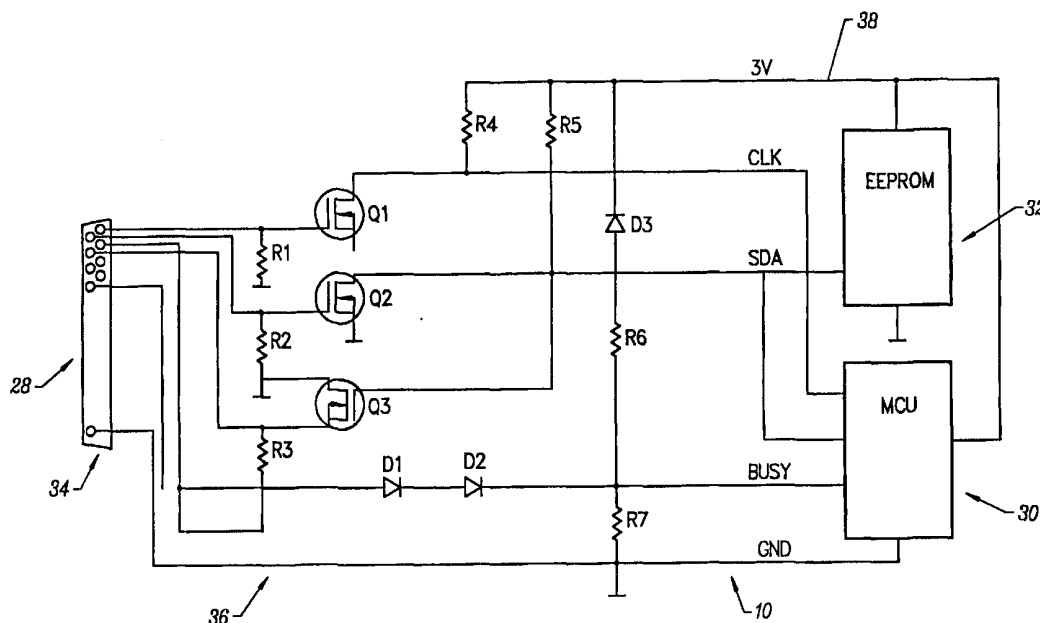




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(21) International Application Number: PCT/US99/09432 (22) International Filing Date: 28 April 1999 (28.04.99) (71)(72) Applicants and Inventors: FOREMAN, Richard, L. [US/US]; Suite D, 9260 Isaac Street, Santee, CA 92071 (US). WU, Frederick, L. [US/US]; P.O. Box 398, Pleasanton, CA 94566 (US). (74) Agents: BIELEN, Theodore, J., Jr. et al.; Bielen, Peterson & Lampe, Suite 720, 1990 N. California Boulevard, Walnut Creek, CA 94596 (US).		(81) Designated States: AE, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZA, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SL, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG). Published <i>With international search report.</i>

(54) Title: ENVIRONMENTAL DATA LOGGING SYSTEM



(57) Abstract

A system for obtaining environmental data such as temperature, pressure, humidity, and the like which utilizes the data acquisition sensor. In the case of obtaining temperature data, the sensor may be in the form of the thermistor (12) which measures a particular temperature value and generates a signal representing the same. A microprocessing unit (30) receives the signal from the data acquisition device and sends the same to an erasable memory unit (32). A data collection computer receives the value signal directly from the erasable memory unit, since access to the erasable memory unit by the microprocessor is shielded (35). The data collection computer (34) can communicate directly with the erasable memory without the need for generating a prior art RS-232 protocol.

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ENVIRONMENTAL DATA LOGGING SYSTEM**BACKGROUND OF THE INVENTION**

The present invention relates to a novel and useful data collection system.

In the prior art, a data logger normally works in conjunction with a programmer/down-loader personal computer, or a data collection instrument of some nature. The prior art systems use a conventional RS-232 serial data communication system which is a restrictive format. A data logger operating under the RS-232 serial format utilizes two lines, transmit (Tx) and receive (Rx). For example, when a personal computer communicates with the logger in the prior systems, the RS-232 protocol must be followed. In addition, data transmitted over the Tx and Rx lines utilize a fixed time interval for the rate of transmission, measured in bits per second. The standard rates under the RS-232 system begin at a standard of 2,400 bits per second and double for increasing data rates. For example, typical rate steps are 2,400, 4,800, and 9,600 bits per second. When logging environmental logging environmental parameters, logger products tend to use a maximum of 9,600 bits per second. In other words, 18 bit data word per millisecond or 1,000 data bytes per second would constitute the maximum rate of transmission under the RS-232 operation for a data logger. A deviation from the standard rate step is not acceptable.

Moreover, a logger microprocessor utilizing the RS-232 data logging standard must include software procedures in a program memory (ROM) to handle the Tx and Rx lines. In addition, the logger microprocessor must generate the time critical intervals of the data rate. The received instructions or data from the host PC must be processed by the logger and stored in non-volatile memory devices, such as EEPROMS, to configure the operation of the data logger. At this time, the data logger microprocessor suspends all other operations when communicating with a PC. In other words, common terminal routines for the host PC

exist to transmit and receive data from the RS-232 logger device. It should be noted that loggers of this type are supplied with the software programmed specifically to simplify data viewing and provide graphing functions by the manufacturers of such loggers.

Although the RS-232 serial data communication system works satisfactorily in certain cases, there are certain deficiencies which limit its specific application to data logger devices. As prior stated, the transfer of data is at a relatively low speed compared to the ability of a PC, which is capable of transferring data at 10 to 40 times the rate of an RS-232 device. Also, the logger unit must supply the power for transfer of data, which tends to limit battery life in self contained logging units. Further, there is a need to generate software which supports the RS-232 signal. This software "overhead" takes precious space in the memory portion of a data logger and it severely limits the capacity of the data logger to gather environmental values. In addition, the cost of the hardware necessary to generate an RS-232 format is relatively high. Moreover, data is not necessarily secure in an RS-232 system, since it is readily accessible unless safeguards are programmed into the software.

United States Patent 4,689,740 describes a computer system which utilizes a clock bus wire and a data bus wire to transmit data. The object of the subject patent is to enable a single two wire line to be used for the interconnection of multiple stations.

Other two wire systems known as MICROWIRE (National Semiconductor) and S.P.I. (Motorola), are also adaptable to data logging operations.

A data transmission system which is particularly applicable to a data logging device without the use of an RS-232 serial format would be a notable advance in the instrumentation field.

SUMMARY OF THE INVENTION

In accordance with the present invention a novel and useful environmental data logging system is herein provided.

The system of the present invention utilizes a data acquisition sensor which is able to detect values of temperature, pressure, humidity, or the like. Once an environmental value is determined, the sensor generates a signal representing the value. The signal is sent to a microprocessing unit which, among other things, receives the signal. The microprocessing unit is also capable of generating data memory read and write functions. Also, the microprocessing unit calibrates the sensor for use.

Erasable memory means is also used in the present invention. The microprocessing unit sends the value signal to the erasable memory means for storage and retrieval. Such erasable memory unit may take the form of a EEPROM and the like. The erasable memory means may have separate areas that are segregated by functions. For example, the EEPROM may perform configuration of the data logger sensor, look-up table items, and store data from the sensor which is retrievable.

The EEPROM works hand-in-hand with a data collection computer which may be a personal computer (PC) or other data collection device. The computer receives the value signal directly from the erasable memory, through a parallel port, without using the RS-232 format and the intervention of the microprocessing unit. Means is provided for shielding access to the erasable memory means by the microprocessing unit while such data collection computer receives the value signal from the erasable memory means. In addition, such connection of the personal computer easily calculates and loads a look-up table located in the EEPROM while the sensor is operating and creating data to be loaded into the EEPROM. Modified tables generated by the data entering the EEPROM acquire by the personal computer, of course, are capable of being

displayed. The PC table, which has been calculated, is also found in the proper format (hexadecimal), such that the table may be used directly from the EEPROM without translation of the same through a serial RS-232. Thus, the computing power of the PC extends the minimal capability of the microprocessing unit in the area of memory retention and computation. In addition, downloading of logged data from the EEPROM to the PC presents at least a 20 percent additional memory space in the EEPROM due to the need not to transmit data from the EEPROM to the PC under the rigid protocol of the RS-232 system. Such shielding means may take the form of a busy line logic which may be programmed into the microprocessing unit.

The system of the present invention also includes means for isolating the EEPROM from an exposed connector or shorted connector. Such electronic "O" ring protects the EEPROM in certain environmental conditions such as immersion in salt water.

The system of the present invention also comprises switch means for activating the data acquisition sensor and microprocessing unit at selected time intervals independent of manual operation. In other words, the data logger of the present invention is capable of logging data, should the data logging unit be not activated by the operator. This "shadow" logging feature assures the acquisition of data by the data logger system of the present invention if the data logger is employed in a transport vehicle, despite non-activation. Such a feature is easily included in the present invention by programming the same into the software of the microprocessing unit.

Since the system of the present invention includes means for shielding access to the erasable memory means by the microprocessing unit in order to allow the personal computer to communicate directly with the erasable memory means, timing is extremely important. The "busy" line to achieve this end has less priority in a logger of the present invention than taking measurements and storing

data. The minimum time required for the PC to wait before sending data or receiving data from the EEPROM is programmed into the PC by software configuration. The result is that the PC will know exactly at what time to access the EEPROM. Accessing too soon would crash the sensor logger, while waiting too long would result in a very inefficient logging mechanism.

It may be apparent that a novel and useful environmental data logging system has been described.

It is therefore an object of the present invention to provide a data logging system which includes a direct memory access between the host personal computer and the erasable memory storage means, such as an EEPROM.

It is another object of the present invention to provide an environmental data logging system which requires a relatively low cost to produce.

Another object of the present invention is to provided an environmental logging system which requires a smaller memory capacity than prior systems using the RS-232 protocol.

Yet another object of the present invention is to provide a data logging system which permits the high speed data transfer between the erasable memory means and the personal computer associated with the data logging system for collecting and processing data.

Yet another object of the present invention is to provide an environmental data logging system in which information may be retrieved from the memory portion of the of the data logging system although the source of power or microcontroller unit is defective.

A further object of the present invention is to provide an environmental data logging system in which formatting between the personal computer and the erasable memory means is easily achieved.

Another object of the present invention is to provide an environmental data logging system which eliminates decoding and transmitting in the rigid RS-232

protocol when downloading log data from the erasable memory means to the data collection computer unit.

A further object of the present invention is to provide an environmental data logging system which exhibits high security against tampering.

Another object of the present invention is to provide an environmental data logging system which is capable of isolating the memory unit from the exposed connector to permit shorted connector operation in extreme conditions.

A further object of the present invention is to provide an environmental data logging system in which logging takes place although manual activation of the data logger has been omitted by error.

Another object of the present invention is to provide a data logging system in which the personal computer is capable of communicating directly with the erasable memory means and possesses an exact time for initiation of such communication resulting in a highly efficient data logging system.

The invention possesses other objects and advantages especially as concerns particular characteristics and features thereof as the specification continues.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a schematic presentation of the RS-232 connection between a data logger and a personal computer serial port.

Fig. 2 is a schematic view of the direct access memory connection of the present invention between a personal computer and a data logger.

Fig. 3 is a prior art functional schematic presenting software methods in the prior art RS-232 connection protocol.

Fig. 4 is a schematic block diagram representing the direct access memory connection software functions of the present invention.

Fig. 5 is a electrical schematic of the memory interface circuit between a personal computer parallel port, the erasable memory means, and microprocessor of the present invention.

Fig. 6 is a block diagram representing the "shadow" logging function preformed in the software of the present invention.

Fig. 7 is a graph representing temperature measured by data logger in the working example of the present invention.

Fig. 8 is a graph representing the temperature measured by the data logger in the working example of the present invention.

For a better understanding of the invention reference is made to the following detailed description of the preferred embodiments thereof which should be referenced to the prior described drawings.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Various aspects of the present invention will evolve from the following detailed description of the preferred embodiments thereof which should be referenced to the herein above described drawings.

The invention as a whole is shown in the drawings by reference character 10. The data logger 10 is employed to record environmental parameters such as temperature, pressure, humidity, and the like. As shown in Figs. 1 and 2, sensor 12 takes the form of a thermistor which measures temperature and translates the same into a signal that is sent back to a microprocessing unit 14. Microprocessing unit 14 may take the form of a OKI semi conductor microprocessor. With reference to Fig. 1, it may be observed that a conventional data logger 16 is depicted in which the microprocessing unit 14 is connected to an erasable memory unit 18 by the data (Sda) and Clock (Clk) lines. Data from the microprocessing unit received from the thermistor 12 is transferred over two lines, the transmit (Tx) and receive (Rx) lines 20 and 22. A ground line 24 (Grd) is also employed in the prior art system. Host PC 26 includes a serial port 28 to accept the Tx, Rx, and GRD lines. Any received instructions or data from the host PC is stored in the EEPROM 18 which configures the operation of loggers 16 to the RS-232 protocol. The microprocessing unit 14 must cease all other operations, at this time, when communicating with PC 26 and require specific software to configure all data passing through Tx and Rx lines according to the RS-232 format. It has been found that this is an extremely restrictive system since data rates are severely limited, higher power is required, and additional software is needed to achieve such transfer of information.

With reference to Fig. 2, it may be observed that the data logger 10 of the present invention employs a microcontroller or microprocessing unit 30 as well as an EEPROM 32. EEPROM 32 may be of the type similar to the

24LC65 manufactured by Microchip Technology, Inc. Most importantly, temperature measurements acquired by thermistor 12 are transmitted to microcontroller unit 14. From there, the data is passed to EEPROM 32. Thus, the logger reads and writes to non-volatile EEPROM 30 during normal operation. Microprocessor however, must always read a "busy" line (Bsy) before entering the EEPROM. The busy line logic incorporated in the present invention tells the logger microprocessor whether to continue such reading and writing functions or the enter a hold loop. Thus, the data (Sda), clock (Clk), and ground (Gnd) lines from personal computer or other data acquisition unit 34 is direct, without utilizing the MCU 14 or the RS-232 format. The software required to achieve this result is incorporated into this application as Appendix I.

Referring now to Figs. 3 and 4, a comparison of the functions performed by the prior art RS-232 connection and the functions determined by the software of the present invention, Appendix I, is shown. Again, the memory "busy" feature permits the PC 34 of the present invention to read and write directly to the memory unit, since the MCU must always pass through the memory "busy" step. Under such shielding means 35, if the memory "busy" is positive, the MCU goes into a hold loop. On the other hand, if the memory "busy" is not positive, the MCU may read and write the memory of the EEPROM in the normal manner.

Turning now to Fig. 5, the logger 10 of the present invention interface 36 between computer 34 and the EEPROM 32 and MCU 30 is depicted. The data logger 10 operates on a 3 volt battery depicted by 3V line 38. All logic levels of the interface must conform to this voltage level. It should be noted that the parallel port logic levels of computers, such as PC 34, vary depending on types of computer designs, and physical design of the port, such as serial port 28 of PC 34 of the present invention. In certain cases, logic high voltages may range from 4.25 to 4.95 volts. Transistors Q1, Q2, and Q3 translate the

levels which may be found in PC 34 by the use of pull-up resistors R4, R5, and R6. Transistor Q1 provides the memory clock signal. Q2 provides the data write signal while Q3 provides the data read signals. Blocking diodes D1 and D2 provide the "busy" request signal to the MCU 30. MCU 30 responds by finishing any pending memory operations and then suspends further execution until the "busy" request line returns to a logic low. During such pause, the Sda and Clk lines to MCU 30 will be at high impedance. Thus, PC 34 now controls the memory of EEPROM 32. The network formed by D3 and R6 provides replacement current to the 3 volt battery to compensate for additional drain from the battery caused by the communication link. Resistors R1, R2, and R3 are pull-down or ground reference resistors, and provide the electronic "0" ring function to protect EEPROM 32. Such resistors also provide an open drain condition of memory connections releasing the memory to the full control of the MCU. It should be noted that Q1, Q2, and Q3 are N-channel enhancement mode MOSFETS. Diodes D1, D2, and D3 are 1n4148 small signal diodes. Resistors are 1-R7 are standard low precision units.

The following is a Table of typical components in the interface circuit of Fig. 5.

TABLE OF COMPONENTS

<u>ITEM</u>	<u>VALUE OR MODEL</u>	<u>SOURCE</u>
P.C. 34	IBM Clone Intel 386, capacity or better	IBM; San Jose, California
R1	220 Kohm	Xicon; Taiwan, Taiwan
R2	220 Kohm	Xicon; Taiwan, Taiwan
R3	10 Kohm	Xicon; Taiwan, Taiwan
R4	10 Kohm	Xicon; Taiwan, Taiwan
R5	10 Kohm	Xicon; Taiwan, Taiwan
R6	100 Kohm	Xicon; Taiwan, Taiwan
R7	220 Kohm	Xicon; Taiwan, Taiwan
Q1	RK7002T116	Rohm; Kyoto, Japan
Q2	RK7002T116	Rohm; Kyoto, Japan
Q3	RK7002T116	Rohm; Kyoto, Japan

D1	1N4148	Rohm; Kyoto, Japan
D2	1N4148	Rohm; Kyoto, Japan
D3	1N4148	Rohm; Kyoto, Japan
EEPROM 32	24LC65	Microchip Technology, Inc. Chandler, Arizona
MCU 30	64164	Oki Semiconductor; Tokyo, Japan

A further enhancement of the present invention includes the provision of "shadow" logging of data. Such "shadow logging" function is also derived from Appendix I, the object code software loaded into the EEPROM. In certain cases, an operator may forget to activate data logger 10 when data logger 10 is used to acquire values, such as temperature measurements, in a transportation vehicle. The "shadow logging" function will automatically take measurements according to the functional diagram shown in Fig. 6. It should be noted that the time interval for such "shadow logging" may be preprogrammed or altered through the use of PC 34.

To coordinate the shielding of the MCU 30 from communication with the EEPROM 32, timing of entry of PC 34 to the EEPROM is necessary. Such auto-synchronization is also programmed into computer 34 and is represented by the software program enclosed is Appendix II hereto. That is to say, the PC 34 synchronizes to the internal speed of recording of MCU 30 and determines entry of PC 34 an appropriate amount of time after the MCU has been shielded from communication with the EEPROM. Such "wait time" must be accurate to prevent delays in the system 10 of the present invention and also to prevent crashing of the EEPROM by PC 34.

The following working example is meant to illustrate the operation of a data logger coming under the present invention, but is not deemed to limit the claims of the patent in any manner.

WORKING EXAMPLE

A data logger, similar to the TQM-500 instrument

manufactured and sold by DeltaTrak, Inc. of Pleasanton, California, was employed with the data logging system 10 of the present invention heretofore described. Thermistor 12 was employed and an alarm temperature of 15 degrees centigrade was set. Sampling took place at one minute intervals for a total time of 5 minutes. A delay time for the alarm was set and the representation of the temperatures measured in Fig. 7 failed to trigger the alarm. However, when the delay was reset to a shorter time period the temperature measurements found in Fig. 8 and a maximum temperature of 13 degrees centigrade activate the alarm as required. Data transmission occurred between a PC and an EEPROM according to the system 10 of Fig. 2.

While in the foregoing, embodiments of the present invention have been set forth in considerable detail for the purposes of making a complete disclosure of the invention, it may be apparent to those of skill in the art that numerous changes may be made in such details without departing from the spirit and principles of the invention.

WHAT IS CLAIMED IS

1. An environmental data logging system comprising:
 - a. a data acquisition sensor for measuring the value of an environmental parameter and generating a signal representing said value;
 - b. a microprocessing unit said microprocessing unit receiving said signal from said data acquisition device;
 - c. erasable memory means said microprocessing unit sending said value signal to said erasable memory means;
 - d. a data collection computer receiving said value signal directly from said erasable memory means; and
 - e. means for shielding access to said erasable memory means by said microprocessing unit while said data collection computer receives said value signal from said erasable memory means.
2. The system of claim 1 which additionally comprises said microprocessing unit includes means for calibrating said data acquisition sensor.
3. The system of claim 2 in which said erasable memory means further comprises means for creating a data look-up table, readable by said data collection computer.
4. The system of claim 1 which further comprises means for generating a memory clock signal to said erasable memory device.
5. The system of claim 1 which further comprises means for isolating said erasable memory from connector shorting.
6. The system of claim 5 which additionally comprises said microprocessing unit includes means for calibrating said data acquisition sensor.
7. The system of claim 6 in which said erasable memory means further comprises means for creating a data look-up table, readable by said data collection computer.
8. The system of claim 7 which further comprises means for generating a memory clock signal to said erasable memory device.

9. The system of claim 8 which further comprises means for isolating said erasable memory from connector shorting.

10. The system of claim 1 which further comprises switch means for activating said data acquisition sensor and said microprocessing unit at selected time intervals.

11. The system of claim 1 which further comprises delay means for preventing communication of said data collection computer with said erasable memory means for a selected time period.

12. The system of claim 11 which further comprises switch means for activating said data acquisition sensor and said microprocessing unit at selected time intervals.

13. The system of claim 12 which further comprises means for isolating said erasable memory from connector shorting.

1/4

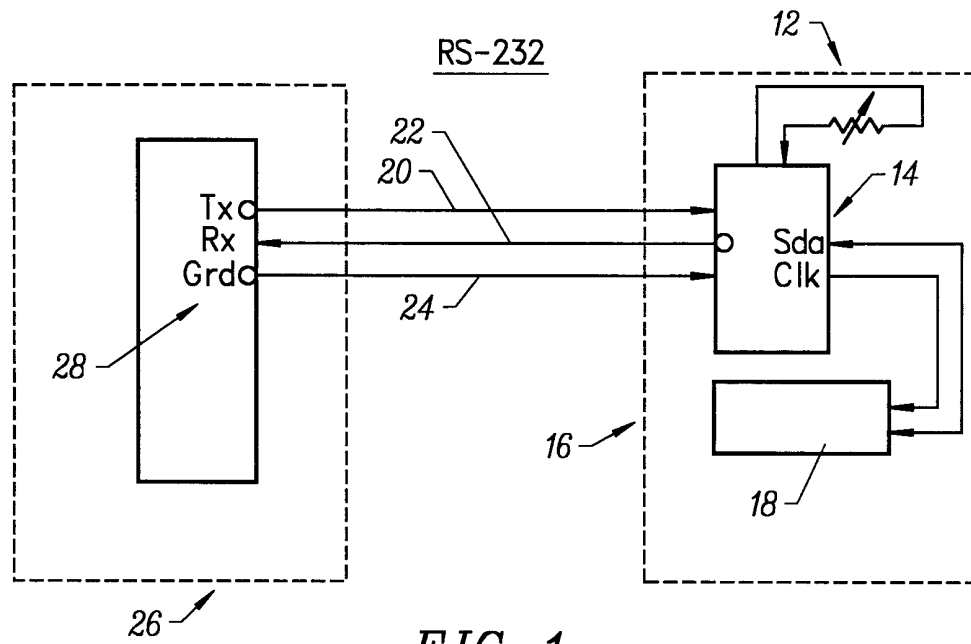


FIG. 1
PRIOR ART

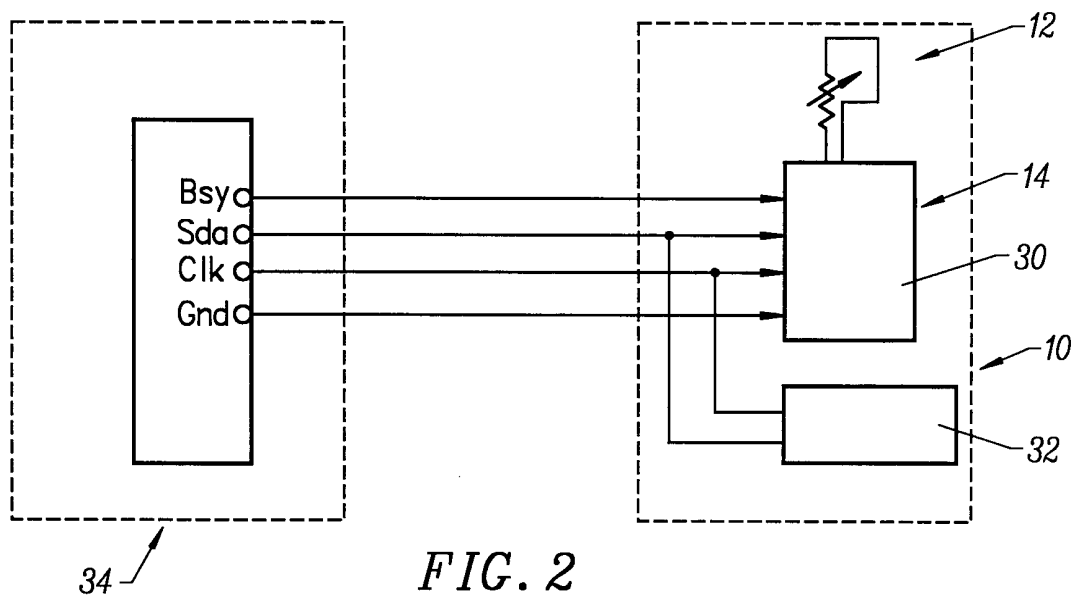


FIG. 2

2/4

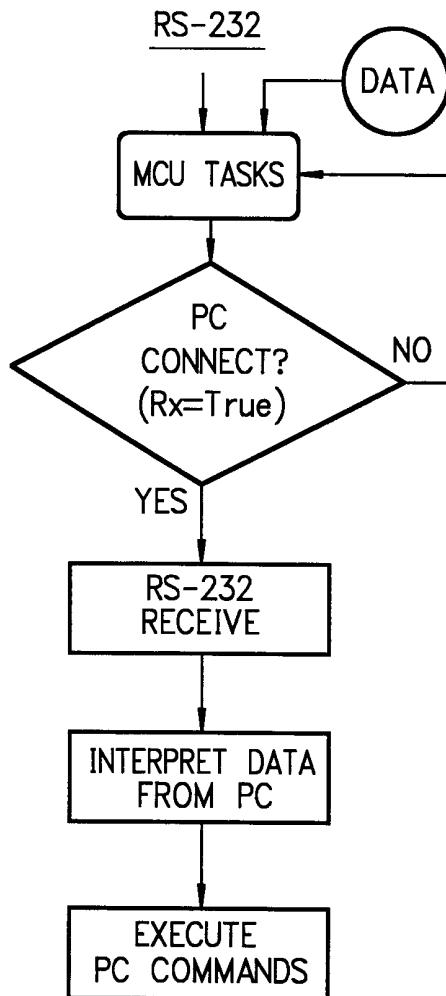


FIG. 3
PRIORART

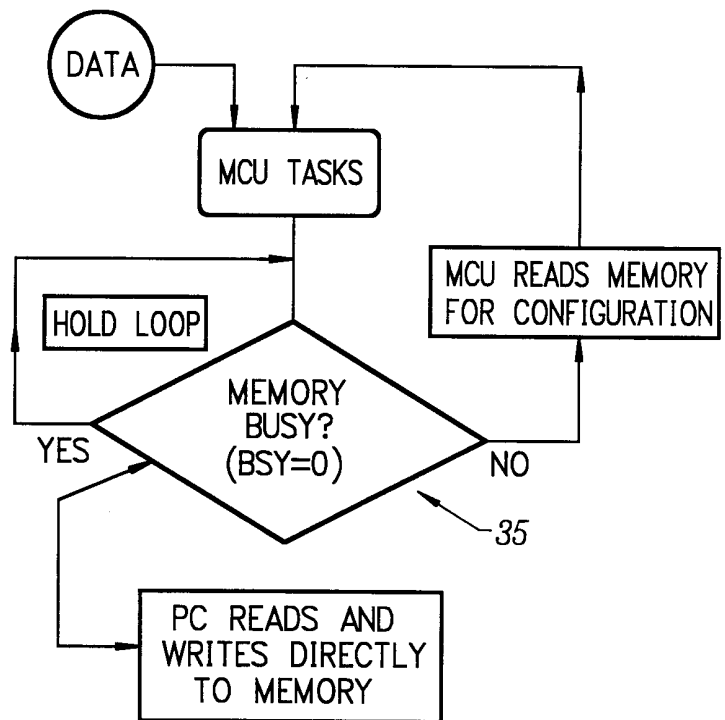


FIG. 4

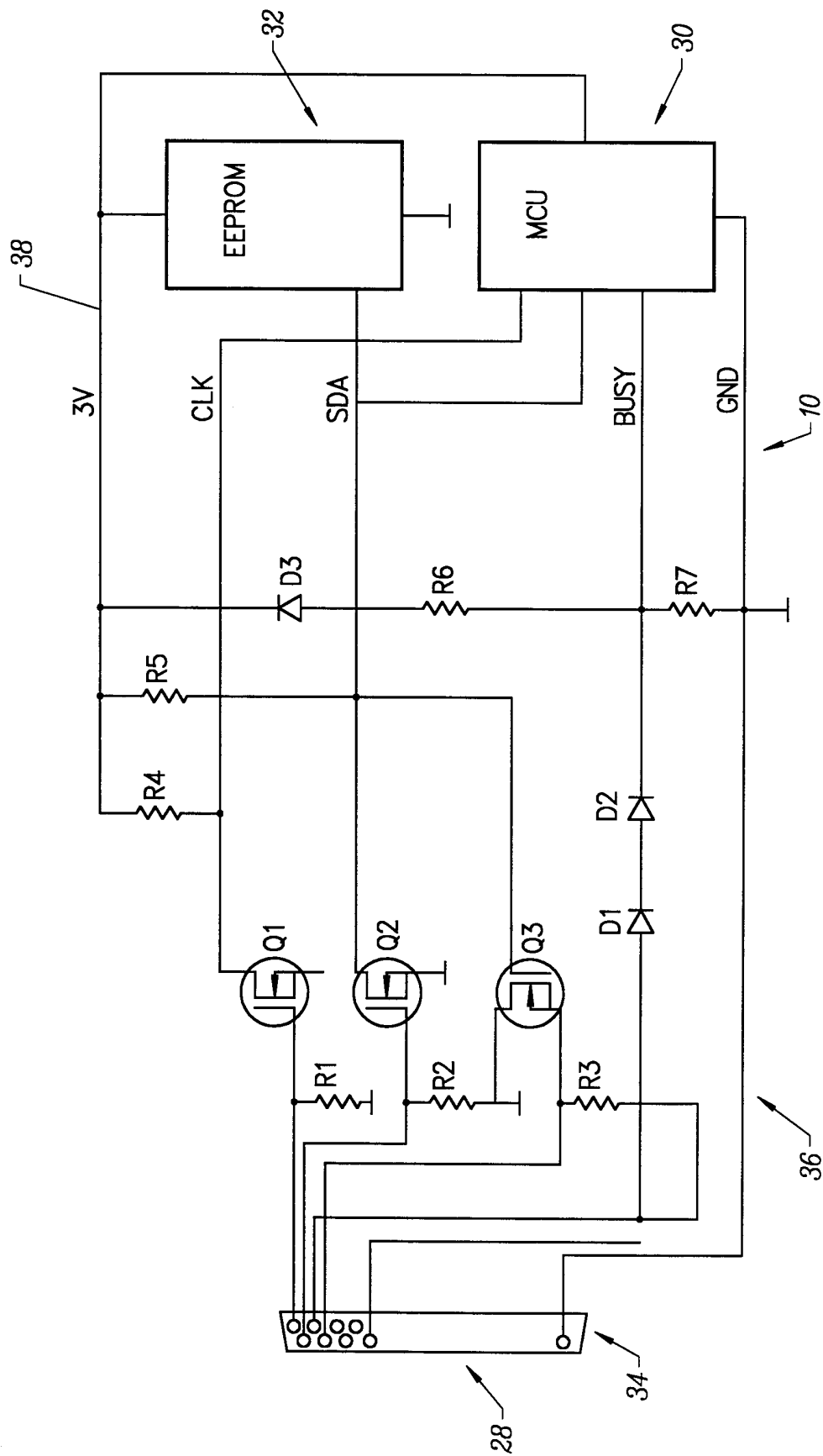


FIG. 5

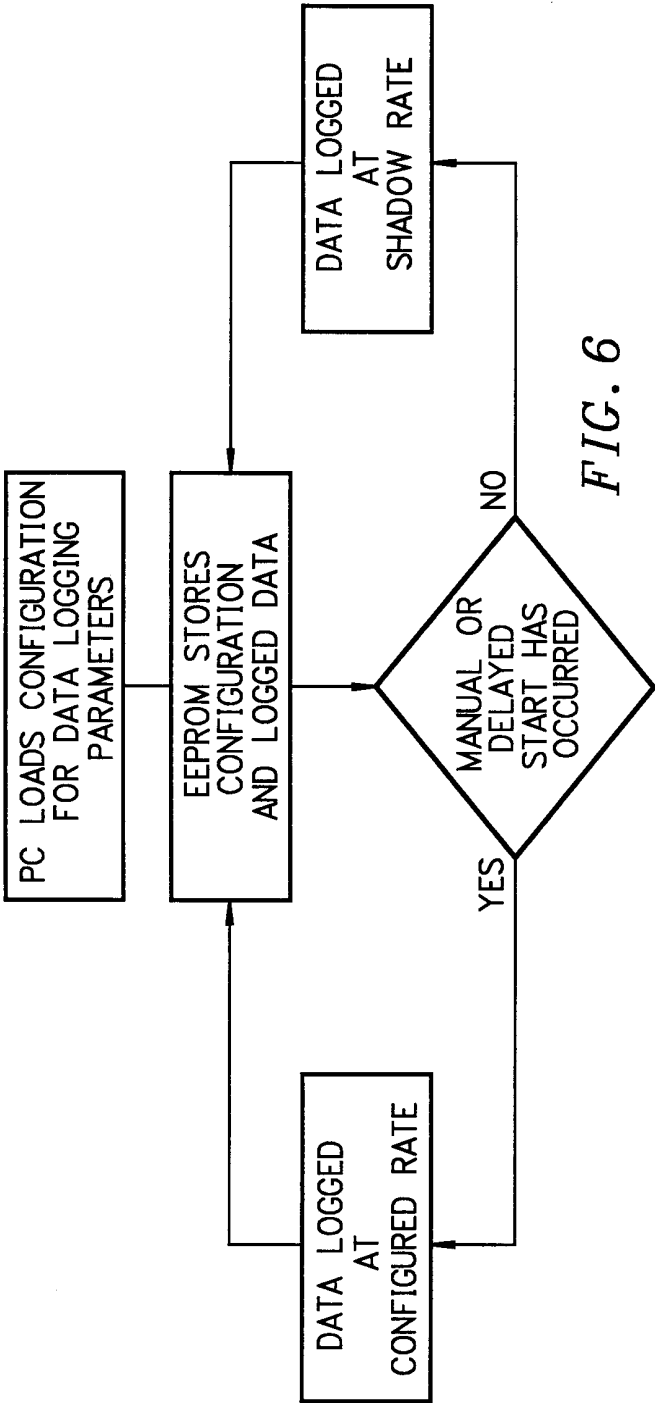


FIG. 6

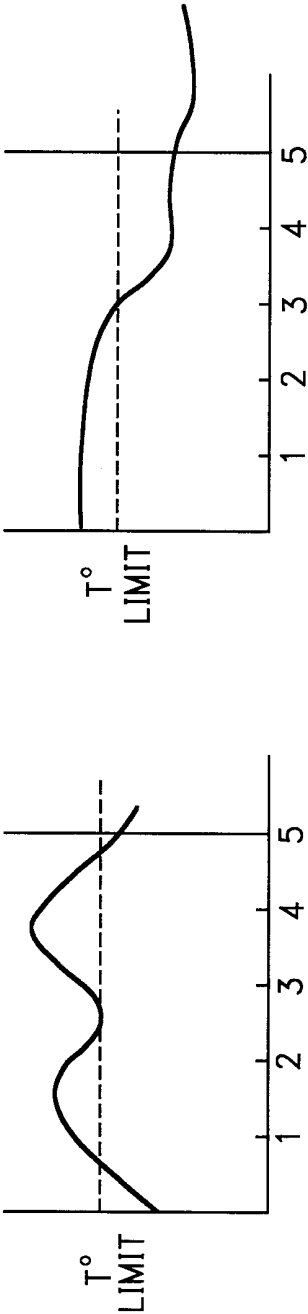


FIG. 7

FIG. 8

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US99/09432

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) : G06F 12/00

US CL : 702/85-88, 98, 99, 127, 130, 138, 189

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)

U.S. : 702/85-88, 98, 99, 127, 130, 138, 189

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
NONE

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
NONE

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 5,896,292 A (Hosaka et al.) 20 April 1999, (20/04/99) fig. 65 and abstract	1-13
Y	US 5,553,267 A (Herlihy) 03 September 1996, (03/09/96) abstract and col. 1	1-13
A	US 5,860,126 A (Mittal) 12 January 1999, (12/01/99) Abstract and col. 3-4	1-13
A	US 4,884,223 A (Ingle et al.) 28 November 1989, (28/11/89) abstract and fig. 2	1-13
A	US 4,747,060 A (Sears, III et al.) 24 May 1988, (24/05/88) abstract and fig. 2A	1-13
A	US 4,689,740 A (Moelands et al.) 25 August 1987, (25/08/87) abstract and figure 1	1-13



Further documents are listed in the continuation of Box C.



See patent family annex.

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Date of the actual completion of the international search

22 JULY 1999

Date of mailing of the international search report

30 AUG 1999

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/US99/09432

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4,212,057 A (Devlin et al.) 08 July 1980, (08/07/80) abstract and fig. 1	1-13