International Journal of Advances in Electrical Engineering

E-ISSN: 2708-4582
P-ISSN: 2708-4574
IJAEE 2022; 3(1): 80-83

www.electricaltechjournal.com
Received: 19-01-2022
Accepted: 23-02-2022

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The future of computing: embedded systems development; a look at the design of integrated utility scale devices

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Abstract
Digital logic are the wave of the future in the world of technology. Components of embedded systems may be found at the heart of any important piece of modern equipment. These include self-driving automobiles, intelligent building layouts, computerized manufacturing processes, aerospace gear, and smart grid electricity systems, among other things. Embedded systems, sometimes known as ES for short, are systems that operate inside other programs to make those other processes more efficient and productive. In this article, recent technical developments in this branch of engineering are discussed, and the study explains how these developments are relevant to practically every other sector of technology in the 21st century. In order to give a comprehensive knowledge of the rising trend of significance of this evolving engineering sector, this article further tends to limit on the modern styles for energy meter reading, which now integrate embedded device dynamics in attempt to optimise its capabilities, thus going to paint a detailed image of the beneficial impacts that are produced by ES Designing.

Keywords: Embedded systems, energy meter, microcontroller, programming

Introduction
Beginning with the creation of hard mechanical or electrical responses to consumer concerns, science has advanced into its present state. Recently, engineers have shown a growing interest in the development of fluid solutions that are compatible with other adaptive characteristics and may contribute to the achievement of more precise outcomes. Automobiles of today have evolved from being merely electromechanical vehicles to being technological marvels that include a plethora of microprocessor devices that are capable of calculating lines of code. According to studies, a typical new-model automobile ships with more than 100 million code lines that are executed by the numerous embedded processors. These commands all carry out certain tasks that contribute to the vehicle's overall effectiveness. These very same applications of technology may be found, to name just a few, in the fields of aviation, medicine, agriculture, and oil & gas, amongst others.

It is essential to keep in mind that the micro computer controllers are a part of what is known as the embedded platform. These controllers collaborate with the many other technical, electric, and digital systems to form the electronic circuit. Controllers have been characterized as computer networks that have specific functions inside a broader mechanical or electronic system, sometimes with real-time processing limitations. This definition was developed over the course of several years. These are often a component of a more comprehensive gadget that also contains other elements such as hardware and moving components. Many of the gadgets that are commonly used nowadays are controlled by embedded systems. It is estimated that embedded systems use around 98% of all microcontrollers that are currently being produced. Because they are computers designed for a particular purpose, special techniques are often entirely encased by the equipment they manage. In contrast to general-purpose processors, embedded systems carry out activities that have been pre-defined and typically have extremely precise needs. In addition, given that the system is designed to do a certain activity, design team are able to utilize it, so lowering the size of the product as well as the costs of it, given that it is often manufactured in mass quantities. When carried out in this manner, the cost reductions have the potential to be compounded by millions of pieces.

As this paper aims to show the improvements this field of Engineering has brought to the technology domain, it narrows down on the Power Systems Digital Energy Metering subject.

Energy is a product of work. It is generally defined as the amount of power used/expended over a time range. In Electrical Engineering, An electrical current that enables one to carry out work is what we mean when we talk about electric power. With this in mind, it is expedient to understand that electrical energy in this case is dependent on a series of analogue variables, primarily current and voltage. These two variables are the active elements used in the derivation of the energy usage per time.

"In most cases, the operation of electricity meters involves continuously measuring the instantaneous voltage (volts), current (amperes), and finding the product of these two to give immediate electrical power (watts). This instantaneous electrical power is then integrated against time to give the amount of energy that was used (Joules, Kilowatt-hours etc.)".

These energy metres are mainly positioned to enable easy quantification of the energy usage per time. In other applications, it is helpful in the process of systematizing the price of the energy that individual consumers utilize.

The concluding part of this paper explains the methodology adopted in the design and simulation of the modern day energy metering system founded on embedded systems dynamics. The paper will also juxtapose its benefits, advantages and improvement areas against the previously employed analogue metering system, thereby validating the positive impact offered by intelligent application of Embedded Systems Engineering in Power Systems.

Literature review

In the year 2009, SukritiJalali of TATA Consultancy Services released a white Paper on „The Trends and Implications in Embedded systems Development, the primary emphasis of the article was a great introduction to integrated devices, including topics such as their essential parts and the many fields in which they may be used. In addition to this, it included a summary of the developing tendencies as well as the consequences these tendencies have for the design and production of these platforms. Sukriti is an Engineers who has over 15 years of involvement expertise in the development and production of real-time integrated devices. These systems have been used to a wide number of areas, including factory automation, auto components, mobility, and process improvement.

In the year 2011, M. C. Ndinechi, O. A. Ogungbenro, K. C. Okafor published a peer reviewed paper on „Digital Metering System: A Better Alternative For Electromechanical Energy Meter In Nigeria‟. The paper expatiates on the energy metering technology which were being used in some parts of Nigeria, although found to be highly unreliable, thereby requiring reading, calculating, and distributing invoices requires a significant amount of labor and time. They brought to light the need of digitizing the current analogue meter used by the "Power Holding Company of Nigeria (PHCN)", as well as the continued growth for smart energy compatibility meters. The paper explicitly showed the design process for a low cost digital meter.

Shifting from the analogue formalities, the device incorporates voltage and current sensors and signal conditioning, all built from discrete components, PIC and liquid crystal display unit. As the PIC is an embedded program driven device, it is programmed in C language. The design displays power consumption per time as well as expected bill to be paid [9].

1. Embedded systems overview

Real-time operations, dependability, repair, and cost-effectiveness are key requirements for integrated devices. As a result, there is a strong pressure placed on both the program and the technology (I/O, Asics, DSP, and FPGA). Because of this, special techniques may be roughly broken up into two distinct categories, which are as follows:

2. “Embedded Software and Embedded Hardware”

Two important subfields within the realm of embedded platforms are the FPGA design for chipset and the Pcb Layout etc. fields. Integrated software is developed via the implementation stage, which also encompasses the creation of mobile applications and embedded systems. Among the most essential pieces of middleware is known as the operating system (OS), and its primary function is to hide the specifics of the hardware resources by providing a more user-friendly appearance to the computer program. In embedded devices, such as mobile phones, cars, and avionics, the operating system also provides a simpler interface to the many sensors and devices that these technologies communicate with. Other systems include: These kinds of systems have very limited access to resources; thus, the operating system has to make optimal use of the CPU and the memory. In moreover, the ES OS has to include support for real-time planning so that it may offer service guarantees based on the temporal limitations of the applications.

“Core Components”

The following is a list of the primary components that make up an embedded system:

1. Microcontrollers / digital signal processors (DSP)
2. Integrated chips Real time operating system (RTOS) - including board support package and device drivers
3. Industry-specific protocols and interfaces
4. Printed circuit board assembly

Statistics show that the African continent is yet to fully tap into this emerging field of Engineering. Currently, no African Higher Institution undertakes Embedded Systems Engineering as a full scale undergraduate or postgraduate course. At best, it is offered as a module within the main course, carrying very few credits and only covering a handful of modules necessary in the field of study. Although technical schools exist which offer few months of training as well as certification courses in this field, it is penitent to note that there is a complete absence of a degree awarding institution in Embedded Systems

Engineering currently in Africa (2015). Consequently, the number of Embedded Systems professionals in the continent are in hundreds or at best, a few thousands and major embedded systems projects are usually outsourced to more developed companies in Europe

Case study: design of modern digital metering system viaprime application of embedded systems

One key aspect of Embedded Systems Engineering is its link to Digital signal Processing. It is essential to keep in mind that computers operate via the use of binary codes, as well as the extraction and processing of results in digital form empowers both user and developer to assess numerically the data being processed. This explains why the digitalization of the metering system results in the development of a much better and user friendly device.

To begin with, "the PIC Microcontroller's high-resolution sigma-delta Analogue-to-Digital conversion" capabilities is used in order to convert the voltage level that are being detected. After that, the relevant operations are performed on these values to obtain their decimal representations. The immediate power, measured in watts, may be calculated by multiplying the decimal voltage by the decimals current. The energy used can be calculated by integrating this value over time and is often expressed in kilowatts (kWh).

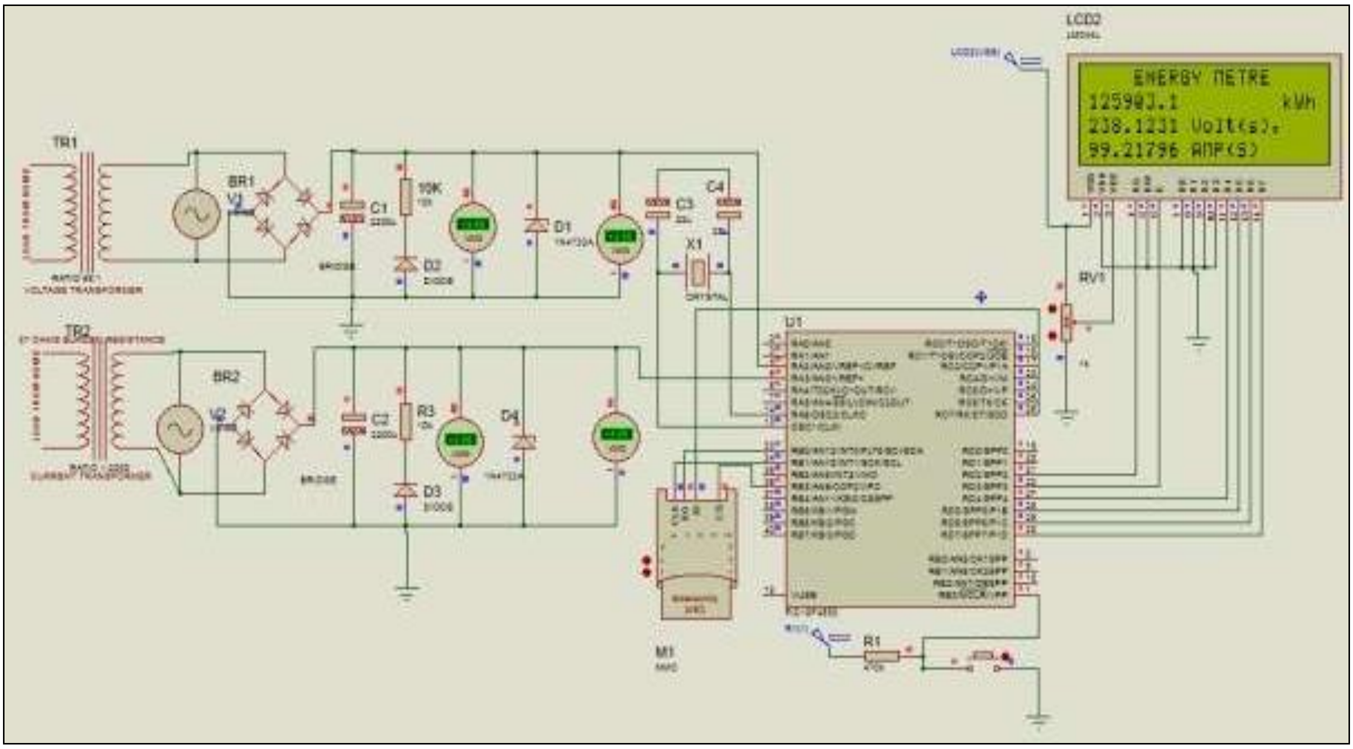

Fig 1: Schematic of the Digitalized Energy Meter

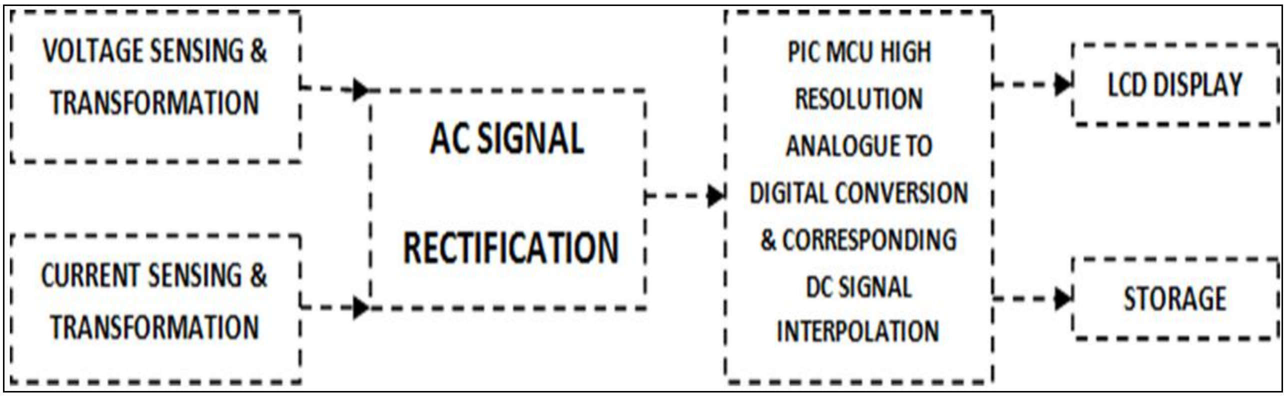

Fig 2: Block Diagram: The operation of the Energy Metre System

The sections below shed more light on the various stages involved in the metering process.

Voltage Sensing & Transformation Stage

The majority of the electrical impulses that we are surrounded by are analog in nature. That indicates a variable's degree of variation is proportional to another measure. The first element is almost always the voltage, but the secondary quantity may be the temperatures, pressure, lighting, pressure, or accelerating.

In the design of the embedded systems digitalized metre, the voltage sensing is done using a voltage step down transformer designed to have a primary to secondary winding ratio of 55:1. The main circuit of this transformers is linked to the voltage that is distributed throughout the house via the electricity distribution box.

$$Vp/Vs = Np/Ns \tag{1}$$

$$V_{PEAK} = \sqrt{2} * V_{RMS} \tag{2}$$

The Energy metre is designed to measure a maximum of 240V, 100A AC signal. This voltage is then transformed into an equivalent between the ranges of 0 to 5V DC. With the transformation system in place, other inputs between 0 and 240V AC will also be automatically transformed. This is due to the fact that the analogous pin of the Microcontrollers can only measure up to 5V DC of power at its highest setting.

"Using the input voltage of 240V as an example, we can deduce from the equation above that the transformer will step down an input voltage (Vp) of 240V AC into 4.35V

R.M.S at its secondary terminal. Furthermore, we can calculate the peak output voltage of the transformer to be 6.2Vpeak using the equation below". This peak secondary terminal output voltage passed through the rectifier circuit will drop 1.2Volts, thereby delivering a total of about 5V DC to the analogue pin of the MCU.

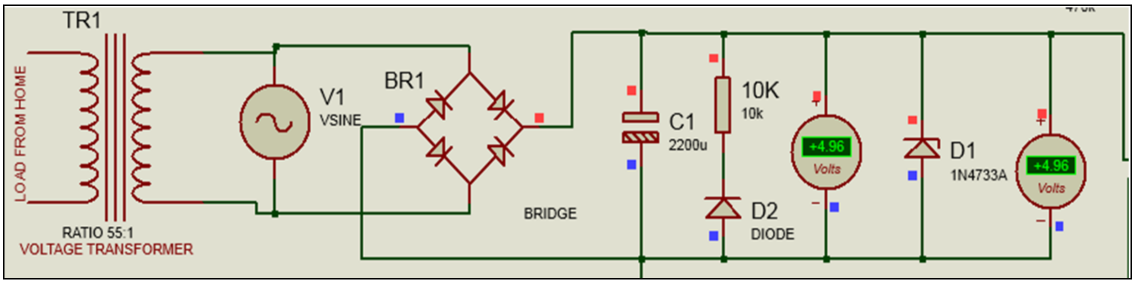

Fig 3: Schematic of the Voltage Transformational System

Key optimization

The digitized energy metering system offers the owner a more user-friendly metre from which concise energy usage reading can be made in numerical values without having to make near estimates as is common with analogue systems used around the world. The system allows the user to see current load status as well as the cumulative energy usage reading.

The Multimedia Memory Card compatibility of the MCU also makes it possible to keep instantaneous energy usage records.

Conclusion

The vivid design example and optimized performance results of the digital energy metre which were based on embedded systems implementations is a close representation of the positive effect embedded systems have on the primary systems they function on. Consequently, this field of Engineering has become of special importance. Oil and Gas industries now employ ES to prevent pipeline vandalization, medicine now makes use of embedded artificial human organs, diagnostic equipment, patient monitoring and surgical systems. A larger percentage of Bank's financial transactions and operations are now via cards with embedded electronic chips. Satellite systems, intelligent buildings, home automation, weather systems, flight control systems, aircrafts management systems and many more fields of technology enjoy varying degrees of ES implementations. It can therefore be stated that Embedded Systems technology is and possesses the potential to be the centre of the 21st century world.

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