The Design of Power Line Carrier Switch which is User-definable by Code

ZHANG Kaisheng

College of Electrical and Information Engineering
Shaanxi University of Science and Technology
Xi'an, China
80649433@qq.com

CAI Wei

College of Electrical and Information Engineering
Shaanxi University of Science and Technology
Xi'an, China
646379475@qq.com

Abstract — **There are some problems in the existing power line carrier switch. Because the code for power line communication is preset by the manufacturer when it is produced, and the preset code cannot be changed by users, so there is so-called coincident code which will lead to mistaken control where the users cannot repair. To deal with this problem, a power line carrier switch has been designed and the code for power line communication is user-definable, so that users can set the code as they wish. A coding rule has been designed to ensure the uniqueness of the code by combining the user-code with the equipment-code. In this way, the mistaken control which is caused by coincident code can be avoided. Furthermore, when Application Programming technology is used to write or read the Flash memory which is in the MCU, the code set by the user is not lost when the power is turned off. A patent of this switch has been applied for.**

Keywords- PLC (Power Line Carrier); User-definable of Code; PLC switch; IAP;

I. INTRODUCTION

Nowadays, there are many kinds of power consumption equipment which are based on Power Line Carrier. Because of the advantage that don't need to lay added communication lines and can realize remote communication in the same transformer station area[1], the Power Line Carrier has good application and development prospects[2]. However, the communication codes of existing power line carrier switches are pre manufactured by the factory [3], then there is the possibility of the existence of duplicate codes between different equipment switches. Meanwhile, communication in the same transformer station area can be realized by Power Line Carrier, thus if two families in the same AC power lines have used the same power line carrier switches[4], the duplicate codes may lead to confusion and mistaken control. And for ordinary users, it's difficult to change the codes by them-selves [5], so they may be helpless about the mistaken control caused by duplicate codes.

In light of this situation, the power line carrier switch which is user-definable of code has been designed, and a coding rule has been presented to make it possible for users to set the communication codes conveniently. In this way, the uniqueness of the code is ensured and the confusion and mistaken control caused by duplicate codes may be under control.

In the whole control system, several power line carrier switches can communicate with each other to realize remote control of power consumption equipment. The principle of the whole structure is shown in Figure 1. When it's chosen to control a specific power consumption equipment in a power line carrier switches, it will be judged whether the code of the chosen equipment matches with current switch, if so, the switch will control the chosen equipment directly; if not, the current switch will send the control code to the other switches by Power Line Carrier through the 220V AC power line. For every switch, after receiving the control code, the conformance between code and equipment will also be judged, then the equipment will be controlled if they are conforming.

If two families which are in the same power supply line have bought and installed the same brand of the same type of power line carrier switch, there may be mistaken control caused by preceding duplicate codes. For example, family A tried to open a balcony lamp, but balcony lamps of both family A and B will be opened because the code of balcony lamps of these two families are duplicate. In this paper, we have designed an electric power line carrier switch and its corresponding coding system to solve the preceding problem.
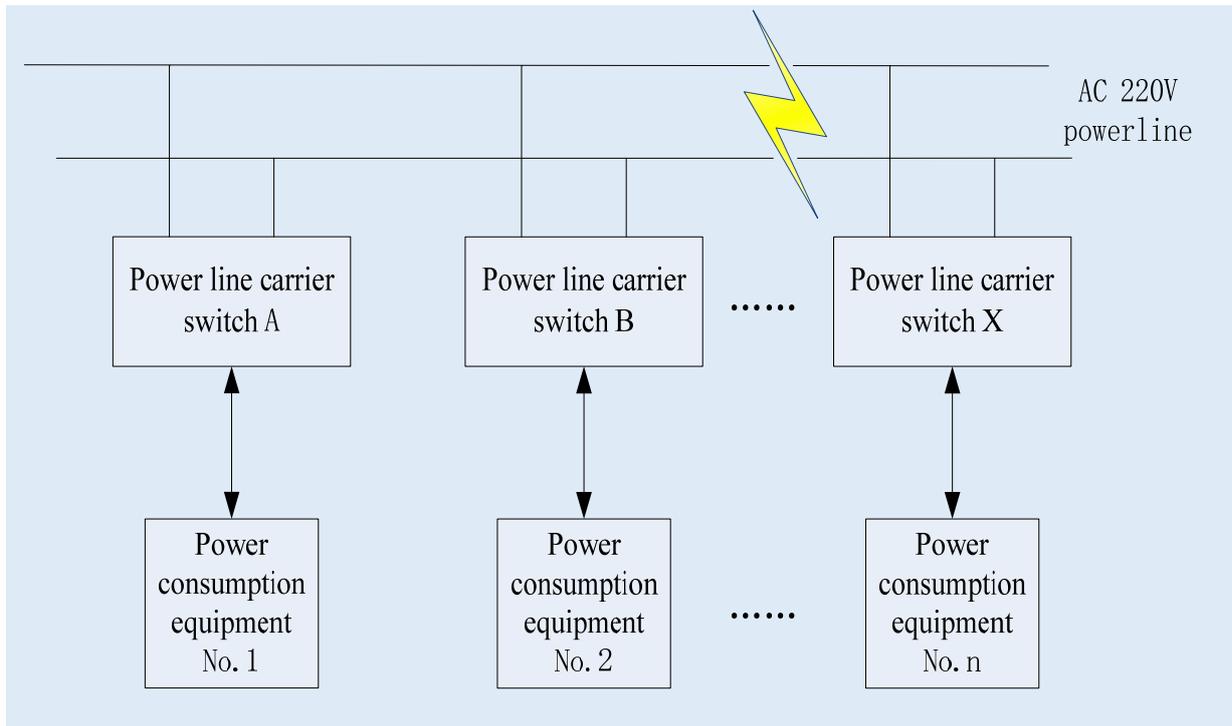
Figure 1. The principle diagram of the whole structure.

II.   HARDWARE OF THE SWITCH

The hardware of power line carrier switch includes key input module, remote control input module, digital display module, power line carrier module, MCU (micro controller unit) and equipment-controlling module. The circuit diagram and physical connection diagram are shown in Figure 2, 3. The key input module is used to achieve the function of choosing the working mode of switch and electrical equipment control command transmission. In order to save space of hardware, there are just four buttons in each switch, from left to right respectively for mode selection key, minus key, plus key and confirm key. The specific function of them will be presented later. The remote control input module is used to achieve the function of specific coding input, so that one remote controller can be shared by various switches [6].The

digital display module can display some state of switch, such as displaying working mode, displaying the input encoding, displaying the state of electrical equipment, and so on. The equipment-controlling module can control the electric equipment as wish according to the output information of the IO port of the microcontroller, for example, to open or close the electric equipment through the photoelectric coupling switch. The power carrier module, which is connecting with micro controller through the serial communication interface TXD, RXD, is responsible for modulating the signal that is need to send to other carrier switch to 220V power line for transmission. The MCU is used as the control center of the whole power line carrier switch, and is responsible for receiving and processing the input signal from the key, the remote control and the carrier module as well as outputting various control signals.

Figure 2. Hardware circuit diagram of power line carrier switch.

Figure 3. phisical connection diagram of power line carrier switch

III. SOFTWARE OF THE SWITCH

The software part mainly divides into the communication code setting section and the equipment control section.

The flow chart of code setting section of the program is shown in Figure 4, the function of which is to make it possible to set and store the encoding when it's the code set mode.
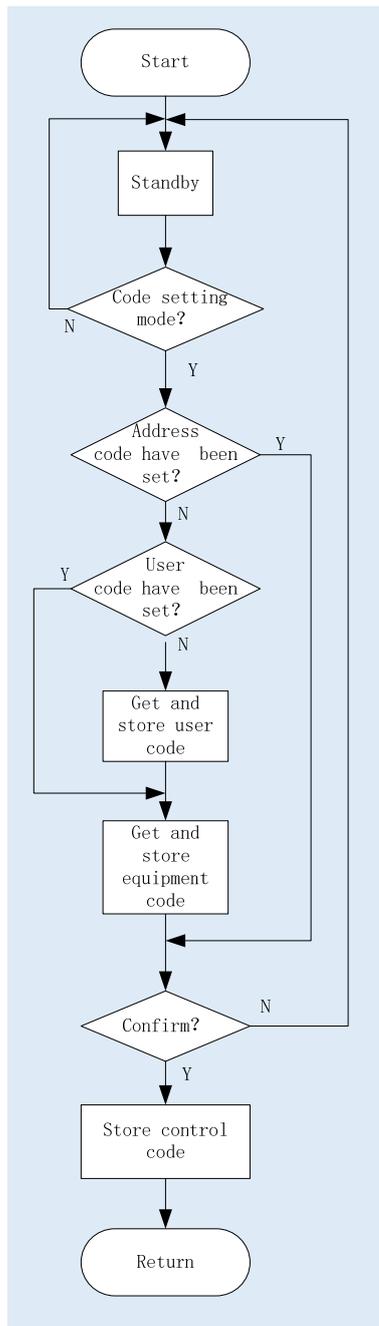
Figure 4. Flow chart of code setting section

Equipment control section is to achieve the following functions: when a specific code of power consumption equipment is chosen in a switches, it will be judged whether the code of the chosen equipment matches with current switch, if so, the switch will control the chosen equipment directly; if not, the current switch will send the control code to the other switches by Power Line Carrier through the 220V AC power line. On the other hand, when the carrier switch receives a control code, the

address code in the control code is judged whether matches with the present equipment, and if it is, the corresponding control is carried out; if not, the operation is not carried out.

While control signal transmitting by Power Line Carrier, there is interference which may lead to code losing. Therefore, the software redundancy method and routing algorithm have been adopted to improve the anti-jamming capability and capacity for transmitting signals, so as to improve the quality of communication [7]. And software redundancy method may occupy a lot of software resource, therefore the response code has been added: the sender using software redundancy method is constantly sending out signals, then the receiver determine whether the signal is effective control signal, if it is, a response code will be sent to the sender to let the sender to stop sending, which can reduce the usage of resources.

When it turns to the storage location of carrier communication encoding, there are two different ways existing, one is storing the encoding with the main function and the sub function data together in the internal microprocessor, that mentioned above called pre manufactured which is hard to change the code. If it's necessary to update, it needs professional operation to program all the program data again; another method is to store in external memory, such as EEPROM, but the disadvantage of this method is that extends the extra hardware space, increases the cost of the system, and reduces the speed of data reading. Therefore, the carrier switch have been designed to use IAP technology, which can only read or write the part that store the carrier communication coding in the Flash, so that the above problems can effectively be solved[8]. When CPU is powered on, the initial code is read from the flash and copied to RAM, then the program will run according to the code. If for setting custom code, code data is written to flash, then is copied and renew the communication code in RAM, after that program will run according to the newest code. The program of reading and writing the flash is as follows:

```
uint8  WriteFlash(uint32 dst, uint32 src, uint32 no)
                                     //write the flash
{
    SelSector((dst/0x1000),(dst+no)/0x1000);
                                     //select sector
    EraseSector((dst/0x1000),(dst+no)/0x1000);
                                     //erase sector
    BlankCHK((dst/0x1000),(dst+no)/0x1000);
                                     //check the blank
                       sector
    SelSector((dst/0x1000),(dst+no)/0x1000);
                                     //select sector
    RamToFlash(dst,src,no);        //write data into flash
    return(Compare(dst,src,no));   //compare the data
}
void ReadFlash()            //read data from the flash
{
    uint32 i;
```

```
    uint8 *p;
    p=(uint8 *)DestAddr;
    for(i=0;i<512;i++)
    {
        shanqu5[i]=*p;
     p++;
    }
}
```

IV. INTRODUCTION OF CODING RULE

To ensure the uniqueness of carrier communication encoding, a new coding rule has been designed. The structure of carrier communication code is shown in Figure 5. Firstly, the user code is used to prevent the case of duplicate code between different users, that is, to deal with the preceding problem of same codes between different families in the same transformer station area who have used the same power line carrier switch. And it's provided in the rules that set user's ID card number as the user code so it can effectively ensure that the user code is different between different users. Secondly, the equipment code is used to prevent the emergence of duplicate code between different power consumption equipment of the same user. It should be noted that the equipment code for 8 digits is only used to explain the rule, rather than the mandatory requirements, so it can be set according to need in the actual application. So the user code and equipment code get together to be the unique address code of each power consumption equipment. Taking into account that there are other modes of operation in addition to the two state of on and off for some of the equipment, the control word is designed as 3 digits, and it also can be changed according to need in the actual application.
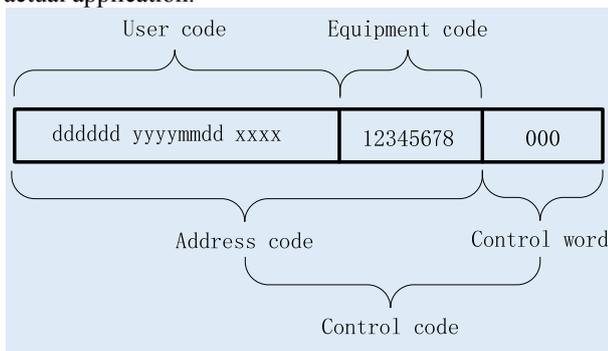

Figure 5. Structure of carrier communication code

In summary, the address code of equipment is consisted of user code and equipment code, then a power line carrier communication control code is consisted of the address code and control word. The effective control of the power consumption equipment can be realized through the transmission and reception of the control code between the carrier switch, and the mistaken control caused by the duplicate code can be avoided simultaneously.

V. TESTING FOR THE SWITCH

The usage method of power line carrier switch is as follows: there are three modes of switch which are standby mode, equipment control mode and code setting mode, and the mode selection key is used to switch to different mode. And the minus key and plus key are used to select equipment to control at equipment control mode, besides, the remote controller can also realize the function of minus key and plus key. And at code set mode, the remote controller is necessary to input the control code more conveniently. After selecting the equipment to be controlled or inputting code, the confirm key will be pushed to confirm what have been operated, so the target equipment will be controlled as wish or the control code will be changed and stored.

In the testing, ten power line carrier switches are used to connect the 220V light bulb, and are inserted in different power sockets. At the same time, in the process of testing the serial data port of switch is connected to the computer by a serial line, and the data being sent can be shown in the software called Serial Port Assistant in computer. After initialization of switch, the No.5 equipment is chosen to be controlled. It is shown in Serial Port Assistant about transmitting code, as shown in Figure 6, and due to the adoption of the method of software redundancy, so the code has been sent more than one time, indicating that the switch can send with custom code. At the same time, the switch which is connecting with No.5 equipment have received the code and No.5 equipment can be correctly controlled. After that, the control code of No.5 equipment is set as 12340301, which means this equipment has been changed into No.3, and trying to send 12340501 in any switch won't make any effect to this equipment, indicating that the control code of it has been successfully reset. And the code 12340301 will make sense for this No.3 equipment (the original No.5).

In addition, to increase the length of power line between two switches, it's found that, the communication distance between two switches is up to 1000 meters which means that this power line carrier switch can be practical application in the field of family, school, office buildings to control power consumption equipment remotely, and there is no need to lay additional communication line so that can save the cost.
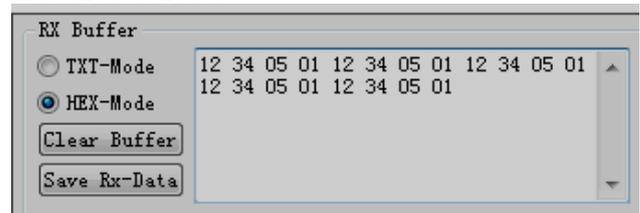

Figure 6. Serial Port Assistant showing data sent by switch

VI. CONCLUDING

The power line carrier switch which is user-definable of code, using the existing power grid as the communication network for control signal, costs less and has better real-time performance than wireless transmission network; meanwhile, compared to the existing power line carrier switch, it's convenient to set control code by the user, which can effectively avoid mistaken control taking place due to duplicate code in family or other place while the power consumption equipment is controlled based on the power line carrier communication.

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