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# Control and Automation of a Phantom Source used for Calibration of Energy Meters

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**ABSTRACT:** Phantom source unit is used for testing the energy meters. It is used to test thread through meters and it can also be operated manually. But manual operation can cause lack of accuracy and lots of errors and it is also time consuming process. Hence automation of the phantom source is done for calibrating meters to avoid manual errors and to reduce the risk of work. Here controlling of the three phase voltages, currents and power factor of a three phase phantom source unit is accomplished by using an Arduino Mega 2560 controller. Program is written in Arduino IDE and user can define the required value by setting in Terminal v1.93b software. Source adjustment (V, I, PF) is done by triggering relay so that it selects the ranges in the phantom unit. Fine adjustment can be done by rotating the motor inside the phantom source unit. For current and power factor the required value can be selected by programming and then fine adjustment is done. It mainly aims the attention on producing accurate values of the source parameters (V, I, PF) ensuring that it has voltage/current with certain accuracy for proper calibration and accuracy of meters using an Arduino controller. All these source parameters of all the three phases (R, Y and B) are controlled and saved with timings to analyze the performance of the system. All these data will be saved in .txt file in PC with timestamps.

**KEYWORDS:** Phantom Source, Arduino Mega 2560, Relay, LCD display, Docklight, Terminal v1.93b.

### I. INTRODUCTION

Phantom unit is used to test the accuracy of energy meters. It is used to provide a controlled source of current value for testing thread through meters. The source parameters (like voltage, current, powerfactor) are controlled such that it is having stable voltage with certain accuracy for proper calibration and accuracy of meter. By implementing control system of a phantom source ensures that the errors are kept within the desired limit. Electrical calibration refers to the process of adjusting and verifying the performance of any instrument which measures electrical parameters. Arduino microcontroller is one of the most popular open source microcontroller boards. Arduino is easy to use hardware and software.

The Arduino IDE utilizes its own programming language, which is based on simple C or C++ instructions. Using Arduino IDE, program is written in a computer. There will be two types of adjustment in this for getting stable voltage and accurate value. They are coarse adjustment and fine adjustment. For current and power factor, selection part and fine adjustment is done. In current and power factor selection the program is written in such a way that depending upon the command given by the user that particular range gets selected. Using both coarse and fine adjustments affords the increased control for user. Data gathering and control action can be done simultaneously using Arduino. Controlling can be achieved by connecting the devices as shown in Fig. 1.

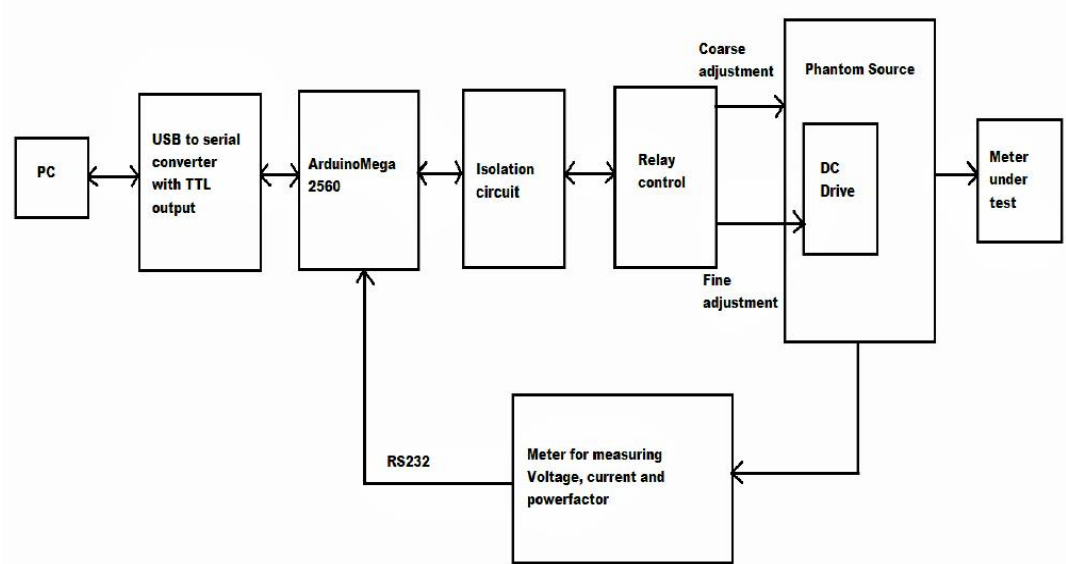


Fig. 1: General block diagram showing controlling of phantom source

## II. CONTROLLING PHANTOM SOURCE USING ARDUINO MEGA 2560

For controlling source parameters there are different types of controllers which are available, out of those we use Arduino Mega 2560 controller because it is simple and easy to handle and program. Arduino Mega 2560 is connected to PC via MAX232 board or USB to RS232 converter with TTL output which will be used for serial transmission and receiving of the meter read data. MAX232 board is used because Arduino Mega 2560 operates at 5V supply and it cannot be directly connected to PC since the output of RS232/computer has +/-12V supply and can damage the Arduino Board. Hence by using MAX232 board is used to obtain TTL output which is required by Arduino Mega 2560. Isolation circuit is used between Arduino Mega 2560 and relay control to protect the Arduino controller from damage if there is any back power flow. For adjusting the current and for power factor, selection method is done first which selects the required range according to the user defined commands. Later fine adjustment is done by rotating motor and taking its value and by verifying it.

Further all these data's will be logged to see how these parameters vary with time and to study how much time is taken for setting the required range. This can be done by using software called Terminal v1.93b. Terminal v1.93b is a simple serial port or COM port terminal emulation program. When the process starts simply by selecting the start log option the data can be logged with time. This logged data will be stored in PC in text file. Fig. 2 shows the connection diagram which describes the connections made for controlling source parameters to get accurate voltage, current and power factor values.

Following are the list of hardware components that are used.

- Arduino Mega 2560
- USB to serial converter with TTL output board
- 16x2 LCD display
- Relays
- 12V power supply
- Three phase Phantom source unit

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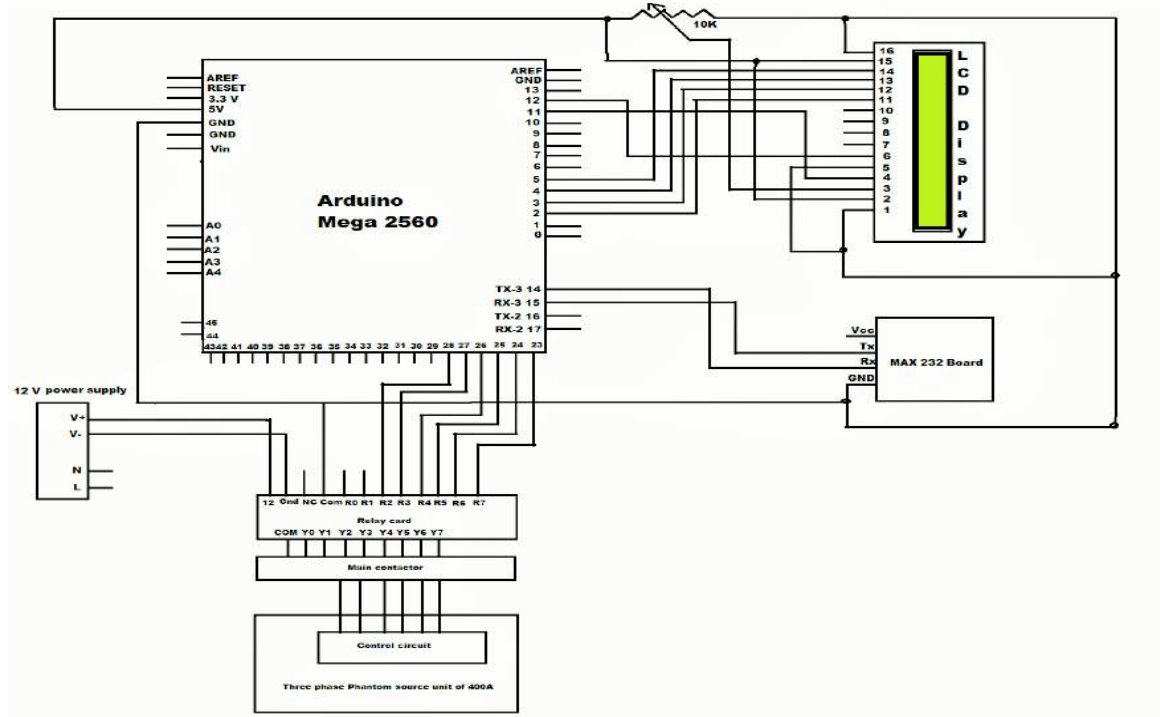


Fig. 2: Connection diagram

## Arduino Mega 2560

It is an open source computing platform that is used for programming electronic devices. Arduino uses a hardware known as the Arduino development board Fig. 3 and software for developing the code known as the Arduino IDE (Integrated Development Environment). These Arduino controllers can be programmed easily using simplified code of C or C++ language in the Arduino IDE. It has 54 digital input/output pins, 16 analog inputs, 4 UARTs (hardware serial ports), a 16 MHz crystal oscillator, a USB connection, a power jack and a reset button.



Fig. 3: Arduino Mega 2560



Fig. 4: MAX232 board

## USB to RS232 serial converter/MAX232 board with led indicator and TTL output board

It is the smallest USB to serial converter module as shown in Fig. 4. It helps user to interface the UART (Universal Asynchronous Receiver and Transmitter) supporting devices with the PCs or laptops through serial or USB port. This module has standard USB connector to minimize the size of the module. MAX232 IC acts as transition stage between RS232 (Recommended Standard 232) and TTL (Transistor-Transistor Logic) voltage levels. One of the pin of MAX232 called receivers (Rx) convert from RS-232 to TTL voltage levels and driver pin (TX) converts from TTL logic to RS-232 voltage levels.

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### 16x2 LCD Display

An LCD is a small low cost display. It can be easily interfaced with a micro-controllers or Arduino. Liquid crystal displays (LCDs) are a commonly used to display data in devices such as calculators, microwave ovens, and many other electronic devices. This is a 16x2 LCD which has a total of 16 pins.

### Relay

The inputs of the 8 channel 12V relay module are isolated to protect any circuitry. A wide range of controllers such as Arduino, AVR, PIC, and ARM and so on can control it. Relay terminals (C, NO, NC) are accessible through screw terminals which makes wiring up the board very easy.

### Phantom Source

Phantom source unit is used to generate different current values based upon the current rating of the meter under test. It is able to generate three-phase voltages and currents with unprecedented stability and measurement accuracy. It is used to control voltage, current and power factor. The power factor can also be adjusted from lead to lag or lag to lead by programming. There will all be motors in that are inbuilt in the three phase phantom unit. This three phase phantom unit can be operated at 230V AC source. It can also be operated manually; coarse adjustments can be done using the selector switches provided and the knob for fine control. From the source output the meter to be calibrated is connected.



Fig. 5: Phantom Source unit

There are three different software's which are used for controlling phantom unit, one for writing code for controlling the source parameters, the other one for serial communication to transmit the meter data to controller and the third one for data logging to analyze the performance of the system.

### Arduino IDE

The code written in Arduino IDE is known as sketch. The software used for developing such sketches is commonly known as the Arduino IDE. First, we should configure the board and port settings to allow us to upload code by connecting our Arduino board to the PC via the USB cable.



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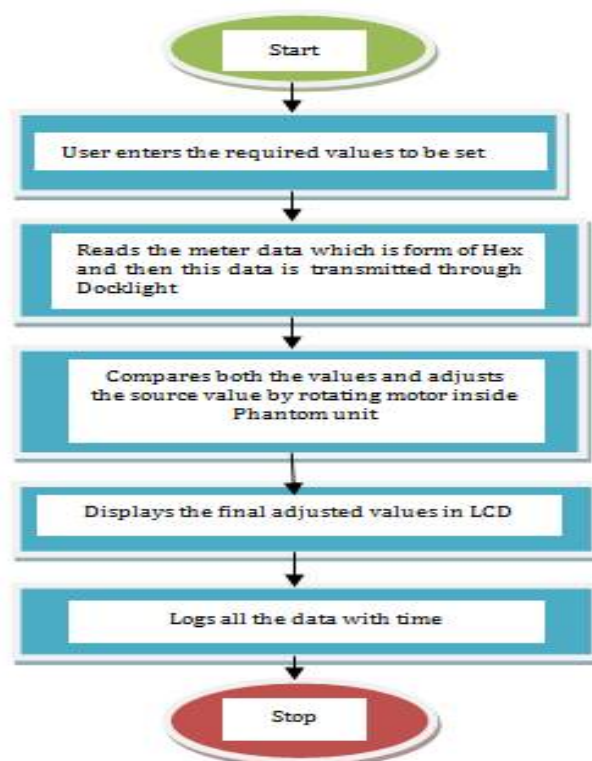
## Terminal V1.93b

Terminal v1.9 b is used in order to communicate with our Arduino mega 2560. Terminal is a simple serial port or COM port terminal emulation program. User can enter the required set value for voltages, current or power factor here. Also, simultaneously when the process starts data logging with each time stampings can be done by simply selecting start log in the terminal window. It is very simple and easy to use.

## Docklight software

Serial communication can be done by using any software that supports serial communication. Docklight is a testing and simulation tool for serial communication, we can monitor communications between two serial devices or we can test the serial communication of a single device. In this work, the program is written in such a way that the value read by the meter will be in hex string. This meter read data is directly transferred to PC through Arduino by transmitting the hex string of meter data through the Docklight software for simulation purpose.

## Flow Chart



## Process description

- User enters the required value to be set in the Terminal v1.93b software. For example for setting R phase voltage, U1 command is given with the voltage value. For Y phase U2 is used like that for current and power factor I and W respectively. R, Y, B phases can be represented as 1, 2 and 3 respectively. If 1 is present in command, it adjusts the R phase, if 2 is present adjusts Y phase, if 3 it adjusts B phase. Depending upon the string if U is present in command then it adjusts the voltage, I for current and W for power factor.
- After this, the next step is source adjustment. The meter data is transmitted through Docklight, this data is in form of hex string and it needs to be converted to decimal. When Docklight is ready to display, these hex values are converted to decimal.

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- The user entered value is compared with the converted meters value. If difference is  $> 0$  means it undergoes coarse adjustment for adjusting voltage only. If this difference is positive, then the Arduino pin assigned as forward will go high making the relay to turn on to which it is connected. If the difference is negative triggers the other relay which is connected to reverse pin of Arduino. In coarse adjustment the value gets increased or decreased by a value of 10. Later it enters into fine adjustment, here if the difference between user value and converted meter data is positive and if it is  $> 0.001$ , then Arduino pin assigned as forward will turn on and it triggers the relay which is connected to it. This makes the motor inside the phantom to rotate in the forward direction. If negative, motor rotates in reverse direction.
- For current and power factor there will be no coarse adjustment, here the first method is range selection. Current ranges will be defined in the program. If the user entered value comes under any one of the range, that particular Arduino pin will go high, selecting that range in the Phantom source unit. After selection, again fine adjustment is done. i.e., when the motor inside the phantom is made to rotate the voltage/current/powerfactor either increases or decreases depending upon the difference between the user entered value and the meter data. This adjustment is done until the required value specified by the user is reached. If the value is adjusted to set value and if it is accurate as the user entered value, then that value will be displayed in the LCD.

### III. RESULTS AND DISCUSSIONS

The Fig. 6 shows the experimental setup for doing source adjustment. The program written in Arduino IDE is uploaded to the Arduino board, and by using the terminal software commands for voltages, power factor selection or currents can be given. According to the code written in the Arduino IDE, first the command is sent later after some delay hex string read from the meter is sent through Docklight for simulation as shown in Fig. 7.

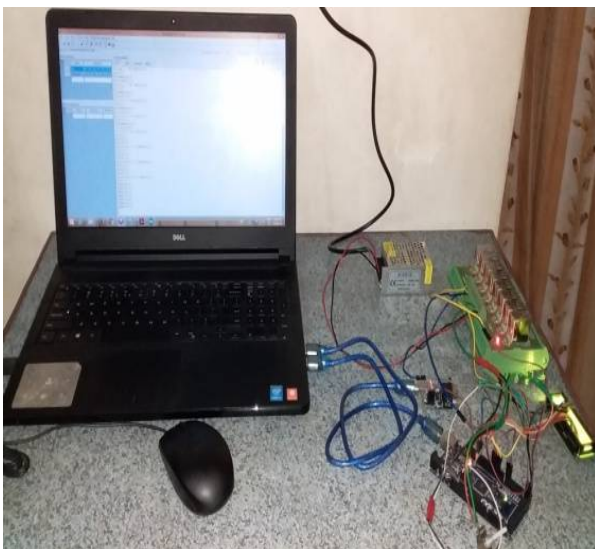


Fig. 6: Experimental setup for coarse adjustment

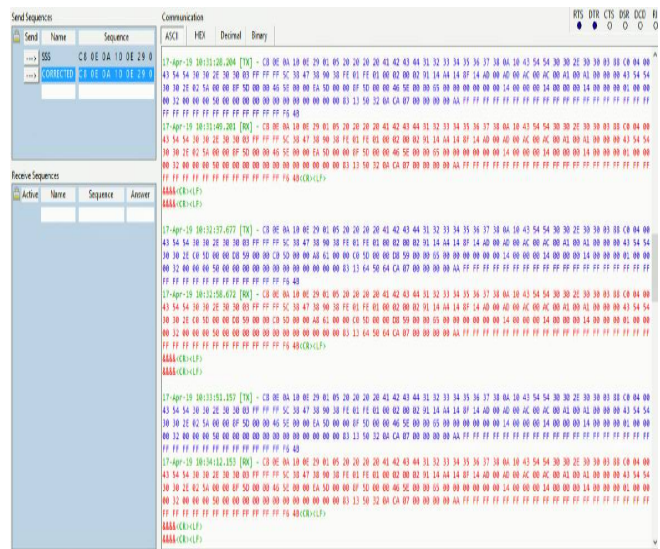


Fig. 7: Transmission of hex string read by meter

Since simulation is done, we are using Docklight in place of meter. Docklight does the work as meter does. Here delay is provided because to establish a serial communication so that the Arduino requires some time to read the complete data. Fig. 8 shows the enlarged image of hex string of meter data sent through Docklight. This hex value will be converted from hex to decimal value then adjustment is done by rotating motor. This converted value is made to display in terminal software as shown in Fig. 9 so that it will become easy for analyzing data and logging those values and the final values are displayed in LCD as shown in Fig. 11.



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Fig. 8: Enlarged image of hex string of meter data sent through Docklight

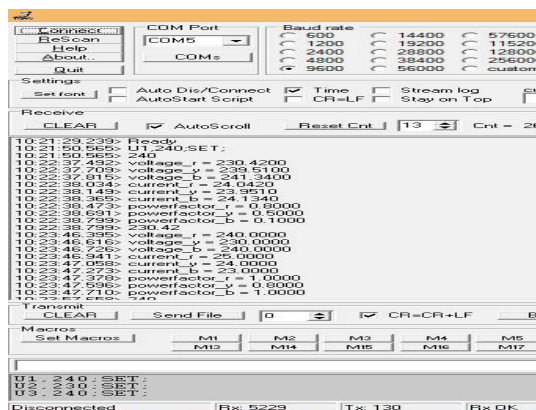


Fig. 9: Terminal software display for setting required source value and for logging data

Finally for logging the data for further analysis it can be done by simply clicking the start log button in the terminal software and by selecting the time of logging. Each value will be displayed with time I.e., in hour: minutes: seconds form. This logged data will be saved in .txt extension and can be viewed in the notepad as shown in Fig. 10.

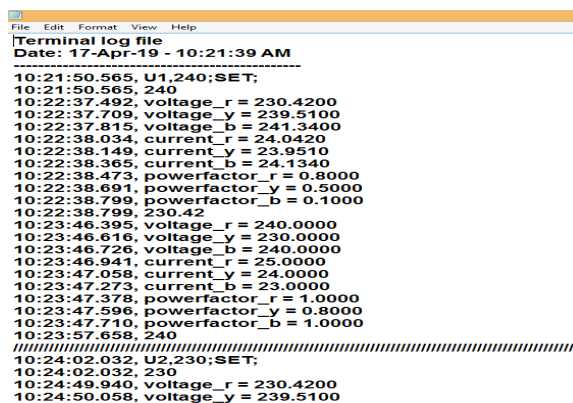


Fig. 10: Logged data saved in .txt form with date and time



Fig. 11: LCD display



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## IV. CONCLUSION AND FUTURE WORK

### A. Conclusion

All the three phase (R, Y, and B) voltages are controlled by coarse and fine adjustment in phantom unit in order to increase or decrease the voltage by writing a program using Arduino Mega 2560 controller. In this controlling process, Docklight software worked like a meter for measuring the voltage, current and power factor. The meter data is transmitted and monitored to check whether serial communication happens without loss of data. During the process of setting value, logging of each data is done with timestamps which also displayed in microseconds. This process continues until required accurate value is reached in order to calibrate and to test the thread through meters. Once the required value is reached, the accurate value is displayed on LCD. All those data's during adjustments are logged with date and time and is saved as text file in the PC in .txt extension. All these process occurs automatically by programming without human intervention. Hence automation and control of three phase phantom source unit is achieved and the efficiency of the system can be improved.

### B. Future Work

Further for analyzing data for ensuring preventive maintenance or to improve efficiency of operation the time difference between the user set value and corrected value obtained after adjustment can be taken to check the delay. By doing this we can study the time taken by the source to get adjusted to accurate value. This can also be represented graphically by plotting the values against time duration. From this the efficiency of operation can be improved. These controllers can also be embedded into a single unit in PCB to reduce the complex connections. Application of IoT system can be done such that when the phantom adjusts the parameters to accurate value, application can be developed so that we can get message to our android system about the time taken by phantom source unit to adjust the source parameters to accurate value set by the user.

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