OPEN ACCESS

European Journal of Engineering Science and Technology
ISSN 2538-9181

Simulation of RF Technology Based Power Theft Detection

Hussien Alalem[1], Abdalla Fadel[2], Abdalla Turki[3], Mona Shlibek[4], Manal Shlibek[5]

[1]Associate Professor - School of Engineering and Applied Science/ Libyan Academy.
[2]Professor - School of Engineering and Applied Science/ Libyan Academy.
[3]Abdalla Turki - General Manager, Tripoli Dairy Company.
[4]MSc - Faculty of Electrical & Electronic Engineering / Tripoli University.
[5]MSc - School of Engineering/ Libyan Academy- Engineer at GECOL.

ARTICLE INFO

Keywords:
GECOL, Adruino, Current Sensors, RF 433 module, LCD displays.

ABSTRACT

No doubt that electricity is an essential thing in our daily life. It has an vital role to facilitate the human life as without it we can not run appliances in our homes, hospitals, offices…etc. Day by day, the demand of electricity increases rapidly due to its uses. This leads to illegal connection of electricity for those who can not pay for it. Such theft of electricity from distribution line leads to huge losses for electricity utilities . Libyan power grid is facing this problem due to huge losses that resulted from illegal usage. This paper is designed to show the simulation by Proteus to design and model of power theft detection and monitoring using RF technology. The proposed system detects the theft whenever is occurred. It is supposed that at substation side which is pole 1 there is Arduino, and at consumed side which is pole 2 there is Arduino as well. Transferring data from Arduino at pole 2 to Arduino at pole 1 through modulo RF 433 MHZ modules. Arduino at pole 2 will calculate electricity theft and transmit data to Arduino at pole 1 to make a comparison between data. This was done in this paper via the UART interface to the UART terminal embedded in the Proteus. The source code has been shown for both Master and Slave boards.

1. Introduction

In Libya, power theft is a common problem, which results in loss of electrical. The general electricity company of Libyan (GECOL) is the solely company responsible for supplying electricity. Because of the electricity theft, GECOL is facing the frequent problems of load shedding. This power theft phenomenon is definitely needed to be decreased as much as possible. The paper is designed to overcome of this phenomenon. As the ways for stealing the electricity is countless so we can never keep track where exactly the theft has occurred. The proposed system via Arduino kit will automatically calculate the real power consumption from houses or buildings in general and compare the real measured data with the assumed consumption data. The Arduino

Corresponding Author E-Mail Address: manal.shlibek@gmail.com

kit attached to energy meter at substation side, which is pole 1, named Master kit. The Arduino kit attached to energy meter at home side, which is pole 2, named Slave kit. The measured data will be transferred via RF 433 MHZ module from Master kit to Slave kit. The Arduino kit attached to every pole consists of Atmega328 and wcs2702 module-current sensor, LCD display, and RF 433 MHZ module. The current sensor senses the amount of current that flow through the Slave kit. the sensed reading will be fed to microcontroller/Atmega328 type. Then the Arduino will calculate this sensed reading and send it to RF module to be transferred to Master kit. Then the RF module will send the calculated data to the substation. Depending on current sensor readings at poles 1 and 2, the power theft is detected. The target of the paper is to design a system which automatically detects and control illegal connection of electricity. The simulation was done in this paper by Proteus to design and model of power theft detection and monitoring using RF technology. Many studies related to electricity theft have been done. In 2013, Pandey, Gill, and Sharma proved that applied Zigbee technology to wirelessly detect the electricity theft, give high efficient and inexpensive method [1]. Moreover, in this year, Patil, Gopal, and Kirtikumar made a real time system to identify wirelessly where exactly the location of illegal tapping is done on a specific distribution line in case a theft is done by tapping. The model was tested for varying amounts of power thefts and also for different types of circuit approximations [2]. By the year 2014, Prashanthi, and Prasad made an organization model to calculate exactly the power consumed in a household consumers from a main source connected on that area at a certain time. This work is detecting the illegal use but not for finding out where exactly it is [3]. In 2015, Dike, et. al. made a system to send a message instantaneously when the theft is done at a certain location [4]. While, two years later, 2017, Prakash, Jebaseeli, and Sindhu identified power theft project using GSM technology. The objective of their project is to design a system which will try to minimize the illegal use of electricity and also reduce the chances of theft. This paper presented the different methods of power theft and the methods to identify the theft occurred in houses and industries [6]. Lastly, in 2018 Saini stated that a primary cause of high distribution losses in India state is a power theft and presented a solution [5]. In the same year, 2018, Khan, Xie, , et. al , designed and Modeled an anti-theft electricity distribution system, their proposed system detects the illegal load and burns it by sending high voltage signal from capacitor bank. The legal load is made safe and uninterrupted during execution of illegal load [7].

2. Proposed System and Methodology

This paper presented a control system that provides a solution of power theft problem by placing the system which will be constructed utilizing the Arduino UNO microcontroller with a wireless module. Arduino UNO microcontroller with current sensor will be formed as a number of Master and Slave boards. Arduino UNO microcontroller was designed to detect exactly where the probable power theft has occurred. They will assist in the distinction of the illegal consumption. However, the Microcontroller will be interfaced between the energy meter and a mobile communication network in order to transfer data wirelessly. A signal will be sent from the Microcontroller to the communication medium in case there is a difference in the compared values. Then a communication medium wirelessly sends a notification message to inform GECOL that there is an additional unexpected consumption detected in that specific home or in that particular electricity pole. As a result, GECOL can ensure whether or not this detected power is authorized by the company. Consequently, the power theft once detected the procedures will be taken by the company. The Master and Slave boards consist of same components (explained in section 2). As

each board has a different functionality, the difference between them is the code written in C/ C++ language.

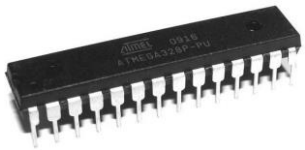
2.1 Functions of Components

2.1.1 Arduino UNO microcontroller

Arduino is an open-source electronics platform based on easy-to-use hardware and software. It's intended for anyone making interactive project. Arduino board senses the environment by receiving inputs from many sensors, and affects its surroundings by controlling lights, motors, and other actuators. Arduino software, you can tell your Arduino what to do by writing code in the Arduino programming language and using the Arduino development environment [8].

2.2 Atmega328:

An Arduino board consist of Atmega328 IC. In this Atmega328 IC we can implement our program [11].



2.3 Rf 433 MHZ

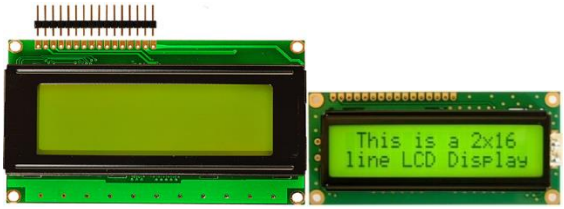
The RF 433MHz Transmitter/Receiver modules with Arduino. One of its application environment is the automobile anti-theft products [9]. An RF module stands for radio frequency module. It is a small electronic device used to transmit and/or receive radio signals between two devices. The medium of this wireless communication does not require line. It is either through optical communication or through radio frequency (RF) communication [10].

2.4 WCS 2702 module-current sensor

The WCS2702consists of a precise, low-temperature drift linear hall sensor IC with temperature compensation circuit and a current path with 98mΩ typical internal conductor resistance. This extremely low resistance can effectively reduce power loss, operating temperature and increase the reliability greatly. Applied current flowing through this conduction path generates a magnetic field which is sensed by the integrated Hall IC and converted into a proportional voltage [12].

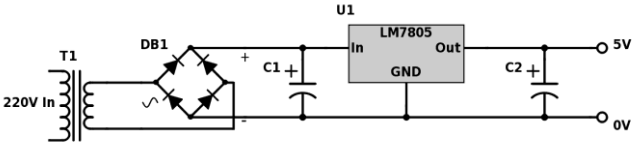
2.5 Liquid Crystal displays (16x2) and (20 x4)

LCD (Liquid Crystal Display) screen is an electronic display module. It is a flat panel display, electronic visual display. In this paper there is an interfacing 20x4 & 16 x2 LCD With Arduino. A 16x2 LCD means it can display 16 Columns and 2 Rows. A 20x4 LCD means it can display 20 Columns and 4 Rows.



2.6 Power Supply

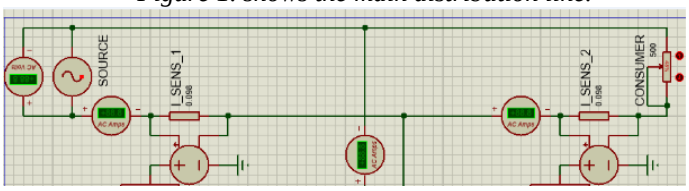
There are many types of power supply. Most are designed to convert high voltage AC mains electricity to a suitable low voltage supply for electronics.



3. Software implementation

The proposed system was designed in Proteus version 8.6. the system takes power supply from the main distribution line as shown in figure1.

Figure 1. shows the main distribution line.



So, the system detects the theft whenever is occurred. It is supposed that at substation side which is pole 1 there is Arduino kit named Master board, and at consumed side which is pole 2 there is Arduino kit as well named Slave board. Transferring data from Arduino at pole 2 to Arduino at pole 1 through modulo RF 433 MHZ modules. Figures 2 and 3 show the Simulation results of both Master and Slave Board respectively.

Figure.2 Simulation result of Slave Board

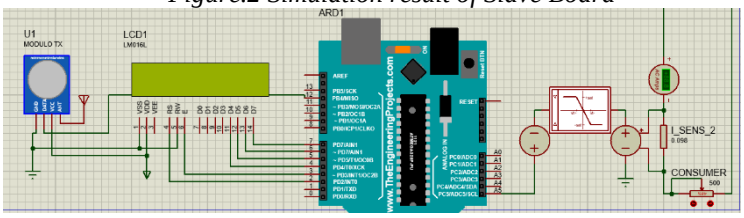
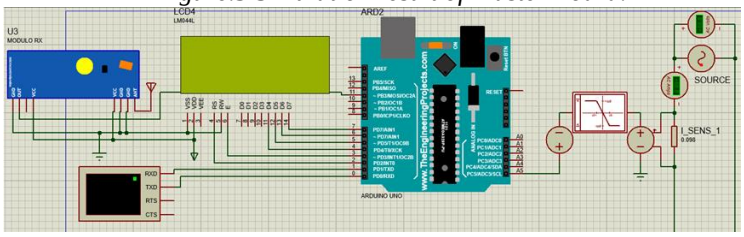


Figure.3 Simulation result of Master Board.



Here, in Proteus simulation, Arduino at pole 1 will calculate electricity theft and transmit data via the UART interface to the UART-terminal embedded in the Proteus as shown in figure 4. When developing a real project (in hardware), the UART interface easily connects to a computer COM port or USB port throuht USB-RS232 adapter.

For best accuracy it will be more correct to use external ADC module (it has greater resolution than in-build arduino ADC). In the proposed system there are two potentiometers and switch:

- Switch 1 "SW1" for switching power line regime (theft or no theft).
- First Potentiometer "Consumer" for adjusting consumer current consumption.
- Second Potentiometer "Theft" for adjusting theft current.

The internal resistance of potentiometer is equal it full resistances (500 Ohm) * percent. From the last figure, it can be clearly seen that voltage drop across a 98 mΩ resistor (its equal to wcs2702 internal resistance) and amplifying the signal to the levels specified in the data sheet for the wcs2702 module. Figure.5 shows the internal construction of wcs2702 module.

Figure.4 Simulation result of the Power Theft Detection System.

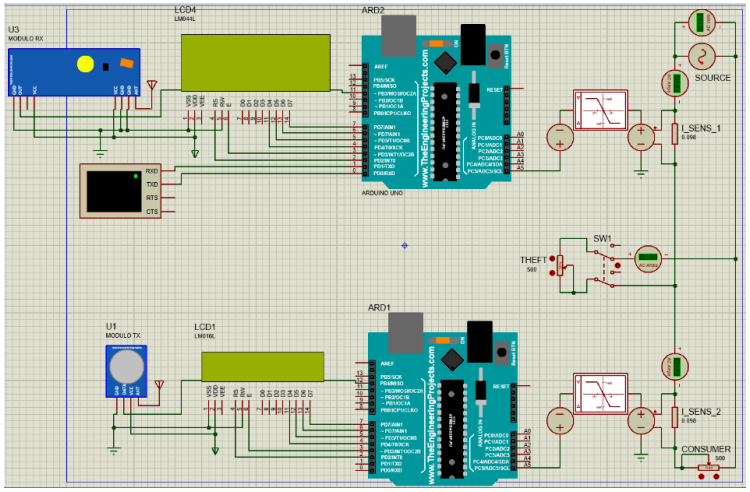
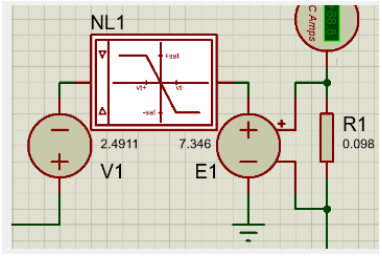


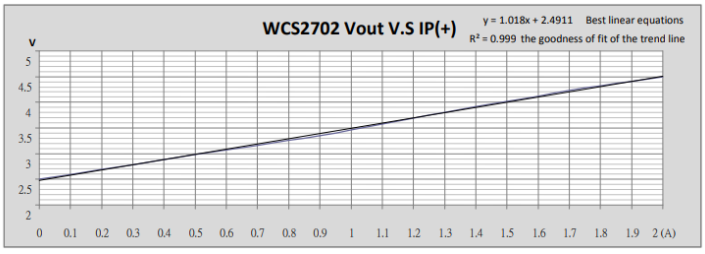
Figure.5 Proteus model of wcs2702 module-current sensor.



The Proteus model of wcs2702 module-current sensor provided:

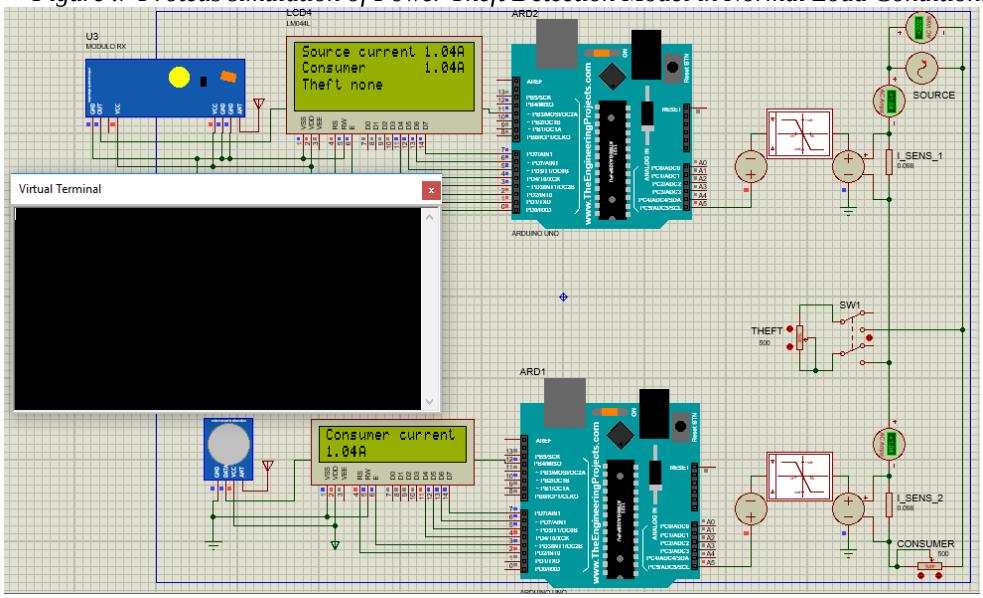
- Internal resistance equal to internal resistance of wcs2702 module
- Galvanic isolation low voltage output part from height voltage line
- Output signal is analogical to output signal of wcs2702 module (Figure 6)

Figure 6. Output signal of wcs2702 module



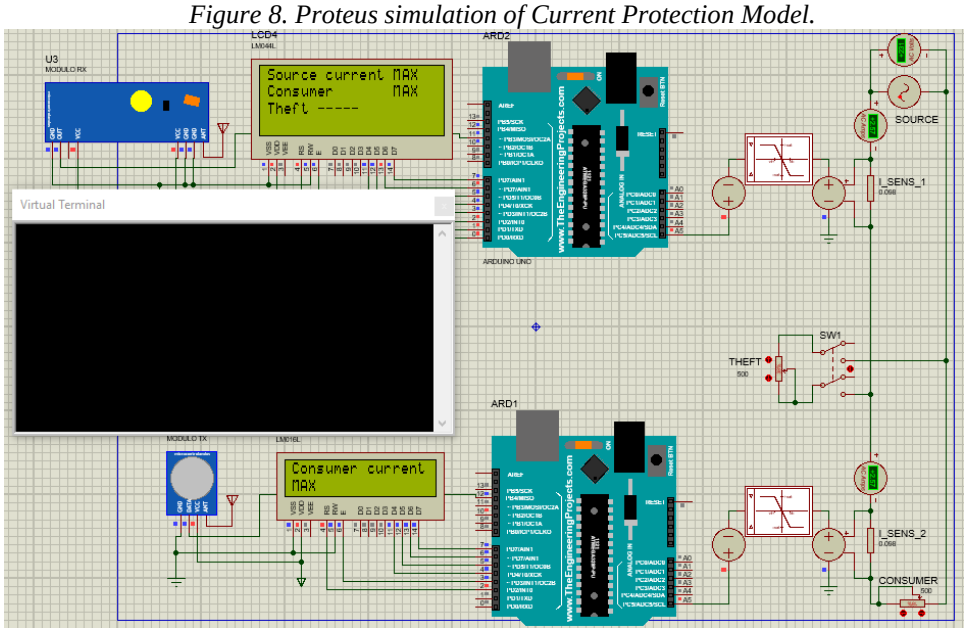
In normal condition (no theft) (Figure 7) consumer part send to source part information about own current consumption and source part compared it with own measured line current. As far as this data is similar, no power theft signal is generated.

Figure .7 Proteus simulation of Power Theft Detection Model in Normal Load Condition.



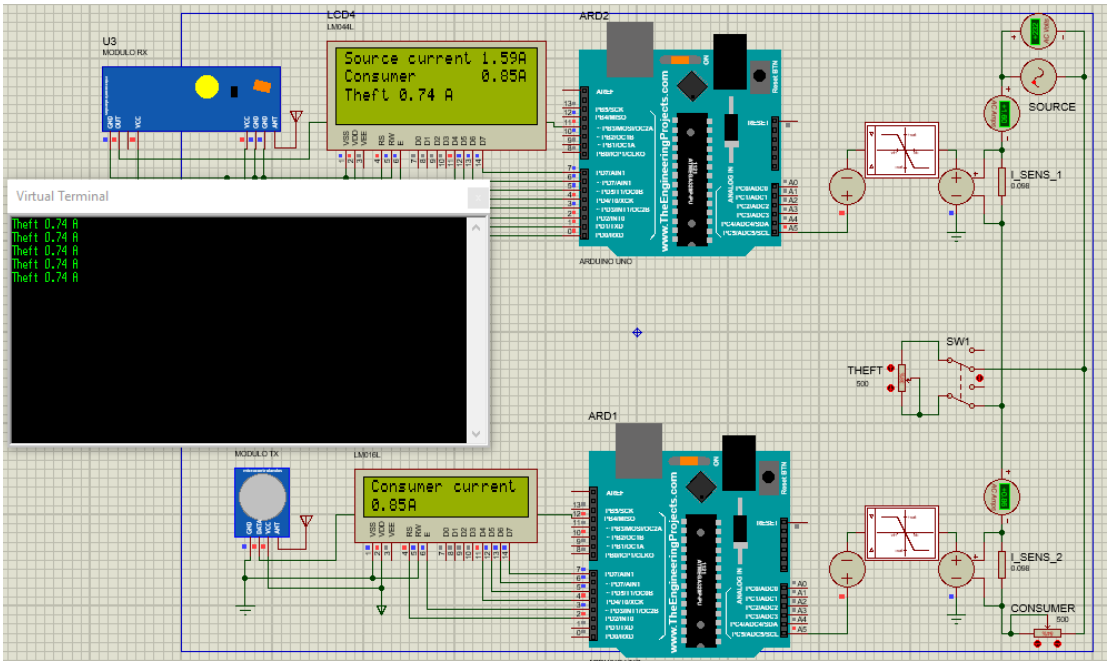
Also model has a program over current protection – if consumer current is greater than current limit of wcs2702 module, then it shows on LCD display (Consumer current: MAX, Source current: MAX) as shown in figure 8.

Figure 8. Proteus simulation of Current Protection Model.



In power theft mode (Figure 9) Source part is detected consumer and source currents mismatch and generated power theft signal on Proteus terminal by UART interface.

Figure 9. Proteus simulation of Power Theft Detection Model in Power Theft Condition.



4. The Source Code of Arduino

4.1 The Source Code of Master Board (Arduino Kit)

```
//for LCD display
#include <LiquidCrystal.h>

//for RX module
#include <RH_ASK.h>
#include <SPI.h>

//lcd pin configuration
const int rs = 2, en = 3, d4 = 4, d5 = 5, d6 = 6, d7 = 7;
LiquidCrystal lcd(rs, en, d4, d5, d6, d7);

//tx module declaration
RH_ASK driver;

//for  error response protection
float previous_source_current=0;

void setup() {
  //lcd init
  lcd.begin(20,4);
```

```
  lcd.clear();
  lcd.setCursor(0,0);
  lcd.print("Source current ");
  lcd.setCursor(0,1);
  lcd.print("Consumer ");
  lcd.setCursor(0,2);
  lcd.print("Theft");

  //rx modules init
  driver.init();

  Serial.begin(9600);
}

void loop() {
  uint8_t buf[12];
  uint8_t buflen = sizeof(buf);
  if (driver.recv(buf, &buflen)){//whole further algorithm is done only if the data came to the receiver
    float source_current=0;
    unsigned long tm=millis();// tm will stored system time on beginning of while(millis()-tm<50) cycle
   float source_current=0;
   unsigned long tm=millis();// tm will stored system time on beginning of while(millis()-tm<50) cycle
   while(millis()-tm<50){//during 50 ms we read the ADC data, convert it to source current (sc) value (rms ac value) and looking tl
     float sc = (float(analogRead(A5)*5)/1024.0-2.4911)/(0.098*7.346)/sqrt(2);
     if(sc>source_current){
       source_current=sc;
     }
   }

   if( (source_current-previous_source_current>0 ? source_current-previous_source_current : previous_source_current-source_current)
     lcd.setCursor(15,0);
     if(source_current<2.45){// if measured value do not exceed wcs2702 current limit
       lcd.print(source_current);
       lcd.setCursor(19,0);
       lcd.print("A");
     }else{
       lcd.print("MAX  ");
     }

     String received=(char*)buf;
float consumer_current=received.toFloat();

lcd.setCursor(15, 1);
if(consumer_current<2.45)
{// if measured value do not exceed wcs2702 current limit
  lcd.print(consumer_current);
  lcd.setCursor(19,1);
  lcd.print("A");
}else{
  lcd.print("MAX  ");
}

lcd.setCursor(6,2);
if(source_current<2.45&&consumer_current<2.45)
{// if measured value do not exceed wcs2702 current limit
if(((source_current-consumer_current)>=0 ?(source_current-consumer_current):(consumer_current-source_current))< source_current*0.05)
  {// finding module source_current-consumer_current and 5% is need becase ADC convert error (in other words consumer current may fe
    lcd.print("none       ");
  }else{
    lcd.print(source_current-consumer_current);
```

```
          lcd.print(" A");
          Serial.print("Theft "); Serial.print(source_current-consumer_current); Serial.println(" A");
        }
      }else{
        lcd.print("-----       ");// if measured currents exceed wcs2702 current limit impossible to find power theft
      }
    }else{
      previous_source_current=source_current;
    }
  }
}
```

4.2 The Source Code of Slave Board (Arduino Kit)

```
#include <LiquidCrystal.h>
#include <RH_ASK.h>
#include <SPI.h>

const int rs = 2, en = 3, d4 = 4, d5 = 5, d6 = 6, d7 = 7;
LiquidCrystal lcd(rs, en, d4, d5, d6, d7);
RH_ASK driver;
int lcd_disp_time=0;

void setup() {
  lcd.begin(16, 2);
  lcd.clear();
  lcd.setCursor(0, 0);
  lcd.print("Consumer current");
  driver.init();
}

void loop() {
  unsigned long tm=millis();
  float consumer_current=0;
  while(millis()-tm<50){
    float cc = (float(analogRead(A5)*5)/1024.0-2.4911)/(0.098*7.346)/sqrt(2);
    if(cc>consumer_current){
      consumer_current=cc;
    }
  }
  if(millis()-lcd_disp_time > 200){
    lcd_disp_time=millis();

    lcd.setCursor(0,1);
    if(consumer_current<2.45){
      lcd.print(consumer_current);
      lcd.setCursor(4,1);
      lcd.print("A");
    }else{
      lcd.print("MAX  ");
    }
  }
  String str = (String)consumer_current;
  uint8_t data[sizeof(str)];
  for(byte i=0; i<sizeof(str); i++){
    data[i]=str[i];
  }
  driver.send(data, sizeof(data));
  driver.waitPacketSent();
}
```

5. Conclusion

This circuit utilizes the RF module (Tx/Rx) for making a wireless communication between Arduino boards. This will help both consumer and utility to use it easily. As the medium of this wireless communication does not require line. So data which represent the total power consumption is transmitted as signals at a particular frequency and a baud rate. A receiver can receive these signals only if it is configured for that frequency can be transferred from energy meters of homes in a certain areas to the substation. The advantages of RF module are numerous such as cheap, high accuracy, reliability, flexibility, and friendly use. RF uses radio frequency to send signals. Rf module has been used because its greater efficiency, and the ability to remove signal variations and noise. This will help the electricity utility can know where exactly the theft has occurred. In addition, RF module used for cellular mobile phone service. So, through mobile phone, consumer can receive SMS message from the electricity utility in case there is theft of electricity.

6. References

Virendra Pandey, Simrat Singh Gill, Amit Sharma, 2013, Wireless Electricity Theft Detection System Using Zigbee Technology, International Journal on Recent and Innovation Trends in Computing and Communication, ISSN2321–8169, volume1 Issue: 4.

Sagar Patil , Gopal Pawaskar , Kirtikumar Patil, April 2013, ELECTRICAL POWER THEFT DETECTION AND WIRELESS METER READING, International Journal of Innovative Research in Science, Engineering and Technology Vol. 2, Issue 4, Copyright to IJIRSET www.ijirset.com 1114.

G. L. Prashanthi, K. V. Prasad.

G. L. Prashanthi, K. V. Prasad, Nov - Dec. 2014, Wireless power meter monitoring with power theft detection and intimation system using GSM and Zigbee networks, IOSR Journal of Electronics and Communication Engineering (IOSR-JECE) e-ISSN: 2278-2834,p- ISSN: 2278-8735.Volume 9, Issue 6, Ver. I, PP 04-08 www.iosrjournals.org www.iosrjournals.org 4 | Page.

Damian O. Dike , Uchechukwu A. Obiora , Euphemia C. Nwokorie , Blessing C. Dike, 2015, Minimizing Household Electricity Theft in Nigeria Using GSM Based Prepaid Meter, American Journal of Engineering Research (AJER) e-ISSN : 2320-0847 p-ISSN : 2320-0936 Volume-4, Issue-1, pp-59-69 www.ajer.org.

Sunita Saini, January 2018, ELECTRICITY THEFT–A PRIMARY CAUSE OF HIGH DISTRIBUTION LOSSES IN INDIAN STATE, International Research Journal of Management and Commerce ISSN: (2348-9766), Impact Factor-5.564, Volume 5, Issue 1, Website- www.aarf.asia, Department of Management Studies, DCR University Science & Technology, Sonepat, India.

November 2017, International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering (An ISO 3297: 2007 Certified Organization) Vol. 6, Special Issue 3, Copyright to IJAREEIE www.ijareeie.com 72, "Power Theft Identification Using GSM Technology". Rhea Prakash, E. Annie Elisabeth Jebaseeli, and Y.S.U.Sindhu. Department of

Electrical and Electronics Engineering, Sathyabama University, Rajiv Gandhi Salai, Chennai, India.

MATEC Web of Conferences 160, 02010 (2018) , EECR 2018., " Designing and Modeling of Automated Anti-theft Electricity Distribution System". Researches Awais Khan1 Wei Xie1, Suhail Aftab Qureshi2, Muhammad Ilyas3, JingChun Lin4 and Guidong Liu4 1 College of Automation Science and Technology, South China University of Technology, Guangzhou, China, Electrical Engineering Department, UET Lahore, Pakistan 3Iqra International University Peshawar, Pakistan. College of Electrical and Information Engineering, GuangDong Baiyun University, Guangzhou, China.

https://www.arduino.cc/

Datasheets/Products/433Mhz_RF-TX&RX.pdf

https://en.wikipedia.org/wiki/RF_module

International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056 Volume: 05 Issue: 03 | Mar-2018 www.irjet.net p-ISSN: 2395-0072.