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Energy Meter Monitoring Over Internet of Things

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Abstract: *The Existing domestic Energy meter reading systems universally exist many problems, such as difficulty in construction, too narrow bandwidth, too low rate, poor real time, not two way communication quickly etc. To solve above problems, this paper uses the wireless technology for Automatic Meter Reading system. A proposed method provides the communication between the Electricity Board section and the consumer section using Internet of things (IOT) for transmitting the customer's electricity consumption and bill information that is calculated using ARM7 microcontroller. The power fluctuations are monitored using the voltage sensor and current sensor are fed to the microcontroller which indicates it to the Electricity Board. Depending on the power generation, the house hold devices are controlled automatically. From Electricity Board section the information regarding the bill amount and payment are communicated to the consumer via Global System for Mobile communication. The power and billing information is continuously transmitted by the use of Internet of Things and monitored by the Electricity Board section. Whenever there is power theft identified can be sent from the Electricity Board section to cut the supply to the customer.*

The main objective of the paper is to develop an IoT based energy meter monitoring system to transmit the number of units consumed and the cost on a monthly basis. Conventionally meter reading is taken manually and a reader has to visit the premises of the costumer it poses different problems. This idea addresses those problems and provides a modern approach to its solution. Since IOT is cost effective compared to SMS, monitoring of energy meters at lower cost is made possible.

Keywords: *Internet of things, ARM7 microcontroller, Energy meter and Global System for Mobile.*

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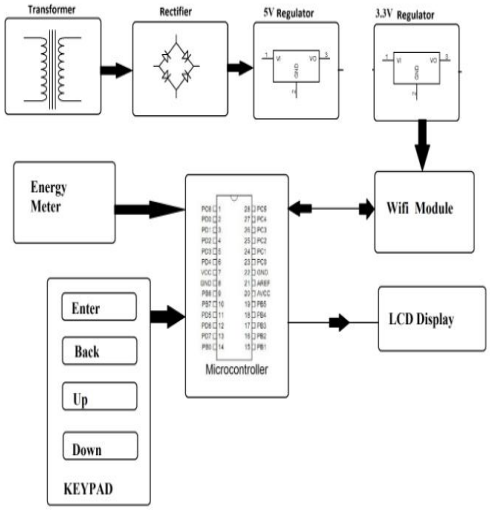
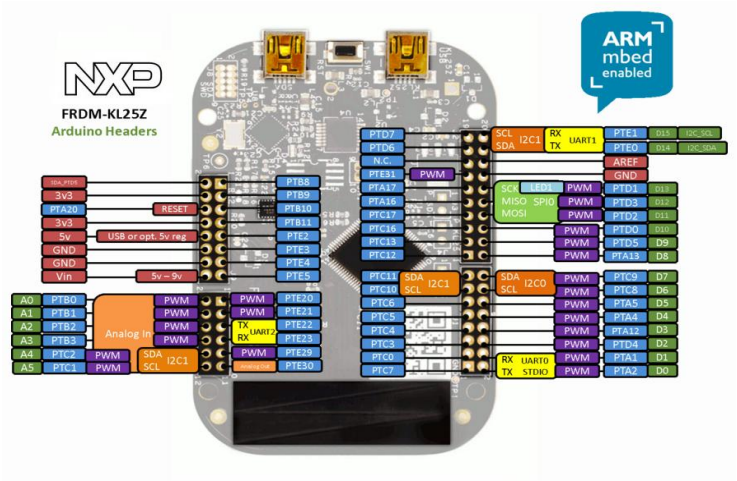
I. Introduction

Embedded systems and Real Time Operating systems (RTOS) are two among the several technologies that will play a major role in making these concepts possible. A large number of people are already depending on operating systems for real time applications, these 'eyes in the sky' are now going to make an impact on our everyday lives in a more significant manner. Embedded systems are pre-designed without connections and operate as per the required task. But in operating systems instruction is design-oriented. These systems are basically platform-less systems Almost every car that rolls off the production line these days makes use of embedded technology in one form or the other; most of the embedded systems in automobiles are rugged in nature, as most of these systems are made up of a single chip. No driver clashes or 'systems busy' conditions happen in these systems. Their compact profiles enable them to fit easily under the cramped hood of a car. These systems can be used to implement features ranging from adjustment of the suspension to suit road conditions and the octane content in the fuel to antilock braking systems (ABS) and security systems. Embedded systems are designed to do some specific task, rather than be a general-purpose computer for multiple tasks. Some also have real time performance constraints that must be met, for reasons such as safety and usability; others may have low or no performance requirements, allowing the system hardware to be simplified to reduce costs. Embedded systems are not always standalone devices. Many embedded systems consist of small, computerized parts within a larger device that serves a more general purpose. For example, the Gibson Robot Guitor features an embedded system for tuning the strings, but the overall purpose of the Robot Guitar is, of course, to play music. Similarly, an embedded system in an automobile provides a specific function as a subsystem of the car itself embedded systems are designed to do some specific task, rather than be a general-purpose computer for multiple tasks [5]. Some also have real time performance constraints that must be met, for reasons such as safety and usability; others may have low or no performance requirements, allowing the system hardware to be simplified to reduce costs.

Block Diagram



Hardware:
Controller used
FRDM-KL25Z
The FRDM-KL25Z is an ultra-low-cost development platform for Kinetis L Series KL1x (KL14/15) and KL2x (KL24/25) MCUs built on ARM® Cortex™-M0+ processor. Features include easy access to MCU I/O, battery-ready, low-power operation, a standard-based form factor with expansion board options and a built-in debug interface for flash programming and run-control. The FRDM-KL25Z is supported by a range of NXP and third-party development software.
Features
NXP KL25Z Kinetis KL2x MCU (MKL25Z128VLK4)
High performance ARM® Cortex™-M0+ Core 48MHz, 16KB RAM, 128KB FLASH USB (Host/Device)
SPI (2)
I2C (2)
UART (3)
PWM (TPM)
ADC (16 bit)
DAC (1x 12bit)
Touch Sensor
GPIO (66)
FRDM-KL25Z Onboard Sensors
MMA8451Q - 3-axis accelerometer
Capacitive touch sensor
Evalution Form factor
81mm x 53mm
5V USB or 4.5-9V supply
Built-in USB drag 'n' drop FLASH programmer
mbed HDK & SDK enabled
Drag-n-drop programming
USB Serial Port
CMSIS-DAP
Online development tools
Easy to use C/C++ SDK
Lots of published libraries and projects

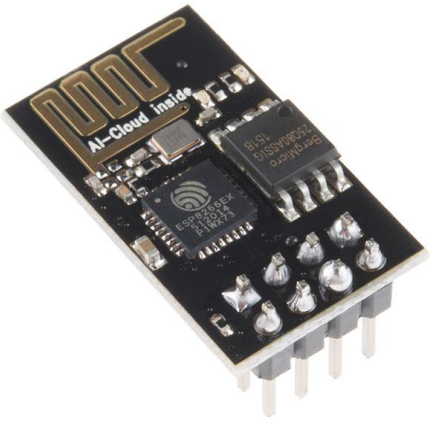


Wi-fi Module:

The ESP8266 Wi-Fi Module is a self-contained SOC with integrated TCP/IP protocol stack that can give any microcontroller access to your Wi-Fi network. The ESP8266 is capable of either hosting an application or offloading all Wi-Fi networking functions from another application processor. Each ESP8266 module comes pre-programmed with an AT command set firmware, meaning, you can simply hook this up to your Arduino device and get about as much Wi-Fi-ability as a Wi-Fi Shield offers (and that's just out of the box)! The ESP8266 module is an extremely cost effective board with a huge, and ever growing, community.

This module has a powerful enough on-board processing and storage capability that allows it to be integrated with the sensors and other application specific devices through its GPIOs with minimal development up-front and minimal loading during runtime. Its high degree of on-chip integration allows for minimal external circuitry, including the front-end module, is designed to occupy minimal PCB area. The ESP8266 supports APSD for VoIP applications and Bluetooth co-existence interfaces; it contains a self-calibrated RF allowing it to work under all operating conditions, and requires no external RF parts.

There is an almost limitless fountain of information available for the ESP8266, all of which has been provided by amazing community support. In the *Documents* section below you will find many resources to aid you in using the ESP8266, even instructions on how to transforming this module into an IoT (Internet of Things) solution!

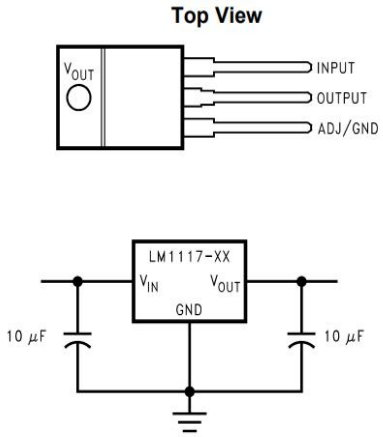


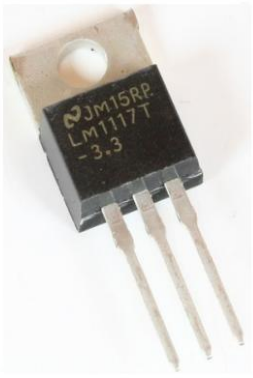
Voltage Regulator

The LM1117 is a low dropout voltage regulator with a dropout of 1.2 V at 800 mA of load current.

The LM1117 is available in an adjustable version, which can set the output voltage from 1.25 to 13.8 V with only two external resistors. In addition, it is available in five fixed voltages, 1.8 V, 2.5 V, 3.3 V, and 5 V.

The LM1117 offers current limiting and thermal shutdown. A minimum of 10-µF capacitor is required at the output to improve the transient response and stability.

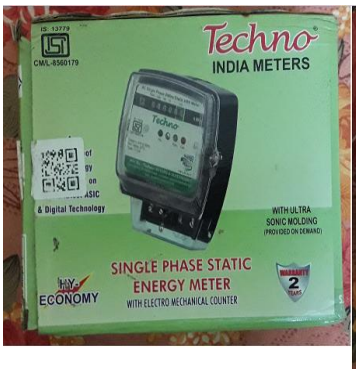




Energy Meter

An electricity meter, electric meter, electrical meter, or energy meter is a device that measures the amount of electric energy consumed by a residence, a business, or an electrically powered device.

Electronic meters display the energy used on an LCD or LED display, in addition to measuring energy used, electronic meters can also record other parameters of the load and supply such as instantaneous and maximum rate of usage demands, voltages, power factor and reactive power used etc. They can also support time-of-day billing, for example, recording the amount of energy used during on-peak and off-peak hours.

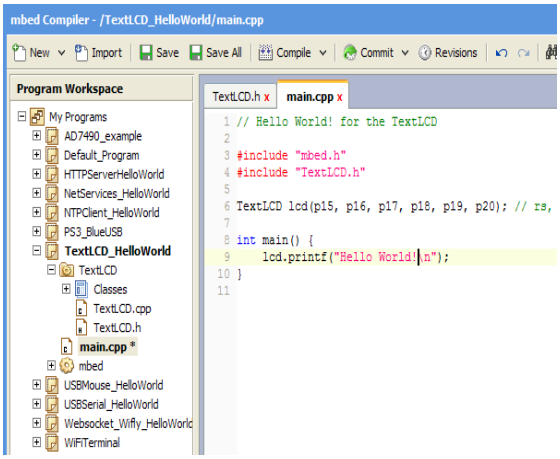


Software

Online compiler IDE (Mbed):

Every Mbed user account gets their own private Compiler workspace which contains their programs. This is private to you, and available wherever you login to Mbed.

The IDE includes a full code editor including syntax highlighting, standard editor keyboard shortcuts, undo/redo, cut/copy/paste, tabs, block/line comment, and even a code auto-formater. This is where you work on your personal workspace, with multiple files, folders, programs, including a drag and drop folder interface

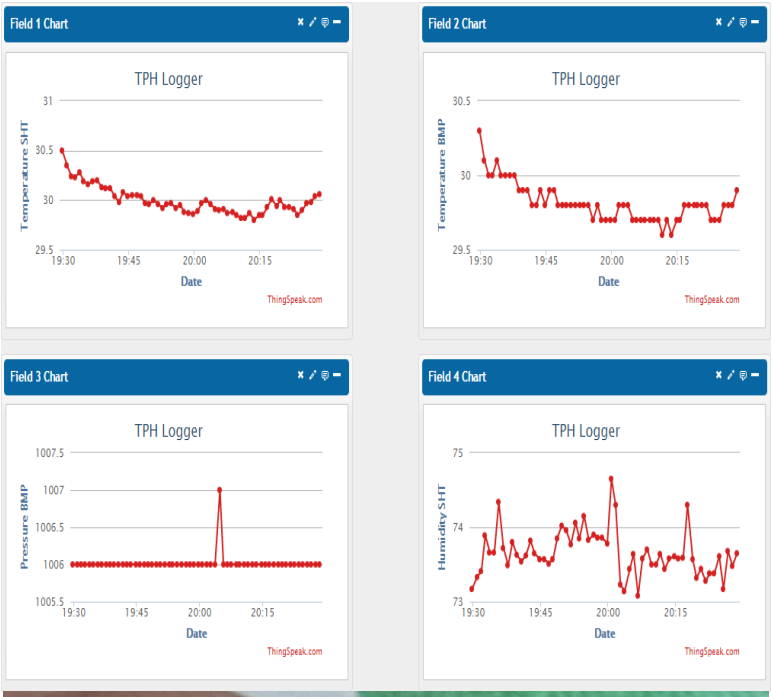


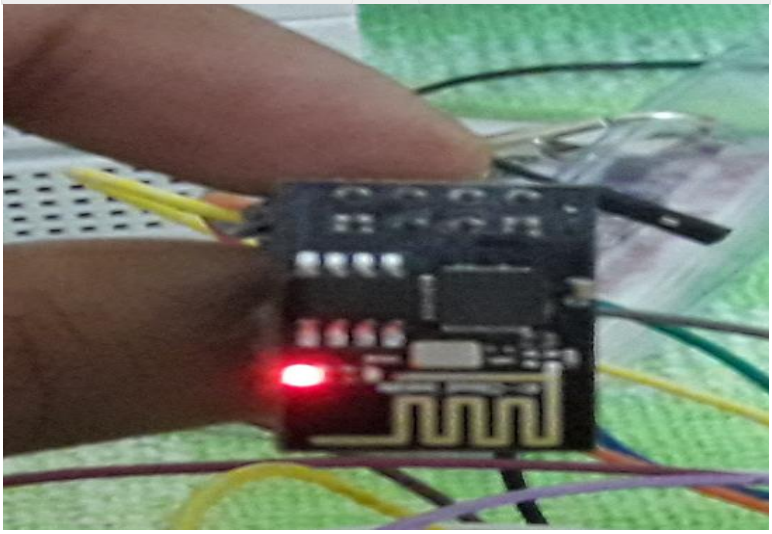
Thingspeak

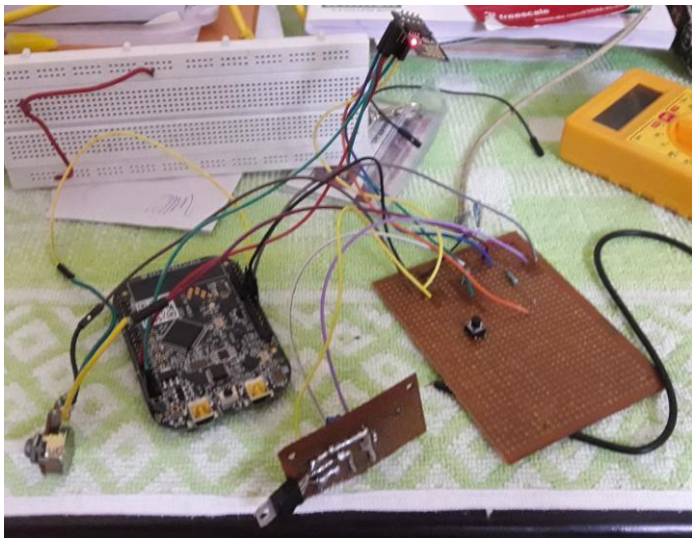
ThingSpeak Features

Collect data in private channels

Share data with public channels reset and MQTT APIs MATLAB® analytics and visualizations ,Alerts ,Event scheduling App integrations Worldwide community, Works With Arduino®, ESP8266 Wifi Module ,Raspberry Pi™ ,Mobile and web apps Twitter®Twilio®MATLAB®



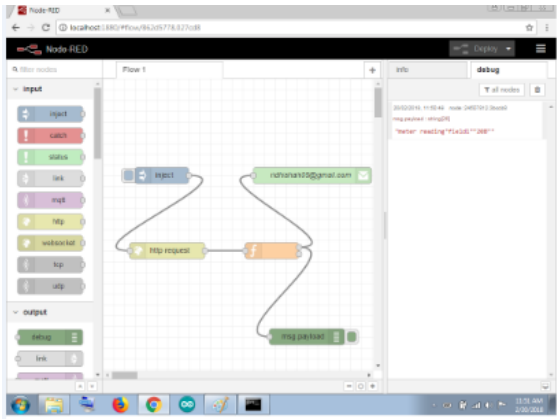




Node RED

Node-RED is a programming tool for wiring together hardware devices, APIs and online services in new and interesting ways.

It provides a browser-based editor that makes it easy to wire together flows using the wide range of nodes in the palette that can be deployed to its runtime in a single-click.



The ESP module uses AT commands to receive the various tasks it has to perform . These AT commands are predefined by the module manufacturer . The KL25Z sends these commands serially to the ESP module . The mentioned AT commands are listed below:

Command Table

Basic:

AT: Just to generate "OK" reply

Wifi:

AT+RST: restart the module

AT+CWMODE: define wifi mode; AT+CWMODE=<mode> 1= Sta, 2= AP, 3=both; Inquiry: AT+CWMODE? or AT+CWMODE=?

AT+CWJAP: join the AP wifi; AT+ CWJAP =<ssid>,< pwd > - ssid = ssid, pwd = wifi password, both between quotes; Inquiry: AT+ CWJAP?

AT+CWLAP: list the AP wifi

AT+CWQAP: quit the AP wifi; Inquiry: AT+CWQAP=?

* AT+CWSAP: set the parameters of AP; AT+CWSAP= <ssid>,<pwd>,<chl>,<ecn> - ssid, pwd, chl = channel, ecn = encryption; Inquiry: AT+CWJAP?

TCP/IP:

AT+CIPSTATUS: get the connection status

* AT+CIPSTART: set up TCP or UDP connection 1)single connection (+CIPMUX=0) AT+CIPSTART= <type>,<addr>,<port>; 2) multiple connection (+CIPMUX=1) AT+CIPSTART= <id><type>,<addr>, <port> - id = 0-4, type = TCP/UDP, addr = IP address, port= port; Inquiry: AT+CIPSTART=?

* AT+CIPSEND: send data; 1)single connection(+CIPMUX=0) AT+CIPSEND=<length>; 2) multiple connection (+CIPMUX=1) AT+CIPSEND= <id>,<length>; Inquiry: AT+CIPSEND=?

* AT+CIPCLOSE: close TCP or UDP connection; AT+CIPCLOSE=<id> or AT+CIPCLOSE; Inquiry: AT+CIPCLOSE=?

AT+CIFSR: Get IP address; Inquiry: AT+ CIFSR=?

AT+CIPMUX: set mutiple connection; AT+ CIPMUX=<mode> - 0 for single connection 1 for mutiple connection; Inquiry: AT+CIPMUX? AT+CIPSERVER: set as server;

AT+ CIPSERVER= <mode>[,<port>] - mode 0 to close server mode, mode 1 to open; port = port; Inquiry: AT+CIFSR=?

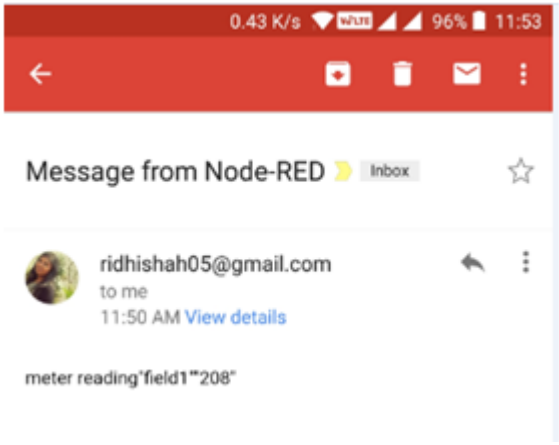
* +IPD: received data

II. Result And Conclusion

The wifi connection has been set up using the ESP module.

To demonstrate this an setup has been developed that includes a potentiometer being connected to the kl25z development board.

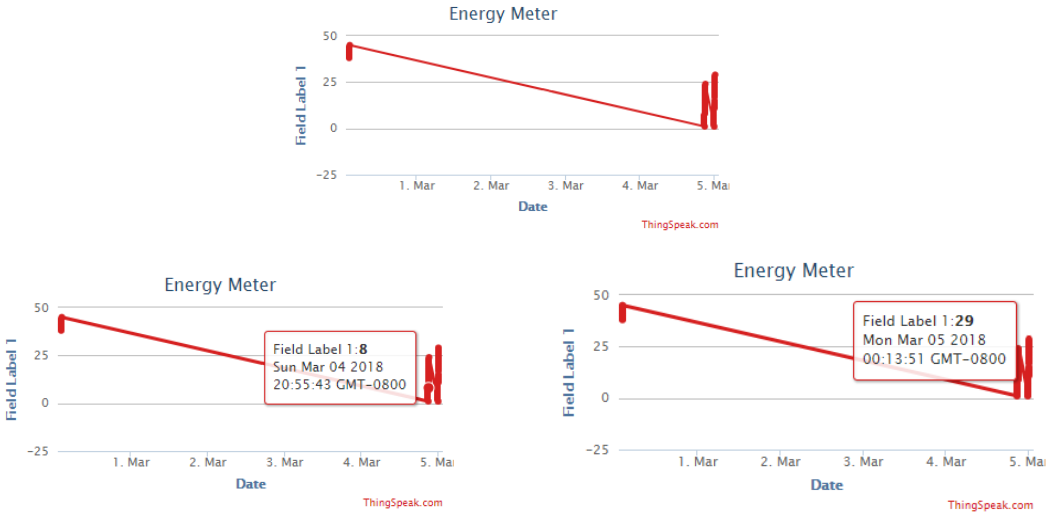
By varying the potentiometer an analog voltage is generated that is fed to the kl25z development



board. The on board ADC of the KL25Z is used to convert the analog signal to its equivalent digital normalized form. Thus on reading the pin to which the potentiometer setup is connected we get a floating point value that varies between 0 to 1.

This value is then scaled by a factor of 255 by the microcontroller and sent to thingspeak.com via the esp wifi module.

The corresponding value is plotted as a graph with respect to time and displayed by thingspeak.com on their website.



Future Scope

- This project aims to reduce the human effort that is spent by power authorities. And helps making society more digitized.
- With advances in technology implementation of this idea can be further improved and made to an industrial scale.
- With better instruments used the accuracy , dependence ,data rates, etc of the implementation can be improved.

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