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# ENHANCEMENT OF ACTIVE POWER FLOW CAPACITY OF TRANSMISSION LINE USING SERIES COMPENSATION

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**ABSRACT:**

**In this paper a series controller from the FACTS (Flexible AC transmission system) family named as 'Thyristor Controlled Series Capacitor' (TCSC) is designed using Microcontroller. A transmission lines operating at high voltages is required to transmit power from generating station to load. The laboratory setup of circuit using a Thyristor controlled reactor in series with a capacitor will discussed in this paper. This paper also presents experimental results of a TCSC connected to a single phase system. This paper investigates the effects of TCSC on transmission line to improve voltage stability. The stability of system has been determined by using V-I and P-V curves.**

**KEYWORDS : series compensation, thyristor valve, transmission line, reactive power, line reactance, controller.**

## INTRODUCTION:

In recent year for compensation we used fixed capacitor method. We connect fixed capacitor series with transmission line and value of capacitor set by inductor which connect in parallel with thyristor valve which adjust the value of capacitor to reduce line reactance. In series compensation we overcome the disadvantages of shunt compensation like it maintain: Rapid, continuous control of the transmission-line reactance, Dynamic control of power flow in selected transmission lines within the network to enable optimal power-flow conditions, Damping of the power swings from local and inter-area oscillations. Closed loop control is achieved by using microcontroller 89S52. The firing angle control of TCR is obtained with the observation of output voltage. Plotted a graph of P-V curve with and without TCSC controller.

## TCSC:

TCSC stands for thyristor controlled series capacitor. In TCSC fixed capacitor connected in series with line and to control the value of capacitance, inductor connected in parallel with it and thyristor valve connected in series with inductor. In TCSC the value of line reactance is controlled by varying the value of inductor with the help of microcontroller. We use microcontroller 89S52, for the adjusting the firing angle of the thyristor valve.

Power transferred in transmission line is given by,

$$P = \frac{V1 * V2}{X} \sin(\delta)$$

Where,
P= power transferred in transmission line
V1=sending end voltage
V2=receiving end voltage
X=line reactance
δ=Power angle

From above equation we state that line reactance is inversely proportional to power. So by varying the line reactance we control the power transfer in transmission line.

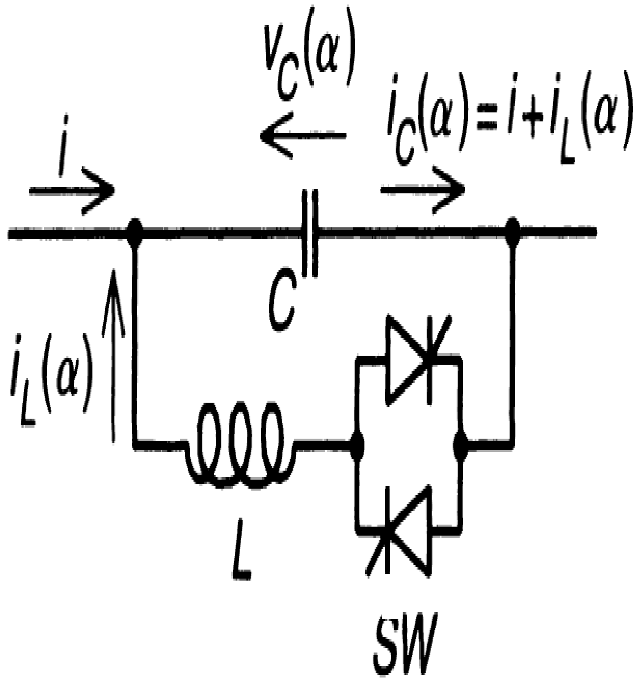


Fig.1 Basic TCSC Scheme

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**CIRCUIT DIAGRAM EXPLANATION OF COMPLETE CIRCUIT:**

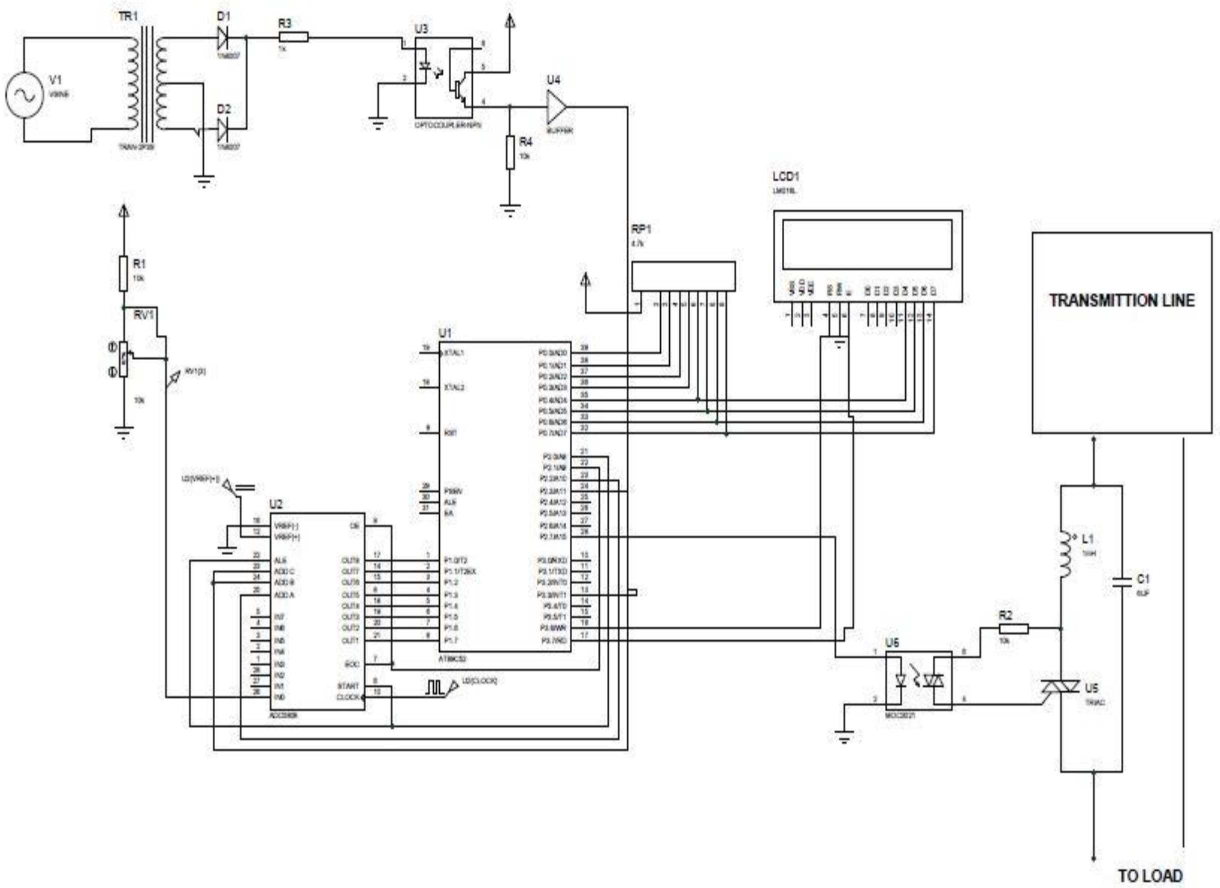


Fig.2 Circuit Diagram Of Controller

We used two step-down transformer, one for providing power to microcontroller unit and another for measurement of output voltage. A 230v, 50Hz step-down transformer whose primary voltage is 230v and secondary voltage is 12v. Which is connected with bridge rectifier and with the help of this bridge rectifier we convert the 12v ac voltage to 12v dc voltage, here a capacitor (12mF, 25v) is used to reduce the unwanted noise and filteration.12v dc voltage is passes through the regulator (LM7805) and resultant output voltage is 5v dc. Output terminal of the regulator is divided in to two terminals, one is goes to optocoupler circuit input and another is goes to the 12th pin (+VCC) of the microcontroller. The 5V pulse width modulation generated by the microcontroller is send to the MOC3021 driver (opt coupler), it is nothing but the gallium arsenide infrared emitting diodes, optically coupled to a silicon bilateral switch where the driver is used to the boost the pulse. Microprocessor (ADC 0808) compare input and output voltage. Microcontroller (89S52) generate pulse and the resulted pulse is sent to the gate terminal of the TRIAC and it is triggered to ON position and makes a close loop to flow the power inside the circuit. The AC voltage of 230V, 50Hz is send to the power line where the inductance and capacitance is used to control the reactive power.

**HARDWARE EQUIPMENT REQUIRED:**

1. Microcontroller 89S52
2. Microprocessor ADC 0808
3. LCD 16LC
4. Decade Counter
5. Voltage regulator 7805
6. Optocoupler

**TRANSMISSION LINE IMPLEMENTATION (PROTOTYPE):**

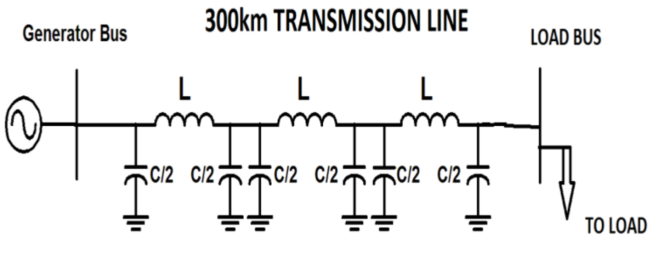


Fig.3 Transmission Line

To build prototype of transmission line first determined the value of capacitance inductance and resistance for 100km transmission line. Then we build 300km transmission line for single phase and work on it. One PI model indicates distance of transmission line per 100km. Here value of line inductor assumed is L= 25 mh/100km, value of line capacitor is C=4μf/100km and value of resistance is R=139 ohms/100km. After transmission line TCSC is implemented at the end of Prototype model.

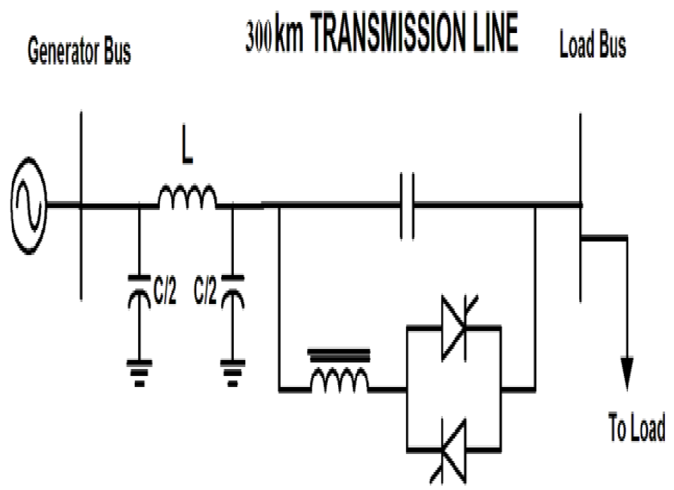


Fig.4 Transmission Line With Controller

**CALCULATIONS OF PARAMETER:**

For the present case to find the value of capacitance and inductance of TCSC controller is based on the net reactance of the transmission line and power flow control through it, The line reactance of transmission line is 50 ohm, hence take fixed capacitor 12 μF (two capacitor of 6μF connected in parallel).

Fixed capacitive reactance,

Xc = 1/2πfc=26.52ohm

Total line reactance,

X = Xl + Xc

Xl = 23.48ohm

Therefore,

Xl = 2πfl

l = 74.73mH

So we must connect minimum 75mH inductance in controller.

Value of capacitance find out by trial and error method.

**RESULT:**

**WITHOUT CONTROLLER:**

We take same experimental observation on prototype model of transmission line. We got a observation as follow:

Table.1 Observations without controller

| V1 (Volt) | I1 (Amp) | W1 (Watt) | V2 (Volt) | I2 (Amp) | W2 (Watt) | LOAD (Watt) |
|---|---|---|---|---|---|---|
| 230 | 0 | 0 | 250 | 0 | 0 | 0 |
| 230 | 0.9 | 120 | 245 | 0.3 | 90 | 100 |
| 230 | 1.15 | 220 | 236 | 0.9 | 180 | 200 |
| 230 | 1.45 | 290 | 226 | 1.3 | 270 | 300 |
| 230 | 1.75 | 400 | 217 | 1.8 | 360 | 400 |

From above table we plot some graph as:

1. **FOR VOLTAGE VS CURRENT:**

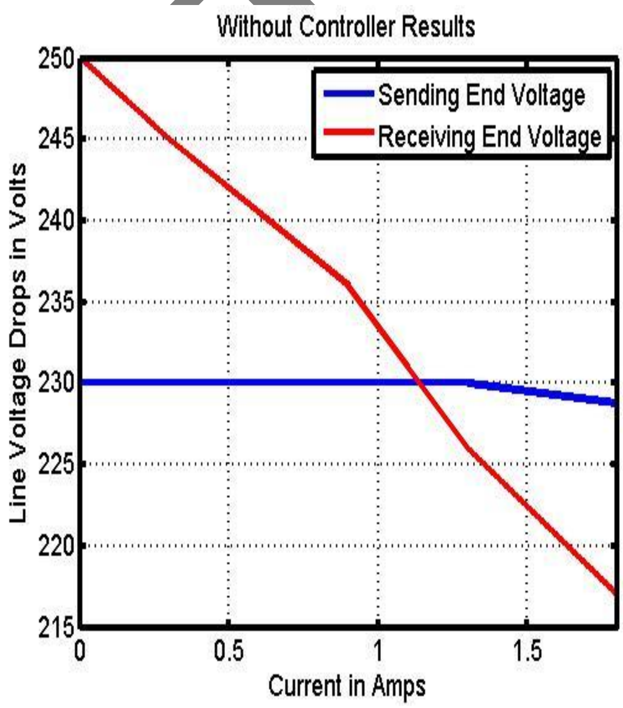


Fig.5 Voltage Vs Current Graph Without Controller

**WITH CONTROLLER:**

After taking a result of without controller we take a observation with controller which gave us result as follow:

Table.2 Observation With Controller

| V1 (Volt) | I1 (Amp) | W1 (Watt) | V2 (Volt) | I2 (Amp) | W2 (Watt) | LOAD (Watt) |
|---|---|---|---|---|---|---|
| 230 | 0 | 0 | 238 | 0 | 0 | 0 |
| 230 | 0.9 | 120 | 232 | 0.3 | 100 | 100 |
| 230 | 1.15 | 220 | 228 | 0.9 | 200 | 200 |
| 230 | 1.45 | 290 | 228 | 1.15 | 300 | 300 |
| 230 | 1.75 | 400 | 228 | 1.75 | 400 | 400 |

From above table we plot a graph as follow:

**1. VOLTAGE VS CURRENT:**

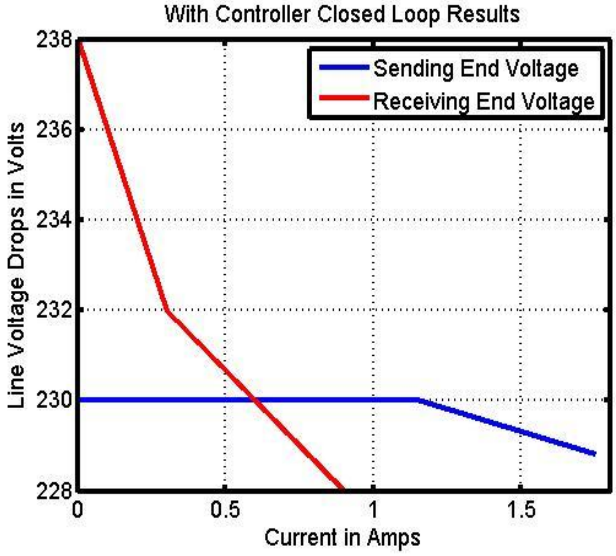


Fig.6 Voltage Vs Current Graph With Controller

Observation table for power and voltage at different values of capacitive reactance :-

Table.3 Power and Voltage At Different Value of Xc

| Xc = 0 | | Xc=0.5Xl | | Xc = 0.75Xl | |
|---|---|---|---|---|---|
| Power transferred (Watts) | Vr (Volts) | Power transferred (Watts) | Vr (Volts) | Power transferred (Watts) | Vr (Volts) |
| 0 | 0 | 0 | 0 | 0 | 0 |
| 60 | 30 | 120 | 30 | 150 | 30 |
| 120 | 60 | 200 | 60 | 220 | 60 |
| 200 | 90 | 280 | 90 | 300 | 90 |
| 280 | 120 | 380 | 120 | 400 | 120 |
| 380 | 150 | 415 | 150 | 450 | 150 |
| 300 | 180 | 430 | 180 | 480 | 180 |
| 150 | 210 | 300 | 210 | 400 | 210 |
| 0 | 230 | 0 | 230 | 0 | 230 |

Xc :- Graph of power vs voltage for above values of

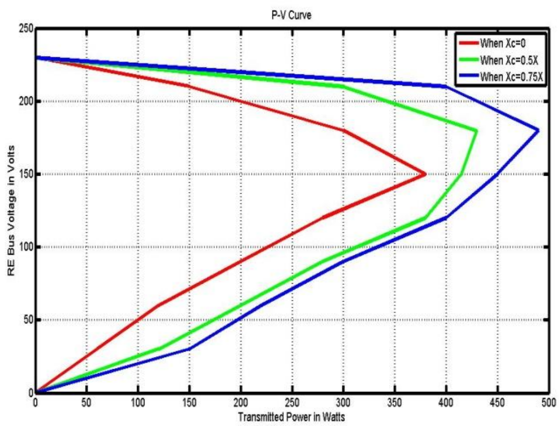


Fig.7 P-V Graph

**CONCLUSION:**

The result shows that when TCSC is connected in the test system, there is improvement in the voltage stability margins. Series capacitive compensation is thus used to reduce the series reactive impedance, this will caused to minimize receiving end voltage variation and the possibility of voltage collapse and it can improve power flow capability of the line. TCSC is more effective than mechanical switching capacitor and synchronous condensers.

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