Biometric enabled smart distribution board for load management

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In this article, two energy management problems are addressed. These problems are the high starting current demanded by inductive loads, and the inefficient manual load shedding.

In the determination of the total loads that an installed generator can support, inductive loads unduly usurp most of the installed capacity. This is because inductive loads usually require starting energy of about one-and-half to twice the operating energy demand. This is not so with resistive loads since the starting current is the same as the operating current. Hence, in determining the capacity of a generator to be installed, allowance is often made to accommodate the starting current of the installed inductive loads. Basing the maximum load capacity of an installed generator on the maximum starting current it can support often de-rates the possible operating maximum load carrying capacity of a generator by about 40%.

This fact makes the loading of a generator to be much less than its operating loading capacity because of the differential between the starting current and the operating current of inductive loads. However, by switching inductive loads in a time delayed sequence solves the problem of de-rating the possible maximum load capacity. Hence, an installed generator operates at maximum capacity both during starting and at steady state.

The second problem is the inefficient load shedding by manually turning off some heavy energy demanding circuits at the distribution board during the use of a standby generator. This is informed by the fact that usually the installed generator capacity is less than the demanded load capacity.

A better and more efficient load shedding is automatically effected by a microcontroller based programmable distribution board as implemented in this work [1]. The total amount of loads that are automatically switchable is based on the pre-defined maximum carrying capacity of an installed generator or the alternate power source. The perennial and incessant power outage in Nigeria has made the commodity a security issue. Hence, the authorisation of distribution board programming is done via fingerprint biometric either via Internet, sms, or 'on-the-board fingerprint sensor. This translates to the fact that the turning on of the generator and the changing of the distribution load scheduling can only be done by biometric authentication.

In this work, three sources of electricity generations are considered and fed into the distribution board and managed automatically via biometric authentication. These power sources are the grid-electricity, standby generator, and solar powered inverter. The programming of the system can be done either via the integrated keypad and fingerprint sensor or via wireless. If by wireless two options are available, either communication with the board is by gsm sms message or by Internet email. And the integrated global position system, gps, device provide location information of the smart distribution board. Hence, it is possible to control and manage a network of these smart distribution boards.

System design

Figure 1 shows the block diagram of the developed biometric enabled smart distribution board for load management. The system is made up of five modules, namely, the e-distribution module, the e-metering module, the e-power change over module, the biometric authentication and position location module, and the telecommunication module. Command, control, and communication among these modules are coordinated by the on-board microcontroller unit. An Atmel AT89C52 microcontroller forms the core of the microcontroller unit. The features of an AT89C52 microcontroller chip include 32 input and output port lines, 256 bytes of RAM, 8k of flash program memory, 3 of 16 bit timer/counters, 8 sources of interrupt, and an UART. The AT89C52 chip has interfaced to it, a Dallas DS1307 real time clock, RTC, that provides time and date stamp; a 4 x 4 keypad for electromechanical man-machine interaction; an 128 x 64 colour lcd display screen, a Sandpiper GPS, SIM900A GPRS/GSM module, and 2k x 8 serial 24C16 EEPROM.

The e-Power Change-Over Switch, e-PCOS, module controls and manages up to three different energy sources. The three energy sources are grid-electricity, standby generator, and solar-powered inverter. However, only one of these three energy sources is allowed

Nigeria, with a population of about 160 million people occupying a space of 923 766 sq km, generates electricity at a pittance peak of about 4 000 MW resulting in abysmal energy per capita of 25 W! This has resulted in perennial and incessant power outages in the country making inevitable the use of standby generators of different capacities all over the country as an alternate power source. The situation is made worse by the 'far from optimal utilisation' of this meagre resource. In Nigeria, all consumers of electricity, ranging from domestic, artisans, SMEs, and big industries, have a common problem. The problem is how to meet their energy need during outage. Power outages in the country last longer than the period of availability of grid-electricity. Hence, it is imperative to efficiently manage the available meagre energy.

Abbreviations

DB - Distribution Board
EEPROM - Electrically Erasable Programmable Read-Only Memory
e-PCOS - e-Power Change-over Switch
GIS - Gas-insulated Switchgear
GPRS - General Packet Radio Service
GSM - Global System for Mobile Communications
OEM - Original Equipment Manufacturer
PIC - Primary or pre-designated Interexchange Carrier
RAM - Random Access Memory
RF - Radio Frequency
RTC - Real-time Computing
SMS - Short Message Service
UART - Universal Asynchronous Receiver-Transmitter

to be connected to e-meter module at a time. The three are prioritised with the grid-electricity source having the highest priority, followed by the standby generator, and the solar-powered inverter the least priority. The priority assignment is based on possible energy capacity of the sources. When the grid-electricity is available, automatically the other two sources are de-activated, and during power outage the inverter is deactivated. But the standby generator can be turned on depending on its pre-defined schedule to power loads within its carrying capacity.

During power outage and the period that the standby generator is out of its operating schedule , the inverter is switched to power all the security related appliances and other loads that will still guarantee operation till the available of higher capacity energy source or over-ridding of the generator schedule in order to maintain power to the mission critical loads. The e-Meter records the energy consumption from the three sources separately with time and date stamping of the readings. The data of energy consumption with its time and date stamping taking at the end of each week for one year for each of the three sources is stored in the EEPROM. The recorded energy consumption from each source is communicated to the source central office on schedule for billing, and the returned bill is displayed on the lcd screen for each source.

The e-Distribution Board, e-DB, houses the micro-circuit breakers protecting the loads. The scheduling of these programmable circuit breakers is pre-defined and those that are protecting inductive loads are switched on in a time delayed sequence. However, the total loads so switched is within the power source carrying capacity. The telecommunications module consists of an OEM 900/1800MHz dual band SIM900A GPRS/GSM module, 433 MHz RF module, and the GPS module. The gprs and gsm provide communication via the Internet and sms text message respectively. While the rf module supports wireless communication within maximum of 300 metres of the smart Distribution Board system.

The GPS module provides geographical coordinate data of the location of the smart Distribution Board. The location data is presented in GIS format, that is, the name of the location but if the name is not known then the geographical coordinate of the location is recorded and display in default.

Biometric integration

A BFM220 touch fingerprint module is directly interfaced to the AT89C52 microcontroller for the purpose of biometric authentication. The fingerprints of up to 10 people per smart Distribution Board are stored as templates in memory as those authorised to re-programme the system or delegate such authority via remote control. Another fingerprint module and a 433 MHz RF module are both interfaced to a PIC16F628 microcontroller and packaged as a remote control unit. This fingerprint module is a swipe type for remotely delegating authority to re-programme the smart Distribution Board [2, 3]. The remote control has a maximum range of 300 metres from the smart board. The delegation of authority via remote control is only valid for 20 seconds within which reprogramming of the board should commence or the delegation becomes invalid.

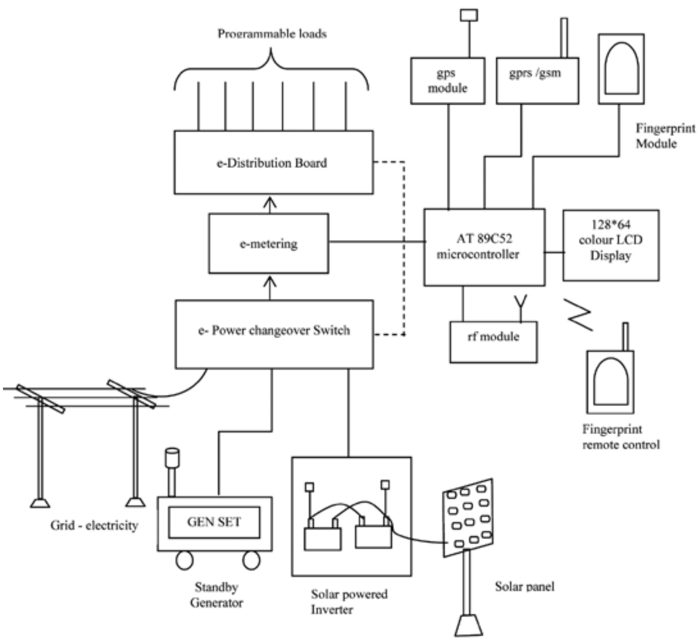

Figure 1: Block diagram of biometric smart distribution board.

Conclusion

A smart distribution board with programmable power shedding and time delayed switching of inductive loads has been developed. The reprogramming of the board is by biometric authentication either directly via the integrated touch fingerprint module or by proxy via a swipe fingerprint in an RF remote control. The developed system was able to carry full load capacity of the nominal rating of the standby generator as a result of time delay switching sequence of inductive loads.

References

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