ABSTRACT

In this paper, we are dealing with an efficient method for reduction in power theft. Electricity theft is estimated to cost billions of dollars per year in many countries. In our present electricity generation system we waste more than half of our resources. Owing to the current lack of advanced anti-theft technology, a novel power theft reducing system is proposed in this paper. The proposed system consists of two circuits and two home models (one authorised and other unauthorised). One circuit is connected at distribution substation and another inside the electric meter installed in the consumers premises of authorised home. Sending end circuit will send high voltage pulse at regular interval of time. While in the case of authorised home a receiving end circuit will reduce this high voltage pulse to regular 230VAC, in unauthorised home it will affect its circuitry. This paper as a whole gives an effective, high performance technique which can efficiently transmits the power to the required area by reducing power theft. It’s design also incorporates effective solution for power theft as required by India’s electricity distribution system. The proposed system can be used for both single phase and three phase system.

Keywords: Electricity theft, High voltage pulse, Anti-theft technology, Distribution substation, Electric meter

1. INTRODUCTION

Many developing countries confront widespread electricity theft from government owned power utilities. In India electricity theft leads to annual losses estimated at US$4.5 billion, about 1.5 percent of GDP. Ultimately the losers are honest consumers, poor people, and those without connections, who bear the burden of high tariffs, system inefficiencies, and inadequate and unreliable power supply. In India, there is no technique so far to detect the specific location of the fault immediately.

The financial impacts of theft are reduced income from the sale of electricity and the necessity to charge more to consumers. Electricity theft is closely related to governance indicators where higher levels are recorded in countries without effective accountability, political instability, low government effectiveness and high levels of corruption. Merely generating more power is not enough to meet present day requirements. Power consumption and losses have to be closely monitored so that the generated power is utilized in an efficient manner. This illegal electricity usage may indirectly affect the economic status of a country. Also the planning of national energy may be difficult in case of unrecorded energy usage.

Electricity theft can be in the form of fraud (meter tampering), stealing (illegal connections), billing irregularities, and unpaid bills. In our proposed system we are focusing mainly on deriving a technique for reduction in electricity theft by illegal connections or direct hooking. This type of theft is generally recorded in slum areas which account for more than 60% of total power theft.
The main aim of our project is to discourage the power theft. We are achieving this by our HV pulse mechanism which generates an HV pulse from distribution station at regular intervals. To demonstrate this effect we have provided two home models i.e. authorized and unauthorized home. The HV pulse generated will travel to home models through distribution network. At the receiving end of authorized home a voltage suppressing circuit will be provided which will neutralize the HV pulse and convert it into normal voltage. But in the case of unauthorized home this pulse will cause damage to its circuitry. This will not only discourage the consumer but also compel him to install electric meter. Thus our proposed architecture minimizes power theft and thereby the losses.

2. PROPOSED ARCHITECTURE

The system consists of two circuits, first for generating high voltage pulse and the second for reducing the high voltage pulse to normal 230V. The high voltage pulse generating circuit will be installed at distribution substation and the voltage suppressing circuit will be installed inside the electric meter of consumer premises.

3. THEORY OF OPERATION

3.1 SMALL WORKING MODEL DESCRIPTION

Here we have demonstrated the system using a small model in which 12Volt AC is referred as normal supply voltage i.e. 230V AC and 24Volt AC as a high voltage pulse.

3.1.1 HIGH VOLTAGE PULSE GENERATING CIRCUIT

HV pulse generating circuit contains Rectifier, Voltage Divider, Voltage Regulator, Relay and a Key. Here 24V AC supply is converted to DC, and this DC voltage is given to a 12V voltage regulator for continuous 12V DC voltage. The output of voltage regulator is connected to relay coil through a push button, so when the button is in NO condition there is no voltage across the relay coil and relay contacts will be at terminal 2. However, if the Push button is NC, 12V DC voltage will appear across the relay coil and it will get charged and the contacts of relay will switch over to terminal 1.

Now, the 24V AC is connected to relay through a voltage divider, such that 24V AC voltage will appear across terminal 1 and 12V AC voltage will appear across terminal 2. So, when Push button is NO, 12V AC will flow through the lines, and when Push button is NC, High voltage i.e. 24V AC will be flowing through the lines.

3.1.2 VOLTAGE SUPPRESSING CIRCUIT

This circuit contains a Rectifier, Voltage Divider, Comparator, Voltage Regulator, Relay and a Microcontroller. Firstly the bridge rectifier circuit converts the AC voltage to DC voltage. The output of rectifier is Compared with a constant 9V DC which is taken from a voltage regulator. The output of this comparator is given to a microcontroller which sends the signal to the relay connected through a transistor.

When normal 230V AC is flowing through the circuit i.e. in this model when 12V AC is coming from the lines, first, rectifier converts it to DC, then 9V DC will appear across inverting terminal of the comparator and 6V AC will appear across non-inverting terminal. This will make the output of comparator high and microcontroller will make its output high. A 12V AC
voltage is continuously appearing at one terminal of the relay coil and voltage at other terminal depends upon the output of microcontroller.

Figure 2 High Voltage Pulse Generating Circuit
When 12V AC flows in the lines, comparator makes the microcontroller output high and 12V DC appear across the second terminal of the relay coil, making both the terminals of the coil at same potential, hence no current passes through the coil and relay contactor will be on terminal 1.

However, when high voltage pulse will come i.e. 24V AC flows through the lines, this will make the controller output low and 0 potential will appear across the second terminal of the relay coil, which will cause a potential difference at the coil and the coil will get charged and the contacts of the relay will switch over to terminal 2. Hence the voltage will be reduced to 12V AC by a voltage divider circuit and will cause no harm to the appliances in premises of authorized home. But in the case of unauthorized home since power is directly taken from overhead lines by illegal connections with no Voltage Suppressing Circuit provided, this pulse will cause damage to its circuitry.

4. COMPONENTS

4.1 Relay

A relay is an electrically operated switch. Many relays use an electromagnet to operate a switching mechanism mechanically, but other operating principles are also used. Relays are used where it is necessary to control a circuit by a low-power signal (with complete electrical isolation between control and controlled circuits), or where several circuits must be controlled by one signal.

A simple electromagnetic relay consists of a coil of wire wrapped around a soft iron core, an iron yoke which provides a low reluctance path for magnetic flux, a movable iron armature, and one or more sets of contacts (there are two in the relay pictured). The armature is hinged to the yoke and mechanically linked to one or more sets of moving contacts. It is held in place by a spring so that when the relay is de-energized there is an air gap in the magnetic circuit. In this condition, one of the two sets of contacts in the relay pictured is closed, and the other set is open. Other relays may have more or fewer sets of contacts depending on their function. The relay in the picture also has a wire connecting the armature to the yoke. This ensures continuity of the circuit between the moving contacts on the armature, and the circuit track on the printed circuit board (PCB) via the yoke, which is soldered to the PCB. When an electric current is passed through the coil it generates a magnetic field that activates the armature and the consequent movement of the movable contact either makes or breaks (depending upon construction) a connection with a fixed contact. If the set of contacts was closed when the relay was de-energized, then the movement opens the contacts and breaks the connection, and vice versa if the contacts were open. When the current to the coil is switched off, the armature is returned by a force, approximately half as strong as the magnetic force, to its relaxed position. Usually this force is provided by a spring, but gravity is also used commonly in industrial motor starters. Most relays are manufactured to operate quickly. In a low-voltage application this reduces noise; in a high voltage or current application it reduces arcing.

4.2 Bridge Rectifier

A bridge rectifier makes use of four diodes in a bridge arrangement to achieve full-wave rectification. This is a widely used configuration; both with individual diodes wired and with single component bridges where the diode bridge is wired internally. Another type of circuit that produces the same output waveform as the full wave rectifier circuit is that of the Full Wave Bridge Rectifier. This type of single phase rectifier uses four individual rectifying diodes connected in a closed loop “bridge” configuration to produce the desired output. The main advantage of this bridge circuit is that it does not require a
special centre tapped transformer, thereby reducing its size and cost. The single secondary winding is connected to one side of the diode bridge network and the load to the other side as shown below;

4.3 COMPARATOR

In electronics, a comparator is a device that compares two voltages or currents and outputs a digital signal indicating which is larger. It has two analog input terminals $V_+$ and $V_-$ and one binary digital output $V_o$. The output is ideally given by:

$$V_o = \begin{cases} 
1, & \text{if } V_+ > V_- \\
0, & \text{if } V_+ < V_- 
\end{cases}$$

(1)

A comparator consists of specialized high-gain differential amplifier. They are commonly used in devices that measure and digitize analog signals, such as analog-to-digital converters (ADCs), as well as oscillators. An operational amplifier (op-amp) has a well balanced difference input and a very high gain. This parallels the characteristics of comparators and can be substituted in applications with low-performance requirements. In theory, a standard op-amp operating in open-loop configuration (without negative feedback) may be used as a low-performance comparator. When the non-inverting input ($V_+$) is at a higher voltage than the inverting input ($V_-$), the high gain of the op-amp causes the output to saturate at the highest positive voltage it can output. When the non-inverting input ($V_+$) drops below the inverting input ($V_-$), the output saturates at the most negative voltage it can output. The op-amp's output voltage is limited by the supply voltage. An op-amp operating in a linear mode with negative feedback, using a balanced, split-voltage power supply, (powered by $\pm V_S$) has its transfer function typically written as:

$$V_{out} = A_o(V_1 - V_2).$$

(2)

However, this equation may not be applicable to a comparator circuit which is non-linear and operates open-loop (no negative feedback).

4.4 VOLTAGE REGULATOR

A voltage regulator is designed to automatically maintain a constant voltage level. A voltage regulator may be a simple "feed-forward" design or may include negative feedback control loops. It may use an electromechanical mechanism, or electronic components. Depending on the design, it may be used to regulate one or more AC or DC voltages. Electronic voltage regulators are found in devices such as computer power supplies where they stabilize the DC voltages used by the processor and other elements. In automobile alternators and central power station generator plants, voltage regulators control the output of the plant. In an electric power distribution system, voltage regulators may be installed at a substation or along distribution lines so that all customers receive steady voltage independent of how much power is drawn from the line.

4.5 Voltage divider

A voltage divider circuit (also known as a potential divider) is a linear circuit that produces an output voltage ($V_{out}$) that is a fraction of its input voltage ($V_{in}$). Voltage division refers to the partitioning of a voltage among the components of the divider. An example of a voltage divider consists of two resistors in series or a potentiometer. It is commonly used to create a reference voltage, or to get a low voltage signal proportional to the voltage to be measured, and may also be used as a signal attenuator at low frequencies. For direct current and relatively low frequencies, a voltage divider may be sufficiently accurate if made only of resistors; where frequency response over a wide range is required, (such as in an oscilloscope probe), the
voltage divider may have capacitive elements added to allow compensation for load capacitance. In electric power transmission, a capacitive voltage divider is used for measurement of high voltage.

\[ \frac{V_{\text{in}}}{Z_1} - Z_2 - V_{\text{out}} \]

**Figure 6** Voltage Divider Circuit

The two resistor voltage divider is used often to supply a voltage different from that of an available battery or power supply. In application the output voltage depends upon the resistance of the load it drives.

4.6 Microcontroller:
The P89V51RB2/RC2/RD2 is 80C51 microcontrollers with 16/32/64 kB flash and 1024 B of data RAM. A key feature of the P89V51RB2/RC2/RD2 is its X2 mode option. The design engineer can choose to run the application with the conventional 80C51 clock rate (12 clocks per machine cycle) or select the X2 mode (six clocks per machine cycle) to achieve twice the throughput at the same clock frequency. Another way to benefit from this feature is to keep the same performance by reducing the clock frequency by half, thus dramatically reducing the EMI. The flash program memory supports both parallel programming and in serial ISP. Parallel programming mode offers gang-programming at high speed, reducing programming costs and time to market. ISP allows a device to be reprogrammed in the end product under software control. The capability to field/update the application firmware makes a wide range of applications possible. The P89V51RB2/RC2/RD2 is also capable of IAP, allowing the flash program memory to be reconfigured even while the application is running.

4.6.1 Features:
- 80C51 CPU
- 5 V operating voltage from 0 MHz to 40 MHz
- 16/32/64 kB of on-chip flash user code memory with ISP and IAP
- Supports 12-clock (default) or 6-clock mode selection via software or ISP
- SPI and enhanced UART
- PCA with PWM and capture/compare functions
- Four 8-bit I/O ports with three high-current port 1 pin (16 mA each)
- Three 16-bit timers/counters
- Programmable watchdog timer
- Eight interrupt sources with four priority levels
- Second DPTR register
- Low EMI mode (ALE inhibit)
- TTL- and CMOS-compatible logic levels
5. CONCLUSION

The proposed system provides the solution for some of the major problems faced by the existing Indian grid system that is wastage of energy by power theft. The losses and financial strain caused by these unauthorised consumers to government is immeasurable. But this proposed design urges the unauthorised consumer to install electric meter and thereby curbing the losses.

6. REFERENCES


[2] Electricity Crisis in India,” www.ElectricityInIndia.com
