**”INVERTER BACKUP INDICATOR USING ARDUINO NANO”**

A Project Stage II Report submitted

In partial Fulfillment of the Requirements for Graduate Degree Course

In

Electrical Engineering

By

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## Academic Year: 2021-2022

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Power cuts are very common in India. Now, with our dependency on electricity for almost everything, things become difficult. The situation worsens during summers. To get rid of these frequent power cuts, it is recommended to use an inverter. An inverter is one of the most commonly used appliances. It is an essential device that can be found not only in factories but also in homes, schools, offices and public buildings. This appliance can save the day in the worst case scenario of a power outage. Like every other appliance, inverters are also prone to glitches. There are some common problems that people face with inverters. Thankfully, some of these problems can be easily fixed without any expert help. Let’s discuss some common issues with inverters and their solutions.

Batteries that are part of a system, such as computer batteries, can have their properties checked and logged in operation to assist in determining remaining charge. A real battery can be modelled as an ideal battery with a specified EMF, in series with an internal resistance. As a battery discharges, the EMF may drop or the internal resistance increase; in many cases the EMF remains more or less constant during most of the discharge, with the voltage drop across the internal resistance determining the voltage supplied. Determining the charge remaining in many battery types not connected to a system that monitors battery use is not reliably possible with a voltmeter. A meter such as an equivalent series resistance meter (ESR meter) normally used for measuring the ESR of electrolytic capacitors can be used to evaluate internal resistance.

ESR meters fitted with protective diodes cannot be used; a battery will simply destroy the diodes and damage itself. An ESR meter known not to have diode protection will give a reading of internal resistance for a rechargeable or non-rechargeable battery of any size down to the smallest button cells which gives an indication of the state of charge. To use it, measurements on fully charged and fully discharged batteries of the same type can be used to determine resistances associated with those states.

The cost of an ESR meter makes it uneconomic for measuring battery voltages as its only function, but a meter used for checking capacitors can take on the additional duty

***Keywords: Arduino Nano, Current Sensor, Voltage Sensor, LCD, I2C and Battery.***

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# INTRODUCTION

In this project our aim is to display remaining capacity of inverter. Small device which can be placed on any inverter by applying some programmable changes like battery capacity and output voltage here, by consideration of project cost we are using small li-po battery to demonstrate project.

Whenever a battery operation is involved for operating a given load, knowing the backup time of the battery becomes an important factor with the system.

However a backup time indicator is mostly never provided even in most of the advanced battery charger units, which makes it impossible for the user to realize the remaining backup power within the associated battery. With such difficult circumstance the user is just left to guess the full discharge time through trial and error methods.

The design of a battery backup time indicator circuit presented here is designed for fulfilling the above requirement so that the user is able to visually monitor the backup time as well as the consumption status of the load connected with the battery continuously.

# LITERATURE SURVEY & PROBLEM STATEMENT

## Literature Survey

Luminous India have inverter battery indicator but shows only remaining percentage of capacity. 90% of inverter manufactures doesn’t have any capacity indicating built in system in their inverters. Remaining inverter with indictors is too much costly.

A 7 segment LED display could make the circuit quite complex, 4 LED indicators, which can be easily upgraded to 8 LEDs by adding another LM324 comparator stage. But this system will be indicating the level in terms of led. Therefore we'll try to implement the design using LCD display so that we can able to see accurate percentage of battery and also how much time inverter will survive on the current load.

A. H. Sabry#1,2 , Wan Zuha Wan Hasan 2, Yasir Alkubaisi#1 , Mohd Zainal Abidin Ab-Kadir1,2 1Electrical and Electronics Department Engineering, Universiti Putra Malaysia (UPM) Selangor, Serdang, 43400, Malaysia design following system.

Backup power system (BPS) compatible with two options of primary power sources; grid-connected power (AC) or solar PV-power (DC), to provide power to household appliances that comprises; a rechargeable battery bank, a charging-balancing circuit to keep the battery fully charged when power from the utility grid is available, a battery management circuit to optimize a voltage output of the system and protect individual batteries from overcharging thereby prolonging the operating lifetime of batteries, a relay switch circuit controlled by the main power source to change-over the load/appliances between direct link through bypassing the main power and the storage battery power when both options of main power are unavailable, three led indicators to display the battery status. Short circuit protection is provided to protect the backup power system from appliance short circuits, and to protect the batteries in the event of a short circuit within the system.

The result shows the excellent utilization of the traditional BPS losses, wherein some appliances, the proposed topology can achieve about 99% power efficiency as compared with the traditional one.

## Problem Statement

The backup time indicator is mostly never provided in inverters and even in most of the advanced battery charger units, which makes it impossible for the user to realize the remaining backup power within the associated battery. With such difficult circumstance the user is just left to guess the full discharge time through trial and error methods.

In India 90% of the inverter manufacturer does not have any capacity indicating built in system in their inverters. The remaining inverters that comes with indicator and advance features that makes them too much expensive.

**Power Supply**

**Load**

**Current**

**Sensor**

Micro-

Controller

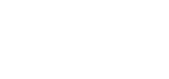
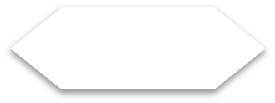
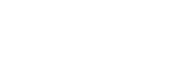
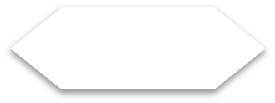
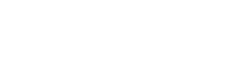
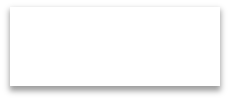
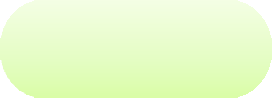
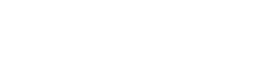
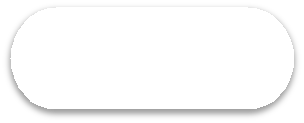
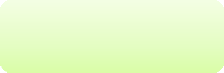
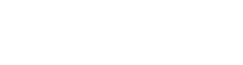
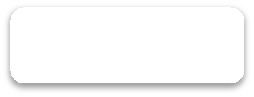
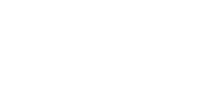
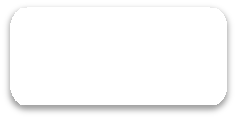
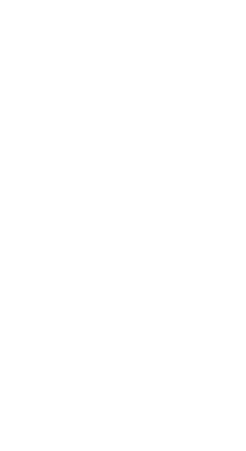
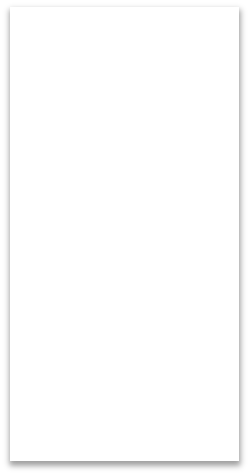
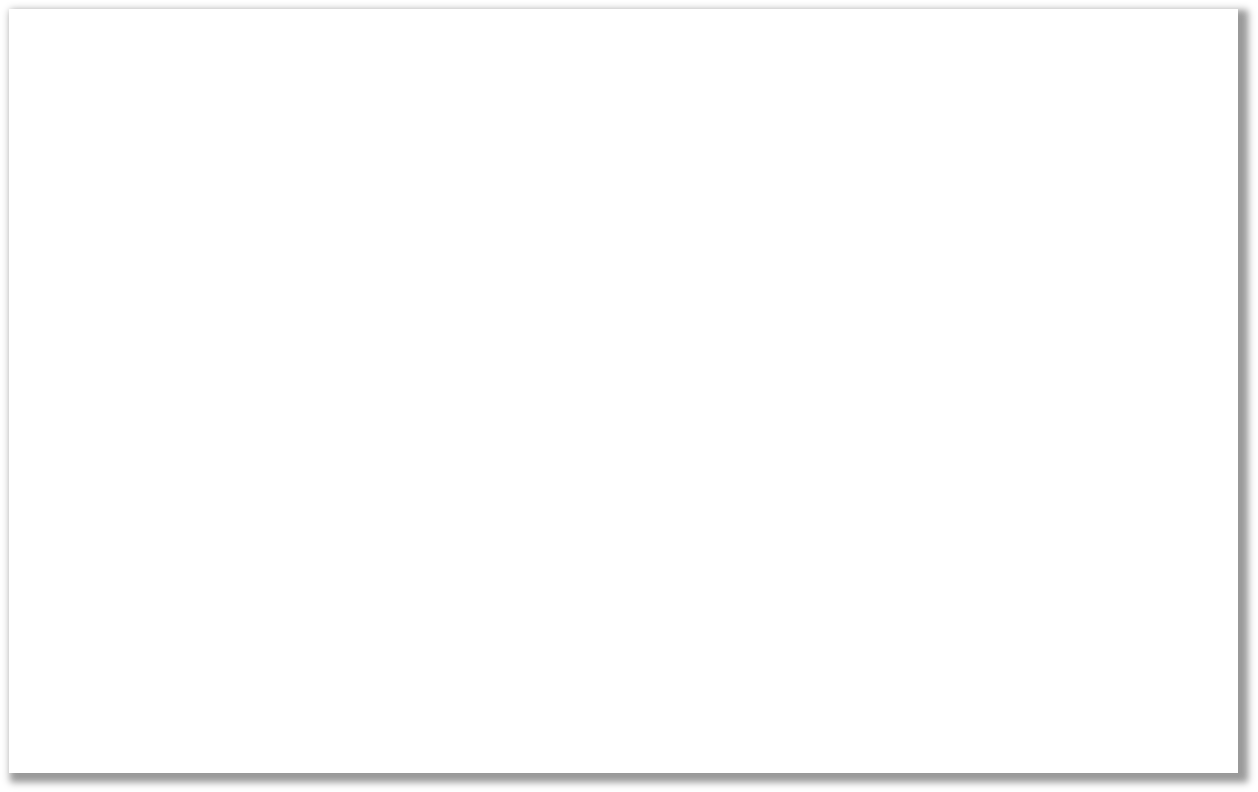
**Display**

**Battery**

**Voltage Sensor**

# THEORETICAL CONCEPT / METHODOLOGY

## Block Diagram:

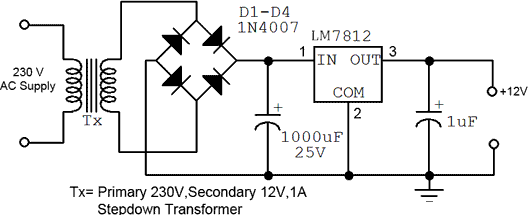


### Fig. 3.1 Block Diagram of Inverter Backup Indicator

The above figure shows the block diagram of inverter backup indicator. Which consist of microcontroller, current sensor, voltage sensor, display, power supply, load and battery. The microcontroller plays the very important role in this project. We can use a power supply for operating the microcontroller and other devices or we can use the same battery supply to operate the components of the system. The load is connected to the battery and the current sensor connect in series with load to sense the load current and it will send the data to microcontroller for further process. The voltage sensor is connected to battery to measure the battery voltage and the measured voltage signals is provided to microcontroller for calculating the backup time.

## Design and Description:

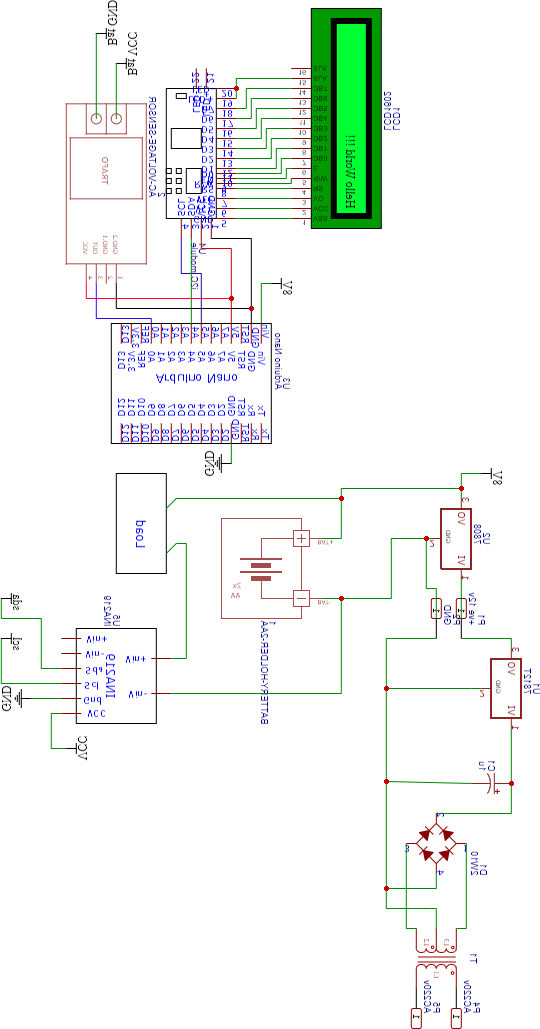
The Ardunio board can operate on 5-18 volt supply here we are using inverter battery as voltage source. To Charge battery, 12V DC adapter has been taken in use.



### Fig. 3.2.1 Power Supply Circuit Diagram

For +12V regulated (fixed voltage) DC power supply. This power supply circuit diagram is ideal for an average current requirement of 1Amp. This circuit is based on IC LM7812. It is a 3-terminal (+ve) voltage regulator IC. It has short circuit protection, thermal overload protection.

In this project Arduino Nano play very important role. The input sensors i.e. Current Sensor and Voltage Sensor reads electrical single from load and battery. The electrical signal received by sensor is converted into small equivalent signal and then send to microcontroller.



### Fig. 3.2.2 Schematic Diagram of Inverter backup indicator

**Pin connection with arduino:**

Arduino Sensor/Actuator

A4 => SDA of current sensor & LCD SDA A5 => SCL of current sensor & LCD SCL A0 => Vout of voltage sensor

The microcontroller received the equivalent signal from the current sensors and voltage sensor at arduino pin number A4, A5 and A0 respectively. Then based on that received signal from the sensors the microcontroller will measures the load current and the battery voltage. Once we get the battery voltage and the load current using these two data we can calculate the backup time of the battery. Then the calculated backup time is displayed on LCD display using microcontroller.

## Calculation:

The marketing department gave you a specification and all it says is “maximize run time, minimize the battery size and cost." But they won't tell you much run time is acceptable.

The electrons that are stored in the battery. We all learned that the measure of charge is the coulomb and that a single electron has 1.602e-19 coulombs of charge. One amp flowing in a wire for one second will use one coulomb of charge, which is 6.24 x 10^18 electrons,.

*Q* = *I*\**t* ( 1 )

Where *Q* is the charge in coulombs, *I* is the current in amps and *t* is the time in seconds.

Batteries were evidently developed by engineers who subscribed to the “whatever’s easiest” system of measurement. They got tired of pulling out their slide rules to divide by 3600 every time they wanted to know how long 24000 coulombs would last them and came up with the unauthorized unit of *amp-hours*. Later, when smaller batteries were used they came up with *milliamp-hours*. Amp-hours means amps times hours. Divide by amps and you get hours, divide by hours and you get amps. Since a battery changes voltage during the discharge, it isn’t a perfect measure of how much energy is stored, for this you would need watt-hours. Multiplying the average or nominal battery voltage times the battery capacity in amp-hours gives you an estimate of how many watt-hours the battery contains.

*E=C\*Vavg* ( 2 )

Where *E* is the energy stored in watt-hours, *C* is the capacity in amp-hours, and *Vavg* is the average voltage during discharge. Yes, *watt-hours* is a measure of energy, just like kilowatt-hours. Multiply by 3600 and you get *watt-seconds*, which is also known as *Joules*.

The following method assumes that you know how many amps you need for the gadget under power.

Step 1.Back of the envelope

If the current drawn is *x* amps, the time is *T* hours then the capacity *C* in amp-hours is

*C = xT* ( 3 )

For example, if your pump is drawing 120 mA and you want it to run for 24 hours

*C =* 0.12 Amps \* 24 hours = 2.88 amp hours Step 2.Cycle life considerations

It isn’t good to run a battery all the way down to zero during each charge cycle. For example, if you want to use a lead acid battery for many cycles you shouldn’t run it past 80% of its charge, leaving 20% left in the battery. This not only extends the number of cycles you get, but lets the battery degrade by 20% before you start getting less run time than the design calls for

*C’ = C/0.8* ( 4 )

For the example above

*C’ = 2.88 AH / 0.8 = 3.6 AH*

Step 3: Rate of discharge considerations

Some battery chemistries give much fewer amp hours if you discharge them fast. This is called the Peukart effect. This is a big effect in alkaline, carbon zinc, zinc-air and lead acid batteries. For example if you draw at 1C on a lead acid battery you will only get half of the capacity that you would have if you had drawn at 0.05C. It is a small effect in NiCad, Lithium Ion, Lithium Polymer, and NiMH batteries.

For lead acid batteries the rated capacity (i.e. the number of AH stamped on the side of the battery) is typically given for a 20 hour discharge rate. If you are discharging at a slow rate you will get the rated number of amp-hours out of them. However, at high discharge rates the capacity falls steeply. A rule of thumb is that for a 1 hour discharge rate (i.e. drawing 10 amps from a 10 amp hour battery, or 1C) you will only get half of the rated capacity (or 5 amp-hours from a 10 amp-hour battery). Charts that detail this effect for different discharge rate can be used for greater accuracy.

For example, if you’re portable guitar amplifier is drawing a steady 20 amps and you want it to last 1 hour you would start out with Step 1:

C=20 amps \* 1 hour = 20 AH Then proceed to Step 2

C‟ = 20 AH / 0.8 = 25 AH

Then take the high rate into account C‟„=25 /.5 = 50 AH

Thus you would need a 50 amp hour sealed lead acid battery to run the amplifier for 1 hour at 20 amps average draw.

Step 4.What if you don’t have a constant load? The obvious thing to do is the thing to do. Figure out an average power drawn. Consider a repetitive cycle where each cycle is 1 hour. It consists of 20 amps for 1 second followed by 0.1 amps for the rest of the hour. The average current would be calculated as follows.

20\*1/3600 + 0.1(3599)/3600 = 0.1044 amps average current. (3600 is the number of seconds in an hour).

In other words, figure out how many amps is drawn on average and use steps 1 and

2. Step 3 is very difficult to predict in the case where you have small periods of high current. The news is good, a steady draw of 1C will lower the capacity much more than short 1C pulses followed by a rest period. So if the average current drawn is about a 20 hour rate, then you will get closer to the capacity predicted by a 20 hour rate, even though you are drawing it in high current pulses. Actual test data is hard to come by without doing the test yourself.

Consideration of above concept we can calculate the backup time of inverter battery as follows,

First we have to calculate the battery percentage. For that lets consider the Vhigh is the voltage of fully charged battery and Vlow is the fully discharged battery. Let‟s K and Kp is actual constant and present constant.

K = Vhigh - Vlow ( 5 )

Kp = Vhigh - Vpresent ( 6 )

Therefore,

Battery percentage (%) = (K – Kp ) x 100 ( 7 )

K

Second we need to calculate the actual capacity (Amp-hour) of battery,

Battery capacity = (Battery %) x ( Total Capacity of Battery ) ( 8 )

100

Now calculate the backup time of inverter battery as Tbackup ,

But

Tbackup = (Battery voltage) x ( Battery capacity ) ( 9 )

Total watts on laod

Total watts (on load) = (Battery Voltage) x ( Load cuurent ) ( 10 )

From equation (9) & (10), Tbackup is given by,

Tbackup = ( Battery voltage ) x ( Battery capacity ) - - - ( 11 ) ( Battery Voltage ) x ( Load cuurent )

Tbackup = Battery capacity ( 12 )

Load cuurent

The above Tbackup formal gives the battery backup time in hours because the battery capacity is always given in the ampere-hours to get the time in min we have to multiply by 60 above equation as (12) follows,

Tbackup (in min) = Tbackup (in hours) x 60 ( 13 )

Using above equation (13) of backup time formula we can calculate the backup time of inverter battery or any battery backup time.

## Hardware Requirement:

### Arduino Nano:

Arduino Nano is one [type of microcontroller](https://www.elprocus.com/arm7-based-lpc2148-microcontroller-pin-configuration/) board, and it is designed by Arduino.cc. It can be built with a microcontroller like Atmega328. This microcontroller is also used in [Arduino](https://www.elprocus.com/arduino-sim-for-iot-based-devices-launched-by-arduino/) UNO. It is a small size board and also flexible with a wide variety of applications. Other [Arduino boards](https://www.elprocus.com/different-types-of-arduino-boards/) mainly include Arduino Mega, Arduino Pro Mini, Arduino UNO, Arduino YUN, Arduino Lilypad, Arduino Leonardo, and Arduino Due. And other development boards are AVR Development Board, PIC Development Board, [Raspberry Pi](https://www.elprocus.com/new-raspberry-pi-3-model-a-with-wi-fi-and-bluetooth/), Intel Edison, MSP430 Launchpad, and ESP32 board.

This board has many functions and features like an Arduino Duemilanove board. However, this Nano board is different in packaging. It doesn’t have any DC jack so that the power supply can be given using a small USB port otherwise straightly connected to the pins like VCC & GND. This board can be supplied with 6 to 20volts using a mini USB port on the board.

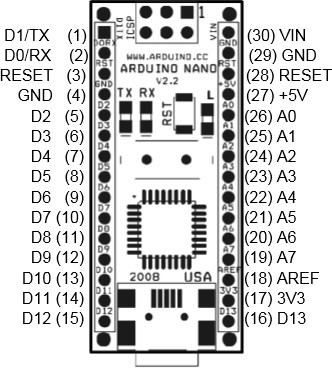
### Arduino Nano Features:

The features of an Arduino nano mainly include the following.

* ATmega328P Microcontroller is from 8-bit AVR family
* Operating voltage is 5V
* Input voltage (Vin) is 7V to 12V
* Input/output Pins are 22
* Analog i/p pins are 6 from A0 to A5
* Digital pins are 14
* Power consumption is 19 mA
* I/O pins DC Current is 40 mA
* Flash memory is 32 KB
* SRAM is 2 KB
* EEPROM is 1 KB
* CLK speed is 16 MHz
* Weight-7g
* Size of the printed circuit board is 18 X 45mm
* Supports three communications like SPI, IIC, & USART

### Arduino Nano Pinout:

Arduino nano pin configuration is shown below and its each pin functionality is discussed below.



### Fig. 3.4.1.1 Arduino Nano Pinout Diagram

Power Pin (Vin, 3.3V, 5V, GND): These pins are power pins

* Vin is the input voltage of the board, and it is used when an external [power source](https://www.elprocus.com/what-are-types-of-renewable-energies/) is used from 7V to 12V.
* 5V is the [regulated power supply](https://www.elprocus.com/regulated-power-supply-circuit-working-applications/) voltage of the nano board and it is used to give the supply to the board as well as components.
* 3.3V is the minimum voltage which is generated from the [voltage regulator](https://www.elprocus.com/lm723-voltage-regulator-pin-configuration-circuit-diagram/) on the board.
* GND is the ground pin of the board

RST Pin( Reset): This pin is used to reset the microcontroller

Analog Pins (A0-A7): These pins are used to calculate the analog voltage of the board within the range of 0V to 5V.

I/O Pins (Digital Pins from D0 – D13): These pins are used as an i/p otherwise o/p pins. 0V & 5V.

Serial Pins (Tx, Rx): These pins are used to transmit & receive TTL serial data. External Interrupts (2, 3): These pins are used to activate an interrupt.

PWM (3, 5, 6, 9, 11): These pins are used to provide 8-bit of PWM output. SPI (10, 11, 12, & 13): These pins are used for supporting [SPI communication](https://www.elprocus.com/serial-peripheral-interface-spi-communication-protocol/). Inbuilt LED (13): This pin is used to activate the LED.

IIC (A4, A5): These pins are used for supporting TWI communication. AREF: This pin is used to give reference voltage to the input voltage.

### Table 3.4.1 Arduino Nano Pinout description

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Pin No. | | Name | Type | Description |
| 1-2, | 5-16 | D0-D13 | I/O | Digital input/output port 0 to 13 |
| 3, | 28 | RESET | Input | Reset (active low) |
| 4, | 29 | GND | PWR | Supply ground |
| 17 | | 3V3 | Output | +3.3V output (from FTDI) |
| 18 | | AREF | Input | ADC reference |
| 19-26 | | A7-A0 | Input | Analog input channel 0 to 7 |
| 27 | | +5V | Output or | +5V output (from on-board regulator) or |
| Input | +5V (input from external power supply) |
| 30 | | VIN | PWR | Supply voltage |

**Arduino Nano Communication:**

The communication of an Arduino Nano board can be done using different sources like using an additional Arduino board, a computer, otherwise using microcontrollers. The microcontroller using in Nano board (ATmega328) offers [serial communication](https://www.elprocus.com/avr-microcontroller-serial-data-communication/) (UART TTL). This can be accessible at digital pins like TX, and RX. The Arduino software

Comprises of a serial monitor to allow easy textual information to transmit and receive from the board.

The TX & RX LEDs on the Nano board will blink whenever information is being sent out through the FTDI & USB link in the direction of the computer. The library-like Software Serial allows serial communication on any of the digital pins on the board. The microcontroller also supports SPI & I2C (TWI) communication.

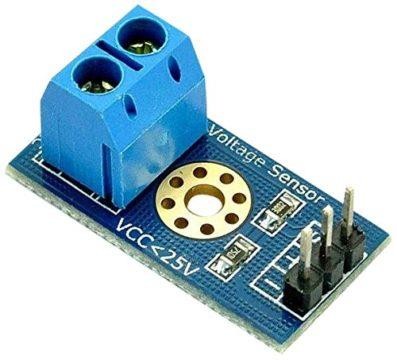
### Arduino Nano Programming:

The programming of an Arduino nano can be done using the Arduino software. Click the Tools option and select the nano board. Microcontroller ATmega328 over the Nano board comes with pre-programmed with a boot loader. This boot loader lets to upload new code without using an exterior hardware programmer. The communication of this can be done with the STK500 protocol. Here the boot loader can also be avoided & the microcontroller program can be done using the header of in-circuit serial programming or ICSP with an Arduino ISP.

* + 1. **Voltage Sensor :**

The voltage sensor module is a 0-25 DC voltage sensing device that is based on a resistive voltage divider circuit. It reduces the input voltage signal by the factor of 5 and generates a corresponding analog output voltage. This is the reason why you can measure the voltage up to 25V using the 5V analog pin of any microcontroller.

The voltage sensor module with Arduino and measure the different Battery voltages.. This voltage measurement circuit is small & portable and you can use it to detect under or over-voltage faults in electrical circuits.



### Fig. 3.4.2.1 0-25V Voltage Sensor Module

The Voltage Sensor Module is a simple but very useful module that uses a potential divider to reduce an input voltage by a factor of 5. The 0-25V Voltage Sensor Module allows you to use the analog input of a microcontroller to monitor voltages much higher than it is capable of sensing.

#### Features & Specifications:

1. Output Type: Analog
2. Input Voltage (V): 0 to 25
3. Voltage Detection Range (V): 0.02445 to 25
4. Analog Voltage Resolution (V): 0.00489
5. Dimensions: 4 × 3 × 2 cm

#### Voltage Sensor Module Pinout:

The voltage sensor module has 5 pins, 2 on the front side and 3 on the backside*.*

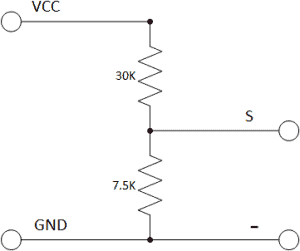
* 1. VCC: Positive terminal of the External voltage source (0-25V)
  2. GND: Negative terminal of the External voltage source
  3. S: Analog pin connected to Analog pin of the microcontroller

4. +: Not Connected

5. -: Ground Pin connected to GND of microcontroller

### Voltage Sensor Module Design & Construction:

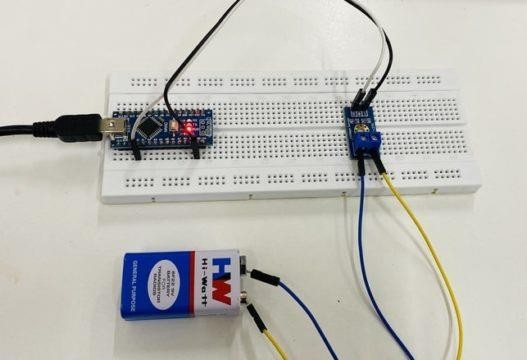
The Voltage Sensor is basically a Voltage Divider consisting of two resistors with resistances of 30KΩ and 7.5KΩ i.e. a 5 to 1 voltage divider. Hence the output voltage is reduced by a factor of 5 for any input voltage. The internal circuit diagram of the Voltage Sensor Module is given below.



### Fig. 3.4.2.2 Voltage Divider Circuit Diagram

The Arduino analog input pin accepts voltages up to 5V. Hence you can use this module easily with Arduino. If the controller has 3.3V systems, the input voltage should not be greater than 3.3Vx5=16.5V.

Arduino AVR chips have 10-bit AD, so this module simulates a resolution of 0.00489V (5V/1023), so the minimum voltage of the input voltage detection module is 0.00489Vx5=0.02445V.

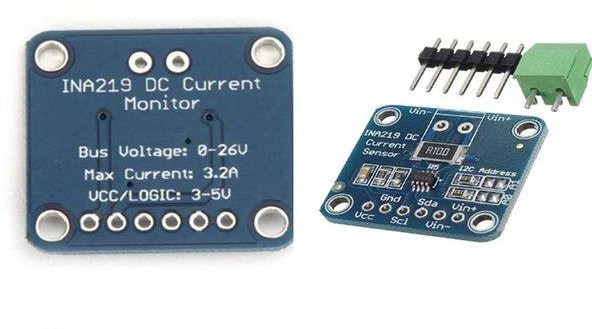


### Fig. 3.4.2.3 Interfacing of Voltage Sensor with Arduino Nano

The voltage sensor detected the reading around 5V when tested with Discharged 3S Lithium-Ion Battery.

### INA219 Current sensor:

The INA219 Current Sensor, with this module we can measure current, voltage, and power of a circuit. The INA219 Current Sensor is an I2C supported interface based zero drift and bi-directional current/power monitoring module. The INA219 Current Sensor can be easily used with Arduino to measure current, power, and it can also sense shunt voltage. This Sensor module is provided with 0.1 ohms, a 1% shunt resistor to fulfill the requirement of current measurements. The INA219 Current Sensor can measure DC voltage up to +26V. There are so many other things which we will discuss in a minute.



### Fig. 3.4.3.1 INA219 Current sensor

**Features and Specifications:**

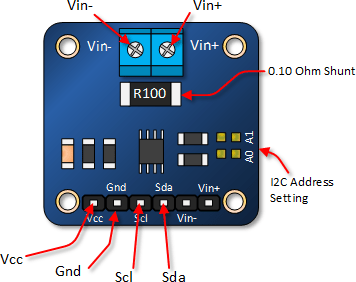
* + - * Operational Voltage: 3 – 5.5 Volts
      * Operating Temperature: -400C – 1250C
      * Maximum Voltage: 6 Volts
      * Bus Voltage Range: 0 – 26 Volts
      * Current sensing Range: ±3.2A with ±0.8mA resolution
      * 0.1 ohm 1% 2W current sense resistor

### Useful Features:

Some of the extra features include:

* + - * It has in-built calibration registers to reduce uncertainty in the power, voltage, and current values.
      * It contains 16 programmable addresses and filtering options.
      * The sensor is available in 2 grades i.e. INA219A and INA219B.
      * The Accuracy is up to 0.5% in INA219B over the temperature.
      * The sensor has two package types i.e. SOT23-8 and SOIC-8.

### INA219 Current Sensor Pinout:



**Fig. 3.4.3.2 INA219 Current sensor Pinout**

The INA219 Current Sensor consists of six pins which are:

* + - * VCC
      * GND
      * SCL
      * SDA
      * Vin –
      * Vin +

In these pins the vcc and gnd pins are used for the power supply. SCL and SDA for the i2c communication and Vin+ and Vin- pins for measuring the voltage. On the board you can see A0 and A1 these are used for the I2C Address selection. The R100 is the Current

Sense Resistor and the small chip in the middle is the INA219 chip. The INA219 Current Sensor is most commonly used:

* + - * Power Profier.
      * Digital Multimeter

### Specifications of the INA219 Current Sensor:

Supply voltage:

The supply voltage range is 3 to 5.5 volts so we can connect the supply to this module directly from our 5 volt or 3.3 volt systems. Due to this wide voltage input range the INA219 Current Sensor module can be powered up using the Arduino‟s 5 volts. This current sensor module can also be easily interfaced with 3.3v compatible controller boards like ESP32 and Nodemcu ESP8266, etc.

Shunt voltage and Bus voltage:

V\_shunt, this is the voltage across the shunt resistor.V shunt and V\_bus are the two measurements acquired directly by this module. The measurement range of these voltages is configurable by programming the registers through the i2c channel. The current measurement range can be determined by these settings and the value of the resistor we use for the shunt resistor. For example if we use a shunt resistor value of 0.1 ohm as in our module, the current measurement range are as shown here:

-0.4 A to 0.4 A

-0.8 A to 0.8 A

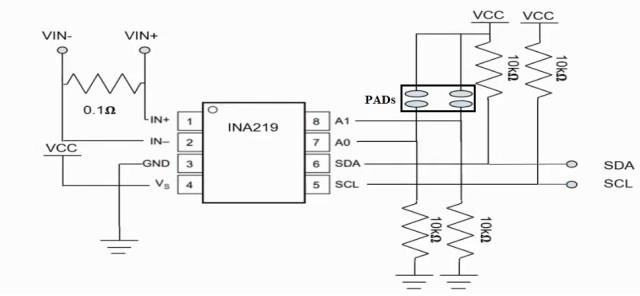
-1.6 A to 1.6 A

-3.2 A to 3.2 A

ADC Resolution:

The resolution of the measurement is also programmable and has a range of 9 to 12 bits. INA219 Module Schematic:

This is the schematic of the module as you can see:



### Fig. 3.4.3.3 INA219 Current sensor Schematic Diagram

It is composed of the INA219 IC with some resistors and one capacitor for noise decoupling but i omitted this for simplicity. Let’s discuss each component one by one, first there are two pull-down resistors connected to the address pins A0 and A1 which are 10 kilo ohm resistors and by default this device will have an address of 40 and hexadecimal value you can change this address by connecting these two pads as shown in the above figure. You can tie these pins to SDA or SCL extending your address options to a number of 16.This is the list of the i2c addresses we can use for each connections made.

The two pull-up resistors on the i2c line which are connected at SDA and SCL are necessary for proper communication with the host. Since i2c devices are only capable of driving the line to a low value and finally the resistor which is connected with the Vin– and Vin+ is called shunt resistor. It is used to measure the voltage drop or the shunt voltage and with the knowledge of the shunt resistor value. We can calculate the amount of current flowing to the load.

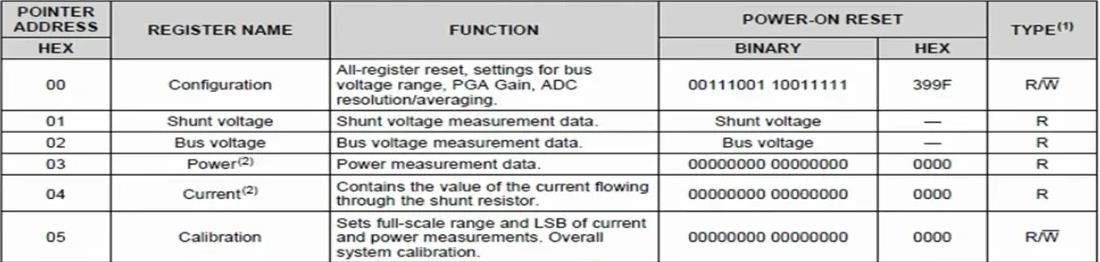
A simple load connected to vcc and we want to measure the voltage and the amount of current flowing through this load, then we can connect the vin+ and Vin- pins of our module.

As we see here and then the current flows through the shunt resistor which results in the voltage drop across the shunt resistor. So this voltage drop is:

V\_shunt = Vdrop V\_bus = Vin –

### INA219 Register Description:

**Table 3.4.3.1 INA219 Current sensor Summery of Register**



Let‟s take a look at the internal register of INA219, as you can see there are six registers, two configurable registers, and four read-only registers; with the configuration register we can set the mode of operation voltage measurement range ADC resolution and so on. The calibration register is used current and power calculations which we can read from the current and power registers. Current and power flowing to the load can be calculated using these formulas directly from the values read from the shunt and bus voltages registers.

Current (A) = (Shunt VoltageeReg \* 10 μV ) / shunt Resistor Power (W) = current \* Bus voltage Reg \* 4 mV

However you can also obtain current and power values directly from the registers after setting the calibration register using this formula:

Current value = 0.04096 (Current LSB \* Rshunt)

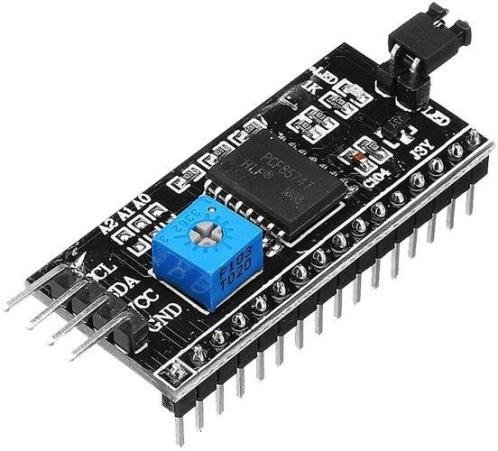
current lsb is the desired resolution of the current register value and should be selected a value between maximum expected current divided by 2 to the 15th to maximum expected current divided by 2 to the 12th and of course the maximum expected current should be equal to or smaller than the current measurement range which was mentioned above. After setting the calibration register you can read the register value from the current and power register and obtain an actual value in amperes and watts using these formulas:

current (A) = Current Reg \* Current LSB Power (W) = Power Reg \* 20 \* current LSB

For example with the maximum expected current of 2 amperes and desired resolution of the current as 100microamperes.

### I2C Module:

I2C Module has a inbuilt PCF8574 I2C chip that converts I2C serial data to parallel data for the LCD display.

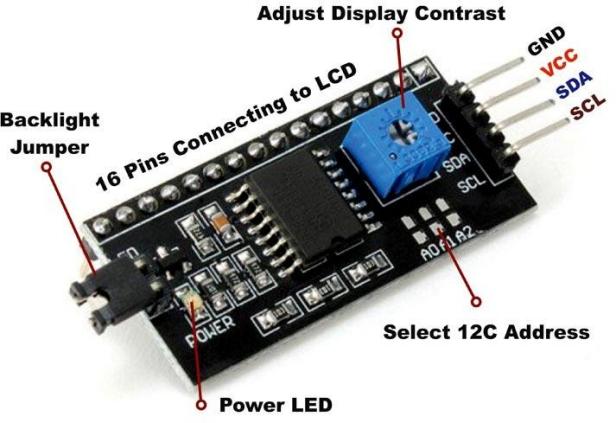


### Fig 3.4.4.1 I2C Module

These modules are currently supplied with a default I2C address of either 0x27 or 0x3F. To determine which version you have check the black I2C adaptor board on the underside of the module. If there a 3 sets of pads labelled A0, A1, & A2 then the default address will be 0x3F. If there are no pads the default address will be 0x27.

The module has a contrast adjustment pot on the underside of the display. This may require adjusting for the screen to display text correctly.

### Pin Configuration of I2C Serial Interface Adapter Module:



**Fig 3.4.4.2 I2C Module Pinout**

The table below shows the pin name, type, and their functions.

### Table 3.4.4 I2C Module Pinout Description

|  |  |  |
| --- | --- | --- |
| Pin Name | Pin Type | Pin Description |
| GND | Power | Ground |
| VCC | Power | Voltage Input |
| SDA | I2C Data | Serial Data |
| SCL | I2C Clock | Serial Clock |
| A0 | Jumper | I2C Address Selection 1 |
| A1 | Jumper | I2C Address Selection 2 |
| A2 | Jumper | I2C Address Selection 3 |
| Backlight | Jumper | Control Backlight of panel |

**Features:-**

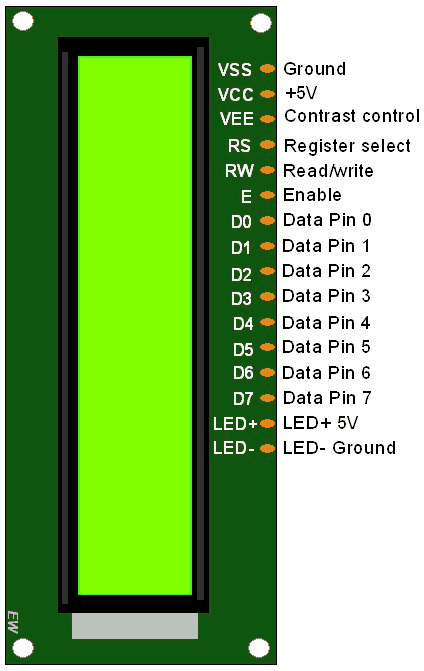
* Operating Voltage: 5V
* Backlight and Contrast is adjusted by potentiometer
* Serial I2C control of LCD display using PCF8574
* Come with 2 IIC interface, which can be connected by Dupont Line or IIC dedicated cable
* Compatible for 16x2 LCD
* This is another great IIC/I2C/TWI/SPI Serial Interface
* With this I2C interface module, you will be able to realize data display via only 2 wires.

### LCD Display (2x16)

The term [LCD stands for liquid crystal display.](https://www.elprocus.com/difference-alphanumeric-display-and-customized-lcd/) It is one kind of electronic display module used in an extensive range of applications like various circuits & devices like mobile phones, calculators, computers, TV sets, etc. These displays are mainly preferred for multi-segment [light-emitting diodes](https://www.elprocus.com/light-emitting-diode-led-working-application/) and seven segments. The main benefits of using this module are inexpensive; simply programmable, animations, and there are no limitations for displaying custom characters, special and even animations, etc.

### LCD 16×2 Pin Diagram:

The 16×2 LCD pinout is shown below.



### Fig 3.4.5.1 LCD 2x16 Pinout Diagram

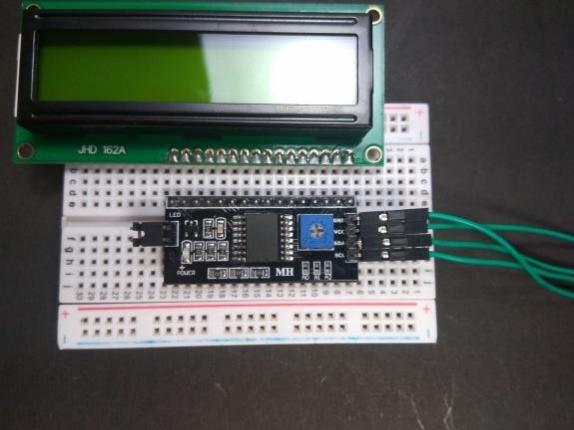
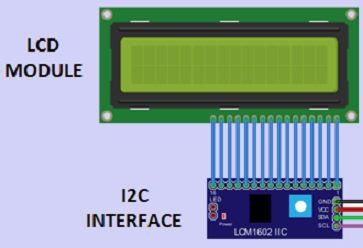
* Pin1 (Ground/Source Pin): This is a GND pin of display, used to connect the GND terminal of the microcontroller unit or power source.
* Pin2 (VCC/Source Pin): This is the voltage supply pin of the display, used to connect the supply pin of the power source.
* Pin3 (V0/VEE/Control Pin): This pin regulates the difference of the display, used to connect a changeable POT that can supply 0 to 5V.
* Pin4 (Register Select/Control Pin): This pin toggles among command or data register, used to connect a microcontroller unit pin and obtains either 0 or 1(0 = data mode, and 1 = command mode).
* Pin5 (Read/Write/Control Pin): This pin toggles the display among the read or writes operation, and it is connected to a microcontroller unit pin to get either 0 or 1 (0 = Write Operation, and 1 = Read Operation).
* Pin 6 (Enable/Control Pin): This pin should be held high to execute Read/Write process, and it is connected to the microcontroller unit & constantly held high.
* Pins 7-14 (Data Pins): These pins are used to send data to the display. These pins are connected in two-wire modes like 4-wire mode and 8-wire mode. In 4-wire mode, only four pins are connected to the microcontroller unit like 0 to 3, whereas in 8-wire mode, 8-pins are connected to microcontroller unit like 0 to 7.
* Pin15 (+ve pin of the LED): This pin is connected to +5V
* Pin 16 (-ve pin of the LED): This pin is connected to GND.

### Features of LCD16x2:

The features of this LCD mainly include the following.

* The operating voltage of this LCD is 4.7V-5.3V
* It includes two rows where each row can produce 16-characters.
* The utilization of current is 1mA with no backlight
* Every character can be built with a 5×8 pixel box
* The alphanumeric LCDs alphabets & numbers
* Is display can work on two modes like 4-bit & 8-bit
* These are obtainable in Blue & Green Backlight
* It displays a few custom generated characters

### Interface LCD Display & I2C Module:



**Fig 3.4.5.2 LCD 2x16 Interfacing with I2C Module**

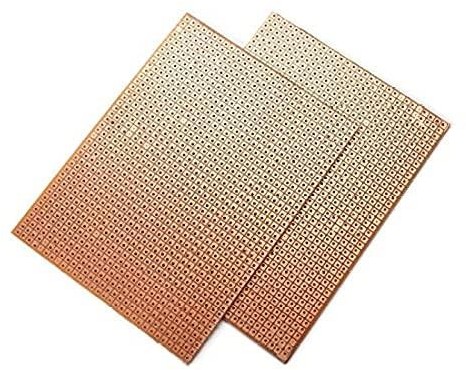
The interfacing of LCD 16×2 to Arduino is very complicated circuits. So to reduce circuitry by using I2C module which is very compact & easy to connection. Simply connect I2C module with LCD parallel & connect I2C modules 4 pins to Arduino. I2C module has 4 output pins which contains VCC, GND, SDA, SCL where 5V supply gives to I2C module through VCC & GND to GND of Arduino. SDA is a data pin & SCL is clock pin of I2C module. To interface LCD and I2C with Arduino we need Liquid Crystal I2C Library in Arduino IDE software.

### Zero PCB

Zero PCB is basically a general-purpose printed circuit board (PCB), also known as perfboard or DOT PCB. It is a thin rigid copper sheet with holes pre-drilled at standard intervals across a grid with 2.54mm (0.1-inch) spacing between holes. Each hole is encircled by a round or square copper pad so that component lead can be inserted into the hole and soldered around the pad without short-circuiting the nearby pads and other leads. For connecting the lead of component with another lead, solder these together or join these using a suitable conducting wire.

Veroboard or strip board is also a general purpose PCB characterized by a 2.54mm regular (rectangular) grid of holes, with parallel strips of copper cladding running in one direction across one side of the board. This general-purpose PCB is known by the name of the original product, Veroboard, a trademark of British company Vero Technologies Ltd and Canadian company Pixel Print Ltd.

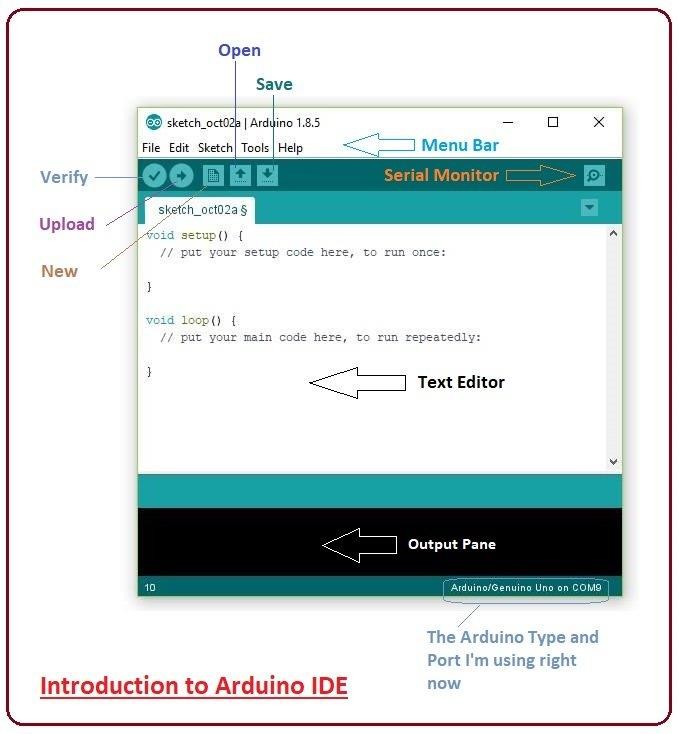
Both zero PCB and veroboard are popular among hobbyists, beginners, and students for rapid prototyping and project works.



**Fig 3.4.6.1 Zero PCB**

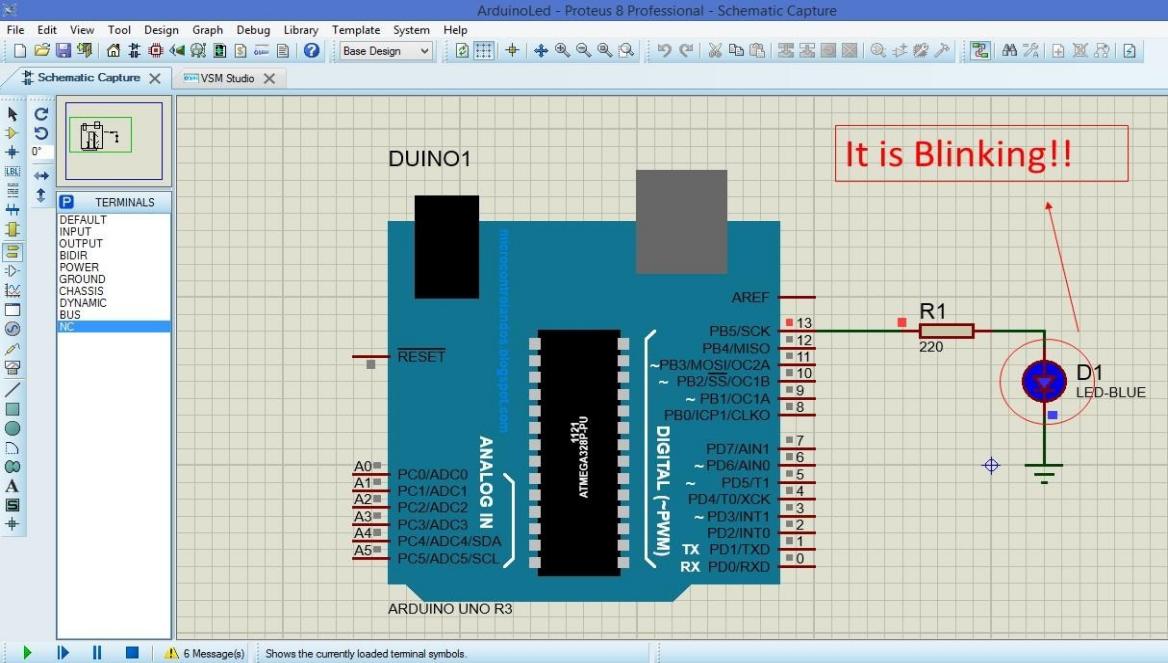
## Software Requirement:

1. IDE Software for loading program in Arduino.



### Fig. 3.5.1 Overview of Arduino IDE Software

1. Proteus Software to make Circuit.



**Fig. 3.5.2 Overview Of Proteus Software**

* 1. **Code :**

# SIMULATION & RESULT

The following is the source code of arduino nano: #include <Wire.h> //for lcd i2c module

#include <LiquidCrystal\_I2C.h> //for lcd display

LiquidCrystal\_I2C lcd(0x27,20,4); // i2c lcd display address #include <Adafruit\_INA219.h> // current sensor lib

Adafruit\_INA219 ina219; //current sensor initialization

const int voltageSensor = A0; // voltage sensor asign void setup(void)

{

Serial.begin(115200); // serial monitor broud rate lcd.backlight(); // lcd backlight on

lcd.begin(16, 2); // lcd initialization

while (!Serial) {

// will pause Zero, Leonardo, etc until serial console opens delay(1);

}

uint32\_t currentFrequency;

Serial.println("Hello!"); lcd.clear();

lcd.print(" Hello!");

if (! ina219.begin()) {

Serial.println("Failed to find INA219 chip"); lcd.clear();

lcd.print(" Failed "); while (1) { delay(10);

}

}

Serial.println("Measuring voltage and current with INA219 ...");

lcd.clear(); lcd.print("Measuring ");

delay(2000);

}

void loop(void)

{

float current\_mA = 0; float current\_amp =0; float cap = 2.2;

float t = 0; float m = 0;

float vOUT = 0.0; float vIN = 0.0; float R1 = 30000.0; float R2 = 7500.0; int value = 0;

float capnow =0; float vhigh = 8.2; float vlow = 6.6;

float k, know, per;

value = analogRead(voltageSensor); vOUT = (value \* 5.0) / 1024.0;

vIN = vOUT / (R2/(R1+R2));

lcd.setCursor(0,0); lcd.print(" Vout = "); lcd.setCursor(9,0); lcd.print(vIN); delay(4000);

//battery percentage calculations

k = vhigh-vlow; know = vhigh - vIN;

per = ((k - know)/k)\*100;

lcd.setCursor(0,0); lcd.print(" Bat = ");

lcd.setCursor(9,0); lcd.print(per); lcd.setCursor(15,0); lcd.print("%"); delay(4000);

current\_mA = ina219.getCurrent\_mA(); current\_amp = current\_mA / 1000;

// battary remaining amper hour calculation

capnow = (per/100)\* 2.2;

//time calculation

t = capnow / current\_amp; m = t \* 60;

Serial.print("Current: "); Serial.print(current\_amp);

Serial.println(" mA"); delay(2000);

lcd.clear(); lcd.print("Current = "); lcd.print(current\_amp); delay(4000); Serial.print("Time: "); Serial.print(m,4); Serial.println(" Min"); lcd.clear(); lcd.print("Time = "); lcd.print(m); lcd.print(" Min");

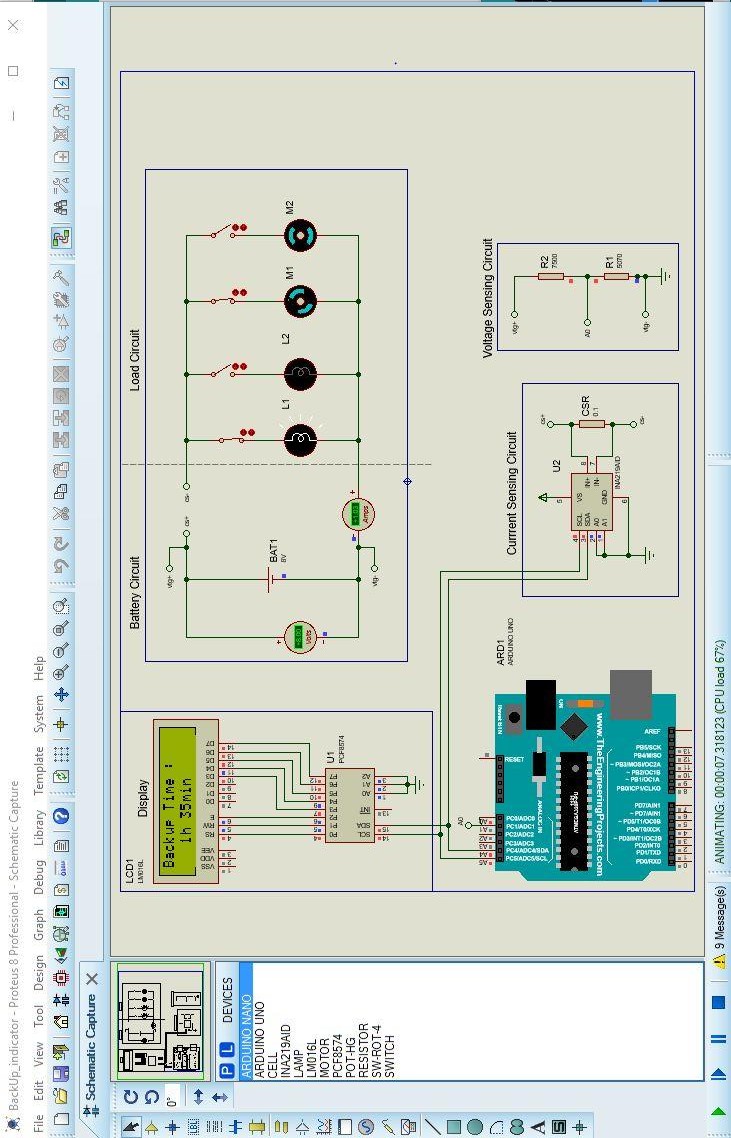
delay(4000);

}

## Simulation Result:

Designing own Voltage Sensor Board with Arduino Microcontroller.

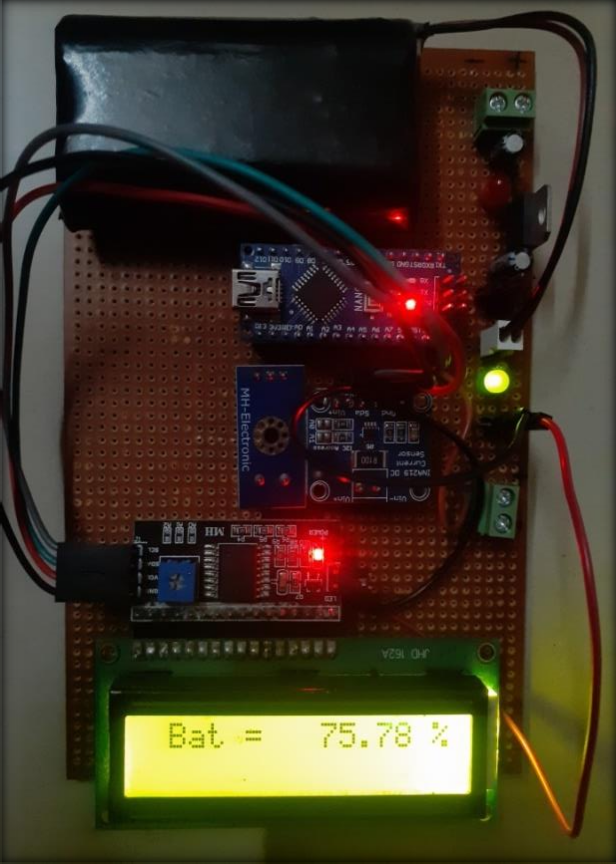
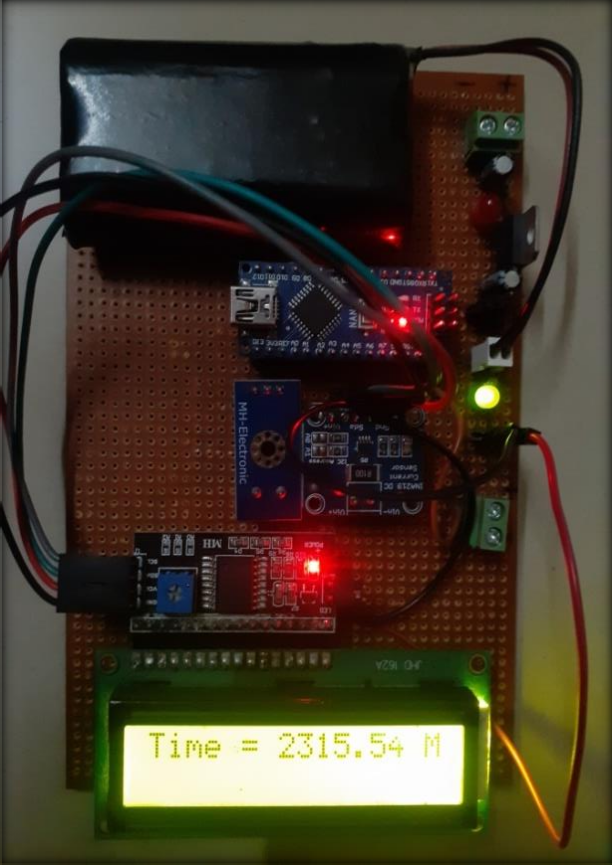
Instead of using above setup, you can make your own portable voltage sensor Board using Arduino ATmega328 microcontroller. Here is the schematic for the project.



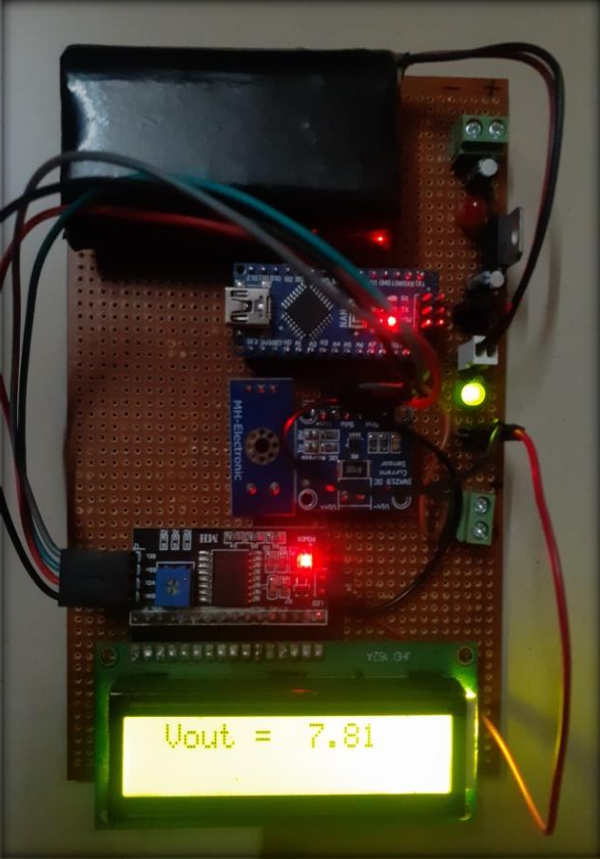
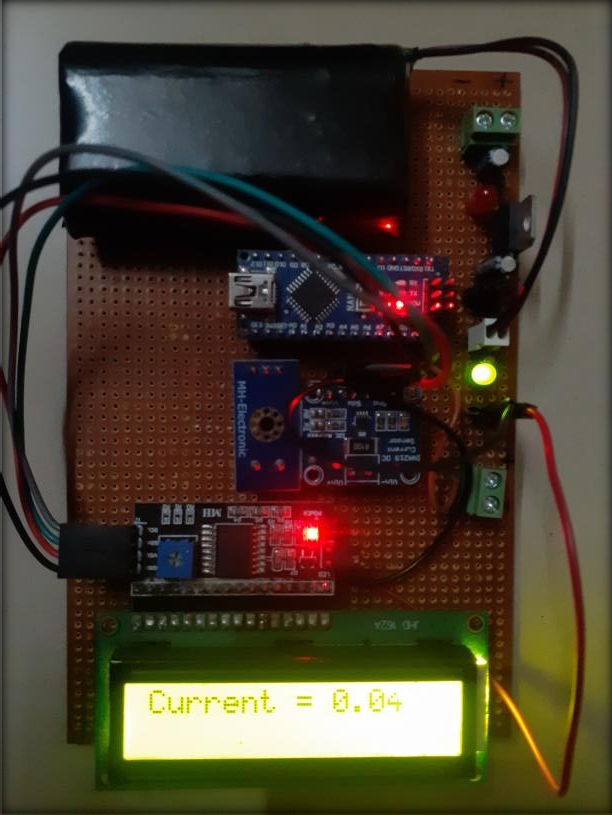
**Fig. 4.2 Results of Simulation**

## Hardware Result:

The schematic has been designed using Proteus online Circuit Schematics & PCB designing tool. The schematic is converted into a PCB. The PCB looks something like below.



### Fig. 4.3.1 Hardware Implementation Fig. 4.3.2 Hardware Implementation Displaying Backup Time Displaying Battery Percentage



**Fig. 4.3.3 Hardware Implementation Fig. 4.3.4 Hardware Implementation Displaying Current Displaying Battery Voltage**

## Cost :

The approximate cost of implementation of this project is given below.

**Table 4.4.1 Cost of Project Implementation:**

|  |  |  |  |
| --- | --- | --- | --- |
| Sr. No. | Components Name | Quantity | Cost (₹) |
| 1. | Arduino Nano | 1 | 960 |
| 2. | Voltage sensor 0-25v | 1 | 126 |
| 3. | INA 219 current sensor | 1 | 289 |
| 4. | Battery 7.4v 2200mah | 1 | 840 |
| 5. | I2C module | 1 | 219 |
| 6. | LCD 2x16 | 1 | 168 |
| 7. | Usb mini B Prog. cable | 1 | 140 |
| 8. | Zero pcb | 1 | 69 |
| 9. | Other hardware | - | 400 |
|  | **Total Cost ( ₹ )** | **=** | **3211** |

## Advantages & Application

### Advantages

* + - The circuit required very less power supply for operation.
    - Simple in construction and less complex circuit.
    - Arduino nano microcontroller uses ATmega328P microcontroller chip which gives faster operation than old microcontroller like 8051 microcontroller and analog interfacing can directly connected in arduino nano.
    - This device can be used with any battery by doing some modification in source code of arduino and sensors.
    - The circuit is compact in size, so less space is required and it can be fitted in small spaces.
    - The cost of the Inverter Backup Time Indicator is very low.

### Applications

* + - In household applications. To manage the use of household appliances which are operating on the inverter battery.
    - To determine the load current and backup time of the battery.
    - In backup power supply of commercial, industrial and residential where battery is used to supply the backup power.
    - It can be used in inverter battery or any other battery for monitoring the battery voltage and backup time of that battery.

# CONCLUSION AND FUTURE SCOPE

## Conclusion:

The inverter backup indicator will help us to find out how many time will survive inverter battery or any battery which is connected to the system on applied load. This system will help the consumer to manage the battery usage according to their functions and be aware of sudden shut down of the inverters.

This device will display the current, voltage, capacity in percentage and remaining backup time of the inverter on LCD display which provided on the device. It helps the consumer to track the inverter battery. Due to small size of inverter backup indicator it can be easy placed on any inverter.

## Future Scope:

The model has been implemented using small battery. A simple procedure is developed to get the inverter backup time. It can be implemented on home inverter batter by making some changes in source code of arduino nano. Instead of using arduino nano board we can directly use the atmega328p microcontroller chip and other sensors we can implement on one single PCB that makes the system more efficient. By making the inverter backup indicator on single PCB consume less power than previous system.

Also it can be connect to the internet by simply changing arduino nano to Node MCU micro controller. Backup time of the battery can be accessible wide widely. Further it can be modified and add more advance feature using latest technologies like GSM, Wifi,etc.

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