



US009231906B2

(12) **United States Patent**
Chu et al.

(10) **Patent No.:** **US 9,231,906 B2**
(45) **Date of Patent:** **Jan. 5, 2016**

(54) **METHOD OF ASSIGNING IDENTIFICATION CODES TO DEVICES IN A NETWORK**

(56) **References Cited**

(75) Inventors: **Man Yin Arthur Newton Chu**, Hong Kong (CN); **Kai Chi Chan**, Hong Kong (CN)

U.S. PATENT DOCUMENTS

4,695,839	A *	9/1987	Barbu et al.	340/3.21
5,715,475	A *	2/1998	Munson et al.	710/10
6,397,280	B1 *	5/2002	Nitschke et al.	710/110
2006/0282549	A1	12/2006	Vinnemann	
2007/0204082	A1	8/2007	Shimizu	
2010/0121537	A1	5/2010	Tanaka	
2012/0221755	A1*	8/2012	Schultz	710/110
2012/0293680	A1*	11/2012	Guan	348/222.1

(73) Assignee: **DEFOND COMPONENTS LIMITED**, Chai Wan, Hong Kong (CN)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 1116 days.

OTHER PUBLICATIONS

European Patent Office, International Search Report in International Patent Application No. EP 11 25 0922 (Mar. 2, 2012).

(21) Appl. No.: **13/268,126**

* cited by examiner

(22) Filed: **Oct. 7, 2011**

Primary Examiner — Titus Wong

(65) **Prior Publication Data**

(74) *Attorney, Agent, or Firm* — Leydig, Voit & Mayer, Ltd.

US 2013/0089157 A1 Apr. 11, 2013

(57) **ABSTRACT**

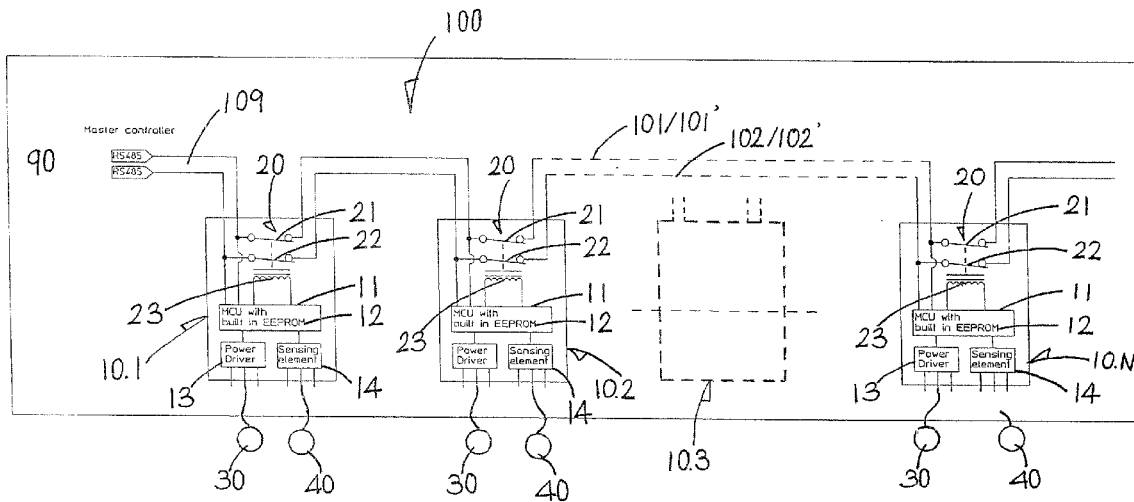
(51) **Int. Cl.**
G06F 3/00 (2006.01)
G06F 13/00 (2006.01)
H04L 29/12 (2006.01)
G06F 12/06 (2006.01)

A method of assigning identification codes to devices, each device including a controller, a memory, and a switch, with the devices connected in a series circuit. The method includes opening all of the switches, supplying a signal, including an identification code, to the first device of the series circuit and storing the identification code in the memory of the first device, closing the switch of the first device to connect to the next device in the series circuit, sending an acknowledgement to the series circuit, and repeating the process for each of the devices, successively, for each of the devices in the series circuit, and assigning a different identification code to each of the devices.

(52) **U.S. Cl.**
CPC **H04L 61/2038** (2013.01); **G06F 12/0676** (2013.01)

(58) **Field of Classification Search**
CPC **G06F 13/00**; **G06F 9/00**
USPC **710/9**
See application file for complete search history.

14 Claims, 5 Drawing Sheets



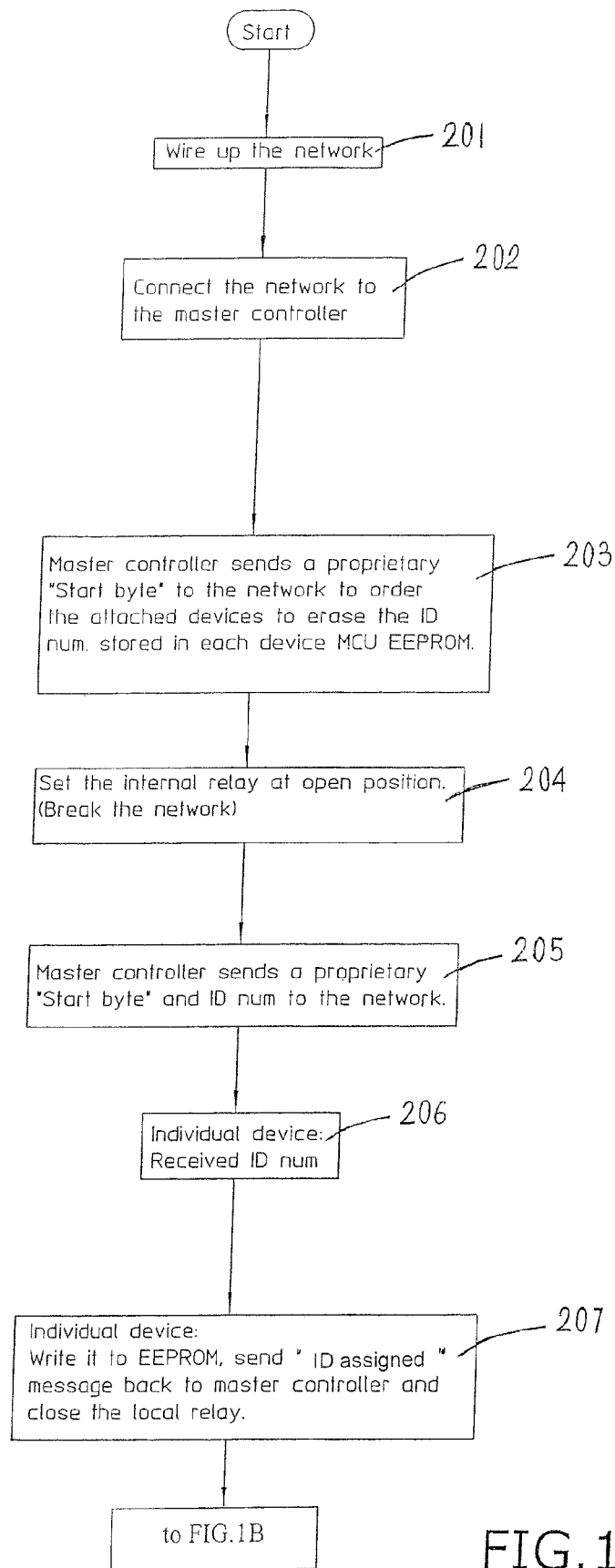


FIG.1A

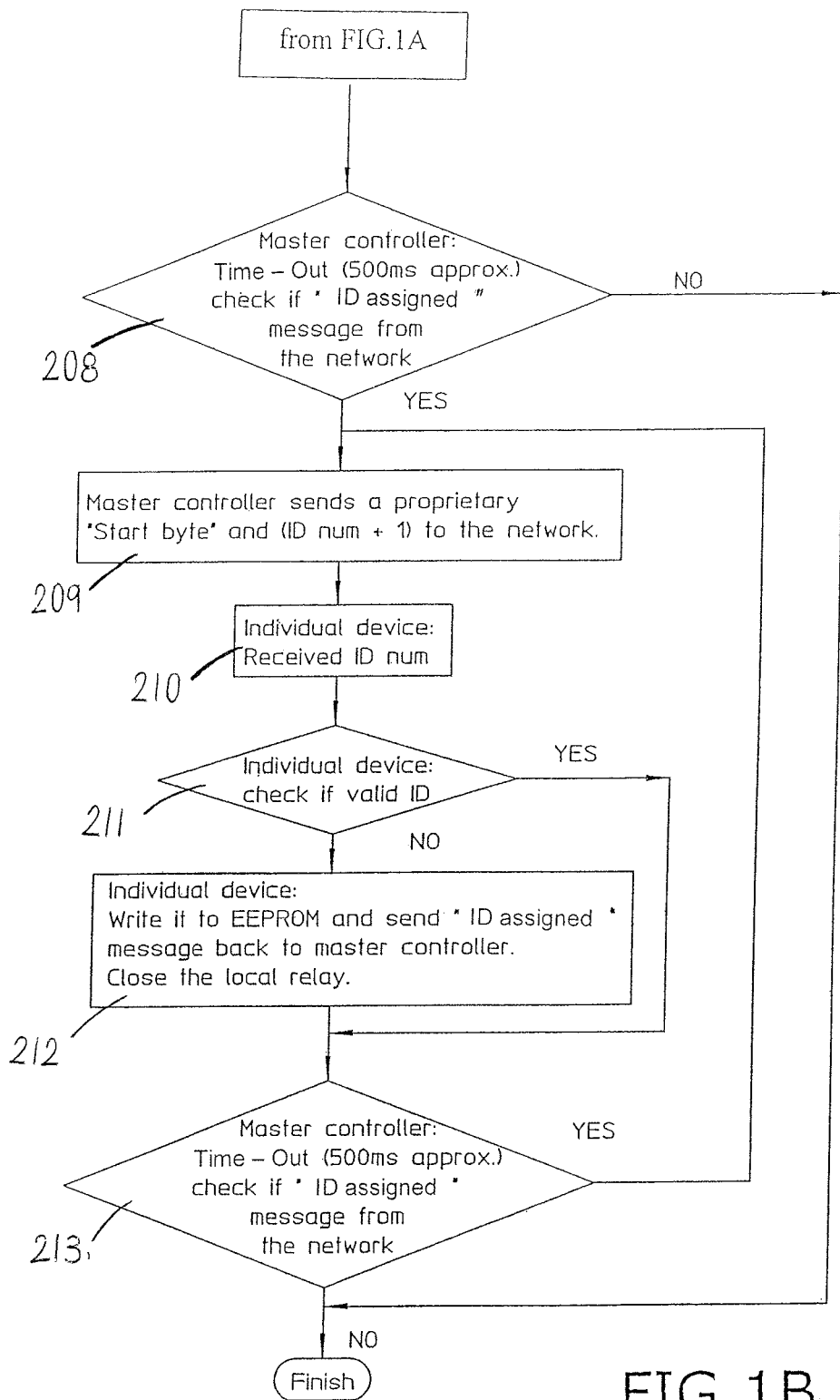
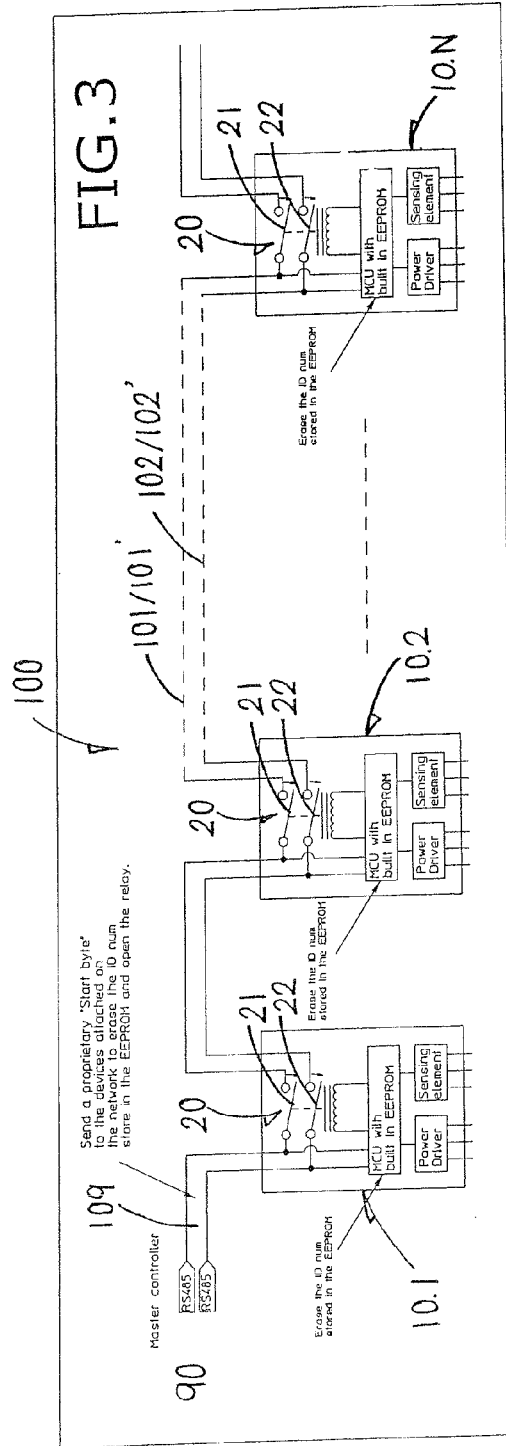
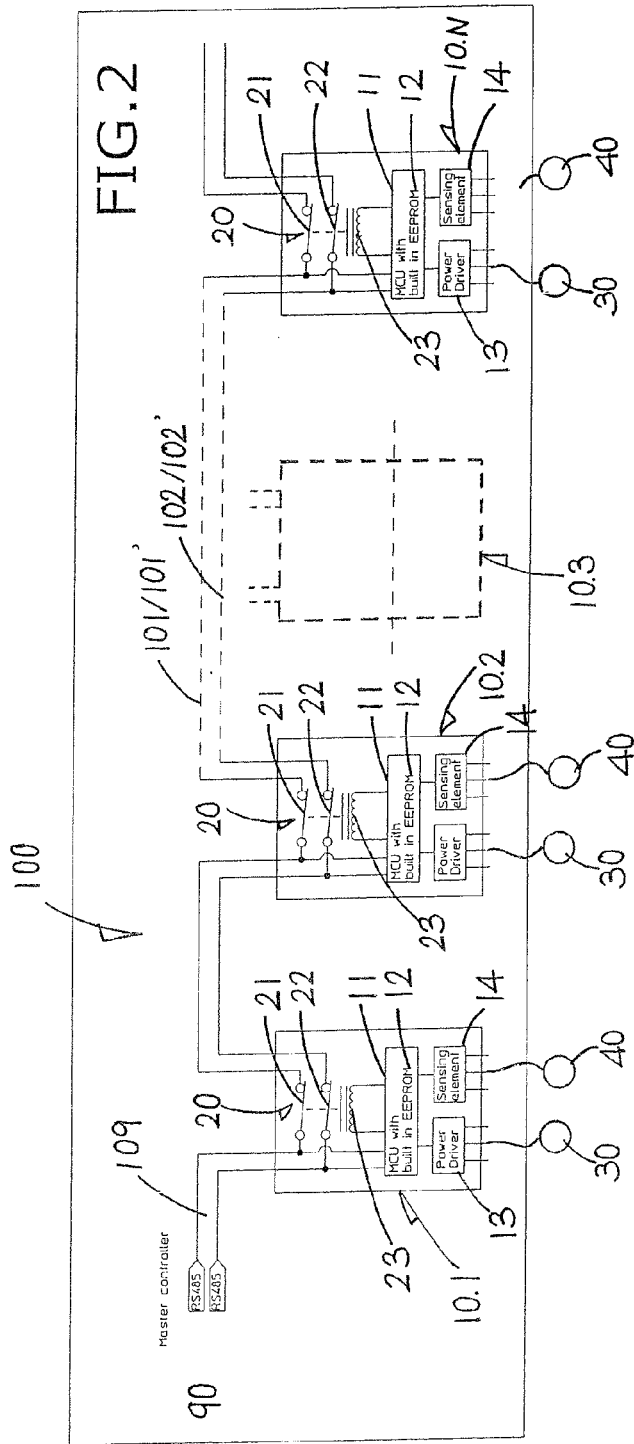
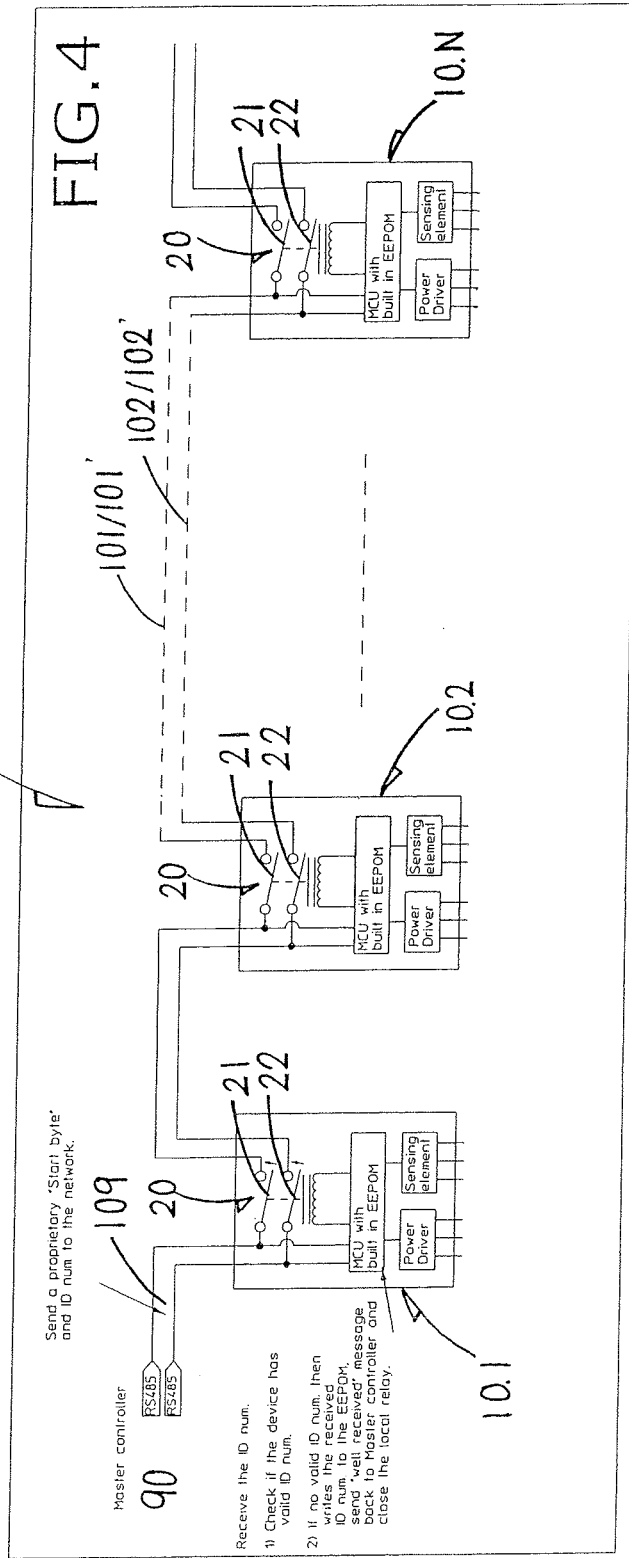
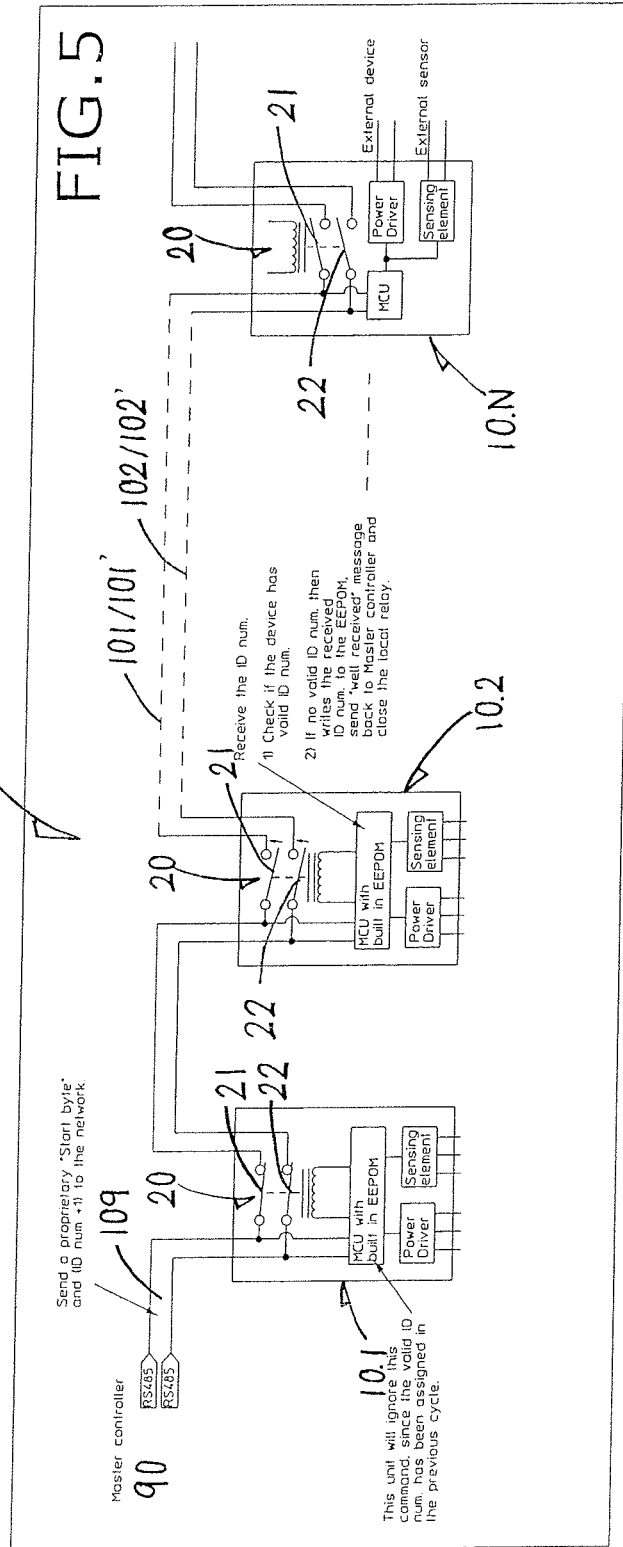


FIG. 1B







1

METHOD OF ASSIGNING IDENTIFICATION CODES TO DEVICES IN A NETWORK

The present invention relates to a method of assigning identification codes to a plurality of devices connected in a network.

BACKGROUND OF THE INVENTION

DMX512 (i.e. Digital Multiplex with 512 pieces of information) is a standard protocol for digital communication networks. It is being widely used in certain industries and in particular the stage lighting industry. RDM (i.e. Remote Device Management) is a protocol enhancement to DMX512 that allows bi-directional communication between each individual device and the master controller. It allows every individual device to report the current status back to the master controller. e.g. temperature and power consumption, etc.

The network construction of DMX512 is based on EIA-485, a standard defining the electrical characteristics of drivers and receivers for use in balanced digital multipoint systems. It supports bi-directional digital communication. Every device linked in the system has a unique identification address or ID code for sending and receiving commands and data between the individual device and the master controller. During installation, it is necessary to assign a unique ID code to each individual device linked in the system either by setting certain DIP switches or programming it onto EEPROM. This makes installation tedious and time consuming.

The invention seeks to mitigate or at least alleviate such a problem by providing a new or otherwise improved method of assigning identification codes to a plurality of devices connected in a network.

SUMMARY OF THE INVENTION

According to a first aspect of the invention, there is provided a method of assigning identification codes to a plurality of devices connected in a network, each device including a controller, a memory and a switch, the method comprising the following steps:

- (a) connecting the devices with their switches in a series circuit from a first device to a second device and so on, and with their controllers connected to an adjacent node of the series circuit at a position upstream of the corresponding switches, the series circuit having a head end including said node of the first device;
- (b) ensuring that all the switches are in an open position;
- (c) providing a signal, including an identification code, to the series circuit at its head end;
- (d) the controller of the first device receiving and then storing the identification code in the corresponding memory, whereby the first device is assigned with the identification code;
- (e) the controller of the first device then closing the corresponding switch to extend the series circuit to the next device;
- (f) the controller of the first device sending an acknowledgement to the series circuit after storing the identification code in the memory in step (d); and
- (g) repeating steps (c) to (f) for each of the remaining devices successively from the second device for assigning a different identification code to each of the remaining devices successively from the second device.

Preferably, step (b) comprises opening all the switches.

Preferably, the switches are normally-closed, and step (b) comprises providing a command to the series circuit at its

2

head end and in response the controllers of all the devices opening the corresponding switches.

More preferably, step (b) includes the controllers of all the devices clearing the corresponding memories before opening the corresponding switches.

It is preferred that step (d) includes the controller of the first device storing the identification code in the memory only when the memory does not hold an identification code.

It is preferred that step (d) includes the controller of the first device checking whether or not the corresponding memory holds an identification code, and then storing the identification code in the memory only when the memory does not hold an identification code.

It is further preferred that step (d) includes the controller of the first device withholding from storing the identification code in the memory when the memory already holds an identification code.

Preferably, step (c) is carried out only when an acknowledgement of step (f) is received in the series circuit.

More preferably, step (c) is carried out only when an acknowledgement of step (f) is received in the series circuit within a time-out period, and the method will terminate when the time-out period expires in the absence of said acknowledgement.

It is preferred that step (g) involves each of the devices connected to the series circuit by the switches that are closed, including the first device.

In a preferred embodiment, the method includes connecting a master controller at the head end of the series circuit for carrying out step (c).

In a specific arrangement, each of the devices has a pair of said switches operating in tandem, which are connected in step (a) to respective said series circuits running in parallel.

It is preferred that each switch is provided by a solenoid relay.

Preferably, step (g) includes progressively changing the identification code from one device to the next device.

It is preferred that each controller is provided by an MCU.

It is preferred that each memory is provided by an EEPROM.

BRIEF DESCRIPTION OF DRAWINGS

The invention will now be more particularly described, by way of example only, with reference to the accompanying drawings, in which:

FIGS. 1A and 1B combined is an operation flow chart that illustrates the operation of an embodiment of a method of assigning identification codes to a plurality of devices connected in a network in accordance with the invention;

FIG. 2 is a functional block diagram of a network of devices on which the method of FIGS. 1A and 1B is to operate;

FIG. 3 is a functional block diagram as that of FIG. 2, showing the initial condition of the devices at start of the method;

FIG. 4 is a functional block diagram subsequent to that of FIG. 3, showing a change in the condition of the first device after having been assigned an identification code; and

FIG. 5 is a functional block diagram subsequent to that of FIG. 4, showing a change in the condition of the second device after having been assigned an identification code, and so forth.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENT

Referring to FIGS. 1A and 1B and 2 to 5 of the drawings, there are illustrated a method of assigning identification or ID

codes to a plurality of devices **10** connected in a network **100** embodying the invention, and the network **100** of devices **10** is also shown. For simplicity, only the first device **10.1**, the second device **10.2**, the third device **10.3** (in dotted outline only) and the *n*th device **10.N** in the network **100** are depicted, including a master controller **90** connected to the network **100** at a head end **109** thereof. The method is hereinafter referred to the auto-addressing method.

In this particular embodiment, the network **100** implements an intelligent lighting control system for use in a commercial or residential building, in which the devices **10** are installed at various floors and/or locations of the building, each being connected with and for controlling the operation of an electrical light unit **30** provided by one or more incandescent bulbs, florescent tubes or LED lamps for illumination. The master controller **90** may be provided by a computer or server located in the management office and installed with appropriate software to perform central controls.

Each device **10** incorporates a number of components, namely an MCU controller **11** with a built-in EEPROM (Electrically-Erasable Programmable Read-Only Memory) **12**, a power driver **13**, a sensing element **14** and a solenoid relay **20**.

The MCU controller **11** may be implemented by alternative options such as a microprocessor control unit, microcontroller unit, microcontrol unit or micro computer unit, to which the other device components are connected for control thereby. It is programmed to perform different various functions and controls including various steps of the auto-addressing method. The EEPROM **12** is an internal erasable memory for storing an ID code or address by reference to which the devices **10** and hence associated light units **30** may be identified and accessed.

The power driver **13** drives an associated light unit **30** connected thereto, and may include a voltage regulator for regulating/converting the mains power to drive the light unit **30**.

The sensing element **14** provides a port for connecting an external sensor **40** to sense a certain parameter relevant to the operation of the light unit **30**. The sensor **40** may be, for example, a temperature probe for sensing the operating temperature of the light unit **30**, or a current coil for sensing the load current of the light unit **30**. Such temperature or current indicates the operating condition or status of the light unit **30** and is being monitored by the MCU **11**. In response to an abnormal or faulty condition, such as overheating or over-current, the MCU controller **11** will disable the power driver **13** to cut off the light unit **30** and/or feedback an alert signal to inform the master controller **90** accordingly.

The solenoid relay **20** is a normally-closed double-pole solenoid relay incorporating a pair of first and second switches **21** and **22** and a solenoid coil **23** for simultaneously operating, i.e. opening and closing, the switches **21** and **22** in tandem. The solenoid coil **23** is connected to the MCU controller **11** for control thereby.

The DMX512 protocol is employed for two-way communication between the master controller **90** and the MCU controllers of the various devices **10** at different remote locations. By nature of the DMX512 protocol, up to 512 light units **30** may be controlled by the master controller **90** via the corresponding devices **10** (i.e. **10.1** to **10.512**), with each light unit **30** being controllable to illuminate a selected one of 255 different levels of light intensity or to turn off. The light intensity of each light unit **30** is controlled by means of the associated power driver **13**, which includes a logic light dimmer operable by way of Pulse Width Modulation (PWM).

At the data-link layer, a DMX512 controller (e.g. master controller **90**) transmits asynchronous serial data at 250 kbaud, in a data format of one start bit, eight data bits, two stop bits and no parity. The start of a packet is signified by a break followed by a logical "mark", known as the "Mark after Break". The break, which signals the end of one packet and the start of another, causes receivers to start reception and also serves as a frame (position reference) for data bytes within the packet. Framed data bytes are known as slots. Following the break, up to 513 slots may be sent. The first slot is reserved for a "start code" that specifies the type of data in the packet. A start code of 0x00 (hexadecimal zero), often referred to as a "start byte", is the standard value used for all DMX512 compatible devices, including lighting fixtures and dimmers. All slots following the start code contain control settings for slave devices (e.g. MCU controllers **11**). A slot's position within the packet determines the device (e.g. device **10**) and function to be controlled, while its data value specifies the control set point.

The network **100** is a balanced digital multipoint system for long distance communication, and for this purpose and to safeguard against electrical noises, the master and MCU controllers **90** and **11** are built compliant to the RS485 standard. Extending from the master controller **90**, a twisted pair of lines **101** and **102** form the backbone of the network **100**, to and along which the devices **10** are connected in a linear configuration sequentially from the first device **10.1** to the second device **10.2** then to the third device **10.3** and so on.

Each device **10** is connected via its own relay **20**, with the relay's first and second switches **21** and **22** connected in series with, and forming a link in, the network lines **101** and **102** respectively. Taking all the devices **10** together, their first switches **21** are connected in one series circuit **101'** along the first line **101** and their second switches **21** in another series circuit **102'** along the second line **102**, and the two circuits **101'** and **102'** run in parallel.

The two lines **101** and **102** or circuits **101'** and **102'**, and hence the network **100** in general, can be cut and later re-connected at each device location by operating the relevant relay **20**.

In each of the devices **10**, the MCU controller **11** is also connected to the network lines **101** and **102**, at an adjacent node of the series circuits and at a position upstream of the associated relay switches **21** and **22**. This arrangement permits communication by the MCU controller **11** with an upstream device (and in particular the master controller **90**) even if the switches **21** and **22** are open and disconnect the downstream devices.

The head end **109** of the network **100** and hence the series circuits **101'** and **102'** includes the said node associated with the first device **10.1**, at which the first device's MCU controller **11** and switches **21** and **22** are connected directly to the master controller **90**. Thus the first device **10.1** is always connected to the master controller **90**.

The operation of the auto-addressing method on the network **100** is now described. The network **100** is first wired up (box **201** of FIG. 1A) and connected to the master controller **90** (box **202**). The switches **21** and **22** of all the devices **10** should initially be closed such that both series circuit **101'** and **102'** are uninterrupted. This is the default condition given that the relays **20** are normally-closed in this embodiment, or measures can be taken to achieve this condition e.g. through manual manipulation.

By being connected to the head end **109** of the series circuits **101'** and **102'**, all commands and signals from the master controller **90** for the network **100** are always issued or provided at the head end **109**.

5

Initially, the master controller **90** sends a proprietary “start byte” command to the network **100** to order all the devices **10** to clear their memories and in particular to erase their ID codes stored in their EEPROMs **12** (box **203**). This step is necessary only in the case of re-installation of the network **100**, when the devices **10** have been assigned with certain ID codes which are no longer valid and should be updated.

To prepare for assignment of ID codes to the devices **10** individually, the network **100** should be broken at every device location. This is done by the master controller **90** issuing a proprietary command to instruct all the devices **10** to open their relays **20**, i.e. the relay switches **21** and (box **204**), and to remain at the all open position. Although this command will break the network linkage, the connection between the master controller **90** and the first device **10.1** will stay, as this is a direct or permanent connection meant to be unbreakable.

The master controller **90** then sends a proprietary “start byte” command and a unique ID code to the network **100** (box **205**). The first device **10.1** receives the ID code (box **206**) as it is the only connected device. The first device **10.1** then writes the ID code onto its EEPROM **12**, sends back an “ID assigned” message to the master controller **90** after the ID code has been stored, and finally closes its relay **20** to re-establish the linkage or connection to the second device **10.2** (box **207**), i.e. extending the series circuits **101’/102’**. The first device **10.1** has now been assigned with an ID code.

The master controller **90** checks whether an “ID assigned” message is received in the network **100** (from any connected devices **10** and this time only the first device **10.1**) within a time-out period of 500 ms (box **208** of FIG. **1B**). In the affirmative, the master controller **90** will send another proprietary “start byte” command with a new or the next ID code, i.e. the last ID code plus 1, to the network (box **209**). The master controller **90** will only do so when an “ID assigned” message is received within the time-out period.

All the connected devices, i.e. only the first and second devices **10.1** and **10.2** at this time, receive the new ID code (box **210**). Each of them then checks whether itself has already been assigned with a valid ID code in the EEPROM **12** (box **211**). In the affirmative, the first device **10.1** will not store the new ID code just received, or any of more new ID codes to come, i.e. skipping the next step (box **212**).

In the absence of a valid ID code, the second device **10.2** proceeds with actions of the next step, i.e. then writing the received ID code onto its EEPROM **12**, sending back an “ID assigned” message to the master controller **90** after the ID code has been stored, and finally closing its relay **20** to reconnect, or extend the series circuits **101’/102’** to, the next i.e. third device **10.3** (box **212**). The second device **10.2** has now been assigned with its own unique ID code.

The master controller **90** checks whether an “ID assigned” message is received from the network (from any connected devices **10** and this time specifically the second device **10.2**) within a time-out period of 500 ms (box **213**). In the affirmative, the master controller **90** will send another proprietary “start byte” command with the next ID code, i.e. the last ID code plus 1, to the network (box **209**).

All the devices now connected, i.e. the first to third devices **10.1** to **10.3**, receive the next ID code (box **210**). Each of them then checks whether itself has already been assigned with a valid ID code in the EEPROM **12** (box **211**). As the first and second devices **10.1** and **10.2** already have their own ID codes, they will not accept any further ID codes, i.e. withholding from storing of any new ID code in their memories when the latter already holds an ID code.

Amongst all the devices having received a valid ID code, being the only one in need of the same, the third device **10.3**

6

proceeds with storing up the received ID code, acknowledging with an “ID assigned” message and then re-establishing the connection to the next i.e. fourth device (box **212**). The third device **10.3** acquires a unique ID code in the same manner as the second device **10.2** did as described above.

The master controller **90** repeated the ID code allocation procedures in cycles for the second and third devices **10.2** and **10.3** and will repeat the same in cycles for the fourth device and then each of the remaining devices in the system successively one by one until all the devices have been assigned with a different ID code.

Each cycle of the procedures involves each or all of the devices **10** connected to the series circuits **101’** and **102’** by the relay switches **21** and **22** that are closed, including the first device **10.1** that is permanently connected. Only the last connected device **10** will respond positively to an ID code provided by the master controller **90**, i.e. storing the ID code, because its EEPROM **12** is empty.

During the process, the master controller **90** progressively changes the ID codes from one device to the next device, thereby preventing duplication of the ID codes to ensure a unique address for each device **10**.

After the last device has acknowledged the allocation, the master controller **90** will send yet another proprietary “start byte” command with the next ID code (box **209**). However, as all the devices have acquired an ID code, none of them will respond with an “ID assigned” message. In the absence of this message, the master controller **90** will terminate the auto-addressing process when the time-out period expires (box **213**).

The method according to the invention allows the system to assign a unique ID code or address to every device linked onto the network **100** automatically, according to the order in which the devices **10** are connected to the network **100**. It saves the need of physical manipulation at each device location. Moreover, the method can simply be repeated after re-installation of the network **100**, e.g. with certain devices **10** removed or added. The order in which the devices **10** are arranged initially, or after alternation, is irrelevant to the carrying out of the method. The identification code or address assigned to each of the devices **10** is guaranteed to be unique, and there is no need to keep record of the same.

It is noted that the subject invention is not restricted to the DMX512 protocol and is applicable to any other network protocols. In a different embodiment, as EEPROM is not the only way to store the ID code, any other all other suitable non-volatile memory devices may be used e.g. flash memory.

The invention has been given by way of example only, and various other modifications of and/or alterations to the described embodiment may be made by persons skilled in the art without departing from the scope of the invention as specified in the appended claims.

The invention claimed is:

1. A method of assigning identification codes to a plurality of devices connected in a network, each device including a controller, a memory, and a switch, the method comprising:
 - (a) connecting the devices in a series circuit, adjacent pairs of the devices being connected at respective nodes of the series circuit, each controller being connected to an adjacent node of the series circuit at a position upstream of the switch of the respective controller, the series circuit having a head end including the node connected to a first device of the series circuit;
 - (b) opening all of the switches of all of the devices and ensuring that all of the switches of all of the devices connected in the series circuit are in an open state by

clearing all of the memories of all of the devices before opening all of the switches of all of the devices;

(c) providing a signal, including an identification code, to the series circuit at the head end;

(d) supplying the signal to the controller of the first device and storing the identification code in the memory of the first device, whereby the first device is assigned the identification code;

(e) closing the switch of the first device to connect to the next device in the series circuit;

(f) sending an acknowledgement to the series circuit after storing the identification code in the memory of the first device; and

(g) repeating (c) to (f) for each of the devices successively following the first device, for each of the devices in the series circuit, and assigning a different identification code to each of the devices in the series circuit; successively following the first device.

2. The method as claimed in claim 1, wherein all of the switches of all of the devices are normally closed, and (b) comprises providing a command to the series circuit at the head end and, in response, opening all of the switches of all of the devices.

3. The method as claimed in claim 1, including carrying out (c) for the next device in the series circuit only when the acknowledgement of (f) is received in the series circuit.

4. The method as claimed in claim 3, including carrying out (c) for the next device in the series circuit only when the acknowledgement of (f) is received in the series circuit within a time-out period, and terminating the method when the time-out period expires without the acknowledgement.

5. The method as claimed in claim 1, including, in (g), operating each of the devices connected to the series circuit by the switches of the devices that are closed, including the first device.

6. The method as claimed in claim 1, including connecting a master controller at the head end of the series circuit for carrying out (c).

7. The method as claimed in claim 1, wherein each of the devices has a pair of the switches, with each pair of switches operating in tandem, including, in (a), connecting a first switch of each pair of switches in a first series circuit and connecting a second switch of each pair of switches in a second circuit, the first and second series circuits running in parallel.

8. The method as claimed in claim 1, wherein each switch is a solenoid relay.

9. The method as claimed in claim 1, wherein (g) includes progressively changing the identification code from one device in the series circuit to a successive device in the series circuit.

10. The method as claimed in claim 1, wherein each controller is an MCU.

11. The method as claimed in claim 1, wherein each memory is an EEPROM.

12. A method of assigning identification codes to a plurality of devices connected in a network, each device including a controller, a memory, and a switch, the method comprising:

(a) connecting the devices in a series circuit, adjacent pairs of the devices being connected at respective nodes of the series circuit, each controller being connected to an adjacent node of the series circuit at a position upstream of the switch of the respective controller, the series circuit having a head end including the node connected to a first device of the series circuit;

(b) opening all of the switches of all of the devices and ensuring that all of the switches of all of the devices connected in the series circuit are in an open state;

(c) providing a signal, including an identification code, to the series circuit at the head end;

(d) supplying the signal to the controller of the first device and storing the identification code in the memory of the first device only when the memory of the first device does not hold an identification code, whereby the first device is assigned the identification code;

(e) closing the switch of the first device to connect to the next device in the series circuit;

(f) sending an acknowledgement to the series circuit after storing the identification code in the memory of the first device; and

(g) repeating (c) to (f) for each of the devices successively following the first device, for each of the devices in the series circuit, and assigning a different identification code to each of the devices in the series circuit successively following the first device.

cent node of the series circuit at a position upstream of the switch of the respective controller, the series circuit having a head end including the node connected to a first device of the series circuit;

(b) opening all of the switches of all of the devices and ensuring that all of the switches of all of the devices connected in the series circuit are in an open state;

(c) providing a signal, including an identification code, to the series circuit at the head end;

(d) supplying the signal to the controller of the first device and storing the identification code in the memory of the first device only when the memory of the first device does not hold an identification code, whereby the first device is assigned the identification code;

(e) closing the switch of the first device to connect to the next device in the series circuit;

(f) sending an acknowledgement to the series circuit after storing the identification code in the memory of the first device; and

(g) repeating (c) to (f) for each of the devices successively following the first device, for each of the devices in the series circuit, and assigning a different identification code to each of the devices in the series circuit successively following the first device.

13. The method as claimed in claim 12, wherein (d) includes withholding from storing the identification code in the memory of the first device when the memory of the first device already holds an identification code.

14. A method of assigning identification codes to a plurality of devices connected in a network, each device including a controller, a memory, and a switch, the method comprising:

(a) connecting the devices in a series circuit, adjacent pairs of the devices being connected at respective nodes of the series circuit, each controller being connected to an adjacent node of the series circuit at a position upstream of the switch of the respective controller, the series circuit having a head end including the node connected to a first device of the series circuit;

(b) opening all of the switches of all of the devices and ensuring that all of the switches of all of the devices connected in the series circuit are in an open state;

(c) providing a signal, including an identification code, to the series circuit at the head end;

(d) supplying the signal to the controller of the first device, checking whether the memory of the first device holds an identification code, and storing the identification code in the memory of the first device only when the memory of the first device does not hold the identification code, whereby the first device is assigned the identification code;

(e) closing the switch of the first device to connect to the next device in the series circuit;

(f) sending an acknowledgement to the series circuit after storing the identification code in the memory of the first device in (d); and

(g) repeating (c) to (f) for each of the devices successively following the first device, for each of the devices in the series circuit, and assigning a different identification code to each of the devices in the series circuit successively following the first device.