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(54) Improvements in or relating to data transmission

(57) A control system for a central heating system comprises at least one thermostat (6) functioning as a transmitter and arranged to transmit data to a receiver unit (4) communicating with a programmer (2). To avoid any risk that the receiver (4) will receive command messages substantially concurrently from two different transmitters (6), each transmitter is arranged to randomise the timings of its transmissions. A twelve bit identification code (36) contained in each command message and unique to the corresponding transmitter is used to effect the randomisation.

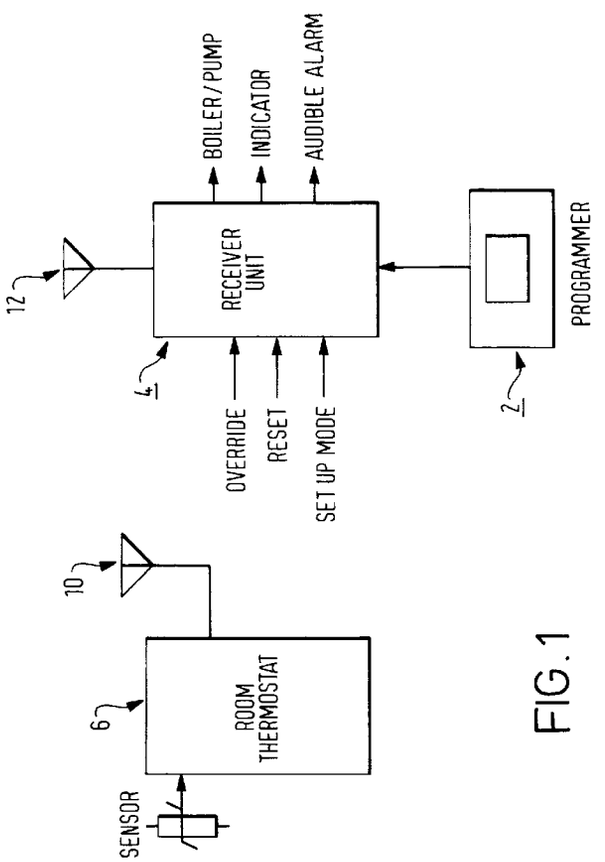

FIG. 1

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Description

The present invention relates to methods of transmitting data and apparatus for use with such methods. For example, the invention relates to a method of validating transmitted data and to a method of controlling a transmitter to transmit data at unique time periods.

In a traditional central heating system, for example, a programmer or controller for operating the boiler is hard wired to thermostats and other control means such that the operation of the boiler can take into account ambient conditions. However, the need for hard wiring makes the system difficult and expensive to install. It also makes subsequent repositioning of thermostats, for example, difficult. It has been proposed to use radio frequency transmission links in such circumstances, but it is necessary to ensure the integrity of communication. In this respect, in a domestic environment, for example, it may be required to communicate to a receiver, such as a central heating programmer, with more than one transmitter, such as a thermostat.

Furthermore, it is important that transmitters and receivers for domestic use, for example, can be produced in the same sort of sizes and at the same sort of costs as traditional controls. This means that sophisticated and expensive systems to provide for synchronous transmission and reception are not acceptable.

Where a receiver is to receive data from more than one transmitter there is a risk that a number of transmissions from different sources will arise concurrently such that none of them is understood by the receiver. The present invention seeks to address this problem.

According to a first aspect of the present invention there is provided a method of controlling a transmitter to transmit data at unique time periods to a receiver, wherein the transmitter stores a random fixed data code, the method comprising the step of determining the intervals between individual data transmissions of the transmitter in dependence upon said random fixed data code of the transmitter.

The transmitter may be arranged to transmit identical individual data transmissions a number of times. Preferably, in this case, the intervals between successive transmissions is determined in dependence upon the random fixed data code of the transmitter.

Additionally and/or alternatively, the transmitter may be arranged to transmit a data transmission, or a package of data transmissions, at intervals, for example once every 5 or 6 minutes. The intervals between such individual transmissions, or such packages thereof, may be determined in dependence upon the random fixed data code of the transmitter.

Preferably, the random fixed data code provides an identification code for the transmitter.

In an embodiment, the or part of the identification code may comprises a random code fixed in the transmitter on manufacture. In this respect, the random code may be stored in the transmitter in any permanent memory device, or it may be fixed in a hardware configuration. For example, a twelve bit pattern may be set for each transmitter at the point of manufacture. This gives 4096 combinations.

To increase the combinations of the identification code further, the identification code may also comprise a product type code, for example, identifying the transmitter as a room thermostat, a tank thermostat, a temperature sensor or a remote control unit. Thus, the identification code of the transmitter may be a code comprising both the product type code and the random code.

In an embodiment, where the transmitter has a twelve bit identification code, selected nibbles of the code may be used to determine different intervals between transmissions to randomise the transmissions. For example, the least significant four bits may be used to determine the interval between a first transmission and a first repeat thereof, and the next four significant bits may be used to determine the interval between the first repeat and a second repeat. The four most significant bits may be arranged to determine the interval between that package of three repeated individual transmissions and a succeeding package of three repeated transmissions.

According to the present invention there is also provided a transmitter arranged to transmit data at unique time periods by the method defined above.

In another aspect, the present invention seeks to provide a simple method of data tracking.

According to a further aspect of the present invention there is provided a method of validating transmitted data, wherein the data transmitted is arranged in a data stream having a start code followed by data bits, the method comprising the steps of receiving said data stream and upon detection of said start code determining time periods between the start code and selected transitions of said data bits and/or between selected transitions, and validating data received if the respective time period determined corresponds, within a preset tolerance, to one of a number of predetermined periods.

As is conventional, the data is represented by the data bits determined between successive transitions of the data stream. With the present invention the period between successive transitions may be determined to validate the data received.

For example, if the data rate is such that each data bit has a period of n mS, depending upon what has gone before, a valid transmission will occur at:

$$n,\ 1.5n,\ 2n,\ 2.5n\ mS$$

Thus, with a method of the invention, the data will be accepted as valid if successive transitions have the period given above and all other periods will be rejected as invalid periods.

In a preferred embodiment, the preset tolerance is less than $\pm\frac{n}{4}$, preferably, the tolerance is $\pm\frac{n}{5}$.

Preferably, the data rate is a range 100Hz to 10kHz. Preferably, the data rate is 1kHz, that is each data bit

has a period of lmS and the tolerance is ± 200μS.

The present invention also relates to a receiver arranged to validate transmitted data by the method defined above.

According to a further aspect of the present invention there is provided a receiver for validating transmitted data, said receiver having processor means, memory means communicating with the processor means, and counting means, the receiver being arranged to reset the counting means on detection of a start code of a data stream and to detect selected data bit transitions whereby the count between selected transitions can be determined and the data represented thereby stored in memory.

The count between selected transitions is chosen to be representative of the time period therebetween. For example, the receiver may further comprise a clock and/or timing means, and said counting means may be arranged to count elapsed time intervals of said clock and/or timing means.

It is particularly convenient if said receiver is provided with timing means in the form of a crystal oscillator.

In a preferred embodiment, each data stream comprises an individual encoded command message including not only a start code but protocol and check bits.

In an embodiment, each said command message also includes an identification code of the associated transmitter. For example, the or part of the identification code may comprise a random code fixed in the transmitter on manufacture. In this respect, the random code may be stored in the transmitter in any permanent memory device, or it may be fixed in a hardware configuration. For example, a 12 bit pattern may be set for each transmitter at the point of manufacture. It will be appreciated that a 12 bit pattern gives 4096 combinations.

To increase the combinations of the identification code further, the identification code may also comprise a product type code, for example, identifying the transmitter as a room thermostat, a tank thermostat, a temperature sensor or a remote control unit.

Where a receiver is to receive data from more than one transmitter there is a risk that a number of transmissions from different sources will arise concurrently such that neither is understood by the receiver. The present invention also seeks to address this problem.

Embodiments of the present invention will hereinafter be described, by way of example, with reference to the accompanying drawings, in which:

Figure 1 shows schematically one embodiment of a domestic central heating system using wireless communications,

Figure 2 shows schematically the message protocol to be used in communications between the elements of the system of Figure 1, and

Figure 3 illustrates bits in a data stream following a violation code and indicating the data carried thereby.

The present invention relates to data transmission, and in particular to methods of ensuring effective communication between a receiver and a number of transmitters. As such, the invention is not limited to the uses to which the transmission techniques may be put. However, to assist in understanding the invention it is described herein below with reference to its use in a substantially conventional domestic central heating system in which a boiler is used to heat water, the heated water not only providing a supply of hot water but also heating the premises.

Figure 1 shows a simple control system for a conventional central heating system. The control for a boiler and pump (not shown) comprises a programmer 2 communicating with a receiver unit 4. The programmer 2 may be substantially conventional and will store details of the times at which the central heating system is required to be on or off, or at high or low levels. As is indicated in Figure 1, the receiver 4 has a number of outputs for controlling the boiler and pump (not shown) of the central heating system and for controlling visual and/or audible indicators and alarms. The receiver 4 is in wireless communication with a room thermostat indicated at 6. This thermostat 6 may be used to set the temperature in a particular room to be heated by the system.

The thermostat 6 functions as a transmitter and is provided with an antenna indicated at 10 which is arranged to be in wireless communication with an antenna 12 of the receiver 4. Thus, the components 4 and 6 of the control system for the central heating system have the advantage over existing systems that they do not need to be hard wired together. This facilitates initial installation. The antennas 10 and 12 are each received within the housing of the respective unit 6 and 4.

In the system illustrated in Figure 1 the receiver 4 is shown receiving information from only a single transmitter, the thermostat 6. However, it will be appreciated that it may be required to have a single receiver as 4 receiving transmissions from a number of separate transmitters. For example, it may be preferred to have the programmer 2 as a separate hand held remote control unit, and to provide for transmissions to the receiver from more than one thermostat. Furthermore, it is required that the receiver unit not react to transmissions, for example, from neighbouring properties, or to other transmissions received on the premises, for example to radio or television receivers, or to other remote control devices. All this means that it is necessary to ensure the highest integrity of communication between the receiver 4 and any transmitters, as 6. The communication protocol is designed to ensure integrity and efficient data transfer and a number of measures are taken.

At present, the chosen frequency for the transmissions is within the band 417.9 to 418.1 MHz for the United Kingdom, and 433.72 to 434.12 MHz for Germany.

Each transmitter, as 6, is arranged to transmit individual encoded command messages including the command data. In this respect, it is preferred that each encoded command message be Manchester encoded and incorporate various protocol and check bits. The format of each command message 30 is illustrated in Figure 2.

As can be seen in Figure 2, each command message 30 commences with a stabilisation code 32 of six bits. This is followed by a start code 34 which is a Manchester violation code and is equivalent to two bits. On receipt of the start code the receiver 4 is ready to receive data and the next data which arrives is a twelve bit product code 36 which acts as an individual identification code for the transmitter 6. This is followed by a three bit type code 38 which also acts to identify the transmitter. The next bit of the message 30, bit 39 is, when set, a learn bit. This learn bit 39 is followed by two bits 40 which are the status bits or command data. There is then a single bit 41 which, if set, provides a low battery warning. This low battery warning 41 is followed by check sum or parity bits 42.

The number of bits for each code can, of course, be chosen as necessary. For example, the number of command bits 40 may be increased if alternative and/or additional command data is to be transmitted.

For integrity of communication it is required that a receiver 4 only act on command data which is within a command message 30 transmitted by an identified transmitter, as 6. In this respect, a respective product code 36 is transmitted by each transmitter and is set on manufacture. It arises from a twelve bit pattern in the transmitter and it will be appreciated that twelve bits provide 4096 possible combinations. Furthermore, the transmitter, as 6, also provides the three bit type code 38 which identifies the transmitter as a thermostat, cylinder thermostat, hand held remote control unit or programmer for example. The type code 38 therefore also acts to provide identification.

The twelve bit product code 36, and if required, the three bit type code 38, are fixed in the transmitter on manufacture. For example, these identification codes 36, 38 may be stored in any permanent memory device, such as a non-volatile memory. Alternatively, the identification codes 36, 38 may be fixed in a hardware configuration. In the illustrated embodiment, at least the twelve bit product code 36 is hard wired.

It is arranged that the receiver 4 only acts on command data received if it is contained within a command message 30 which carries both a product code 36 and a type code 38 which are the same as codes stored in the receiver memory. It is preferably arranged that the receiver unit 4 learn the identification of the or each transmitter 6 with which it is to communicate during initialisation. Thereafter, the receiver 4 rejects and fails to act on any spurious transmissions received from other sources.

In normal run mode, the or each transmitter 6 is arranged to transmit command messages 30 to the receiver unit 4 at regular intervals. In a preferred embodiment, each transmitter 6 sends three identical individual command messages 30 in succession at a first time interval, and then sends a further set of three command messages 30 at a second time interval which is preferably five or six minutes later than said first time interval. Packages of three individual command messages 30 continue to be sent at five or six minute intervals. It will be appreciated that if each command message 30 is repeated three times there is redundancy in the information provided and this aids in the efficiency of the data transfer.

If the transmitter 6 is adjusted, its existing normal run mode is interrupted and is then replaced by a new normal run mode in response to the change of status. In this respect, if the user adjusts the temperature required by the thermostat, for example, it is clearly required that that new command be transmitted to the receiver unit 4 substantially immediately rather than after a five or six minute interval as might be the case if the information were to be transmitted by the normal run mode in existence at the time of the adjustment. Thus, a new normal run mode is initiated in response to any change of status of the transmitter 6 whereby a first package of command messages is transmitted. Thereafter, packages of three individual command messages 30 continue to be sent at five or six minute intervals.

It will be appreciated that there is a risk that the receiver 4 will receive command messages 30 substantially concurrently from two different transmitters 6. To avoid this, each transmitter 6 is arranged to randomise the timings of its transmissions. In this respect, the twelve bit identification code 36 is used to effect the randomisation.

In one scheme, for example, where the transmitter is arranged to send three repeats of an individual command message in succession, the identification code is employed as follows.

The three repeats of the individual command message are to be sent in succession and are to be spaced by at least a nominal 1 second. The actual spacing between the first transmission and the first repeat or second transmission is set to be 1 second plus a number of 16ths of a second, determined by the four least significant bits of the transmitter identification code. The second repeat or third transmission occurs 1 second plus a number of 16ths of a second, determined by the four middle bits of the identification code, after the first repeat. The next set of three repeated transmissions are spaced from the preceding package of three transmissions by 5 minutes plus a number of 16ths of a second, determined by the four most significant bits of the identification code of the transmitter. Thus, transmission timings occur at:

First message,
first package : T_0
Second message,
first package :

$$(T_0 + 1\ \text{sec} + \frac{I_{LS4}}{16}\ \text{sec}) = T_1$$

Third message,

first package :

$$(T_1 + 1\ \text{sec} + \frac{I_{MS4}}{16}\ \text{sec} = T_2$$

First message, :

next package :

$$(T_2 + 5\ \text{mins} + \frac{I_{HS4}}{16}\ \text{sec}) = T_{01}$$

Where,

T_0 = Start time
I = Identification code 36
I_{LS4} = 4 least significant bits of I
I_{MS4} = 4 mid significant bits of I
I_{HS4} = 4 highest significant bits of I

It will be appreciated that, given that each product code 36 is physically different from another, and that there is only a one in 4096 chance of coincidence, then the transmission scheme set out above will provide for transmissions from a number of transmitters 6 to a receiver 4 without coincidence.

For a domestic environment, for example, it is required to keep the transmitter and receiver technology as simple and sturdy as possible without expensive apparatus at each end to provide the necessary synchronism between the transmitter and receiver. However, it is, of course required to validate the data received, which data is determined by the periods between negative going transitions. The data is Manchester encoded and is provided in a data stream at a bit rate of 1kHz per second. This, of course, means that each data bit has a lmS period and that the length of the data stream, without the preamble and violation codes, is 28mS.

An acceptance tolerance band is used to determine if each received negative going transition is valid. In this respect, the tolerance band needs to be less than $\pm \frac{n}{4}$ bit, and for 1mS bits it is preferred that the tolerance band is $\pm$ 200μS seconds. This means that the time between negative edges will nominally be 1, 1.5, 2, or 2.5mS and that all other time periods will be invalid.

Figure 3 shows the bits which might follow the violation code and illustrates how the preceding bits determine the interval which is acceptable. Figure 3 also illustrates graphically that the intervals 1, 1.5, 2, and 2.5mS are valid.

It will be appreciated that in asynchronous transmissions generally, the receiver and transmitter are brought into coincidence by the arrival and detection of a start code. However, thereafter any error between the timing of the transmitted signal and that of the receiver can become cumulative. The present scheme is very simple, but as it looks only at the interval between one negative going transition and the preceding one, no accumulation of errors is set up.

The hardware configuration and software required to detect and assess the validity of the data received are within the competence of any one skilled in the art and are not further described herein except to say that to facilitate real time processing the data is preferably stored in the receiver memory and is utilised after all of the received data has been validated.

Variations and modifications to the embodiments described and illustrated may be made within the scope of the present application.

Claims

1. A method of controlling a transmitter to transmit data at unique time periods to a receiver, wherein the transmitter stores a random fixed data code, the method comprising the step of determining the intervals between individual data transmissions of the transmitter in dependence upon said random fixed data code of the transmitter.

2. A method as claimed in Claim 1, wherein the transmitter is arranged to transmit identical individual data transmissions a number of times.

3. A method as claimed in Claim 2, wherein the intervals between successive transmissions is determined in dependence upon the random fixed data code of the transmitter.

4. A method as claimed in any preceding claim, wherein the transmitter is arranged to transmit a data transmission, or a package of data transmissions, at intervals, the intervals between such individual transmissions, or such packages thereof, being determined in dependence upon the random fixed data code of the transmitter.

5. A method as claimed in any preceding claim, wherein said random fixed data code provides an identification code for the transmitter, and wherein the or part of the identification code comprises a random code hard wired into the transmitter on manufacture.

6. A method as claimed in Claim 5, wherein the transmitter has a twelve bit identification code, selected nibbles of the code being used to determine different intervals between transmissions to randomise the transmissions.

7. A transmitter arranged to transmit data at unique time periods by a method as claimed in any preceding claim.

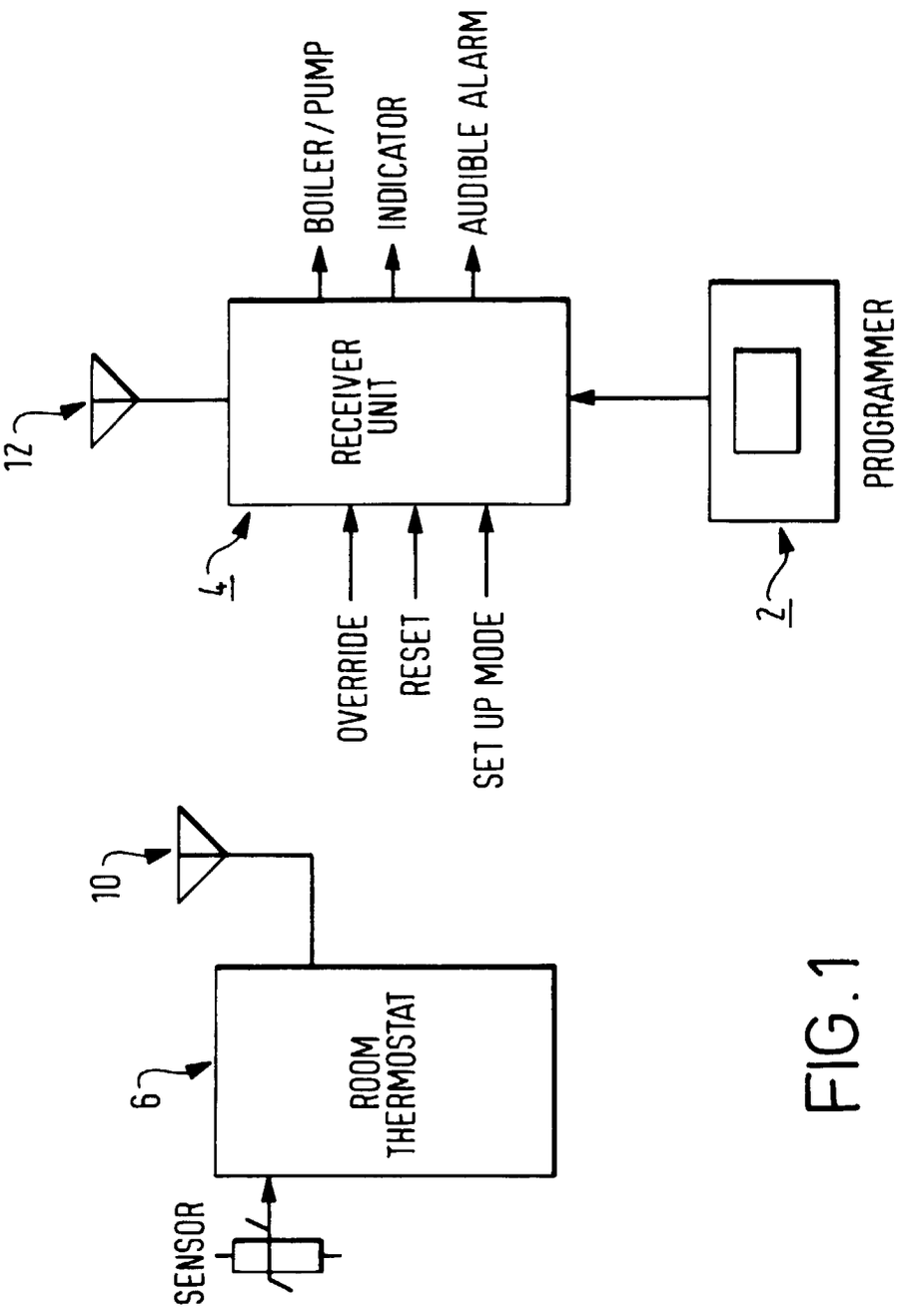

BOILER/PUMP
INDICATOR
AUDIBLE ALARM
RECEIVER UNIT
PROGRAMMER
12
4
2
OVERRIDE
RESET
SET UP MODE
10
6
ROOM THERMOSTAT
SENSOR

FIG. 1

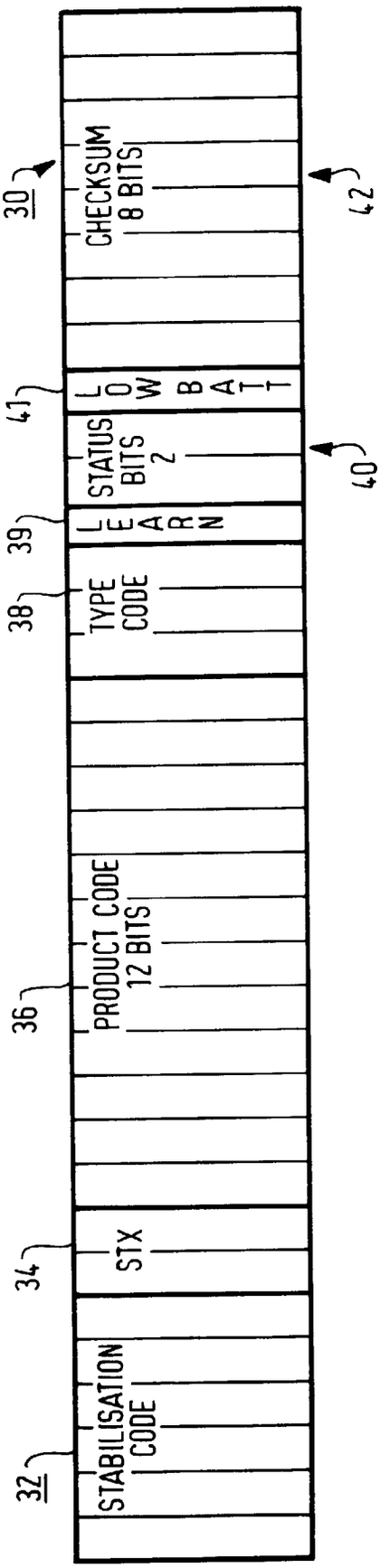
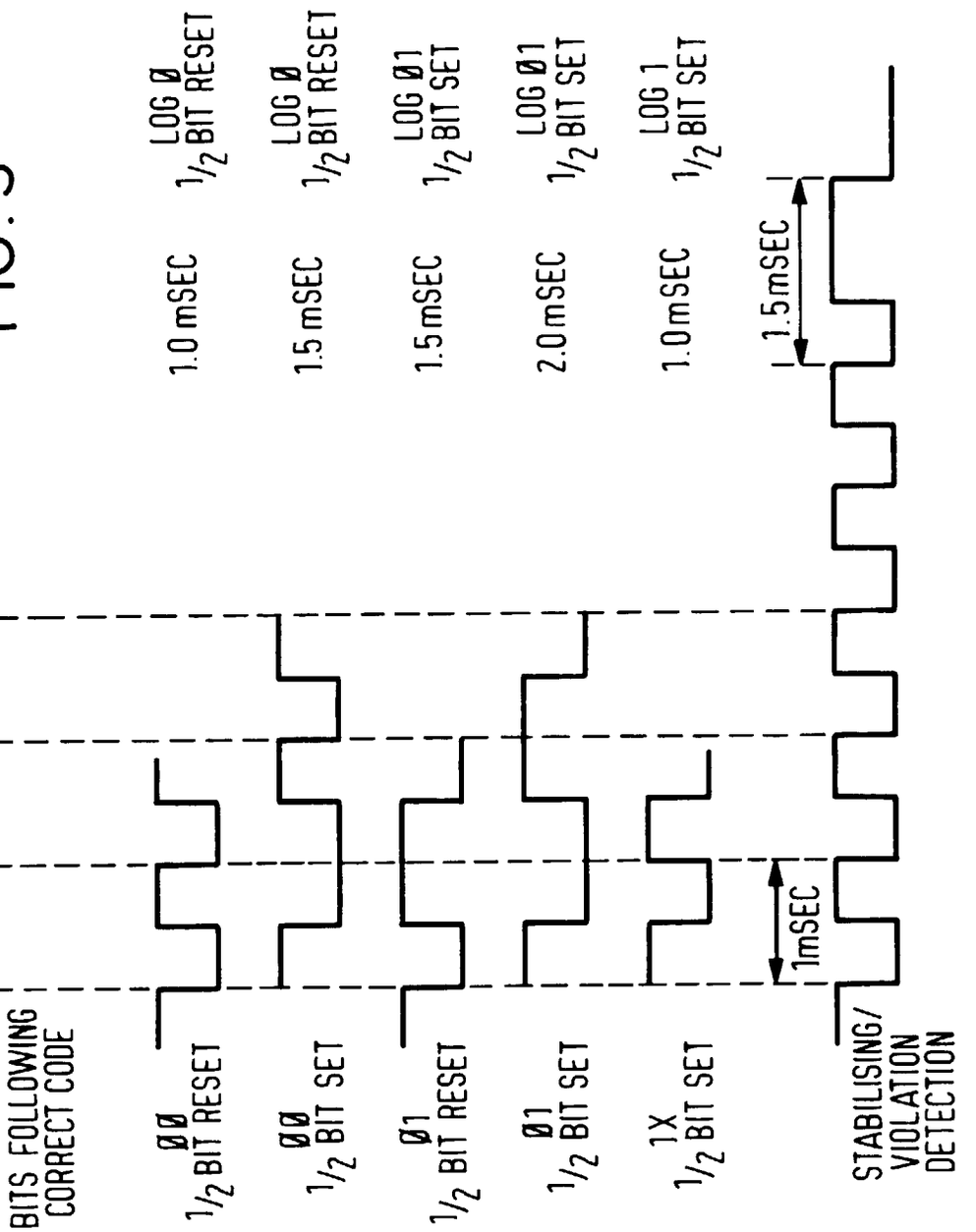

30
32
STABILISATION CODE
34
STX
36
PRODUCT CODE 12 BITS
38
TYPE CODE
39
LEARN
40
STATUS BITS 2
41
LOW BATT
42
CHECKSUM 8 BITS

FIG. 2

FIG. 3


BITS FOLLOWING CORRECT CODE
ØØ 1/2 BIT RESET
ØØ 1/2 BIT SET
Ø1 1/2 BIT RESET
Ø1 1/2 BIT SET
1X 1/2 BIT SET
STABILISING/ VIOLATION DETECTION
1mSEC
1.5mSEC
1.0 mSEC
1.5 mSEC
1.5 mSEC
2.0 mSEC
1.0 mSEC
LOG Ø 1/2 BIT RESET
LOG Ø 1/2 BIT RESET
LOG Ø1 1/2 BIT SET
LOG Ø1 1/2 BIT SET
LOG 1 1/2 BIT SET

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 96 30 2039

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X	DE-A-31 19 119 (BOSCH GMBH ROBERT) 9 December 1982 * page 7, line 12 - page 8, line 29; claims 1,6,7; figures 1,2 *	1-4,7	G08C15/00
X	GB-A-2 234 617 (STOLAR INC) 6 February 1991 * page 20, line 17 - line 30; claims 1,4; figure 1 *	1-4,7	
X	DE-A-23 51 013 (LICENTIA GMBH) 17 April 1975 * claims 1-6; figures 1-3 *	1-4,7	
X	FR-A-2 674 658 (FUSILIER JEAN MARIE ;BOUROUIS DANIEL (FR)) 2 October 1992 * claims 1,6,7,9; figures 1,3,4 *	1,4,7	
			TECHNICAL FIELDS SEARCHED (Int.Cl.6) G08C

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	24 June 1996	Wanzeele, R

CATEGORY OF CITED DOCUMENTS

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