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Controlled Area Network Implementation for Monitoring and Protecting Power Theft in Distribution Transformer Using Zigbee and SCADA

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ABSTRACT: Protection of power transformer is a very challenging problem in power system relaying. Since it is very important to minimize the over loading and duration of unwanted outages, there is a high demand imposed on power transformer protective relays. Various relaying principles have been proposed and used to protect transformers against different types of faults. Relays involving over current, over voltage and overheating principles protect the transformers against overloads and externally applied conditions.The main objective is to protect the entire distribution system against tapping of power from unauthorized points by using SCADA, Zigbee. SCADA is used for supervisory control and monitoring. Zigbee technique acts as a communication medium between the master and slave devices. To implement CAN protocols for message conveyance between master and slave devices and to develop the hardware using microcontroller based relay system.

I. INTRODUCTION

Power theft in the transmission line is a major problem which causes heavy loss to country. About 20% of power is lost due to theft. There is no efficient technique to inspection by APTC (Anti- Power Theft Control) is the only method practiced till now. This method is not efficient in remote areas. This is because access to most of these areas is very restricted and hence manual inspection may not be possible. Another problem with this type of inspection is that it is not very reliable because some errors tend to get overlooked by human beings. Such discrepancies can be avoided by using microcontroller based relay system where there is no human interface.

This project deals with the monitoring and controlling of power theft in distribution transformers automatically using microcontroller based relay system. The relay is used to trip the circuit whenever theft occurs. The distribution transformer is protected from power theft using zigbee, controlled area network implementation, microcontroller based relay system and SCADA. Zigbee act as a wireless communication between master and slave devices. CAN is a multimaster broadcast serial bus and act as a transceiver for sending and receiving the messages through master and slave devices. The AVR microcontroller is a Modified Harvard Architecture machine with program and data stored in separate physical memory systems that appear in different address spaces, having the ability to read the data items from the program memory using special instructions. SCADA programming is used for supervisory control and monitoring the power theft in that occurs in the distribution transformer.

II. LITERATURE SURVEY

The author of this paper has presented an approach towards detection of Non-technical Losses (NTLs) of Large Power Consumers (LPC). The main motivation was to reduce its NTLs in the LPC distribution sector. Remote meters installed at premises of LPC customers transmitted power consumption data including remote meter events wirelessly to Metering Services. The remote meter reading (RMR) for customers were recorded based on half-hourly intervals. The technique was to correlate the half-hourly RMR consumption data with abnormal meter events. The correlated data provided information regarding consumption characteristics, which exposed abnormal consumption behavior Pilot testing results, indicated the proposed technique was effective with 55% detection hit rate.

P. Kadurek, *Student member, IEEE*, J. Blom, J. F. G. Cobben, W. L. Kling, *Member, IEEE*
The author of this paper has provided the importance and the economic aspects of theft detection. The author proposed a novel methodology for automated detection of illegal utilization of electricity in the future distribution networks equipped with smart metering infrastructure. The necessary data required for smart meters and distribution substations

were defined, in order to unlock this feature in distribution network. The paper also proposed the measures, which should be undertaken by the smart metering standards.

Conclusion

From the literature survey it was observed that power theft was done in transmission and distribution line. Their power theft control methods are not efficient in remote areas because accesses to most of these areas are restricted and hence manual inspection may not be possible. To overcome the above disadvantages the automatic operation for monitoring and controlling power theft in distribution transformer was proposed. To protect the entire distribution system against tapping of power from unauthorized points by using Zigbee and SCADA.

OBJECTIVE

The aim of the project is to protect and monitor the distribution transformer against tapping of power from unauthorized points using power system concepts. The objective of the project is as follows:

- To identify and protect the theft in the distribution system.
- Intuitively using SCADA for supervisory control and monitoring.
- To implement CAN transceiver for message conveyance between master and slave devices.
- To implement zigbee for wireless communication.
  To develop the hardware using microcontroller based relay system.

III. METHODOLOGY

The project includes following chapters:
The overview of the project and the literature survey was given in Chapter 1. Chapter 2 consists of block diagram and its operation. Distribution transformer and its components are discussed in Chapter 3. Chapter 4 deals with microcontroller and its features. CAN protocol and its features are discussed in Chapter 5. Zigbee network model is explained in Chapter 6. SCADA system operation is mentioned in Chapter 7. Chapter 8 deals with software module. Conclusion and Future scope of the project is given in Chapter 9.

MICROCONTROLLER INTRODUCTION

The AVR is a Modified Harvard architecture machine with program and data stored in separate physical memory systems that appear in different address spaces, but having the ability to read data items from program memory using special instructions. Flash, EEPROM, and SRAM are all integrated onto a single chip, removing the need for external memory in most applications. Some devices have a parallel external bus option to allow adding additional data memory-mapped devices. Almost all devices (expect the smallest Tiny AVR chips) have serial interfaces which can be used to connect larger serial EEPROMs or flash chips. Program instructions are stored in non-volatile flash memory. Although they are 8-bit MCUs, each instruction takes one or two 16-bits words. The size of the program memory is usually indicated in the naming of the device itself.

The ATmega8 consist of 16k bytes of In-System Programmable Flash Program memory with Read-While-Write capabilities, 512 bytes EEPROM, 1K byte SRAM, 32 general purpose I/O lines, 32 general purpose working registers , on chip debugging support and programming, three flexible Timer/Counters with compare modes, Internal and External Interrupts, a serial programmable USART, a byte oriented Two-wire serial interface, an 8-channel, 10-bit ADC with optional differential input stage with programmable gain, a programmable Watchdog Timer with Internal Oscillator, an SPI serial port, and six software selectable power saving modes

POTENTIAL TRANSFORMER

Voltage transformers or potential transformers are a type of instrument transformer, used for metering and protection in high-voltage circuits. They are designed to present negligible load to the supply being measured and to have a precise voltage ratio to accurately step down high voltages so that metering and protective relay equipment can be operated at a lower potential. The high voltage side is connected as phase to ground to the supply of the distribution transformer that has to be protected.

Measurement of Voltage

The circuit used for measuring voltage in the secondary of the transformer is shown in the Fig 3.1. It consists of a zener diode D1and a PN junction diode D2. It uses a bridge rectifier BR1 and also variable resistances.

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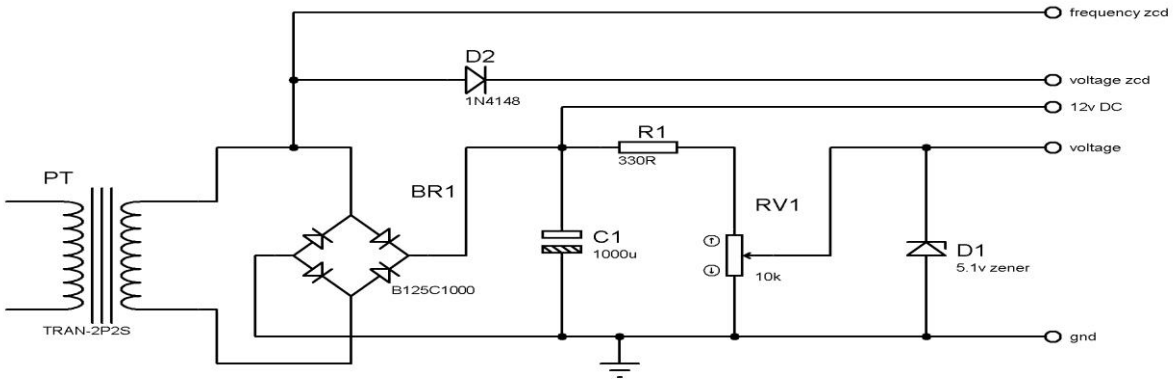

Fig 3.2 Circuit for measurement of voltage

FEATURES OF ATMEGA8

The AVR core combines a rich instruction set with 32 general purpose working registers. All the 32 registers are directly connected to the Arithmetic Logic Unit (ALU), allowing two independent registers to be accessed in one single instruction executed in one clock cycle. The resulting architecture is more code efficient while achieving throughputs up to ten times faster than conventional CISC (Complex Instruction Set Computer) microcontrollers.

The ATmega8 AVR is supported with a full suite of program and system development tools, including C compilers, macro assemblers, program debugger/simulators, In-Circuit Emulators, and evaluation kits. Typical values contained in this data sheet are based on simulations and characterization of other AVR microcontrollers manufactured on the same process technology. Min and Max values will be available after the device is characterized.
Program Flash memory space is divided in two sections

- Boot Program Memory
- Application Program Memory

Both sections have dedicated Lock bits for write and read/write protection. The SPM instruction that writes into the Application Flash memory section must reside in the Boot program section. During interrupts and subroutine calls, the return address Program Counter (PC) is stored on the Stack.

IV. CONTROLLED AREA NETWORK

INTRODUCTION

CAN is a multi-master broadcast serial bus standard for connecting electronic control units (ECUs).Each node is able to send and receive messages, but not simultaneously. A message consists of an ID usually chosen to identify the message-type or sender and up to eight data bytes. It is transmitted serially onto the bus.
The devices that are connected by a CAN network are typically sensors, actuators, and other control devices. These devices are not connected directly to the bus, but through a host processor and a CAN controller.
If the bus is free, any node may begin to transmit. If two or more node begin sending messages at the same time, the message with the more dominant ID (which has more dominant bits, i.e., zeros) will overwrite other nodes less dominant IDs, so that eventually (after this arbitration on the ID) only the dominant message remains and is received by all nodes.

FEATURES OF CAN

The features of CAN are

- Message Transmission
- System flexibility
- Communication speed
- Remote data request
- Error detection, error notification, and error recovery functions
- Error confinement
- Connection.

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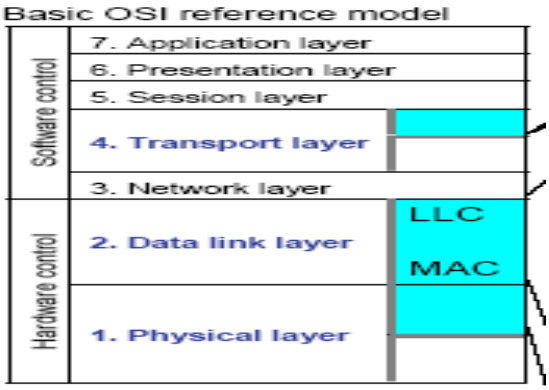
CAN PROTOCOL AND STANDARDS

The important CAN standards are

- ISO 11898
- ISO 11519



The two types of control present in CAN layers are hardware and software control. The hardware control consists of physical and data link layer. The software control is carried out by network, transport, session, presentation and application layer.

CAN controller CAN controller is hardware with a synchronous clock.

ReceivingThe CAN controller stores received bits serially from the bus until an entire message is available, which can then be fetched by the host processor (usually after the CAN controller has triggered an interrupt).

Sending The host processor stores it's transmit messages to a CAN controller which transmits the bit serially onto the bus.

Transceiver Transceiver is possibly integrated into the CAN controller.

V. ZIGBEE

ZIGBEE WIRELESS NETWORK

Zigbee is a low-cost, low-power, wireless mesh networking standard. The mesh networking provides high reliability and more extensive range. Zigbee is designed for wireless controls and sensors. It allows wireless two-way communications between lights and switches, thermostats and furnaces, hotel-room air conditioners and the front desk, and central command posts. It travels across greater distances and handles many sensors that can be linked to perform different tasks. Zigbee basically uses digital radios to allow devices to communicate with one another.

FUNCTION OF ZIGBEE NETWORK MODEL

Zigbee network consists of several types of devices. A network coordinator is a device that sets up the network, is aware of all the nodes within its network, and manages both the information about each node as well as the information that is being transmitted/ received within the network. Every Zigbee network must contain a network coordinator. Full Functions Devices (FFD's) may be found in the network, and these devices support all of the 802.15.4 functions. They can serve as network coordinators, network routers, or as devices that interact with the physical world. The final device found in these networks is the Reduced Function Device (RFD), which usually only serve as devices that interact with the physical world.

Zigbee operates in two main modes:

- Non-Beacon mode
- Beacon mode.

Beacon mode is a fully coordinated mode in that the entire device knows when to coordinate with one another. In this mode, the network coordinator will periodically "wake-up" and send out a beacon to the devices within its network. This beacon subsequently and wakes up each device and if not, the device returns to sleep.In any case, Zigbee obtains its overall low power consumption because the majority of network devices are able to remain inactive over long period of time.

ZIGBEE VS BLUETOOTH

Zigbee and Bluetooth are both operating in the same frequency band of 2.4 GHz and belonging to the same wireless private area network. Bluetooth is geared towards user mobility and eliminating cabling between short-distanced devices, zigbee is more oriented towards remote control and automation. Bluetooth aims at doing away with the cabling between devices that are in close proximity with each other for example between mobiles phone and a laptop or desktop or a printer and a PC. Users with Bluetooth supported handsets are able to effortlessly exchange documents,

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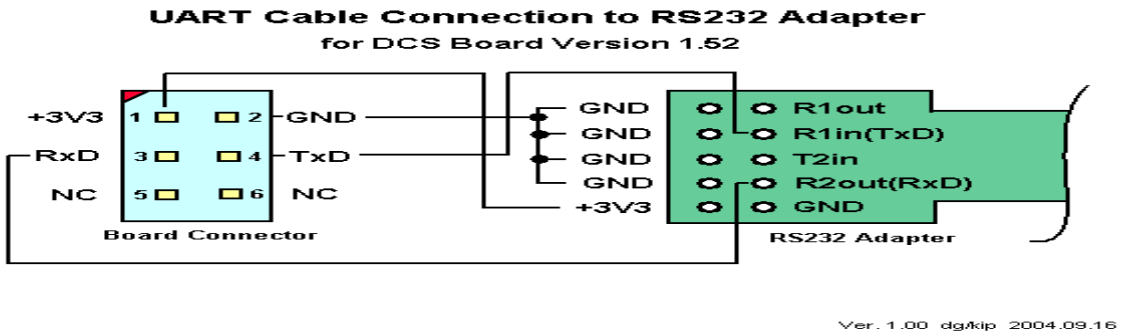
calendar appointments and other files.Zigbee supports protocols for defining a type of sensor network that controls applications used in residential and commercial settings such as air conditioning, heating and lighting. It harmonizes the application software layers specified by the zigbee alliance and the IEEE 802.15 that defines the physical and protocol layers. Zigbee is anticipated to be able to eliminate electrical cabling in houses thereby allowing the freedom of wireless light switches.

RS-232 CABLE

RS-232 (Recommended Standard 232) is a standard for serial binary single-ended data and control signals connecting between a *DTE* (Data Terminal Equipment and DCE -Data Circuit-terminating Equipment.



These are commonly used in computer serial ports. The standard defines the electrical characteristics and timing of signals, the meaning of signals, and the physical size and pin out of connectors.

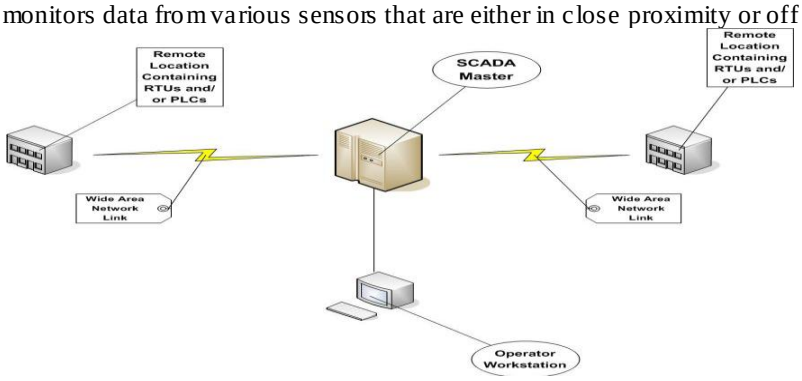
USB is designed to make it easy for device drivers to communicate with hardware. However, there is no direct analog to the terminal programs used to let users communicate directly with serial ports.

SCADA

GENERAL

SCADA stands for supervisory control and data acquisition. It generally refers to industrial control systems: computer systems that monitor and control industrial, infrastructure, or facility-based processes.

SCADA SYSTEMA SCADA system includes signal hardware (input and output), controllers, networks, user interface (HMI), communications equipment and software. All together, the term SCADA refers to the entire central system. The central system usually monitors data from various sensors that are either in close proximity or off site.



Remote Terminal Unit

The brain of a SCADA system is performed by the Remote Terminal Units (sometimes referred to as the RTU). The Remote Terminal Units consists of a programmable logic converter. The RTU are usually set to specific requirements, however, most RTU allow human intervention, for instance, in a factory setting, the RTU might control the setting of a conveyer belt, and the speed can be changed or overridden at any time by human intervention.

SOFTWARE MODULE

INTRODUCTION

Visual Basic (VB) is the third-generationevent-driven programming language and integrated development environment (IDE) from Microsoft for its COM programming model. VB is also considered a relatively easy to learn and use programming language, because of its graphical development features and BASIC heritage. Visual Basic was derived from BASIC and enables the rapid application development (RAD) of graphical user interface (GUI) applications, access to databases using Data Access Objects, Remote Data Objects, or ActiveX Data Objects, and creation of ActiveX controls and objects. Scripting languages such as VBA and VBScript are syntactically similar to Visual Basic, but perform differently.

A programmer can put together an application using the components provided with Visual Basic itself. Programs written in Visual Basic can also use the Windows API, but doing so requires external function declarations. The final release was version 6 in 1998. Microsoft's extended support ended in March 2008 and the designated successor was Visual Basic .NET (now known simply as Visual Basic).

VI. CONCLUSION & FUTURE SCOPE

Power theft is a very challenging problem which has to be controlled. In the proposed project the microcontroller based relay system is designed to trip the circuit when theft occurs. Thus the distribution transformer is protected against tapping of power theft from unauthorized points using the power system equipments. Accuracy in finding errors, no human interface and automatic detection of power theft are the advantages of this project. This can be implemented in Electricity Board and power industries for controlling power theft.
Power theft in residential areas can be identified by placing protective devices in each consumer unit. This project deals with star network of zigbee, whereas Zigbee with a mesh Network can communicate data faster and travel over longer distances. The exact theft point can be identified by implementing relays.

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