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Modified transformer monitored by real time system based on GSM network in nuclear power plant

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ABSTRACT

A processor for PIC microcontroller in field programmable gate array (FPGA) is designed; its application is implemented and discussed in this paper. The application is monitoring of transformer parameters in real time using global system for mobile (GSM) module. Energy between two or more circuits is transferred through electromagnetic induction in transformer. For high voltage electric power transmission, Transformers are important and economical in practical. In high power transformer, it is essential to monitor various parameters to ensure safe and reliable operation. An embedded system has been designed and monitored by real time for the transformer, that carries out acquisition of voltage, current, and temperature of transformer and process the acquired data. This system enables the fault and status reporting via GSM module, allowing the most cost effective communication infrastructure for monitoring and acquiring data of transformer. In the prototype hardware kit, a small prototype transformer is used. The input and output current, voltage and temperature of core are monitored and transmitted through GSM.

KEY WORDS: Power plant, GSM based network

1. INTRODUCTION

Transformers in real time has already been widely known and implemented with various techniques (Pylvanainen, 2007). The monitoring function is mostly done to reveal significant parameters that reflect conditions of transformers, such as voltages, currents, and temperatures (Ali, 2004). The existence of the GSM provides further flexible monitoring in many areas, including power transformers. Hence, some approaches are developed to perform monitoring throughout the world by using a GSM connected network. This is applied to transformer in relation to this research work.

In this paper, a prototype model is developed for real time monitoring the transformer using FPGA in which PIC microcontroller have been designed using Verilog programming. The FPGA will act as PIC microcontroller (Ab-Rahman, 2009). In that FPGA real time monitoring of transformer using GSM module is implemented as a modified one.

System Architecture: It contains design of micro controller and implementation.

Pic Micro Controller Design: In FPGA, the PIC microcontroller is implemented. The advantage of implementing PIC in FPGA is i) a matrix of reconfigurable gate array logic circuitry that, when configured, is connected in a way that creates a hardware and software implementation (Chatterjee, 2010), application. These tools are enabling embedded control system designers to create and adapt FPGA-based applications more quickly (Prabahar, 2011).

FPGAs are programmable circuits composed of a set of logic cells known as Configurable Logic Block (CLB) (Poza, 2006). In / Out Blocks (IOB) are responsible for the FPGA interfaces with the external environment and Switch Box (SB) is the responsible element for the interconnection between the CLB routing through channels (Dharmawan, 2010). To build a PIC microcontroller with FPGA dynamic reconfiguration of instruction is required. This may change during the running time and a fixed instruction set implemented by fixed hardware development time.

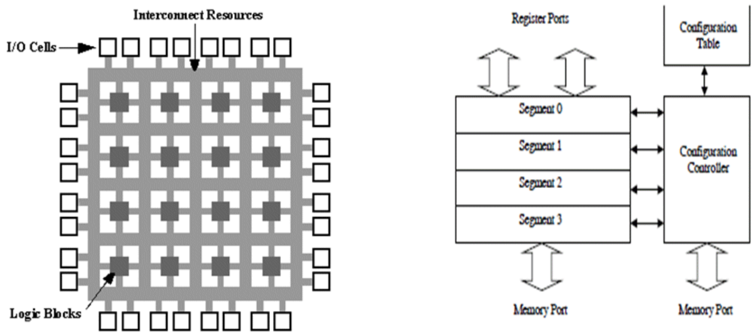

Figure.1. Component elements of the FPGA and its RFU Structure.

The statement creation and combination are made through a Reconfigurable Functional Unit (RFU) processor built into the microcontroller. This unit allows us to send customized instructions to the processor and then use them as instructions fixed. This form of coupling gives limited space on the processor. The RFU could also be attached as an external drive attached via the main bus. If segments are used, the configuration of an instruction is done in a hierarchical manner. The instruction is assigned on segment sets, and inside those segments, the processing elements are configured (figure 1).

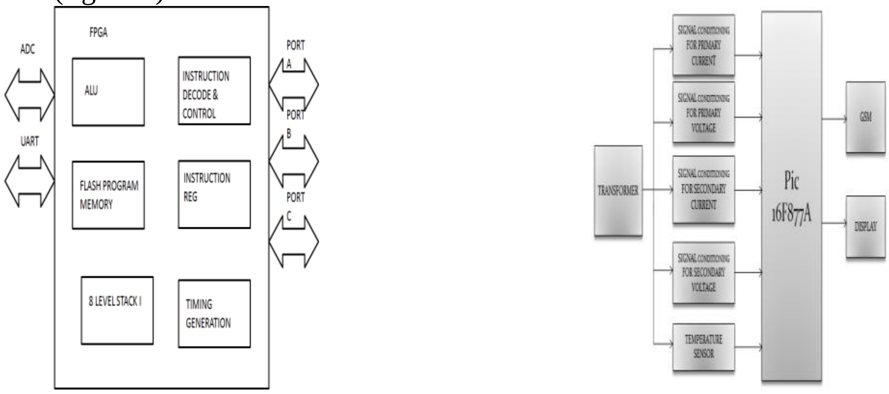

Figure.2.PIC Controller in FPGA and Block diagram real time monitoring of transformer

The architecture of PIC microcontroller is given (figure 3) which is being implemented in FPGA using verilog programming (Donglai, 2005).

Implementing Application: The real time monitoring system contains the following blocks. The blocks are transformer, signal conditioning block, processing block and GSM module. The conditioning and processing blocks are designed up of some modules to acquire and control the parameters of the transformer (Abniki, 2010) and developed using a modular approach (Ahmed, 2004). The power supply provides voltages of 415 V on the transformer primary terminals while the load draws currents of up to a maximum rating of 24 A on the sides of the transformer secondary. Figure 3 shows the block diagram of implementing PIC microcontroller in FPGA.

Device	Program FLASH	Data Memory	Data EEPROM
PIC16F874	4K	192 Bytes	128 Bytes
PIC16F877	8K	368 Bytes	256 Bytes

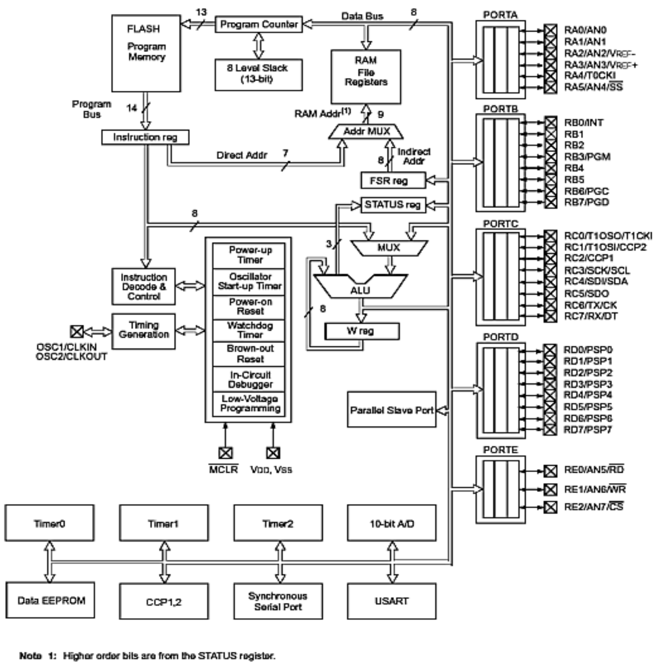

Figure.3.Architecture of PIC16f877a

The simulation of PIC microcontroller (Figure 4) being implemented in FPGA (Chatterjee, 2010). Voltages and currents on each of the sides of the transformer are got by using some D3600 voltage transformers and LTS 25-NP current transducers; These current transducers have an accuracy of 0.7% with a 50-Ω internal measuring resistance, a 25-A primary current (nominal RMS), and a 25˚C ambient temperature. The frequency bandwidth varies from dc to 100 kHz (for 0–0.5 dB). Transformer temperatures as well as of the switching devices are got by using digital temperature sensors LM35.

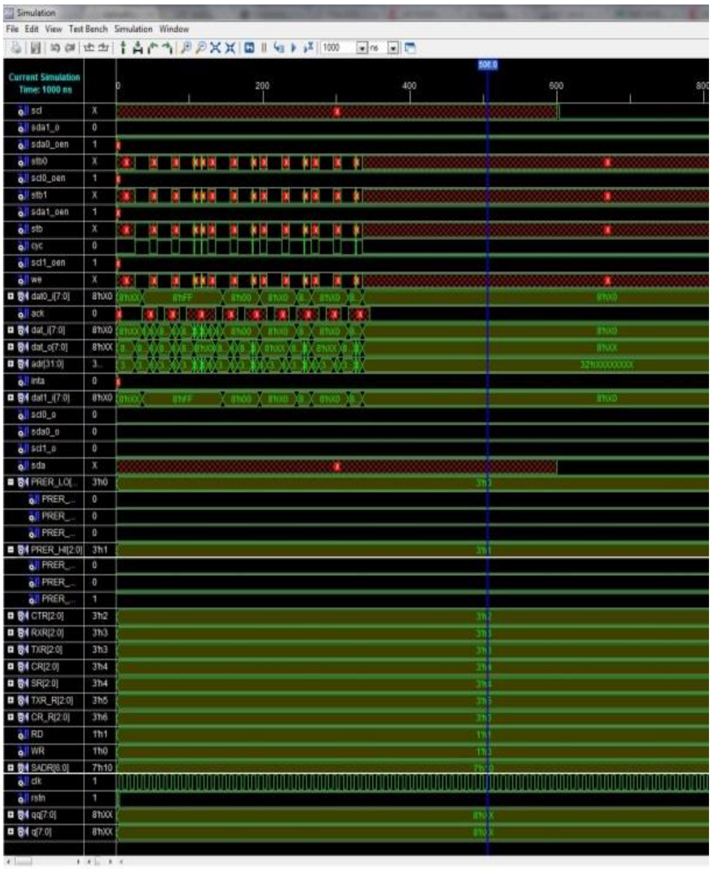

Figure.4.Simulation results of PIC microcontroller implemented in FPGA.

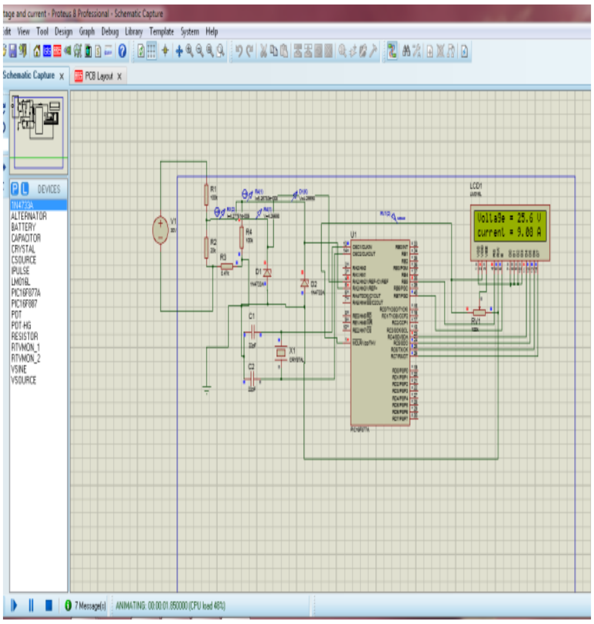

Figure.5.Output of voltage and current measurement of proposed transformer at v=25.6V, I=9.08A

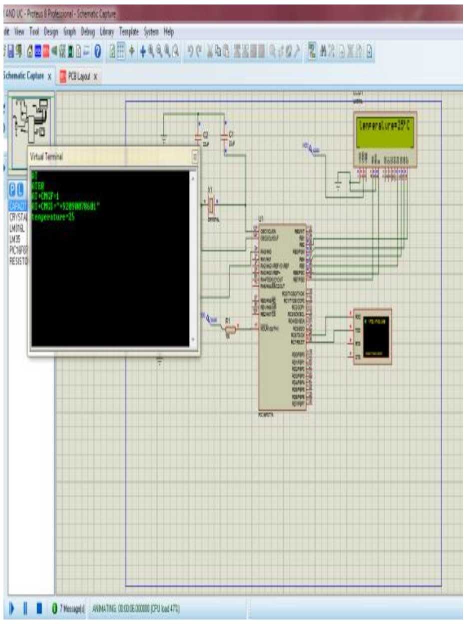

Figure.6.Output of temperature measurement at 25°C

The winding configurations on all phases are chosen by the acquisition modules based on the variations of the load and set by turning on or off the switching devices through the use of some drivers. In the embedded system, a PIC controller being used to acquire the data of V, I and T which is also interfaced with GSM module to send the data to user when requested about the transformers real time monitoring. The computer in this system is used for experimentation purposes and eliminated when the most compact remote real time monitoring system is needed. In addition, this computer is used for debugging developed programs and for writing the codes of firmware to the microcontrollers. The block diagram of transformer application is shown for the real time monitoring (Vijendra Babu, 2008, 2010, 2015).

Measurements: Measurements can be divided into two groups in any systems. The first group is intended to get parameters from signals of voltages and currents. The sensors (VT, VTs, CT, and CTs) provide low-voltage output signals (*V*VTp, *V*VTs, *V*CTp, and *V*CTs) which are fed to signal conditioning circuits. These circuits outputs contain dc offsets. They change in the range of 0 to 5 V. These outputs are then sampled by a only one 10-bit analog-to-digital converter (ADC) in the PIC16F877A. Those signals need to be acquired through a multiplexing mechanism. In other words, the samplings of these signals cannot be performed at the same time. The next sampling can only be initiated after the analog-to-digital conversion of the previous sample has finished. This equation 1 is attained by considering that the implemented line frequency of 50 Hz and by assuming that the voltage signal is sinusoidal

$V\_n = (Vn + Vn+1)/2 \cos (4.22^{\circ})$ (1)

Based on the line frequency of 50 Hz, a sampling frequency of 8.533 kHz was chosen for the four sequenced channels. For the same time intervals between the samples, the sampling frequency of each channel will be 8.533/4 = 2.133 kHz. This will lead to acquiring approximately 42.66 samples of each channel per waveform period or a total of 512 samples of the four channels within three waveform periods. The ADC digital data are temporarily saved as 16-bit numbers in an array and processed through some subroutines to get output parameters, i.e., RMS voltages/currents, powers, power factors, efficiency, and harmonic contents. The second group involves measurements of temperatures. Sensors are used to measure switching devices temperatures on each phase. Further, sensors may be attached on the surfaces of the core and windings to measure temperatures of the transformers. These sensors give resolution outputs that are read directly by the digital input pin of PIC16F877A. The output in snapshot of transformer voltage and current measure in proteus software is shown in figure 5.

Remote Monitoring Modules: In these system, GSM is used and 240 × 230 graphic liquid crystal display (LCD) modules are the main parts which support the remote monitoring. A GSM module and user interface forms an interactive module which is then functioned as a client as well as a server. Connections to a network are supported by the use of an onboard GSM module. This module combined with the PIC16F877A enables a reliable application for real time monitoring of the transformer to be easily developed. An external 32-kB static random access memory is provided for temporary data storage. The board is connected to a computer serially through an RS232 interface. To reprogram the PIC16F877A, an in-system programming (ISP) programmer for PIC microcontrollers is used and connected to the ten-pin ISP connector. The same hardware elements and connections were used for client and server GSM modules in the embedded system. More importantly, the display will show significant parameters of the transformer as well as waveforms of voltages and currents in stimulation using proteus software. The snapshot for measurement of temperature, voltage and current being measured and displayed in the LCD of the circuit (Fig.5,6). The GSM module instead which is being displayed in virtual terminal in proteus which is being programmed instead of an hardware circuit for real time monitoring of transformer.

Applications: The whole monitoring systems include applications for microcontrollers in the embedded system using microcontrollers. Applications for computers were used for testing purposes of using voltage and current in first zone, using temperature in second zone, and using GSM in third zone.

That is the acquisitions of voltage, current, temperature are being collected by using the embedded system designed in FPGA. Then the acquired data is displayed in the LCD and GSM module i.e. mobile of an operator of the transformer this also being implemented in application can be verified at the third layer of operation in the computer by using the simulation using proteus. Furthermore the computer is also used in programming PIC controller using MIKROC for real time monitoring of transformer is being designed and being studied about designing of PIC controller in FPGA using programming and simulation (Chatterjee, 2010).

2. CONCLUSION

The modified transformer system uses real time monitoring is proposed and developed. It is very useful in understanding conditions of the transformer. It also enables operators to monitor the parameters away from the Transformer. The result of the experimentations showed that the system could handle real time monitoring control tasks for the transformer. These system may be useful either embedded system and GSM or computers or both of them. This make them the most compact system. This proposed system is easy to operate, to maintain, and to reproduce massively with low cost for applications in the fields like nuclear power plant (Salai Thillai Thilagam, 2015).

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