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Design of Energy Meter with One Second Logic for Energy Calculation

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Abstract: *To improve the economic benefits of electric power enterprises, it is essential to reduce the production cost and energy loss. Further it is also required to improve the metering to provide reliable electric energy metering data, strengthen the effective management of power calculation and adopt an accurate, reliable and systematic electric energy metering mode. In the work presented in this paper, the metering engine is given with voltage and current input. Depending on sampling rate of ADC which is based on line frequency, voltage and current values are sampled and are converted to digital signals. The converted ADC values of voltage and current are read and energy is calculated, accumulated and averaged. So if energy is averaged for a longer duration, then percentage of error decreases.*
Keywords: *Analog to digital converter (ADC), Microcontroller based energy meter, Phase locked loop (PLL).*

I. INTRODUCTION

The energy meter is a critical part of the electric utility infrastructure. It does not provide a control function for the power system, but it is one of the most important equipment from a monitoring and accounting point of view. Meters keep track of the amount of electricity transferred at a specific location in the power system, most often at the point of service to a customer. Utilities need accurate metering data to manage transactions, billing, ensure reliability and streamline operations. The electric power utilities pay more attention to the accuracy of electric energy meter because it will not only affect the efficient utilization of electric power resources, but also will affect the economic benefits of electric power enterprises [1].

Electronic Energy Meter (EEM) is based on Digital Micro Technology (DMT) and uses no moving parts. So the EEM is known as Static Energy Meter. In EEM the accurate functioning is controlled by a specially designed micro controller. In addition to micro controller, analogue circuits, voltage transformer, current transformer etc. are also present to sample current and voltage. The input data is compared with a programmed reference data and finally a voltage rate will be given to the output. This output is then converted into digital data by the AD converters (analogue- digital converter) present in the micro controller chip [2].

The digital data is then converted into an average value. Average value or mean value is the measuring unit of power. The output of controller is available as Pulses indicated by the LED (Light emitting diode).
Figure.1 shows the block diagram of energy meter.

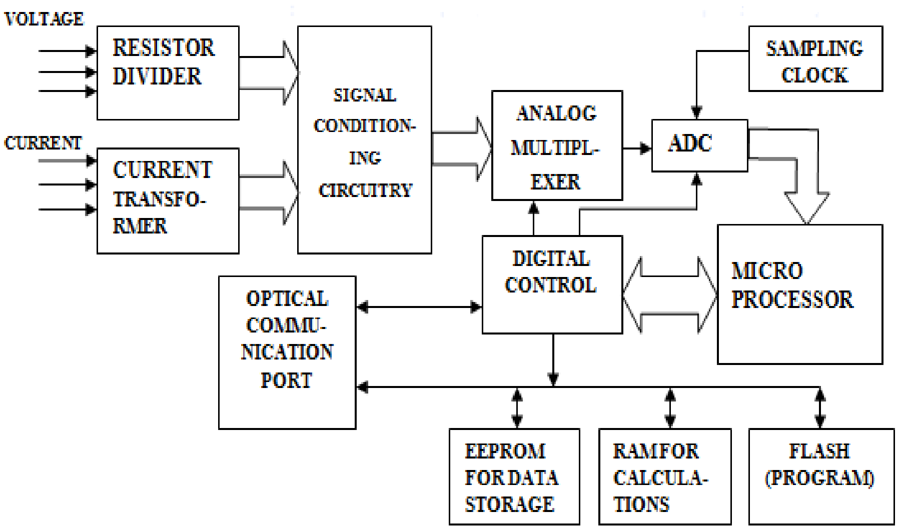

Figure.1: Block diagram of energy meter

II. BACKGROUND

The metering engine is given with voltage and current input. For sine wave signals, amplitude and frequency are two possible changing parameters. Since the frequency of the mains varies, it is important to first measure the mains frequency accurately and then phase shift the voltage samples accordingly.

The instantaneous I and V signals for each phase are accumulated. A cycle tracking counter and sample counter keep track of the number of samples accumulated. When set samples values have been accumulated, the background process stores these in registers and notifies the foreground process to produce the average results like RMS and power values [2]. For frequency measurements, we do a straight line interpolation between the zero crossing voltage samples. Figure.2 depicts the samples near a zero cross and the process of linear interpolation.

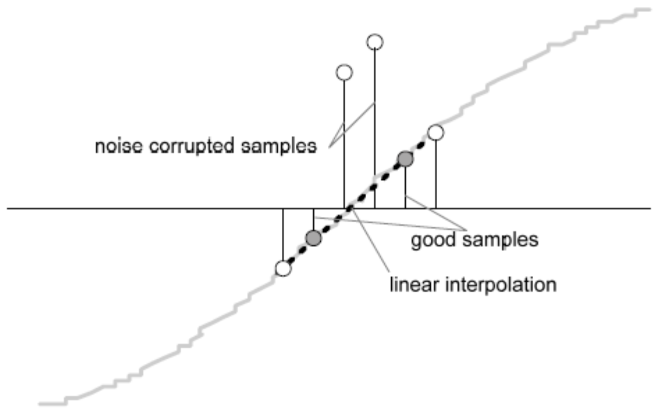

Figure.2: Frequency measurement

Since noise spikes can also cause errors, we use the rate of change check to filter out the possible erroneous signals and make sure that the two points are interpolated from are genuine zero crossing points. For example, if you have two negative samples, a noise spike can make one of them positive and therefore making the negative and positive pair looks as if there is a zero crossing.

In meter application Phase locked loop is used for line frequency synchronization with ADC sampling frequency. PLL follows line frequency. Line frequency is not always constant. Sometimes it varies from the grid side, which is acceptable. When the frequency changes then time duration changes.

There should be a line frequency sync operation which synchronizes the sampling frequency with line frequency. This can be achieved using Phase Locked Loop (PLL).

III. ACCURACY IN ENERGY METERING

Accuracy evaluation represents one of the most critical aspects mainly when digital energy metering is considered. In the microcontroller-based energy meters the accuracy is influenced by the following specific factors [3]:

- Voltage and current sensors
- Analog electronics
- AD Converter resolution
- Sampling rate
- Properties of algorithms adopted to compute energy
- Type of arithmetic computation adapted

IV. ENERGY CALCULATION PROCESS

Energy measurement is based on the processing of voltage and current. Energy calculation process involves sampling of voltage and currents and is sensitive to frequency variations and if it is not taken care it can cause errors. Depending on sampling rate of ADC which is based on line frequency, voltage and current values are sampled and are converted to digital signals. The converted ADC values of voltage and current are read and energy is calculated, this energy is accumulated and is averaged. The calculation of the energy value is based on averaging method.

Following are the formulae to calculate active and reactive power [2] [4].

$$P_{Act} = \left(\frac{\sum_{n=1}^{Sample\ count} V_n \times I_n}{Sample\ count}\right)$$

$$P_{React} = \left(\frac{\sum_{n=1}^{Sample\ count} V_{90,n} \times I_n}{Sample\ count}\right)$$

Where,
Vn = Voltage sample at the n^{th} sample instant
In = Current sample at the n^{th} sample instant
Sample count= Number of samples in specified duration.
V90, n = Voltage sample at the n^{th} sample instant shifted by 90 degrees

The consumed energy is then calculated based on the active power value for each frame.

$$E_{Act} = P_{Act} \times \text{sample count}$$

$$E_{React} = P_{React} \times \text{sample count}$$

For reactive energy we use the 90 degree phase shift approach for two reasons:
1. This allows us to measure the reactive power accurately down to very small currents.
2. This conforms to international specified measurement method.

For changing inputs, accuracy of energy calculation depends on both measurement time averaging and time latency during which the input signal is not subjected to change. The line frequency may vary from grid side (acceptable variation) the accuracy of the energy calculation depends on the number of cycles considered for energy calculation. More cycles used for energy calculation, the more accurate it is.

PLL follows line frequency and if line frequency is changed then based on that PLL takes corrective action and thus the synchronization between sampling frequency and line frequency is achieved. Even if PLL is present for frequency synchronization, PLL takes some time to detect the change in frequency, there is some transition time. In that transition time sampling rate may vary. This can cause error in calculation. If we consider more number of cycles then this error reduces. In this paper 50 cycles are considered as it is the standard input frequency.

V. DESIGN OF ONE SECOND ENERGY LOGIC ALGORITHM

An interrupt for every One second from RTC will set the flag to indicate the Micro Controller Unit (MCU) to do the energy calculation using the accumulated voltage and current samples. The active energy is the measure of active power accumulated over a period of time. The accumulated active power for 1sec is multiplied with 1sec to get the active energy for 1sec. This watt-sec value is converted to kWh to get the basic measure of active energy.

The kWh for every 1sec is being accumulated with the previous value to get the cumulated kWh. Other instantaneous parameters like voltage RMS, current RMS, active power (kW), apparent power (kVA) and power factor are also calculated from the sampled and accumulated values of voltage and current. The flow of basic energy calculation is shown in Figure.3

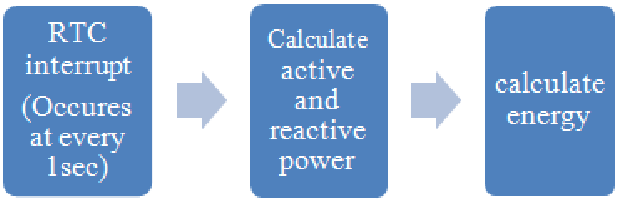

Figure.3: One second energy calculation process.

Figure 4 shows the flowchart of one second energy calculation process.

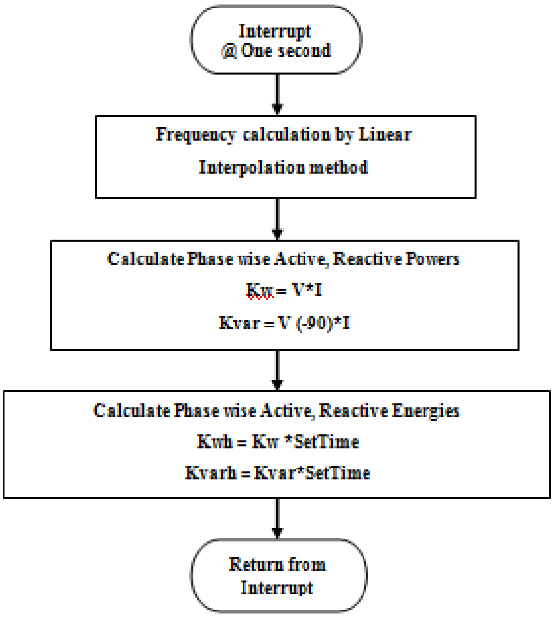

Figure.4: flowchart of one second energy calculation process.

VI. TEST RESULTS

Test results (Unity power factor) of the energy meter with percentage of the error are shown in table 1.

$$Power = \frac{VI}{1000} KW$$

Test results show the percentage of error to be 0.3. So for CLASS 1 type of meter 0.3% of error is acceptable. The test is conducted for the maximum duration of 20minutes and error is within the accepted limits.

Voltage	**Current**	**Time**	**Power in Kw**	**Error (%)**
240	5	1min	3.5999	0.316
240	5	5min	3.5999	0.300
240	5	10min	3.5999	0.319
240	5	20min	3.5999	0.310

Table.1: Test results

VII. CONCLUSIONS

Properties of algorithms adopted to compute energy is one among the factors that influences accuracy in the microcontroller-based energy meters. With the proposed energy calculation mechanism energy is averaged for one second so that percentage of error decreases.

REFERENCES

[1]. Discussion on Method of Improving the Accuracy of Electric Energy Metering YanhuaNing, XinruCai,Jiangxi, ocational and Technical College of Electricity, Nanchang, 330032, China. 2nd International Conference on Education Technology and Information System (ICETIS 2014)

[2]. APPLICATION NOTE-Atmel AVR1631: Single Phase Energy Meter using XMEGA A, 8-bit Atmel Microcontroller.

[3]. P. Mirandola, F. Veroni - ENEL/DSR/CRA Milan – Italy Gandelli - Politecnico di Milano –Italy “A New Approach to the Evaluation of Energy Metering Accuracy”.

[4]. P. A. V. Loss, M.M. Lamego, G.C.D. Soma and J.L.F. Vieira ,” A Single Phase Microcontroller Based Energy Meter”, IEEE Instrumentation and Measurement, Technology Conference,St. Paul, Minessota, USA, May 18-21,1998

[5]. Liu Xian-chun, Xiao Yu-ling, Zhao Liang-qin,” Design of Three-phase Multi-purpose Standard Electric Energy Meter”, 2011IEEE International Conference on System Science, Engineering Design and Manufacturing Informatization.

[6]. A high accuracy standard for electricity meters April 2011 / White paper by Lance.