first frequency is at least one order of magnitude lower than the second frequency.
8. The method of claim 6 or claim 7, in which the first frequency comprises any frequency in the range of 10kHz to 250kHz.
9. The method of any one of claims 1 to 8, in which the calculating of the analyte concentration is computed with an equation of the form:

$$G_0 = \left[ \frac{I_E - \text{Intercept}}{\text{Slope}} \right]$$

where

$G_0$  represents an analyte concentration

$I_E$  represents, or is, a signal value or measurement proportional to analyte concentration measured at the *SpecifiedSamplingTime*, quoted in nA;

Slope represents the value obtained from calibration testing of a batch of test strips of which this particular test strip comes from, quoted in nA(mg/dL); and

Intercept represents the value obtained from calibration testing of a batch of test strips of which this particular test strip comes from, quoted in nA.

10. A method according to any one of claims 1-8, the method further comprising:  
deriving a batch slope for the test strip based on the physical characteristic from the obtaining step,  
wherein the calculating of the analyte concentration is based on the measured output signal at the specified sampling time and the derived batch slope,  
wherein the test strip is from a batch of test strips and the batch slope is defined as the measured or derived gradient of the line of best fit for a graph of measured glucose concentration plotted against actual glucose concentration for the batch of test strips.
11. The method of claim 10, in which the derived slope is determined from an equation of the form:

$$NewSlope = aH^2 + bH + c$$

where

*NewSlope* represents the derived slope;

*H* is measured or estimated physical characteristic;

*a* is  $1.4 \times 10^{-6}$  +/- 10%,

*b* is  $-3.8 \times 10^{-4}$  +/- 10%,

*c* is  $3.6 \times 10^{-2}$  +/- 10%.

12. The method of claim 11, in which the calculating of the analyte concentration is computed with an equation of the form:

$$G_0 = \left[ \frac{I_E - Intercept}{NewSlope} \right]$$

where

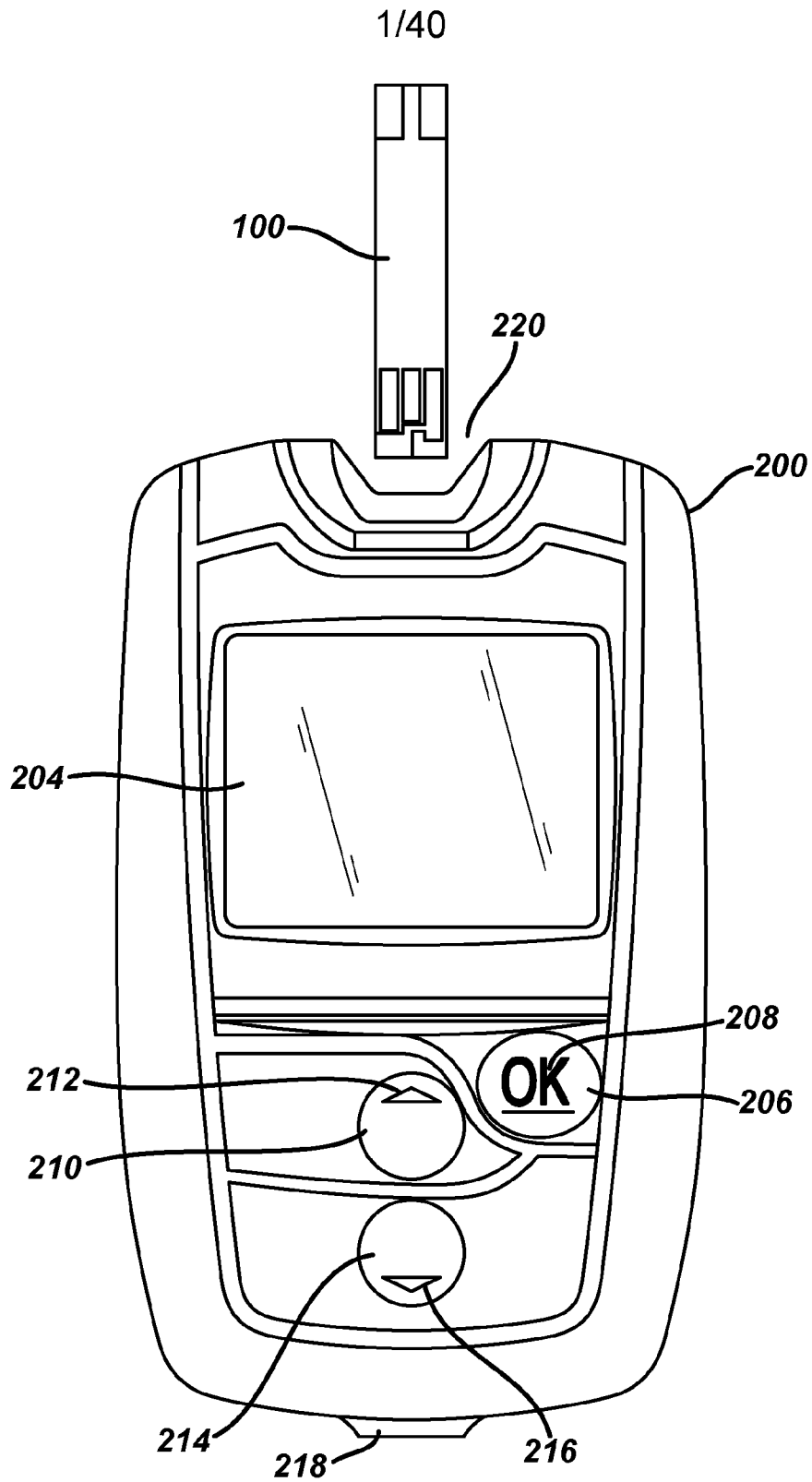
$G_0$  represents an analyte concentration

$I_E$  represents a signal proportional to analyte concentration measured at the *SpecifiedSamplingTime*, quoted in nA;

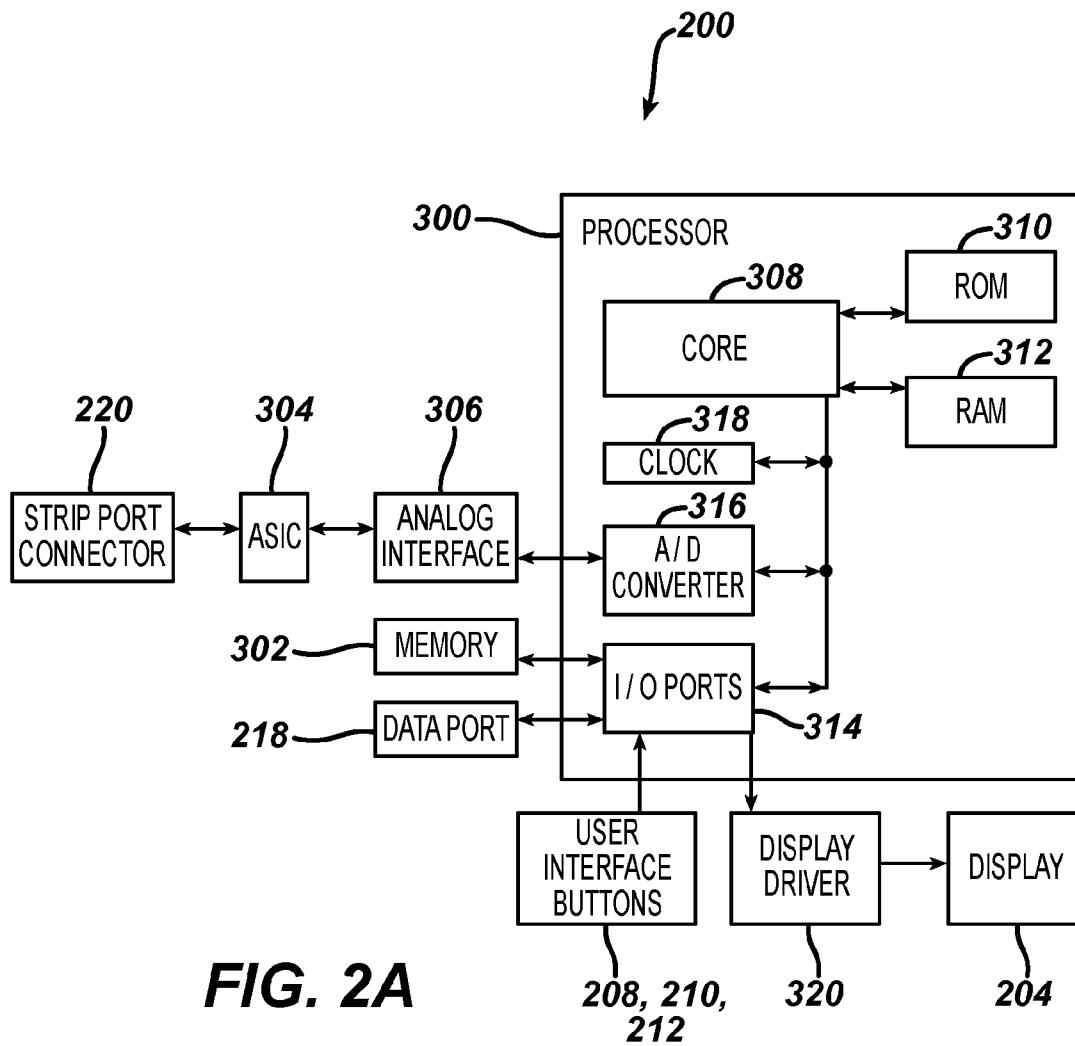
*NewSlope* represents the value derived from the measured or estimated physical characteristic, quoted in nA/(mg/dL); and

Intercept represents the value obtained from calibration testing of the batch of test strips of which this particular strip comes from, quoted in nA.

13. A glucose meter comprising:
  - a housing;
  - a test strip port connector configured to connect to respective electrode connectors of a test strip; and
  - a processor programmed to perform steps b) to g) of the method of any one of claims 1 to 12.
14. The meter of claim 13, wherein the processor configured to perform steps b) to g) of the method of any one of claims 1 to 12 is further configured to determine the analyte concentration of the sample based on the specific sampling time within 10 seconds of a start of the test sequence.
15. A glucose measurement system comprising:
  - a glucose meter comprising:
    - a housing; and
    - a test strip port connector configured to connect to respective electrode connectors of a test strip; and
  - a processor programmed to perform steps b) to g) of the method of any one of claims 1 to 12.
16. The glucose measurement system of claim 15, further comprising
  - a test strip including:
    - a substrate; and
    - a plurality of electrodes connected to respective electrode connectors.

**FIG. 1**

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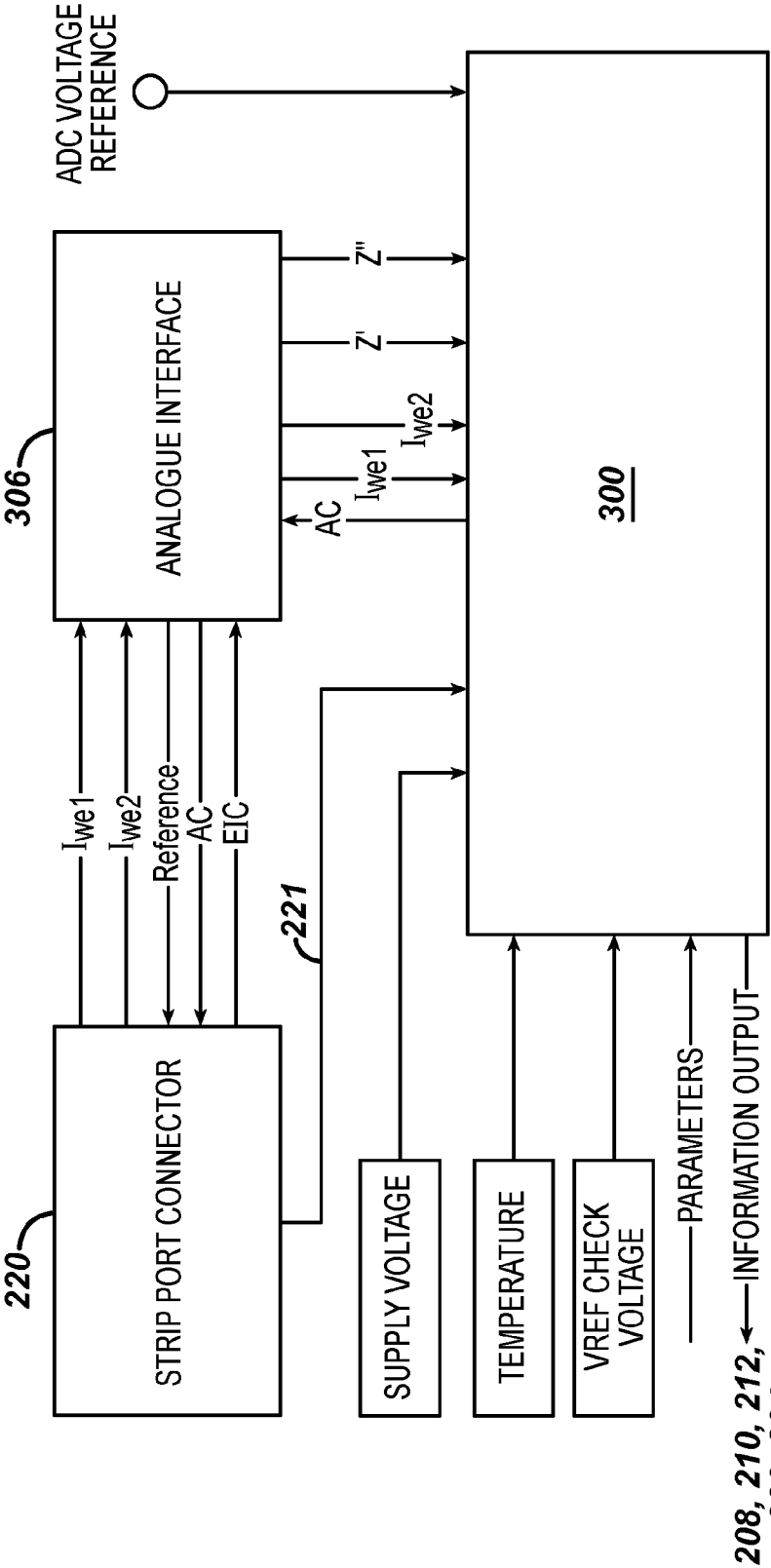
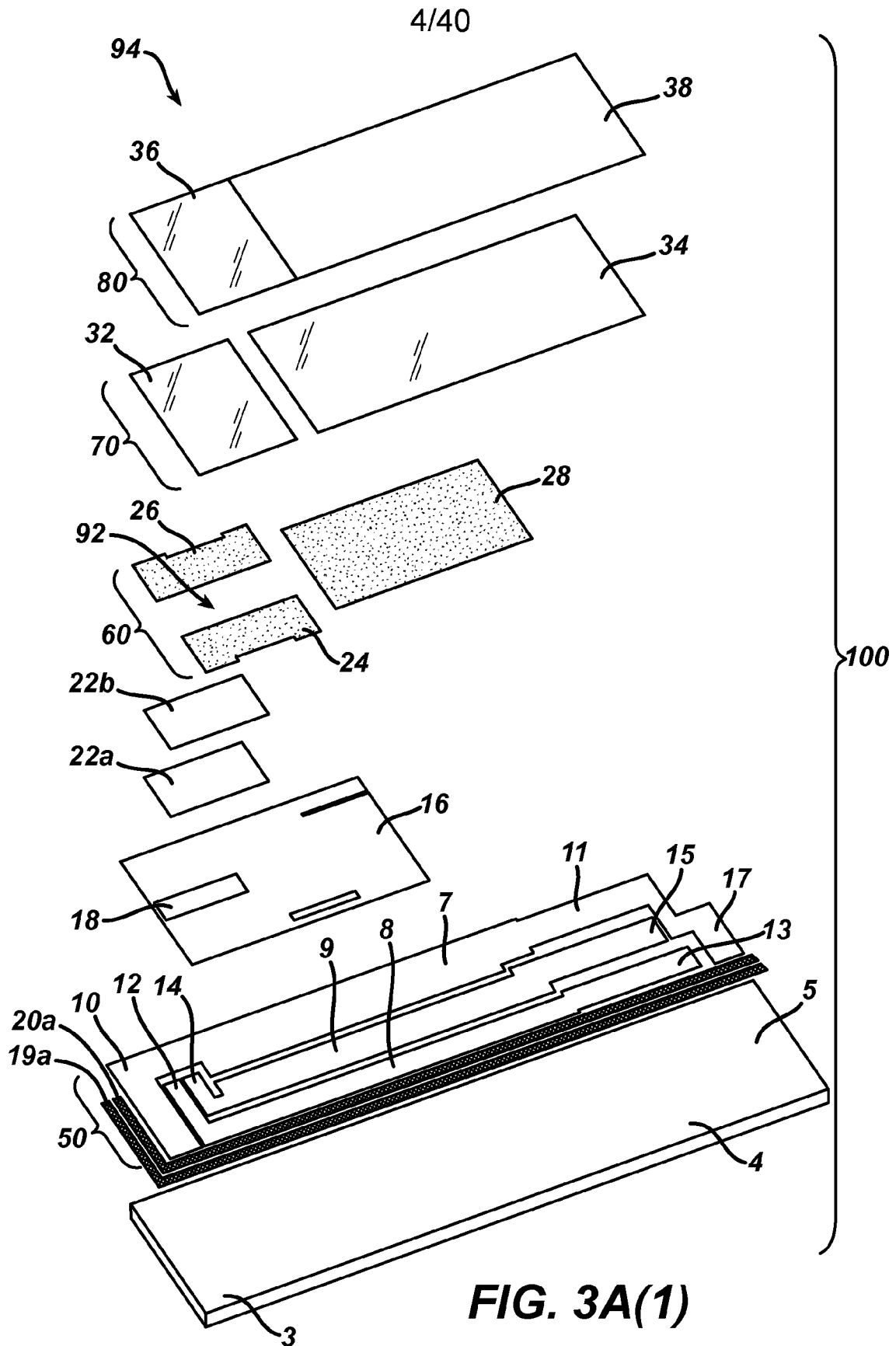
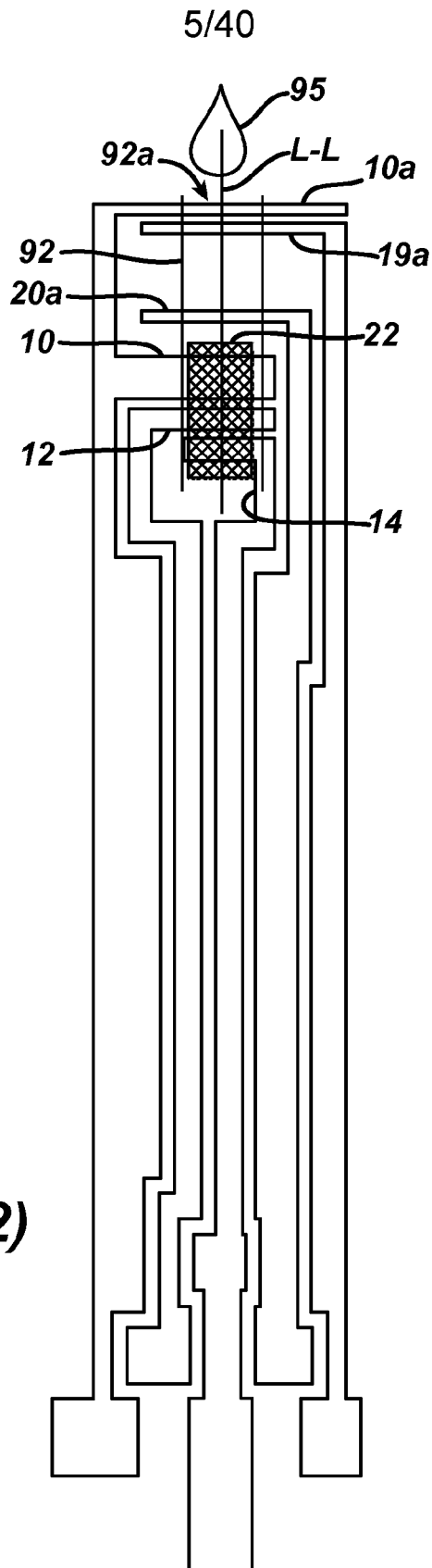
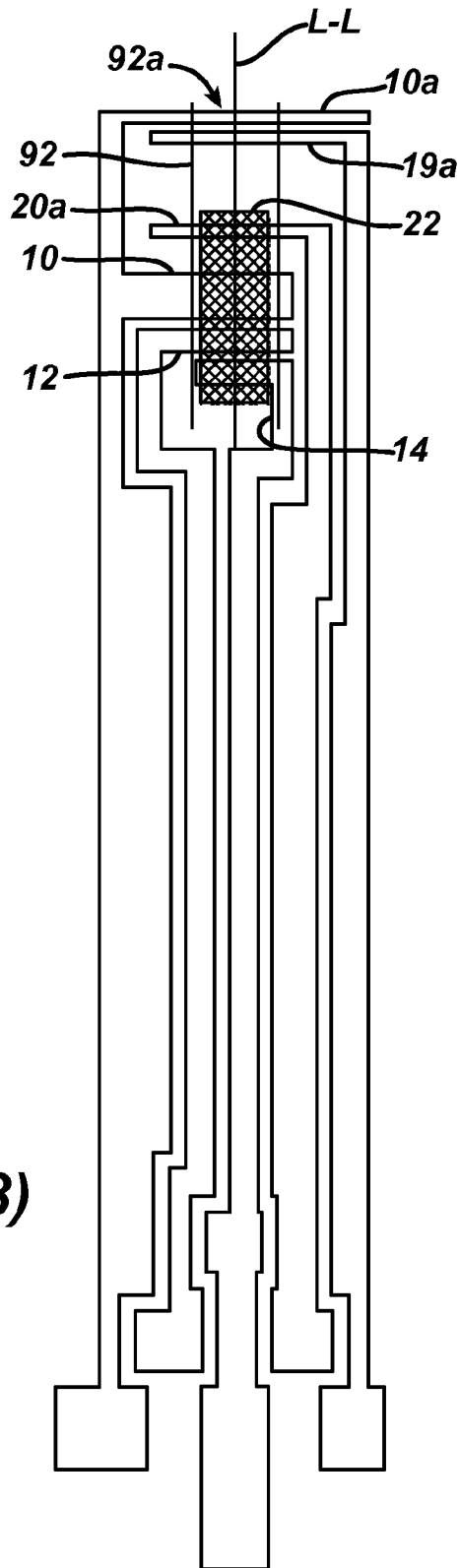


FIG. 2B

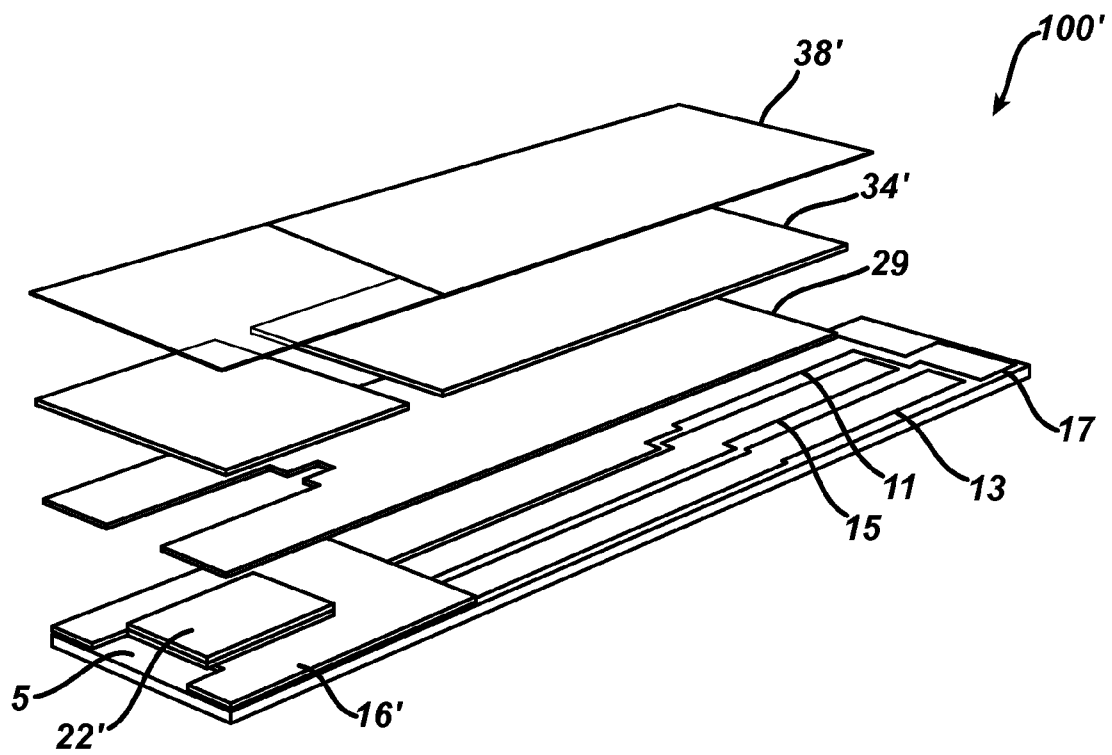


**FIG. 3A(2)**

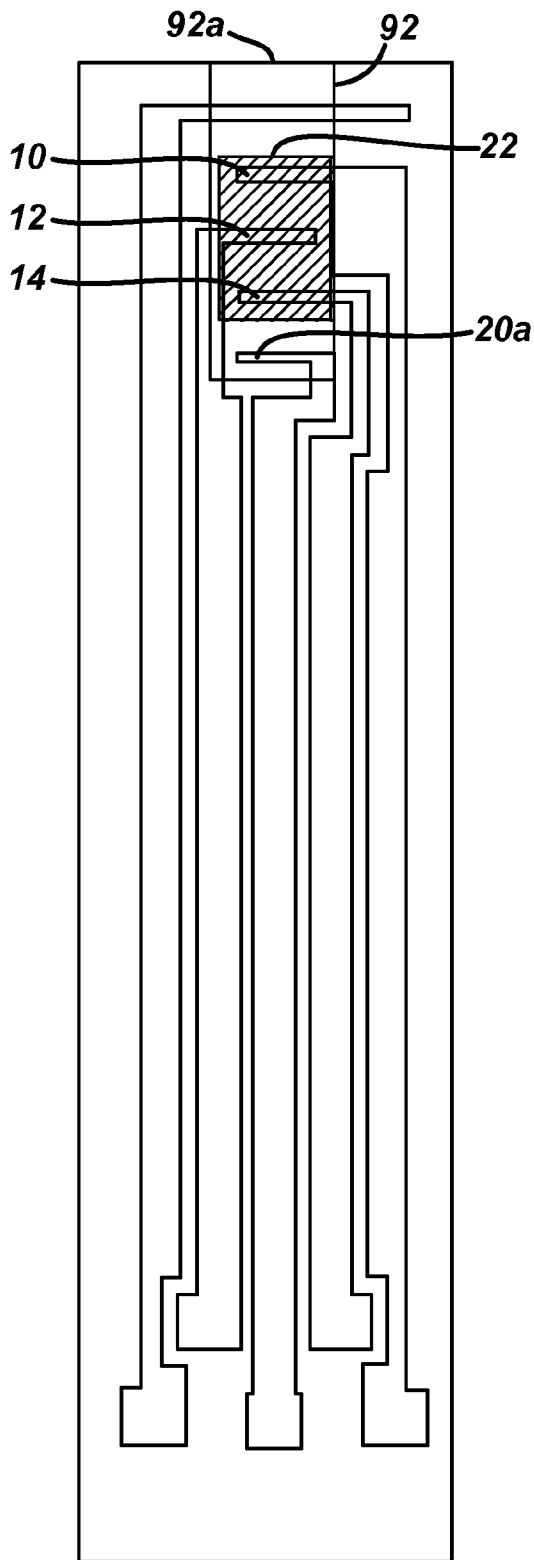
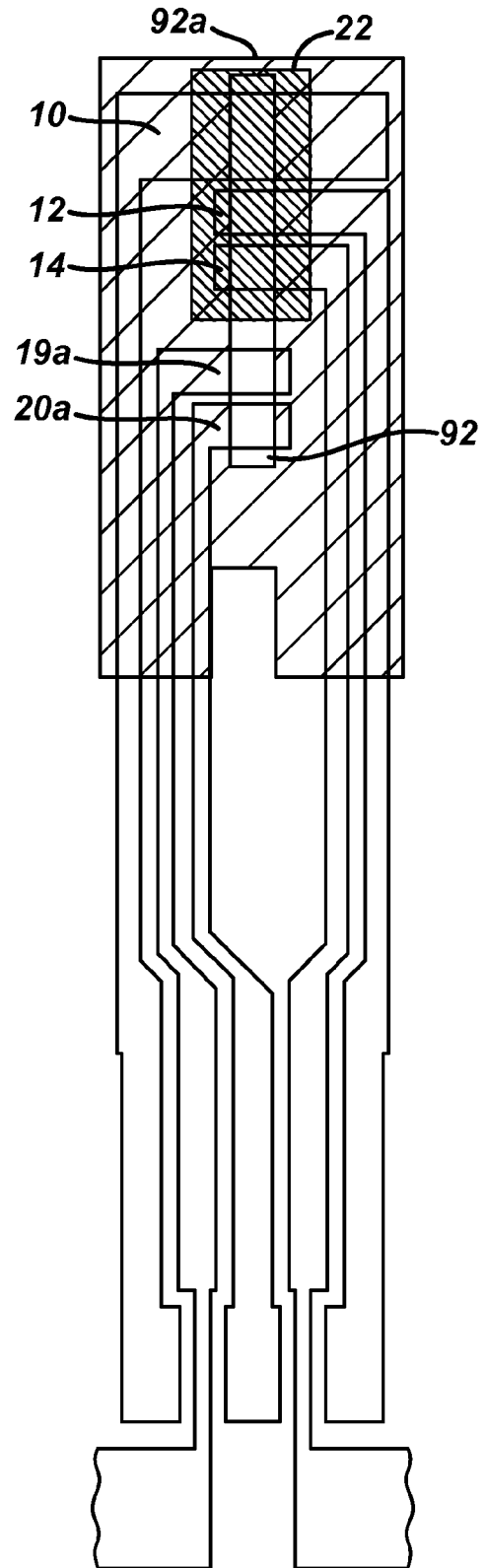
6/40

**FIG. 3A(3)**

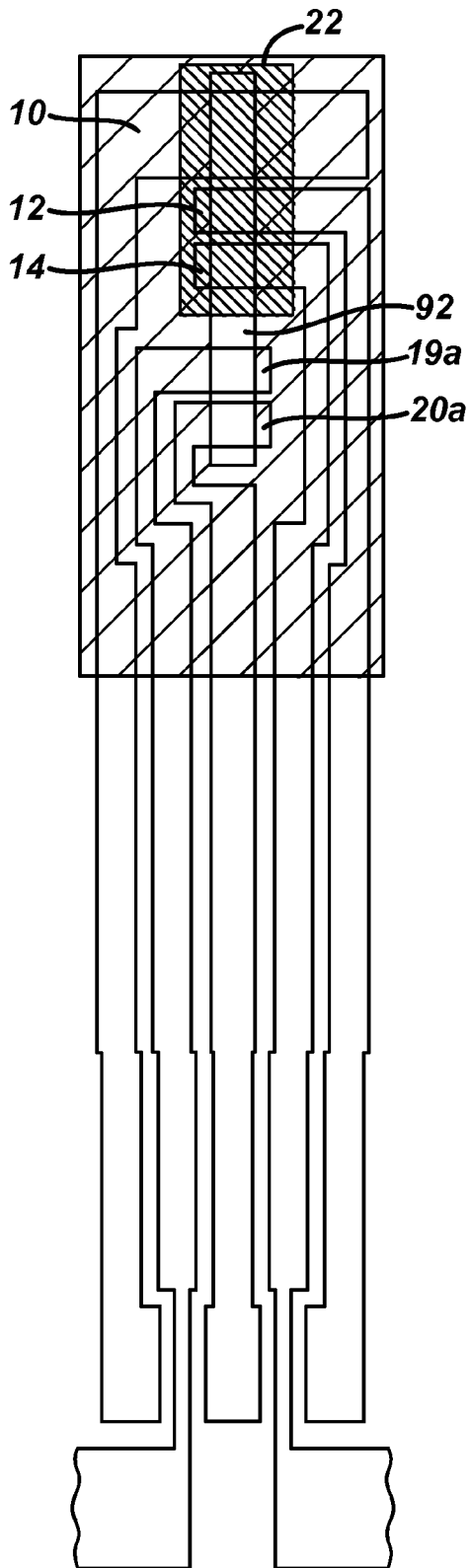
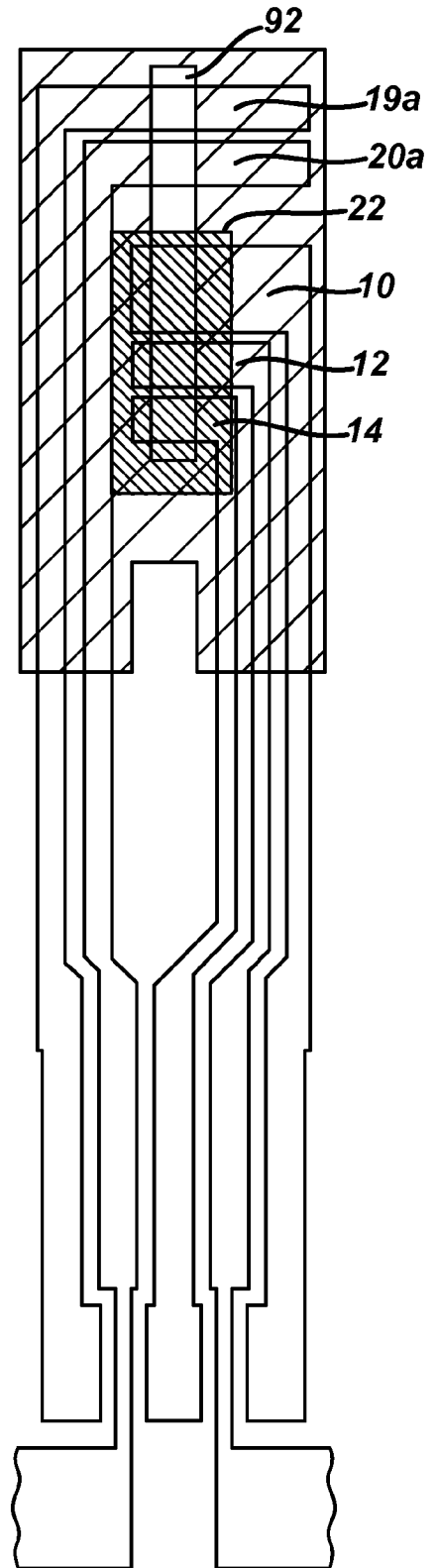
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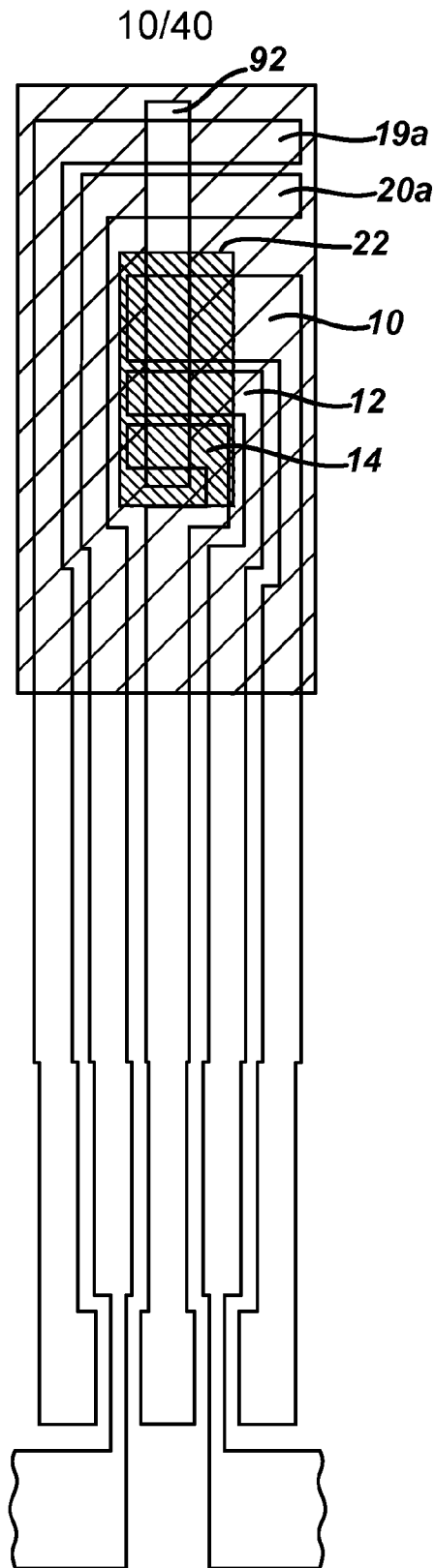
**FIG. 3A(4)**

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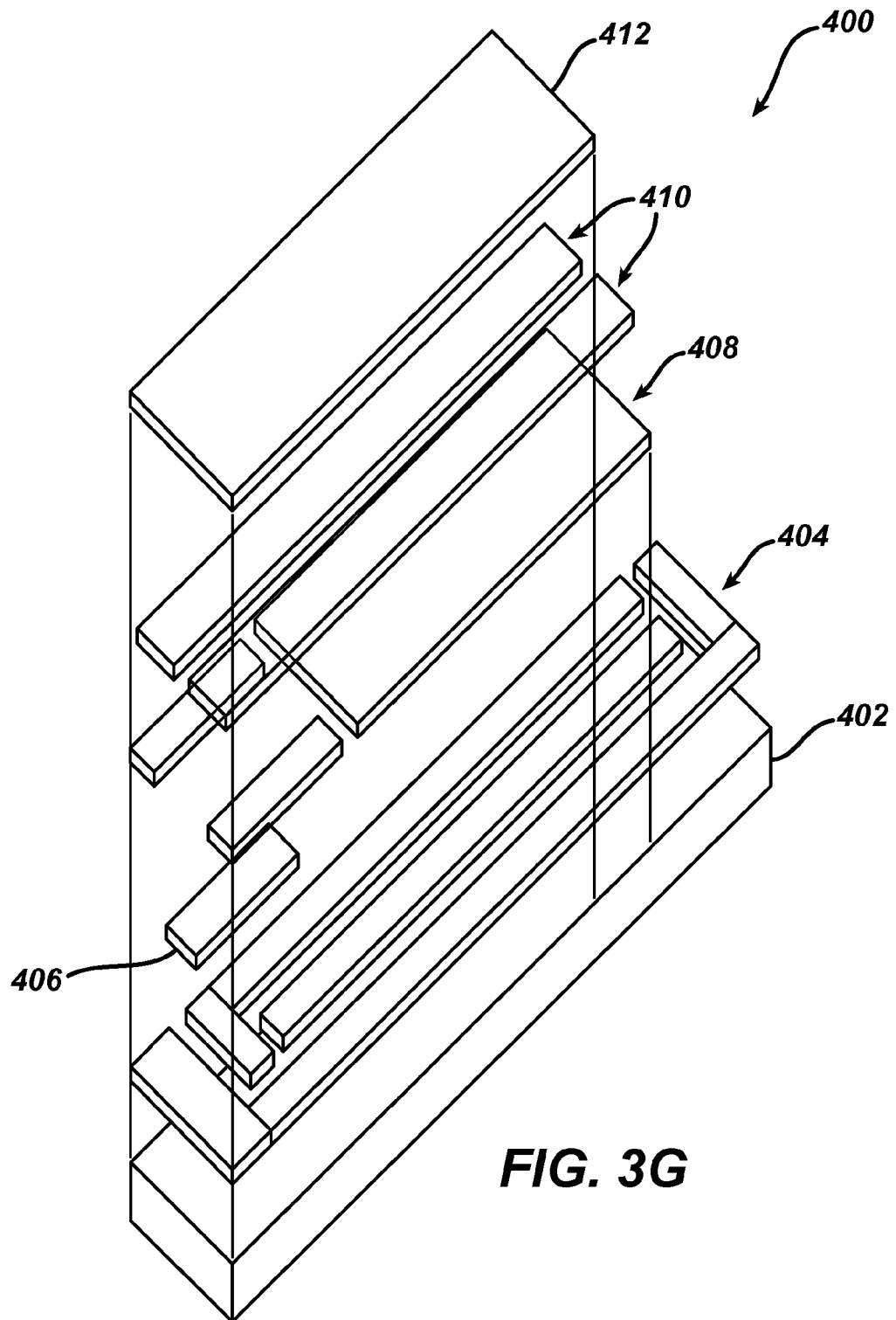
**FIG. 3B****FIG. 3C**

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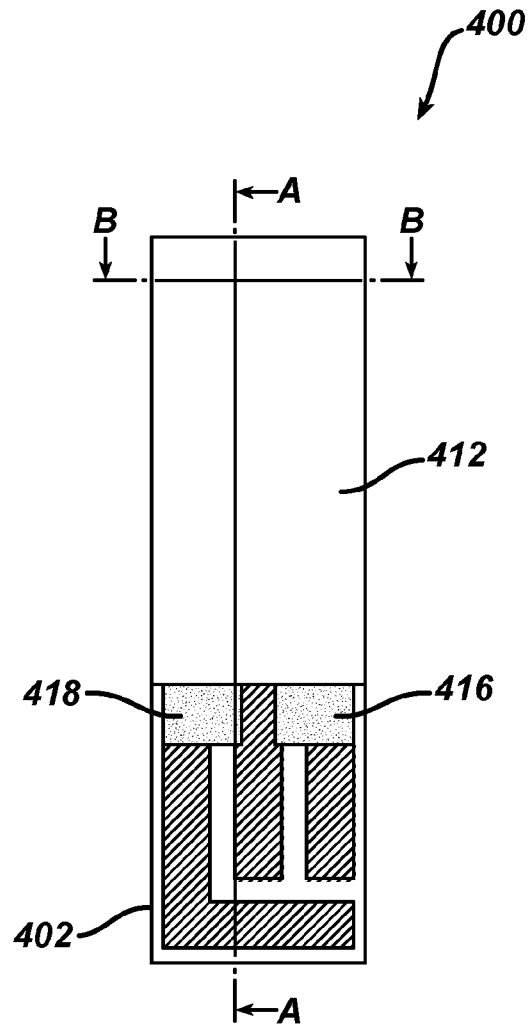
**FIG. 3D****FIG. 3E**

**FIG. 3F**

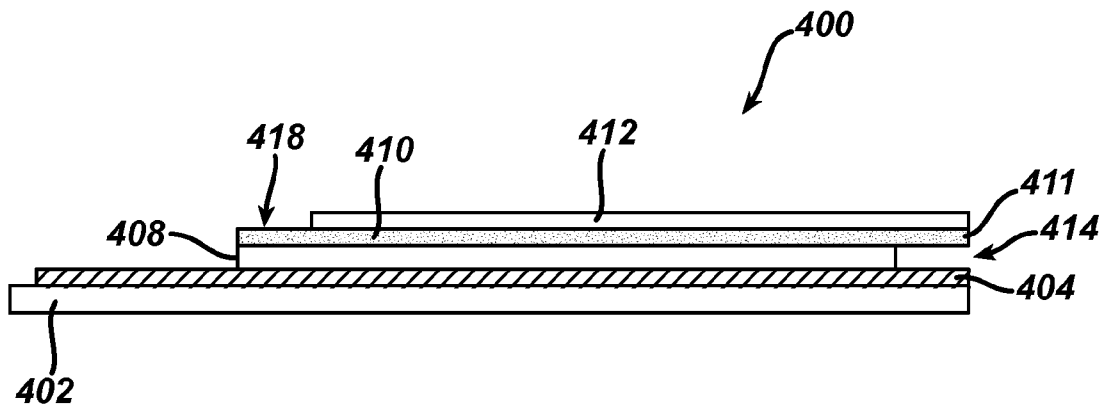
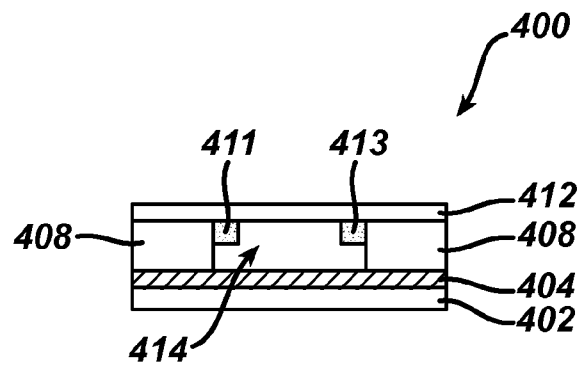
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**FIG. 3G**

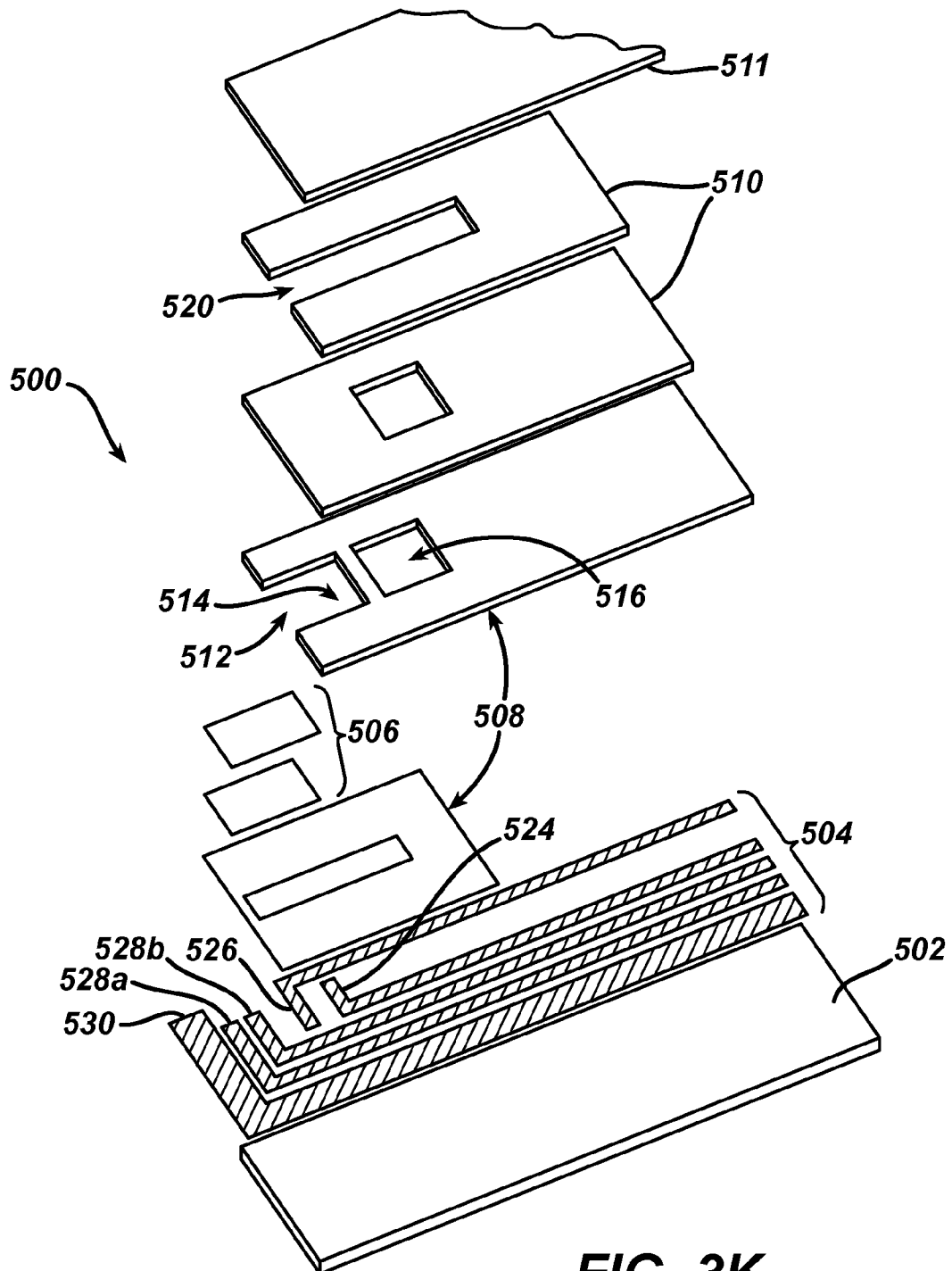
12/40

**FIG. 3H**

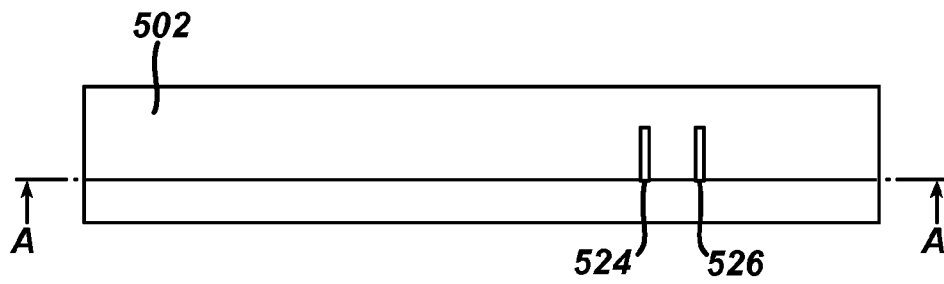
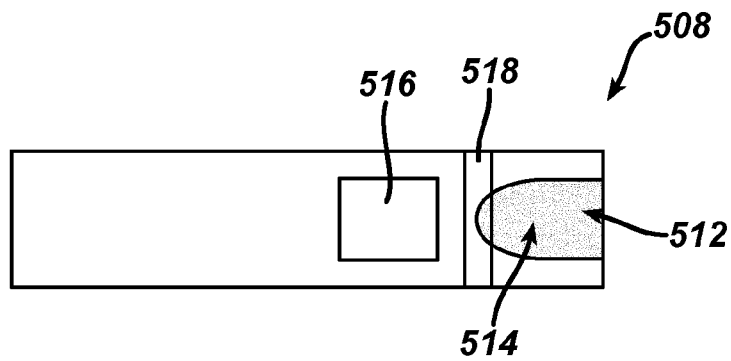
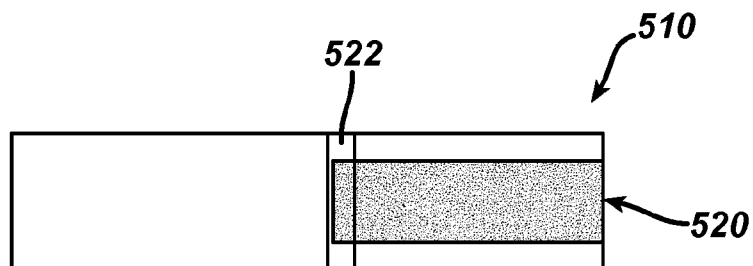
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**FIG. 3I****FIG. 3J**

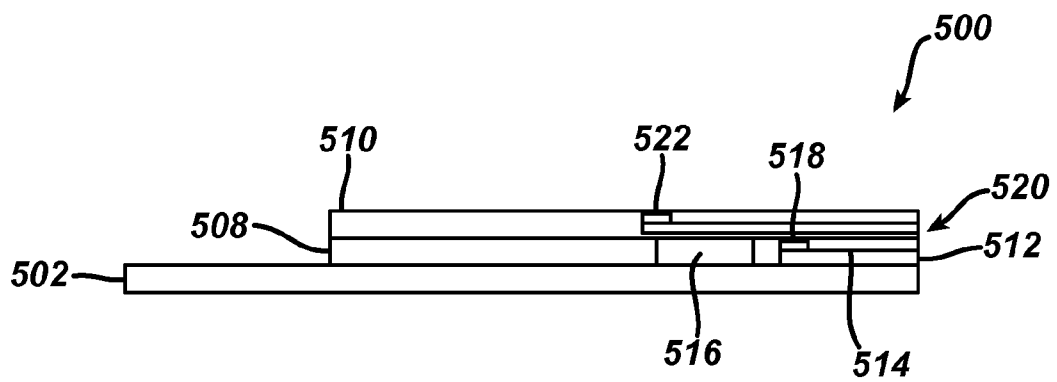
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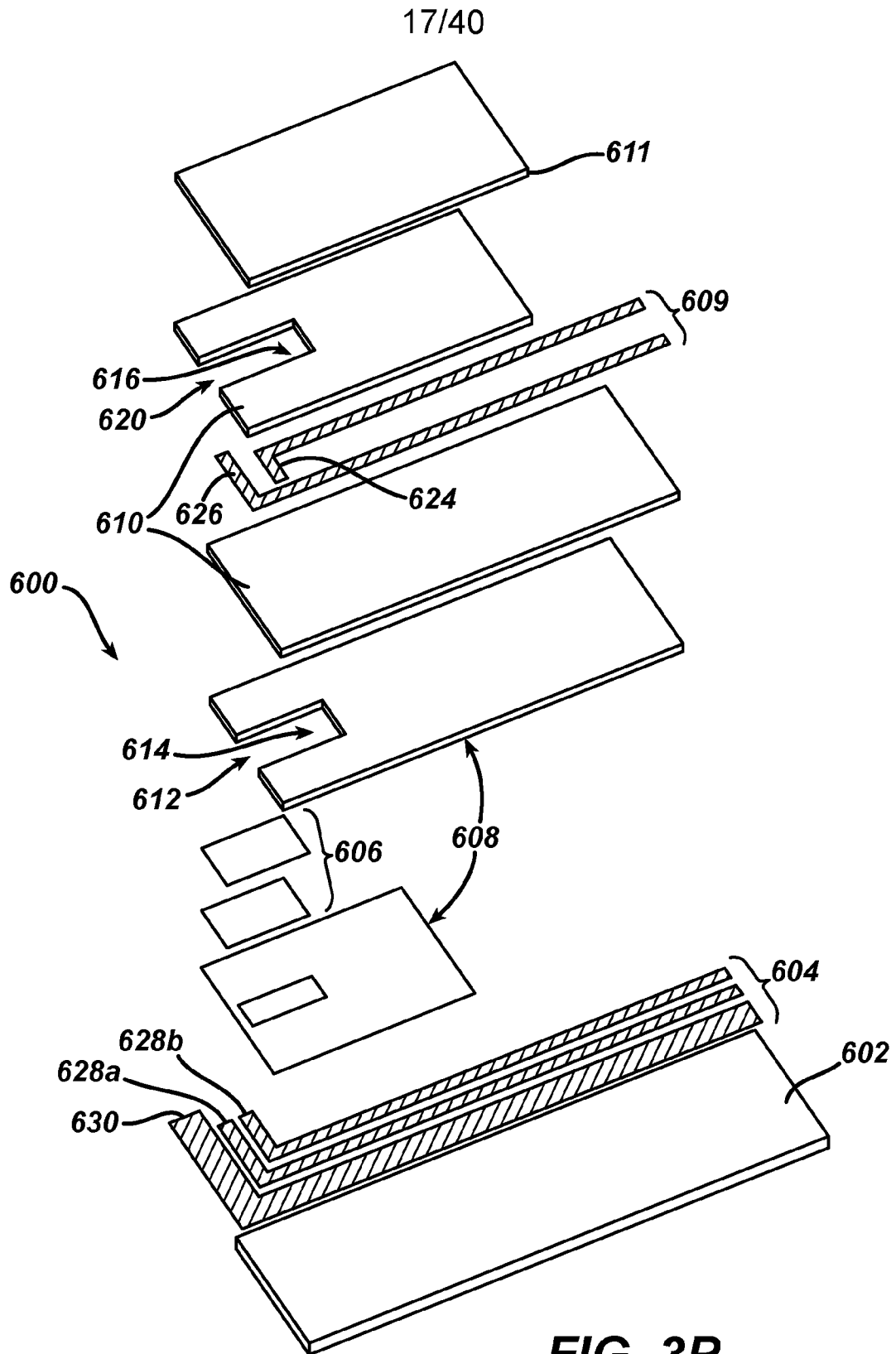
**FIG. 3K**

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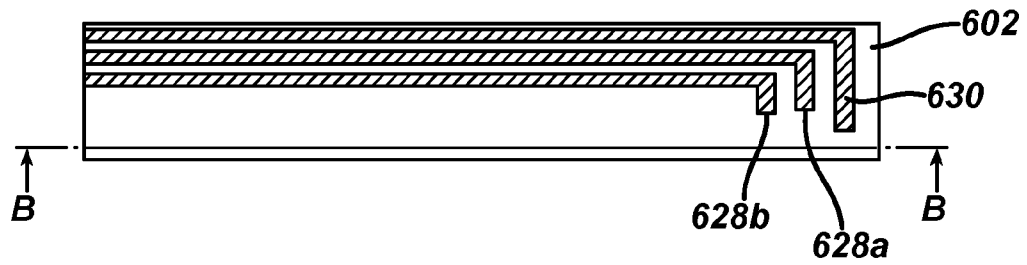
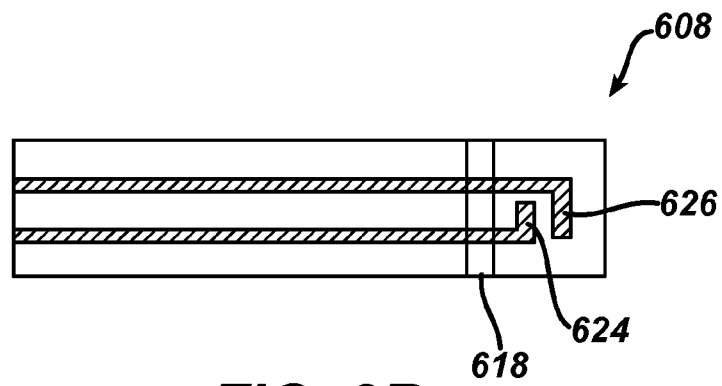
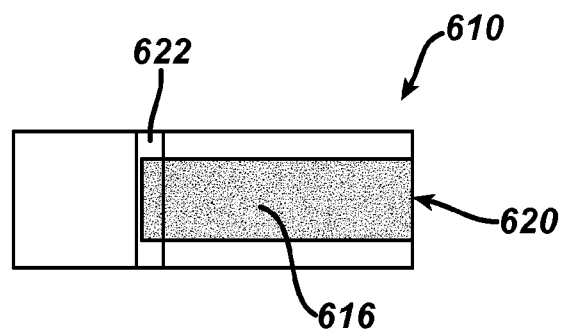
**FIG. 3L****FIG. 3M****FIG. 3N**

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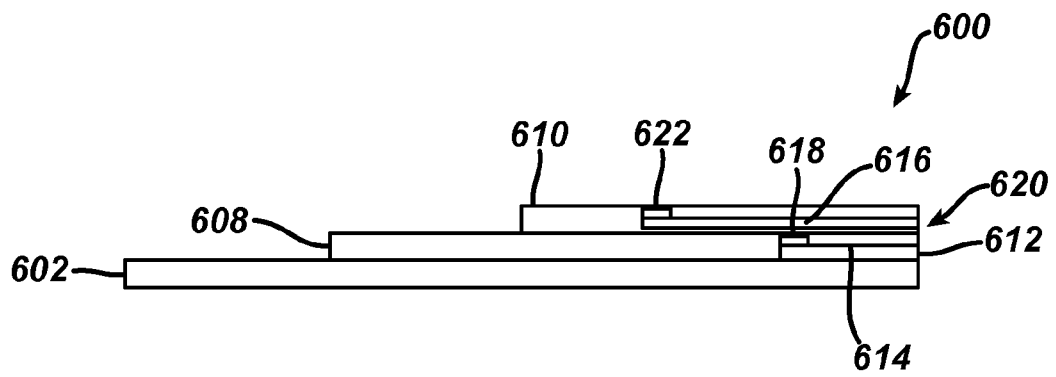
**FIG. 30**

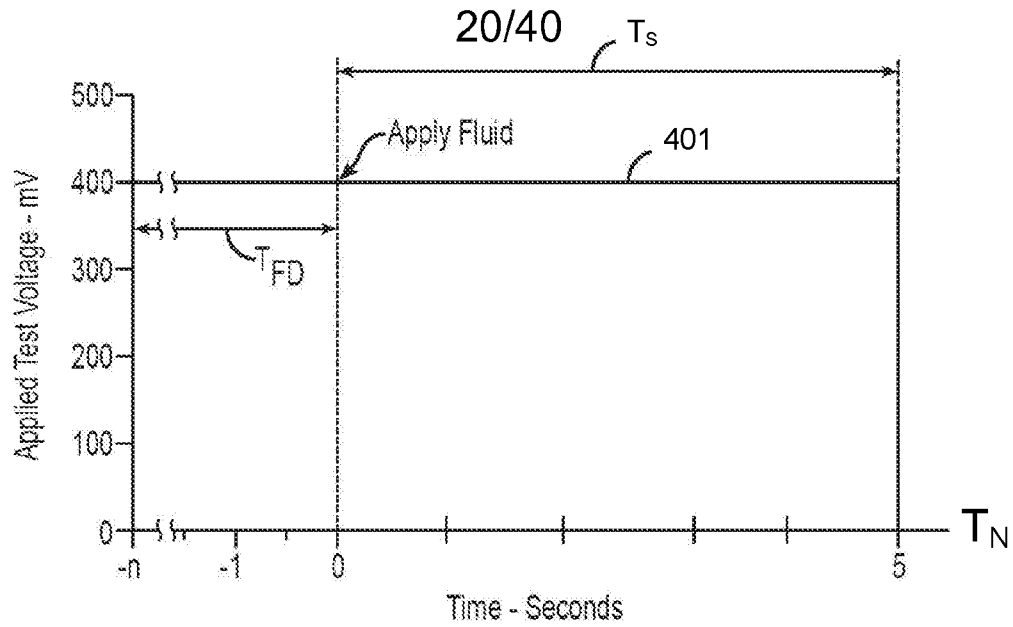
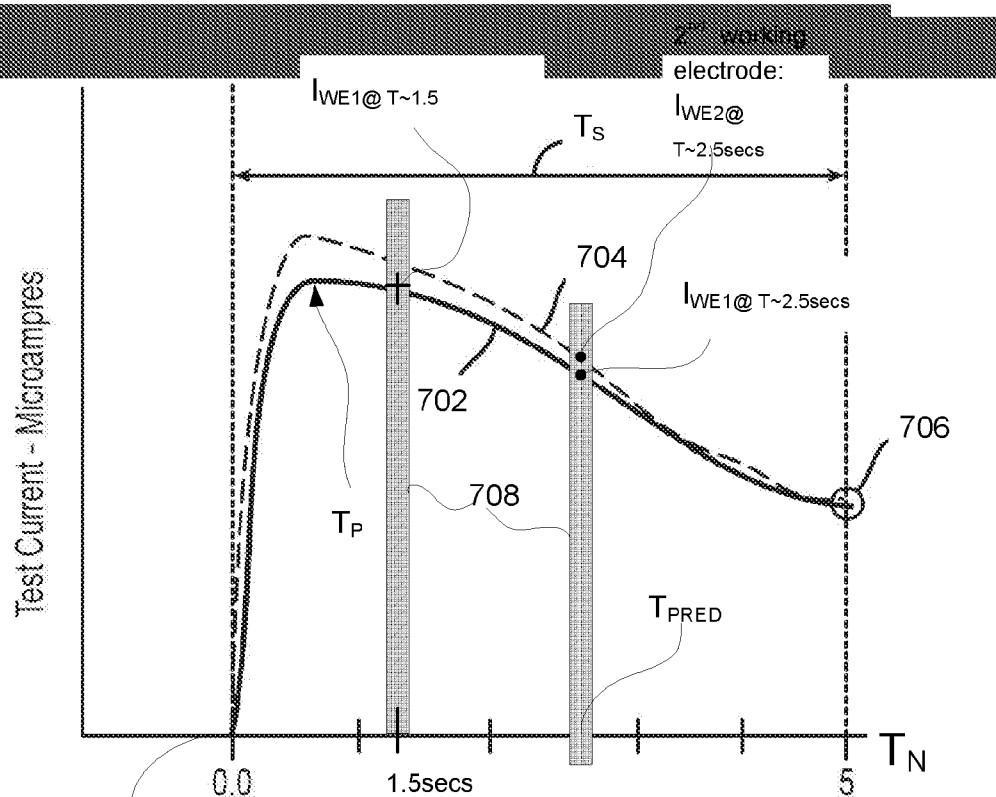


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**FIG. 3Q****FIG. 3R****FIG. 3S**

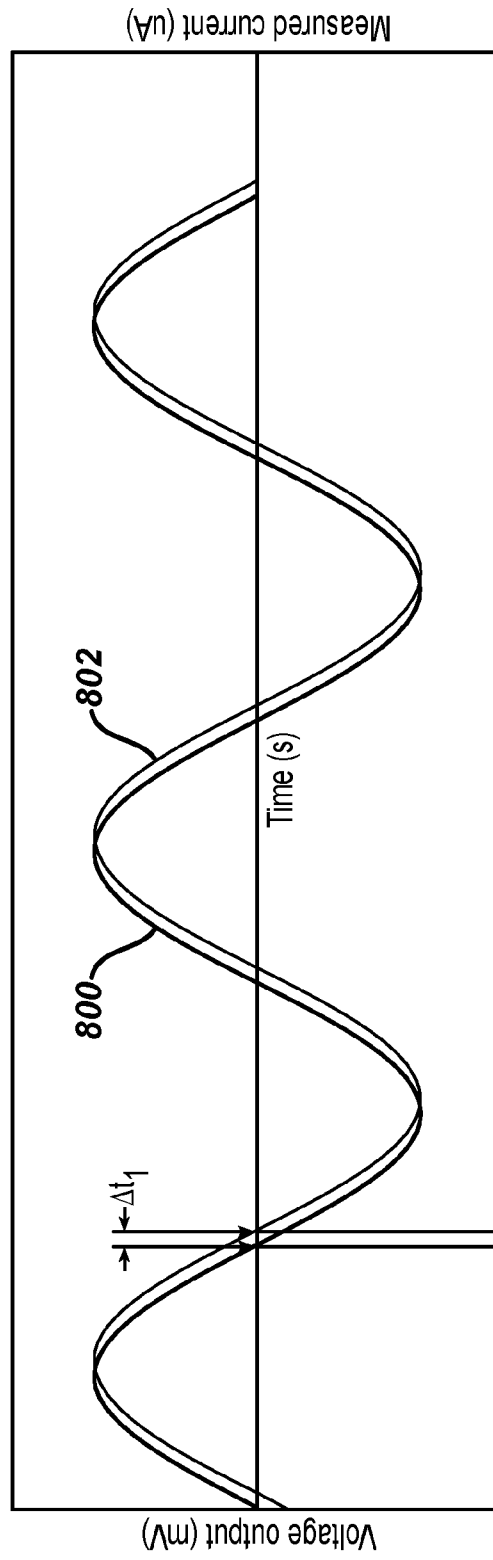
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**FIG. 3T**

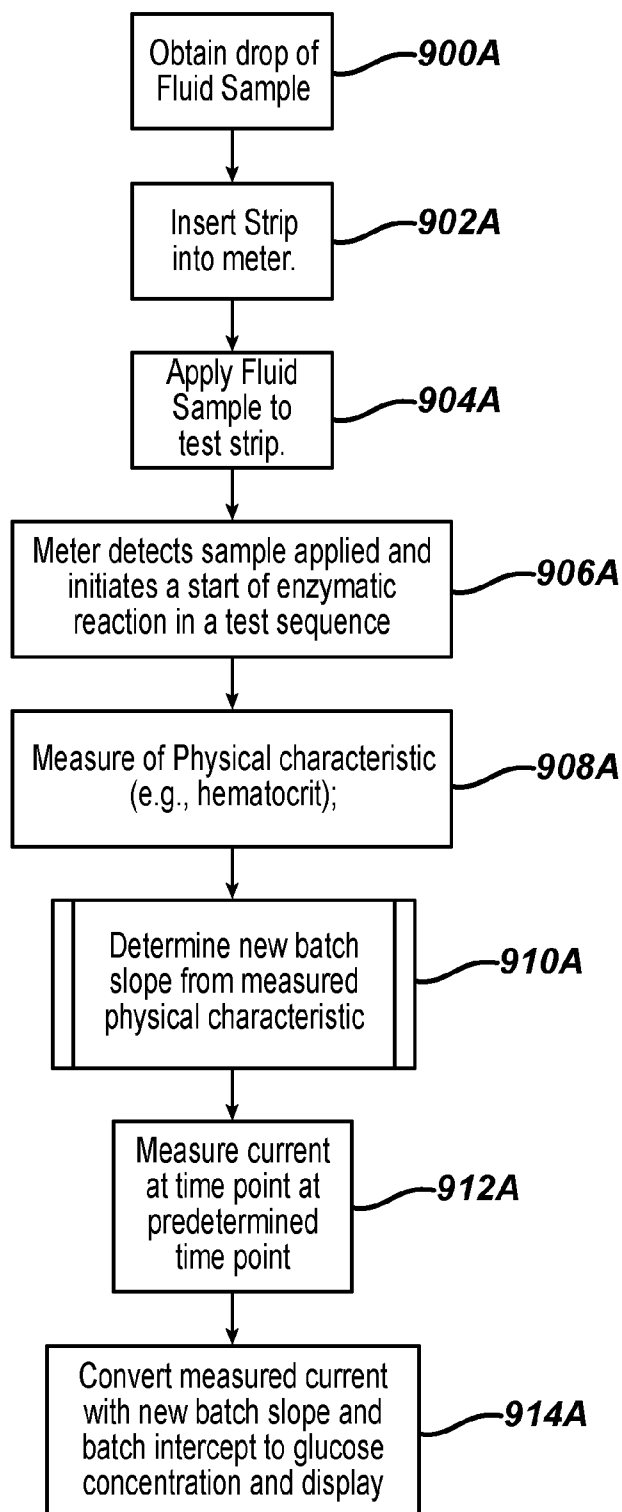
**FIG. 4A****FIG. 4B**

Start of Test  
Sequence

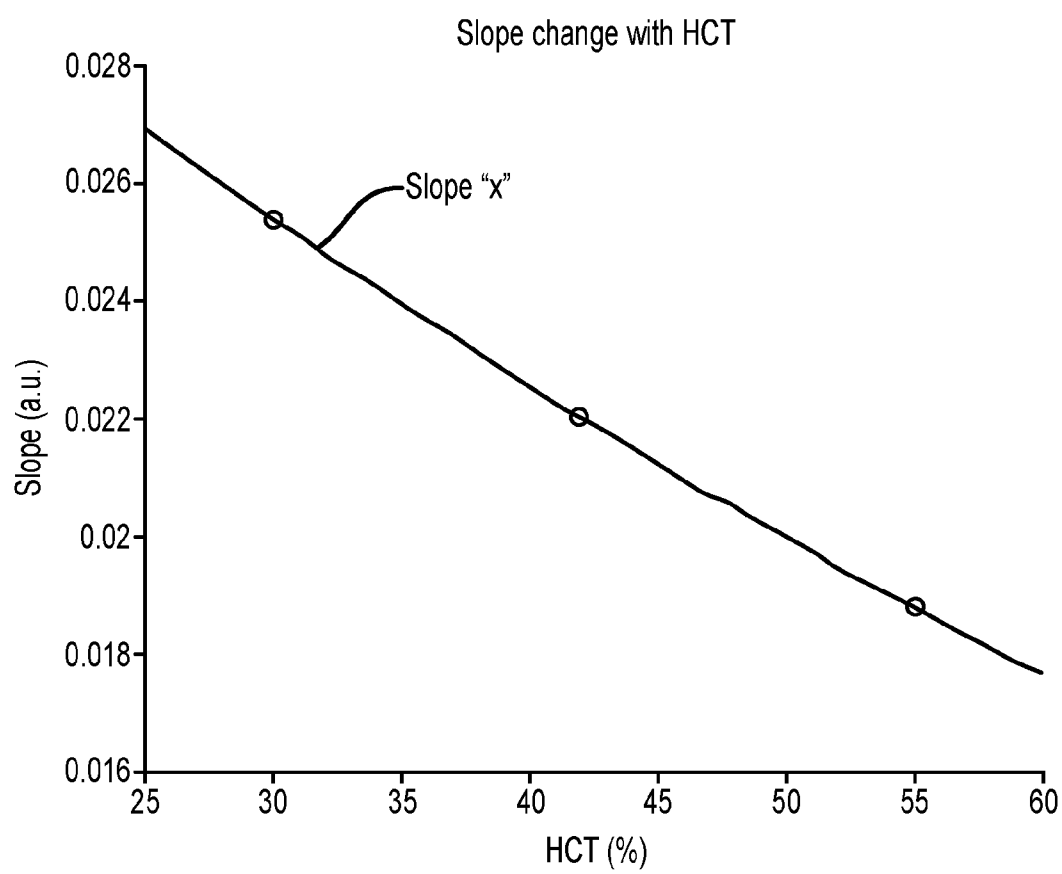
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**FIG. 5**

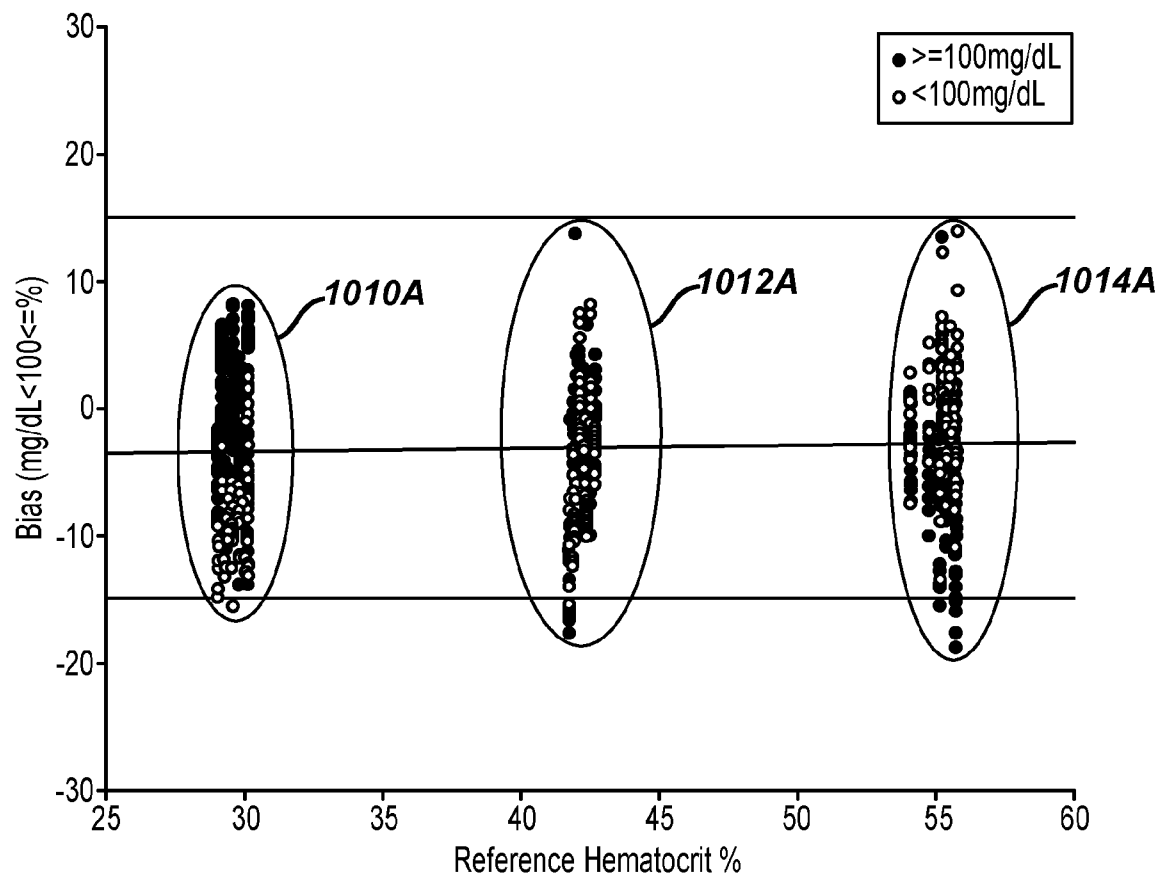
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**FIG. 6A(1)**

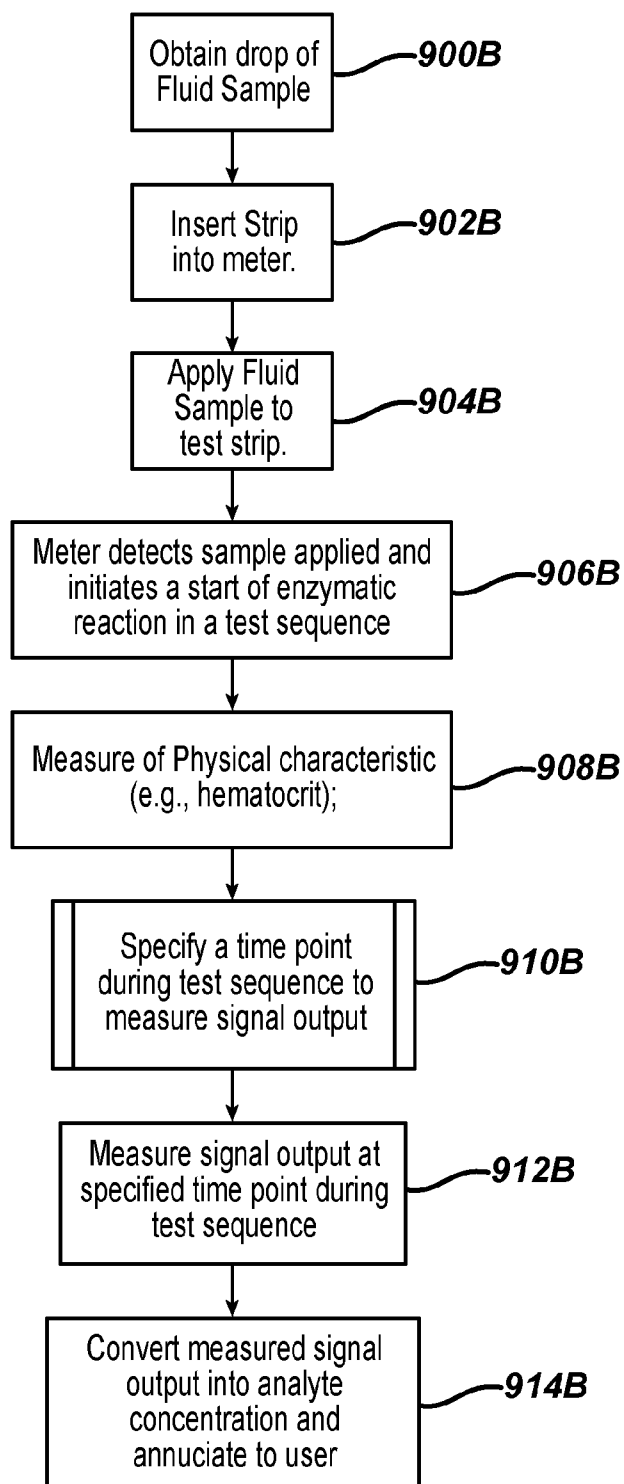
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**FIG. 6A(2)**

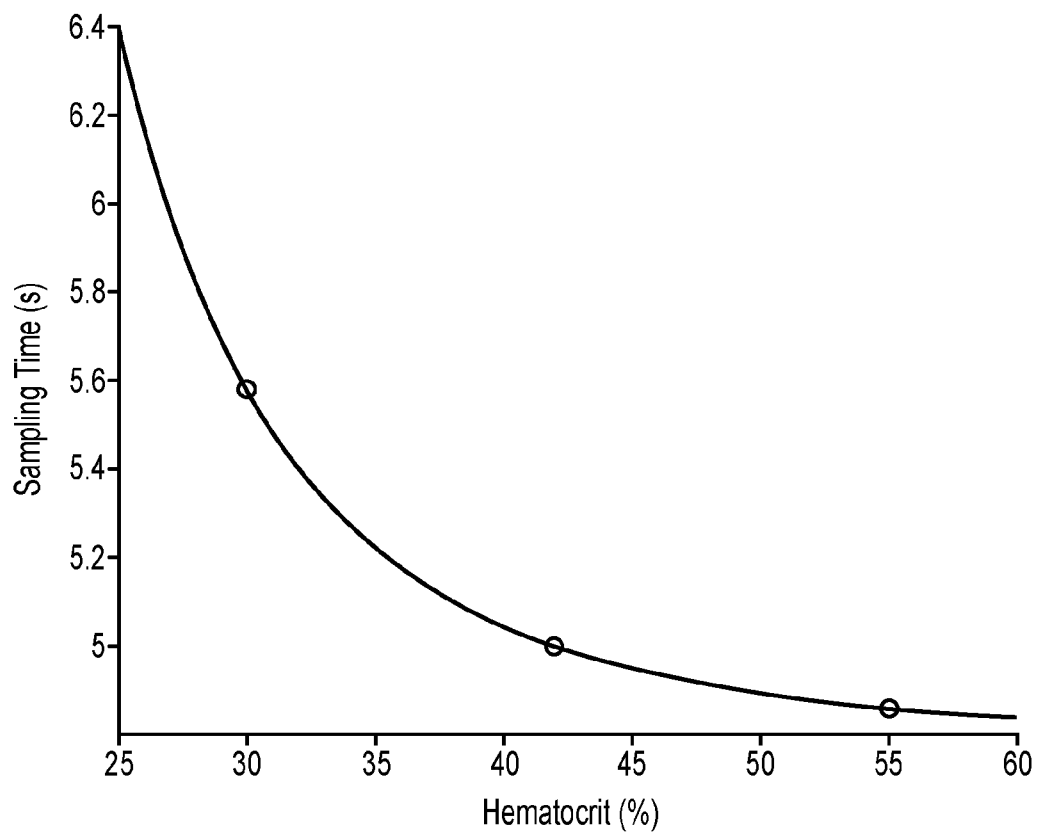
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**FIG. 6A(3)**

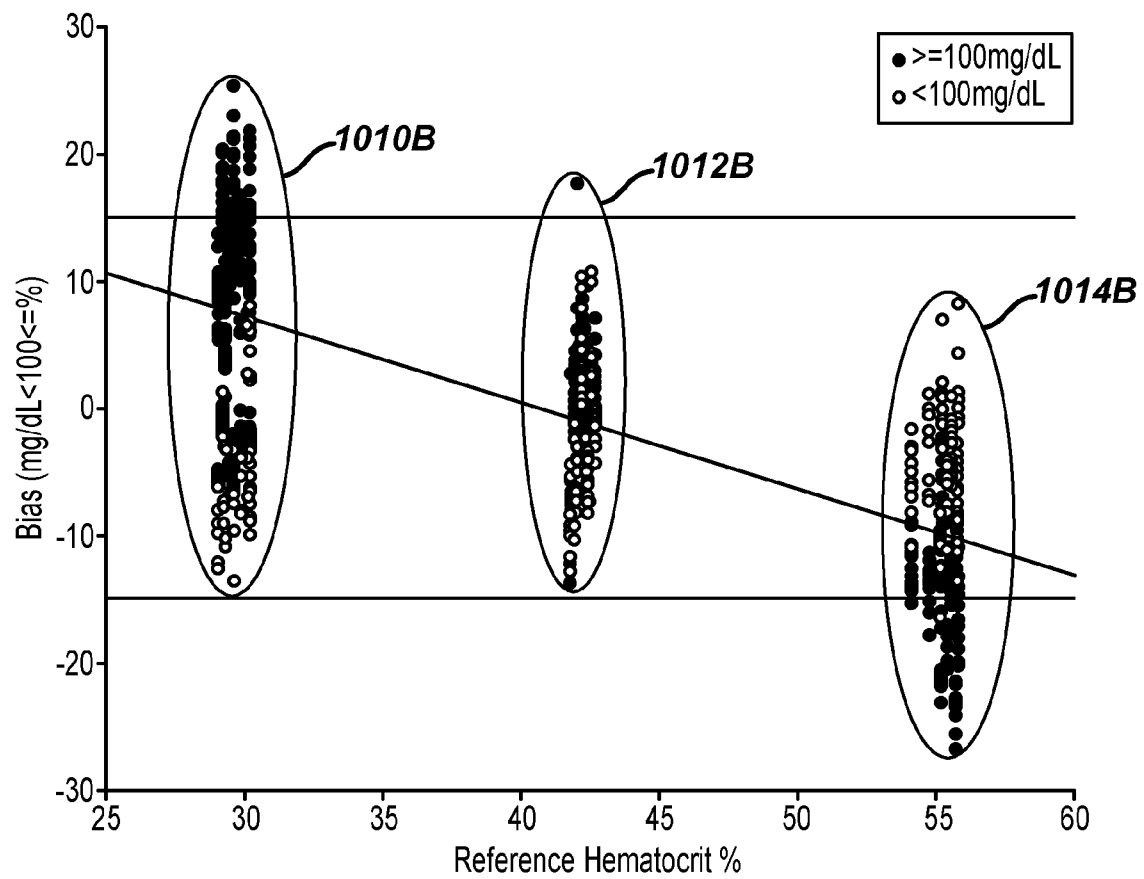
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**FIG. 6B(1)**

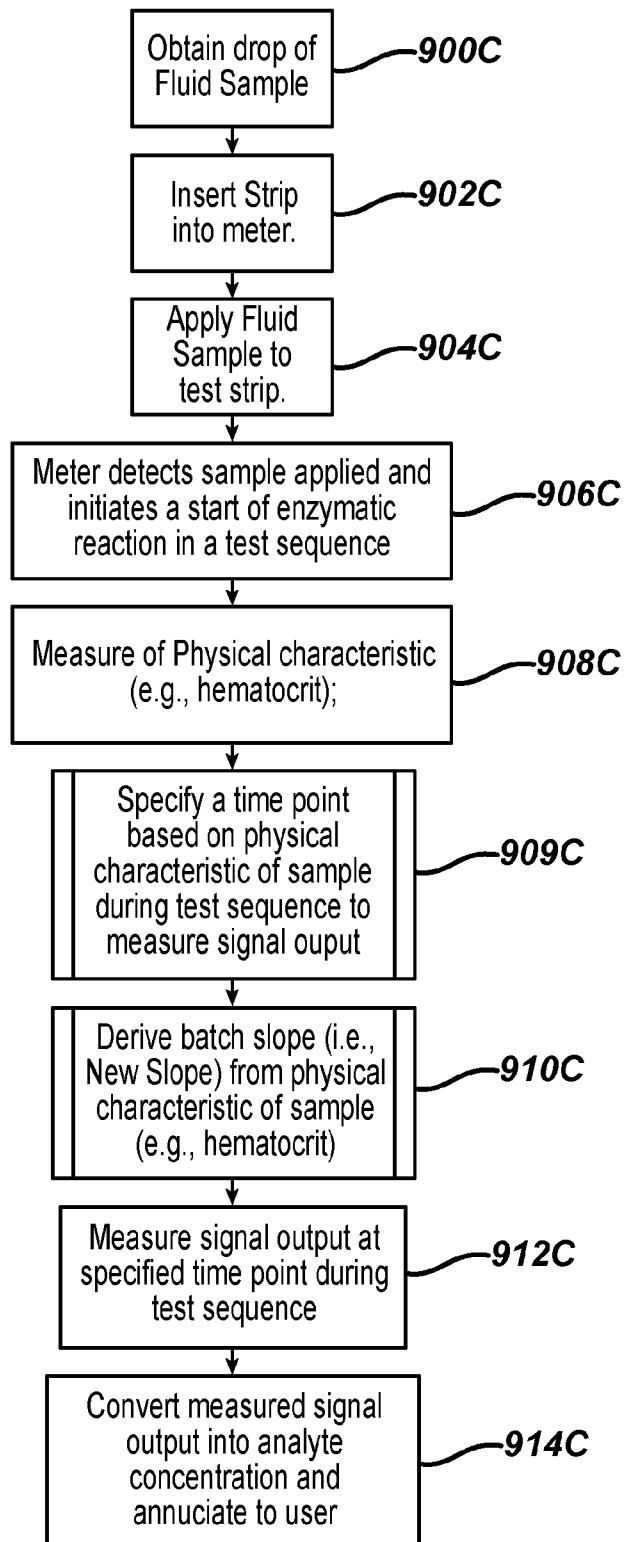
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**FIG. 6B(2)**

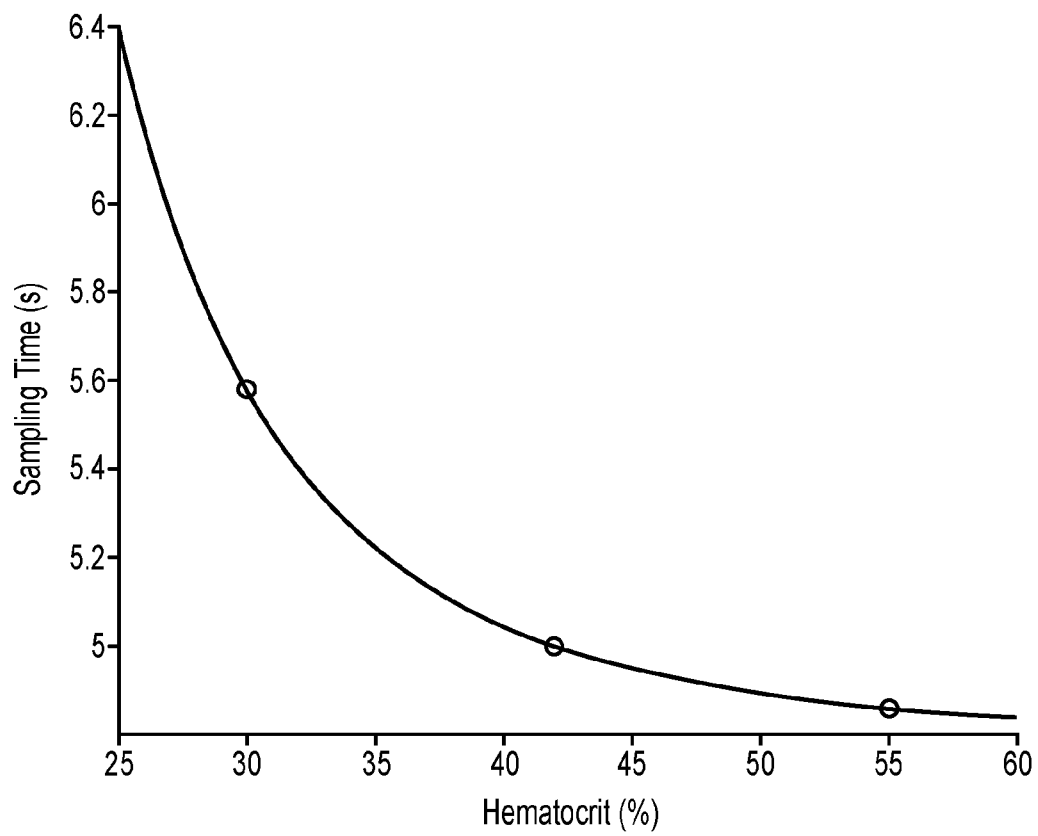
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**FIG. 6B(3)**

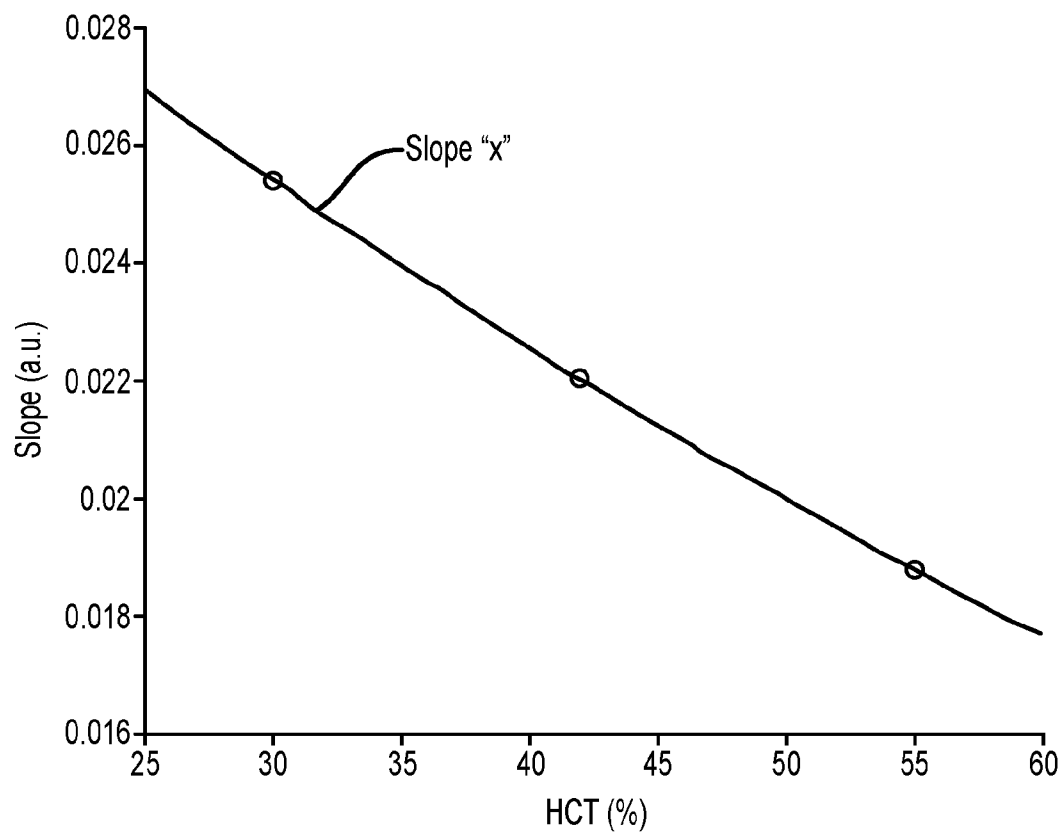
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**FIG. 6C(1)**

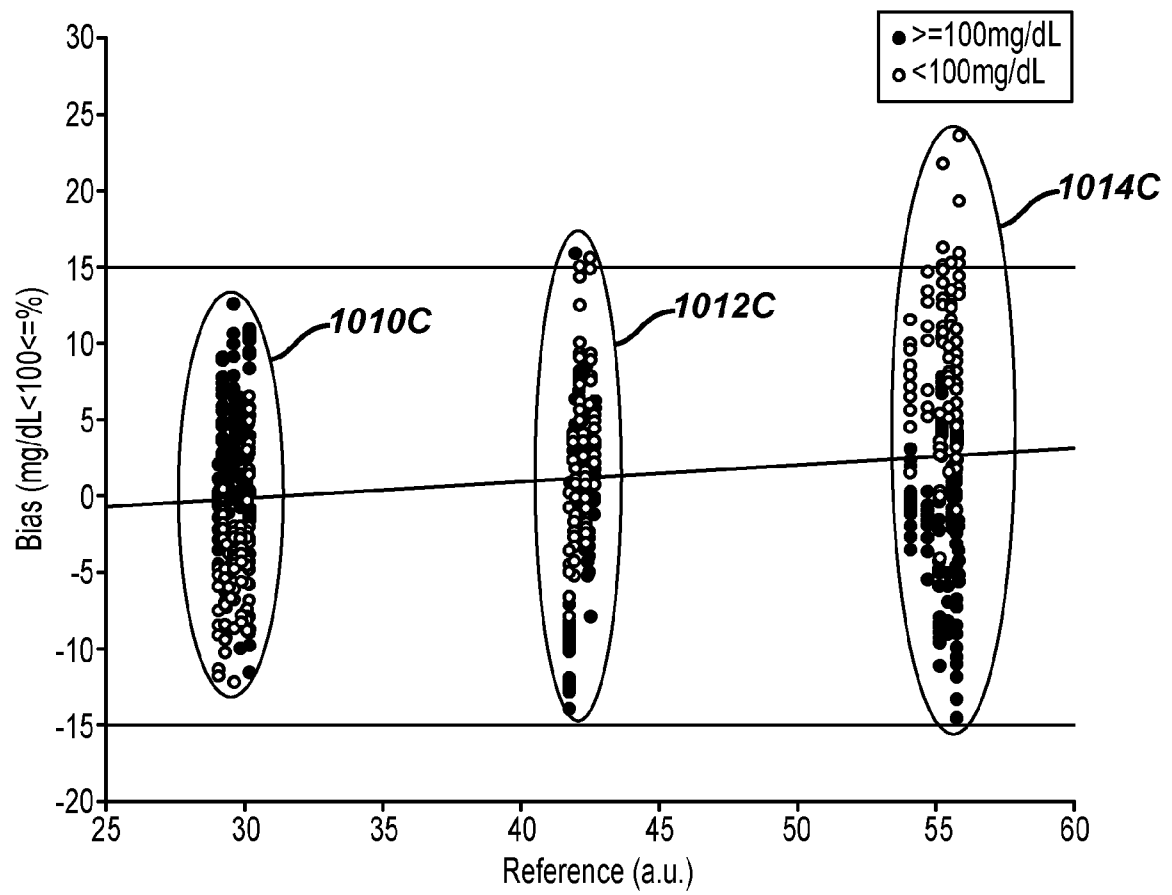
29/40

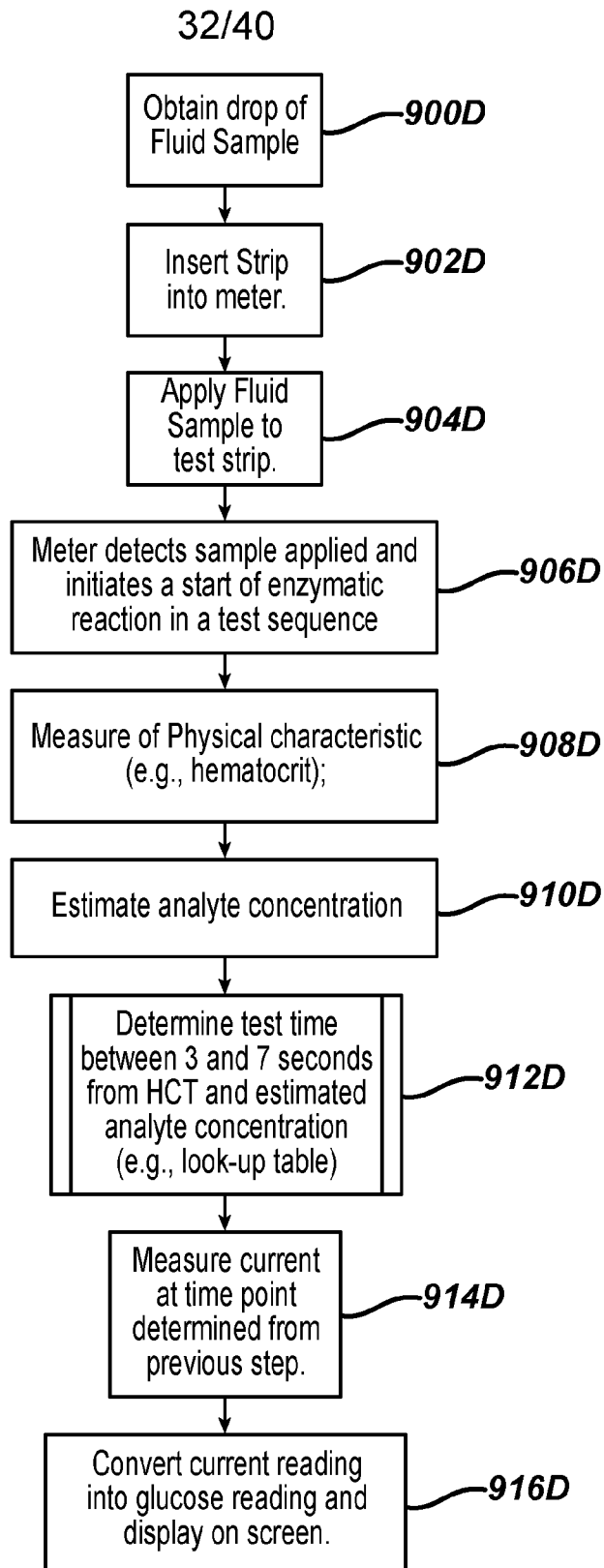
**FIG. 6C(2)**

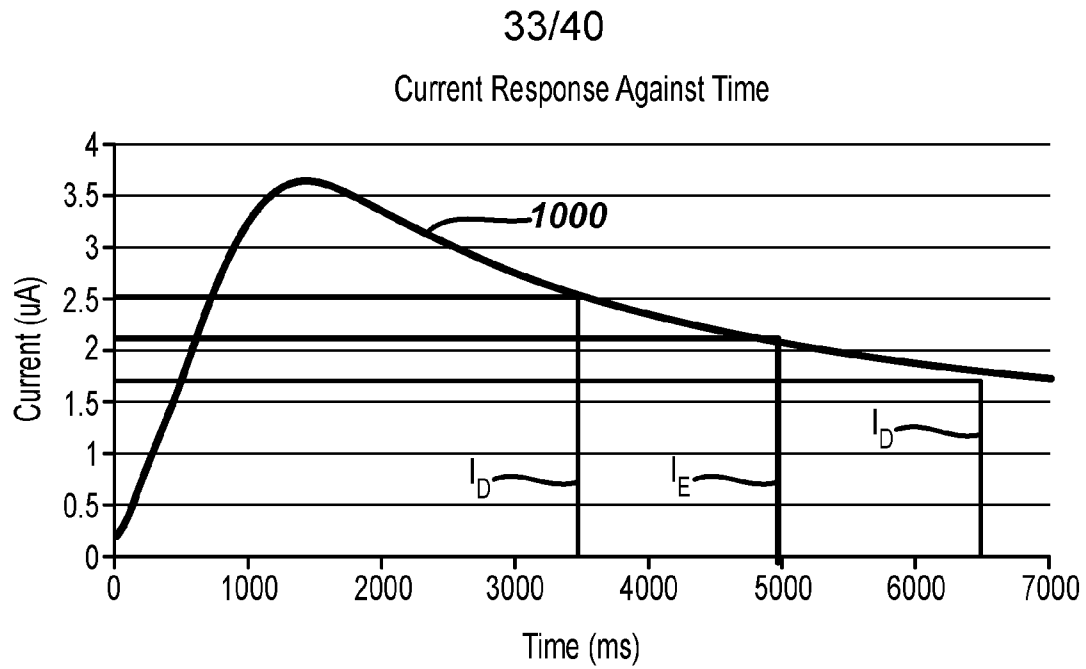
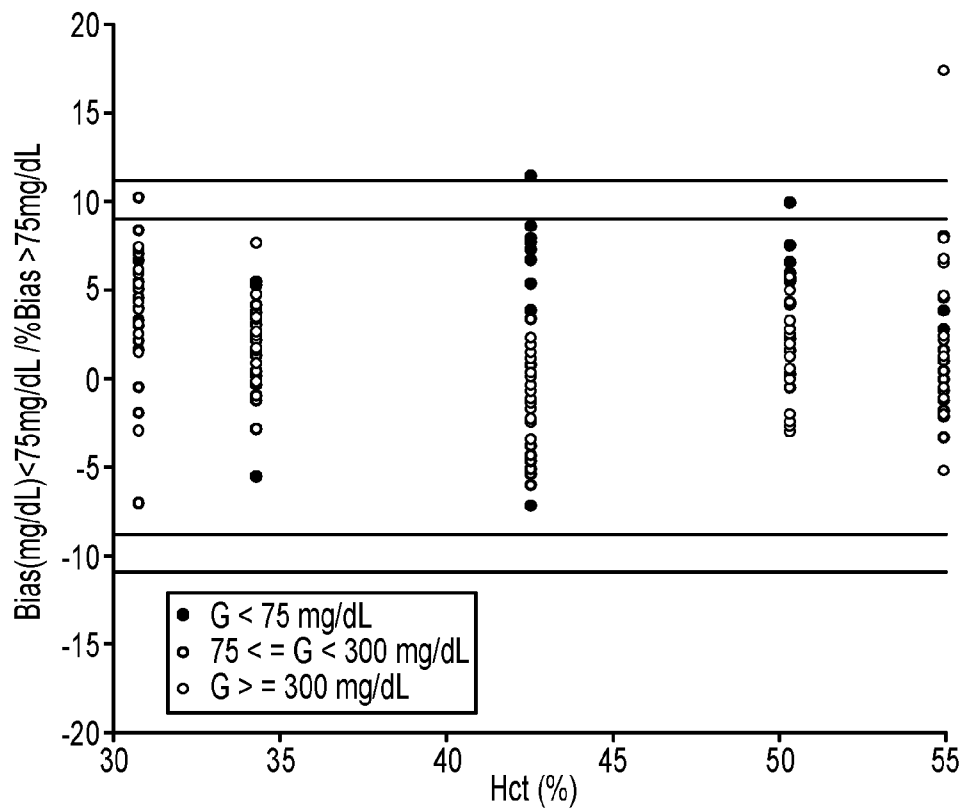
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**FIG. 6C(3)**

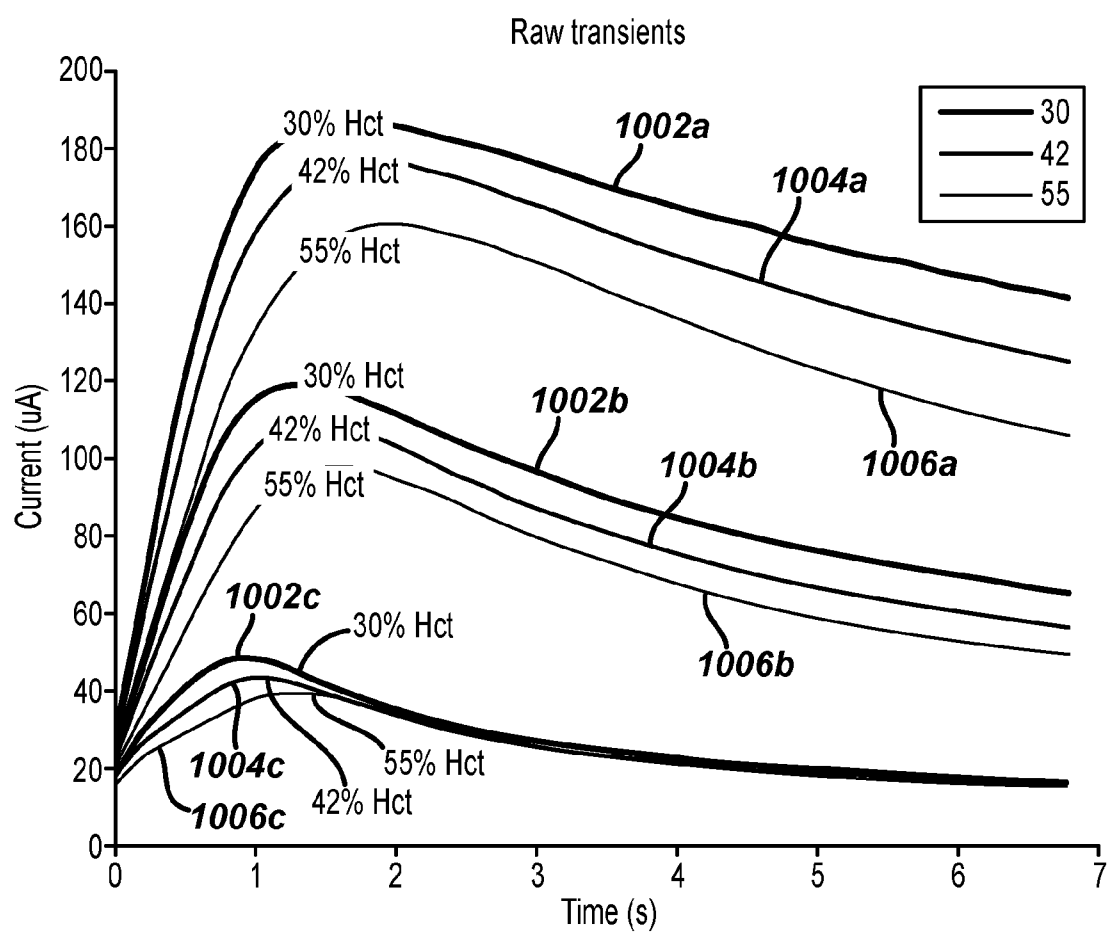
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**FIG. 6C(4)**

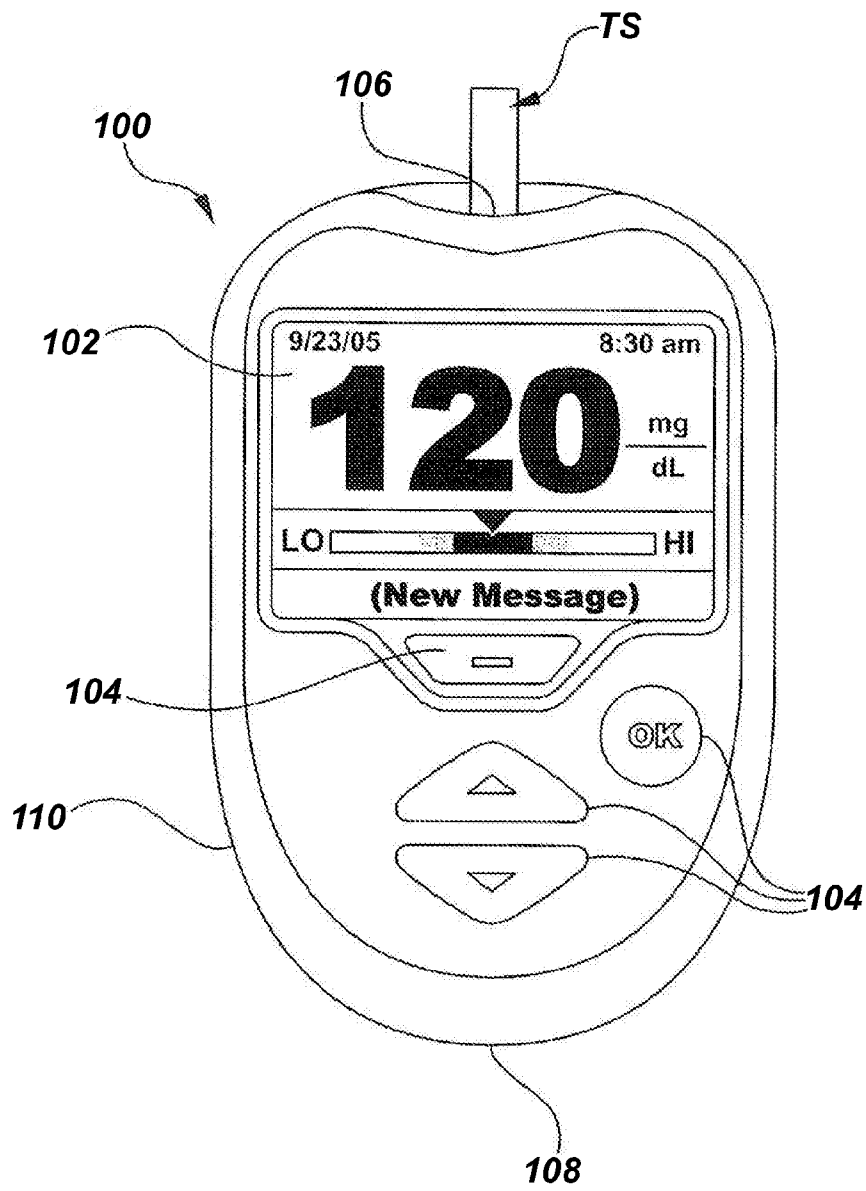
**FIG. 6D(1)**

**FIG. 6D(2)****FIG. 6D(3)**

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**FIG. 7**

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**FIG. 8**

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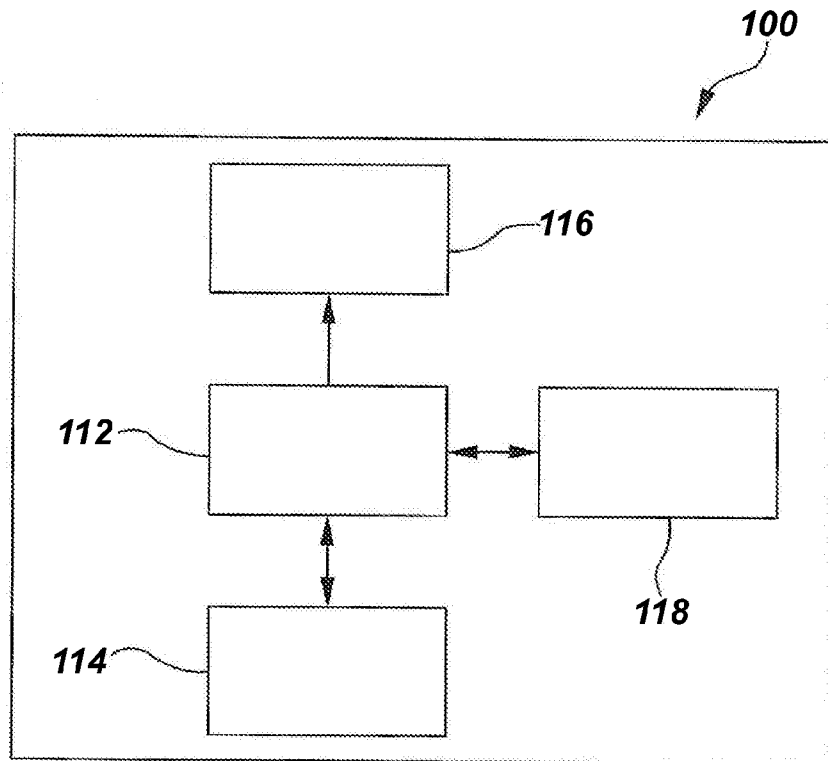
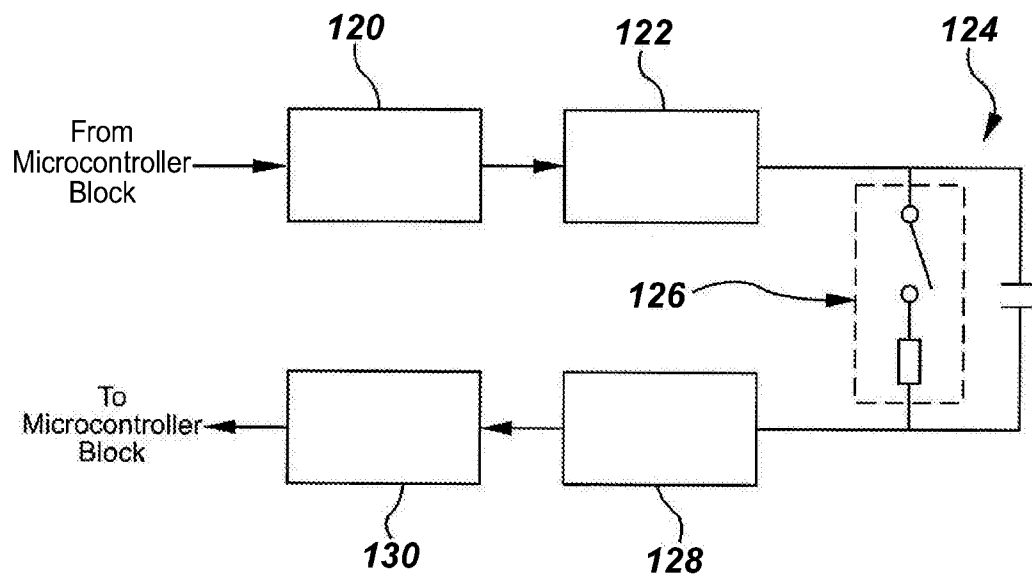
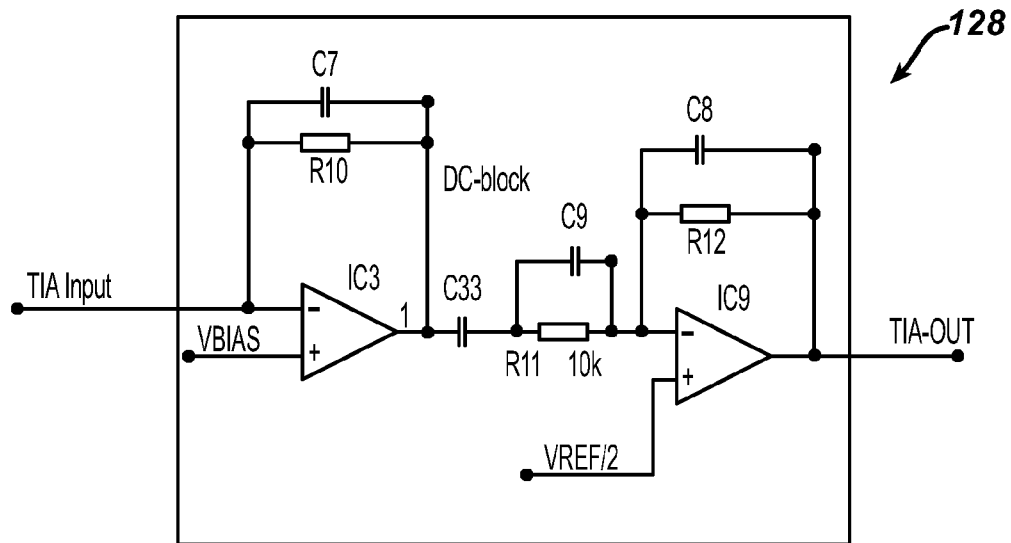
**FIG. 9****FIG. 10**

**FIG. 11**

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**FIG. 12**

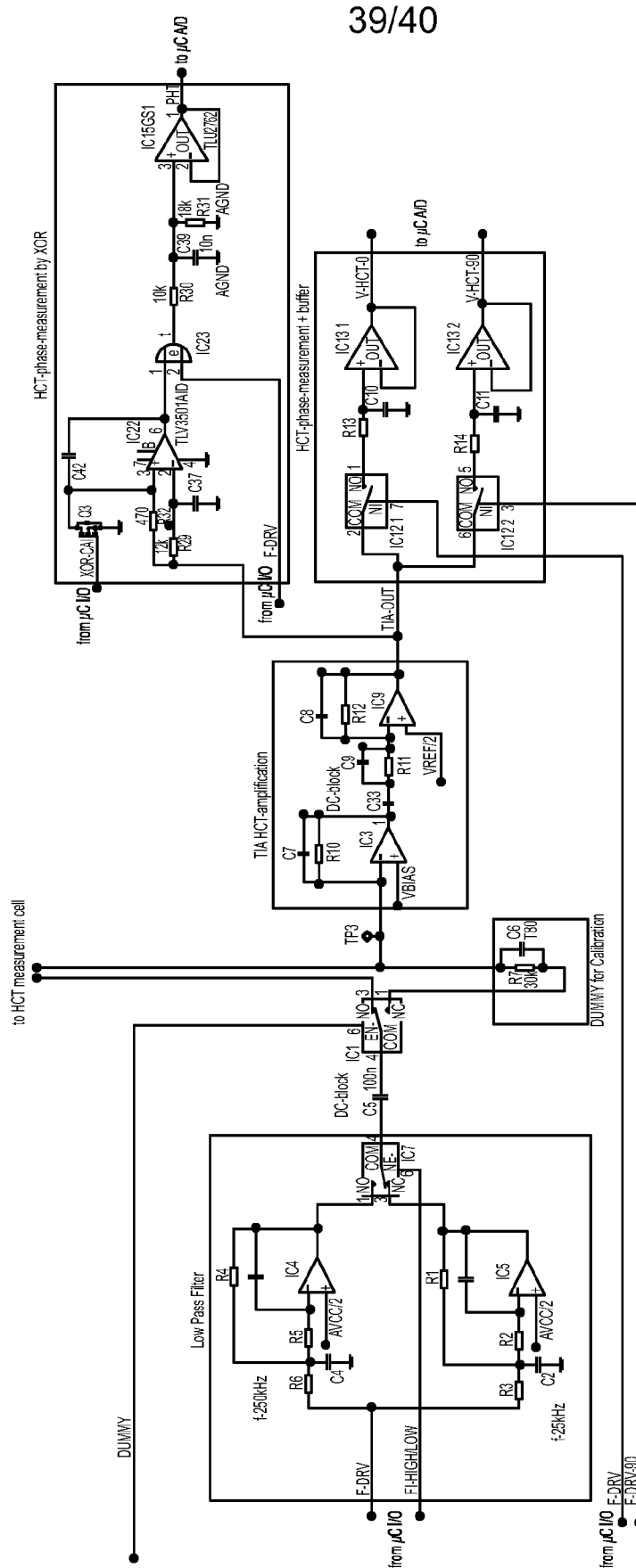
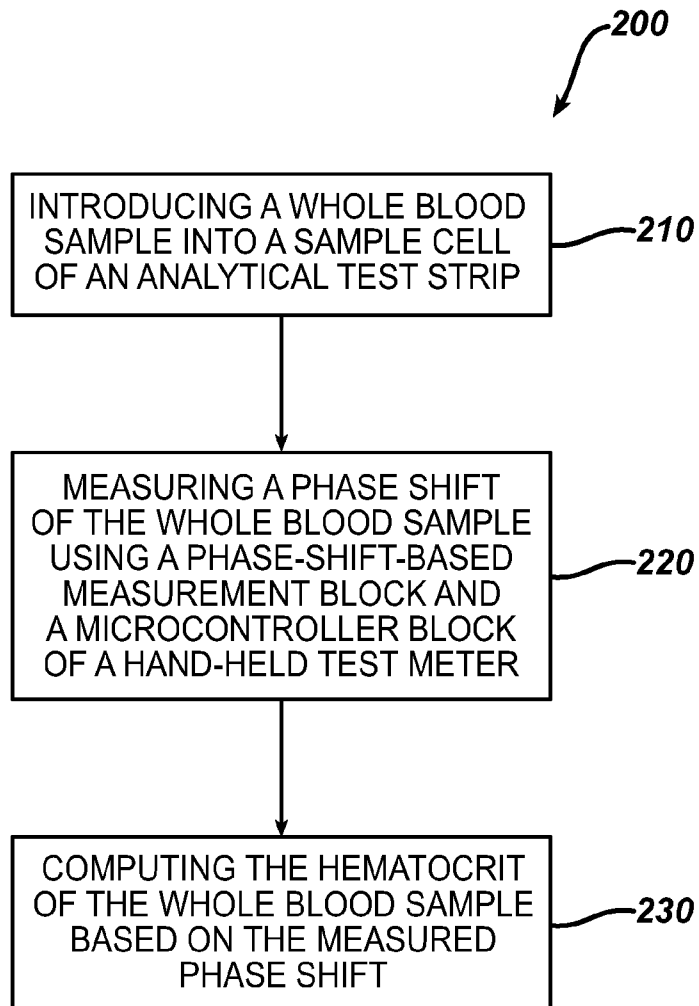


FIG. 13

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**FIG. 14**

