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RESEARCH ARTICLE

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IMPROVE THE VOLTAGE STABILITY OF TRANSMISSION LINE VOLTAGE USING FACTS DEVICE CALLED STATIC VAR COMPANSATOR(TSC+TCR)

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ABSTRACT

This project investigates the effects of Static Var Compensator (SVC) on voltage stability of a power system. The funtctonalional structure for SVC built with a Thyristor Controlled Reactor(TCR)istor & Thyristorised Switched Capacitor (TSC) and its model are described. The model is based on with changes voltage the firing of angle of the TCR & TSC are also changed. A Power System uter computer Aided Design/Electromagnetic Transients including DC (PSCAD/EMTDC) and proteus v8.1 is used to carry out simulations of system under study and detailed model &results are shown to access the performance of SVC on the voltage stability of the system.

Key words– Thyristorised Controlled Reactor(TCR), Thyristorised Switched Capacitor(TSC),Voltage stability, Microcontroller.

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I.INTRODUCTION

Today's changing electric power systems create a growing need for flexibility, reliability, fast response and accuracy in the fields of electric power generation, transmission, distribution and consumption.

Flexible Alternating Current Transmission Systems (FACTS) are new devices emanating from recent innovative technologies that are capable of altering voltage, phase angle and/or impedance at particular points in power systems.[4]

Their fast response offers a high potential for power system stability enhancement apart from steady-state flow control. Among the FACTS controllers, Static Var Compensator (SVC) provides fast acting dynamic reactive compensation for voltage support during contingency events which would otherwise depress the voltage for a significant length of time. SVC also dampens power swings and reduces system losses by optimized reactive power control.[1]

Energy stored in capacitive or inductive elements of the network give changes the reactive power flow. Reactive power flow strongly influences the voltage levels across the network. Voltage levels and reactive power flow must be carefully controlled to allow a power system to be operated within acceptable limits. The system operator will perform switching actions to maintain a secure and economical voltage profile while maintaining a reactive power balance equation:

MVAR Demand + Reactive losses + Shunt reactors

The 'System gain' is an important source of reactive power in the above power balance equation,which is generated by the capacitive nature of the transmission network itself. By making decisive switching actions in the early morning before the demand increases, the system gain can be maximized early on, helping to secure the system for the whole day.Harmonic ents current can be reduced by a filter placed at the output of the device. Typically this will consist either just a capacitor or with inductor to reduce the harmonics.[2]

II. PSCAD Software Simulation[3]

We are carried out the simulation of 3ph system byusing PSCAD software.

Simulation data :-We are using 11kv transmission line of 50km length having shunt charging capacitor per km is 12.1nF and and series inductor is 0.78mH per km.(Shown in Fig.1)

The rating of transformer is:-

1 MVA ; 66kv/11kv

7KVA;11kv/440v

The 66kv/11kv is step down transformer. The load of 0.5MW,1kvar (delta connected) is connected to the load bus(bus-2) having voltage rating is 11kv.

- The load of 1kvar is changed with different values so that the variation of voltage at that bus is carried out.
- By changing the load the voltage is changed due to changing the reactive power demand at that bus-2.
- We are choosing the value of shunt capacitor bank is 0.5µF per phase for maintaining the voltage at bus-2 upto 11kv.
- The value of shunt reactor is 0.15H for reducing the voltage during light

Load condition. These values are chosen according to the maximum variation of load of 20% above and below the specific limit.

The total line capacitance (C) = 12.1nF*50km = 605nF

The total line inductance (L)= 0.78mH*50km= 39mH

Surge impedence (Z) =(L/C)^0.5 Ω = 254 Ω

Surge impedence loading (Po) = V^2/Z =0.5MW

This value is give the maximum loading of the line without compensation.

The delta connected TSC and TCR is connected to the bus 3(compensator bus).

We carried out the observation with different values of L load.

The following equation is used to find out the voltage with different values of reactive power:-

V= S/I where, S=Apparent power(MW)

V=voltage at bus-2(KV)

I=current drawn by load (Amp)

III. Observation Table

(NOTE: The value of active power (MW) is make constant for analysis purpose.)

- This observations are obtained without compensation at bus-2.

TABLE1:- Voltage monitoring without compensation

Sr. No.	Load (kvar)	V (KV)	P (MW)	Q (kvar)	I (Amp)
1.	1	10.49	0.498	1.009	47.25
2.	5	10.48	0.496	5.03	47.33
3.	8	10.47	0.495	8.052	47.28
4.	15	10.46	0.493	15.06	47.15
5.	20	10.45	0.493	20.03	47.075
6.	28	10.43	0.492	27.96	46.87
7.	35	10.42	0.487	34.85	46.85

- From this observation we can say that the voltage at bus-2 is changed because of increase in demand of reactive power.
- Now the SVC is connected at bus-3 with 3ph transformer of rating 11kv/440v.
- Here, the one advantage is that due to step down of voltage the rating of equipment is reduce. Which will reduce the cost of equipment.
- After applied the compensation at bus-3 following observation are taken :-

TABLE2:- Voltage monitoring after compensation

Sr. No	Load (kvar)	I (amp)	P (MW)	Q (kvar)	V(kv)	Alpha (deg)
1.	1	55.016	0.658	0.820	11.96	52.48
2.	5	52.99	0.612	4.08	11.55	48.98
3.	8	54.33	0.602	7.052	11.08	42.03
4.	15	53.68	0.592	12.06	11.03	35.12
5.	20	53.39	0.585	18.14	10.96	29.46
6.	28	52.05	0.561	25.38	10.78	25.31
7.	35	47.71	0.503	31.46	10.55	15.14

IV. Important conclusions

1. Here the current is higher as compared to uncompensated line line because this current is sumofthe current drawn by load and current required for charging the capacitor.
2. When we are connecting the compensator to the transmission line at load end the reactive power supplied by line is reduced because the TSC is supplied reactive power as per requirement and it is changed by changing the firing angle of thyristors.
3. After connecting the SVC the active power transfer capability of line is increased and voltage profile will also increase this will stabilize voltage fluctuation and maintain the load stability.
4. In this type of compensator the size of reactor required is less as compared with FC-TCR type compensator.
5. In Fig.1 we are connecting the current limiting reactor of 0.5mH which is reduce the switching transient and the 3rd harmonics are already suppressed because the load is delta connected.

V. Design of hardware model[3]

We are design the hardware model for 230V.

In the hardware model there are one inductor having value is 0.318H for absorption of reactive power during light load condition and one capacitor having value is 5µF for provide the reactive power during higher loading condition for maintain the voltage stable and within permissible limit.

Here the variation of voltage is 10% above and 10% below from the reference level of 230v.

Because the value of inductor is sufficient to absorb the reactive power when the value of voltage is increased upto the 255V.

Also the capacitoris sufficient to provide the reactive power when the voltage is decreased upto 205V.

VI. Calculation Part

Part-1 For TCR Configuration :

Here, L=0.318H, f=50Hz

$Xl=2*\pi*f*L=100\Omega$

Qtcr for 230V = $230^2/100=529$ Var

Qtcr for 253V = $253^2/100=640$ Var

So, So, the range of reactive power for variation of 10% voltage is 64

640- 529=110Var.

No Now, the variation of firing angle of TCR with different values of volt voltage give in table-3 by using following equations:-

Btcr Btcr= $1/\dot{\omega}L * [(2-2\alpha+\sin 2\alpha)/\pi]$

Wh Where, $\dot{\omega}=2*\pi*f$ and α is from $\pi/2 \leq \alpha \leq \pi$ for T1 and $2\pi/3 \leq \alpha \leq 2\pi$ for T2

Qtcr Qtcr= V^2*Btcr ; V is the increment in voltage

Btcr = Susceptance of inductor

TABLE 3:- Firing angle calculation of TCR

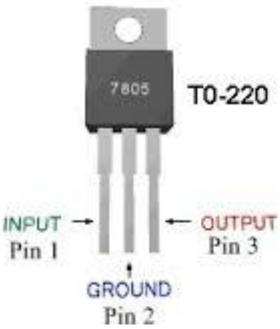
Sr. No	V (Volt)	Btcr (mʊ)	Xtcr (Ω)	Qtcr (Var)	Itcr (mA)	Firing angle(degree)
1.	5(235)	0.26	3846	11.5	13	69+90=159
2.	10(240)	3.44	290.69	23	34	33+90=123
3.	15(245)	5.39	185	35	80	22+90=112
4.	20(250)	6.81	146	46	136	15+90=105

Sr.No.	Name of components	Rating of components	Number of quantity
1.	Potential Transformer	230/12-0-12V & 230/3V	1
2.	Diode(IN4007)	-	8
3.	Voltage regulator (7805/7812)	-	1
4.	Op-Amp(741)	-	1
5.	Thyristor(2p4m)	600V , 2Amp	6
6.	Inductor (Choke coil)	0.318H	1
7.	capacitor	5 µF	2
8.	ADC0808	-	1
9.	P89V51RD2BN	-	1
10.	Microcontroller development board	-	1

Description:

1.Voltage Regulator IC:-

There are two voltage regulators used in circuit.



7812 is used for microcontroller.

7805 is used for ADC.

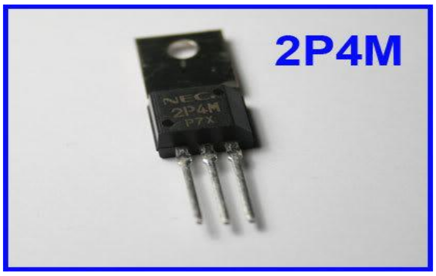
2. ADC(0808):

It is used for generating digital code equivalent to voltage given to ADC.

This digital code is given to microcontroller for generating pulses to trigger thyristors.

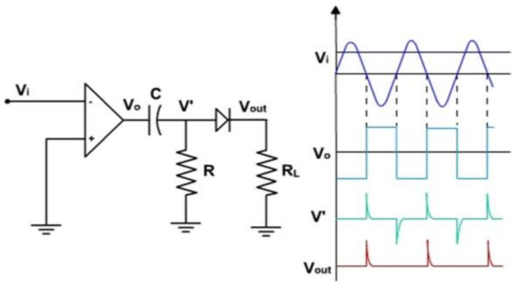
3. T

3. Thyristor 2P4M:



Thyristor is used for controlling the firing pulses of capacitor and inductor to regulate system voltage.

4. Zero Crossing Detector(ZCD):



This is used for initializing delay which is given to thyristor for changing firing angle.

5. Microcontroller P89V51RDBN:-

This is used for generating firing pulses for capacitor and inductor of different voltage.

Advantages:

1. Stabilized voltage at the receiving end of long lines.
2. Increased productivity as stabilized voltage means betterutilized capacity.
3. Reduced reactive power consumption due to improvement in power factor, which gives lower losses and improved tariffs.
4. TSC-TCR can quickly operate to disconnect all the capacitors from the compensator during voltage swings but in FC-TCR it is not possible.
5. Enables better use of equipment (particularly transformers and cables)
6. Reduced voltage fluctuation.
7. Suppressed the third harmonics due to delta connection of SVC.
8. Controller's response time is fast and also it is depends on characteristic of system where it is connected.
9. They are, in general, cheaper, higher-capacity, faster and more reliable than dynamic compensation schemes such as synchronous condensers.

Disadvantages:

1. Due to switching of capacitor the transients are increased.
2. Overload capacity is limited.
3. Due to switching the losses are increased.
4. External cooling systems are needed for control the temperature of thyristors.
5. The control circuit is complex.

6. During the operation of control circuit the controller's own time delay is added which will leads to malfunctioning of thyristors triggering.

Applications:

1. It is used for control voltage oscillation at load bus.
2. It is used for provide the reactive power at mid-point on the transmission line to reduce the voltage sag.
3. Damping of power oscillations
4. unbalance load fluctuation control at receiving end.

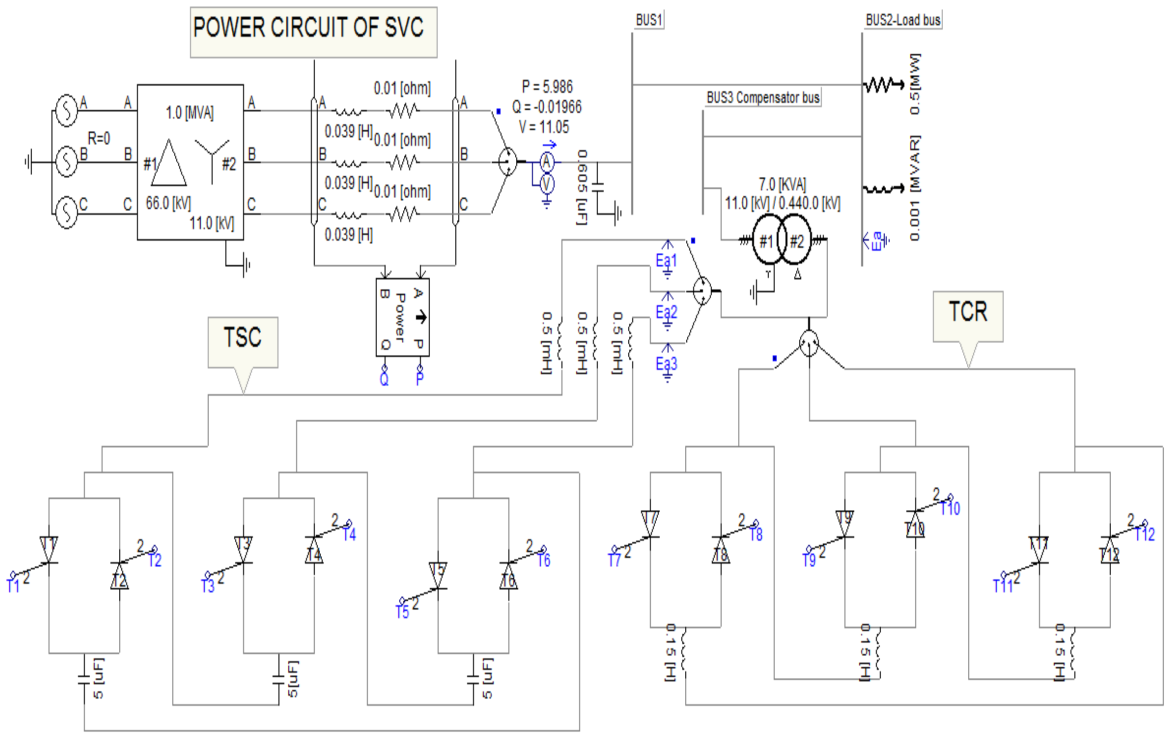


Fig 1. Power Circuit of 11kv transmission line

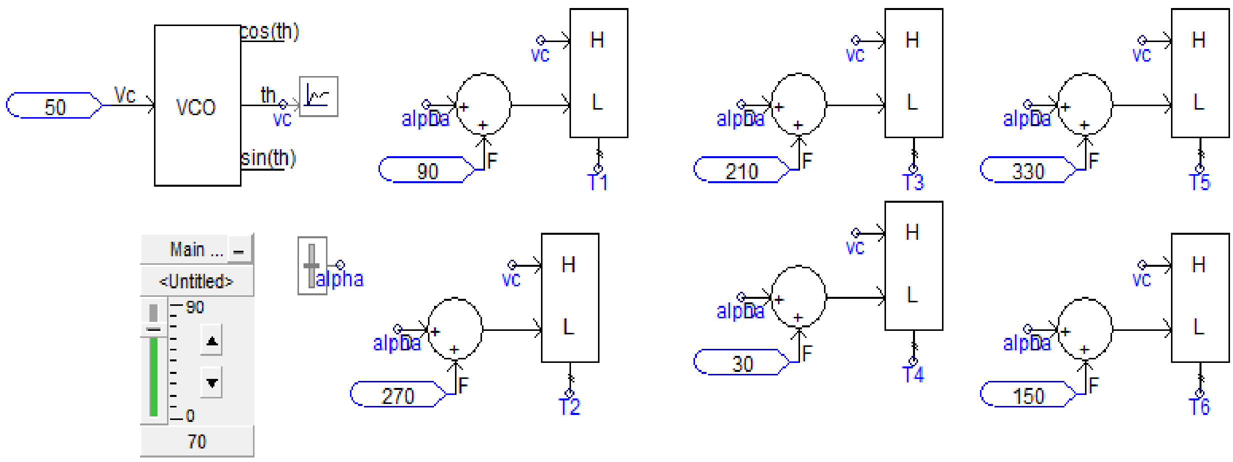


Fig 2. Control circuit of TCR

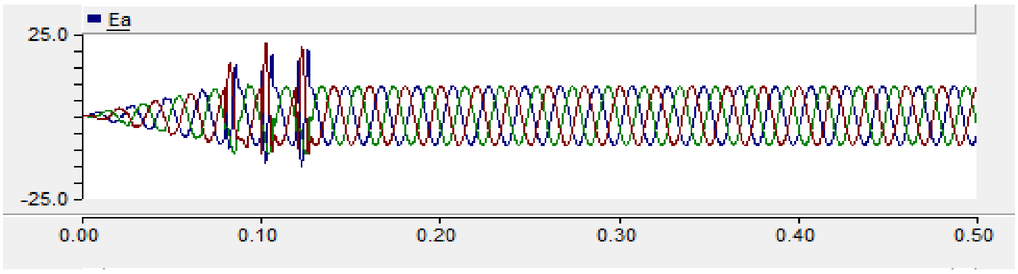


Fig 3.Load voltage during switching of capacitor

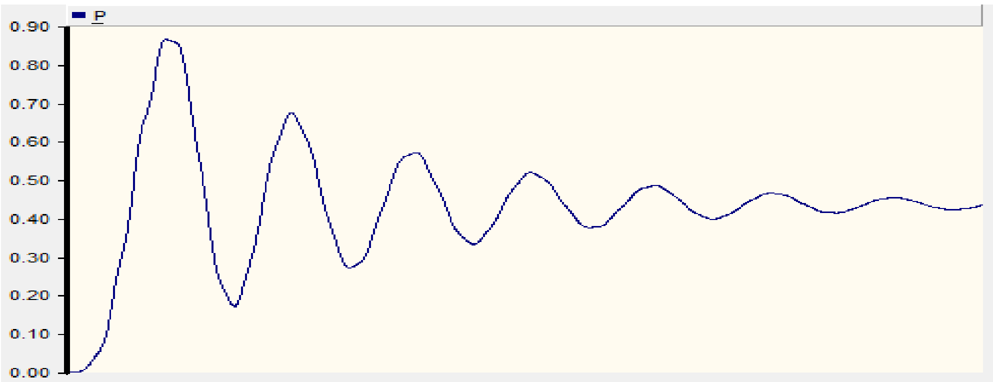


Fig 4. Power Oscillation during Switching of SVC

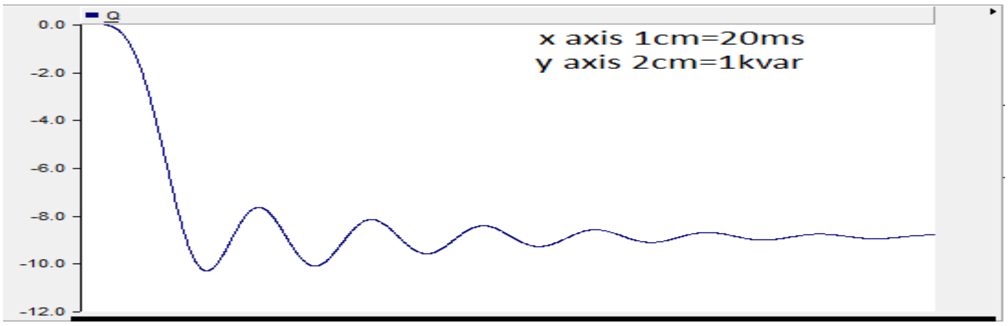


Fig 5. Reactive power stability during switching of TSC

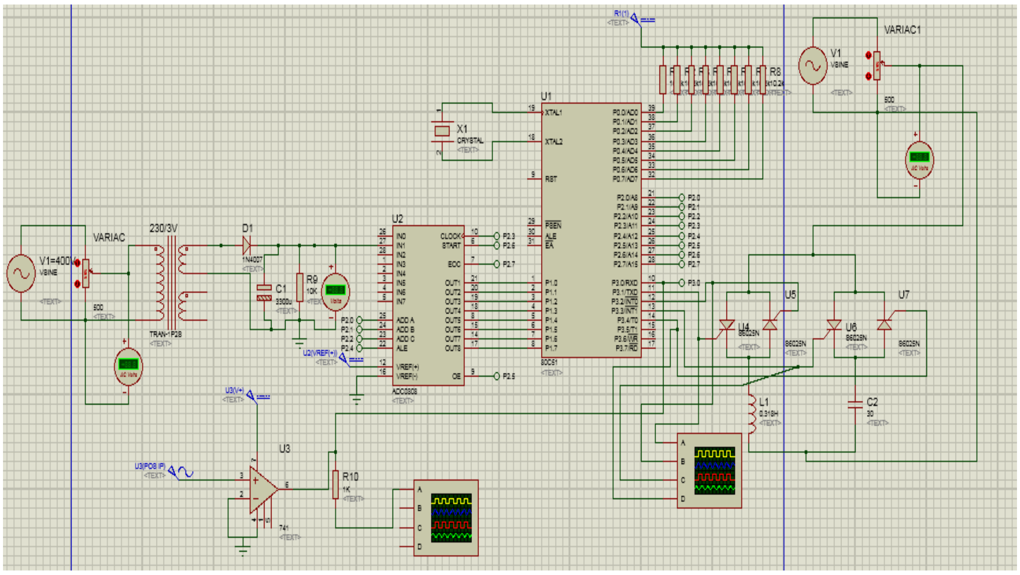


Fig 6. Simulation model of 230v SVC in PROTEUS 8.1v

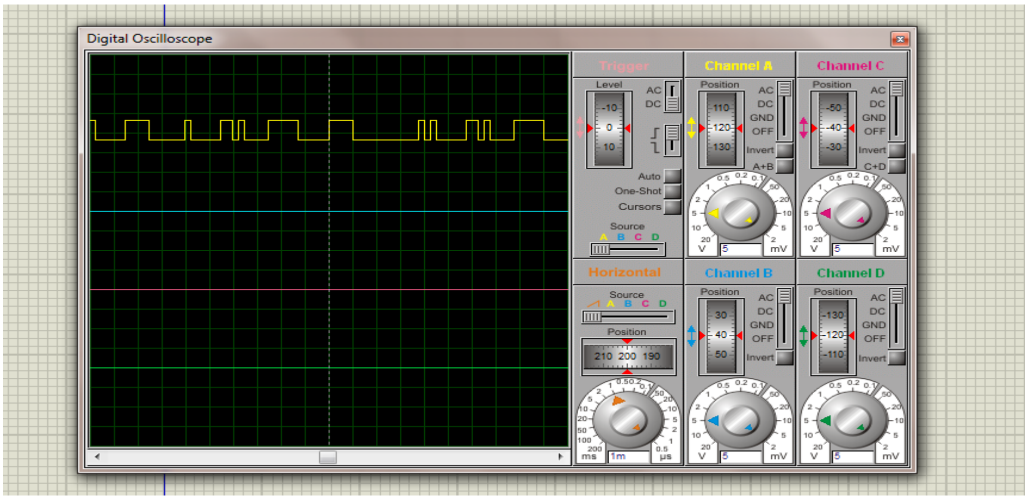


Fig 7. PWM pulses applied to the thyristors with 10% duty cycle
(NOTE :The duty cycle is changed with changing in the reference voltage)

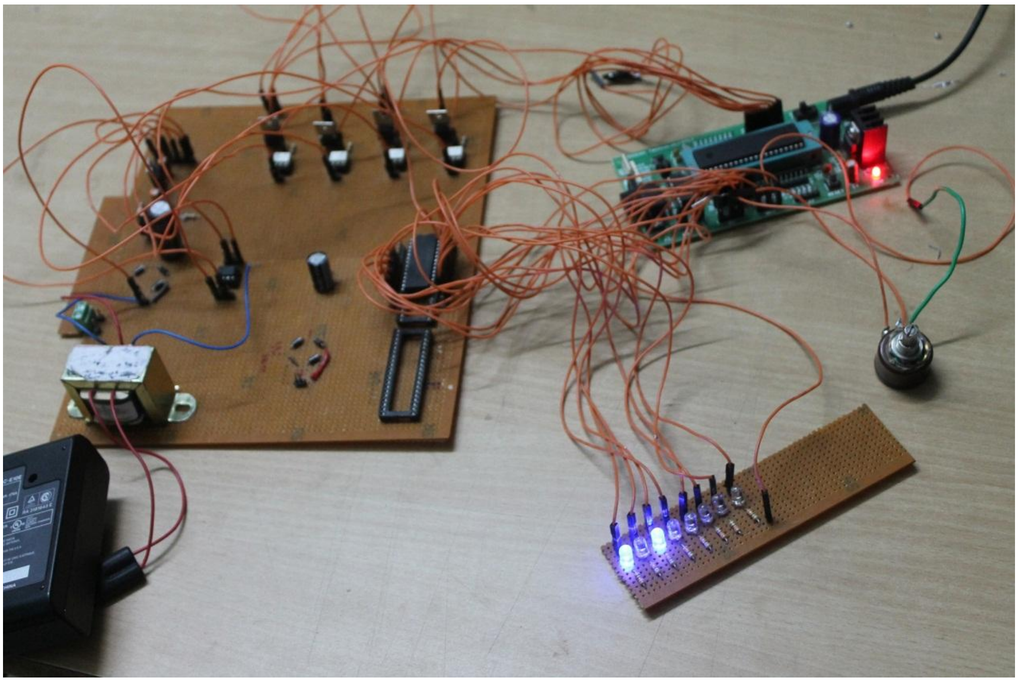


Fig 8. Hardware model of 230v SVC which is consisting of control and power circuit

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