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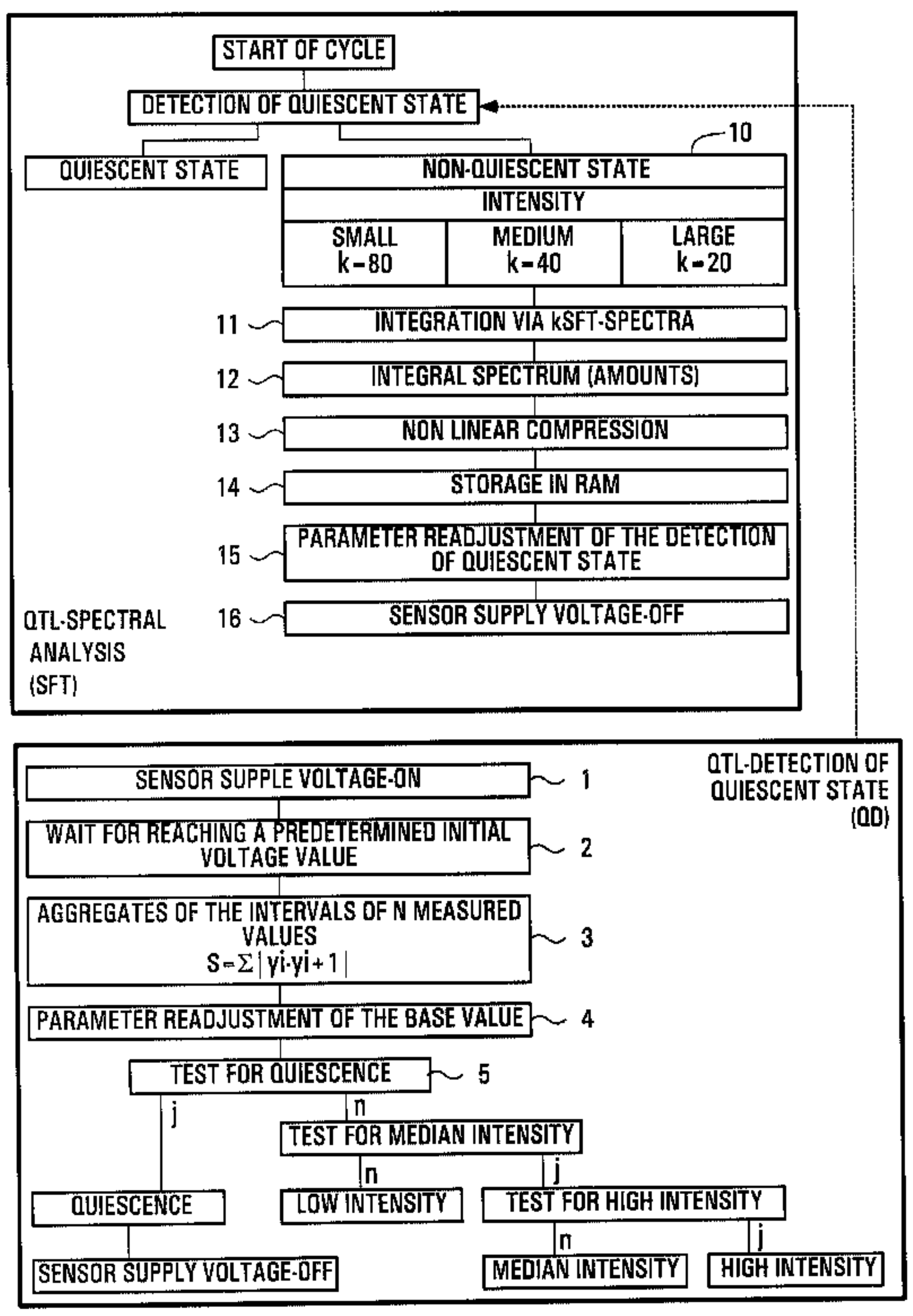
(54) Titre : DISPOSITIF ET PROCEDE POUR LE CONTROLE DU TEMPS DE TANSIT D'ARTICLES TRANSPORTES
(54) Title: DEVICE AND METHOD FOR MONITORING THE TRANSIT TIME OF TRANSPORTED ARTICLES



(57) Abrégé/Abstract:
In a device and a method for monitoring the transit time of transported articles, in which the movement of a consignment is recorded by a monitoring system acceleration sensor of which the measured values are stored and delivered to an evaluation arrangement, a predetermined number of K frequency spectra are determined in each predetermined cycle period T in order to give predetermined number of N measured values in each case, the K frequency spectra are integrated, and the integrated frequency spectra are stored in a memory.

20365-3709

ABSTRACT

In a device and a method for monitoring the transit time of transported articles, in which the movement of a consignment is recorded by a monitoring system acceleration sensor of which the measured values are stored and delivered to an evaluation arrangement, a predetermined number of K frequency spectra are determined in each predetermined cycle period T in order to give predetermined number of N measured values in each case, the K frequency spectra are integrated, and the integrated frequency spectra are stored in a memory.

WO 95/22061 PCT/EP95/00469

A Device and a Method for Monitoring the Transit Time of Transported Articles

Description

The present invention is in the domain of monitoring the transit time of transported articles.

It is usual to use transit time checking devices in order to monitor the transit time of postal consignments; these devices are mailed with the postal consignments that are to be transported, and they incorporate devices by which the movement of the postal consignments is recorded. The known devices of this kind incorporate a movement sensor that records movement during the whole time the consignment is en route. The forces that are encountered en route act on the sensor, the measured values from which are then set out in a movement-time diagram. If the consignment is quiescent, i.e., if it is not being transported, no recording takes place. Using such devices, it is possible to establish whether or not the consignment has remained unmoved for several days after a transportation phase lasting several hours, a situation that is unacceptable.

The movement-time diagram that is recorded by the transit time checking device can be analyzed at a central point and, by using a nominal/actual comparison, it is possible to identify the locations of possible holdups in delivery or despatch, since the transportation routes and transportation times for normal cases are known values. Also known is a transit time monitoring apparatus that incorporates a memory for the measured values and analysis electronics, the movement sensor, the memory for the measured values, and the analysis electronics being mounted on a semi-flexible base, that is of the same thickness as a normal letter, which is about 5 mm. This transit time monitoring apparatus is so configured that it can be handled by letter sorting machines and is not rejected when it undergoes stiffness measurement in the letter-processing machines used in post offices.

The journal Markt und Technik [Marketing and Technology], No. 10, of 9 March 1979, pp. 60-62, describes a method and a device for monitoring the shock loads to which transported articles are subjected; this uses an acceleration sensor, the measured values from which are stored and passed to an analysis device. When this is done, the signals of the three components x, y, and z are integrated. The integrated values are stored in a memory. The secondary values are digitized.

The known devices entail the disadvantage that they permit the detection of only two states, i.e., movement and quiescence. They do not permit any more precise distinction between the types of motion that are actually encountered during a movement state, or of the transportation means that are used.

It is the task of the present invention to create a device and a method for monitoring the transit time of transported articles, with which it is possible to identify the transportation means, transportation events, and types of movement that occur when a consignment is en route.

According to one aspect of the present invention, there is provided a method of monitoring the transit time of transported articles, in which the movement of a consignment is recorded by a monitoring system with an acceleration sensor, the measured values from which are stored and delivered to an evaluation arrangement, characterized in that a predetermined number of K frequency spectra consisting of a predetermined number of M spectral lines is determined in each predetermined cycle period T in order to give a predetermined number of N measured values in each case, so that at the end of each cycle period T there are precisely M integrated spectral lines; and in that the integrated frequency spectra are stored in a memory, the measured values being stored in the memory throughout the total transit time of a transported article, and at the destination an evaluation is supplied in order to reconstruct the transportation sequence.

According to another aspect the invention provides a device for carrying out the method for monitoring the transit time of transported articles, in which the movement of a consignment is recorded by a monitoring system with an acceleration sensor, the measured values from which are stored and delivered to an evaluation arrangement, characterized in that in the evaluation arrangement in a predetermined cycle period T, the measured values of the sensor are digitized and a predetermined number K of frequency spectra are determined from a predetermined number N of measured values in each case, each frequency spectrum consisting of a predetermined number of M of frequency lines; the K frequency spectra are integrated, and the integrated frequency spectra are stored in a memory, the analysis arrangement incorporating a device for determining and storing a predetermined number of integrated frequency spectra of the measured values from the movement sensor.

According to yet another aspect the invention provides a method of monitoring the transit time of transported articles, in which the movement of a consignment is recorded by a monitoring system with an acceleration sensor, the measured values from which are stored and delivered to an evaluation arrangement, characterized in that in each case, in a predetermined cycle period T, the measured values are digitalized and a predetermined number K of frequency spectra, consisting of a predetermined number M of spectral lines, are calculated from a predetermined number of, in each instance, N measured values; in that the K frequency spectra are integrated, so that at the end of each cycle period T there are precisely M integrated spectral lines; and in that the integrated frequency spectra are stored in a memory, the measured values being stored in the memory for the total duration of the transit time of a transported article, and at the destination an evaluation is supplied in order to reconstruct the transportation sequence.

The present invention can also be realized by using a narrow-band bypass filter to determine the frequency spectra.

In particular, the present invention makes it possible to analyze the measured values from the sensor in a way that conserves both energy and memory resources.

It is possible to match the sensitivity of the method to the movement energy, in that the number k of frequency spectra across which integration is effected is reduced as the movement energy increases.

In a preferred embodiment of the present invention, calculation of a frequency spectrum is undertaken only if the movement energy is greater that a predetermined minimal movement energy S_m, which means that one can proceed in a particularly energy-effective manner.

A particularly simple unit of measurement for the movement energy is the sum of the aggregates of the intervals between adjacent measured values or the dispersion of adjacent measured values in a predetermined measurement interval.

A further reduction of the amount of memory that is required can be achieved by a non-linear compression of the integrated spectra.

An adaptation of the value of the minimal movement energy at a constant sensitivity is achieved by way of a parametric adaptation.

Optimal use of available battery energy over time is achieved in that the number k of frequency spectra across which integration is carried out and the cycle period T are controlled as a function of the supply voltage of the test system that is used when it is under load from the movement sensor.

In order to take into account the possible loss of capacity of the batteries that are used as a power supply, particularly at low temperatures, if the value falls below a predetermined value, the supply voltage of the movement sensor is deactivated, and it is only reactivated if the supply voltage reaches a second, predetermined value.

The present invention will be described in greater detail below on the basis of the drawings appended hereto. These drawings show the following:

Figure 1: the integrated intensity spectrum of a mail-box emptying trip, transportation by road, transportation by air, and a delivery;

Figure 2: a sequence diagram of the intensity dependent calculation of frequency spectra;

Figure 3: a diagram showing different sensor cycles as a function of intensity;

Figure 4: the voltage during automatic power-consumption monitoring;

Figure 5: the state transitions associated with the voltage curve shown in Figure 4.

In a preferred embodiment of the present invention, the device consists of an acceleration sensor, a micro-controller with an integrated analog/digital converter, and a memory, in particular a RAM. In order that the device can be processed in letter-sorting machines, and in order that it will not be rejected during stiffens tests that are performed in the letter-processing machines that are used in post offices, it is advantageous that it be configured in C6 standard letter format. The movement sensor emits a sensor signal that is proportional to the acceleration, and this is digitalized by the analog/digital converter (ADU). The signal is further processed into frequency spectra in the micro-controller by a Fourier transformation, and these frequency spectra are stored in compressed form in the memory. After the measured values have been recorded, the spectra that have been stored in the memory are read out and analyzed. When this is done, the frequency spectra are associated by time with the chronological progress of the movement of the device during transportation. Since the different transport media, such as transportation by motor vehicle, rail, foot, and aircraft each display characteristic spectrum patterns, it is possible to identify the time sequences of the transportation process.

Figure 1 shows the characteristic intensity spectra for four types of transportation: a mail-box emptying trip, road transportation, air transportation, and delivery. In addition to identification of the transportation medium or type of transportation, the spectra also permit identification of the particular transportation events that occur, such as departure, arrival, changes in speed, and the like, since each such event is reflected in the oscillation characteristics of the transportation medium, and these are recorded by the device according to the present invention. It has been found to be particularly advantageous to use spectra with frequencies of 8, 16, 24, and 32 Hz.

One embodiment of the method according to the present invention will be described in greater detail below. According to the sequence diagram shown in Figure 2, the method operates in cycles with cycle times T of 60 seconds, for example. Once the cycle has started, the first step is detection of a quiescent state. If a letter is en route for several days, the quiescent state accounts for a considerable proportion of the total en route time, and can amount to between 50 and 95 per cent. For this reason, identification of this quiescent state is particularly important. In principle, detection of the quiescent state can also be effected with the help of an analysis of the spectral functions; however, detection with a separate detection method or with a separate quiescence detector entails the advantage of greater speed and, under certain circumstances, greater sensitivity and thus lower energy consumption relative to sensitivity.

At the beginning of the cycle, the sensor supply voltage is switched on and there is a wait until it reaches a predetermined initial voltage value of the sensor. This takes into account the fact that the sensor starts to respond according to an exponential function with a characteristic transient time T_s. As an example, the time that passes after application of the sensor supply voltage until the sensor output voltage begins to respond at 1/2 LSB (least significant bit) of the stationary end value is to be selected as the response time of the sensor. Detection of quiescence takes place in the front part of the response curve. Quiescence detection should be effected at the greatest possible sensitivity, so that the movement state can be identified reliably, even at low movement intensities. On the other hand, calculation of spectral functions is not necessary in this range. For this reason, the total energy of the sensor signal is used for quiescence detection. Measurement units for the total energy are the dispersion (square of the standard deviation) of the sensor signal in a defined measurement interval or the curvature, i.e., the sum of the aggregates of the intervals between adjacent measured values in a defined measurement interval. In the case of the last standard, one uses the fact that the curvature of the response curve is a function of the degree of vibration excitation of the sensor.

In the sequence diagram that is shown in Figure 2, summation is effected over the intervals between N sampled values.

$$S = \sum_{i=1}^{N} |y_i - y_{i+1}|$$

A quiescent state is the presumed to exist if the following applies:

$$S < S_{TH}\ (N)$$

Sensitivity of the movement detection is thus dependent on how close S_{TH} (N) approaches S (quiescence), the absolute quiescence curvature value.

Once quiescence detection has taken place in the front section of the response curve of the sensor, the spectral function in the section behind it is calculated, so that after the quiescence detector has recognized "movement," the spectra in the same cycle are determined. In this case, the quiescence detector and calculation of the spectral function must be so matched to each other that a movement state identified by the quiescence detector can be confirmed as one of 0 different spectra. Stable function of the quiescence detector at higher sensitivity can be achieved by an automatic parameter adaptation of S_{TH} (N). To this end, S_{TH} (N) is broken down into two terms

$$S_{TH}(N) = S_{base} + S_{par}.$$

S_{base} is the adapted base value of the threshold S_{TH} (N), whereas S_{par} is the constant-parameter part that determines the sensitivity of movement detection. Adaptation of the base value S_{base} is effected after each calculation of the curvature S by determining the minimum from the former S_{base} and the current curvature value S.

$$S_{base} = \min(S_{base}, S)$$

With this parameter adaptation it is possible to ensure that the base value of the threshold S_{TH} (N) is held constantly at the quiescent curvature value. Consistency between quiescence detection and calculation of the spectra is ensured in that for the case that the spectra all result in an intensity 0, once the quiescence detection of identified movement, the basis value of the threshold is increased by 1. This case can also occur if the base value of the threshold S_{base} has drifted down, or if a brief movement takes place only during quiescence detection and no movement follows during the later measurement period for the spectra calculation. If, in the latter case, the base value is raised erroneously, a correction is made during quiescence detection in the subsequent cycle and the associated parameter readjustment.

The test for quiescence 5 follows, after calculation of the energy unit S and the parameter readjustment of the base value S_{base}. In the event of a positive result to this test (j), the sensor supply voltage is switched off. In the negative case (N), a test for median intensity, $S > S_{medi}$ follows, S_{medi} being a predetermined value that describes a median movement energy. In the event that the result of this test is negative (N), it is followed by integration across a predetermined number of spectra that is characteristic at low intensity. If the result of this test is positive, (j) , it is followed by a test for high intensity, $S > S_{high}$; if the result is negative, it is followed by a classification of the movement as medium intensity; if the result is positive (j), it is classified as high intensity.

A large, medium, or small number of spectra will be integrated, depending on whether the classification of intensity is low, medium, or high. The integration across K spectra, in each case across N sampled values, corresponds to averaging across K spectra and reduces the effect of statistical variations. Since the influence of such variations is higher at lower intensities, or is reduced as intensity increases, the number of cumulated spectra can be reduced as the intensity increases. The preferred number of spectra across which integration is carried out is K = 80 for low intensity, K = 40 for medium intensity, and K = 20 for high intensity.

Since the measured values are time-discreet signals it is preferred that work be carried out with the formalism of the discreet Fourier transformation and the integration 11 be carried out as accumulation. From the formalism of the discreet Fourier transformation it follows that for the preferred case of four spectral lines, in each case F1, F2, F3, F4 always consist of real and imaginary parts $F_m = Re_m + Im_m$, with m = 1, ..., 4. The real and imaginary parts Re_m and Im_m of the spectral lines are then represented from sequential sampled values f_0, f_1, ..., f_7, as follows:

$$Re_1=F(f_0-f_4)+F\cos(\pi/4)(f_1+f_4-f_3-f_5)$$
$$Im_1=F(f_2-f_6)+F\cos(\pi/4)(f_1+f_3-f_5-f_7)$$
$$Re_2=F(f_0-f_2+f_4-f_6)$$
$$Im_2=F(f_1+f_5-f_3-f_7)$$
$$Re_3=F(f_0-f_4)+F\cos(\pi/4)(f_3+f_5-f_1-f_7)$$
$$Im_3=F(f_6-f_2)+F\cos(\pi/4)(f_1+f_3-f_5-f_7)$$
$$Re_4=F(f_0+f_2+f_4+f_6-f_1-f_3-f_5-f_7)$$
$$Im_4=0$$

F is a factor that is to be suitably selected in order to minimize the rounding error (F = 16).

The spectral integration 11 is carried out by summing of the individual spectral parts of $|F_m|_i$ across K spectra in each case.

$$SF_m = \sum_{i=1}^{k} |F_m|_i$$

It is advantageous to undertake the formation of the aggregates in an approximation, which manages without squaring or extracting roots.

$$|F_{mi} = \max(|Re_{mi}, |Im_{mi})$$

The dynamic range of the intensities is in the order of magnitude of 10^5. For this reason, in order to reduce the memory requirement for storing the spectra, it is advantageous to subject the integral spectral lines to a non-linear compression 13 and thereby reduce the dynamic range by one order of magnitude to 2^4. This makes it possible to combine each two spectral lines to one byte in memory. In a preferred embodiment, the compression is carried out by way of a table look-up. When this is done, the values for the compression table are determined according to a potential function

$$g(n) = AW*b^n$$

The compression table is thus

n	g(n)
0	AW * b^0
1	AW * b^1
2	AW * b^2
....	....
14	AW * b^{14}

AW is the table entry with the lowest value, and determines the lower limit of system sensitivity. The table entry with the highest value is $AW \cdot B^{14}$. The dynamics of the compression table are determined by B and can be calculated from AW and AW $\cdot B^{15}$. After completion of the non-linear compression 13 the spectra 14 are stored in memory, preferably in a RAM.

As has already been discussed in connection with the parametric readjustment of the base value, it is advantageous to couple the result of the Fourier transformation back to the base value of the threshold in order to achieve optimal synchronisation of the response threshold between the quiescence detector and the Fourier transformation. This parametric readjustment 15 follows storage of the spectra in the RAM. After completion of the parametric readjustment, the voltage supply of the sensor is switched off for this cycle 16.

Figure 3 shows three different sensor cycles: a cycle at high intensity, a cycle at low intensity, and a cycle with quiescence detection QD. It can be seen that at high intensity, both quiescence detection and the Fourier transformation take place in the transient response range of the sensor or the sensor voltage U_{sens}. At low intensity, at which integration is carried out over a larger number of measured values, the Fourier transformation takes place in the rear part of the response curve. In contrast to this, when quiescence detection has taken place, the sensor voltage is switched off immediately after the conclusion of QD.

Figure 4 shows the no-load voltage of the battery used to supply the voltage for a device according to the present invention, and the battery voltage under the load of the sensor U_{lsens} as temperature varies as a function of time T. In order to take reduced battery capacity into account, it is advantageous to match the power consumption of the device to the capacity that is available at a particular time or the measured voltages. This is best achieved in that the number of spectra that are summed, or the cycle times, or the number of measured values that are analyzed, or both, be matched to the battery capacity.

The following table shows a preferred temperature dependent power match.

Power State (PS)	Characteristics	Cycle [s]	Max. Integration
0	Normal Operation	60	80
1	Reduced Power Operation 1	60	20
2	Reduced Power Operation 2	4 * 60	20
3	Reduced Power Operation 3	16 * 60	20
4	Suspended Power Operation	16 * 60	Sensor off
5	Ultimate Sleep Mode	off	Sensor off

The different voltages correspond to the different power states PS with cycles of differing lengths and numbers of spectra across which integration is carried out. In principle, during temperature-controlled power matching, the power consumption is reduced if the voltage U_{LSENS} falls below the critical voltage U_2.

Figure 4 first shows the measured load voltage U_{LSENS} as greater than U_2; the device is in PS 0, normal state. The energy consumption at that time is determined by the current movement intensity. The cycle time amounts to a constant 60 seconds; at rest times, the device is in a quiescent state and during movement it is preferred that a total spectrum made of up 20, 40 or 80 spectra be calculated as a function of movement intensity.

If U_{LSENS} falls below U_2, then the device goes into PS 1, in which the power consumption is reduced. The system remains in PS 1 until such time as the measured voltage U_{LSENS} is no longer smaller than U_2 - dU but not greater than U_2 + H. As hysteresis, the parameter H ensures that the system begins to respond on the transition from PS 1 to PS 0.

Generally speaking, the following relationships apply to the transitional states:

Transition to PS (i+1) if $U_L < U_2 - i\ dU$

Transition to PS (i-1) if $U_L > U_2 - (i-1)\ dU + H$

If the prevailing load voltage U_{LSENS} falls below the critical value U5, with U5 + U2-N·du, then a transition is made to the so-called suspended mode (PS4), time t2. In the suspended mode, sensor activity is discontinued and the remaining battery capacity is reserved in order to maintain the data.

In the suspended mode, measurement of the batter voltage U_{LADU} is carried out at a multiple of the usual cycle time, i.e., not under sensor load. This leads to the fact that U_{LADU} is greater than UL_{LSENS}; see Figure 4 at time t2. With the transition to suspended mode, the battery can, within certain limits, regenerate since in this case it only has to take care of a small load. This can lead to an increase in the no-load voltage, which is not necessarily related to an actual increase in battery capacity. For this reason, the transition from the suspended mode to mode PS 3 is only made if the measured U_{LADU} has increased by at least dU_{ADU} = U1-U3. This case is shown in Figure 4 at time T3. DOADU should be executed as a parameter.

At the end of the battery life, during voltage measurement, the load can lead to the breakdown of battery voltage and thus to loss of data. For this reason, in the event that the measured battery voltage falls below a specific threshold value U4 in suspended mode, there is a transition to an irreversible sleep mode PS 5. This sleep mode does not provide for a transition to any other power state, and time is not recorded, either.

Figure 5 is a graphic representation of the transition states during automatically matched power consumption in the device according to the present invention.

THE EMBODIMENTS OF THE INVENTION IN WHICH AN EXCLUSIVE PROPERTY OR PRIVILEGE IS CLAIMED ARE DEFINED AS FOLLOWS:

1. A method of monitoring the transit time of transported articles, in which the movement of a consignment is recorded by a monitoring system with an acceleration sensor, the measured values from which are stored and delivered to an evaluation arrangement, characterized in that a predetermined number of K frequency spectra consisting of a predetermined number of M spectral lines is determined in each predetermined cycle period T in order to give a predetermined number of N measured values in each case, so that at the end of each cycle period T there are precisely M integrated spectral lines; and in that the integrated frequency spectra are stored in a memory, the measured values being stored in the memory throughout the total transit time of a transported article, and at the destination an evaluation is supplied in order to reconstruct the transportation sequence.

2. A method of monitoring the transit time of transported articles, in which the movement of a consignment is recorded by a monitoring system with an acceleration sensor, the measured values from which are stored and delivered to an evaluation arrangement, characterized in that in each case, in a predetermined cycle period T, the measured values are digitalized and a predetermined

number K of frequency spectra, consisting of a predetermined number M of spectral lines, are calculated from a predetermined number of, in each instance, N measured values; in that the K frequency spectra are integrated, so that at the end of each cycle period T there are precisely M integrated spectral lines; and in that the integrated frequency spectra are stored in a memory, the measured values being stored in the memory for the total duration of the transit time of a transported article, and at the destination an evaluation is supplied in order to reconstruct the transportation sequence.

3. A method as defined in Claim 1, characterized in that the determination of the frequency spectra is effected with one or more band-pass filters.

4. A method as defined in one of the Claims 1 to 3, characterized in that detection of the movement energy of the consignment is effected; and in that the determination of a frequency spectrum is only made if the movement energy is greater than a predetermined minimal movement energy S_m.

5. A method as defined in one of the Claims 1 to 4, characterized in that the sum of the aggregates of the

intervals between adjacent measured values or the variation of adjacent measured values in a predetermined measurement interval is used as a measurement unit for the movement energy.

6. A method as defined in Claim 4 or Claim 5, characterized in that the number K of the frequency spectra across which integration is carried out is reduced as movement energy increases.

7. A method as defined in Claim 1 to Claim 6, characterized in that non-linear compression of the integrated spectra is effected before said spectra are stored in memory.

8. A method as defined in one of the Claims 4 to 6, characterized in that an adaptation of the values of the minimal movement energy S_m is effected in such a way that $S_m = S_{base} + S_{par}$, S_{par} being a constant fraction that establishes the sensitivity of the movement detection, and S_{base} is recalculated after each calculation of S according to $S_{base} = Min(S_{base}, S)$.

9. A method as defined in one of the Claims 1 to 8, characterized in that the number of frequency spectra across which integration is carried out, and/or the cycle time T, is varied as a function of the supply voltage of

the test device as measured under load from the movement sensor.

10. A method as defined in Claim 9, characterized in that if the supply voltage falls below a predetermined value U_5, the movement sensor is deactivated; and in that measurement of the battery voltage U_{LADU} is made under no load, and it is only reactivated if U_{LADU} exceeds a predetermined value.

11. A method as defined in Claim 10, characterized in that if the measured battery voltage falls below a predetermined value U_4, a transition is made to an irreversible sleep mode.

12. A method as defined in one of the preceding claims, characterized in that K is set to equal 20, or 40, or 80.

13. A method as defined in one of the preceding claims, characterized in that spectra of frequencies of 8, 16, 24, and 32 Hz are used.

14. A device for carrying out the method for monitoring the transit time of transported articles, in which the movement of a consignment is recorded by a monitoring system with an acceleration sensor, the measured values

from which are stored and delivered to an evaluation arrangement, characterized in that in the evaluation arrangement in a predetermined cycle period T, the measured values of the sensor are digitized and a predetermined number K of frequency spectra are determined from a predetermined number N of measured values in each case, each frequency spectrum consisting of a predetermined number of M of frequency lines; the K frequency spectra are integrated, and the integrated frequency spectra are stored in a memory, the analysis arrangement incorporating a device for determining and storing a predetermined number of integrated frequency spectra of the measured values from the movement sensor.

15. A device as defined in Claim 14, characterized in that the analysis arrangement incorporates a device for compressing the integrated frequency spectra before said spectra a stored.

16. A device as defined in Claim 14 or Claim 15, characterized in that detection of quiescent states or movement states of a predetermined movement energy is effected by the analysis arrangement.

17. A device as defined in one of the Claims 15 or 16, characterized in that the analysis device incorporates a

device for adapting power consumption as a function of battery capacity, in which the number K of frequency spectra across which integration is carried out, and/or the number of measured values that are analyzed is varied.

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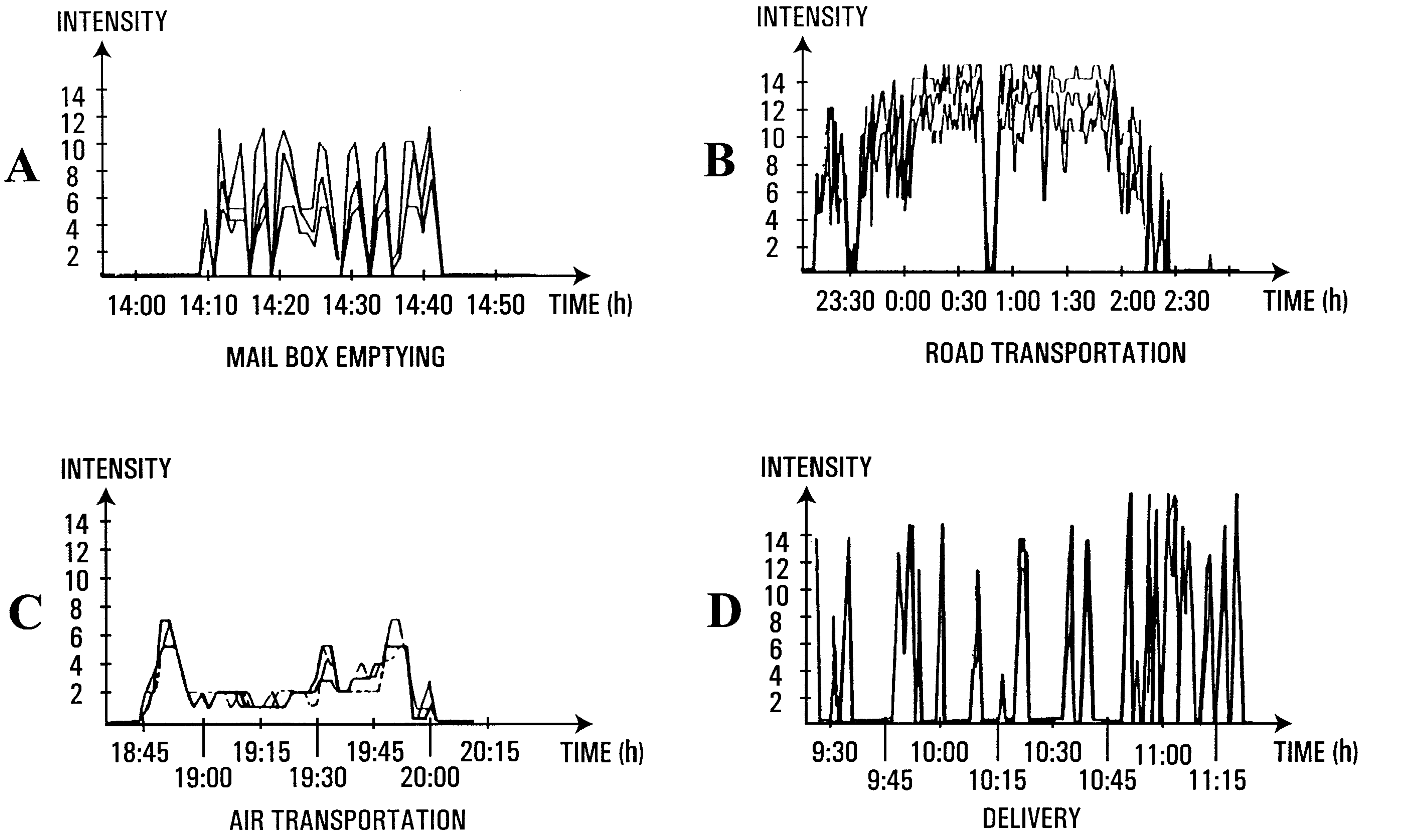
Patent Agents

FIG. 1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INTENSITY
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12
10
8
6
4
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B
INTENSITY
14
12
10
8
6
4
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ROAD TRANSPORTATION
C
INTENSITY
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12
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4
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AIR TRANSPORTATION
D
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4
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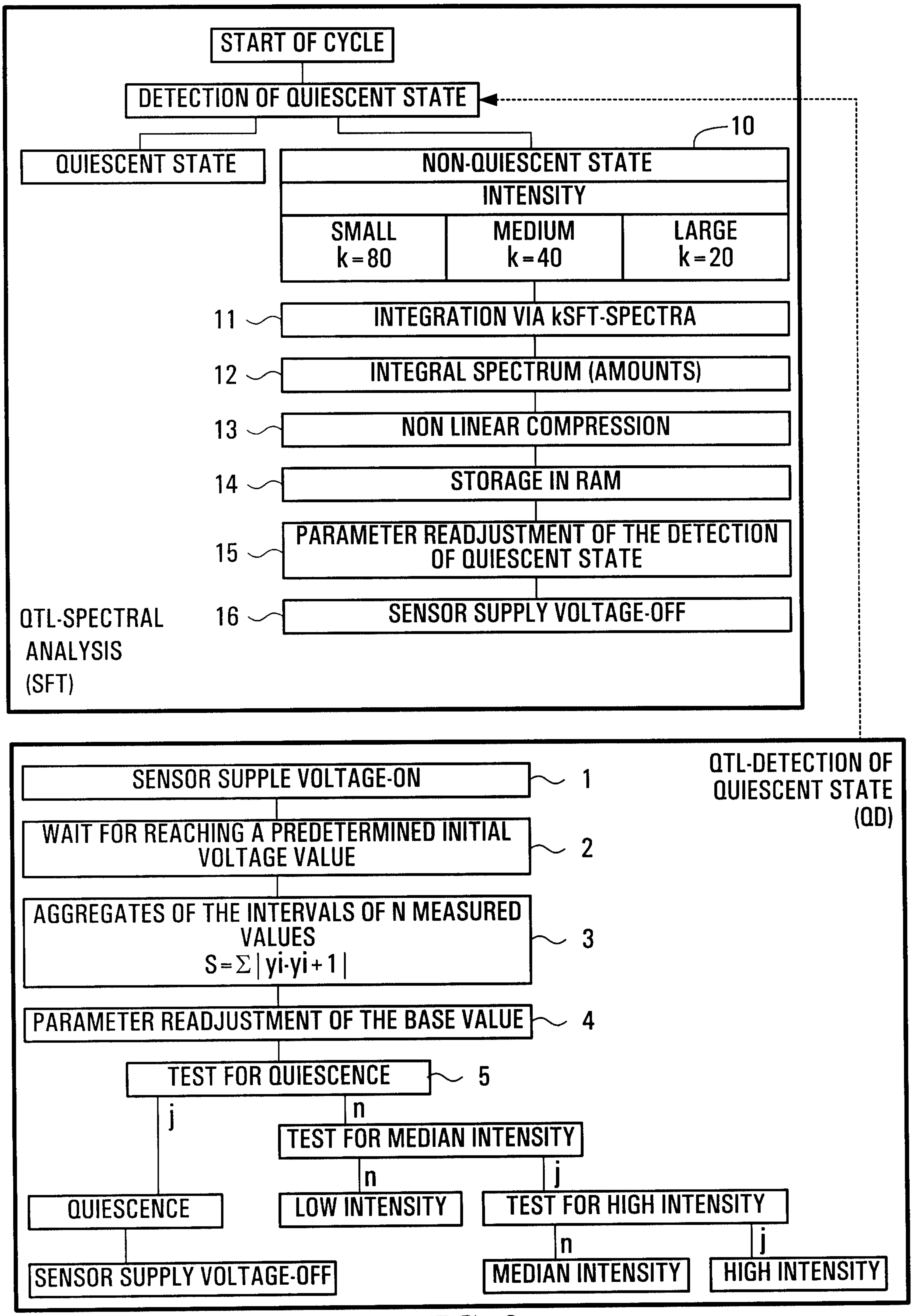

START OF CYCLE
DETECTION OF QUIESCENT STATE
QUIESCENT STATE
NON-QUIESCENT STATE
10
INTENSITY
SMALL k=80
MEDIUM k=40
LARGE k=20
11
INTEGRATION VIA kSFT-SPECTRA
12
INTEGRAL SPECTRUM (AMOUNTS)
13
NON LINEAR COMPRESSION
14
STORAGE IN RAM
15
PARAMETER READJUSTMENT OF THE DETECTION OF QUIESCENT STATE
16
SENSOR SUPPLY VOLTAGE-OFF
QTL-SPECTRAL ANALYSIS (SFT)
QTL-DETECTION OF QUIESCENT STATE (QD)
SENSOR SUPPLE VOLTAGE-ON
1
WAIT FOR REACHING A PREDETERMINED INITIAL VOLTAGE VALUE
2
AGGREGATES OF THE INTERVALS OF N MEASURED VALUES
S=Σ|yi-yi+1|
3
PARAMETER READJUSTMENT OF THE BASE VALUE
4
TEST FOR QUIESCENCE
5
j
n
TEST FOR MEDIAN INTENSITY
n
j
QUIESCENCE
LOW INTENSITY
TEST FOR HIGH INTENSITY
n
j
SENSOR SUPPLY VOLTAGE-OFF
MEDIAN INTENSITY
HIGH INTENSITY

FIG. 2

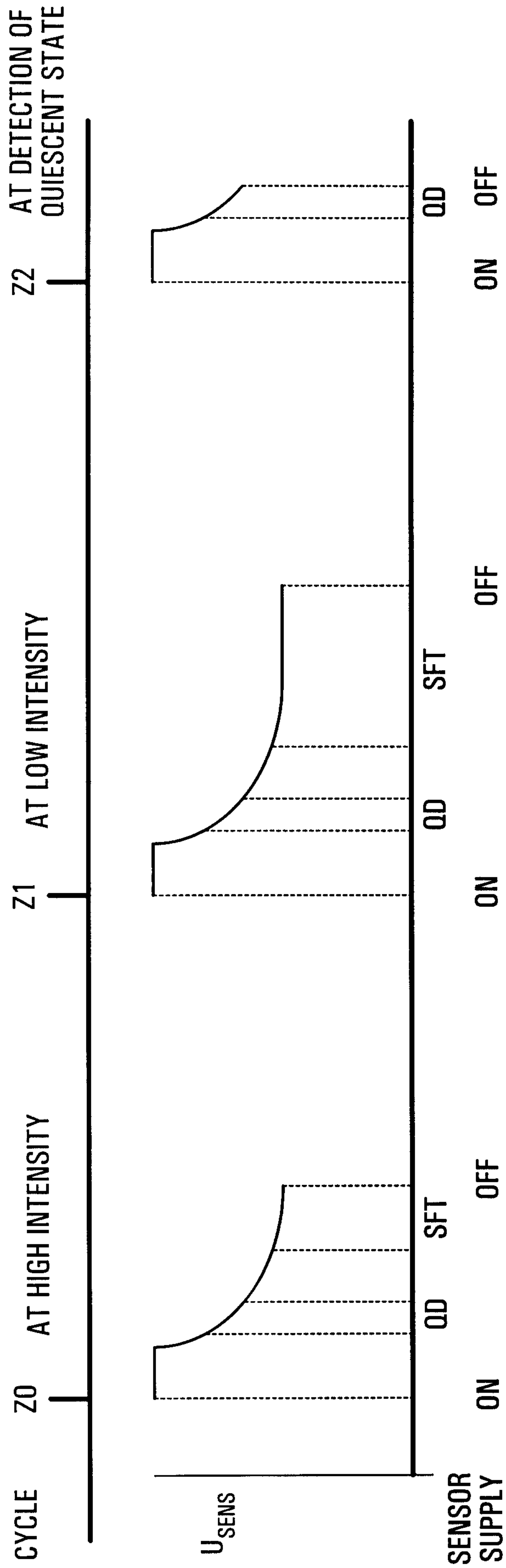

AT DETECTION OF QUIESCENT STATE
AT LOW INTENSITY
AT HIGH INTENSITY
Z2
Z1
Z0
CYCLE
U_{SENS}
SENSOR SUPPLY
QD
OFF
ON
QD
SFT
OFF
ON
QD
SFT
OFF
ON

FIG. 3

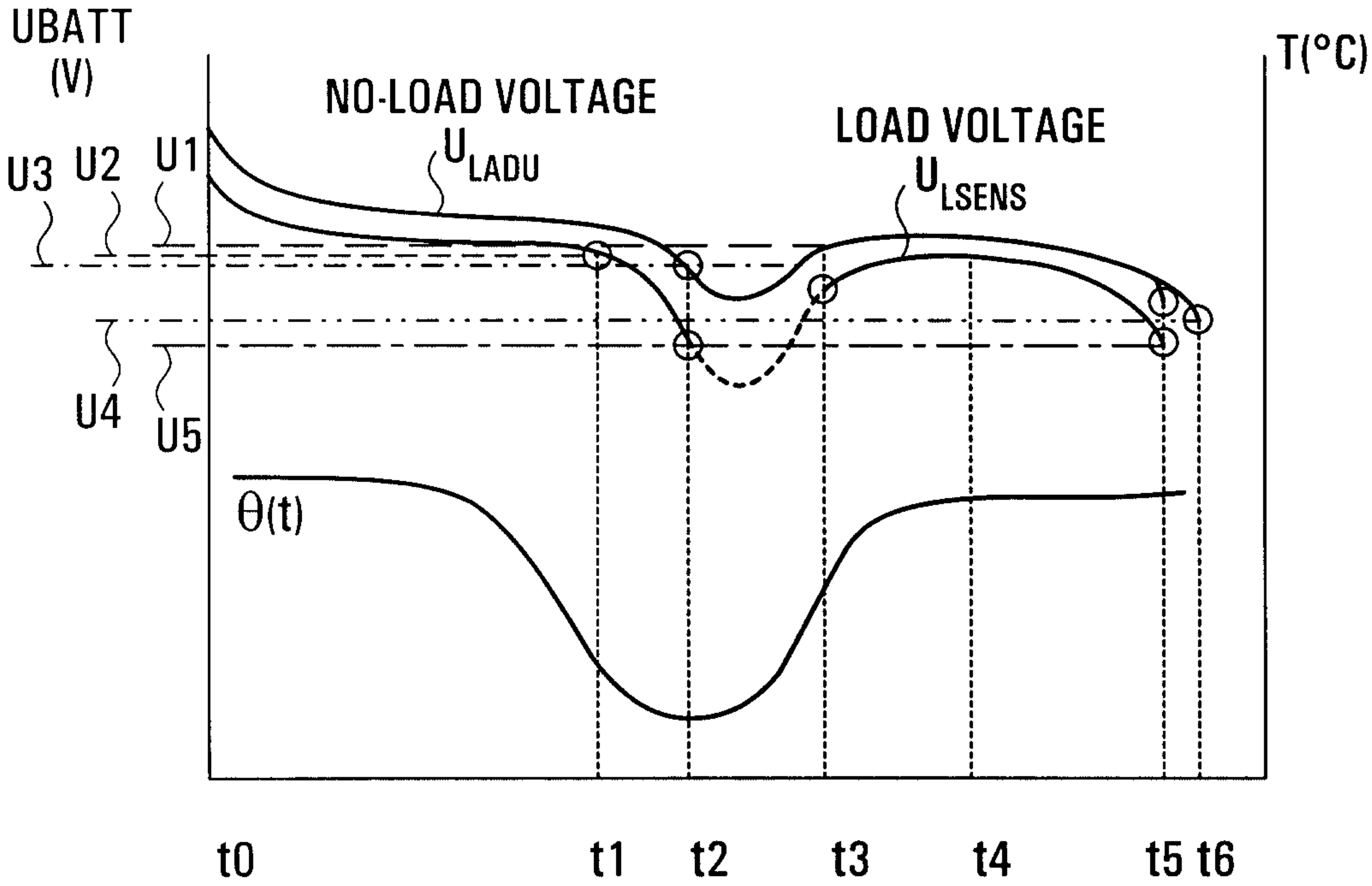

UBATT
(V)
T(°C)
NO-LOAD VOLTAGE
U_{LADU}
LOAD VOLTAGE
U_{LSENS}
U3 U2 U1
U4
U5
θ(t)
t0
t1
t2
t3
t4
t5 t6

FIG. 4

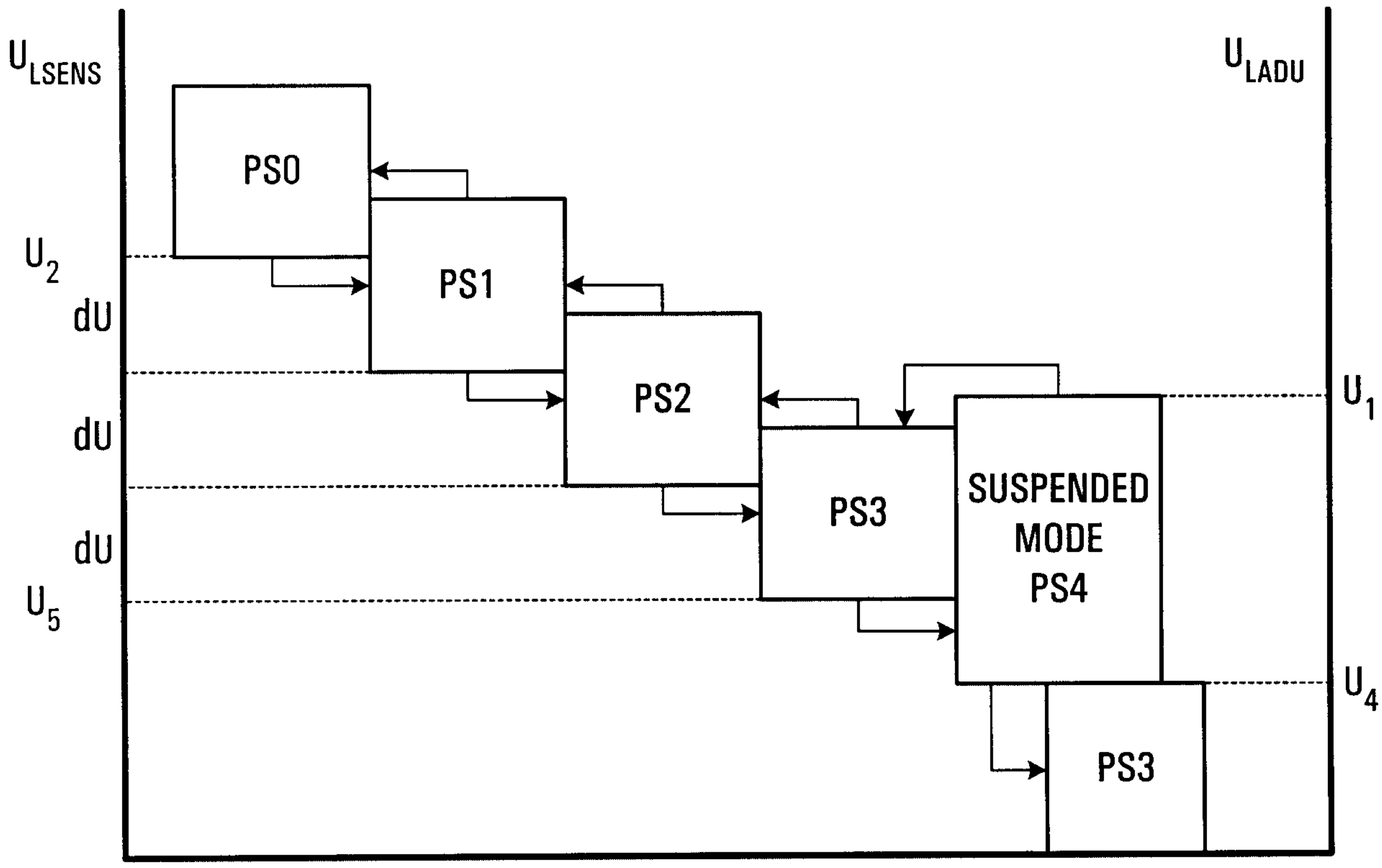
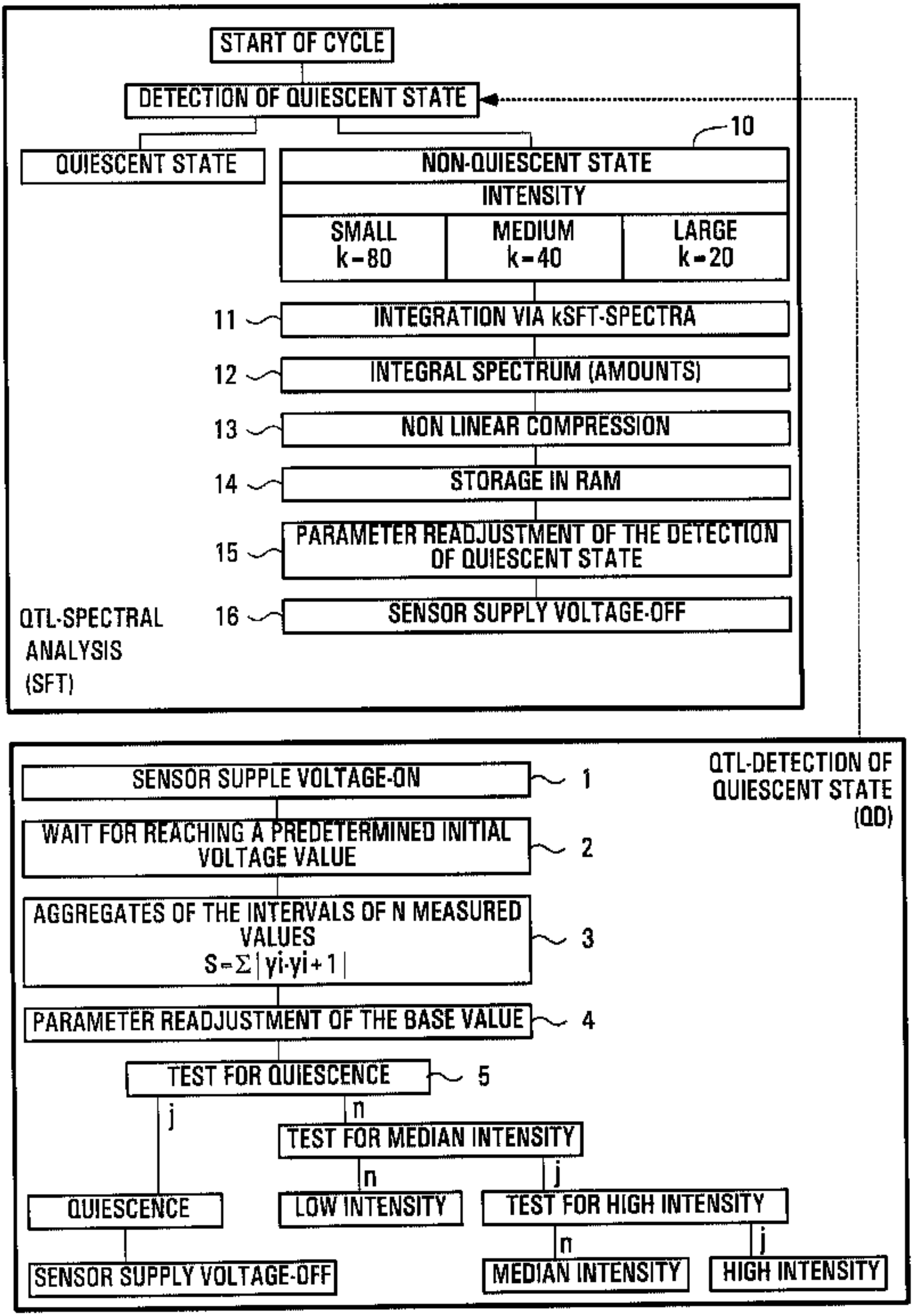

U_{LSENS}
U_{LADU}
PS0
PS1
PS2
PS3
SUSPENDED MODE PS4
PS3
U_2
dU
dU
dU
U_5
U_1
U_4

FIG. 5


START OF CYCLE
DETECTION OF QUIESCENT STATE
10
QUIESCENT STATE
NON-QUIESCENT STATE
INTENSITY
SMALL k=80
MEDIUM k=40
LARGE k=20
11 INTEGRATION VIA kSFT-SPECTRA
12 INTEGRAL SPECTRUM (AMOUNTS)
13 NON LINEAR COMPRESSION
14 STORAGE IN RAM
15 PARAMETER READJUSTMENT OF THE DETECTION OF QUIESCENT STATE
16 SENSOR SUPPLY VOLTAGE-OFF
QTL-SPECTRAL ANALYSIS (SFT)
QTL-DETECTION OF QUIESCENT STATE (QD)
SENSOR SUPPLE VOLTAGE-ON 1
WAIT FOR REACHING A PREDETERMINED INITIAL VOLTAGE VALUE 2
AGGREGATES OF THE INTERVALS OF N MEASURED VALUES
S=Σ|yi-yi+1| 3
PARAMETER READJUSTMENT OF THE BASE VALUE 4
TEST FOR QUIESCENCE 5
j
n
TEST FOR MEDIAN INTENSITY
n
j
QUIESCENCE
LOW INTENSITY
TEST FOR HIGH INTENSITY
n
j
SENSOR SUPPLY VOLTAGE-OFF
MEDIAN INTENSITY
HIGH INTENSITY