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Digital Monitoring Cum Control of a Power Transformer with Efficiency Measuring Meter



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ABSTRACT

With the advancement of technology there has been a rapid growth in almost each and every field, particularly in the field of instrumentation, design of a crucial instrument that contains fuzzy algorithms is possible with microcontroller chips. The system designed here falls under the subject of electrical instrumentation, in this field we have different instruments for measuring the electrical parameters such as voltage, current, frequency, etc. But there is no such instrument that can measure the efficiency of a power transformer directly. Hence a system is designed with micro controller that measures the efficiency of a power transformer and displays the same in percentage. In addition to the display of percentage, here the system is designed to measure and display the other parameters like load current, line voltage, and T/F body temperature. Control circuit is also implemented such that the transformer is protected from burning due to various reasons and fault condition will be displayed through LCD. As the system is intended to display lot of information simultaneously, two display sections are designed, with the help of one LCD parameter values and failure causes are displayed. Similarly with the help of another display, transformer efficiency with input and output powers are displayed.

In general, to calculate the efficiency of any transformer, first some load should be applied in the secondary of the transformer. Then voltages in the primary and secondary of the transformer should be measured and also the currents in the input and output of the transformer. Thus we get the power (Watts) of primary and secondary windings of the transformer (W = V x I) and finally dividing output power by input power & multiplying with 100 will be giving the efficiency of the transformer in percentage (%). This process is a bit lengthy and takes much time to calculate the efficiency as the voltages and currents have to be measured individually both in the primary and secondary of the transformer. So here a system is designed, which does all the above calculations internally through an embedded system and will be displayed through the LCD. This proto-type module is constructed with 1:1 ratio single phase power transformer that generates 220V at secondary and is able to deliver a maximum output power of 132 Watts. With the help of two CT's and two PT's, currents and voltages of both windings of the transformer are measured & converted into digital by the ADC. Based on this information, the controller program is prepared to calculate the efficiency internally and displays the same.

Keywords: ***89S51, A/D Converter chip, LM324, LM 555, Voltage Regulator.***

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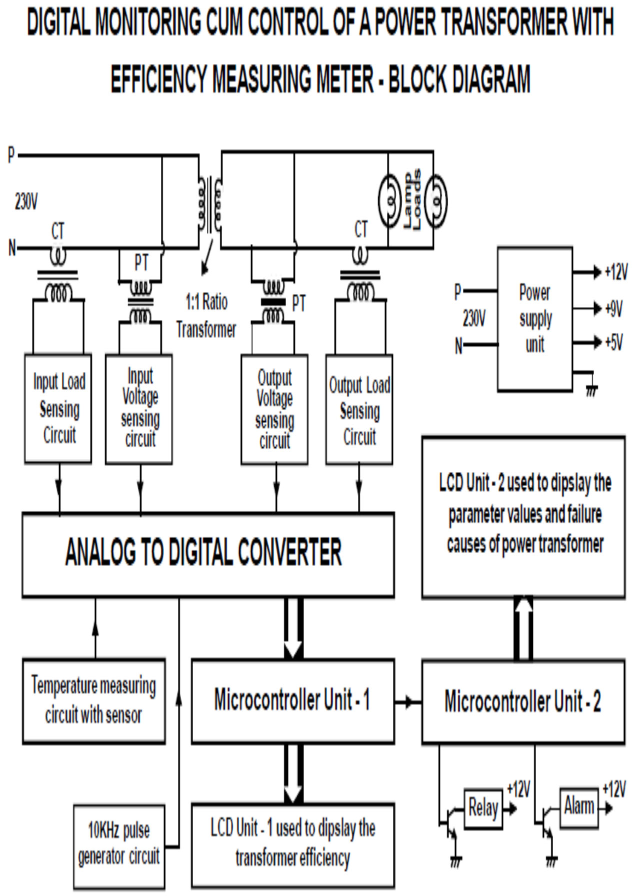
Block diagram



INTRODUCTION

The primary purpose of this project work is to measure & display the transformer efficiency continuously. The system is designed such that the measuring circuits are built with the transformer, there by additional instruments are not required for measuring the efficiency. This kind of arrangement is essential for few transformers where load conditions are differed frequently. Because of the irregular loads efficiency may fall down, hence continuous monitoring is essential & according to the load conditions, in time action is necessary, otherwise life of the transformer may decrease. Here in addition to the display of efficiency, transformer is protected burning due to the over loads, over temperature and voltage fluctuations. To achieve this, control action must be implanted such that whenever any parameter value exceeds to its preset value, immediately the controller breaks supply to the transformer at primary side and hence the transformer is protected.

The parameters selected here are very important, because most of the transformers are burning because of these three reasons only. One common reason is over load, any transformer in the world can not supply more power then its rating and often transformers are over loaded. There fore load measuring is an important activity and it is primary requirement for any power transformer.

The second important activity is thermal protection; here transformer body temperature must be measured and displayed continuously. Similarly the input supply to the transformer also must be measured and displayed for smooth operation. Measuring different parameters through corresponding sensors, converting these values in to digital, displaying the parameter values in digital and controlling the transformer accordingly are the main activities by which life of the transformer can be increased. Here all these activities are processed and they are implemented over a small power transformer which can deliver a maximum power of 150 watts approximately.

To prove the concept practically, a prototype module is constructed with 1:1 ratio single phase transformer, this transformer is designed to deliver a maximum current of 0.6 Amps current at 230V approximately. Hence applied load to the secondary should not exceed more then 138 watts as continuous load. Different ratings of lamp loads are used to test the efficiency, in addition over load protection circuit is also implanted such that the supply will be disconnected when load current exceeds to its preset value. The transformer used here consists of an iron core made of laminated sheets, well insulated from one another. The primary & secondary coils are wound on the same core, but are well insulated with each other. In addition both the coils are insulated from the core.

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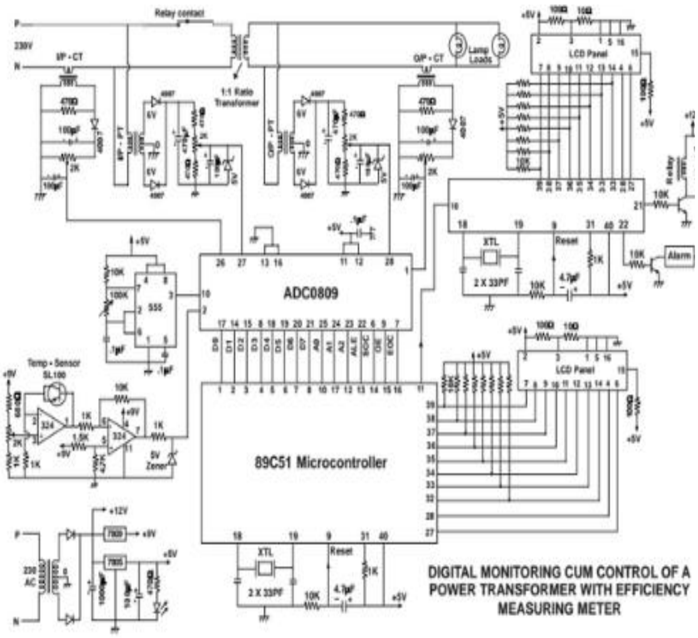

FUNCTIONAL DESCRIPTION FOR MEASURING EFFICIENCY

The procedure of efficiency measurement is set in motion with power transformer; this is the basic electrical device need to measure the efficiency of it. For this purpose single phase transformer is used, in general transformers categorized in to two types, step-up or step-down, but here this transformer is designed to produce equal voltage at secondary that is applied at primary. This type of transformer is called as one-to-one, i.e. the ratio is 1:1. The secondary voltage will be the same as primary at no-load condition, as described in the introduction this transformer is rated for 138Watts, there by it can drive a maximum load of 150Watts comfortably. To create difference in efficiency, transformer is over loaded by connecting additional load of another 100Watts lamp. Thereby the demo module is having three lamps, & these lamps are powered through switches. When one lamp is energized, the voltage may fall down by 2-3 % approximately, if another load is activated the voltage may fall down by another 2%, this is treated as normal condition, but when third lamp is energized, the voltage may fall down drastically because the transformer is overloaded. There by the load conditions are differed manually to create the difference in efficiency.

FUNCTIONAL DESCRIPTION OF TRANSFORMER MONITORING CUM CONTROL SYSTEM

These days, we find lot of transformers are burning because of over loads, voltage variations and over heating. The body temperature of a transformer rises due to overloads and continuous long run, because of these reasons the transformer may shutdown automatically. Particularly, in the rural areas we find shutdown of transformers due to agricultural pump-sets, and we know it takes lot of time to repair and it involves lot of cost. Hence, the transformer failure prevention is become essential for smooth transmission and distribution. For simulation of the faults in the demonstration unit, single phase transformer of 1: 1 ration is used and above parameters are carried over this transformer and the corrective action is initiated when the parameters crosses its limits. The transformer used here can deliver a maximum power of 150Watts.

LOAD MONITORING CIRCUIT

For monitoring the secondary load of power transformer, current transformer is used. The current transformer is used with its primary winding connected in series with load carrying the current to be measured and, therefore, the primary current is dependant upon the load connected to the system and is not determined by the load (burden) connected on the secondary winding of the current transformer. The primary winding consists of very few turns and, therefore, there is no appreciable voltage drop across it. The secondary winding of the current transformer has larger number of turns, the exact number being determined by the turn’s ratio. Depending up on the current flowing through primary, proportionate voltage will be developed across the secondary.

The output of the CT is rectified, filtered and it is fed to the microcontroller. As the data obtained from the CT will be in the form of analog and where as the microcontroller will not accept analog data, it has to be converted in to digital. In general most of the microcontroller chips need external ADC, here also

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using eight channels ADC externally all the analog channels outputs are converted in to digital. Here 8-channels ADC is essential because it has to except multiple channels data for the conversion.

TEMPERATURE SENSING CIRCUIT

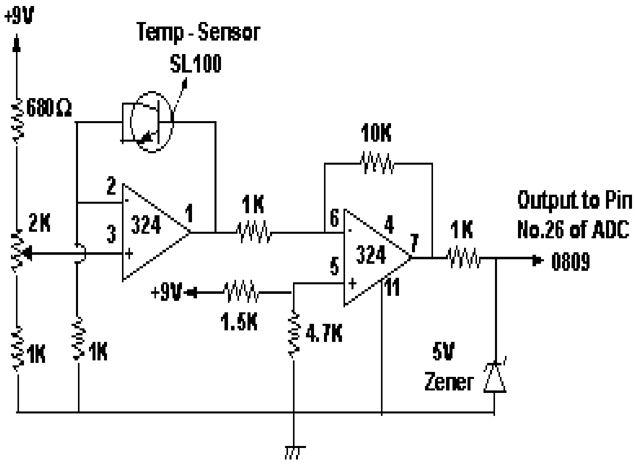
The temperature sensing circuit contains two op-amps & they are used to amplify the signal strength. The temperature sensor wired with one op-amp is configured as differential amplifier, there by the difference between two inputs created by the sensor according to the temperature is amplified. The output of this differential amplifier is further amplified with second op-amp. The second op-amp is configured as voltage amplifier. In the first stage an ‘NPN’ General purpose transistor (SL100) is used as a temperature sensor and this transistor is having ‘TIN’ metal body so that it can absorb the heat properly. This transistor is connected in feed back loop (input to output). This first stage is designed in such a way so that, as the transistor body temperature rises, according to the temperature, the base- emitter or base-collector junction resistance decreases. This variation in the sensor in the form of resistance is converted in to the proportionate dc level & difference created due to hike in the temperature is amplified at input side.

The circuit design consisting of a temperature transducer converts the temperature in to proportionate voltage at its output. For this, semi conducting device is used as a sensor, this sensor junction characteristics are depends upon the temperature. For a transistor, the maximum average power that it can dissipate is limited by the temperature that collector - base junction can with stand. Therefore, maximum allowable junction temperature should not be exceeded. The average power dissipated in collector circuit is given by the average of the product of the collector current and collector base voltage. At any other temperature the de-rating curves are supplied by the manufacturer to calculate maximum allowable power (Pj).

$$(Pj) = \frac{Tj - Tc}{Qj}$$

Where TC is case temperature, Tj is junction temperature and Qj is the thermal resistance in this project work LM 324 is used. LM 324 is a quad op-amp IC i.e., this device is having four op-amps internally, out of four op-amps only two op-amps are used for measuring the temperature accurately. The circuit diagram shown in the next page is designed to operate at 9V DC, for this purpose constant voltage source is derived from the power supply unit. Here 7805 three pin voltage regulator is used.

The following is the diagram of temperature measuring circuit



VOLTAGE MONITORING CIRCUIT

The voltage sensing circuit is designed with potential transformer (PT). Here two PT’s are used for measuring the power transformer primary & secondary windings voltages independently. In general these transformers are extremely accurate-ratio step-down transformers and are used to measure high voltages at primary side. The transformation ratio will be accurate, gives the proportionate true voltage on secondary side.

The PT used in this project work can generate 6V at secondary when 220V applied at primary. This voltage

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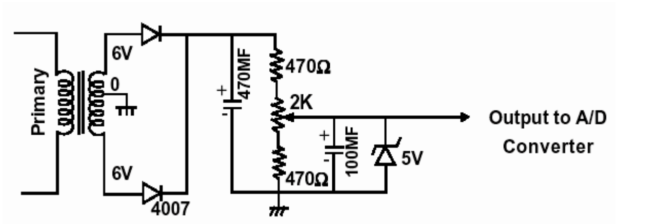
varies proportionately according to the line voltage; here the line voltage is nothing but main transformer primary or secondary. The primary voltage is constant according to the line supply; where as the secondary voltage of main transformer varies according to the load applied to it. The PT secondary is rectified & filtered for converting the ac to pure dc, this voltage is adjusted to the required level & it is fed to ADC for converting the analog information in to digital. Based on this digital data the controller can read both winding voltages & displayed independently through LCD.

The following is the circuit diagram of the High voltage Sensing



PULSE GENERATOR

The required clock pulses for the ADC are generated through 555 Timer IC, this chip is configured as Astable multi-vibrator (Self Oscillator). In this mode of operation the required frequency can be adjusted using two external components i.e., resistor and capacitor. Keeping capacitor value constant where as by varying the value of resistor the frequency can be adjusted from 1Hz to 50 KHz. Here the required frequency is 10 KHz approximately. The ADC used in this project work belongs to signatics, & the manufacturer of this device recommends operating the device by feeding 10 KHz frequency for fast response. The conversion time depends up on the clock signal, obviously it should be less then 20 milliseconds. The required frequency can be adjusted using variable resistor of 100K (RB).

Criteria for choosing 89c51Microcontroller

1. The first and foremost criterion in choosing a microcontroller is that it must meet the task at hand efficiently and cost effectively. In our project we have chosen an 8-bit microcontroller, which can handle the computing needs of the task most effectively.
1. The highest speed this microcontroller can support is 12MHZ
2. To fulfill our requirements in terms of space, assembling, we have chosen the 40-pin DIP.
3. To support the memory requirement we have chosen it as it includes 4K ROM and 128byte RAM.
4. As there are 32 I/O pins and 2 timers, it supports our input-output requirement greatly.
6. We have used the battery power product like an RTC the power consumption is critical for it.
7. In choosing this controller we have considered the availability of an assembler, debugger, simulator etc.
8. The ready availability in needed quantities both now and in the future. Currently, of the leading 8-bit microcontrollers, the 8051 family has the largest number of diversified suppliers.

A/D CONVERTER

The main function of this converter is to convert the analog information produced by the CT's, PT's and temperature sensing circuit in to digital through eight bit data. Most of the real physical quantities such as temperature, voltage, current etc. are available in analog form. Even though an analog signal represents a real physical parameter with accuracy, it is difficult to process further in digital circuits. Therefore for processing, it is often convenient to express this variable in digital form. It gives better accuracy for the process automation.

The analog signal obtained from the transducer is sampled at a particular frequency rate. The sampled signal has to be held constant while conversion is taking place in ADC. This requires that ADC should be preceded by a sample and hold circuit built in with the same device. The ADC output is a sequence in binary digit. Here in this project work Microcontroller is used to perform the numerical calculations of the desired control algorithm.

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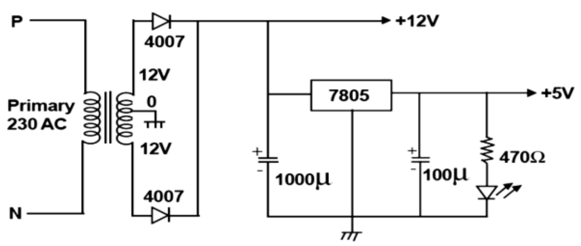
POWER SUPPLY UNIT

The power Supply is a Primary requirement for the project work. Before designing a power supply, first we must calculate how much current is required to drive entire circuit including LCD & Microcontroller unit. As per the calculations based on the assumption, it is estimated that the entire circuit power consumption of efficiency measuring module will not exceed more then 250 milliamps. Similarly the section of the project work (i.e. digital monitoring cum control of power transformer), power consumption also consumes another 250 milliamps power from the same power source. Therefore both sections of project work including two display units together consumes nearly 500 milliamps power from single power supply unit, hence a higher rating transformer of 1000 milliamps rating at secondary is to be selected for the safe side.

The following is the circuit diagram of Power supply.



CONCLUSION

The project work Titled **"Digital monitoring cum control of power Transformer with Efficiency Measuring Meter"** is successfully designed & developed, a demo unit is fabricated & it is implemented over one single phase transformer for the live demonstration. The main concept is to measure and display the on load efficiency; in addition transformer is protected from burning due to various reasons. The same system with required modifications,it can be implemented over power distribution transformers at electric sub-stations, such that the on line efficiency can be measured and displayed continuously. In addition other important parameters related to sub-station can be monitored & displayed, if required sub-station can be controlled accordingly. The future work will be focused about sub-station automation. If required the data of entire power transformer can be transmitted directly to the monitoring station, from where all the sub-stations are monitored. The technology can be further enhanced, such that the received information can be stored in the computer at remote place. When the data is stored in computer it will be quite helpful for further analysis.

By adopting these types of instruments everywhere at power distribution points, maintenance of these power systems will become quite easy. With the help of a centralized monitoring station designed with computer, all the transformers data can be accumulated at one place from where the concern person is monitoring entire zone. The main advantage of using this kind of system is that, in addition to the monitoring of transformer, by implementing control technology, it also protect the power system burning due to various reasons, there by life of the transformer can be increased.

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