

Instantaneous Power Measurement using Hall Sensor

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Abstract- Power consumption is an important area which has various applications. However, in most cases, the amount of electricity consumed by an appliance is not readily apparent. Many devices are equipped with an information tag with states the power consumption, but this is typically an average or maximum, and does not allow straightforward monitoring of such devices such as solid state TVs which often draw power even when "off". The idea behind this is to measure & to monitor power consumption in household, an industry, particular locality at any certain time constant. The total power is obtained by multiplying by instantaneous voltage of the load from voltage sensor by instantaneous current of load from hall sensor and summing the results of multiple phases. The total power is calibrated to the full scale of power meter for display to the operator.

Index Terms- Hall effect, Hall Effect current sensor, Instantaneous Power

I. INTRODUCTION

Power is defined as $p=iv$ where v and i the instantaneous values of the voltage and current. For constant DC, power is simply product of the voltage and current of the device. For AC it is not quite so simple. Power measurement in AC circuits can be quite a bit more complex than with DC circuits for the simple reason that phase shift complicates the matter beyond multiplying voltage by current to determine the product (multiplication) of instantaneous voltage and current= $I_{rms}V_{rms}\cos\theta$. where θ is the angle by which the current lags(inductive) or leads(capacitive) the voltage.

This paper is organized as follows. The proposed model and steps of the system are explained in section 2. Experimental result and analysis are presented in section 3. The conclusion is summarized in section 4.

This proposed model consists of measure hall voltage which is proportional to instantaneous current, measure ac voltage from potential transformer; multiply ac voltage and ac current by analog multiplier to measure and to monitor instantaneous power consumption at any certain time constant.

II. RESEARCH ELABORATION

A: Hall effect

When a current carrying conductor is placed into a magnetic field, a voltage will be generated perpendicular to both the current and the magnetic field. The principal is known as the Hall Effect.

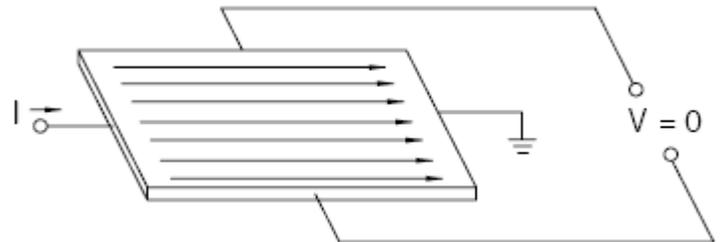


Fig-1: hall Effect principle when no magnetic field is present

Fig-1 shows a thin sheet of semi conducting material (Hall element) through which a current is passed. The output connection are perpendicular to the direction of current when no magnetic field is present current distribution is uniform and no potential difference is seen across the output.

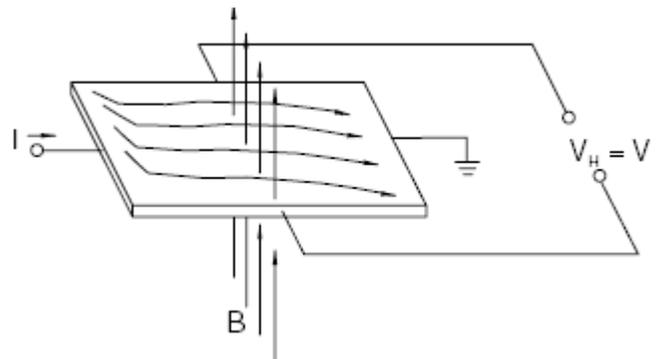


Fig-2: Hall Effect principle when magnetic field is present

When a perpendicular magnetic field is present, as shown a Lorentz force is exerted on the current. The force disturbs the current distribution, resulting in a potential difference (voltage) across the output. This voltage is called Hall voltage (V_H). The interaction of the magnetic field and current is shown in the equation below

$$V_H \propto I \times B \dots\dots\dots(i)$$

B. Hall Effect current Sensor

An open-loop Hall Effect current (Fig-3) measurement system is the easiest to understand. The Hall generator is mounted in the air gap of a magnetic core placed around the current carrying conductor or bus. This Hall Generator "chip". The conductor produces a magnetic field proportional to the current it is carrying. The magnetic core concentrates the magnetic field which is then sensed by the Hall Generator "chip" together with its electronic driving electronics. Because the

output of the Hall Generator “chip” is quite low, it is amplified to a useful level. In open loop designs, this amplified signal is the measurement output.

The performance of an open loop technology sensor is dependent upon the linearity of the Hall Generator “chip” and the linearity of the magnetic core. At higher currents, the linearity of the magnetic core declines quite rapidly dramatically degrading performance.

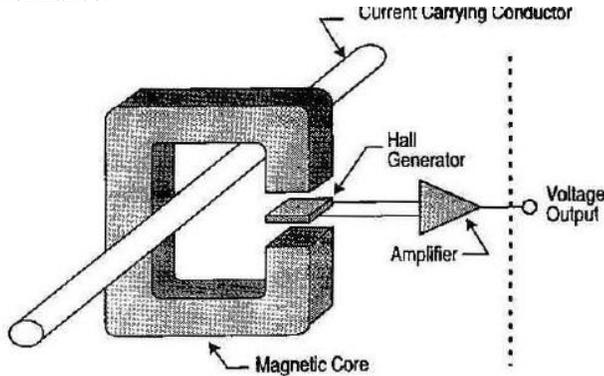


Fig-3: Open loop Hall Effect current sensor

A Closed loop Hall Effect (Fig-4) current measurement system starts with the same five basic building blocks: The magnetic core, Hall Generator “chip”, its constant current source and its amplification. However, in a closed loop design, this amplified Hall Generator “chip” signal is used quite differently. In a closed loop design, this signal is passed through coils wound around the core at a precise number of turns to offset or “null” the concentrated magnetic field in the core from the current carrying conductor or bus.

The measurement output is simply the current it takes to ‘null’ the flux in the core accounting for the turns ratio of the coil around the core to accomplish this. The Closed loop technique allows great improvements in sensor performance. By driving the core to nearly zero magnetic flux, the effects of magnetic core linearity as well as the effects of Hall Generator “chip” linearity are practically eliminated. This also eliminates the performance effects of temperature on the performance of the Hall Generator “chip”. The result is superior linearity, low temperatures drifts and fast measurement response.

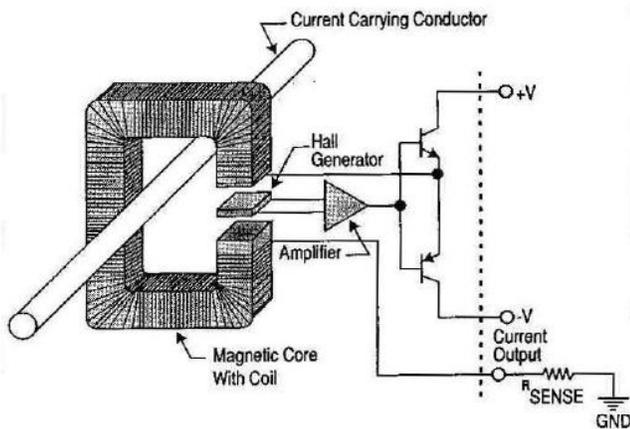


Fig-4: Close loop hall effect current Sensor

III. SYSTEM DEVELOPMENT

Instantaneous voltage is obtained from the voltage sensor (potential transformer) and instantaneous current is obtained from hall current sensor. Instantaneous current & instantaneous voltage is multiplied by electronic millimeter to calculate power.

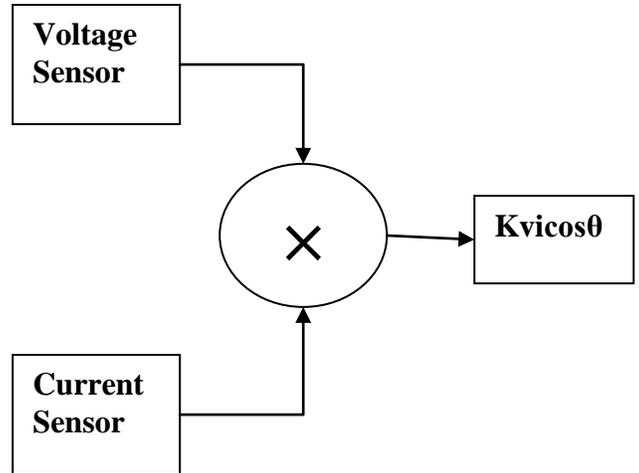


Fig-5: Proposed model

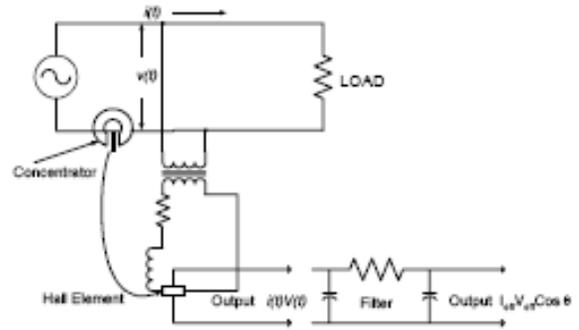


Fig-6: Schematic Diagram of the Power Measurement System

CSNE 151series close loop current sensor is used to measure instantaneous ac current and potential transformer is used to measure instantaneous ac voltage. Instantaneous current and instantaneous voltage is multiplied by electronic multiplier to calculate instantaneous power.

IV. RESULT AND ANALYSIS

The CSN Series Hall sensor is based on the principles of the Hall effect and the null balance or zero magnetic flux method (feedback system) and having the features of Current sensing up to 1200 amps, measures AC, DC and impulse Current, Lowest cost/performance ratio, Rapid response, High overload capacity, High level of electrical isolation between primary and secondary Circuits, Industrial operating temperature range, Small size and weight.

The magnetic flux in the sensor core is constantly controlled at zero. The amount of current required to balance zero flux is the measure of the primary current flowing through the conductor multiplied by the ratio of the primary to secondary windings. This closed loop current is the output from the device and presents an image of the primary current reduced by the number of secondary turns at any time. This current can be expressed as a voltage by passing it through a resistor.

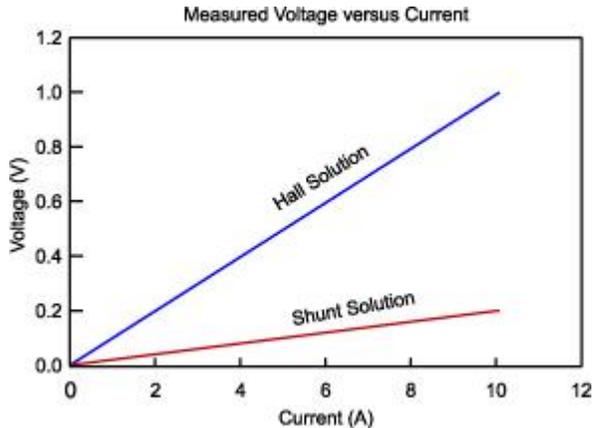
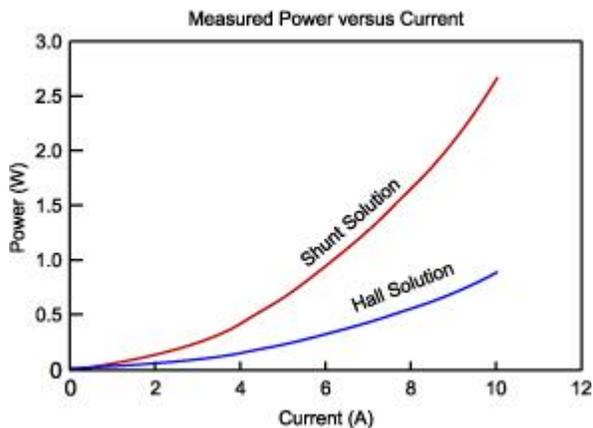


Fig-7: Graphical Representation of Measured Hall Voltage versus Current.



V. CONCLUSION

It provides a low cost alternative way to measure & to monitor of consumed instantaneous power automatically. It is proposed further extension to the system with added functionality such as storing and remote sensing.

REFERENCES

- [1] Paul Emerald, "Non Intrusive Hall Effect Current Sensing Techniques Provide Safe, Reliable Detection for Power Electronics," Allegro Microsystem, Inc Technical Paper STP 98-1, page 2.
- [2] "Using Current Monitoring for Load Analysis," Kele Technical Reference PM6, accessed 062802.
- [3] Pavel Ripka (ed.), "Magnetic Sensors and Magnetometers", 2001 Artech House Inc., Norwood, MA
- [4] D.Porto et al, "Design of a new air-cored transformer-Analytical modeling experimental validation", 39th IEEE-IAS annual conference record, Seattle, USA, 2004

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