ISSN (Online) 2321-2004
ISSN (Print) 2321-5526

IJIREEICE

International Journal of Innovative Research in
Electrical, Electronics, Instrumentation and Control Engineering

Vol. 8, Issue 6, June 2020

Super-Capacitor Based Metro Train

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Abstract: We can generate energy from most of the sources like solar, wind, hydro, coal as a Fuel in plant etc. But in most there is cost problems for plant establishing, running, Maintenance or availability of resources (fuels) which are going to be exhausted one day. New generation of rapid transit trains requires a more effective energy management for reduction of energy consumption during the journey. In the country like India where the population is growing up drastically ,so it is necessary to control traffic in big cities of India and also it is necessary to control pollution in environment, so that's why metro is the best way to reduce traffic and also these mass transit vehicles enable large reduction in terms of emissions. This metro is not completely depended on electricity means to say that here the continuous supply will be eliminated which is use to drive metro with the help of overhead line. We also reduced overhead line and other electrical equipment required in metro train system. We are going to drive our metro train with the help of super-capacitor bank, it acts as a source. This super capacitor unit will give continuous supply to motor of the train. It is having one-time installation cost. The super- capacitor-based metro train is one of the best achievements in future by seeing rapid consumption of coal and other fuel in present situation.

Keywords: Super-capacitor, Aurdino Nano ATMEGA328P, regulators, Solar panel, DC Motor

I. INTRODUCTION

Metro trains have enabled easy and safe transit and is therefore regarded as the green transportation mode as compared to buses and private car services. Metro trains are mostly used in big cities for fast transit as distance between two stations is less. However, due to large-scale operations of metros especially in big cities and high-frequency services, a great amount of energy is consumed for the daily operations. In present scenario, railway traction drives make the use of overhead contact lines for transferring the electrical energy from the feeding substations to the moving rail vehicles by means of sliding current collector known as pantograph. Due to overhead lines, huge amount of losses is observed which reduces the overall efficiency of the system. By reducing the long overhead lines, we can reduce the losses in traction system. We are going to drive metro train with the help of super-capacitor, it is a type of battery which is huge and very bulky, as this capacitor required some place to install it on train so that it will give power supply to motor. The charging of super capacitor is done by conventional as well as non-conventional sources at every station. The solar panels are used as a non-conventional source which is mounted on the station's roof. On the basis of working of metro-train, the super-capacitor system has been used for energy that tries to limit overhead current and, consequently drop of voltage at the train pantograph. This will eliminate the use of overhead lines, construction of signal poles, electric wires and will also reduce the cost of maintenance. The super capacitor-based metro train will be great achievement in future by looking for rapid consumption of fuel in present situation.

II. OBJECTIVE

- Eliminate continuous use of overhead catenaries.
- Solar based metro train.
- Reduce risk of line failure.
- Charging super capacitor by conventional/non- conventional source.

III. PROJECT METHODOLOGY

As the aim of project is to drive the metro train on super-capacitor, the super-capacitors are connected in series and parallel combination according to the voltage and current requirement. This super-capacitor acts like a battery and placed in train so that it directly transmits its power to the motor of the metro train. Hence, battery also gets discharged by giving its power for full filling the need of some system operation. Super-capacitor also gets discharged after some period of time by supplying continuous power to motor, so it is necessary to charge this capacitor unit. The charging of super-capacitor is done at every metro station by pantograph which is mounted at roof of metro train. An overhead catenary is installed at every station to provide charging to super-capacitor through the pantograph. When the train reaches at any station the pantograph directly attached to overhead catenary and charging process is takes place. We are using two sources as a power supply to the overhead catenary i.e. solar panel as a non-conventional source and SMPS (switched mode power supply) as conventional source to perform the metro operation more efficiently.

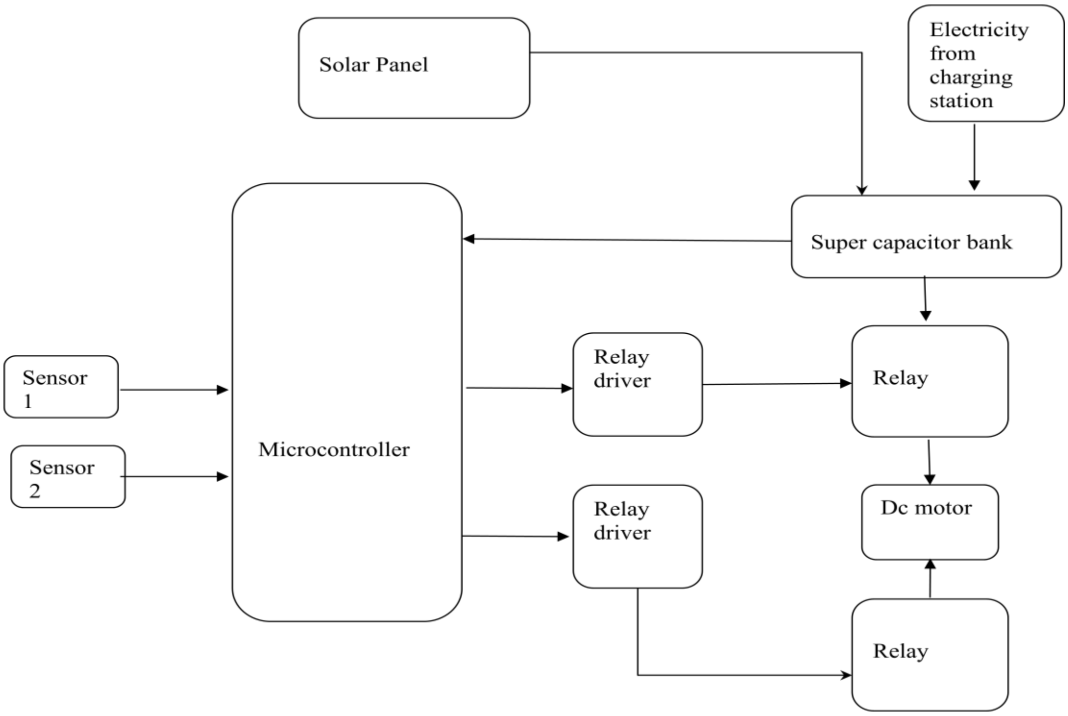

Fig.1 Block Diagram of Super-Capacitor Based Metro Train

The power comes from both the sources is stored in a battery which is also installed at metro station, this battery supplies power to the overhead catenaries installed at that particular station for charging of the super-capacitor bank. This same installation is done at every station for charging of super-capacitor. The forward and reverse operation of motor is controlled by the microcontroller through the relays. There are two relays provided in metro circuit which performs forward and reverse operation by switching one relay at a time. The microcontroller sends the signal to relay and according to signal received by the relay, switching is takes place and motor will be operated.

IV. WORKING OPERATION

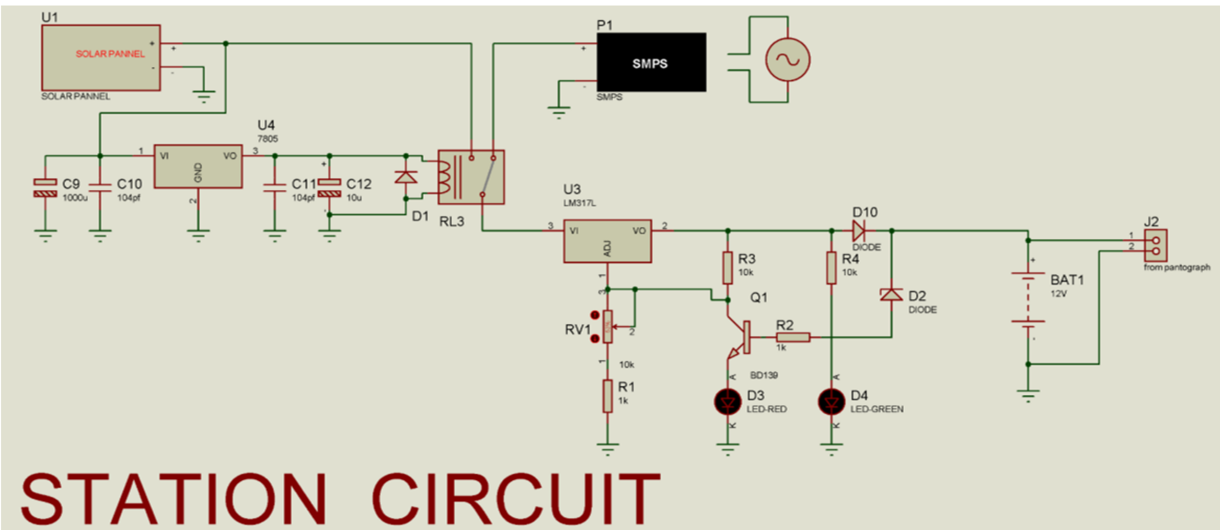

Fig.2 circuit diagram of station circuit

DOI 10.17148/IJIREEICE.2020.8615

IJIREEICE

ISSN (Online) 2321-2004
ISSN (Print) 2321-5526

International Journal of Innovative Research in
Electrical, Electronics, Instrumentation and Control Engineering

Vol. 8, Issue 6, June 2020

Operation of station circuit:

Station circuit consists of solar panel, SMPS, IC7805, IC LM317L, Relay, capacitors, transistor BD 139, zener diode, resistors, LED indicators and 12-volt battery. In this station circuit, there are two sources are available i.e. solar panel and SMPS. Both the sources are connected to relay RL3. Normally, relay is in NC condition which is connected to SMPS. As solar energy is variable during daytime, output power given by solar panel is also variable. Therefore, IC 7805 is used to stabilize the voltage. Whatever voltage will come from the solar panel it converts into 5 volts. The range of IC 7805 is between 17 to 25 volts. It means that when 17 to 25 volts comes from solar panel only then the 7805 gives 5-volt constant supply otherwise. The capacitors C9, C10 are connected in series with input pin, and capacitors C10, C11 are connected in series with the output pin of 7805. Basically, these capacitors are used as filters as well as to remove transient waves during transient periods, so that the output voltage is in more stabilized form. When the constant 5 volt comes from output pin of 7805, the NC contact of relay shifted to NO contact. It gives supply to adjustable voltage regulator IC LM 317L which converts the variable voltage into 12 volt constant voltage. Whatever the voltage comes from source it gives 12 volts constant supply. When the 12V comes from LM317L the series connected diode gets forward biased and the 12V constant power stored to battery. When the diode is in conduction form green LED will glow, which showing battery is not fully charge. When the battery gets fully charged the reverse current will flow from zener diode and zener diode activates the transistor Q1. As one end of the transistor is ground, the circuit will off through the resistance. And red LED will glow, which showing battery is fully charged. Because of that power will not waste.

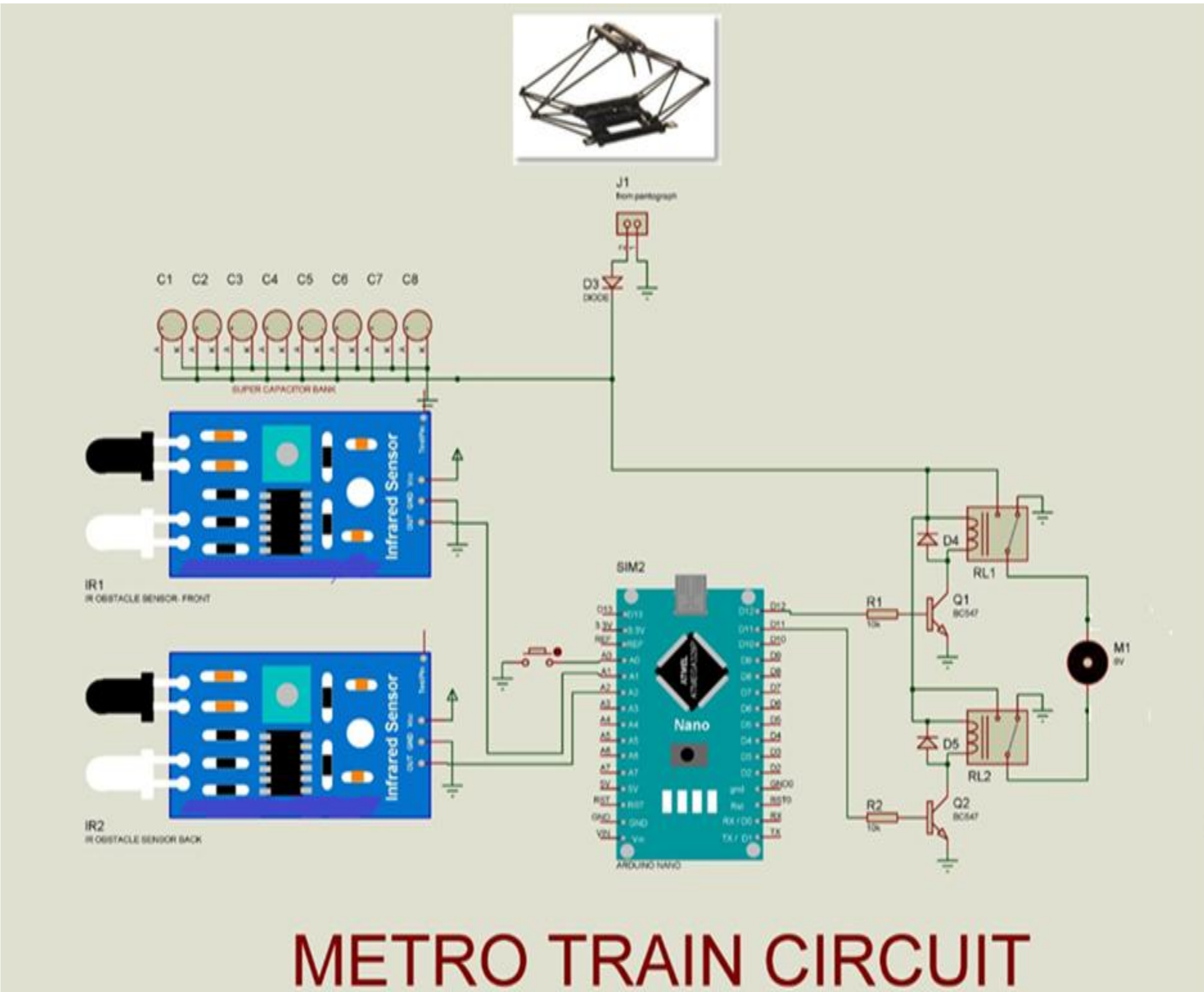

Fig.3 circuit diagram of metro train circuit

Operation of Metro train circuit:

Above circuit shows the pantograph J1 which is mounted at the top of metro train which is used to give the incoming DC power to the super-capacitor bank. The super-capacitor bank is also installed in train. This power is supplied by the overhead catenary installed at the station and this catenary is connected to battery. This incoming supply goes in super-capacitor bank and stores the power. A diode D3 is connected between pantograph and super-capacitor bank to

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avoid reverse flow of power. The power from super-capacitor bank directly goes to motor M1 through relays RL1 and RL2 for running operation of train. The power also goes to microcontroller ATMEGA 328P for the control operation of train. When the power goes through relay RL1, another relay RL2 is grounded. It means only one relay will operate at a time. When the motor will operate through relay RL1, the motor runs in forward direction and when motor operate through relay RL2, the motor runs in reverse direction. The forward and reverse direction of motor is controlled by microcontroller. Basically the microcontroller gives the signals to relay for ON and OFF mode. D12 pin of microcontroller is connected to relay RL1. Similarly the D11 pin is connected to relay RL2. The microcontroller gives signal to relay and that signal is weak, due to which relay is unable to operate. So the transistor Q1 & Q2 is provided through resistors R1 & R2. The transistor amplifies the signal and sends it to relay for operation. The infrared sensors IR1 & IR2 are connected to pin A1 & A2 of microcontroller. These sensors are used for obstacle detection on the track. As they detect any obstacle on the track, the microcontroller receives the signal and gives stop signal to relay. This is done by internal programming of microcontroller. When the train will stop, we have to run it after removal of obstacle. So, to start the train a simple push button is provided.

Complete Working And Operation:

Consider forward operation of motor. The supply coming from super-capacitor bank is goes in relay RL1, the relay shift its contact from NO to NC. This shifting signal to relay is given by the microcontroller. At the same time the relay RL2 is connected to ground contact i.e. NO. The motor starts moving in forward direction and the train starts it's running in forward direction. As the motor runs, the super-capacitor bank gets almost discharged when it reaches the next station. So on that station, the overhead catenary is provided to charge the super capacitor bank through the pantograph. It takes near about 30 to 60 seconds to get charged. Once the capacitor bank charged, it runs till next station as explained above. This phenomenon is repeated at every station and for both forward and reverse operation of metro train. Now, if the last station is reached by the metro, we have to run the train in reverse direction. For reverse direction movement of motor, the microcontroller gives signal to both relays and the relay RL1 contact is shifted to NO and the relay RL2 contact is shifted to NC. By shifting the relay contacts, the polarity of motor gets reversed and the motor runs in reverse direction.

If in case, there is any obstacle is founded on track of metro train, the infrared sensors which is provided at both the ends of metro train detects the obstacle from a certain distance and give signal to the microcontroller. To stop the train, if the motor is in forward direction, microcontroller reads the signal coming from that infrared sensor which is connected at forward side of metro train and gives stop signal to the relay RL1. For forward direction, the relay RL1 was connected to NC contact now it shifts to NO contact and both the relays is at NO contact so, the train will stop. If the motor in reverse direction and the obstacle is detected, the sensor connected to other end sends signal to microcontroller and further the microcontroller sends stop signal to relay RL2. For reverse operation the relay RL2 was connected to NC contact but due to stop signal given by microcontroller the NC contact is shifted to NO. Contact and train will stop.

V. RESULTS AND DISCUSSION

- Rating of super-capacitor : 1f/5.5V
- Number of super-capacitors we used =10 = (2*5)
- In our project we used total 10 super-capacitor, having 2 super-capacitors by using 5 pairs. This super-capacitors are connected in series and parallel. In one pair both super-capacitors are connected in series and such total 5 pairs connected in parallel. Also thus we, consider each pair is as 1 cell and thus, there are total 5 cells
- Total super-capacitor voltage in one pair (1 cell) i.e. (SCtv) = C1+C2 = 5.5V+5.5V = 11Volts
- Its equivalent capacitance after series parallel connections is 2.5Farad
  i.e. 1*1/1+1 + 1*1/1+1 +1*1/1+1 + 1*1/1+1 + 1*1/1+1 = 2.5Farad
- Practically each cell draws a constant current of 200mA up to 2 minutes.
- So, the total current of super-capacitor cell connected in parallel is given as
  i.e. SCtc = Cell1+Cell2+Cell3+Cell4+Cell5 =200mA+200mA+200mA+200mA+200mA= 1ampere
- Track length - 7 feet
- Weight of prototype train model - 300 grams.

1) Farad to mAh conversion:-

We know the formula of capacitance,

C=Q/V

Farad=Amp/sec/volts

i.e. F×V=Amp/Sec

2.5×11=27.5Amp/Sec

27.5 (Amp/sec)/3600 (1hr) = 7.63mAh=0.00763AH

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2) Motor Rating is 0.3Amp, 6volts
0.00763 (AH)/0.3 (Amp) = 0.0253 hr
Motor run time = 0.0253×3600
=91.54sec ~ 90sec

Charging time of supercapacitor:
Transient response time t of super-capacitor is measured in term of T = R*C in sec
In this project,one super-capacitor is used of rating 1f and its resistance R is 30 ohms so, the equivalent resistance of all the super-capacitors after series parallel connection is given below.
R = 1/2*30+1/2*30+1/2*30+1/2*30+1/2*30 =12 ohms
Charging time T = R*C = 12* 2.5
T= 30 sec

Discharging Time of Super-Capacitor:
For a super-capacitor discharging circuit, the voltage across the capacitor (V_C) as a function of time during the discharge period is defined as:
$Vc = Vo\, e^{-t/rc}$
Where, V_C is the voltage across the capacitor V_S is the supply voltage
t is the elapsed time since the removal of the supply voltage rc is the time constant
Initial capacitance voltage – capacitor discharged voltage
V= Vo-Vc = 11- 0.547
V= 10. 453 volts
10. 453 discharged voltage in 90 sec.
Therefore 90 sec is the discharging in time for super-capacitor bank.
Now, discharging time for LOAD CONTENT
With load 0.40 amps
T = 0.00763 *3600 /0.40
= 68.67 sec
Run time of motor = 68.67 sec

Calculation for solar panel:
Solar panel =10 w
The battery used in this project is 2.5 Ah
Battery charging time (hr) = Total battery power / solar power
=25w / 10w = 2.5 hrs

Dc motor 6 Volts 0.3 Amp calculation:
M=the weight in kg that can D.C. motor can carry
G=acceleration (gravity) 9.81
R= radius of shafted wheel

1) Linear speed =Rated RPM*2*3.14*R /60
= $1500*2*3.14*2*10^{-3}$ /60
=0.314
M=Power (w)/G*Linear speed
But P=F*V
F = m*a
= 0.6*1.81 = 5.886
Assume velocity v = 0.3 m/sec
P= 5.886*0.3
= 1.76 watts
P= 1.8 Watts
M = 1.8/ 9.81*0.314
M = 0.584 KG
Load torque =$0.584*9.81*2*10^{-3}$
T_L= 0.011 N-M
T starting = 0.35 kg cm = 350 g cm = 0.034NM
T starting > load torque

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Table for One Time Charging

1.Discharging time	90 sec
2.Charging time	30 sec
3.Load to be carried	584grms
4. Run time of motor	90 sec

VI. CONCLUSION

We conclude that our project aims is to design reliable system which having greater efficiency. The use of super-capacitor has many advantages and prevent from technical snags related with overhead catenary. It also reduces the risk of line failure as we reduced overhead catenary. Use of solar energy to drive our metro train also reduces the consumption of conventional fuels required for generation of electrical energy.

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