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Smart Energy Meter and Feedback System for Effective Utility of Power

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Abstract: The authors provide an outline of the potentialities of the sensing systems and IOT to monitor efficiently the energy flow among nodes of electric network. The design and development of a Smart Power monitoring Meter has reported in this paper. System has been designed that can be used to monitor electrical parameters such as voltage, current and power. The system consists of a smart sensing unit that detects the electrical parameters .It can reduce costs for the consumers and thereby improve grid stability. A developed prototype has been extensively tested and experimental results have compared with conventional measuring devices. Monitoring and control of smart grids is essential for its efficient and effective functioning.

Keywords: IoT, smart sensing

I. INTRODUCTION

Improvements in power electronics technologies and utilization of renewable energy sources for power generation have given rise to the use of distributed generation and create concept of smart grids and micro grids to overcome rapid increase in the demands for electricity and depletion of conventional energy sources. Monitoring of power system parameters like voltage, current and power at distribution level is crucial for efficient functioning of smart grid. The power exchange between the smart grid and the utility grid happens by switching. This switching needs complete synchronism between the smart grid and the utility grid. An economic & reliable communication backbone along with accurate monitoring system is essential. Monitoring of the power system essentially has two main modules: communication module which is the backbone and the sensor module for sensing the different parameters like voltage, current and power. The basic communication architecture is simple and the actual network topologies can be very diverse and depend mostly on the field level network. The sensor node is one of the main parts of a WSN. The hardware of a sensor node generally includes four parts: the power and power management module, a sensor, a microcontroller, and a wireless transceiver. The power module offers the reliable power needed for the system. The sensor is the bond of a WSN node which can obtain the environmental and equipment status. A sensor is in charge of collecting and transforming the signals, such as light, vibration and chemical signals, into electrical signals and then transferring them to the microcontroller. The microcontrollers receive the data from the sensor and processes the data accordingly.

II. WIRELESS POWER TRANSFER

Wireless Power Transfer (WPT) using magnetic resonance is the technology which could set human free from the annoying wires. In fact, the WPT adopts the same basic theory which has already been developed for at least 30 years with the term inductive power transfer. WPT technology is developing rapidly in recent years. At kilowatts power level, the transfer distance increases from several millimeters to several hundred millimeters with a grid to load efficiency above 90%. The advances make the WPT very attractive to the Electric Vehicle (EV) charging applications in both stationary and dynamic charging scenarios. This paper reviewed the technologies in the WPT area applicable to EV wireless charging. By introducing WPT in EVs, the obstacles of charging time, range, and cost can be easily mitigated. Battery technology is no longer relevant in the mass market penetration of EVs. It is hoped that researchers could be encouraged by the state-of-the-art achievements, and push forward the further development of WPT as well as the expansion of EV. For energy, environment, and many other reasons, the electrification for transportation has been carrying out for many years. In railway systems, the electric locomotives have already been well developed for many years. A train runs on a fixed track. It is easy to get electric power from a conductor rail using pantograph sliders. However, for electric vehicles, the high flexibility makes it not easy to get power in a similar way. Until now, the EVs are not so attractive to consumers even with many government incentive programs. Government subsidy and tax incentives are one key to increase the market share of EV today In an EV, the battery is not so easy to design because of

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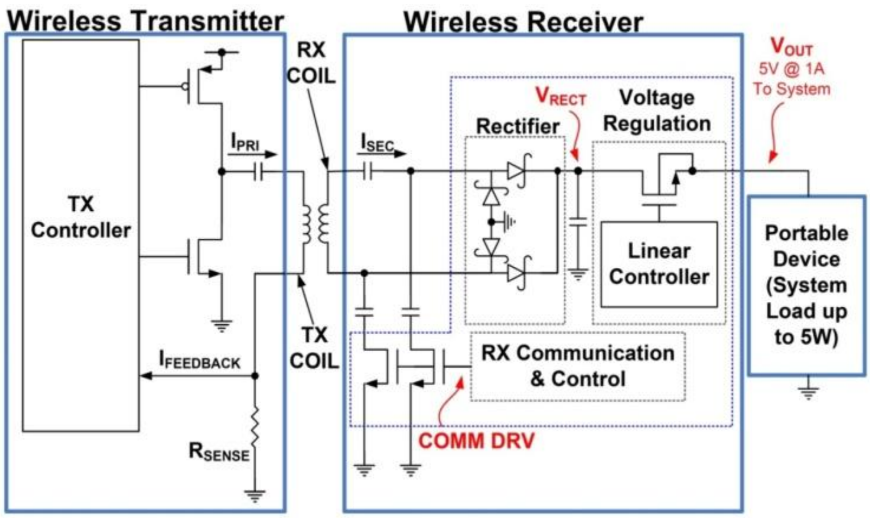
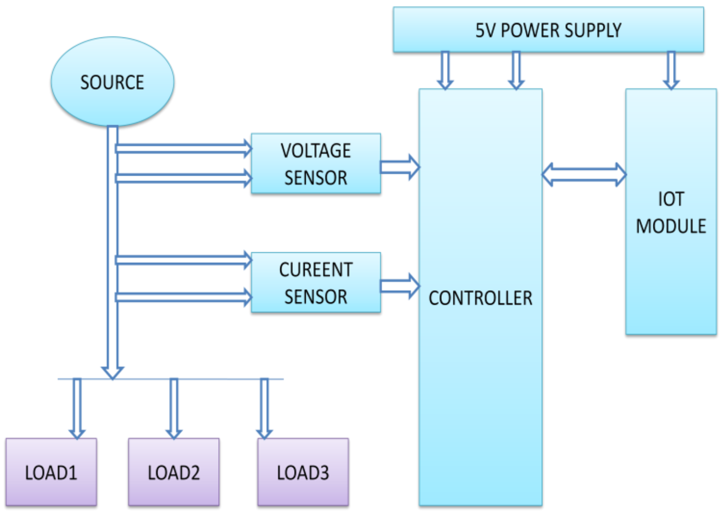
the following requirements: high energy density, high power density, affordable cost, long cycle life time, good safety, and reliability, should be met simultaneously. Lithium-ion batteries are recognized as the most competitive solution to be used in electric vehicle.



III. BLOCK DIAGRAM



The power meter has been projected in order to permit the interoperability among several meters geographically distributed in the grid. For this reason, a software-based control panel has been developed to make possible the communication with each meter. The program runs on a server which could simulate the control center of a smart power grid. By internet network or the same electric network, the control station can get access simultaneously to several meters of the grid acquiring the computed data. The control station can even reconfigure or reprogram the single meter if required.

IV. CURRENT TRANSDUCERS AND SWITCHES

Current transducers convert monitored current to a proportional AC or DC voltage or milliamp signal. These small devices have extremely low insertion impedance. Inductive transducers are easier to install because they are two-wire, self-powered (0–5 VDC or 0–10 VDC outputs), or loop-powered (4-20mA output) instruments. Hall effect transducers are generally four-wire devices and require a separate power supply. Because both types can be connected directly to data systems and display devices, they are ideal for monitoring motors, pumps, conveyors, machine tools, and any electrical load that requires an analog representation over a wide range of currents. Designed for monitoring and switching AC and DC circuits, current-operated switches integrate current sensing and signal conditioning with a limit alarm.

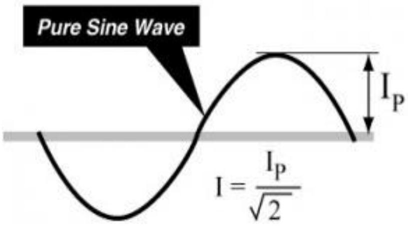


Fig: Sine waveform

The switch output is activated when the current level sensed by the limit alarm exceeds a user-selectable threshold. Inductive current switches generally feature solid-state output switches. They are self-powered and consequently are a good choice for retrofits, renovations, and temporary monitoring. A Hall effect current switches have either a solid-state or relay output. Their high power requirements preclude a self-powered design, and a separate power source requirement increases their installation cost.

V. METHODS OF CURRENT SENSING

Current sensors facilitate the automation of industrial pumping stations by allowing real-time monitoring of pumps, compressors, heaters, fans, and other powered equipment. Measuring power input can help improve efficiency, safeguard personnel, and reduce motor maintenance costs in a wide range of factory applications. This photo was shot from an overhead crane at National Fuel Gas's natural gas compressor station in Ellisburg, Pennsylvania. The five integral engine/compressors (large-bore, slow-speed, ~200 rpm, ~2200 hp), made by Dresser-Rand, are running in parallel. Each panel on the left controls and monitors an engine/compressor unit. (Courtesy of Basic Systems, Inc.)

Hall Effect Sensor: Hall effect and induction use different techniques to measure the magnetic field around a current-carrying conductor. The Hall effect sensor is best suited to DC current, and the inductive sensor to AC current. Hall effect and induction are noncontact technologies based on the principle that for a given current flow, a proportional magnetic field is produced around the current-carrying conductor. Both technologies measure this magnetic field, but with different sensing methods.

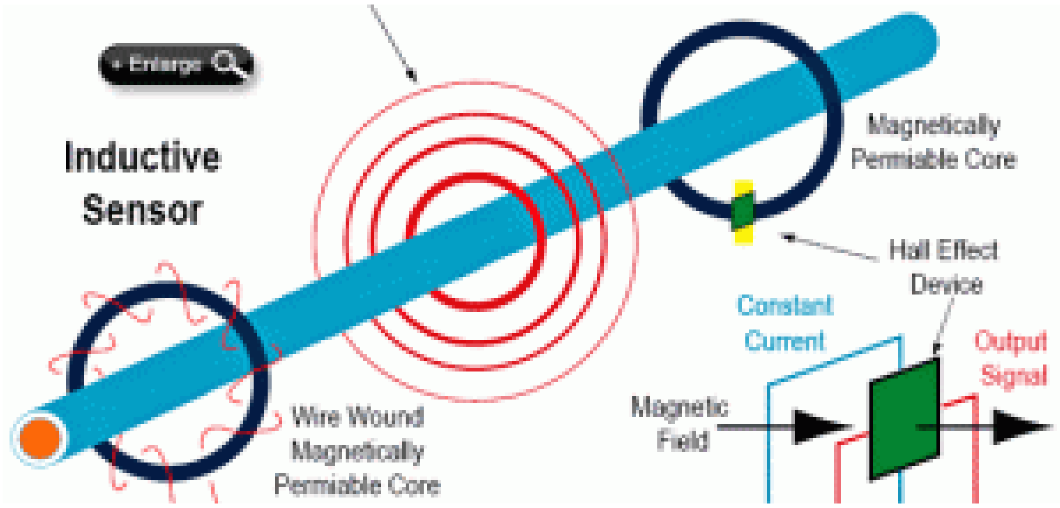


Fig.1.8.1 Hall Effect Current Sensor

Voltage Sensor: A voltage transformer theory or potential transformer theory is just like a theory of general purpose step down transformer. Primary of this transformer is connected across the phase and ground. Just like the transformer used for stepping down purpose, potential transformer i.e. PT has lower turns winding at its secondary. The system voltage is applied across the terminals of primary winding of that transformer, and then proportionate secondary voltage appears across the secondary terminals of the PT. The secondary voltage of the PT is generally 110 V. In an ideal potential transformer or voltage transformer, when rated burden gets connected across the secondary; the ratio of primary and secondary voltages of transformer is equal to the turns ratio and furthermore, the two terminal voltages are in precise phase opposite to each other. But in actual transformer, there must be an error in the voltage ratio as well as in the phase angle between primary and secondary voltages. The errors in potential transformer or voltage transformer can be best explained by phasor diagram, and this is the main part of potential transformer theory. The difference between the ideal value Vp/KT and actual value Vs is the voltage error or ratio error in a potential transformer, it can be expressed as,

Phase Error or Phase Angle Error in Potential or Voltage Transformer

The angle ′β′ between the primary system voltage Vp

The reversed secondary voltage vectors KT.

Vs is the phase error.

VI. SIGNAL CONDITIONING PROCESSES

Signal conditioning can include amplification, filtering, converting, range matching, isolation and any other processes required to make sensor output suitable for processing after conditioning

Signal Conditioning: In electronics, signal conditioning means manipulating an analog signal in such a way that it meets the requirements of the next stage for further processing. Most common use is in analog-to-digital converters in control engineering applications, it is common to have a sensing stage (which consists of a sensor), a signal conditioning stage (where usually amplification of the signal is done) and a processing stage (normally carried out by an ADC and a microcontroller). Operational amplifiers (op amps) are commonly employed to carry out the amplification of the signal in the signal conditioning stage.

Filtering: Filtering is the most common signal conditioning function, as usually not all the signal frequency spectrum contains valid data. The common example is 50/60 Hz AC power lines, present in most environments, which will produce noise if amplified.

Isolation: Signal isolation must be used in order to pass the signal from the source to the measuring device without a physical connection: it is often used to isolate possible sources of signal perturbations. Also notable is that it is important to isolate the potentially expensive equipment used to process the signal after conditioning from the sensor.
Magnetic or optic isolation can be used. Magnetic isolation transforms the signal from voltage to a magnetic field, allowing the signal to be transmitted without a physical connection (for example, using a transformer). Optic isolation takes an electronic signal and modulates it to a signal coded by light transmission (optical encoding), which is then used for input for the next stage of processing.

VII. IC VOLTAGE REGULATORS

IC voltage regulators are three-terminal devices that provide a constant DC output voltage that is independent of the input voltage, output load current, and temperature. There are three types of IC voltage regulators: IC linear voltage regulators, IC switching voltage regulators, and DC/DC converter chips. IC linear voltage regulators use an active pass element to reduce the input voltage to a regulated output voltage. By contrast, IC switching voltage regulators store energy in an inductor, transformer, or capacitor and then use this storage device to transfer energy from the input to the output in discrete packets over a low-resistance switch. DC/DC converter chips, a third type of IC voltage regulators, also provide a regulated DC voltage output from a different, unregulated input voltage. In addition, DC/DC converters are provide noise isolation regulate power buses. For each type of IC voltage regulator, the output voltage can be fixed or adjusted to a value within a specified range. IC voltage regulators are available with a variety of features. Some devices have more than one output or channel. Others have an internal circuit to control the amount of current produced, or an error flag for monitoring outputs that drop below a nominal value. Reverse voltage protection prevents damage in applications where users can accidentally reverse battery polarity. Thermal shutdown protection turns off IC voltage regulators when the temperature exceeds a predefined limit. Shutdown (inhibit) pins are used to disable regulator outputs. Regulators employed here is a 3 terminal voltage regulator (78xx series). IC regulator units provide regulation of either a fixed positive voltage, a fixed negative voltage, or an adjustable set voltage.

VIII. THREE-TERMINAL VOLTAGE REGULATORS

Fig shows the basic connection of a three-terminal voltage regulator IC to a load. The fixed voltage regulator has an unregulated dc input voltage, Vi, applied to one input terminal, a regulated output dc voltage, Vo, from a second terminal, with the third terminal connected to ground. For a selected regulator, IC device specifications list a voltage range over which the input voltage can vary to maintain a regulated output voltage over a range of load current. The specifications also list the amount of output voltage change resulting from a change in load current (load regulation) or in input voltage (line regulation). The series 78 regulators provide fixed regulated voltages from 5 to 24 V. Figure shows how one such IC, a 7812, is connected to provide voltage regulation with output from this unit of +12V dc. An unregulated input voltage VI is filtered by capacitor C1 and connected to the IC’s IN terminal.

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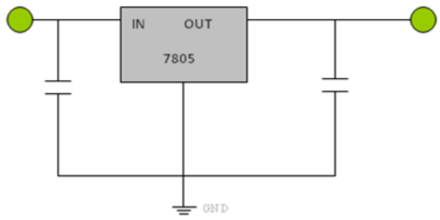
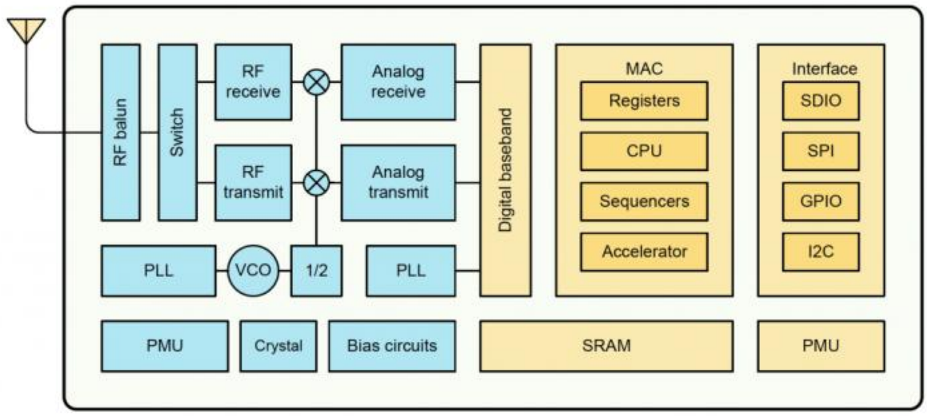


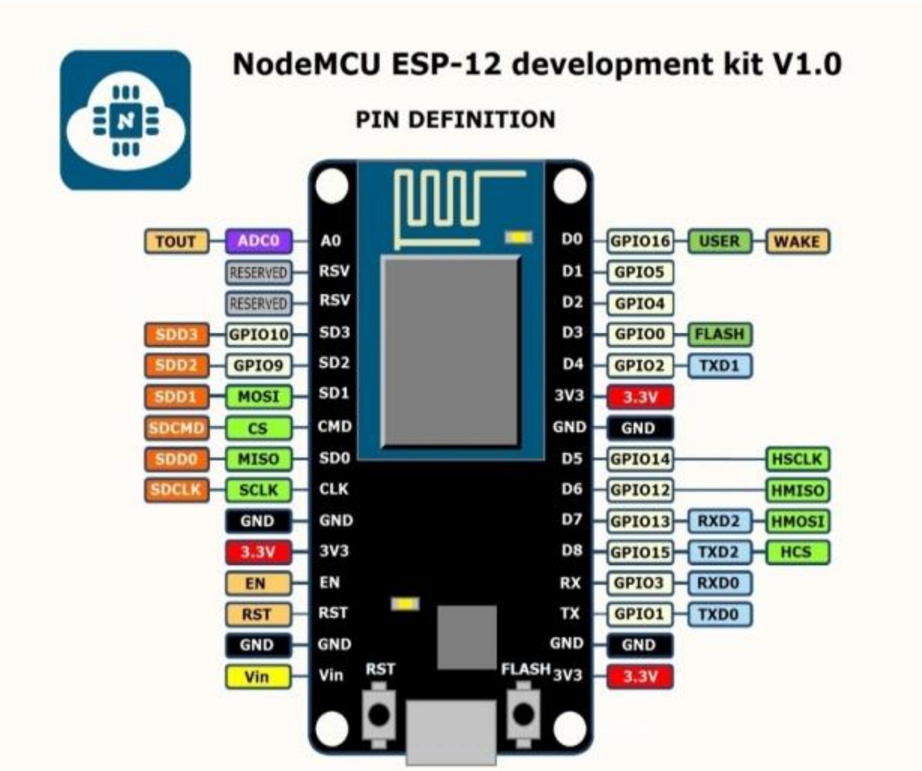
Fig: circuit diagram of fixed positive regulator

The IC's OUT terminal provides a regulated + 12V which is filtered by capacitor C2 (mostly for any high-frequency noise).

IX. NODE MCU ESP8266

NodeMCU is an open source IoT platform. It includes firmware which runs on the ESP8266 Wi-Fi SoC from Espressif Systems, and hardware which is based on the ESP-12 module. The term "NodeMCU" by default refers to the firmware rather than the development kits. The firmware uses the Lua scripting language. It is based on the eLua project, and built on the Espressif Non-OS SDK for ESP8266. It uses many open source projects.





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As Arduino.cc began developing new MCU boards based on non-AVR processors like the ARM/SAM MCU and used in the Arduino Due, they needed to modify the Arduino IDE so that it would be relatively easy to change the IDE to support alternate toolchains to allow Arduino C/C++ to be compiled for these new processors. They did this with the introduction of the Board Manager and the SAM Core. A "core" is the collection of software components required by the Board Manager and the Arduino IDE to compile an Arduino C/C++ source file for the target MCU's machine language. Some ESP8266 enthusiasts developed an Arduino core for the ESP8266 WiFi SoC, popularly called the "ESP8266 Core for the Arduino IDE". This has become a leading software development platform for the various ESP8266-based modules and development boards

X. CONCLUSION

The real-time monitoring of the electrical appliances can be viewed through a website. The processed voltage, current values are displayed on LCD screen, which can be controlled through application A Proteus is software for microprocessor simulation, schematic capture, and printed circuit board design. It is developed by Lab center Electronics. The sensor networks are programmed with various user interfaces suitable for users of varying ability and for expert users such that the system can be maintained easily. The current and voltage of a transformer is monitored continuously using wireless sensors. When the hacker tries to theft a load it sent a message notification to a customer. The simulation is carried out in Proteus software and simulations are showed.

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