

Networking of Digital Energy Meter Using Power Line

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Abstract: This paper presents an implementation methodology of smart automatic digital meter reading using Power line communication and ARM microcontroller. Several public utilities and equipment manufacturers are currently pursuing projects that will use domestic and industrial data communication networks for meter reading. Architects are giving serious consideration to including fiber-optic networks or high speed transmission lines in new homes to provide the infrastructure for future home automation. For the present, however, the existing mains network that every home has an excellent basis for introducing higher levels of automation. This paper suggest method where and how we can utilize communication system for automated transmission of data to facilitate bill generation at the utility side, fault detection, temper detection, load calculation and many more

Keywords: PLCC, ARM, Networking, Automation, Energy Meter

I. INTRODUCTION

The Recent technology has given us the edge whereby one can take at relook at the energy meter from a different perspective and change both the approach and strategy to detect and fight tamper, Faults and pilferage. The introduction of advanced meters in residential areas has produced additional privacy issues that may affect even ordinary customers [11][12][13].

The cost of electricity in the above scenario takes on a new meaning. Consumers expect incentives and market oriented offers as they proceed to become more efficient and comply with the utilities' efficiency guidelines. All this leads to optimized costs and higher efficiency. This situation places a requirement to communicate in real time and that has led us towards automatic Meter reading technologies. The benefits of remote networked metering are many and listed below.

- Load prediction and Management
- Automatic Billing – Reduce meter reading effort
- Theft detection
- Attractive Tariff offers and Enable Trading
- Improve load profile
- High speed fault detection and resolved
- Monitoring and controlling in real time

Automatic meter reading Network architecture basically divided in three different categories GSM based communication, PLCC based communication and Hybrid communication

II. ENERGY METER HARDWARE DESIGN

Here design of network metering used power line as communication medium. Design the digital meter and interface it with PLCC board. Mainly divide in two part hardware design.

Hardware design starts with the selection of components. The major component selection involves selection of microcontroller, serial communication, LCD display, LCD driver, SMPS power supply component, Modem chip, OP-AMP selection. The most important is microcontroller selection because complete design of energy meter based on it.

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The op-amp plays a vital role in signal conditioning circuit for energy meter. Here we used Philips ARM7 controller for faster processing and also for data computation. Main feature of the LPC2xxx series are as follow [1][6]

- Philips series lpc2xxx, arm core(RISC architecture)
- 3 stage pipeline
- Von Neumann architecture
- T: Thumb instruction set
- D: Includes debug extensions
- M: Enhanced multiplier (32x8) with instructions for 64-bit results
- I: Core has Embedded ICE logic extensions
- S: Fully synthesizable (soft IP)
- Flash technology: 0.18u Flash with ARM7
- Broad tool chain: high quality & low cost.
- Lowest pin count and smallest packages in the market

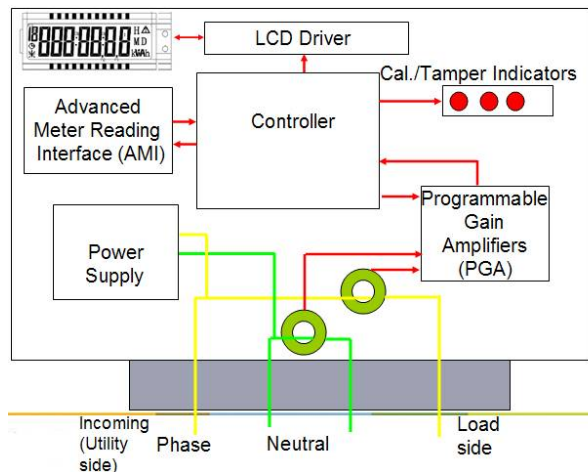


Figure 1. Block diagram of the system

Figure 1 shows the main block diagram of the system. In that incoming utility side provide the 230v, 50 Hz frequency and other side connects the load. Interface advanced meter reading PLCC card with controller. Energy meter software is embedded inside the microcontroller.

Main Blocks of the Energy Meter Hardware:

- Power supply
- Analog Section (signal acquisition)
- Microcontroller(LPC 2103)
- LCD driver(PCF8576D) & Panel
- On chip RTC
- Communication interface
- Programmer

Energy meter circuit requires dc voltage to make controller & analog section working. Mainly three types of supplies are available for converting universal main 230V, 50 Hz to 5V, 3.3V, 1.8V DC.

In analog section Current & Potential transformers are used for measurement purpose. It steps down the current & voltage respectively. Here use the current transformer of 2500 turns & 22/10 ratio for current signal & for voltage used

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potential divider circuit. Amplify the current signal according to the appropriate range after that provide signal to microcontroller pin. In analog section we are using two OP-AMP & four bilateral switches. By using bilateral switch we can adjust op-amp gain. Here in energy meter circuit two switches are connected in parallel to op-amp. By closing or opening the switches we get three different ranges (low, medium and high). So, we get wide range of output current. 230 volt Input is divided using voltage divider circuit and gives it to the controller. One op amp used for phase current and another for neutral. Use two OPAMP for temper detection [7].

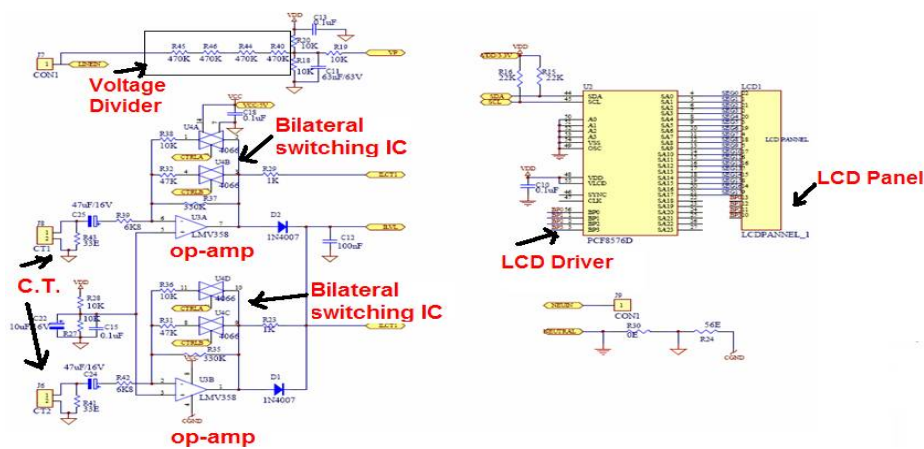


Figure 2. Signal conditioning and LCD section schematic

Figure 2 shows Voltage signal connected to the controller on ADC channel 1. Line current connected to ADC channel 2 and Neutral current connected to the ADC channel 3 of the 32 bit ARM7 LPC2103 Microcontroller.

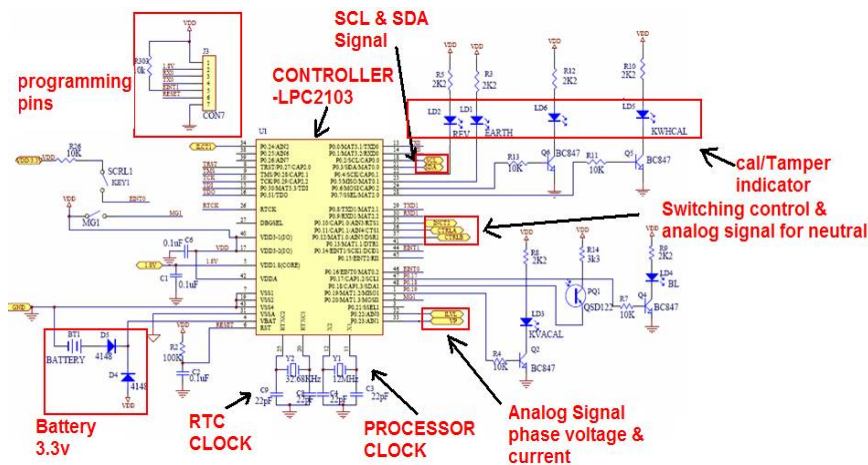


Figure 3. Microcontroller section schematic

Figure3 consists of controller information: Microcontroller (LPC2103)[5] core required 1.8V and peripheral required 3.3V. External clock 12 MHz and RTC required 32.768 kHz crystal. 3.3V battery connected to controller for real time.

For temper detection & pulse count interfaced LED. LCD connected to microcontroller to display voltage, current, active energy, apparent energy, time, date, power factor etc. To load the program to microcontroller need the

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programmer tool. Here we use dongle as programmer. Programming into the chip requires seven pins of the controller. Here 10 bit, 8 channels ADC is available. At the time of shutdown (power off) condition save the necessary data into flash by writing to flash using the external interrupt at the time of zero crossing detect.

III. PLCC HARDWARE DESIGN

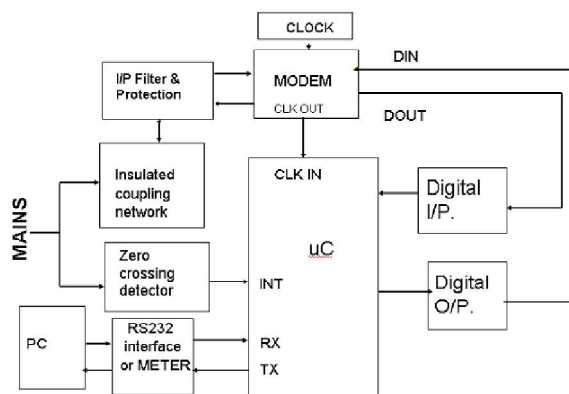


Figure 4. Power line carrier communication block diagram

Figure 4. indicate the controller connected to the different blocks. Data will transmit/receive through power line. The basic function of the coupling network is an efficient high pass behavior in order to prevent 230V, 50 Hz frequency.

Receiving section needs an antialiasing filter to operate properly. For this reason the complete behavior of the coupling network is in fact a band pass filter. Here center frequency equal to carrier frequency. In transmission mode, the band pass behavior is used to eliminate the unexpected harmonics of the digitized carrier and the aliasing component around the sampling frequency. At the time of zero crossing we are transmitting/receiving the data through power line. Here modem is required for transmitting and receiving data outside.

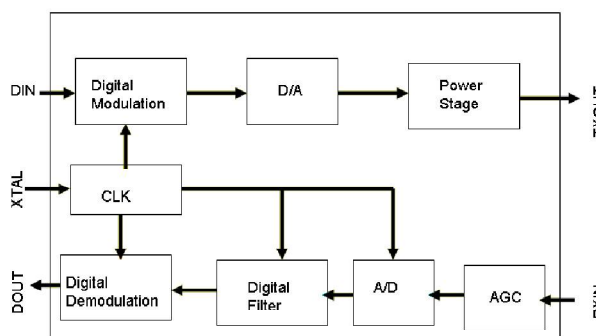


Figure 5. Modem block diagram

Internal block diagram of modem is given in figure 5. Here we are using IC TDA5051 [8] which work on Amplitude Shift Key modulation technique.

Controller signal provides to DATAIN pin of modem. Modem modulate signal, convert digital signal to equivalent analog and after amplifying transmit the data on power line. Also it receives signal from power line, amplify the signal, convert analog signal to digital and then demodulate signal. Provide the demodulate signal to microcontroller which is

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available on DATAOUT pin of the Modem. Modem used external clock of 7.3728MHZ. Transfer the data at maximum 1200 baud rate. Carrier frequency is 115.2 KHz. and microcontroller CLOCKOUT frequency 3.6864MHz.

IV. SOFTWARE TOOLS & METHODS

To design the energy meter and communicate to PLCC card we have used μ vision3 IDE keil software tool. μ vision3 integrates all tools including c compiler, macro assembler and linker/locator and hex file generator.

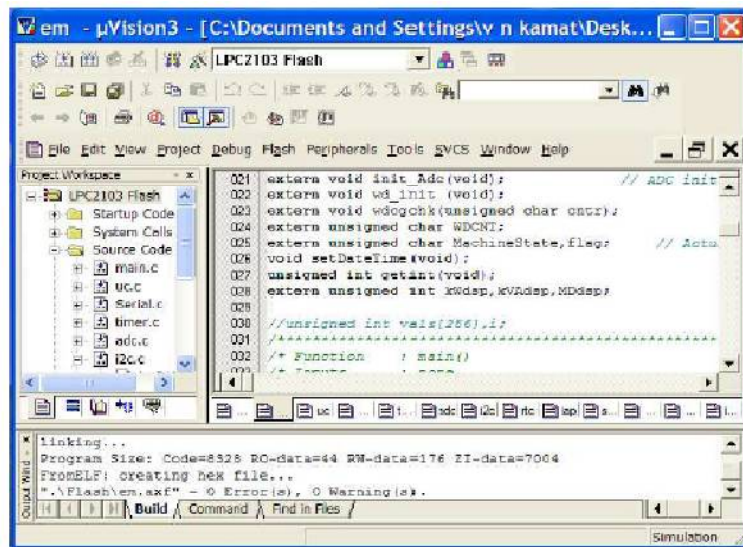


Figure 6. Keil μ VISION3 IDE

As shown in figure 6 the μ vision3 IDE is a window based software development platform that combines a robust editor, project manager and make facility.

In digital energy meter we were taking samples of voltage and current from signal conditioning block and using ADC converter. From the digital samples find the V_{rms} , I_{rms} , KWh, KVAh, Power factor, frequency. Display all the parameters on LCD and send to PLCC card at certain interval.

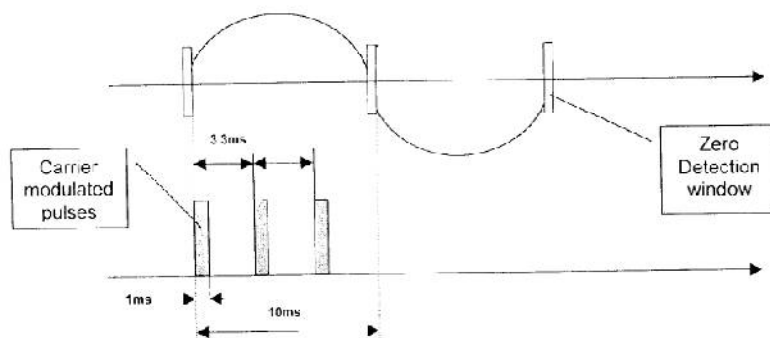


Figure 7. Transmit bit

In figure 7 PLCC card transmission mode technique explained. Each bit of a frame is sent (or received) just after the zero crossing point. A “ONE” is represented by a carrier-modulated pulse of 1 ms; a “ZERO” is an absence of modulation. Each bit must be sent three times, with the appropriate delay.

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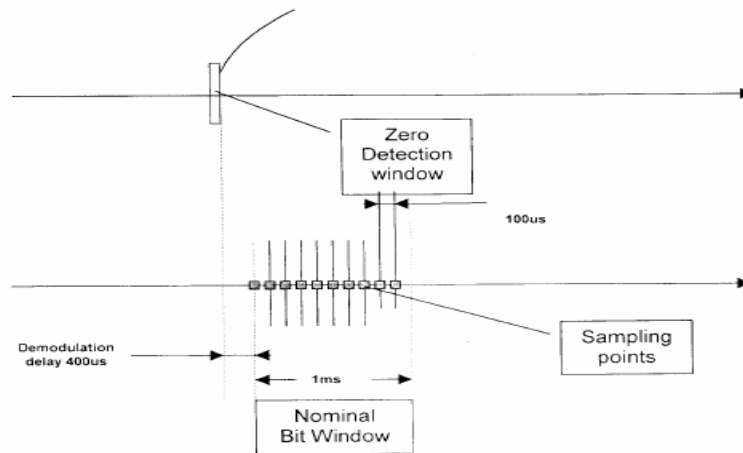


Figure 8. Reception bit

As shown in figure 8 the bit detection is more complex. In order to improve the communication reliability, each bit “window” (a bit window is a time slot where a bit is expected) is sampled 10 times at a 100µsec rate. This is done by sampling the output of the TDA5051A [8].

After that decision threshold is required to determine if the sampled bit is zero or a one. Since the demodulation of any incoming bit takes several 100µsecs. One has to start sampling after an initial delay, called demodulation delay. The demodulation delay is not really constant and varies with the signal amplitude, but an average value of about 400µsec. This delay also depends on the XTAL frequency; higher is the XTAL frequency lower is the demodulation delay.

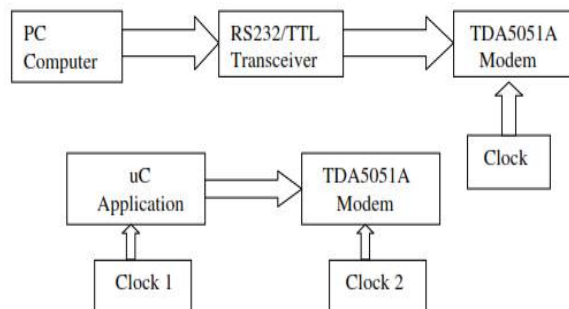


Figure 9. Not synchronize clock

As shown in figure 9 problem occurs when interface between controller & modem. The modem chip a DATAIN signal being completely synchronous with the digital clock of the TDA5051A [8]. Such a case, a certain phase relationship between the rising edge of DATAIN and the digital clock of the modem causes a wrong behavior of the modulator. This will lead to an incomplete carrier shaping process, missing the “tail” of the modulation. So for that purpose provide the synchronization between modem & controller.

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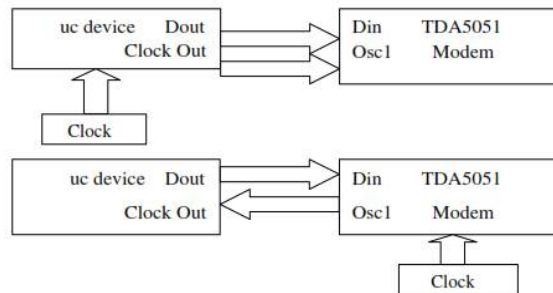


Figure 10. Synchronize clock

In figure 10 share the same digital clock for both the microcontroller and modem chip the best way to solve the problem. This can be achieved by either using the modem clock to feed the microcontroller or by driving the modem with microcontroller.

Generally microcontrollers are expected that the I/P-O/P port operation to be synchronous with the clock. The phase relation between datain rising edge and the modem clock will be always the same.

V. INTEGRATION & TESTING

The important part in design is hardware-software integration and testing of complete system.



Figure11. Energy Meter Setup

In figure 11 the programmer tool connects with the main board of energy meter.RS232 connect with programmer tool and PC. Using ISP method load the program into the chip.

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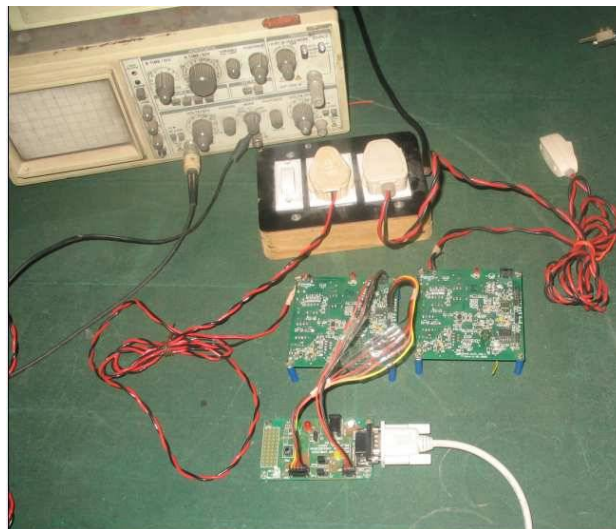


Figure 12. PLCC Setup

In figure 12 one board works as master and another as slave. Here also programmer tool used to load the program. Without any external wiring or interface both master and slave can communicate with each other through power line.

VI. CONCLUSION

The networked meter is an ultimate solution that would fit in the role of an energy management device, to reduce the utilities' technical and commercial losses, and also offer better services to the consumers. It still shows that PLCC technology implementation takes some more time to come. Development of this solution needs detailed studies, modeling and characterization of our LT system under our operating environments, and then designing appropriate PLCC systems matched to their characteristics, and aimed to meet performance requirements.

All the functionalities required for the product are achieved. The new design provides better functionality, higher accuracy and higher reliability with compliance to all type test requirements. The objectives like low cost, lower manufacturing time, lesser no of variants are achieved, low power consumption.

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