POWER MEASUREMENT AND TRANSMISSION USING GSM TECHNOLOGY

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Abstract - Power consumption is a major issue for both the private sector and industry area as well. It follows the time over which power is consumed when operating a device equals money in the particular area. Due to this unavoidable cost to each individual, there is a need for an accurate and affordable means of determining the amount of energy consumed by a particular device which is related to the power factor. Main aim of the system is to achieve reliable power measurements by taking phase difference between voltage and current. i.e., taking power factor, into account and to accurately sense the voltage and current used over a typical house hold as well as industrial devices. This system is useful for industrial application as power consumed by the load will be displayed on mobile of user as well as liquid crystal display placed on station.

***Key Words*:** Embedded system, power factor improvement, current sensing, voltage sensing, GSM Technology, analog to digital converter.

1. INTRODUCTION

The electric supply used for domestic as well as commercial purpose is alternating in nature. The 90% of electric energy used, now a days is alternating current in nature. Thus measurement of electrical power consumed by such alternating circuits is now a day's important. This power circuit provides an independent and tangible means of estimating energy costs on a per device basis. This ability to calculate power consumption and its associated costs, perceivably, has numerous applications of both technical and economic importance to consumers.

Power consumption is a major concern for both the private citizen and industry alike. Nearly all appliances and machinery are powered by electricity supplied at a kilowatt per hour rate from an electric utility company. It then follows that the time over which power is consumed when operating a device equals money. Due to this unavoidable cost to each individual, there is a need for an accurate and affordable means of determining the amount of energy consumed by a particular device. The power circuit provides an independent and tangible means of estimating energy costs on a per device basis. This ability to calculate energy consumption and its associated costs, perceivably, has numerous applications of both technical and economic importance to consumers. At present, an affordable and convenient means for consumers to accurately measure the power consumption of the electrical devices in their homes is not readily available. Comparisons could then be made between similar machines, to see which consumes the most energy. Utilizing these design constraints, we hope to provide the average consumer with a very powerful and useful tool for power measurement. The power meter will undergo a barrage of tests to ensure the above design objectives are met. In particular, circuit simulations should aid us in designing voltage and current-sensing circuits capable of accurately handling the ranges typical of household circuits.

2. OBJECTIVE

The objective of this power circuit is to perform quick and cost effective measurements and transmission and provide meaningful results that the observer can understand. The design objectives for proposed power circuit are:

1. **Voltage**: The power meter will sense voltages in the range of 0 to $230V_{rms}$.

2. **Current**: The power meter will sense currents in the ranges of 0 to 6 A.

3. **Power**: The power meter will be powered by a 5V, -5V power supply.

4. **Power Factor Calculation**: The power meter's microcontroller will calculate the power factor in software by using the zero crossings of the input signals.

5. **Power Measurement Range**: The power meter will measure between 0 W and 4000 W of power.

6. **Tolerance**: The power meter will measure power with a tolerance of no more than ± 1%.

3. ORGANIZATION

The system design is based on a microcontroller that can make the necessary calculations and provide excellent functionality. Also GSM plays the major role in this project which is useful to get the information about power consumed by a particular load by sending SMS on mobile. The system is simple, low cost & user friendly.

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At present, an affordable and convenient means for consumers to accurately measure the power consumption of the electrical devices in their homes is not readily available. However, if a consumer is able to measure the AC power drawn from a particular household circuit, then they would be able to calculate the cost of operating that piece of equipment. Comparisons could then be made between similar machines, to see which consumes the most energy.

4. METHODOLOGY

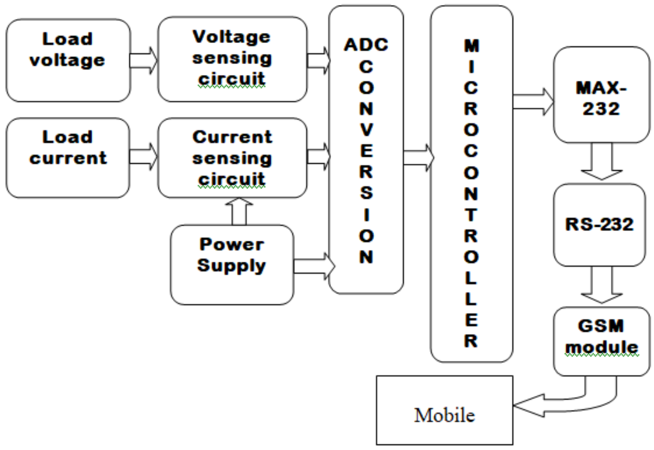

Fig -1: Block diagram of Power circuit

1) Basics of Microcontroller

The AT89S52 is a low-power, high-performance CMOS 8-bit microcontroller with 8K bytes of in-system programmable Flash memory. The device is manufactured using Atmel's high-density nonvolatile memory technology and is compatible with the industry standard 80C51 instruction set and pin out. The on-chip Flash allows the program Memory to be reprogrammed in-system or by a conventional nonvolatile memory programmer. By combining a versatile 8-bit CPU with in-system programmable Flash on a monolithic chip, the Atmel AT89S52 is a powerful microcontroller which provides a Highly-flexible and cost-effective solution too many embedded control applications.

The AT89S52 provides the following standard features: 8K bytes of Flash, 256 bytes of RAM, 32 I/O lines, Watchdog timer, two data pointers, three 16-bit timer/counters, a six-vector two-level interrupt architecture, a full duplex serial port, on-chip oscillator and clock circuitry. In addition, the AT89S52 is designed with static logic for operation down to zero frequency and supports two software selectable power saving modes.The Idle Mode stops the CPU while allowing the RAM, timer/counters, serial port, and Interrupt system to continue functioning. The Power-down mode saves the RAM contents but freezes the oscillator, disabling all other chip functions until the next interrupt or hardware reset.

2) Power Supply

A **power supply** is a important device that supplies electrical energy to one or more electric loads. The term is most commonly applied to devices that convert one form of electrical energy to another, though it may also refer to devices that convert another form of energy (e.g., mechanical, chemical, solar) to electrical energy. A regulated power supply is one that controls the output voltage or current to a specific value; the controlled value is held nearly constant despite variations in either load current or the voltage supplied by the power supply's energy source.

Every power supply must obtain the energy it supplies to its load, as well as any energy it consumes while performing that task, from an energy source. Depending on its design, a power supply may obtain energy from:

i) Electrical energy transmission systems. Common examples of this include power supplies that convert AC line voltage to DC voltage.

ii) Energy storage devices such as batteries and fuel cells.

A power supply may be implemented as a discrete, stand-alone device or as an integral device that is hardwired to its load. In the latter case, for example, low voltage DC power supplies are commonly integrated with their loads in devices such as computers and household electronics. In our project we have designed the power supply for fixed 5V and -5V using 7805 and 7905 linear regulator IC.

3) Current sensing circuit - Current Transformer

Current transformers (CTs) are an indispensable tool to aid in the measurement of AC current. They provide a means of scaling a large primary (input) current into a smaller, manageable output (secondary) current for measurement and instrumentation. A CT utilizes the strength of the magnetic field around the conductor to form an induced current on its secondary windings. This indirect method of interfacing allows for easy installation and provides a high level of isolation between the primary circuit and secondary measurement circuits. CT's are available in various sizes, designs and input ranges and output signal types. This application note will attempt to address many of the common CT types, and how to select the correct CT for a particular installation. A CT is useful for measurements made on AC waveforms. It acts just like a regular voltage transformer, but typically has only one primary winding (the wire carrying the current to be measured). Unlike a regular voltage transformer, there is no physical connection made to the measured line. The CT uses magnetic fields generated by the AC current flowing through the primary wire to induce a secondary current. The ratio of the number of secondary turns to the number of primary turns determines the amplitude core CTs tend to have lower accuracy and worse phase shift performance compared to a similar solid core CT.

4) Current to Voltage converter

A current-to-voltage converter (or transimpedance amplifier) is an electrical device that takes an electric current as an input signal and produces a corresponding voltage as an output signal. Three kinds of devices are used in electronics: generators (having only outputs), converters (having inputs and outputs) and loads (having only inputs). Most frequently, electronic devices use voltage as input/output quantity, as it generally requires less power consumption than using current.

In some cases, there is a need for converters having current as the input and voltage as the output. A typical situation is the measuring of current using instruments having voltage inputs. A current-to-voltage converter is a circuit that performs current to voltage transformation. In electronic circuitry operating at signal voltages, it usually changes the electric attribute carrying information from current to voltage. The converter acts as a linear circuit with transfer ratio $k = V_{OUT}/I_{IN}$, called the Tran impedance, which has dimensions of [V/A] (also known as resistance). That is why the active version of the circuit is also referred to as a Tran resistance or Tran impedance amplifier.

Typical applications of current-to-voltage converter are measuring currents by using instruments having voltage inputs, creating current-controlled voltage sources, building various passive and active voltage-to-voltage converters, etc. In some cases, the simple passive current-to-voltage converter works well; in other cases, there is a need of using active current-to-voltage converters. There is a close interrelation between the two versions - the active version has come from the passive one.

5) Zero Crossing Detectors

A zero crossing detector is used for detecting the zero crossings of AC signals. A typical AC signal is the sine wave which goes up and down the zero level. In the system operational amplifier in different configuration is used to design zero crossing detector. Many electronic systems need to know when the signal crossed the zero level. The answer to that problem is the zero crossing detectors.

6) Voltage Transformer

The standards define a voltage transformer as one in which "the secondary voltage is substantially proportional to the primary voltage and differs in phase from it by an angle which is approximately zero for an appropriate direction of the connections." This, in essence, means that the voltage transformer has to be as close as possible to the "ideal" transformer. In an "ideal" transformer, the secondary voltage vector is exactly opposite and equal to the primary voltage vector, when multiplied by the turn's ratio. In a "practical" transformer, errors are introduced because some current is drawn for the magnetization of the core and because of drops in the primary and secondary windings due to leakage reactance and winding resistance. One can thus talk of a voltage error, which is the amount by which the voltage is less than the applied primary voltage , and the phase error, which is the phase angle by which the reversed secondary voltage vector is displaced from the primary voltage vector.

7) GSM module:

GSM is a cellular network, which means that mobile phones connect to it by searching for cells in the immediate vicinity. There are five different cell sizes in a GSM network- macro, micro, pico, femto and umbrella cells. The coverage area of each cell varies according to the implementation environment. Macro cells can be regarded as cells where the base station antenna is installed on a mast or a building above average roof top level. Micro cells are cells whose antenna height is under average roof top level; they are typically used in urban areas. Pico cells are small cells whose coverage diameter is a few dozen metres; they are mainly used indoors. Femto cells are cells designed for use in residential or small business environments and connect to the service provider's network via a broadband internet connection. Umbrella cells are used to cover shadowed regions of smaller cells and fill in gaps in coverage between those cells.

There are also several implementations of the concept of an extended cell, where the cell radius could be double or even more, depending on the antenna system, the type of terrain and the timing advance. Indoor coverage is also supported by GSM and may be achieved by using an indoor pico cell base station, or an indoor repeater with distributed indoor antennas fed through power splitters, to deliver the radio signals from an antenna outdoors to the separate indoor distributed antenna system. These are typically deployed when a lot of call capacity is needed indoors; for example, in shopping centers or airports. However, this is not a prerequisite, since indoor coverage is also provided by in-building penetration of the radio signals from any nearby cell. The modulation used in GSM is Gaussian minimum-shift keying (GMSK), a kind of continuous-phase frequency shift keying.

5. Working of the system

To build this system, the design will be broken into four phases. The first phase will consist of designing the voltage sensing and the current-sensing circuits. As the input supply consists of $230V_{rms}$ and the maximum voltage that can be applied to the ADC0809 is only 5V. The input supply must be step down in order to prevent the ADC from getting damage. As, the load voltage will not vary, the voltage is step down using voltage transformer. Similar is the case for current measurement. As, current is going to change depending on the load, current transformer is used to limit that current. The second phase will be the A/D conversion of the sensed signals.
As microcontroller is able to understand only digital signals, the analog signal must be first converted into digital form. This conversion can be done using ADC chip. The A/D converter converts the analog voltage and current into proportional digital voltage and current, so that it's output can be given to the microcontroller. The third stage is the microcontroller, to calculate, update, and store energy consumption over a specified time period. This leads to the fourth and final phase where microcontroller send its results to the mobile through GSM using RS232 cable to display the overall record of the power consumed by a particular load.

6. System Design

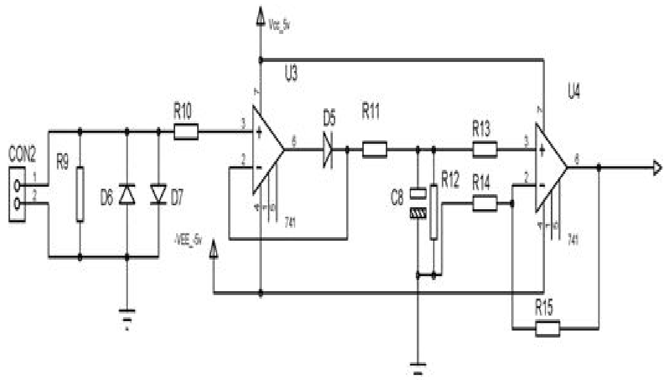

Fig -2: Current feedback circuit

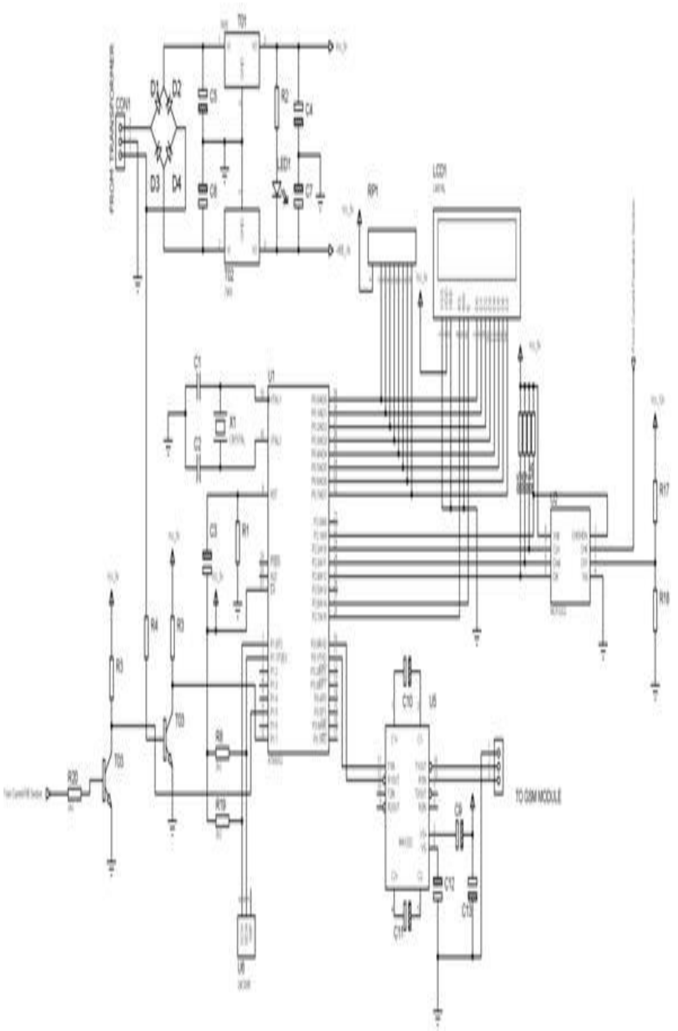

Fig -3: Circuit diagram of power measurement

Circuit Diagram Description:

The above fig. shows the circuit diagram of power transmission and measurement using GSM. The procedure is as follows:

1) Voltage transformer: voltage transformer acts as the voltage sensing circuit. As we know that the voltage parameter remains constant in power measurement. So the input voltage can be directly applied to the ADC. But as we know that the maximum voltage that can be applied to the ADC is 5V. So, it is necessary to step down the input voltage by using step down voltage transformer. The output of voltage transformer is given to the zero crossing detectors.

2) Current transformer: the current drawn by the load cannot be given as it is to the ADC chip. For that it is necessary to step down such a high current. This is done by using current transformer. The rating of current transformer depends upon the turn's ratio.

3) Current feedback circuit: the current obtained from the current transformer is converted into voltage using current to voltage converter which is rectified by using precision rectifier LM741. the output of this is then filtered using filter capacitor. As output of this is very small it is further amplified by using op-amp 741. This output is given to the second zero crossing detector.

4) Zero Crossing Detectors: the output of the voltage transformer is the sine wave. This sine wave is converted into square wave by using zero crossing detectors. This conversion is done by using transistor BC547 which acts as a switch.

5) Analog to Digital conversion: the output of the zero crossing detector is applied to the MCP 3208 which is 12-bit serial ADC. Though this ADC is the serial ADC, but it is hundred times faster than the 0809ADC which is a parallel ADC. ADC converts the analog input voltage into digital voltage which is required for micro controller AT89S52.

6) Microcontroller: the heart of this project is the micro-controller AT89S52. here all the calculations related to the power are done by this controller. The output of the controller is then given to the LCD as well as to the GSM module using RS-232 interface.

7) LCD display: The corresponding output is displayed on LCD.

8) GSM Module: It is a tri-band/quad band GSM/GPRS solution in a compact plug-in module. It comes in size 40x33x2.85mm. Sim300 delivers GSM/GPRS 900/1800/1900MHz performance for voice, SMS, data and fax in a small form factor and with low power consumption. SIM300 provides two unbalanced asynchronous serial ports. The GSM module is designed as a DCE (Data Communication Equipment), following the traditional DCE-DTE (Data Terminal Equipment) connection, the module and the client (DTE) are connected through the following signal (as following figure shows). Auto bauding supports baud rate from 1200 bps to 115200 bps.

7. Performance Analysis

Case 1: At no load condition

1. Output voltage = 0 V.
2. Output current = 0 A.
3. Power consumption = 0 W.

Case 2: Resistive Load

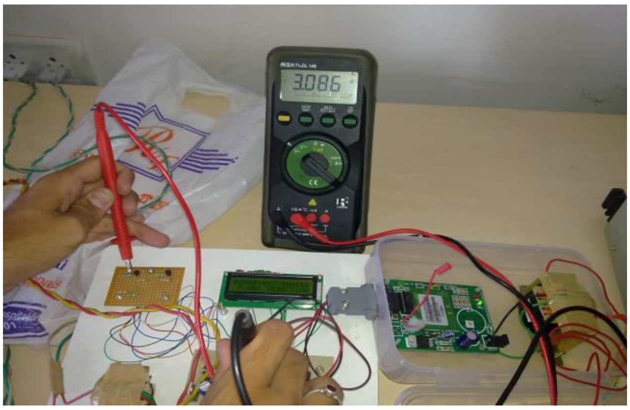

Fig -4: Output of amplifier stage = 3.086 V

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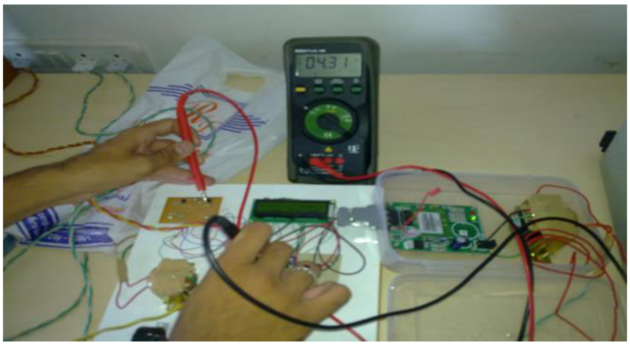

Fig -5: Input of zero crossing detector = 4.31 V

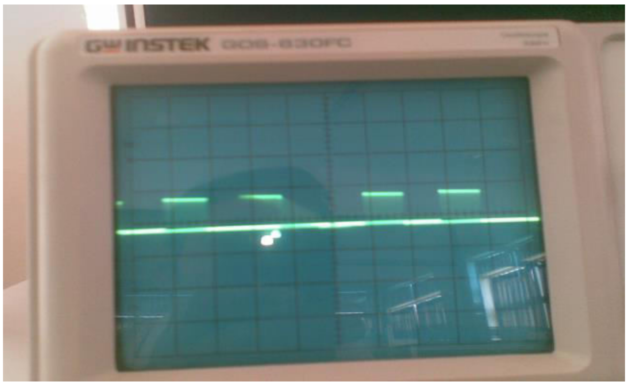

Fig -6: Output of zero crossing detector = 4.6 V

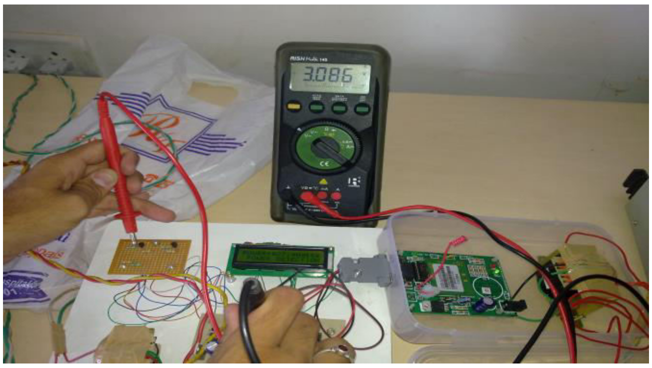

Fig -7: Input of I to V converter (I to V) = 3.086 V

Fig -8: Output of I to V converter = 3.23 V

8. CONCLUSION

In this system we propose power circuit provides an independent and tangible means of estimating energy costs on a per device basis. This ability to calculate power consumption and its associated costs, perceivably, has numerous applications of both technical and economic importance to consumers. With the help of the system we can measure the power of resistive as well as inductive load which is available in industry and house hold. When measurement of power will fulfill suddenly message will transmit to the user through GSM module.

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