Journal of Engineering Research and Reports

Volume 23, Issue 12, Page 302-320, 2022; Article no.JERR.94573
ISSN: 2582-2926

Performance of an Anisotropic Magneto-Resistive Sensor Electrical Energy Meter

Fredrick M. Kagucia [a#*], Owino George [b†] and Franklin M. Manene [a]

[a] Department of Electrical and Control Engineering, Egerton University, Kenya.
[b] School of Aerospace and Vehicle Engineering, Technical University of Kenya, Kenya.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/JERR/2022/v23i12786

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/94573

Original Research Article

Received: 12/10/2022
Accepted: 19/12/2022
Published: 23/12/2022

ABSTRACT

This paper presents a digital electrical energy meter based on an Anisotropic Magneto-Resistive (AMR) current sensor and an Arduino micro microcontroller. This study aimed at designing and fabricating a digital electrical energy meter using the AMR sensor which overcomes some of the shortcomings of traditional current sensors used in most energy meters, display electrical energy, consumer"s terminal voltage, supply current, power factor and „real-time" power consumption. The study was carried out in the Department of Electrical and Control Engineering, Egerton University between September 2018 and December 2020. The meter was designed using Proteus 8 Professional software and fabricated on a printed circuit board. Algorithms were developed in C-language and stored in the microcontroller to continuously sample voltage and current signals derived from a successive supply voltage divider and the AMR current sensor, respectively. The

---

[#] Post Graduate Student;
[†] Professor;
**Corresponding author: Email: kaguciafred@gmail.com;*

sampling frequency was 2 kHz and every 10,000 samples were carried out to compute the Root Mean Square (RMS) values of voltage and current. The fabricated meter digitally computed the cumulative electrical energy in kilo-Watt-hours (kWhrs) and the other variables and displayed them on a 16×2 Liquid Crystal Display (LCD) after a consumption of every 0.01 kWhrs. Statistical results on the displayed variables indicated that the meters tested were not significantly different at 0.95 confidence level implying that those meters had similar performance. The extra displays are important and useful to power consumers and service providers in energy utilization and improvement of the quality of the power supplied. Power factor is an exceptional feature in the prototype meter beneficial to both consumers and power agencies in the decision-making process of reducing bills and power distribution costs leading to improved efficiency and service delivery.

Keywords: *AMR current sensor; arduino micro-microcontroller; Sampling; LCD; electrically erasable programmable memory.*

ABBREVIATIONS

ACEEE : *American Council for an Energy-Efficient Economy*
ADC : *Analogue to Digital Conversion*
AMR : *Anisotropic Magneto-Resistive*
AMRg : *Automatic Meter Reading*
ANOVA : *Analysis of Variance*
CT : *Current Transformer*
EEPROM : *Electrically Erasable Pogrammable Memory*
GMR : *Giant Magneto-Resistive*
IEC : *International Electro-technical CommissionI*
OT : *Internet of Things*
KEBS : *Kenya Bureau of Standards*
kWhr : *kilo-Watt-hour*
LCD : *Liquid Crystal Display*
LSD : *Least Significant Different*
MHz : *Mega-Hertz*
OPAMP : *Operational Amplifier*
PCB : *Printed Circuit Board*
Pf : *power factor*
RMS : *Root Mean Square*
SAS : *Statistical Analysis of Systems*
TMR : *Tunneling Magneto-Resistive*

1. INTRODUCTION

Electromechanical meters have been used over a century and have been used in Kenya for over a century. They have an excellent combination of simplicity and reliability but lack the additional functionalities needed to integrate customers with a smart grid, such as real-time bills, range of measured quantities and communication capability. For these reasons, the transition to solid-state electrical energy meters has not therefore been one of choice, but of necessity as noted by Seal and McGranaghan [1].

Electrical energy meters may be classified into Electromechanical/induction, Electronic and Smart /Prepaid types as noted by Nwagbo and Baah [2]. Smart meters are basically electronic devices which measure the energy consumption regularly and report this to the consumers, utility companies and also third party service providers as reported by Aswathi et al. [3]. A Prepaid energy meter enables power utilities to collect electricity bills from the consumers prior to its consumption [4]. Payments are made using tokens and power is cut off after the consumption of units paid for but restored automatically after another token is paid. Postpaid metering involves payment of energy consumed after usage as noted by Shomuiywa et al. [5].

An Automatic Meter Reading (AMRg) system consists of a consumption measurement, meter reading and data transmission, and data processing and billing as noted by Arun et al. [6]. If meter data from the analogue input circuits is available in electronic form it becomes feasible to add communications to the meter, allowing the meter to use AMRg to access data remotely via a communication link [7]. This remote reading technique has the advantage of saving utility providers the expense of periodic trips to physical locations for meter readings [8].

The most common current sensors used for electricity metering devices are resistive shunts, Hall- effect sensors and current transformers as noted by Koon [9]. These sensors have several shortcomings which need to be addressed. Rogowski coil sensors are widely used in USA. Current transformers and current shunts have been used at the analogue inputs of modern wireless digital electrical energy meter having a microcontroller, a transmitter and a receiver with good results as reported by Ashiquzzaman et al. [10]. Current measurement is considered to be more challenging because it requires a wider range of measurements and processing of a wider range of frequencies that are present in the