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Smart Energy Meter With Tamper Detection And Communication Feature

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Abstract

The paper presents Smart Energy Meter embedded with Arm Cortex M0 microcontroller. The controller has inbuilt metrology engine that calculates the power consumption automatically from the line voltage and current sensed. The calculated consumption is then shown on the LCD display as well as the remote display panel (desktop/ laptop) by wireless communication through Wireless M-Bus. Multiple meters are installed to implement the logic of tamper detection. It facilitates remote connection/ disconnection of the meter by the user as well as electricity board. Online meter monitoring eliminates the manual task of meter reading gy the electricity board representative, going home to home for bill generation.

Keywords : *Microcontroller, LCD, Remote Display, Wireless M-Bus, Tamper Detection, Remote connection/ disconnection*

Introduction

Energy meters are combination of analog and digital components working together to give the output in the form of digital readings that is what the total power consumed by any industrial or residential building.

As the use of electricity around the world progressed, the price for electricity has become competitive. The need for accurate measurement of the electricity consumed has become very important issue both for the consumers as well as the electricity board. Utility companies started feeling the pressure for better instruments. Utility companies are being forced to find solutions that will demand more sophisticated energy measurement methods, providing greater amount of information on the consumer's power consumption.

The Smart Energy Meter is the best solution to face the present day scenario of urgent need of accurate and user friendly electrical consumption measuring device.

Smart energy meter

1. Features:

1.1 The Controller

Smart Energy Meter needs a controller for energy and power measurement, data transmission, real-time clock keep up and data display on meters front panel.

Our Smart Energy Meter is embedded with ARM Cortex M0 microcontroller EM773. It is

a low cost 32 bit energy metering IC. It comes with inbuilt metrology engine with two current inputs and a voltage input that calculates the energy consumption. Our Smart Energy Meter is programmed to measure the real as well as apparent part of the electricity consumed. So the measured results are in terms of kVAh instead of kWh as measured by the conventional meters.[1]

1.2 Automated Monitoring

The user as well as the electricity board is able to monitor the meter reading frequently at a negligible time intervals online on one's desktop or laptop. It is also possible to monitor readings floor wise, room wise and even appliance wise as per meter installation. It is possible to manage the appliance operating time by setting a timer for it. The consumption can be monitored in digital as well
as graphical view. The user can monitor and smartly manage his/her usage to control bills.

The user can do such operations just at the click of a button on the interface. Hence, its very much user friendly.[2][3][9]

1.3 Communicability

Our Smart Energy Meter is using Wireless M-bus[1][8] for communication purpose. It can also be expanded to work on GSM or/and PLCC. Communication is required between two meters as well as the meter and display wherever the user wishes to monitor the readings and control the appliances.[6][12]

1.4 Tamper detection

Meter tampering has become a common thing in almost all villages and cities. Its not a new thing nowadays to listen of electricity thefts. We have made provision in our Smart Energy Meter to tackle this problem. The concept being implemented is as follows:

There will be a main meter down the building or outside the house which will measure the overall power consumed by that building as coming from the electricity company. There will be sub meters installed floor wise or room wise as per convenience and necessity. The sub meters can also be attached to individual appliance if its desired to be monitored. Now suppose A is the main meter and B,C, D are the sub meters. Now if the measured consumption comes out to be such that it satisfies the equation

$$A=B+C+D$$

it means there is nowhere tampering in the system. But if this equation fails to satisfy then tampering can be detected and dealt with. [6][11]

1.5 Remote Operation

The feature of communication gives the smart energy meter system to be handled remotely. This feature is of great benefit to the electricity company as it removes the need of manual analysis of the meter. There is no need for any person to go home to home to know the individual readings. The electricity board can remotely monitor the readings and generate bills. Also there is a provision for remote connection and disconnection of the meter in case of new installation, change of place or disconnection in case of nonpayment of bill.[10][9]

2. Block diagram

The block diagram shows the inter connection between the main meter and the sub meters. The sub meters are no different in construction than the main meter.

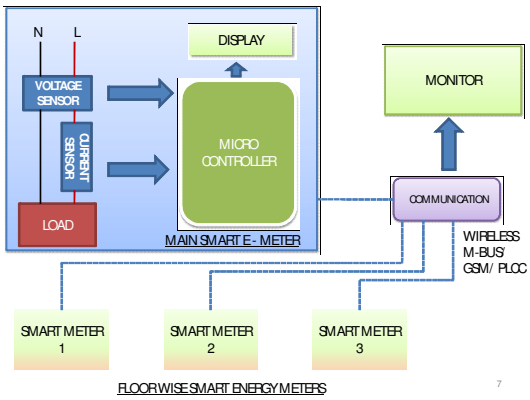

Fig. 1: BLOCK DIAGARM

3. Schematics

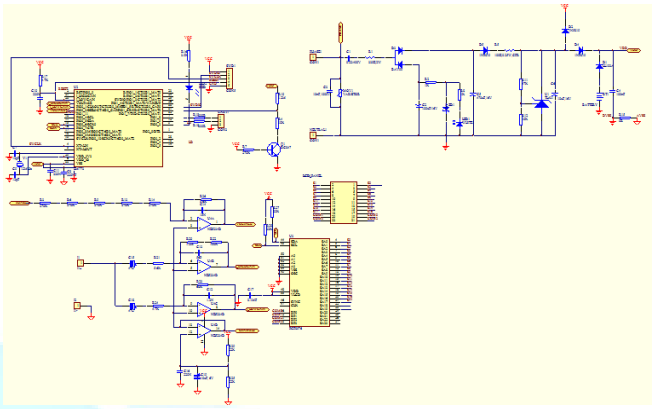

Fig2. Smart Energy Meter Schematic

4. Working

The current and voltage coming from the supply is sensed by the sensors. Its output is given to the controller that has inbuilt metrology engine which calculates the electricity consumed. Same work is done by the sub meters that are installed as per necessity. The measured outputs are available on the meter display as well as on the remote panel (PC) via Wireless M-Bus.

- Sensing line current and voltage to measure electricity consumption.
- Floor wise consumption monitoring for:
  - Regulating consumption to reduce bill.
  - Electricity theft detection.
- Communication via Wireless M Bus for online meter reading.
- Remote connection/disconnection of the meter as per requirement.

5. Results & discussion

We are able to measure supply which is coming from electricity board at our home. By this, we are able to monitor that supply voltage as we did measurement via smart energy meter. That allows us to monitor and manage our consumption and thus control our usage of supply which cause control on our electricity bills. It also facilitates Electricity Company for remote connection / disconnection of the meter and as well as tamper detection.

The final controllable display is as shown below:

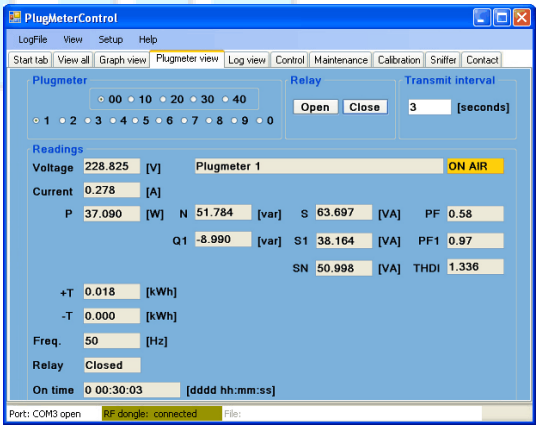

Fig.3. PLUGMETER CONTROL

Here, as we can see the voltage and current are coming from electricity board. From them, power is calculated in VA (volt-ampere) instead of Wh (watt-hour) as calculated by conventional meter. Here we can also monitor the improved power factor taking into consideration kVAh(apparent energy) which is not done by the conventional meter. The main thing useful to us is we are considering the harmonic distortion in our calculation. So we can measure accurate power.[1]

Comparison of meter reading at different time instants:

SR. NO.	*CURRENT (A)*	*VOLTAGE (V)*	*POWER*			*POWER FACTOR*		*HARMONIC DISTORTION*
			P(W)	*S(VA)*	*S1(VA)*	*PF*	*PF1*	*THDI*
1.	0.278	228.125	37.090	63.697	38.164	0.58	0.97	1.336
2.	0.316	243.180	38.055	76.760	39.243	0.50	0.97	1.681
3.	0.325	241.931	38.940	78.745	40.142	0.49	0.97	1.683
4.	0.313	242.222	36.523	75.778	37.693	0.48	0.97	1.744
5.	0.311	243.126	36.530	75.511	37.723	0.48	0.97	1.693

Table 1· METER READINGS COMPARISON

Here,
S (VA) is the actual power consumed as obtained by current and voltage multiplication which is calculated by the Smart Energy Meter.
The S1(VA) is the power calculated by the conventional meters.
PF is the power factor calculated by the Smart Energy Meter whereas PF1 is the power factor calculated as per the conventional meter readings.
THDI is the total harmonic distortion in the electrical supply coming from the Electricty Company.

The harmonic distortions are neglected and the apparent part of the current is not taken into consideration by the conventional meters while calculating the power. Hence the power factor PF1 is almost unity. But the Smart Energy Meter also considers the harmonics and uses the apparent energy consumed while calculating. Hence there is difference between PF and PF1, S and S1 as can be seen from the above table.

6. Conclusion

A smart user friendly energy meter is developed that is capable of energy measurement, tamper detection, communication and remote operation
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