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Smart meter design using MSP430 microcontroller

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Abstract**:** *This paper is aimed to review significant development in the design and analysis of smart meter based on msp430 microcontroller. A smart meter is a digital energy meter that measures the consumption of electrical energy and provide other additional information as compare to the conventional energy meter. Smart meters are considered as a key component of the smart grid. Smart metering allow continues reading and recording of many electrical parameters like voltage, current, frequency, active power (kWh), apparent power (kVAh). Smart meters will enable two-way and real time communication between the consumer and utility. Considering the increase of electricity demand in India, Smart meter can decrease the power losses and increase the power quality. This paper introduce a low cost wireless smart meter based on 16 bit MSP430 microcontroller. The meter design and development of hardware and software are introduced in details.*

Keyword- *Smart meters, GSM, SIM900, TI-msp430*

I. INTRODUCTION

From last some years, electricity demand is significantly increased in residential households and company with the use of different electrical devices. This sudden increase is a concern to many developing and developed countries with the demand in very quick increase use of electricity. This paper concentrate on a smart metering technology development for distributing electricity reliably and very efficiently to the customers. The biggest disadvantage of earlier used conventional meters were that they provide very rare information to the customers, which is fulfill by using the modern electrical smart meter. A smart meter allow consumers to know their electricity consumption of electricity for their devices in their own houses. The purpose of this paper is to analyze and measurement of power consumption using a modern smart meter.

Smart meters involves a two way communication among customers and utility company. Smart meters are used to detect outages and for billing information collection and notice repair members to reach at appropriate location quickly. These type of meters usually make a close connections among the smart distribution and substation.

"Smart Meters" generally include sensor for real-time or sensor for near real-time, power quality monitoring and electricity blackout notification. It will give benefits like simple automated meter reading (AMR). These benefits are likewise in multiple respects to advanced metering infrastructure (AMI) meters. The interval type and time-of-use meters effectively inducted to measure industrial and commercial consumers consumption.

Hence the checking of electricity deregulation and market-aimed pricing all over the world, Distribution company have been observing for equalize usage with the generation. Conventional electricity meters can only measure total usage, therefore give very less data of where the electricity was used at metered site. Smart meters deliver a way of measurement of this type of specific data, permitting price set by utilities to day to day consumption. The smart meters will contain measurements of harmonic distortion and permitting analysis of power quality problems.

Particularly, if generation is controlled, prices can be increase if power from other administration or more expensive generation is carried online. The exponent verify that billing consumers by time-of-day will financially effect to the customers to adjust their consumption habits. The monitoring the market design utilities desire that

"price signals" should hold the construction for more generation. In the certain concerns, low profit and compromising customers may not get profit from day to day time-of-use tariffs.

II. BASIC BLOCK DIAGRAM OF MODERN SMART METER

Smart meters use voltage and current sensors to get the input signals. Signal conditioning, ADC, and computations are done inside the micro controller unit (MCU). Additional hardware components are required for other operations like communication, time and date measurements, and data backup and storage. A smart meter is typically composed of following hardware components:

- Voltage and current sensing unit
- Power supply
- Energy measurement unit (metering IC)
- Microcontroller
- Real time cock
- Communicating system.

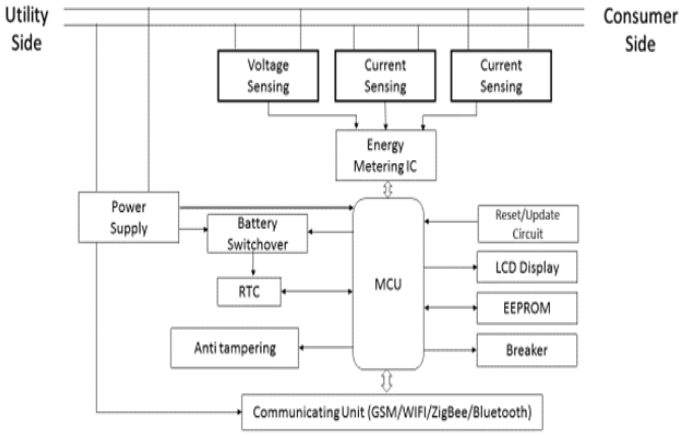

Fig. 1 Hardware structure of a modern smart meter

III. SYSTEM HARDWARE

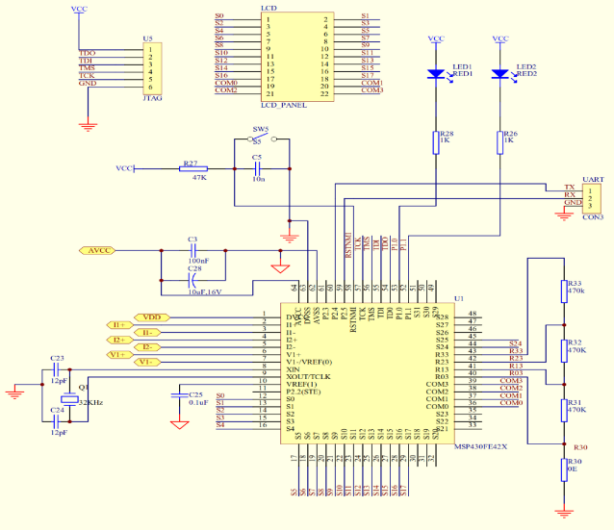

Fig 3. Digital Processing section of TI-based meter

In the heart of the metering design is an energy measurement IC; that calculates watts and accumulates watt-hours. The energy measurement IC must interface with the chosen sensors and accurately perform calculations and interface with an external display. The external display of an energy meter can either be mechanical or electronic in nature. A stepper motor counter is an example of a mechanical counter, while a digital counter and liquid crystal-display (LCD) are examples of electronic counters.

An advantage of using an LCD-display is that the meter can display more than one measurement parameters at a time. For example, the display could include power information in watts, kWh, apparent power (VA), power factor and/or meter temperature. The LCDs require non-volatile memory to store data in the event of a power shutdown. Figure 3 shows the schematic of the digital processing section.

The chip is connected to various peripherals as can be seen. Eye catching features are Universal Asynchronous Receiver Transmitter (UART), the Joint Test Action Group (JTAG) and LCD. Debugging via JTAG facilitates you to load your code and find out errors. It provides testing facility supporting single stepping and break pointing.

IV. SYSTEM SOFTWARE

Instruments and third party developers offer Integrated Development Environments (IDE) to program all MSP430 devices. Full C-compilers are also available enabling development and debugging code in seconds. The debugging and emulation's intelligence resides in the high-level driver files MSP430.dll and HIL.dll. MSP430 IDEs such as Code Composer Studio or IAR Embedded Workbench access the debugger through these library files.

Software tool for Coding

The IAR Embedded Workbench IDE is a very powerful Integrated Development Environment that allows you to develop and manage complete embedded application projects. It is a development platform, with all the features found in everyday working applications.

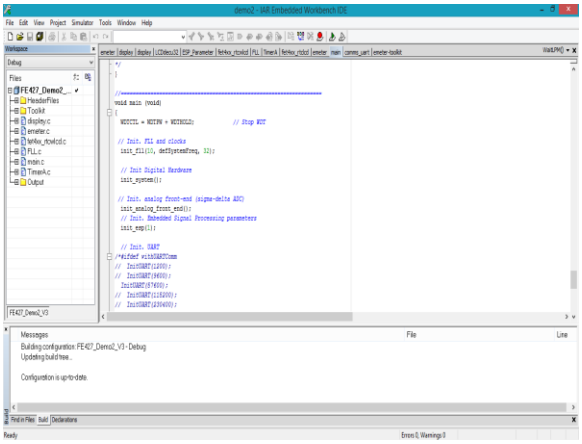

Fig 4. Adding project to your workspace

Building Project for TI-meter: The fig 4 shows the IAR Embedded Work-bench IDE window with different components.

There is two types of debugger in this IDE.
Simulator: It runs entirely on our computer and don't need any external hardware. It shows the results based on the features of devices that it models. The simulator gives complete insight into the features it models. However, it does not include the peripherals and is unsuitable for investigating the interaction between the MSP430 and its external signals.

Emulator: It looks similar to simulator on computer but the program runs on a real device. The MSP430 Flash Emulation Tool debugger (FET debugger) allows for launching code on to the on-chip ash. The full resources of the microcontroller are available and it reacts to all aspects of its working environment. The debugger can stop the CPU and read back the state of any register to the PC so that one may examine various aspects of the program. It requires

a program on the PC, called the C-SPY FET Debugger, and an interface to communicate between the PC and the JTAG interface of the MSP430.

V. HARDWARE IMPLEMENTATION AND ANALYSIS

The PCB designed for energy meter using TI-MSP430 is shown in figure 5
Dimensions: 85mm x 78.25mm

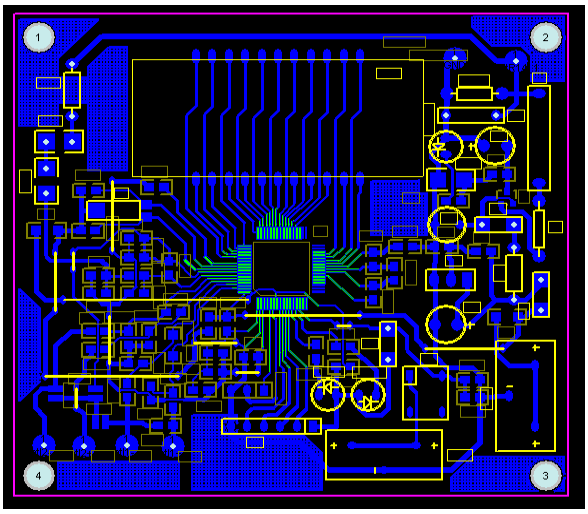

Fig.5 TI meter PCB layout

This is single layer PCB. After the hardware is designed the next step is to develop it. The Gerber file of the design document is needed for PCB manufacturing. Once the PCB is ready it needs to be assembled.

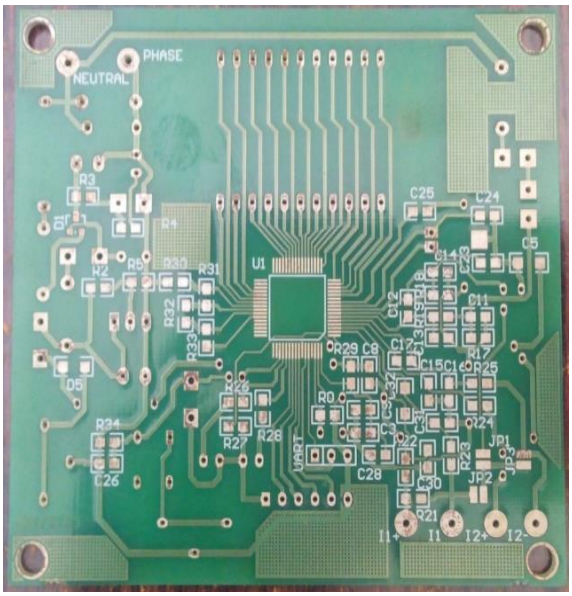

Fig. 6 TI meter PC

Hardware (Mounted PCB)

The component of power supply, LCD, LEDs, push button and the JTAG connected are located on the layer of the PCB as shown in figure.

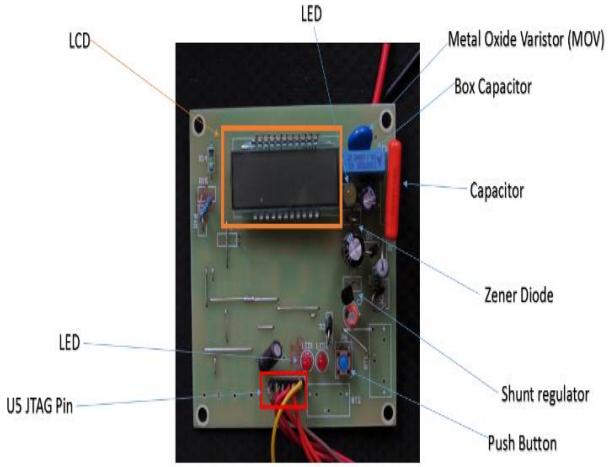

Fig. 7 PCB top view

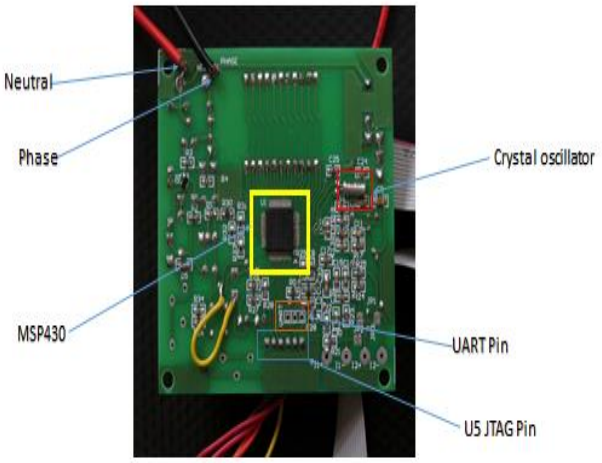

Fig.8 PCB Bottom view

VI. RESULT

Energy-meter outputs: Once the metering code is loaded into the flash the code begins execution and shows results. Various display parameters like voltage, current, frequency, active power and apparent energy shows in figures.

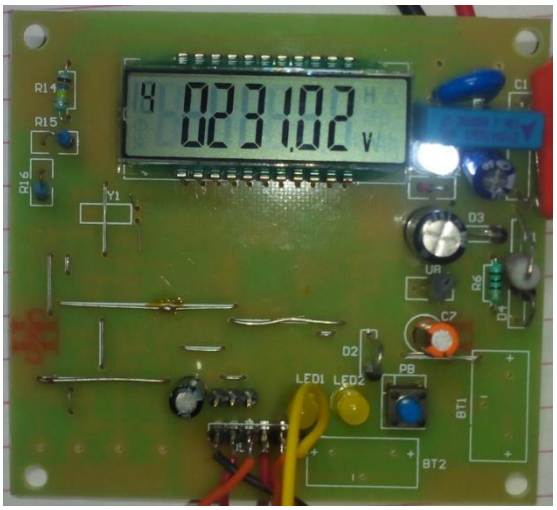

Fig. 9 Voltage reading

Fig.10 Current reading

Fig. 11 Frequency reading

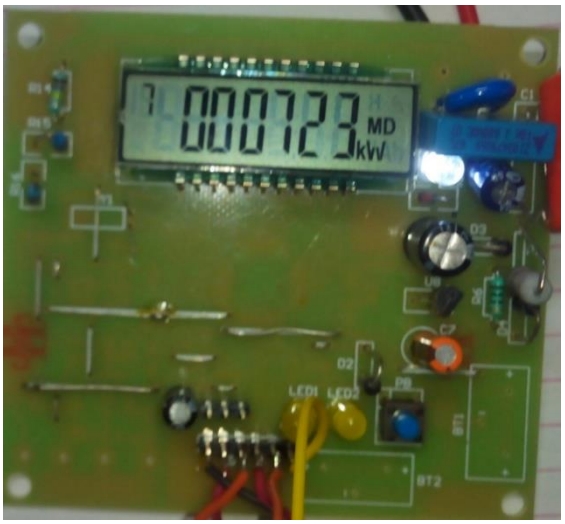

Fig. 12 kW reading

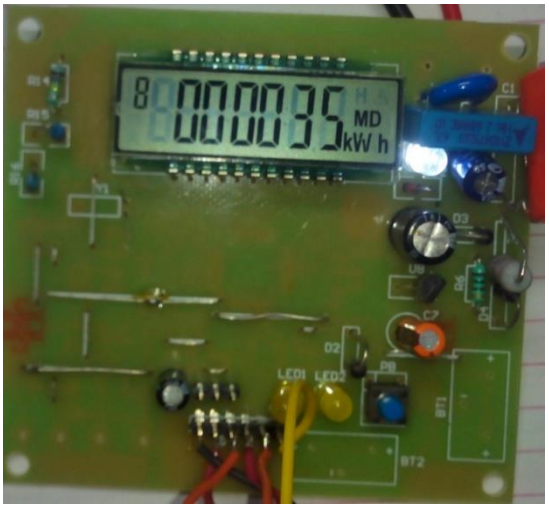

Fig. 13 kWh reading

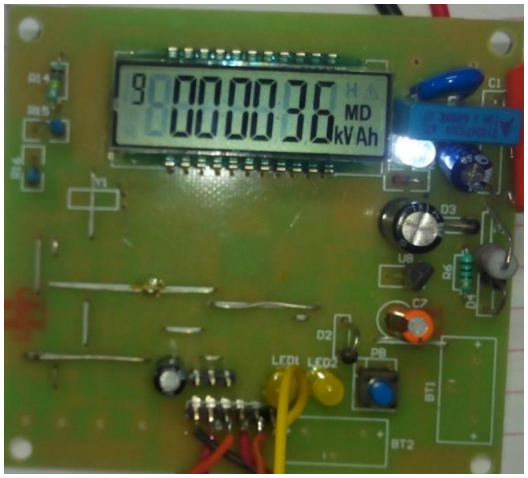

Fig. 14 kVAh reading

Comparison between Energy meter and Smart meter

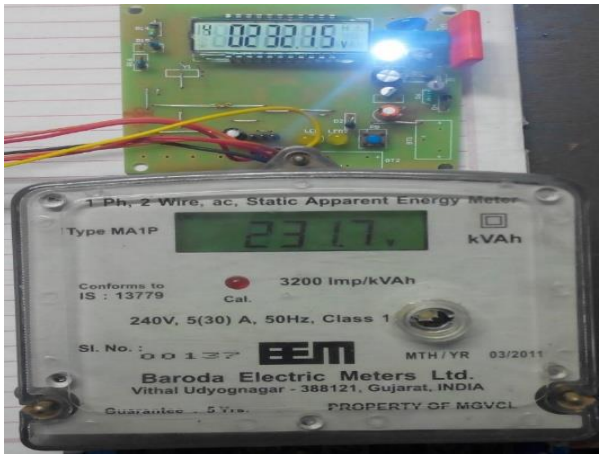

Fig. 15 Comparison between Energy meter and Smart meter

There were energy meters available from electric meters and TI based smart meter.

Parameters	**Without Load**		**With Load (40 watt Bulb)**	
	Energy Meter	TI Smart Meter	Energy Meter	TI Smart Meter
Voltage	231.7V	232.15V	213.01V	213.46V
Current	0.0	0.0	0.39A	0.32A
Frequency	-	49.99	-	50.01
kwh	0.0	0.0	0.08	0.08
kVAh	0.0	0.0	0.08	0.08

Table 1 Comparison between Energy meter and Smart meter

From the reading it is clear that both meters record were nearly same.

VII. CONCLUSION

Modern smart meter have more functionality then conventional electrical meter. Smart meter provide real-time information. From the analysis we can say that MSP430 microcontroller is an ideal choice for building up an efficient energy meter and a smart meter.MSP430 is best suitable as it requires low supply voltage range, ultra-low power consumption, anti-tampering characteristics and high performance for precision measurement for the design of the digital smart meter. So using smart meter the electricity losses can be reduced and system will become more stable.

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