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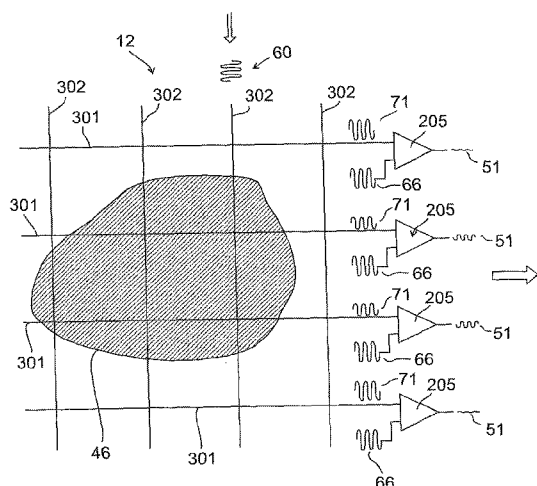


FIG. 4

(57) Abstract: A digitizer system includes a mutual capacitance sensor including a first set of parallel conductive lines and a second set of parallel conductive lines, the first and second set of conductive lines arranged in a grid pattern, a memory for storing at least one parameter for characterizing a signal detected on at least one conductive line in the second set of parallel conductive lines, responsive to triggering at least one conductive line in the first set of parallel conductive lines while no user interaction is present over the sensor, and circuitry operative to trigger at least one conductive line in the first set of parallel conductive lines, synthesize a reference signal based on the at least one parameter stored, subtract the reference signal from output on at least one conductive line in the second set of conductive lines, and sample the output after subtraction.



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SYSTEM AND METHOD FOR DETECTION WITH A CAPACITIVE BASED DIGITIZER SENSOR

5 RELATED APPLICATION/S

This application claims the benefit of priority under 35 USC 119(e) of U.S. Provisional Patent Application No. 61/474,281 filed April 12, 2011, the contents of which is incorporated herein by reference in its entirety.

10 FIELD OF THE INVENTION

The present invention, in some embodiments thereof, relates to capacitive based digitizer sensors and, more particularly, but not exclusively, to detection with a capacitive based digitizer sensor.

15 BACKGROUND OF THE INVENTION

Digitizing systems that allow a user to operate a computing device with a stylus and/or finger are known. Typically, a digitizer is integrated with a display screen, e.g., over-laid on the display screen. The detected position of the stylus and/or conductive object, such as a finger or another body part, provides input to a computing device
20 associated with the display, and is interpreted by the computing device as commands or input to commands. Examples of such devices include tablet Personal Computers (PCs), pen enabled laptop computers, personal digital assistants (PDAs) or any hand held devices such as palm pilots and mobile phones.

U.S. Patent No. 7,843,439, entitled "Touch Detection for a Digitizer" assigned to
25 N-Trig Ltd., the contents of which is incorporated herein by reference, describes a digitizing system including a transparent digitizer sensor overlaid on a flat panel display (FPD). The transparent digitizing sensor includes a matrix of vertical and horizontal conductive lines for sensing location of one or more of a stylus and/or a finger. Input to the digitizer sensor includes one or more of electromagnetic (EM) transmission from the
30 stylus touching the sensing surface and capacitive coupling due to a conductive object such as a finger touching the screen. Location of a finger is detected by triggering one conductive line at a time along one axis of the grid and detecting output in response to

each signal applied from a plurality of conductive lines along the other axis. The digitizing system is capable of detecting position of simultaneous occurrences of multiple styluses and/or multiple finger touches.

US Patent No. 7,902,840 entitled "Apparatus for Object Information Detection and Methods of Using Same" assigned to N-Trig Ltd., the contents of which is incorporated herein by reference, also describes a digitizer sensor and/or touch screen sensitive to capacitive coupling and objects adapted to create a capacitive coupling with the sensor when a signal is input to the sensor. A digitizer sensor includes a series of activated electrodes and passive electrodes. An AC signal, e.g. a pulsed and/or burst AC signal, sequentially activates electrodes and in response to activating an active electrode, the passive electrodes are sampled. It is further disclosed that to speed up report rate, the active electrodes are divided into a number of groups and the active electrodes in each group are activated sequentially but the groups work simultaneously. AC signals with non-mutually interfering (orthogonal) frequencies are applied to each of the groups working simultaneously.

U.S. Patent Application Publication No. 2009-0127005 entitled "System and Method for Detection with a Digitizer Sensor" assigned to N-Trig Ltd., the contents of which is incorporated herein by reference, describes an additional method to speed up report rate. It is disclosed that orthogonal signals having the same frequency are simultaneously transmitted on a plurality of conductive lines along one axis of a grid based digitizer sensor, and in response signals on conductive lines of the other axis of the sensor are sampled. The sampled signals are decomposed into orthogonal components, and the orthogonal components are analyzed to detect user interaction at cross junctions of the sensor between the plurality of conductive lines along one axis and the conductive lines along the other axis.

U.S. Patent Application Publication No. 2009-0273579 entitled "Multi-Touch Detection" assigned to N-Trig Ltd., the contents of which is incorporated herein by reference, describes a system and method for first identifying conductive lines of a grid-based digitizer sensor affected by user interaction without scanning all the conductive lines, and then scanning only those portions and/or lines of the sensor to determine the locations of the user interactions along the identified conductive lines. During a first stage of detection, a plurality of conductive lines are triggered or interrogated

simultaneously to identify conductive lines affected by user interaction without scanning. During a second stage of detection, the identified lines along one axis are scanned by triggering one conductive line at a time and detecting output in response to each signal applied from a plurality of conductive lines along the other axis.

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SUMMARY OF THE INVENTION

According to an aspect of some embodiments of the present invention there is provided a system and method for improving resolution of output sampled and/or for reducing the number of bits required to sample and/or encode output from a capacitive based digitizer sensor. Typically output provided by a mutual capacitance based sensor originates from a triggering signal transferred to cross lines due to an existing capacitance between conductive lines of the sensor around junctions, and also due to changes in capacitance due to a presence of a finger and/or conductive object, e.g. a conductive object with high impedance to ground. According to some embodiments of the present invention, prior to sampling output from the sensor, a portion of signal representing changes to the transferred triggering signal due to a presence of a finger and/or conductive object is isolated from a portion of the signal representing the triggering signal that is transferred due to coupling of the cross lines when no interaction is present. Typically, by isolating the portion of the signal representing changes due to a presence of a finger and/or conductive object, amplitude of the output is reduced. Optionally, amplitude of the output signal is between 0-35% of the original signal. According to some embodiments of the present invention, the reduction in amplitude achieved is used to reduce amplitude of input to an analogue to digital converter (ADC) required for sampling and/or to increase a resolution of the sampled signal.

According to an aspect of some embodiments of the present invention, there is provided a digitizer system including a mutual capacitance sensor including a first set of parallel conductive lines and a second set of parallel conductive lines, the first and second set of conductive lines arranged in a grid pattern, a memory for storing at least one parameter for characterizing a signal detected on at least one conductive line in the second set of parallel conductive lines, responsive to triggering at least one conductive line in the first set of parallel conductive lines while no user interaction is present over the sensor, and circuitry operative to trigger at least one conductive line in the first set of

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parallel conductive lines, synthesize a reference signal based on the at least one parameter stored, subtract the reference signal from output on at least one conductive line in the second set of conductive lines, and sample the output after subtraction.

Optionally, the reference signal has a same frequency as a signal for triggering
5 the at least one conductive line in the first set of parallel conductive lines.

Optionally, the at least one parameter stored is amplitude of the signal detected on the at least one conductive line in the second set of parallel conductive lines while no user interaction is present over the sensor.

Optionally, the memory is operative to store parameters for characterizing signals
10 detected on each of the conductive lines in the second set while no user interaction is present over the sensor.

Optionally, the circuitry is operative to synthesize a reference signal for each conductive line in the second set.

Optionally, the circuitry is operative to subtract by analog subtraction the
15 reference signal from output on each conductive line in the second set.

Optionally, the reference signal is an AC signal.

Optionally, the reference signal is a burst signal.

Optionally, the circuitry includes at least one differential amplifier for subtracting the reference signal from the output by analogue subtraction.

Optionally, the circuitry is operative to invert the reference signal and add the
20 inverted reference signal to the output.

According to an aspect of some embodiments of the present invention, there is provided a method for detection with a digitizer sensor including providing a mutual capacitance sensor including first set of parallel conductive lines and second set of
25 parallel conductive lines, the first and second set of conductive lines arranged in a grid pattern, storing at least one parameter for characterizing a signal detected on a conductive line in the second set responsive to triggering a conductive line in the first set while when no user interaction is present over the sensor, synthesizing a reference signal based on the at least one parameter stored, subtracting the reference signal from output
30 on at least one conductive line in the second set of conductive lines responsive to triggering a conductive line in the first set, and sampling the output after subtraction.

Optionally, the reference signal has a same frequency as a signal for triggering the at least one conductive line in the first set of parallel conductive lines.

Optionally, the at least one parameter stored is amplitude of the signal detected on the at least one conductive line in the second set of parallel conductive lines while
5 when no user interaction is present over the sensor.

Optionally, the method includes storing parameters for characterizing signals detected on each of the conductive lines in the second set while no user interaction is present over the sensor.

The method includes synthesizing a reference signal for each conductive line in
10 the second set.

The method includes subtracting by analog subtraction the reference signal from output on each conductive line in the second set.

Optionally, the reference signal is an AC signal.

Optionally, the reference signal is a burst signal.

15 According to an aspect of some embodiments of the present invention, there is provided a method for detection with a digitizer sensor including providing a mutual capacitance sensor including a first set of parallel conductive lines and a second set of parallel conductive lines, the first and second set of conductive lines arranged in a grid pattern, triggering a plurality of conductive lines in the first set of parallel conductive
20 lines simultaneously with a triggering signal, subtracting the triggering signal from output on the plurality of conductive lines in first set, sampling the output on the plurality of conductive lines in first set after subtraction, determining if a user interaction is presence on the sensor from the output sampled, and scanning the sensor responsive to detecting the presence of a user interaction.

25 Unless otherwise defined, all technical and/or scientific terms used herein have the same meaning as commonly understood by one of ordinary skill in the art to which the invention pertains. Although methods and materials similar or equivalent to those described herein can be used in the practice or testing of embodiments of the invention, exemplary methods and/or materials are described below. In case of conflict, the patent
30 specification, including definitions, will control. In addition, the materials, methods, and examples are illustrative only and are not intended to be necessarily limiting.

BRIEF DESCRIPTION OF THE DRAWINGS

Some embodiments of the invention are herein described, by way of example only, with reference to the accompanying drawings. With specific reference now to the drawings in detail, it is stressed that the particulars shown are by way of example and for
5 purposes of illustrative discussion of embodiments of the invention. In this regard, the description taken with the drawings makes apparent to those skilled in the art how embodiments of the invention may be practiced.

In the drawings:

FIG. 1 is a simplified circuit diagram of an exemplary digitizer sensor for mutual
10 capacitance touch detection for use with some embodiments of the present invention;

FIGs. 2A, 2B and 2C are simplified output signals provided by an exemplary digitizer sensor and components of the output signal originating from a transferred triggering signal and finger touch, in accordance with some embodiments of the present invention;

15 FIGs. 3A, 3B and 3C are simplified output signals provided by an exemplary digitizer sensor and components of the output signal originating from a transferred triggering signal and touch of a conductive object in accordance with some embodiments of the present invention;

FIG. 4 is a schematic illustration of a digitizer sensor whose output is connected
20 to an array of differential amplifiers for isolating a touch signal from the sensor output, in accordance with some embodiments of the present invention;

FIG. 5 is a schematic illustration of a digitizer sensor with a reference signal added to the sensor output, in accordance with some embodiments of the present invention;

25 FIG. 6 is a simplified diagram of an exemplary digitizer system in accordance with some embodiments of the present invention;

FIG. 7 is a simplified flow chart of an exemplary method for defining reference signals for a digitizer sensor in accordance with some embodiments of the present invention; and

30 FIG. 8 is a simplified flow chart of an exemplary method for isolating a detection signal from output of a digitizer sensor in accordance with some embodiments of the present invention.

DESCRIPTION OF SPECIFIC EMBODIMENTS OF THE INVENTION

The present invention, in some embodiments thereof, relates to capacitive based digitizer sensors and, more particularly, but not exclusively, to detection with a capacitive based digitizer sensor.

5 According to some embodiments of the present invention, a portion of signal representing changes to the transferred triggering signal due to a presence of a finger and/or conductive object is isolated from a portion of the signal representing the triggering signal that is transferred when no interaction is present. According to some
10 embodiments of the present invention, amplitude of the portion of the signal representing the triggering signal that is transferred when no interaction is present is determined during a calibration procedure while a user is not interacting with the digitizer sensor and used to reduce amplitude of signal that is input to an ADC. Typically, the portion of the signal representing the transferred triggering signal when no
15 interaction is present is assumed to have a same frequency as the triggering signal on the orthogonal axis but with reduced amplitude. Typically, variations in amplitude may exist between different sensing lines due to variability in mechanical structure of the sensor and/or due to variable distances of each of the conductive lines to an edge of the sensor from which the triggering signal is introduced.

 In some exemplary embodiments, during the calibration, amplitudes of the
20 output obtained from each of the conductive lines is recorded and later used to synthesize signals to be subtracted from output obtained during user interaction with the digitizer sensor. Typically, a different signal is synthesized for each conductive line providing output. Alternatively, an average of all the amplitudes detected is used to synthesize one signal to be subtracted from all the conductive lines providing output.
25 Optionally, during calibration a plurality of amplitudes are recorded for each sensing conductive line, each amplitude of the plurality corresponding to a different conductive line triggered in the orthogonal axis. Optionally, an average of the amplitudes determined responsive to the different conductive lines triggered in the orthogonal axis is computed and the average amplitude is used to synthesize signals to be subtracted
30 from output.

 In some exemplary embodiments, in one or more operational modes of the digitizer sensor, a plurality of conductive lines is triggered simultaneously. According to

some embodiments of the present invention, during the calibration procedure amplitudes are detected responsive to the simultaneous triggering. In some exemplary embodiments, during operation of the digitizer system, different signals are synthesized depending on the operational mode of the digitizer sensor, e.g. depending on the number of conductive lines triggered simultaneously.

According to some embodiments of the present invention, during a search operational mode, e.g. prior to detecting a user interacting with the digitizer sensor, all sensor lines along one axis are triggered simultaneously. Optionally, during the search mode, output is detected from the same conductive lines that are triggered. In some exemplary embodiments, prior to sampling output, the triggering signal is subtracted from the output.

According to some embodiments of the present invention, amplitudes detected during a calibration procedure are updated during start-up of the digitizer system. Optionally, amplitudes are periodically updated during operation of the digitizer system while user interaction is not detected by the digitizer sensor.

In some exemplary embodiments, signal subtraction and/or isolation of the portion of signal representing changes to the transferred triggering signal due to a presence of a finger and/or conductive object is performed with a differential amplifier. Alternatively, the signal subtraction and/or signal isolation is achieved by introducing an inverse of the synthesized signal or the triggering signal to input to an amplifier associated with a conductive line.

For purposes of better understanding some embodiments of the present invention, as illustrated in FIGS. 2-8 of the drawings, reference is first made to the construction and operation of a known mutual capacitance touch sensor as illustrated in FIG. 1. Known mutual capacitance touch sensors are typically formed with a plurality of horizontal conductive lines 301 and a plurality of vertical conductive lines 302 that cross to form a grid with a plurality of junctions 40. The horizontal conductive line is isolated from the vertical conductive line at each junction 40, and a certain amount of capacitance exists between orthogonal conductive lines. When a finger 46 and/or conductive object 45, e.g. conductive object with high impedance to ground, touches (or hovers over) the sensor, the capacitance formed at touched junctions 42 is altered. A change in capacitance at one or more touched junctions 42 can be detected by triggering

one or more parallel conductive lines, e.g. vertical line 302 of sensor 12 with an AC signal 60 and then detecting signals, e.g. signals 65, 70 and/or 75 crossing by virtue of the capacitance to conductive lines 301 that cross conductive lines 302. Optionally, signal 60 is a burst signal that is repeated at a pre-defined repetition rate. Typically, output from sensor 12 is amplified with one or more amplifiers 455.

Typically, on conductive lines 301 with no user interaction, e.g. conductive object and/or finger, a signal 65 is detected responsive to a triggering signal applied to one or more conductive lines 302. Typically, the presence of a finger decreases the amplitude of signal 65. Typically, amplitude of signal 70 detected on conductive line 301 touched by finger 46 is 5-30% lower than amplitude of signal 65 obtained when no finger is present. Alternatively, a conductive object 45 increases amplitude of the coupled signal. Typically amplitude of a signal 75 obtained from conductive lines 301 in the presence of conductive object 45 is greater than amplitude of signal 65 obtained when no conductive object is present. Changes in amplitude of the coupled signal typically depend for example on a size of the conductive object, material composition of the conductive object, and its proximity to sensor 12.

Reference is now made to FIGS. 2A, 2B and 2C showing simplified output signals obtained by an exemplary digitizer sensor, and components of the output signals originating from a transferred triggering signal and finger touch respectively, in accordance with some embodiments of the present invention. According to some embodiments of the present invention, in response to a trigger signal provided on a conductive line 302 while a finger 46 touches and/or hovers over the conductive line, a signal 70 is detected from a conductive line 301 (FIG. 1). Typically, amplitude 95 of signal 70 is a function of capacitive coupling between conductive line 301 and conductive line 302 and also a function of a change in the capacitive coupling due to the presence of finger 46. Typically, signal 65 represents the portion of the triggering signal that is transferred due to coupling of the cross lines when no interaction is present, and can be used to define a reference signal for output detected during user interaction with the sensor. Typically, signal 65 is similar to triggering signal 60 but may typically have lower amplitude than triggering signal 60 and optionally a different phase. Typically, signal 65 has a same phase as signal 70. Typically, the presence of a finger increases the capacitive coupling and decreases amplitude of the output.

Typically, amplitude 95 of signal 70 is between 5-30% smaller than amplitude 90 of signal 65. For exemplary purposes, two burst signals are shown in each of FIGS. 2A, 2B and 2C.

Typically, signal 50 represents the portion of the triggering signal that provides information regarding a presence of an object and is defined by the difference between signal 70 and signal 65 obtained when no interaction is present. Typically, a phase of signal 50 will be opposite a phase of signal 70 and signal 65 since amplitude 90 of signal 65 greater than amplitude 95 of signal 70. In some exemplary embodiments, amplitude 85 of signal 50 is between 70-95% of amplitude 95 of signal 70. The present inventor has found that signal 50 includes information regarding change in capacitive coupling introduced by finger 46, while signal 65 does not include information regarding change in capacitive coupling introduced by finger 46. The present inventor has also found that by isolating signal 50 and/or by removing signal 65 from signal 70, the amplitude of output that requires sampling is reduced without losing information regarding a presence of finger 46. Optionally, by reducing the amplitude of the signal prior to sampling, a dynamic range of an ADC can be used to sample lower amplitude signal 50 with a higher resolution. Alternatively, a smaller number of bits can be used to represent the amplitude.

It is noted that although in FIG. 1, amplitude of signal 65 obtained when no user interaction is present is shown to be the same for all conductive lines with no user interaction, signal 65 and/or signal amplitude 90 for each of conductive lines 301 may differ due to variations in mechanical structure in different regions of sensor 12, location of the triggered line with respect to the sensor line and/or due to noise. According to some embodiments of the present invention, signal 65 and/or signal amplitude 90 is detected for each of conductive lines 301 during a calibration procedure, and used to define a reference signal that is later subtracted from the corresponding lines prior to sampling output from the conductive lines during user interaction with the digitizer sensor. Optionally, during calibration, amplitude of the output is attenuated prior to sampling to avoid saturation of the ADC.

Reference is now made to FIGS. 3A, 3B and 3C showing simplified output signals provided by an exemplary digitizer sensor and components of the output signals originating from a transferred triggering signal and touch of a conductive object,

respectively, in accordance with some embodiments of the present invention. According to some embodiments of the present invention, in response to triggering a conductive line 302 of digitizer sensor 12 with a burst signal 60 in the presence of a conductive object, a signal 75 crosses to one or more conductive lines 301 due to capacitive coupling between conductive lines 301 and 302 around junctions 42 (FIG. 1). Typically, amplitude 98 of signal 75 is a function of the capacitive coupling between conductive line 301 and conductive line 302, and also of a change in the capacitive coupling due to the presence of a conductive object 45. Typically, reference signal 65 is similar to triggering signal 60 but may typically have lower amplitude than triggering signal 60 and optionally a different phase. Typically, signal 65 has a same phase as signal 75. Typically, the presence of a conductive object increases amplitude of the output by up to 10%.

Typically, a signal 53 represents the portion of the triggering signal that provides information regarding a presence of an object and is defined by the difference between signal 75 and signal 65. Typically, a phase of signal 53 will be the same as a phase of signal 75 and signal 65 since amplitude 98 of signal 75 is typically greater than amplitude 90 of signal 65. The present inventor has found that signal 53 includes information regarding change in capacitive coupling introduced by conductive object 45 while signal 65 does not include information regarding change in capacitive coupling introduced by finger 46. As described above in reference to FIGS. 2A-2C, amplitude of output that requires sampling can be reduced without losing information regarding a presence of conductive object 45 by isolating signal 53 and/or by subtracting signal 65 from signal 75.

According to some embodiments of the present invention, signal 65 and/or signal amplitude 90 is detected for each of conductive lines 301 during a calibration procedure and used to define a reference signal that is later subtracted from the corresponding lines prior to sampling output from the conductive lines during user interaction with the digitizer sensor. For exemplary purposes, two burst signals are shown in each of FIGS. 3A, 3B and 3C.

Reference is now made to FIG. 4 showing a schematic illustration of a digitizer sensor whose output is connected to an array of differential amplifiers for isolating a touch signal from the sensor output, in accordance with some embodiments of the

present invention. According to some embodiments of the present invention, one or more conductive lines 301 of sensor 12 provide output generally referred to as output 71 in response to triggering a conductive line 302 with a triggering signal 60. According to some embodiments of the present invention, each output 71 from conductive lines 301 is fed into a first input of a differential amplifier 205 and a pre-defined reference signal 66 is fed into a second input of differential amplifier 205. Typically reference signal 66 is defined based on one or more signals 65 detected during calibration. Typically, output from differential amplifier 205 is generally referred to as output 51. In some exemplary embodiments, output 51 obtained from conductive lines 301 affected by finger 46 will have an amplitude reflecting a difference in amplitude between output 71 and reference signal 66. Optionally, phase of output 51 obtained from a conductive line affected by finger 46 will be shifted by 180 degrees with respect to a phase of reference signal 66 but may also have a similar phase depending on the reference signal used. In some exemplary embodiments, output 51 obtained from a conductive line that is not affected by finger 46 and/or any other interaction, will have a lower amplitude signal as compared to signal obtained in the presence of a finger.

Reference is now made to FIG. 5 showing a schematic illustration of a digitizer sensor with a reference signal added to the sensor output, in accordance with some embodiments of the present invention. According to some embodiments of the present invention, one or more conductive lines 301 of sensor 12 provide output generally referred to as output 71 in response to triggering one or more lines 302 with a triggering signal 60. According to some embodiments of the present invention, each output 71 from conductive lines 301 is added to reference signal 66. According to some embodiments of the present invention, a phase of reference signal 66 is shifted by 180 degrees with respect to a phase of output 71 so that the addition of reference signal 66 and output 71 provides for isolating output 51 from output 71 and/or subtracting reference signal 66 from output 71.

Typically, reference signal 66 are synthesized burst signals that are synthesized based on pre-defined amplitude, frequency, phase and duration that is stored in memory. Typically, amplitude of signal 66 for each of conductive lines 301 is determined during a calibration procedure performed while a user is not interacting

with the sensor. Optionally, frequency and duration of burst signal 66 are pre-defined and typically the same as the frequency and duration of triggering signal 60. Typically, parameters of reference signal 66 are stored in memory associated with circuitry of sensor 12. Optionally, one or more parameters of reference signal 66 are periodically
5 updated, e.g. during user interaction with sensor 12. Optionally, parameters defining reference signal 66 are stored for each conductive line 302 that is triggered since the output obtained from conductive line 301 may be different depending on which of conductive lines 302 are triggered. Typically reference signal 66 is based on one or more signals 65 detected when no finger and/or object is present on sensor 12.

10 It is noted that although in FIG. 4 and FIG. 5 only one conductive line 302 is shown to be triggered with triggering signal 60, in some exemplary embodiments, in one or more operational modes of a digitizer, a plurality of conductive lines 302 and/or all the conductive lines 302 are triggered simultaneously. Typically, amplitude of output 71 obtained when a plurality of conductive lines 302 are triggered
15 simultaneously will be higher than amplitude of output 71 when only one line is triggered. In some exemplary embodiments, reference signals for each of conductive lines 301 are determined responsive to triggering a plurality and/or all conductive lines 302 and one or more parameters of the detected signals are stored. Optionally, during an operational mode in which a plurality and/or all the conductive lines 302 are
20 triggered, the stored parameters are used to synthesize an appropriate reference signal 66 for a mode when a plurality and/or all the conductive lines 302 are triggered.

Reference is now made to FIG. 6 showing a simplified diagram of an exemplary digitizer system in accordance with some embodiments of the present invention. The digitizer system 100 may be suitable for any computing device that enables touch
25 and/or hover input between a user and the device, e.g. mobile and/or desktop and/or tabletop computing devices that include, for example, FPD screens. Examples of such devices include Tablet PCs, pen enabled lap-top computers, tabletop computer, PDAs or any hand held devices such as palm pilots and mobile phones or other devices that facilitate electronic gaming. According to some embodiments of the present invention,
30 the digitizer system comprises a sensor 12 including a patterned arrangement of conductive lines, which is optionally transparent, and which is typically overlaid on a

FPD. Typically sensor 12 is a grid based sensor including horizontal and vertical conductive lines.

According to some embodiments of the present invention, circuitry is provided on one or more PCB(s) 30 positioned around sensor 12. According to some
5 embodiments of the present invention, one or more ASICs 16 connected to outputs of the various conductive lines in the grid is positioned on PCB(s) 30. Typically, ASICs 16 function to process the received signals at a first processing stage and to sample the sensor's output into a digital representation. Optionally, ASIC 16 includes one or more filters to remove irrelevant frequencies. Optionally, filtering is performed prior to
10 sampling. According to some embodiments of the present invention, ASICs 16 include circuitry 17 for subtracting a reference signal from the sensor's output prior to sampling the output into a digital representation. The signal is then sampled by an A/D, optionally filtered by a digital filter and forwarded to digital ASIC unit, for further digital processing. Alternatively, the optional filtering is fully digital or fully analog.

15 The digital output signal is forwarded to a digital unit 20, e.g. digital ASIC unit also on PCB 30, for further digital processing. According to some embodiments of the present invention, digital unit 20 together with ASIC 16 serves as the controller of the digitizer system and/or has functionality of a controller and/or processor. Output from the digitizer sensor is forwarded to a host 22 via an interface 24 for processing by the
20 operating system or any current application.

According to some embodiments of the present invention, digital unit 20 together with ASIC 16 includes memory and/or memory capability. Memory capability may include volatile and/or non-volatile memory, e.g. FLASH memory. Optionally, the memory unit and/or memory capability, e.g. FLASH memory is a unit separate from the
25 digital unit 20 but in communication with digital unit 20. According to some embodiments of the present invention, one or more tables and/or databases may be stored to record one or more parameters of reference signal 66 that is to be subtracted from or added to the sensor's output prior to sampling. Optionally, circuitry 17 includes memory for storing amplitude of one or more reference signals 66.

30 The memory may also include a write-once memory device which may be hard coded with the relevant information during manufacturing or calibration.

According to some embodiments of the invention, digital unit 20 receives the sampled data from ASIC 16, reads the sampled data, processes it and determines and/or tracks the position of physical objects, such as a stylus 44, a token 45 and/or a finger 46 touching the digitizer sensor. According to some embodiments of the present invention, digital unit 20 determines the presence and/or absence of physical objects, such as stylus 44, token 45 and/or finger 46 over time. In some exemplary embodiments of the present invention hovering of an object, e.g. stylus 44, finger 46 and hand, is also detected and processed by digital unit 20. Calculated position and/or tracking information are reported to the host computer via interface 24.

According to some embodiments of the present invention, during a detection mode, e.g. a multi-touch detection mode, digital unit 20 together with ASIC 16 triggers each conductive line along one axis of the sensor, one line at a time, with a burst AC signal. Typically, in response to triggering, ASIC 16 sample signals, e.g. simultaneously in all conductive lines crossing the triggered line, e.g. all conductive lines of the orthogonal axis. Typically, this triggering and detecting procedure is repeated until all the conductive lines in the active axis have been triggered and interaction in all junction points formed between the crossing lines has been detected. Optionally, more than one conductive line is triggered simultaneously using orthogonal signals as described for example in incorporated US Patent No. 7,902,840 and/or in incorporated U.S. Patent Application Publication No. 2009-0127005.

According to some embodiments of the present invention, digitizer system 100 operates in a search mode at a start-up of the system and/or after a pre-defined period in which no interaction, e.g. finger touch interaction has been detected. According to some embodiments of the present invention, during a search mode all conductive lines along one axis of sensor 12, e.g. the shorter dimension of sensor 12 are triggered simultaneously. Optionally, the conductive lines are triggered with a same triggering signal. Optionally, in response to triggering, output on the same conductive lines is detected. Optionally, prior to sampling output, signal subtraction is performed to subtract the triggering signal from the sensor output. Optionally, if user interaction is detected during the search mode, digitizer system 100 changes to a detection mode, e.g. multi-touch detection mode.

The present invention is not limited to the technical description of the digitizer system described herein. The present invention may also be applicable to other digitized sensor and touch screens known in the art, depending on their construction. The present invention may also be applicable to other touch detection methods known
5 in the art.

Reference is now made to FIG. 7 showing a simplified flow chart of an exemplary method for defining reference signals for one or more operational modes of a digitizer sensor, in accordance with some embodiments of the present invention. According to some embodiments of the present invention, during a calibration
10 procedure 705 while no object, e.g. finger, palm, stylus, and conductive object is interacting with the digitizer, one or more conductive lines of the digitizer sensor are triggered (block 710). In some exemplary embodiments, calibration is performed during a system start-up. Optionally, calibration is repeated periodically in response to detection a period with no interaction with the digitizer sensor. Optionally, calibration
15 is performed in response to user command.

According to some embodiments of the present invention, outputs on one or more conductive lines that cross the triggered lines are detected in response to the triggering. According to some embodiments of the present invention, one or more parameters of outputs detected on each of the conductive lines are determined (block
20 720). Optionally, amplitude of the output is determined. Optionally, phase of the output is detected. According to some embodiments of the present invention, one or more of the determined parameters are recorded. Optionally, amplitude detected on each of the lines is determined and stored. Optionally, average amplitude of all the amplitudes detected on the conductive lines is stored.

In some exemplary embodiments, output is detected responsive to triggering each of the conductive lines along one axis and the parameters detected for each triggering event are associated with a conductive line that was triggered (block 730). Optionally, an average of the parameters detected responsive to triggering of the different conductive lines is stored. According to some embodiments of the present
30 invention, parameters stored are used to reconstruct and/or synthesize a reference signal to be subtracted from output of the digitizer sensor during user interaction with the digitizer.

Reference is now made to FIG. 8 showing a simplified flow chart of an exemplary method for isolating a detection signal from output of a digitizer sensor in accordance with some embodiments of the present invention. According to some embodiments of the present invention, during user interaction with the digitizer sensor (block 805), one or more lines of the digitizer sensor is triggered (block 810). According to some embodiments of the present invention, one or more reference signals are synthesized based on the one or more stored parameters for defining the reference signal (815). In some exemplary embodiments, a signal is synthesized for each conductive line to be sampled. Alternatively, one signal is synthesized for all the conductive lines. In some exemplary embodiments, a different signal is synthesized responsive to each line triggered in the orthogonal axis. Optionally, one signal is synthesized per conductive lines sampled.

According to some embodiments of the present invention, the synthesized reference signal is subtracted from output of the digitizer sensor (block 820). Optionally, subtraction is performed with a differential amplifier. Optionally, subtracting is performed by adding an inverse of the reference signal to the output of the digitizer sensor. According to some embodiments of the present invention, output of the digitizer sensor after subtraction is sampled (825). According to some embodiments of the present invention, user interaction is detected based on the sampled signal (block 830). Typically, output and phase of the sampled signal is used to identify the type of user interaction and its location. Typically, sampled output above a pre-defined amplitude threshold on one or more conductive lines is an indication of a presence of a user interaction. Typically, a phase of the output is used to differentiate between a token 45 and a finger 46.

The terms "comprises", "comprising", "includes", "including", "having" and their conjugates mean "including but not limited to".

The term "consisting of" means "including and limited to".

The term "consisting essentially of" means that the composition, method or structure may include additional ingredients, steps and/or parts, but only if the additional ingredients, steps and/or parts do not materially alter the basic and novel characteristics of the claimed composition, method or structure.

As used herein the term "method" refers to manners, means, techniques and procedures for accomplishing a given task including, but not limited to, those manners, means, techniques and procedures either known to, or readily developed from known manners, means, techniques and procedures by practitioners of the chemical, pharmacological, biological, biochemical and medical arts.

It is appreciated that certain features of the invention, which are, for clarity, described in the context of separate embodiments, may also be provided in combination in a single embodiment. Conversely, various features of the invention, which are, for brevity, described in the context of a single embodiment, may also be provided separately or in any suitable sub-combination or as suitable in any other described embodiment of the invention. Certain features described in the context of various embodiments are not to be considered essential features of those embodiments, unless the embodiment is inoperative without those elements.

WHAT IS CLAIMED IS:

1. A digitizer system comprising
 - a mutual capacitance sensor including a first set of parallel conductive lines and a second set of parallel conductive lines, the first and second set of conductive lines arranged in a grid pattern;
 - a memory for storing at least one parameter for characterizing a signal detected on at least one conductive line in the second set of parallel conductive lines, responsive to triggering at least one conductive line in the first set of parallel conductive lines while no user interaction is present over the sensor; and
 - circuitry operative to:
 - trigger at least one conductive line in the first set of parallel conductive lines;
 - synthesize a reference signal based on the at least one parameter stored;
 - subtract the reference signal from output on at least one conductive line in the second set of conductive lines; and
 - sample the output after subtraction.
2. The system of claim 1, wherein the reference signal has a same frequency as a signal for triggering the at least one conductive line in the first set of parallel conductive lines.
3. The system of claim 1 or claim 2, wherein the at least one parameter stored is amplitude of the signal detected on the at least one conductive line in the second set of parallel conductive lines while no user interaction is present over the sensor.
4. The system of any one of claims 1-3, wherein the memory is operative to store parameters for characterizing signals detected on each of the conductive lines in the second set while no user interaction is present over the sensor.
5. The system of claim 4, wherein the circuitry is operative to synthesize a reference signal for each conductive line in the second set.

6. The system of claim 5, wherein the circuitry is operative to subtract by analog subtraction the reference signal from output on each conductive line in the second set.
7. The system of any of claims 1-6, wherein the reference signal is an AC signal.
8. The system of claim 7, wherein the reference signal is a burst signal.
9. The system of any one of claims 1-8, wherein the circuitry includes at least one differential amplifier for subtracting the reference signal from the output by analogue subtraction.
10. The system of any one of claims 1-8, the circuitry is operative to invert the reference signal and add the inverted reference signal to the output.
11. A method for detection with a digitizer sensor, the method comprising:
 - providing a mutual capacitance sensor including first set of parallel conductive lines and second set of parallel conductive lines, the first and second set of conductive lines arranged in a grid pattern;
 - storing at least one parameter for characterizing a signal detected on a conductive line in the second set responsive to triggering a conductive line in the first set while when no user interaction is present over the sensor;
 - synthesizing a reference signal based on the at least one parameter stored;
 - subtracting the reference signal from output on at least one conductive line in the second set of conductive lines responsive to triggering a conductive line in the first set;
 - and
 - sampling the output after subtraction.
12. The method of claim 11, wherein the reference signal has a same frequency as a signal for triggering the at least one conductive line in the first set of parallel conductive lines.

13. The method of claim 11 or claim 12, wherein the at least one parameter stored is amplitude of the signal detected on the at least one conductive line in the second set of parallel conductive lines while when no user interaction is present over the sensor.
14. The method of any one of claims 11-13, comprising storing parameters for characterizing signals detected on each of the conductive lines in the second set while no user interaction is present over the sensor.
15. The method of claim 14, comprising synthesizing a reference signal for each conductive line in the second set.
16. The method of claim 15, comprising subtracting by analog subtraction the reference signal from output on each conductive line in the second set.
17. The method of any of claims 11-16, wherein the reference signal is an AC signal.
18. The method of claim 17, wherein the reference signal is a burst signal.
19. A method for detection with a digitizer sensor, the method comprising:
providing a mutual capacitance sensor including a first set of parallel conductive lines and a second set of parallel conductive lines, the first and second set of conductive lines arranged in a grid pattern;
triggering a plurality of conductive lines in the first set of parallel conductive lines simultaneously with a triggering signal;
subtracting the triggering signal from output on the plurality of conductive lines in first set;
sampling the output on the plurality of conductive lines in first set after subtraction;
determining if a user interaction is presence on the sensor from the output sampled; and
scanning the sensor responsive to detecting the presence of a user interaction.

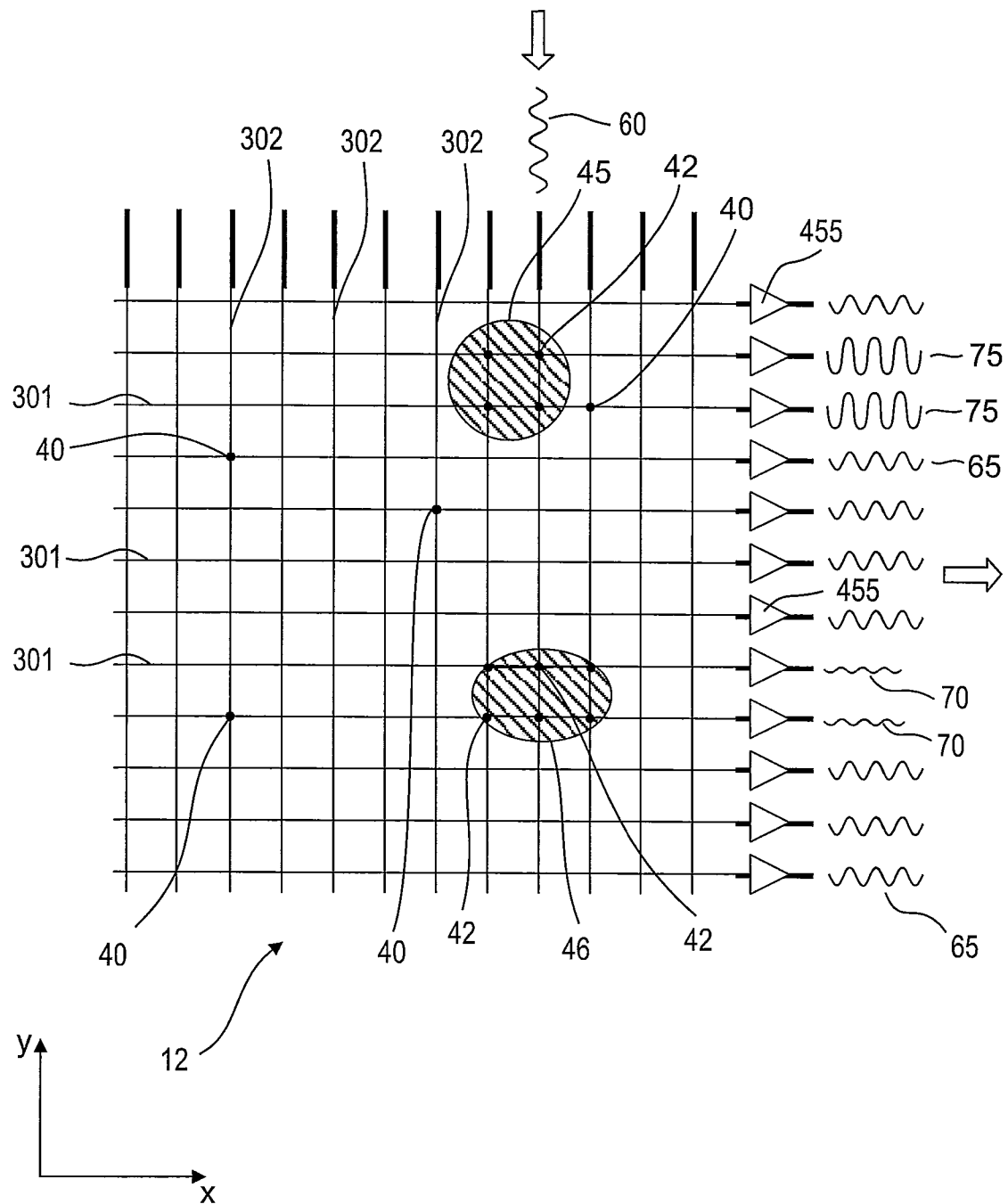
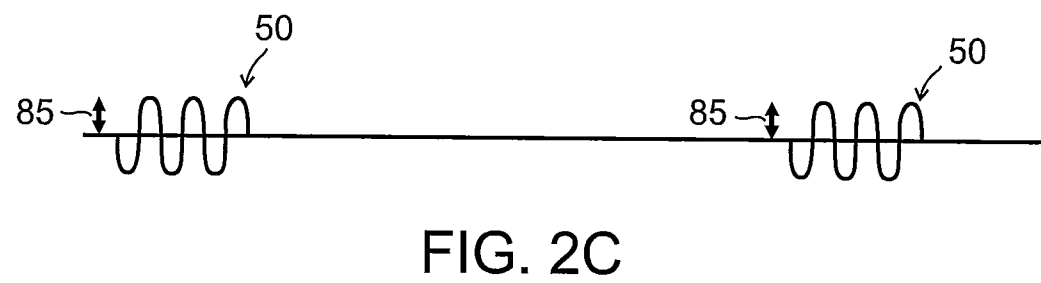
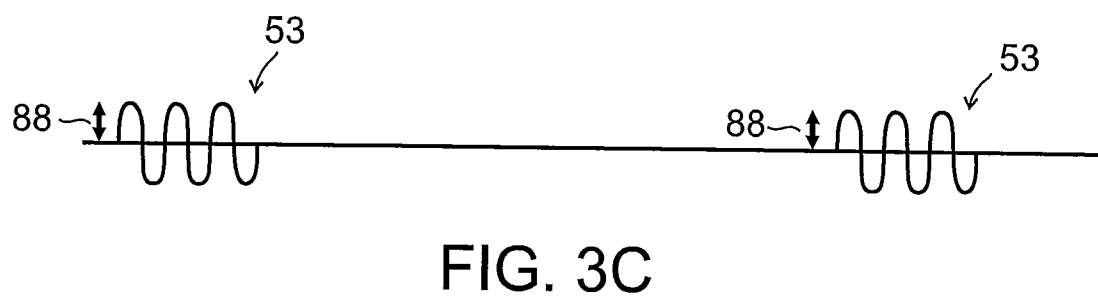
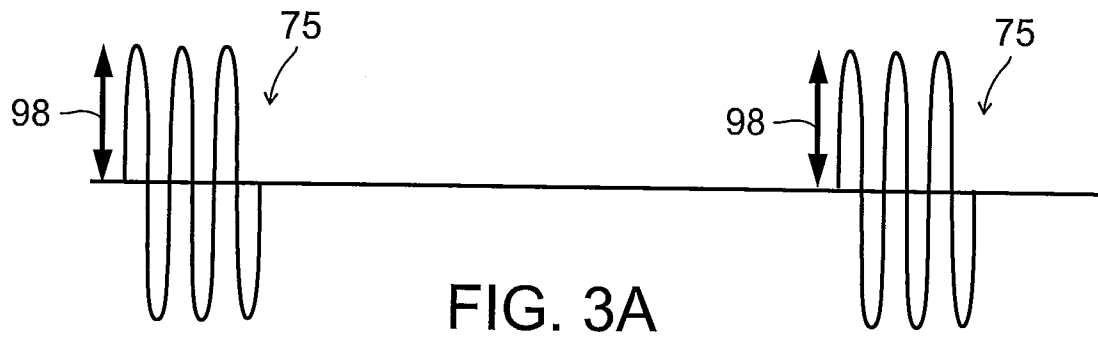


FIG. 1





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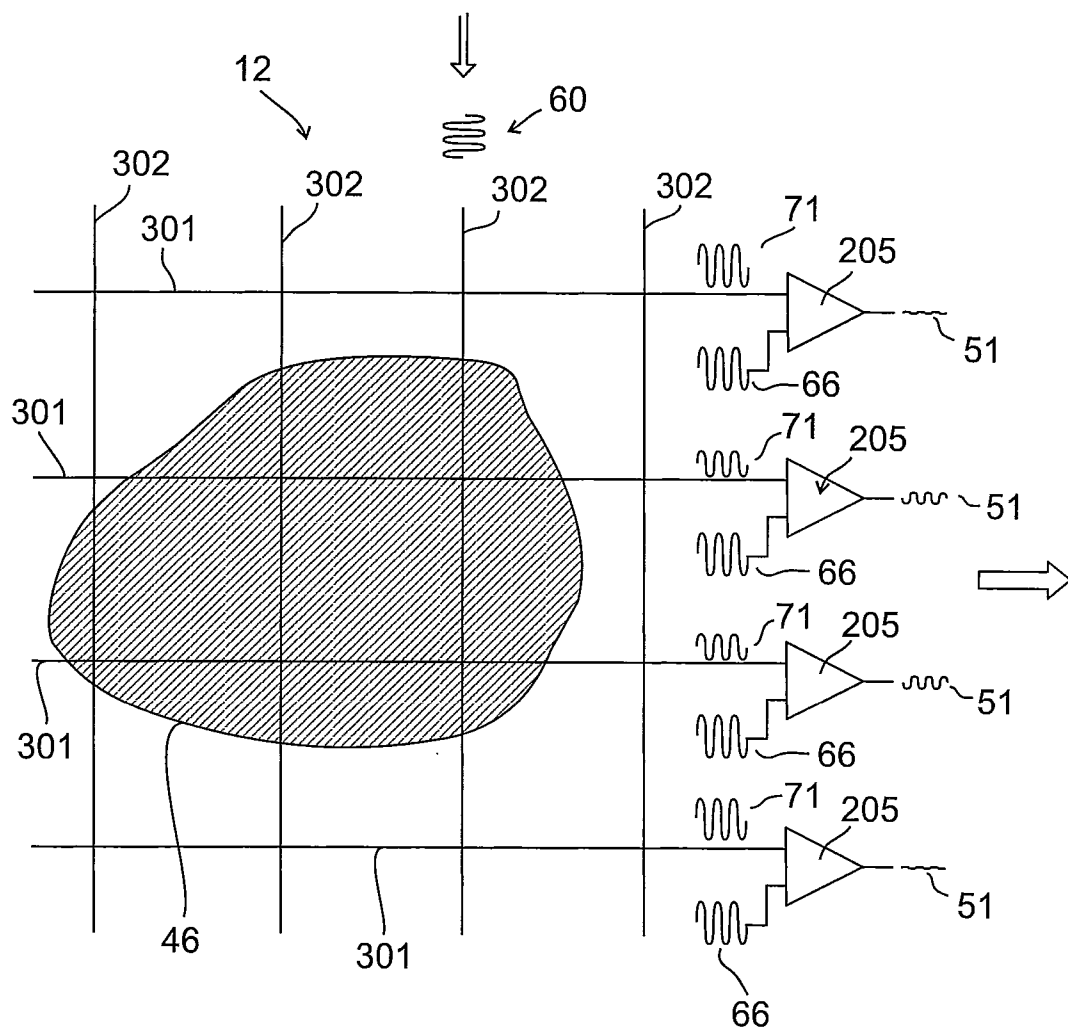


FIG. 4

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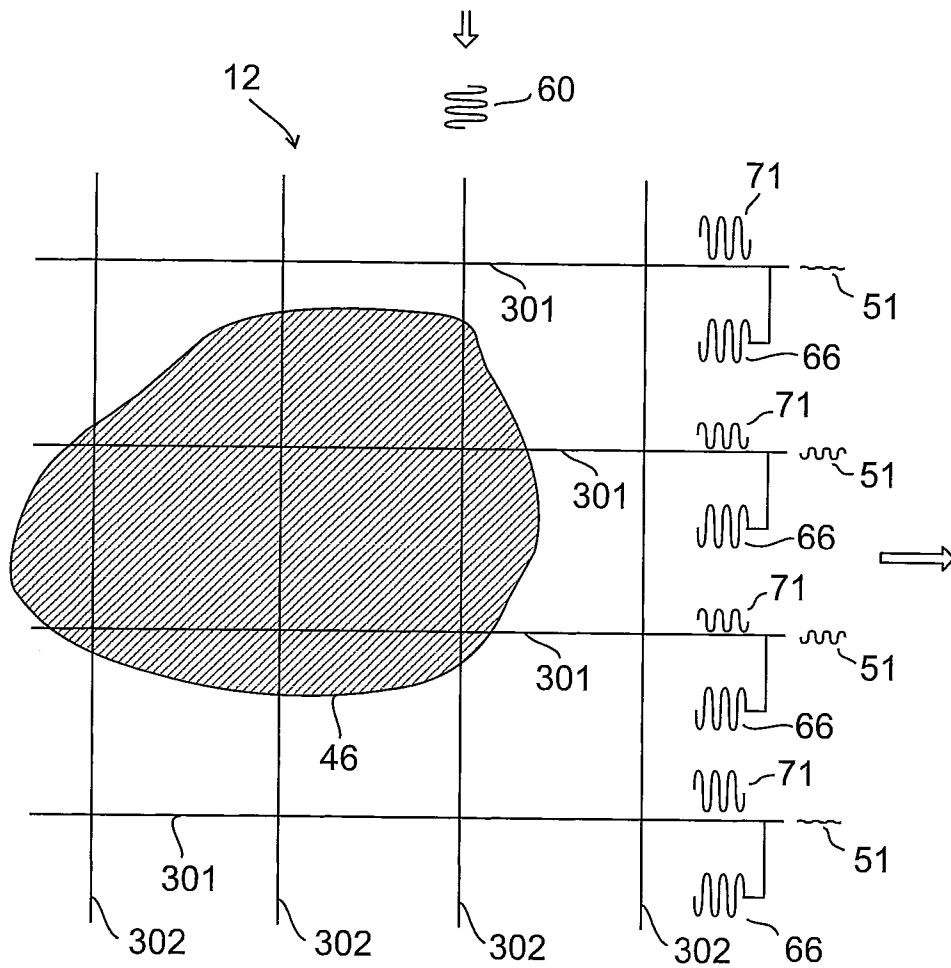


FIG. 5

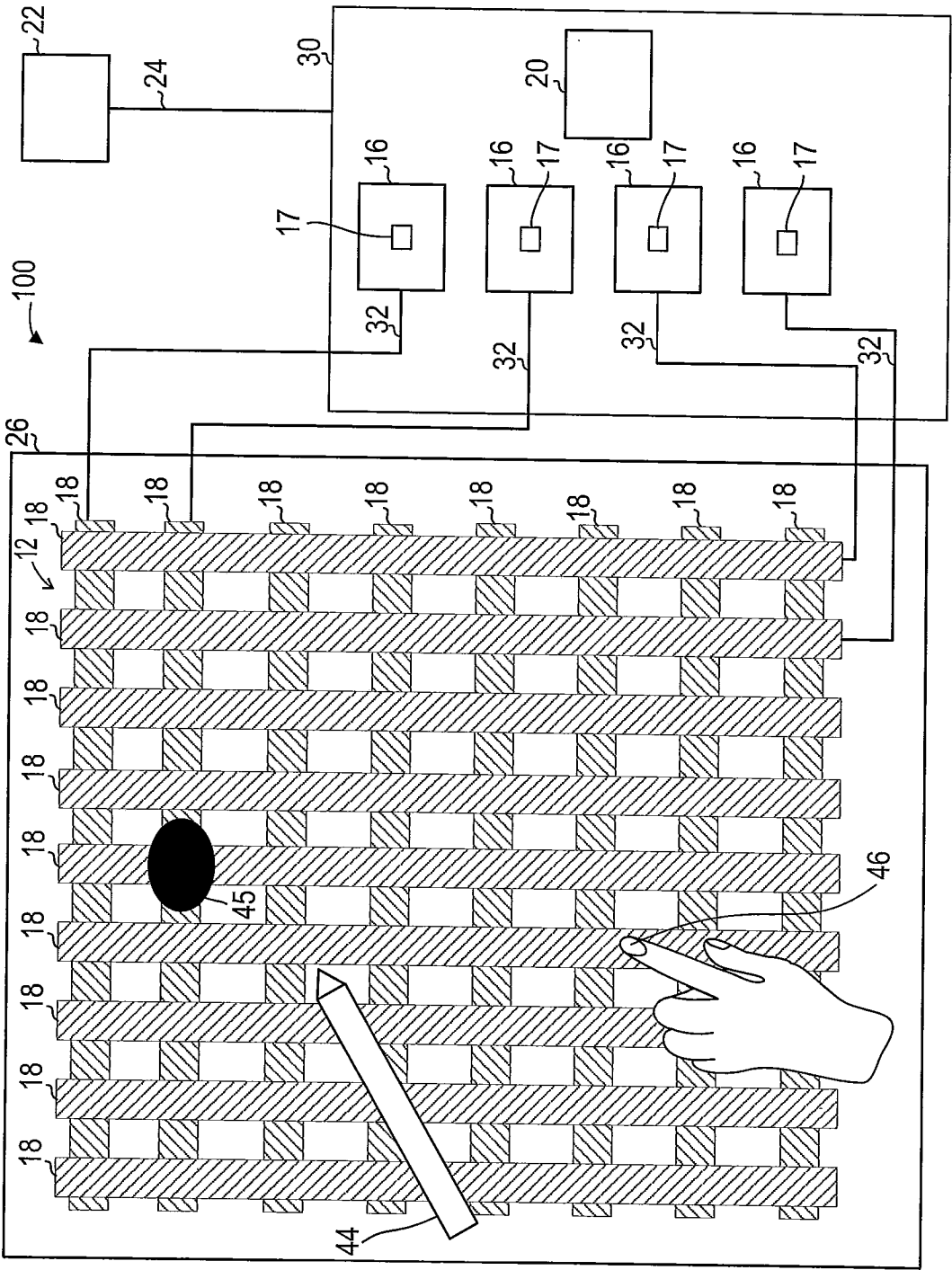


FIG. 6

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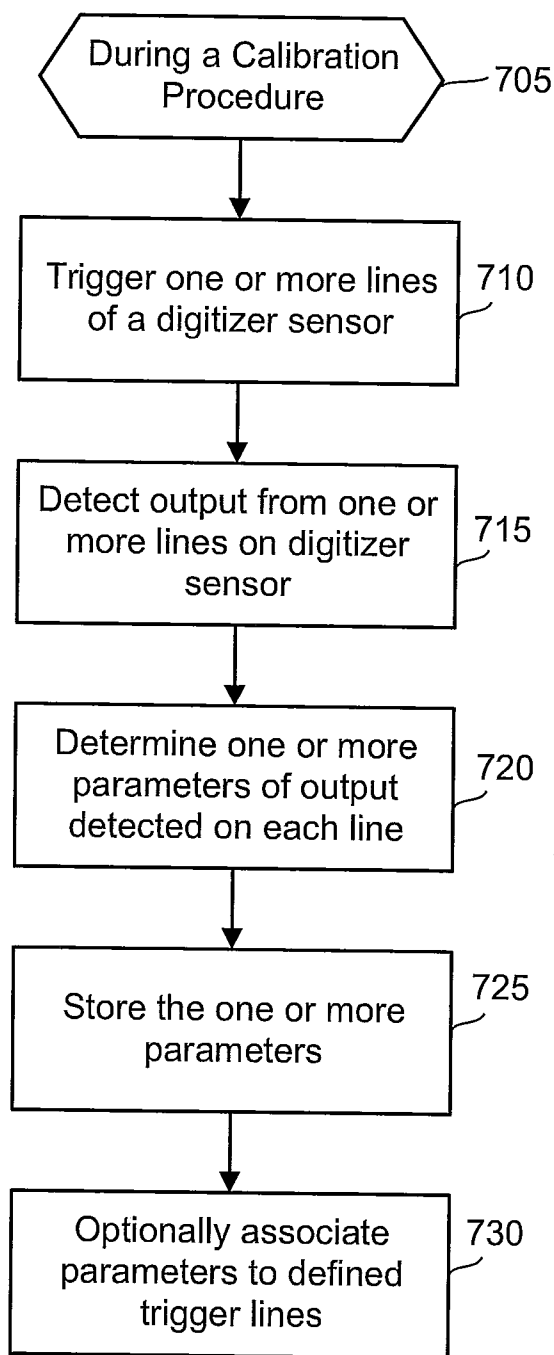


FIG. 7

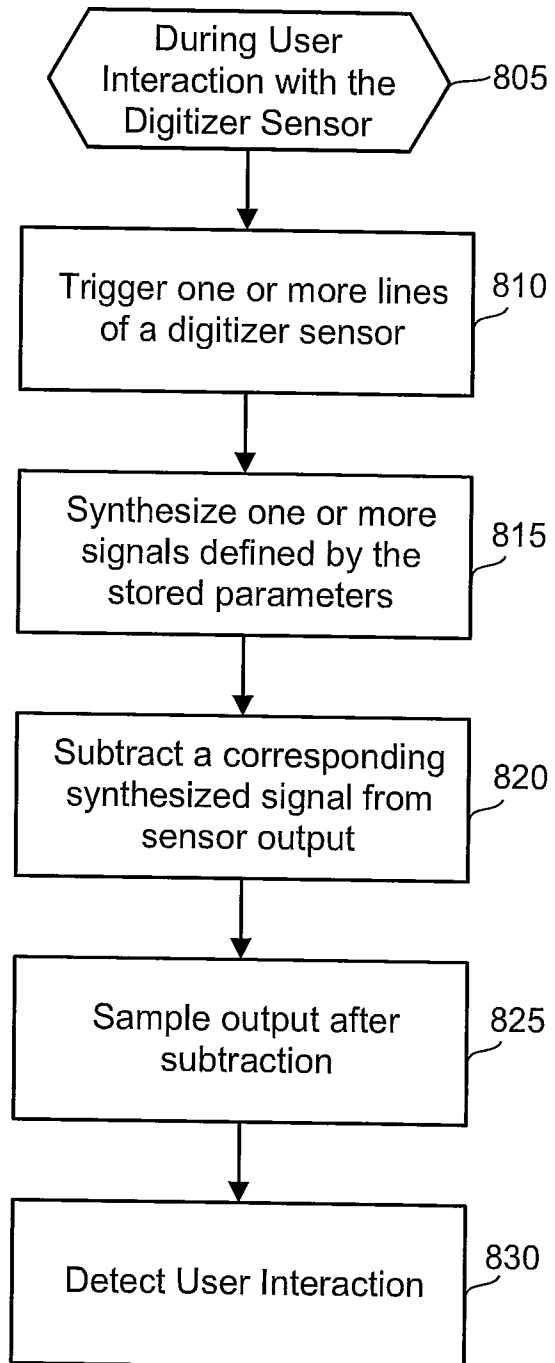


FIG. 8

INTERNATIONAL SEARCH REPORT

International application No
PCT/IL2012/050127

A. CLASSIFICATION OF SUBJECT MATTER INV. G06F3/044 G06F3/041 ADD.		
According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) G06F		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) EPO-Internal, WPI Data		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2002/186210 A1 (ITOH AKIHISA [JP]) 12 December 2002 (2002-12-12) paragraph [0025] - paragraph [0026] paragraph [0055] - paragraph [0058]; claim 6	1-18
X	----- US 2008/158175 A1 (HOTELLING STEVE PORTER [US] ET AL) 3 July 2008 (2008-07-03) paragraph [0008] - paragraph [0011] paragraph [0064] - paragraph [0070] paragraph [0088]; claims 1-6, 11-18, 23-26, 30-32; figures 8-12, 17	1-18
X	----- US 2008/158178 A1 (HOTELLING STEVE PORTER [US] ET AL) 3 July 2008 (2008-07-03) paragraph [0007] - paragraph [0008] paragraph [0057] - paragraph [0063]; claims; figures 8-12 ----- -/--	1-18
☒ Further documents are listed in the continuation of Box C. ☒ See patent family annex.		
* Special categories of cited documents : "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier application or patent but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family		
Date of the actual completion of the international search 4 July 2012		Date of mailing of the international search report 04/10/2012
Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016		Authorized officer Durand, Jacques

INTERNATIONAL SEARCH REPORT

International application No

PCT/IL2012/050127

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2009/153152 A1 (MAHARYTA ANDRIY [UA] ET AL) 18 June 2009 (2009-06-18) paragraph [0019] - paragraph [0023] paragraph [0057] - paragraph [0067] paragraph [0094] - paragraph [0096] paragraph [0113]; figures -----	1,3-8, 11,13-18

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IL2012/050127

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:
2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

1-18

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☐ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1-18

A digitizer system comprising
a mutual capacitance sensor including a first set of parallel conductive lines and a second set of parallel conductive lines, the first and second set of conductive lines arranged in a grid pattern;
a memory for storing at least one parameter. for characterizing a signal detected on at least one conductive line in the second set of parallel conductive lines, responsive to triggering at least one conductive line in the first set of parallel conductive lines while no user interaction is present over the sensor; and circuitry operative to:
trigger at least one conductive line in the first set of parallel conductive lines;
synthesize a reference signal based on the at least one parameter stored;
subtract the reference signal from output on at least one conductive line in the second set of conductive lines; and
sample the output after subtraction.

2. claim: 19

A method for detection with a digitizer sensor, the method comprising:
providing a mutual capacitance sensor including a first set of parallel conductive lines and a second set of parallel conductive lines, the first and second set of conductive lines arranged in a grid pattern;
triggering a plurality of conductive lines in the first set of parallel conductive lines simultaneously with a triggering signal;
subtracting the triggering signal from output on the plurality of conductive lines in first set;
sampling the output on the plurality of conductive lines in first set after subtraction;
determining if a user interaction is presence on the sensor from the output sampled; and
scanning the sensor responsive to detecting the presence of a user interaction.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/IL2012/050127

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2002186210 A1	12-12-2002	JP 2002366304 A US 2002186210 A1	20-12-2002 12-12-2002
US 2008158175 A1	03-07-2008	NONE	
US 2008158178 A1	03-07-2008	US 2008158178 A1 US 2012038581 A1 WO 2008085419 A1	03-07-2008 16-02-2012 17-07-2008
US 2009153152 A1	18-06-2009	CN 101896825 A KR 20100135220 A TW 200946926 A US 2009153152 A1 US 2012200307 A1 WO 2009078944 A1	24-11-2010 24-12-2010 16-11-2009 18-06-2009 09-08-2012 25-06-2009