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Energy Metering by using Power Line Communication

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Abstract - Everywhere automation is needed to reduce the work. We decided to put in to practice the meter reading using power line communication. It can be measure real time and also save the time. It had better user interface and digital data analysis. Data was send over existing carrier by using power line that's minimizes the complexity and cost of system. Energy meter reading was a monotonous and costly work. The meter reader people run through each meter and catch the meter reading manually to issue the bill which will later be entered in the billing software for payment automation. If the manual meter reading and bill data entry process can be automated then it minimizes the hard task and financial wastage system. It was used for data collecting from the meter and processing the collected data for billing and other decision purposes. We had proposed an automatic meter reading system which was low cost, high performance and cover highest coverage area. In the data receiving and processing unit meter reading was collected from the transceiver which controlled by another microcontroller. There was computer application that will take the data from the microcontroller. This was help to avoid any tampering or break down of energy.

Keywords- *ARM7 controller, FSK Modulator IC 555, FSK Demodulator IC 565, Power line isolation*

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I. INTRODUCTION

Power is important factor of modern society. Electricity has become synonymous with life in the industrialized world. Power line data transmission is the art of sending data through power lines. The basic process includes three steps:

- Modulate the data so that it can be sent over the transmission medium.
- Transmit the signal in such a manner to minimize signal distortion.
- Receive and demodulate the signal to extract the data.

A device that can achieve the above steps called a power line modem. There are many types of modems utilised in most of the homes that allow us to communicate over the telephone and cable mediums. Modems are built specifically for their transmission medium, that is to say, a dialup modem will not work on the cable medium. Each type of modem employs some type of modulation or demodulation scheme, such as FSK, PSK, or ASK. [1, 2].

There are two ways to decrease the strain on the power line infrastructure, to build more grids, or make the grids more efficient. In our opinion the latter is a better option because building more inefficient grids will not decrease the problems that we are faced with. How do we achieve more efficiency in the power grids? The answer to this question is Power line data transmission. Power-on-Demand (PoD) means exactly what it sounds like distributing power dependent on the demand and need. Electricity providers are turning to power-on-demand technologies to relieve the stress on the exhausted power grids. Energy providers do not want to build more and more complex and expensive grids, instead, they would like to focus their time and money into more efficient and long term solutions. PoD is the solution that the electrical utility sector has been longing for. PoD systems put in to practice to supply the consumers on the grid with the amount of energy that they need at any time, and this amount can be varied at any moment. PoD systems can also be used between many utility companies to sell and buy excess generated power when needed. Thus, PoD systems involve communication between two parties. This paper gives the implementation of a PoD system [2,3].

II. MATERIALS AND METHODS

Block Diagram of the system

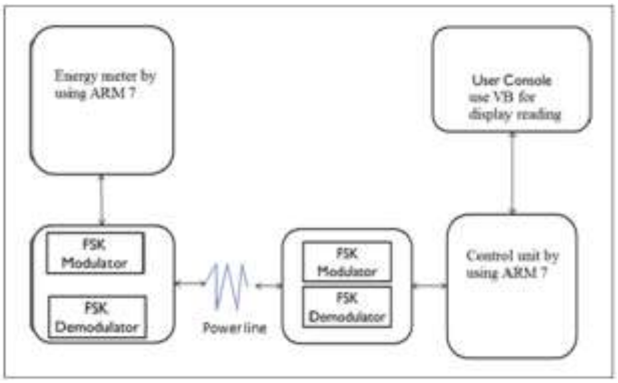

Figure: Basic Block Diagram

The Energy Metering system diagram is shown above in Figure. There are two basic units that are needed to facilitate the communication between the power company (vendor) and the consumer. The consumer unit would be located at the client's building and the vendor unit would be used by the power company. The consumer unit consists of energy meter by using ARM 7 Processor. Energy meter is measure current, voltage, KWH, time, date etc. This output of energy meter data is modulated by using FSK modulator. FSK modulator is connected to power line by using isolation transformer. At the vendor side same isolation transformer is used to connect power line and demodulator circuit. The vendor unit consists of a Trans-receiver circuit, ARM 7 Processor and a User console which could be computer combo. ARM 7is used for controlling purpose in feature number of meter are connected so that time by using keypad all meter are controlled. The overall system that was envisioned is shown below, but the system that was implemented does not include the user consoles. Due to time constraints and because priority was given to the trans-receiver circuits. The main focus of design was the trans-receiver circuits that would allow us to send and receive data through the power line medium [5, 6, 7].

Consumer Unit Description

Consumer unit consisting of ARM7 controller, FSK modulator and demodulator, signal conditioning, voltage meter, current meter and watt meter. ARM7 is used for energy metering purpose. In that unit FSK transmitter and FSK receiver is used for the modulation and demodulation. IC 555 is used for FSK modulation and IC 565 used for FSK demodulation purpose. This both block isolated with power line for communication. Signal conditioning, voltage meter, current meter and watt meter all this block used for display energy meter reading.

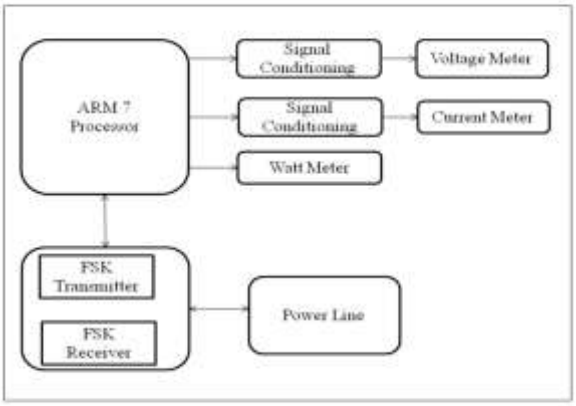

Figure: Consumer Unit

Vendor Unit Description

Vendor unit consisting of ARM7 controller, FSK modulator and demodulator, consol unit. In vendor unit FSK transmitter and FSK receiver is used for the modulation and demodulation. In that IC 555 is used for FSK modulation and IC 565 used for FSK demodulation purpose. ARM 7 is used controlling and consol unit is used for analysis purpose. In consol unit visual basic is used.

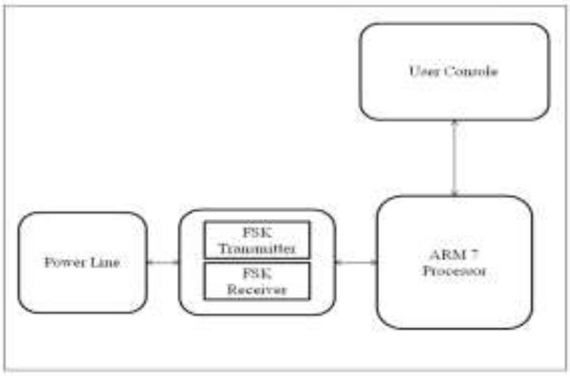

Figure: Vendor Unit

III. RESULT AND DISCUSSION

Practical result of FSK modulation circuit

FSK generator is formed using IC555 as an astable multivibrator whose frequency is con-trolled by state of Q1 transistor. In other words, the output frequency of FSK generator depends on the logic state of digital data input. When the input is logic 1, transistor Q1 is of. Under this condition the 555 works in its normal mode as an astable multivibrator, that is capacitor charges through Ra and Rb to 2/3Vcc and discharges through Rb to 1/3 Vcc. Thus c charges and discharges through 2/3 to 1/3 Vcc. When input is logic 0, transistor on, which in turn connects the resistance Rc across Ra. This action reduces the charging time of capacitor and increases the output frequency [6].

The system was tested by using the equipment provided in laboratory, namely a function generator and digital storage oscilloscope (DSO) to view the input and output waveforms. Before connecting energy meter to the FSK modulator and demodulator circuit were individually tested. First the modulator circuit was tested. By applying a TTL waveform of 104Hz to the modulator input, we verified that an FSK waveform was created and displayed on the DSO. Figure shows results that are practically generated, when energy meter signal is applied to the input of FSK modulator and voltage of this signal is 4.8V

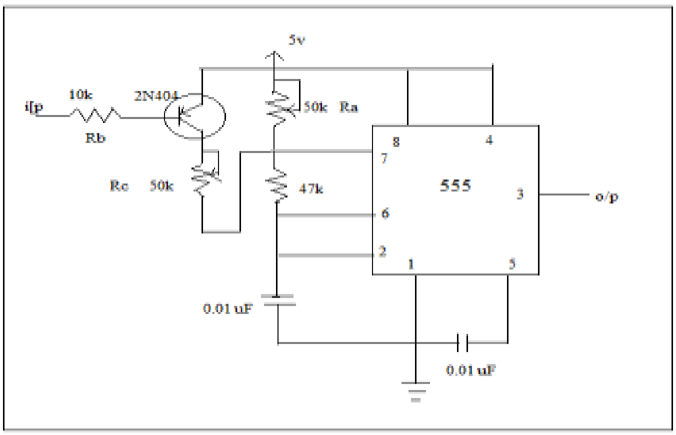

Figure: FSK Modulator

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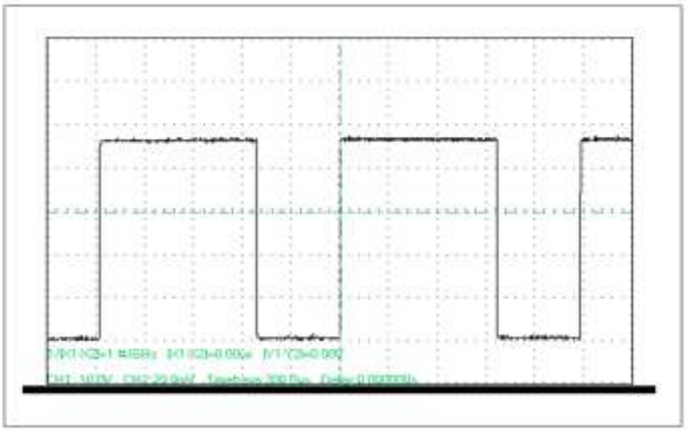

Figure: Practical result of FSK modulation circuit. Practical result of FSK demodulation circuit

In FSK generator modulated data is transmitted through power line. Power line contains both signals that are 50 Hz and modulated data so it is need to demodulate signal. In FSK demodulation circuit capacitive coupling used to remove dc level. As the signal appears at the input of 565, loop locks to the input frequency and tracks it between the two frequencies. Resistor R1 and C1 determine the free running frequency of the VCO, while C2 is a loop filter capacitor; it is used to remove overshoot on the output pulse. RC ladder filter is used to remove the carrier component from the output. Before connecting energy meter to the FSK modulator and demodulator circuit were individually tested. First the modulator circuit was tested. By applying a TTL waveform of 104Hz to the modulator input, we verified that an FSK waveform was created and displayed on the DSO. This signal is given to input of FSK demodulation circuit and waveform display on DSO. Figure shows results that are practically generated, when energy meter signal is applied to the input of FSK modulator, output of modulator is given to demodulator and demodulated output is given to control unit. Voltage of this signal is 3.2V [6].

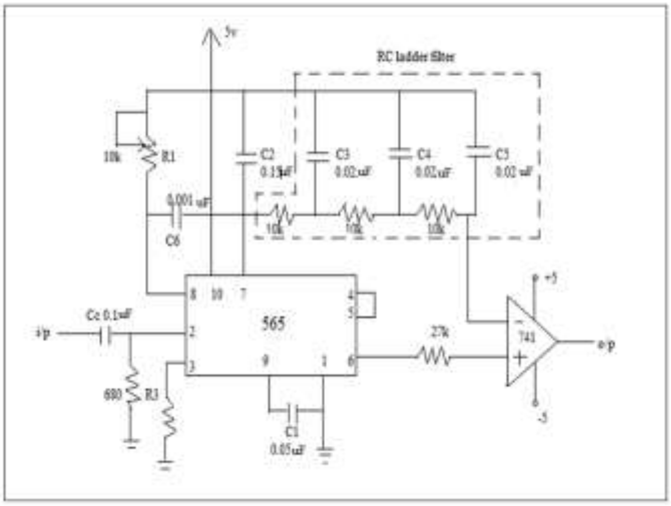

Figure: FSK Demodulator

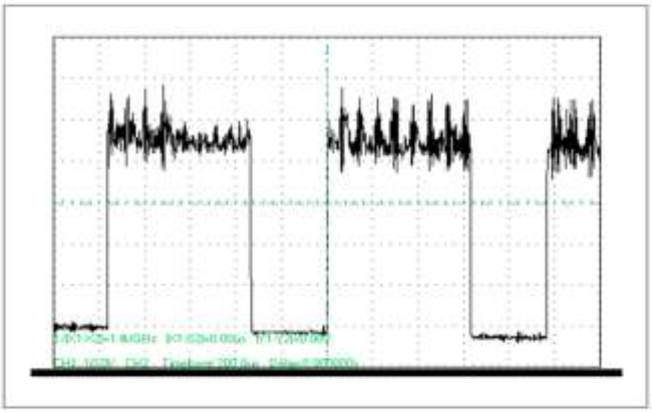

Figure: Practical result of FSK demodulation circuit

High Frequency Transformer

In power line communication modulation and demodulation circuit is connected to power line, modulation and demodulation circuit contains low voltage and power line contains high voltage so in that case chances to burn circuit. That reason High Frequency Transformer is used to protect low voltage circuit.

Calculation of High Frequency Transformer

Step Up Transformer:-Ferrite Core

Primary Calculations:-

Power source is 12V.

Output Voltage is 230V.

Switching Frequency is 1033HZ

Formula for Calculating Number of Required Primary Turns is,

N_{pri} = (Vin * 108)=(4*F*B_{max}*Ac)

Where,

V_{in}= Input Voltage = 12V

F = Switching Frequency = 1033Hz

B_{max} = Maximum Flux Density

Range of B_{max} is 1300G to 2000G

So consider B_{max} = 1500G

Ac = E_ective Cross-sectional Area in cm2

Ac is given in datasheet of ferrite cores is 1.25

N_{pri} = (12 * 108)=(4*1033*1500*1:25)

N_{pri} = (12 * 108)=7747500

N_{pri} = 154.88

We better make sure that B_{max} is still within acceptable bounds

B_{max} = (V_{in} * 108)=(4*F*N_{pri}*Ac)

B_{max} = (12 * 108)=(4*1033*154*1:25)

B_{max} = (1.2 * 109)=795410

B_{max} = 1508.6

So B_{max} is acceptable bounds

Secondary Calculations:-

Output Voltage = 230

Primary side voltage is 12V of 98 % Duty Cycle.

Voltage Ratio = V_{sec} / V_{pri}

Voltage Ratio = 230/12

Voltage Ratio = 19.166 V

Formula for calculating Turns at Secondary Side,
$V_{sec} / V_{pri} = N_{sec} / N_{pri} = I_{pri} / I_{sec}$.
$19.166 = N_{sec} / N_{pri}$
Put value of N_{pri},
$19.166 = N_{sec} / 154$
$N_{sec} = 19.166 * 154$
$N_{sec} = 2951.56$
Auxiliary Winding Calculations:-
Let's say we need an auxiliary winding to provide 19V.
$N_a = N_{sec} / N_{aux} = V_{sec}/(V_{aux} +V_d)$
V_d = Output Diode Forward Drop = 0.5 V
So, $N_a = 230/19.5$
$N_a = 11.79$
$N_a = N_{sec} / N_{aux}$
$N_{aux} = N_{sec} / N_a$
$N_a = 2951/11.79$
$N_a = 250.29$
Let's round o_ N_{aux} to 250 and then see what the output voltage is,
$N_a = N_{sec} / N_{aux} = V_{sec}/((V_{aux} + V_d))$
$N_a = 2951/250$
$N_a = 11.80$
$V_{sec} / N_a = V_{aux} + V_d$
$V_{aux} + V_d = 230/11.80$
$V_{aux} + V_d = 19.49$
$V_{aux} = 19.49-0.5$
$V_{aux} = 18.99$

Advantages of energy meter by using power line communication system are listed bellow

- Accurate measurement of transmission losses.
- Smart automated process instead of manual work.
- Accurate information from the network load to optimize maintenance and investment.
- Customized rates and billing dates.
- Detection of tampering of meter.
- Better network performance and low cost efficiency.
- Demand and distribution management.
- More intelligence to business planning.

Applications

Vendor side (company) uses

- Monitoring the energy consumed /supplied and energy accounts /reconciliation over a particular duration.
- Monitoring the maximum demand, voltage levels, current, power consumption/ load on each meter.
- Ability to detect tamper events and outage occurrences.
- Remotely connect / disconnect power supply through meter.
- Calculate transformer loading and sizing from interval data.
- 15 minute interval data gives accurate load information for supply scheduling, switching operations, planning etc.
- Monitor voltage at each premise to know conditions when to operate capacitor switches or regulators.
- Consistent and granular data for improved accuracy.

Customer side uses

- Clear and accurate billing.
- Automatic outage information and faster recovery.
- Better and faster customer service.
- Flag potential high consumption before customer gets a high bill.

IV. CONCLUSION

Our power suppliers are given the burden of supplying us with a constant power supply, but this burden cannot always be met. We have proposed the idea of a device that would allow communication between the power suppliers and their large industrial clients in the hope that the communication would lower the probability of power failures. The interesting feature about the device is that it communicates through the power lines. A successful implementation of this type of technology would open the door to new data services that could also be provided through the power lines. Like data is transmitted Pc to printer trough power line. The circuit would need to be able to receive energy meter data, modulate it, and then interface with the power line using isolation transformer.

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