Microcontroller Based Transformer Monitoring and Controlling System Using Zigbee

M.Anand, R.Sum, G.Nithya, B.Mahalakshmi

Abstract - The objective of this paper is to monitor the transformer parameters such as voltage, current, frequency and temperature and to control using microcontroller with the help of zigbee transceiver. This paper prescribe about the transformer which is used for powering the machines where the incoming supply voltage and the rated voltage of the distribution system are different. The transformer windings and insulation may get damaged due to severe fault conditions. In many cases the transformer may burst. It explain how to monitor the above parameters and isolate the power supply during emergencies. The output voltage is measured with the help of potential transformer. The output current is measured with the help of current transformer, similarly temperature sensor is used to monitor temperature rise in the transformer. Zigbee is wireless transceiver where we can send and receive the data through this module. The monitored parameters will be sent to the PC through zigbee. The cooling system of the transformer is performed if winding temperature exceeds a certain value. During severe fault conditions, relay is operated and the power supply to the transformer is isolated.

Index Terms – Current, Frequency, Microcontroller, Temperature, Transformer, Voltage and ZigBee.

I. INTRODUCTION

Nowadays industries are shifting towards automation, two components of today’s industrial automations are programmable controllers and robots. In order to aid the tedious work and to serve the mankind, today there is a general tendency to develop an intelligent operation. In my paper each transformer is designed with a microcontroller based kit and also attached with ZigBee transceiver for monitoring and controlling the transformer parameters. The monitored parameters of multiple transformers are transmitted through their respected ZigBee transceiver and are processed in a PC connected with ZigBee transceiver. If the monitored parameters of transformers are equal or less than pre-set value then the transformer will continue its normal functions. But if monitored parameters exceed pre-set value, measures will be taken to ensure normal functioning of the transformer. Under extreme conditions transformer will be isolated.

II. EXISTING SYSTEM

At present PLC based kits are used with wired connection for monitoring. These kits have a fixed input and output ports and also it is costly. It is difficult while connecting many device together as it uses star topology.

III. PROPOSED SYSTEM

In this paper we implemented microcontroller and ZigBEE for data processing and transmission respectively and also using ZIGBEE protocol which enables us to connect more than 200 devices together without any interference. ZIGBEE network is a low power signal transceiver which reduces power consumption and is also a listen-before-talk network. Microcontroller allows us to use multi ported pin

A. Block Diagram

Fig. 1 PC Side Block Diagram

In this side transformer parameters such as voltage, current values are obtained by Zigbee transceiver and displayed in monitor screen, Loading and tripping operation of the transformer are also done from this section

M.Anand PG scholar, Bannari Amman Institute of technology, Erode, India Mobile No: 9443437731.
R.Sum PG scholar, Bannari Amman Institute of Technology, Erode, India, Phone No: 9842428490
G.Nithya PG scholar, Bannari Amman Institute of technology, Erode, India Mobile No: 9865033082.
B.Mahalakshmi PG scholar, Bannari Amman Institute of Technology, Erode, India, Phone No: 8883795455
IV. HARDWARE DESCRIPTION

A. Liquid Crystal Display (LCD)

Liquid crystal cell displays (LCDs) are used in similar applications where LEDs are used. These applications are display of numeric and alphanumeric characters in dot matrix and segmental displays.

LCDs are of two types:
1. Dynamic scattering type
2. Field effect type

1. Dynamic Scattering Type

The liquid crystal material may be one of the several components, which exhibit optical properties of a crystal though they remain in liquid form. Liquid crystal is layered between glass sheets with transparent electrodes deposited on the inside faces. When a potential is applied across the cell, charge carriers flowing through the liquid disrupt the molecular alignment and produce turbulence. When the liquid is not activated, it is transparent. When the liquid is activated the molecular turbulence causes light to be scattered in all directions and the cell appears to be bright. This phenomenon is called dynamic scattering.

2. Field Effect Type

The construction of a field effect liquid crystal display is similar to that of the dynamic scattering type, with the exception that two thin polarizing optical filters are placed at the inside of is also of different type from employed in the dynamic scattering cell.

V. SENSORS

A. Voltage Transformer

Voltage transformers (VTs), also referred to as "Potential Transformers" (PTs), are designed to have an accurately known transformation ratio in both magnitude and phase, over a range of measuring circuit impedances. A voltage transformer is intended to present a negligible load to the supply being measured. The low secondary voltage allows protective relay equipment and measuring instruments to be operated at a lower voltages.
B. Current Transformer

In electrical engineering, a current transformer (CT) is used for measurement of electrical currents. Current transformers, together with potential transformers (PT), are known as instrument transformers.

When current in a circuit is too high to directly apply to measuring instruments, a current transformer produces a reduced current accurately proportional to the current in the circuit, which can be conveniently connected to measuring and recording instruments. A current transformer also isolates the measuring instruments from what may be very high voltage in the monitored circuit. Current transformers are commonly used in metering and protective relays in the electrical power industry.

The LM35 comes in many different packages, including the following.

1. TO-92 plastic transistor-like package,
2. TO-46 metal can transistor-like package
3. 8-lead surface mount SO-8 small outline package
4. TO-202 package. (Shown in the picture above)

![Fig.6 Connection of LM35 with microcontroller](image)

VI. MICROCONTROLLER

A. AVR Microcontroller

The AVR is a modified Harvard architecture 8-bit RISC single chip microcontroller which was developed by Atmel in 1996. The AVR was one of the first microcontroller families to use on-chip flash memory for program storage, as opposed to One-Time Programmable ROM, EPROM, or EEPROM used by other microcontrollers at the time.

B. ATMEGA 8 Microcontroller Features

AVR High-performance and Low-power RISC Architecture

1. Lead-free, RoHS-compliant package.
2. 131 powerful instructions -- most single clock cycle execution.
3. 32 x 8 general-purpose working registers.
4. Fully static operation.
5. Up to 16 MIPS throughput at 16 MHz
6. On-chip 2-cycle Multiplier.
7. Non-volatile Program and Data Memories.
8. 512 Bytes EEPROM (100,000 Write/Erase Cycles)
9. 1 Kbytes internal SRAM

C. LM35- Temperature Sensor

We can measure temperature more accurately by using LM35 than using a thermistor. It has an output voltage that is proportional to the Celsius temperature. The scale factor is 0.01V/°C. The LM35 does not require any external calibration or trimming and maintains an accuracy of +/-0.4°C at room temperature and +/- 0.8°C over a range of 0°C to +100°C. Another important characteristic of the LM35DZ is that it draws only 60 micro amps from its supply and possesses a low self-heating capability. The sensor self-heating causes less than 0.1°C temperature rise in still air.
C. Pin Configuration

<table>
<thead>
<tr>
<th>Pin</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>RST</td>
</tr>
<tr>
<td>2</td>
<td>RXD</td>
</tr>
<tr>
<td>3</td>
<td>TXD</td>
</tr>
<tr>
<td>4</td>
<td>INT1</td>
</tr>
<tr>
<td>5</td>
<td>RXD</td>
</tr>
<tr>
<td>6</td>
<td>TXD</td>
</tr>
<tr>
<td>7</td>
<td>VCC</td>
</tr>
<tr>
<td>8</td>
<td>GND</td>
</tr>
<tr>
<td>9</td>
<td>PB6</td>
</tr>
<tr>
<td>10</td>
<td>PB7</td>
</tr>
<tr>
<td>11</td>
<td>T1</td>
</tr>
<tr>
<td>12</td>
<td>A0/AD0</td>
</tr>
<tr>
<td>13</td>
<td>A1/AD1</td>
</tr>
<tr>
<td>14</td>
<td>PB0</td>
</tr>
<tr>
<td>15</td>
<td>PB1</td>
</tr>
<tr>
<td>16</td>
<td>AD5/ADC5</td>
</tr>
<tr>
<td>17</td>
<td>AD4/ADC4</td>
</tr>
<tr>
<td>18</td>
<td>AD3/ADC3</td>
</tr>
<tr>
<td>19</td>
<td>AD2/ADC2</td>
</tr>
<tr>
<td>20</td>
<td>AD1/ADC1</td>
</tr>
<tr>
<td>21</td>
<td>AREF</td>
</tr>
<tr>
<td>22</td>
<td>AVCC</td>
</tr>
<tr>
<td>23</td>
<td>PC0</td>
</tr>
<tr>
<td>24</td>
<td>PC1</td>
</tr>
<tr>
<td>25</td>
<td>PC2</td>
</tr>
<tr>
<td>26</td>
<td>PC3</td>
</tr>
<tr>
<td>27</td>
<td>PC4</td>
</tr>
<tr>
<td>28</td>
<td>PC5</td>
</tr>
</tbody>
</table>

Fig. 7 ATmega8 Pin Configuration

D. Architectural Overview

In order to maximize performance and parallelism, the AVR uses a Harvard architecture with separate memories and buses for program and data. Instructions in the Program memory are executed with a single level pipelining. While one instruction is being executed, the next instruction is pre-fetched from the Program memory. This concept enables instructions to be executed in every clock cycle. The Program memory is In-System Reprogrammable Flash memory. The fast-access Register File contains 32 x 8-bit general purpose working registers with a single clock cycle access time. This allows single cycle Arithmetic Logic Unit (ALU) operation. In a typical ALU operation, two operands are output from the Register File, the operation is executed, and the result is stored back in the Register File – in one clock cycle.

The ALU supports arithmetic and logic operations between registers or between a constant and a register. Single register operations can also be executed in the ALU. After an arithmetic operation, the Status Register is updated to reflect information about the result of the operation.

The Program flow is provided by conditional and unconditional jump and call instructions, able to directly address the whole address space. Most AVR instructions have a single 16-bit word format. Every Program memory address contains a 16- or 32-bit instruction.

Program Flash memory space is divided into two sections, the Boot program section and the Application program section. 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. The Stack is effectively allocated in the general data SRAM, and consequently the Stack size is only limited by the total SRAM size and the usage of the SRAM. All user programs must initialize the SP in the reset routine (before subroutines or interrupts are executed). The Stack Pointer

The data SRAM can easily be accessed through the five different addressing modes supported in the AVR architecture. The memory spaces in the AVR architecture are all linear and regular memory maps.

The I/O memory space contains 64 addresses for CPU peripheral functions as Control Registers, SPI, and other I/O functions. The I/O Memory can be accessed directly, or as the Data Space locations following those of the Register File, 0x20 - 0x5F.

E. Applications

Microcontrollers are designed for use in sophisticated real time application such as

1. Industrial control
2. Instrumentation and
3. Intelligent computer peripherals

They are used in industrial application to control

1. Motor
2. Robotics
3. Discrete and continuous process control
4. In missile guidance and control
5. In medical instrumentation
6. Oscilloscopes

VII. ZigBee

ZigBee is a specification for a suite of high level communication protocols using small, low-power digital radios based on an IEEE 802 standard for personal area networks. Applications include wireless light switches, electrical meters with in-home-displays, and other consumer and industrial equipment that requires short-range wireless transfer of data at relatively low rates. The technology defined by the ZigBee specification is intended to be simpler and less expensive than
other wPANS, such as Bluetooth. ZigBee is targeted at radio-frequency (RF) applications that require a low data rate, long battery life, and secure networking. ZigBee has a defined rate of 250 kbps best suited for periodic or intermittent data or a single transmission from a sensor or input device. The name refers to the waggle dance of honey bees after their return to the beehive.

A. Technical Overview

ZigBee is a low-cost, low-power, wireless mesh network standard. The low cost allows the technology to be widely deployed in wireless control and monitoring applications. Low power-usage allows longer life with smaller batteries. Mesh networking provides high reliability and more extensive range. ZigBee chip vendors typically sell integrated radios and microcontrollers with between 60 KB and 256 KB flash memory.

ZigBee operates in the industrial, scientific and medical (ISM) radio bands: 868 MHz in Europe, 915 MHz in the USA and Australia, and 2.4 GHz in most jurisdictions worldwide. Data transmission rates vary from 20 to 900 kilobits/second.

The ZigBee network layer natively supports both star and tree typical networks, and generic mesh networks. Every network must have one coordinator device, tasked with its creation, the control of its parameters and basic maintenance. Within star networks, the coordinator must be the central node. Both trees and meshes allows the use of ZigBee routers to extend communication at the network level.

B. Device Types

There are three different types of ZigBee devices

1. Zigbee Coordinator (ZC)

The most capable device, the coordinator forms the root of the network tree and might bridge to other networks. There is exactly one ZigBee coordinator in each network since it is the device that started the network originally. It is able to store information about the network, including acting as the Trust Centre & repository for security keys.

2. Zigbee Router (ZR)

As well as running an application function, a router can act as an intermediate router, passing on data from other devices.

3. ZigBee End Device (ZED)

Contains just enough functionality to talk to the parent node (either the coordinator or a router); it cannot relay data from other devices. This relationship allows the node to be asleep a significant amount of the time thereby giving long battery life. A ZED requires the least amount of memory, and therefore can be less expensive to manufacture than a ZR or

<table>
<thead>
<tr>
<th>Feature</th>
<th>IEEE 802.11b</th>
<th>Bluetooth</th>
<th>ZigBee</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power Profile</td>
<td>Hours</td>
<td>Days</td>
<td>Years</td>
</tr>
<tr>
<td>Complexity</td>
<td>Very Complex</td>
<td>Complex</td>
<td>Simple</td>
</tr>
<tr>
<td>Nodes/Master</td>
<td>32</td>
<td>7</td>
<td>64000</td>
</tr>
<tr>
<td>Latency</td>
<td>up to 3 seconds</td>
<td>up to 10 seconds</td>
<td>30ms</td>
</tr>
<tr>
<td>Enumeration</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Range</td>
<td>100 m</td>
<td>10 m</td>
<td>70 m</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>300 m</td>
</tr>
<tr>
<td>Extendability</td>
<td>Roaming possible</td>
<td>No</td>
<td>YES</td>
</tr>
</tbody>
</table>

VIII CONTROLLING EQUIPMENTS

A. Relay Driver

Relays are electrically controlled switches. In the usual type, a coil pulls in an armature when sufficient coil current flows. Many varieties are available including latching” and “stepping” relays; the later provided the cornerstone for telephone switching stations, and they’re still popular in pinball.
machines. Relays are available for dc or ac excitation, and coil voltages from 5 volts up to 110 volts are common. “mercury-wetted” are “reed” relays are intended for high-speed (~ 1 ms) applications, and giant relays intended to switch thousands of amps are used by power companies. Many previous relay applications are now handled with transistor or fet switches, and devices known, as solid-state relays are now available to handle ac switching applications. The primary uses of relays are in remote switching and high-voltage switching because it is important to keep electronic circuits electrically isolated from the ac power line, relays are useful to switch ac power while keeping the control signals electrically isolated. The electrical relay offers a simple on / off switching action in response to a control signal. When a current flows through the coil of wire a magnetic field is produced. This pulls a movable arm, the armature, that forces the contacts to open are close; usually there are two sets of contacts with one being opened and the other closed by the action. This perhaps an electric heater in a temperature controls system.

C. Transformer Oil Cooling

Enerfin’s transformer oil coolers are custom designed for each application, in keeping with your needs. We have three types of coolers to suit most applications.

The OFAF (Oil Forced Air Forced) model is designed and manufactured with our extruded aluminium fin tubes. The coolers are delivered with motors and fans assembled and connected.

The OFWF (Oil Forced Water Forced) model is of the shell and tube type. This model can be manufactured using two concentric tubes with a double tube plate, equipped with a leak detector (optional).

The ONWF (Oil Natural Water Forced) model has a natural convection design. This model is manufactured using our extruded aluminium fin tubes inside a rectangular shell to optimize thermal performance. This model can also be manufactured using two tubes with a double tube plate, equipped with a leak detector (optional).

D. Transformer Fan Cooling

Heat from core losses and copper losses must be dissipated to the environment. In dry type transformers, cooling is accomplished simply by circulating air around and through the coil and core assembly, either by natural convection or by forced air flow from fans. This cooling method is usually limited to low-voltage indoor transformers (5 kV and below) having a three-phase rating below 1500 KVA. At higher voltages, oil is required to insulate the windings, which prevents the use of air for cooling the core and coils directly. At higher KVA ratings, the losses are just too high for direct air cooling to be effective.

| Temperature > 55 °C | LED 1 Glows | Fan Operates |
| Temperature > 65 °C | LED 2 Glows | Oil Pump Operates |
| Temperature > 75 °C | LED 3 Glows | Alarm Operates |

Fig.9 Hardware Results

VIII. SOFTWARE DESCRIPTION

A. VISUAL BASIC (FRONT END)

Visual Basic (VB) is the third-generation event-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

B. AVR Editor

1. Design Aspect Of Software Development

The general aspect of the software design consists of the following procedure

1. Problem definition and software specification
2. Software structure design
3. Program coding
4. Testing and debugging
2. Problem Definition and Software Specification

In this procedure the problem should be clearly studied and it should be defined to the software clearly as possible. This involves a good understanding of the problem. Unclear definition leads to lot of expenses at a later stage. After defining the problem clearly, it is defined as software specifications, defining goals of the software.

3. Software Structure Design

In this important procedure where the program is broken down into a number of well-designed sub problems to whatever level required. This method of software development, is known as the “top down” methods, is extremely useful in systematic software design.

4. Program Coding

Here the structure of program designed in the previous section is loaded in AVR studio software. The IDE supported for the AVR studio the program can be run on the hardware after assembled and compiled. Once the language for the program is prepared it is immediately translated into machine level language program and theses machine codes can be run on the hardware.

5. Testing And Debugging

The design is tested ‘bottom up’ that is the smallest program modules are tested and then integrated into large until program works properly is incorporated to large in this stage. In the software development of the proposed system, the above mentioned procedure is followed.

FLOW CHART

- **Fig.10 Visual Basic Screen**

6. Algorithm

1. Get the input values such as oil temperature, winding temperature.
2. If the winding temperature exceeds 55°C LED 1 glows indicating that the fan operates.
3. If the winding temperature exceeds 65° C LED 1, LED2 glows indicating that the fan and oil pump operates respectively.
4. If the oil temperature and winding temperature exceeds 75°C LED1, LED2, LED 3 glows indicating that the fan, oil pump, alarm operates respectively.

- **Fig.11 Transformer cooling function operation**
IX. RESULT AND DISCUSSION

**Fig.12 Fan indicator**

When oil level reaches 55°C cooling fan starts, this is indicated by the LED light

**Fig.13 Oil pump indicator**

When the oil level exceeds 65 °C transformer oil pump is started along with cooling fan, so two LEDs indicate their operations respectively.

**Fig.14 Alarm Indicator**

When oil temperature reaches above 75 deg C, alarm is been operated. The CONNECTED command in display indicates that the ZigBee is in connected state.

**Fig.15 Transformer monitoring screen**
X. CONCLUSION

In this paper we have presented a design of a system based on AT mega 8 microcontroller that is used to monitor and control the voltage, current and temperature of a distribution transformer. The proposed system has been designed to monitor the transformer’s essential parameters which continuously monitor the parameters throughout its operation. If the microcontroller recognizes any increase in the level of voltage, current or temperature values the unit has been made shutdown in order to prevent it from further damages. The system not only controls the distribution transformer in the substation by shutting it down, but also displays the values throughout the process for user’s reference. This claims that the proposed design of the system makes the distribution transformer more robust, against some key power quality issues which makes the voltage, current or temperature to peak. Hence the distribution is made more secure, reliable and efficient by means of the proposed system.

REFERENCES


M.Anand completed Bachelor of Engineering (B.E) in year of 2013 currently pursuing Master of Engineering (M.E) in Power Electronics and drives. I completed my research in wireless communication for transformer monitoring .Now I started a research on Multilevel inverter for PV application using Space vector modulation technique. I have presented the paper on Piezo electric energy harvester and secured first place

R.Sum completed bachelor of engineering (B.E) in year of 2013. Currently pursuing Master of Engineering (M.E) in Power Electronics and drives. I completed my research in Multilevel inverter for motor application. Now I started research analysis of shunt active filter based on pq theory.

G.Nithya completed bachelor of engineering (B.E) in year of 2013 .Currently pursuing Master of Engineering (M.E) in Power Electronics and drives. I completed my research in DC to DC converters. Now I started research in analysis of electronic ballast for fluorescent lamp

B.Mahalakshmi completed bachelor of engineering (B.E) in year of 2013. Currently pursuing Master of engineering (M.E) in Power Electronics and drives. I completed my research in cascaded H bridge multilevel inverter DC link inverter fed induction motor. Now I started my research on design of SI –NPC for grid connected PV system.