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Design and Analysis of Electronics Energy Meter's Fraud Protection and Data Receive by Optical Port Communication

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Abstract – **An energy meter is a device that able to measure electric energy at any one time. The energy data is very important for the study about energy demand especially in residential sector. The meters that can be found in the market nowadays are expensive because they work on operation principle that requires the use of expensive hardware. A single-phase digital Electronics Energy Meter is based on microcontrollers; this digital energy meter does not have any rotating parts. The energy consumption is calculated using the output pulses of the energy meter chip and the internal counter of microcontroller. As soon as the supply is restored, energy meter restarts with the stored values. A single-phase energy meter prototype has been implemented to provide measurement up to 40A load current and 230V line to neutral voltage. Necessary program for microcontrollers is written in c-language. Hence, a digital meter that can measure electrical energy consumed by domestic appliances such as kettle, television, toaster, and others has been developed. This meter is robust, user friendly and informative enough for the purpose of simple data gathering.**

The accurate measurement of electricity supply and subsequent billing to residential properties has traditionally been achieved through electromechanical meters. Although, this solution has several disadvantages including long term accuracy, cost of calibration and limited communication. These issues can be overcome using digital power meters where it is possible to achieve long term accuracy by removing analog components which are prone to drift over temperature and time. The goal of this project is to design an electronic energy meter which calculates instantaneous power at all power factor and gives low frequency pulse output which is directly proportional to real power. This low frequency pulse output is further used by a microcontroller which calculates energy in terms of Kwh and Displays it on LCD. The function of microcontroller is not only limited to display of Energy but it also calculates maximum demand, detects different types of tamper such as magnetic tamper, neutral missing etc., it serves as an interface between RTC, EEPROM and the LCD display and also interacts with the outside world. The meter should have all the tamper and fraud protection features Current Reversal (CR), Earth Tamper (ET), Meter Cover (CO), Magnetic Tamper, Neutral Missing, Neutral disturbance. Data Receive by Optical port Communication.

Keywords – **Electronic meter, Microcontroller, Magnet sensor.**

I. INTRODUCTION

An electric meter or energy meter is an essential device that goes with consumption of commercially distributed energy. It enables systematic pricing of energy consumed by individual consumer as it measures the amount of electrical energy consumed by a residence, business, or an electrically powered device. They are typically calibrated in billing units, the most common one being the Kilowatts hour which is equal to the amount of energy used by a load of one kilowatt over a period of one hour, or 3,600,000 joules.

Some meters measured solely the length of your time that charge flowed, with no measure of the magnitude of voltage or current. These were solely fitted to constant- load applications. Neither sort is probably going to be used these days. Additionally, to metering supported the quantity of energy used, different forms of metering area unit offered. Meters that measured the quantity of charge (coulombs) used, referred to as charge unit meters, were employed in the first days of electrification. These were dependent upon the availability voltage remaining constant for correct measure of energy usage, that wasn't a possible circumstance with most provides.

Generally, electricity meters operate by incessantly measurement the fast voltage (volts) and current (amperes) and finding the merchandise of those to present fast wattage (watts) that is then integrated against the clock to present energy used (Joules,

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Kilowatt-hours etc.). Meters for tinier services (such as small residential clients) may be connected directly in-line between supply and customer. For larger masses, quite concerning two hundred amps of load, current transformers area unit used, so the meter may be placed aside from in line with the service conductors [2].

The meters have two basic classes, mechanical device and electronic. This paper resides on the electronic meter (i.e. the digital meter). An example of a conventional mechanical device meter is shown in figure one. It's a spinning disc and a mechanical counter show. This kind of meter operates by enumeration the revolutions of a metal disc that rotates at a speed proportional to the facility drawn through the most fuse box near coils spin the disc by causing eddy currents and a force proportional to the fast current and voltage. A static magnet exerts a damping force on the disc, stopping its spin once power has been removed. This category of meters encompasses a range of limitations that has created it grossly inapplicable to be used in good energy initiative setting that embrace however not restricted to its degree of accuracy. The area unit several strategies of error correction in digital electricity meters that area unit typically supported the acknowledged strategies of A/D converters error correction [5]. Most of those strategies use code correction supported standard method. Whereas in digital electricity meter, proportion error may be as low as 0.01%, in analogue meters it's typically on top of 0.05%. Secondly, the orientation downside related to mechanical device energy meter is totally a nonissue in a very digital energy meter. Thus, installation is formed easier. Thirdly, the user-friendly show within the digital meters makes energy reading from time to time terribly simple. The fourth and therefore the most serious occurrence of the mechanical device energy meter is its no-interface capability to external devices. This terribly set back is incredibly serious in good grid technology application.

Electronic meters live energy exploitation extremely integrated elements or different bespoken integrated circuits. These devices digitalize the fast voltage and current via a high-resolution sigma-delta ADC.

Computing the merchandise of the voltage and current provides the fast power in watts. Integration over time provides energy used, that is sometimes measured in power unit hours (kWh). The design technique for digital meters is influenced by 3 major factors namely; desired device value, efficiency and overall size. Whereas the price is influenced by users' general affordability, the potency and size should strictly accommodate normal.

These area unit voltage and current sensors. The voltage part device designed around a step down element and voltage divider network senses each the part voltage and cargo voltage. The second sensing element could be a current sensor; this senses the present drawn by the load at any purpose in time. It's designed around a current electrical device and different active devices (such as voltage comparator) that convert the perceived current to voltage for process. The output from each sensor is then fed into a symbol (or voltage) conditioner that ensures matched voltage or amplitude to the feedback circuit, it conjointly contain a symbol electronic device that change serial switch of each signal to the analogue input of the peripheral interface controller (PIC). The feedback circuit targeted on a PIC computer circuit. The PIC is chosen as a result of it contain 10 bit analogue to digital convertor (ADC), terribly versatile to program and sensible for peripheral interfacing. The ADC converts the analogue signals to its digital equivalent; each signals from the voltage and current sensors area unit then increased suggested by that of embedded code within the PIC. Here the error correction is taken because the offset correction by decisive worth the worth of the input quality with short-circuited input and storing this price within the memory to be used because the correction value device standardization. The PIC is programmed in C language. Such except the number circuit it simulates, it's ready to use the received knowledge to calculate power consumption per hour, still because the expected charges. These area unit showed on the liquid display connected to the circuit.

II. PROPOSED WORK

Tamper and Fraud Protection/Monitoring

The meter should have all the tamper and fraud protection features

Current Reversal (CR): The meter should record energy consumption correctly in forward direction irrespective of the direction of current in current circuit. The current reversal shall be indicated in the LCD.

Current Reversal Tamper with date and time in the memory.

Earth Tamper (ET): On using earthing in place of neutral (i.e. when return path off the load is not terminated back of the meter and instead current is drawn partially or fully through a local earth) irrespective of phase and neutral connected correctly to the meter or reversed (the neutral current is more

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than phase current) the meter should register accurately. The Earth tamper shall be indicated in the LCD.
Earth Tamper with date and time in the memory.
Meter Cover (CO): In the event the meter is forcibly opened, even by 2 to 4 mm variation of the meter cover, same should be recorded as tamper event with date & time stamping and the meter should continuously display as C- OPEN" that the cover has been tampered.
Magnetic Tamper: The meter should record energy with in specified limit in presence of stray magnetic field (AC magnet, DC magnet, Permanent magnet) and record the influence of abnormal magnetic field with date and time in the memory. The Magnet tamper shall be indicated in the LCD.
Neutral Missing: When the neutral from both incoming and outgoing side and any one of the neutral are disconnected & the load is taken through earth, the meter should record energy as per rated voltage, rated frequency & UPF.
The meter shall continue to record energy as per prevailing condition even if the neutral is accidentally or incidentally disconnected.
Such neutral related disturbances shall be recorded and indicated in form of blinking in LCD segment.
Neutral Disturbance: The Meter recording ought to be insensitive to passage of DC voltage or ought to log as an occasion within the memory as neutral disturbance. The meter ought to record energy as per voltage measured between incoming part and neutral once DC signal/voltage is injected on the neutral through a diode/device. A conformity take a look at on this condition are distributed at V_{ref} applied between incoming part and diode terminal.

III. Methodology Used

Voltage measurement by voltage circuit. And primary current measurement by shunt and secondary current measurement by CT.
By using embedded C language, we programing of controller.
At actual condition both current (primary current and secondary current) equal.

A. Voltage Measurement

Voltage activity is sometimes obtained by voltage division technique or a step down voltage electrical device. Deciding concerning that technique ought to be used, is said to the work wants. Voltage division approaches square measure utilized in this project.

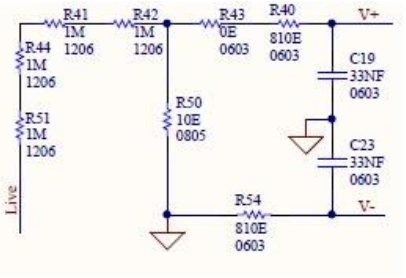

Figure 1: Voltage Measurement Circuit

B. Primary Channel Current Measurement Circuit

This circuit provide mV Voltage's sample to ADC with 500uE shunt.

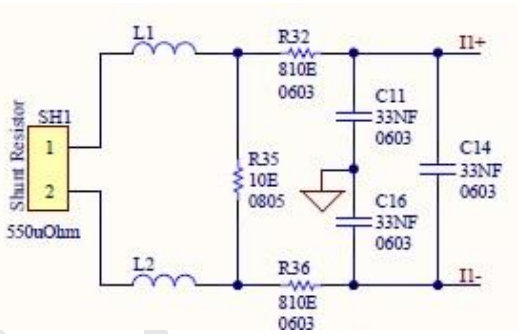

Figure 2: Primary Channel Current Measurement circuit

C. Secondary Channel Current Measurement

This circuit provide mV Voltage's sample to ADC with 130E-150E CT.

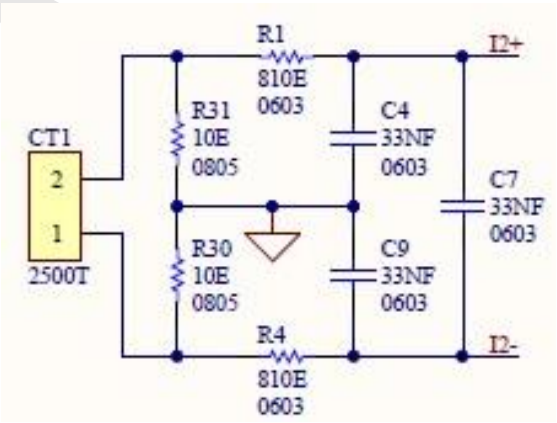

Figure 3: Secondary Channel Current Measurement Circuit

When controller's ADC have negative sample of current then we deduct current Reversal.
When primary current and secondary current have 10% difference than we deduct earth tamper.
When we get cover open interrupt according to cover open circuit then we show cover open on LCD.

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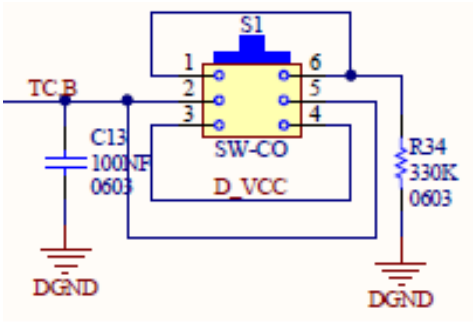

Figure 4: Cover open circuit

We use SOT-23AH180 for magnet field deduct. According to circuit controller pin high when we get low then we deduct magnetic tamper.

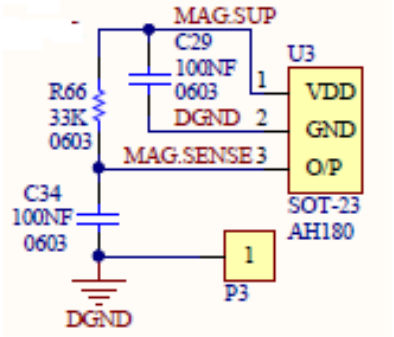

Figure 5: Magnet field sensor Circuit

Meter voltage less than 10V and current greater than 1A than we deduct neutral missing tamper. For this we use neutral missing CT and neutral missing circuit.

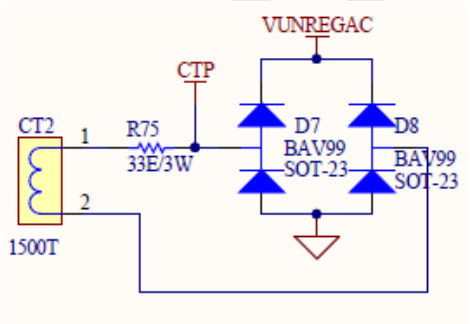

Figure 6: Natural missing Measurement Circuit

When voltage less the 230 V. and secondary current is 6mA than we get neutral disturbance.
All Tamper save in EEPROM with date and time we use this circuit.

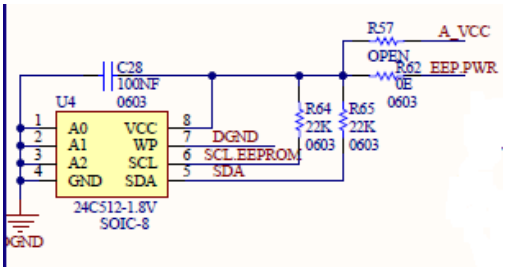

Figure 7: Saving the tamper in EEPROM

D. Data Analysis and Display

After voltage and current measurement procedure, next step is information analysis and show. Samples square measure taken from ADC peripherals and skilful following steps:

- Offset Removal each voltage and current sample contains an offset DC worth, to live the correct worth of RMS voltage and RMS current offset removal is critical.
- Gathering samples when eliminating offset, accumulate one thousand sample in one second and calculate RMS voltage, RMS current, and consumed power on the premise of one thousand samples.
- Display for showing the calculated information or RMS voltage, current and energy, it's necessary. Microsoft Visual Studio C could be an artificial language that's designed for building associate degree application that run on the .NET Framework. C is straightforward, efficient, type-safe, and object-oriented.

IV. Experimental Results

Current Reversal (CR): Meter has accuracy with in limit. Only reverse current show on meter display.

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Earth Tamper (ET): Meter has accuracy with in limit. Only Earth current show on meter display.

Meter Cover (CO): When meter cover open, we find cover open on meter display

Magnetic Tamper: When magnet field detect than we run our mete on reference voltage and I_{max} current.

Neutral Missing: At neutral missing tamper we found our meter on reference voltage and actual current.

Neutral Disturbance: At neutral Disturbance tamper we found our meter on reference voltage and actual current.

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Data Receive by Optical port Communication

Date Time	Duration	Event Name	Voltage (V)	Current (A)	PF	kWh	kVah
Earth Loading							
01/08/2019 14:39:00	00:20:00	Earth Loading - Restoration	229	0	0	2.8	NA
01/08/2019 14:19:00	-	Earth Loading - Occurrence	229	5.65	0.98	2.39	NA
31/07/2019 23:23:00	00:22:00	Earth Loading - Restoration	229	0	0	2.39	NA
31/07/2019 23:01:00	-	Earth Loading - Occurrence	230	30.37	0.96	0.16	NA
influence of permanent magnet or AC/ DC electromagnet							
01/08/2019 15:49:00	00:05:00	influence of permanent magnet or AC/ DC electromagnet - Restoration	222	0	0	4.21	NA
01/08/2019 15:44:00	-	influence of permanent magnet or AC/ DC electromagnet - Occurrence	240	30	1	3.56	NA
Meter Cover Opening							
01/08/2019 16:43:01	00:00:00	Meter Cover Opening – Occurrence	0	0	0	0	NA
Neutral Disturbance HF & DC							
01/08/2019 15:39:00	00:08:00	Neutral Disturbance - HF & DC - Restoration	240	30	1	3.56	NA
01/08/2019 15:31:00	-	Neutral Disturbance - HF & DC - Occurrence	222	5.67	1	3.38	NA
31/07/2019 19:01:00	00:02:00	Neutral Disturbance - HF & DC - Restoration	230	30.32	0.96	0.16	NA
Phase R CT reverse							
01/08/2019 14:39:00	00:20:00	Phase – R CT reverse – Restoration	229	0	0	2.8	NA
01/08/2019 14:19:00	-	Phase – R CT reverse - Occurrence	229	5.65	0.98	2.39	NA
31/07/2019 23:23:00	00:22:00	Phase – R CT reverse – Restoration	229	0	0	2.39	NA

V. CONCLUSION

In this paper style and implementation of reliable digital Energy Meter supported 8051 microcontroller is delineate. With the designed new energy meter measurement and LCD of the specified information square measure potential. Every system section is fastidiously designed to fulfil the specified accuracy and information measure. C language code is microcode compact and also the entire energy calculation rule is dead in minimum range of computer hardware cycle. During this accomplishment, completely different ways for sensing the present and voltage square measure planned and enforced. This technique is intended supported associate degree 8051 microcontroller that acts as an information acquisition process and show system. A current and a voltage signals square measure connected to their analog inputs and born-again into digital kind. The sampled signals of the present and voltage square measure manipulated by microcontroller to live energy meter parameter. The microcontroller will thus value the RMS values of measured signals at the side of the consumed energy at the measurement terminals that modify the calculation of all alternative energy related quantities. During this case study we tend to plan a straightforward and versatile show technique wherever the measured information is simply monitored and show for user. The new measurement system will definitely facilitate to decrease economical usage of your time as compared to traditional technique of obtaining an equivalent results. All the table provides comparison between the quality and proto type.

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