

## Enhancement of stability in multibus system using Static Synchronous Series Compensator (SSSC)

Sangeetha C.N

Department of Electrical and Electronics, SMEC

### -----ABSTRACT-----

*In recent days most of the power system controlling techniques depends on the fast acting power electronic based FACTS Controllers. This paper describes a suitable approach to compensate the active and reactive power and also to damp out the oscillations in a multibus (six bus) power system using Static Synchronous Series Compensator (SSSC). The power system under consideration is simulated by using MATLAB/SIMULINK software. The dynamic Performance of SSSC is presented by voltage and current waveforms obtained for a selected bus in a six bus system.*

**Key words** – Active and Reactive power, FACTS, Multibus system, Static Synchronous Series Compensator (SSSC)

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### I. INTRODUCTION

Nowadays the effective operation of the power transmission system is essential to meet the utility requirement, while still the system has to maintain reliability and security. Because of the uneven growth in power demand and lack of power generation facilities nowadays most of the power systems are interconnected. However the existing transmission systems are unavailable to meet the interconnected power system loads and this will lead to the variation in voltage profile and hence it will affect the stability of the system.

The power flow through the AC transmission lines mainly depends on line impedance, the magnitude of the sending end voltage, the magnitude of the receiving end voltage and the phase angle between the sending and receiving end voltage. The power flow through the transmission line is increased by providing suitable reactive power compensation. In earlier days the transmittable power was increased by cancelling a portion of reactive line impedance by using series capacitive compensation.

Most of the power systems are subjected to electromechanical oscillations. Power system stabilizers are used to eliminate these oscillations to some extent. Because of the implementation of fast acting power electronic based switching incorporated FACTS controllers, these oscillations damp out in high speed and thus improve the system stability. Many of the FACTS devices are connected in shunt or in series either without storage element or with storage element for effective compensation.

In recent days series connected FACTS controllers such as SSSC is most suitable alternative means to damp out such electromechanical oscillations. The main component of SSSC is a voltage source converter (VSC) which injects an alternating voltage at fundamental frequency in series with the transmission line. The voltage injected by VSC is in quadrature with the line current due to this it can compensate both inductive as well as capacitive reactance, and thus influence the power flow through the transmission line. Generally SSSC is used to control the power flow through the transmission line, it can also be used for damping out the oscillations in transient mode and thus improve the transient stability. This paper describes how SSSC is used in a six bus system to improve the stability in transient mode.

### 1. Static Synchronous Series Compensator Configuration

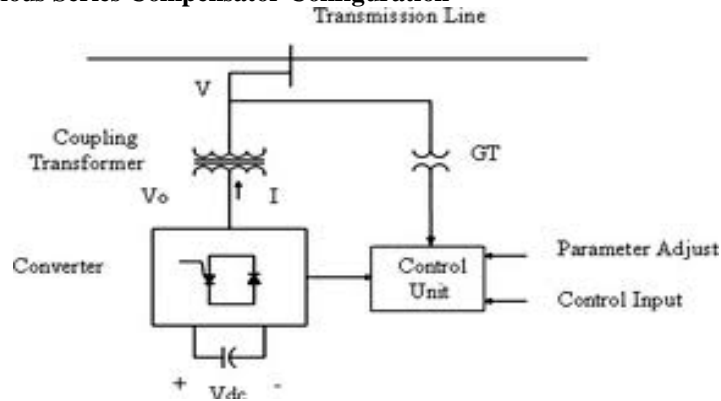


Fig 1: Basic configuration of SSSC

“Fig. 1” shows the basic configuration of SSSC. The main component of SSSC is a Voltage Source Converter (VSC). It is equipped with an energy source to enhance the active and reactive power exchange with an AC system. The series connected SSSC inject an AC voltage in phase quadrature with line current, and thus the control of power flow through the transmission line is attained by adjusting the magnitude and phase angle of the injected voltage.

Basic equations representing the power flow through the transmission line is given by

$$P_q = \frac{V^2}{X_{eff}} \sin \delta \quad (1) \quad Q_q = \frac{V^2}{X_{eff}} (1 - \cos \delta) \quad (2)$$

Where

$$X_{eff} = X_L (1 - X_q/X_L) \quad (3)$$

$X_q$  is the capacitive reactance due to injected voltage.

$X_L$  is the inductive reactance of the transmission line.

$V$  is the voltage magnitude ( $V_s = V_r = V$ )

$$\delta = \delta_s - \delta_r \quad (4)$$

### II. MODELLING OF THE PROPOSED SIX BUS SYSTEM

The dynamic performance of the SSSC is presented by real time voltage and current waveforms obtained after simulation. The simulation diagram for a two machine six bus system is given below. In this system SSSC is used for controlling the power flow through a 500KV transmission system. The system which has been made in ring mode consisting of six buses(B1-B6),connecting each other by transmission lines having length 150 KM,150KM,50KM,50KM,50KM respectively.The system has been supplied by two power plants with phase to phase voltage 13.8 KV. The simulation results obtained for each bus is given below. The SSSC has been connected to a bus that shows more variations in real and reactive power values.

### 3.1 Simulation diagram

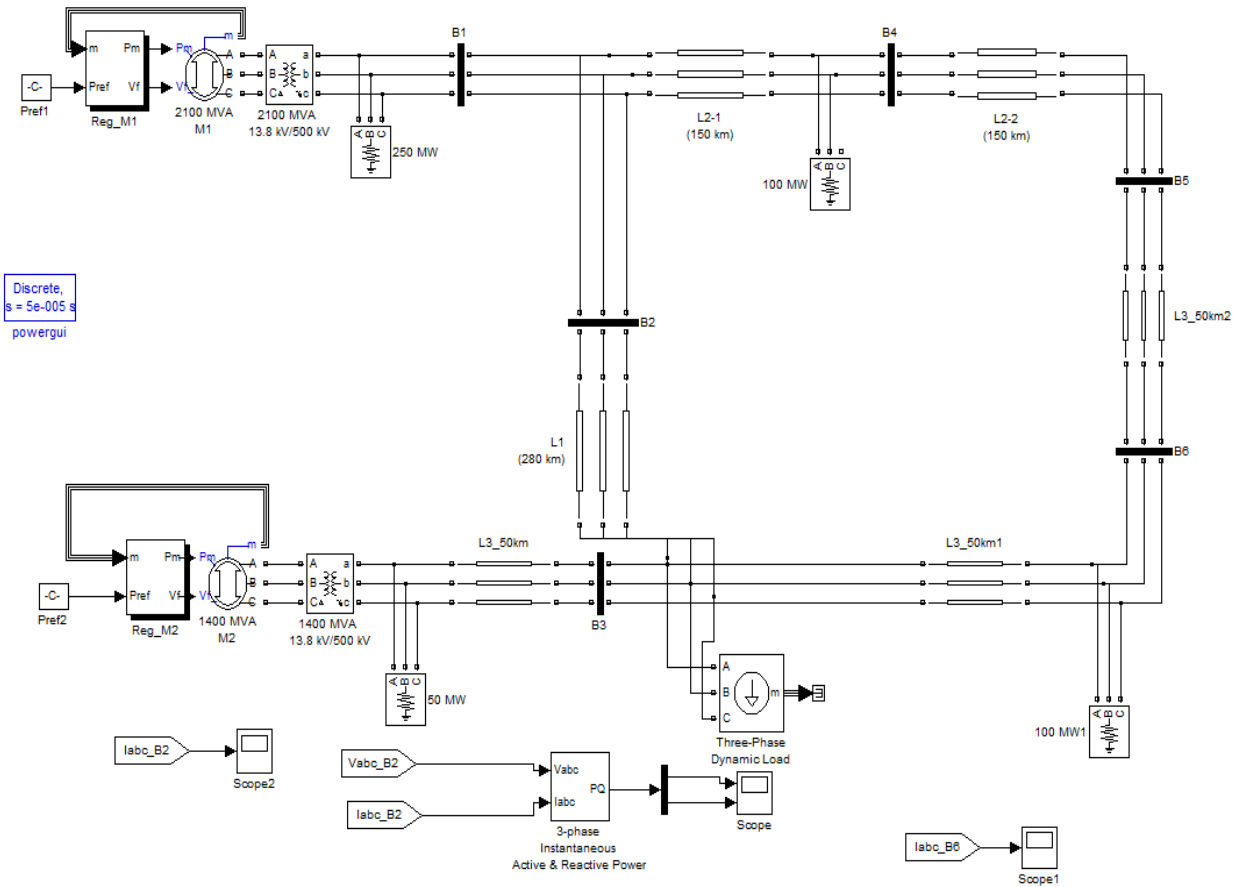


Fig 2: Simulation set for a two machine six bus system without SSSC

First the system has been simulated in MATLAB/SIMULINK environment. The voltages and powers in all the six buses have been found out and given as a “Table” below. Because of the variation in powers at bus 2, it is selected as the candidate bus to which SSSC has to be installed.

Table 1. Results after simulation

Bus No.	voltage	Current	Active power	Reactive power
1	1 pu	13.5 pu	20.06 pu	-3.77 pu
2	1 pu	6.7 pu	9.96 pu	1.82 pu
3	1 pu	10 pu	14.7 pu	-.49 pu
4	1 pu	5.5 pu	8.45 pu	-.048 pu
5	1 pu	5 pu	8.59 pu	-.8 pu
6	1 pu	5.8 pu	9.2 pu	-.82 pu

### 3.2 Necessary wave forms for the selected bus-2

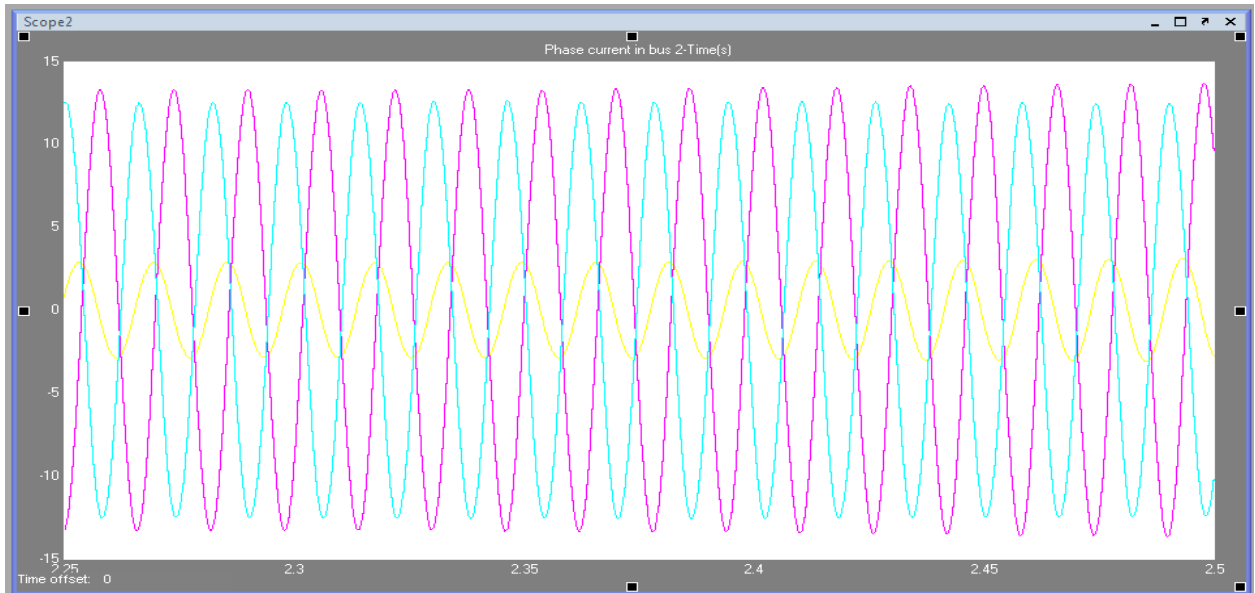


Fig 3: Current of bus 2 without SSSC

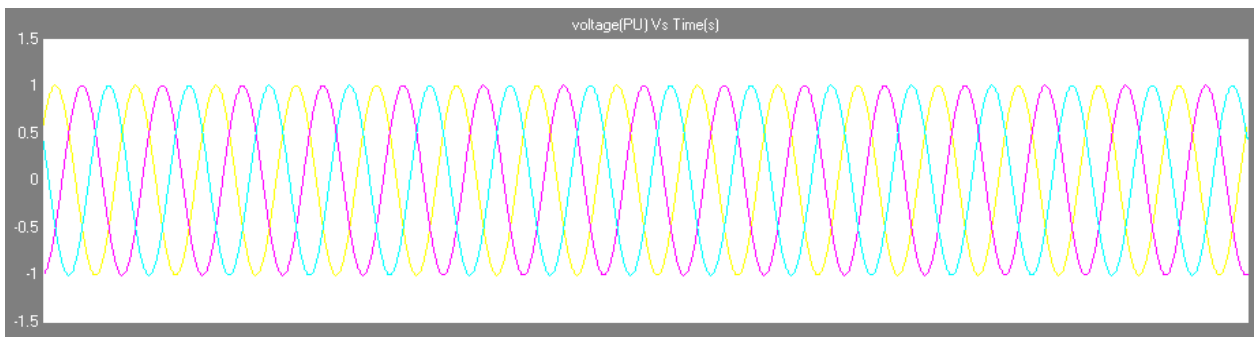


Fig 4: Voltage of bus 2 without SSSC

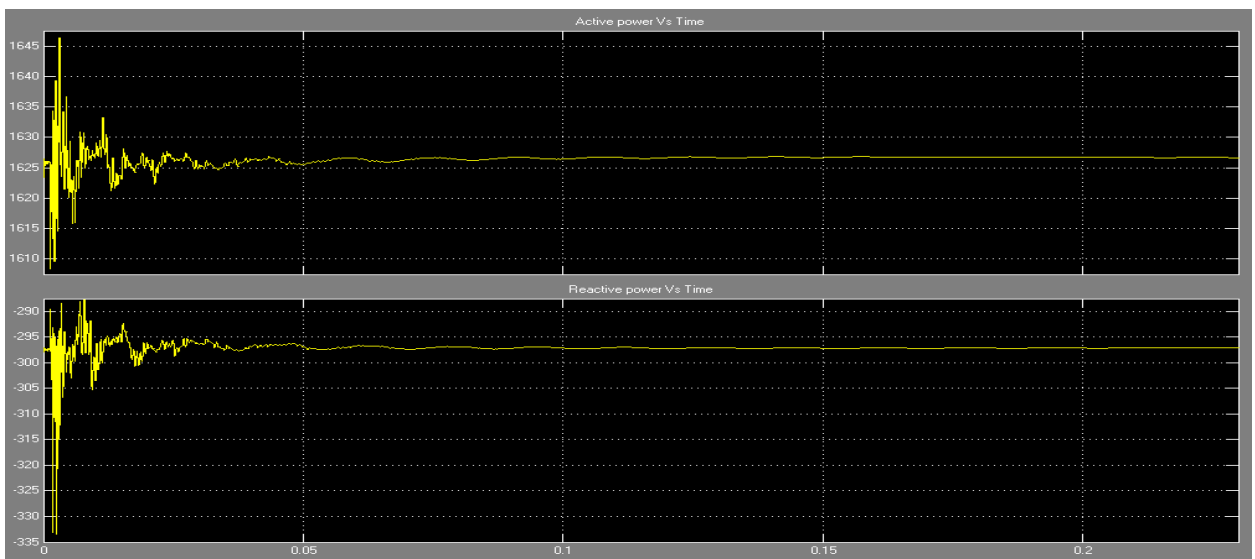


Fig 5: Active and Reactive powers of bus 2 without SSSC

### 3.3 Two machine six bus system with SSSC

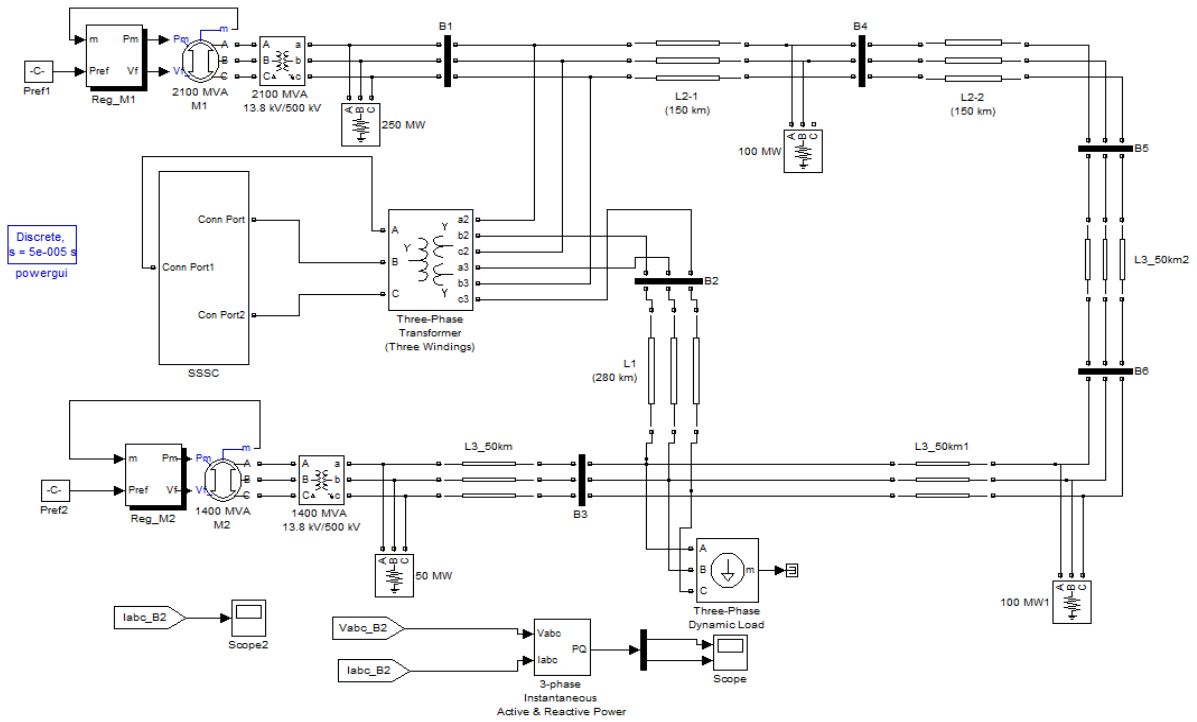


Fig 6: Simulation set up for a two machine six bus system with SSSC

### 3.4 Necessary wave form for current of bus 2 in the presence of SSSC

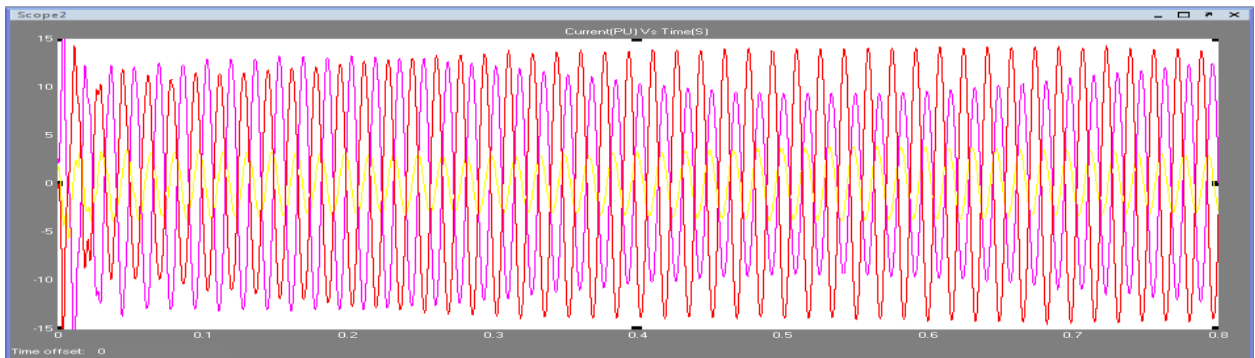


Fig 7: Current of bus 2 in the presence of SSSC

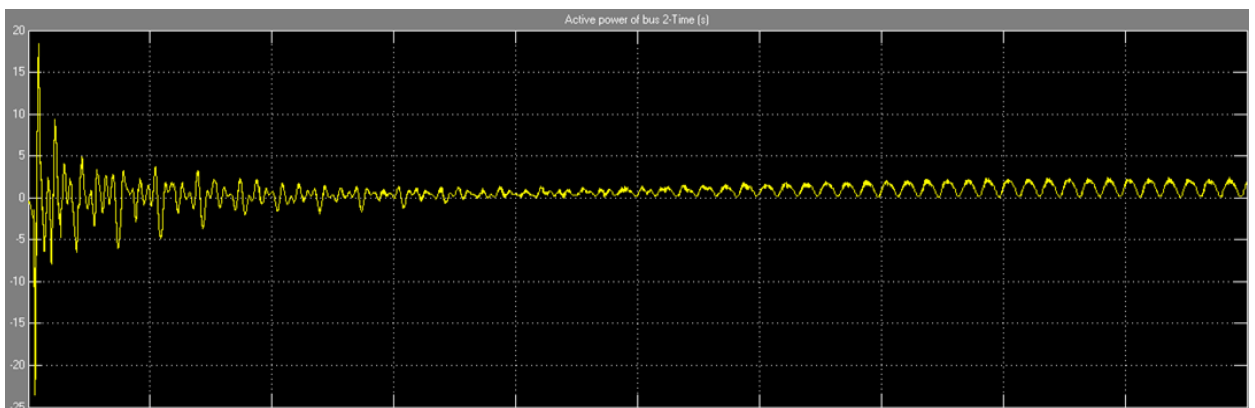


Fig 8: Active power of bus 2 in the presence of SSSC

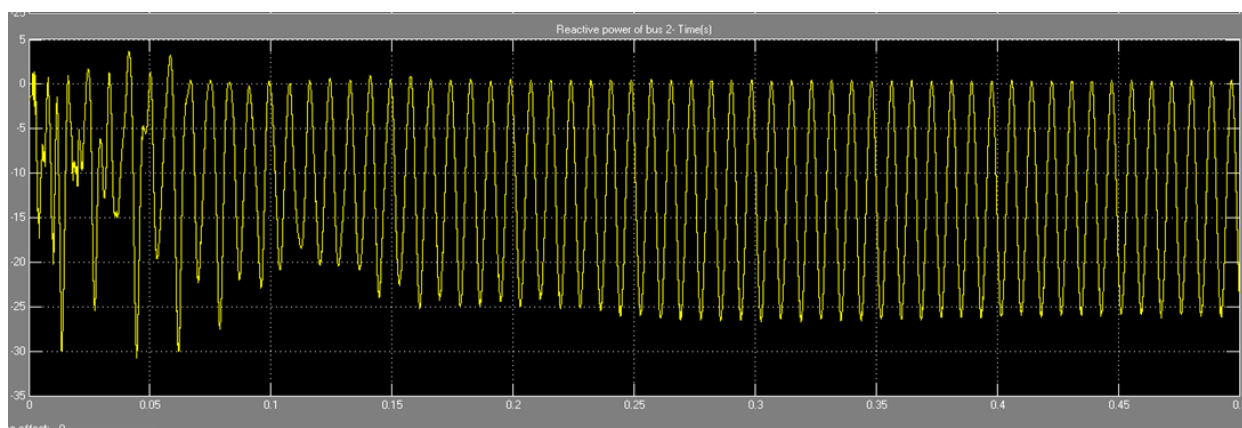


Fig 9: Reactive power of bus 2 in the presence of SSSC

### 3.5 Bus- 2 Parameters without and with SSSC

After simulation we have been obtained the real time voltage, current, power variations at bus 2. The active and reactive powers at bus 2 got oscillated due to large loads of the system and which keep continuing for almost 3 sec. Because of the ohmic loads the active power oscillations are more compared to reactive power oscillations. The preliminary controlling systems such as governor, PSS are used for damping these oscillations. According to the figures it is also clear that the voltage and current waveforms are closer to sinusoidal waveforms. The voltage amplitude is 1 per unit and the current amplitude is 6.7 per unit.

SSSC is mainly used for controlling the active and reactive power flow through the transmission system and also to improve the transient stability of the system. From the simulation result it is clear that after the installation of SSSC the active power oscillation damping time will be less than the mode without SSSC. Also it will decrease the reactive power damping time.

## III. CONCLUSION

Static synchronous series compensator is capable of enhancing the power flow through the transmission system by injecting a fast changing voltage in series with the line. The injected voltage is in quadrature with line current and hence it can provide both inductive and capacitive compensation. Here the performance of SSSC is presented by the real time voltage and current waveforms obtained after the simulation of a six bus system. The application of this can be extended to a multi machine multibus system to investigate the problems related to stability.

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## BIOGRAPHY

Sangeetha C.N received B .Tech in EEE from Adi Sankara Institute of Engineering And Technology, India in 2007. Presently I am Pursuing M Tech in SMEC Hyderabad, India. I had four years of experience in education field. My areas of interest are Power Quality and Electrical measurements.