Impact of Non Linear Load on Power Quality

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***Abstract*—**Power quality is a major issue in today's power system. This is mainly affected by the generation of harmonics. The growing use of electronic equipment produces a large amount of harmonics in distribution systems because of non-sinusoidal current consumed by non-linear loads. Along with the increasing demand on improving power quality i.e. generally defined as any change in voltage, current, or frequency that interferes with the normal operation of electrical equipment. Nowadays, nonlinear loads are widely used in industries. These loads mainly generate the harmonic into the power system. These harmonics cause a lot of disadvantages such as the erroneous measurement of electric meters, protective device failures, loss in transmission lines and electric devices, and short-life electronic equipments. Therefore, it is seriously to mitigate or eliminate the harmonic in the system.

Harmonics not only increases the losses in the system but also produces unwanted disturbance to source voltage, source current etc. This has motivated the introduction of an filter for improving the power quality.

Keywords - *FACTS, PCC, Power Quality, THD, Non Linear Load.*

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I. INTRODUCTION

The performance and working of a shunt active power filter depends on various factors. Out of that, the reference generation is the most important. The method to generate the reference template is responsible for the reference of currents that must be followed by an inverter to produce the desired compensation currents that will mitigate harmonic currents generated by non-linear loads. Due to the intensive and large use of power converters and other non-linear loads in industry and by consumers in domestic and agricultural sector, it is observed an increasing deterioration, distortion of the power systems voltage and current waveforms. Simply the power quality is a measurement of ideal power supply; maintaining the supply at its rated value is called as power quality. As per IEEE dictionary the power quality is defined as "The concept of powering and grounding electronic equipment in such a manner that it is suitable for the operation of equipment and fit with wiring system and remaining connected equipment". Power quality is an important issue among the today's electric world, day by day problem related to power quality is increases and it is essential to limit this problem using suitable remedies over it.

II. POWER QUALITY

Power Quality (PQ) has become an important issue to electricity consumers at each levels of usage. The PQ issues can be defined as "Any power problem occurs in voltage, current or frequency deviations that results in failure or wrong operation of customer equipment". The use of power electronic based equipment has a significant impact on quality of electric power supply. The switch mode power supplies

(SMPS), dimmers, current regulator, frequency converters, low power consumption lamps, arc welding machines, etc. are some of power electronics based devices.

III. BLOCK DIAGRAM DESCRIPTION

Figure 1 shows a simple block diagram ofnonlinear laod connected to the three phase source. It consists of mainly three blocks which are given below.

The voltage and current waveform at load side is no sinusoidal in case of without filter but after connecting filter at source side the output waveform can be sinusoidal.

A. Three Phase Source

Three phase source comes from the generating station. This generating station may Thermal Power Plant, Tidal Power Plant, Hydro Power Plant, Nuclear Power Plant and number of another type. The three phase source rating is high nearly 33KV, 66KV, 132KV or more than 132KV. Figure 1 shows that this block is connect to the transmission line box. This source connect to transmission line through various devices such as transformer, relay etc.

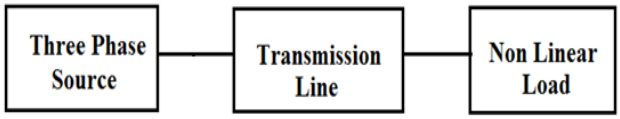

Figure 1: Block diagram of connection of nonlinear load

B. Transmission Line

Transmission line contains number of devices such as tower, insulators, conductors etc. Transmission line is high voltage (HV) line. It has number of devices and hence there may produce harmonic which may pollute the power system. Transmission line is used to transfer the electricity from generating station to distribution station. The construction of this line is highly rigid and contain large conductor.

C. Non Linear Load

Nonlinear load produced harmonics in power system and reduced the power quality of system. There are number of type of nonlinear load in power system such as induction motor, uninterrupted power supply, speed drive, inverter, rectifiers, bridges etc. Expected waveform op output voltage and current at load side is linear or sinusoidal but due to nonlinear load the output waveform is non-sinusoidal. This is the last part of the block diagram shown in figure 1.

IV. SIMULINK MODEL DESCRIPTION

Figure 2 shows the system design of three phase nonlinear load without filter. The load current waveform is non sinusoidal due to nonlinear load. The source current waveform may be sinusoidal but due to nonlinear load there is small variation in source current.

A. Three Phase Source

Three phase source block of Sim Power system is used as three phase voltage source and for this it is important to add following data.

B. V-I Measurement

Three PhaseV-I measurement block is used to measure line to ground voltage and line current. V-I measurement block consist of a following data and this data is necessary for proper simulation.

C. Power GUI

This block is neede to run any Sim Power system model. It provides option for configuration of simulation and analysis of system. Without this block simulation will not run in any condition. It is used to store the equivalent simulink circuit that represents the state-space equations of the model.

D. Non Linear Load

In nonlinear load two components are connected which include three Inductors and IGBT. Nonlinear load produced harmonics in power system and reduced the power quality of system. Components of nonlinear load are:

a) Inductors
b) IGBT

These components are explained as below:

a) Inductor

The inductor block models a linear inductor, described with the following equation and fig.4.1.4 (a) gives the representation of inductor.

$$V = L\frac{dI}{dt} \qquad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where,

I=Current
V=Voltage
L=Inductance
T=Time

b) IGBT

The IGBT turns on when the collector-emitter voltage is positive and greater than Vf and a positive signal is applied at the gate input (g > 0). It turns off when the collector emitter voltage is positive and a 0 signal is applied at the gate input (g = 0). The IGBT device is in the off state when the collector-emitter voltage is negative. Note that many commercial IGBTs do not have the reverse blocking capability. Therefore, they are usually used with an antiparallel diode.

V. SIMULINK MODEL

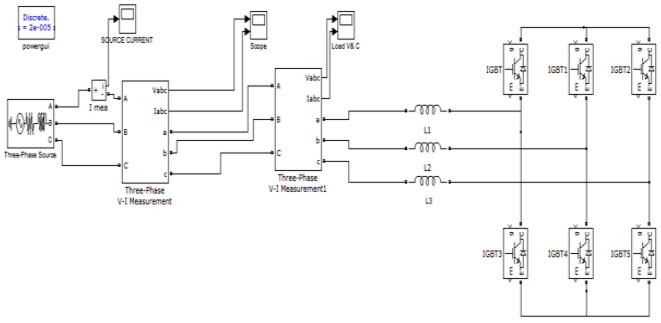

Figure 2: Simulink model of three phase nonlinear load without filter

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VI. SIMULATION RESULT OF NON LINEAR LOAD

A. *Source Current*

Due to the non-linear load connected to the system, harmonics are produced in load current waveform as shown in Figure. In normal condition the source current is sinusoidal but due to nonlinear load there is slight change in the waveform of source current. After connecting shunt APF we will get the sinusoidal current at source side. Figure 2 gives the simulink result of three phase source current without shunt APF.

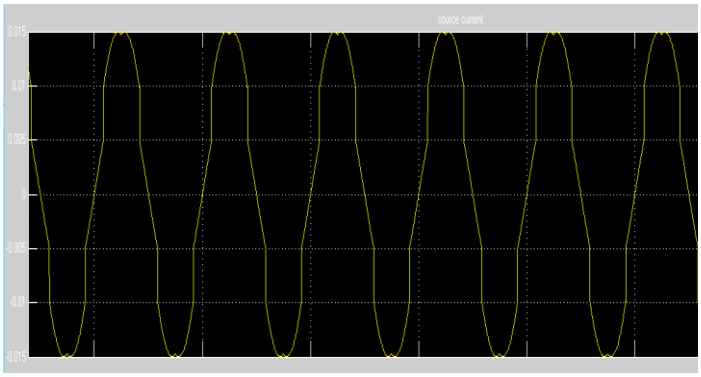

Figure 3. Simulink result of three phase source current without filter

B. *Load Voltage and Current*

Sinusoidal load voltage waveform of three phases which is shown in figure 3. Load current is non-sinusoidal because of nonlinear load is connected as an output.

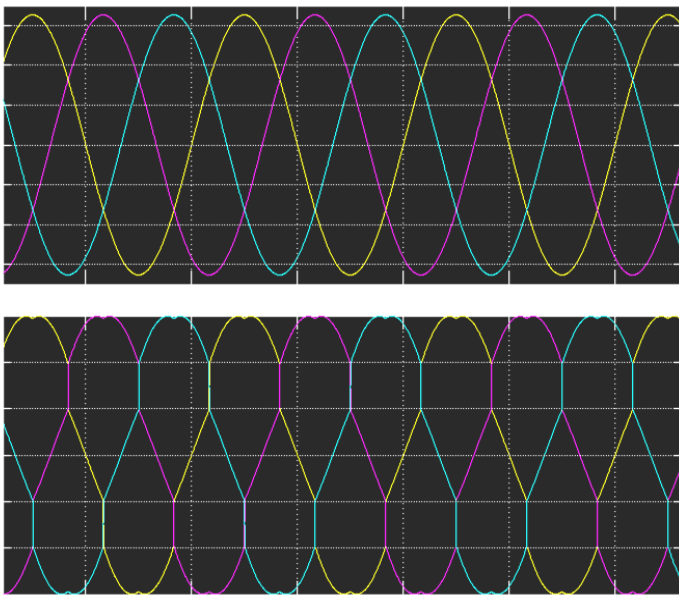

Figure 4: Simulink results of three phase nonlinear load voltage and current

C. *Expected Load Current*

For better quality of power it is important to maintain the sinusoidal current at load side. After connecting the shunt APF we will get the sinusoidal load current which is shown in figure 5.

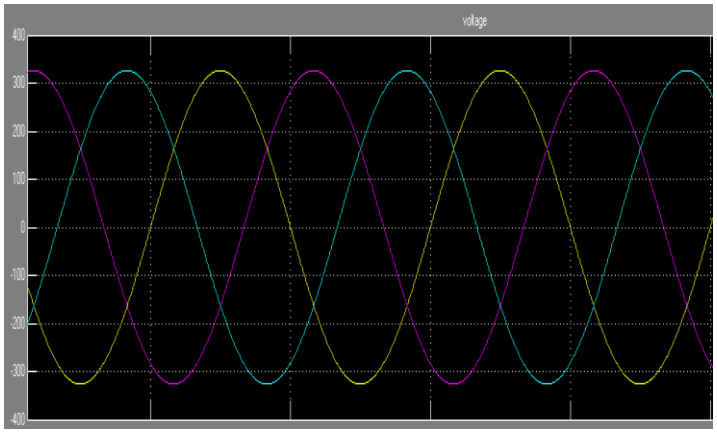

Figure 5: Output waveform of three phase nonlinear current with filter

D. *Total Harmonic Distortion (THD)*

The total harmonic dstortion is find out with the help of FFT analysis. THD of simulink model without filter is 11.65%. THD of non linear load without shunt APF is shown in figure 6.

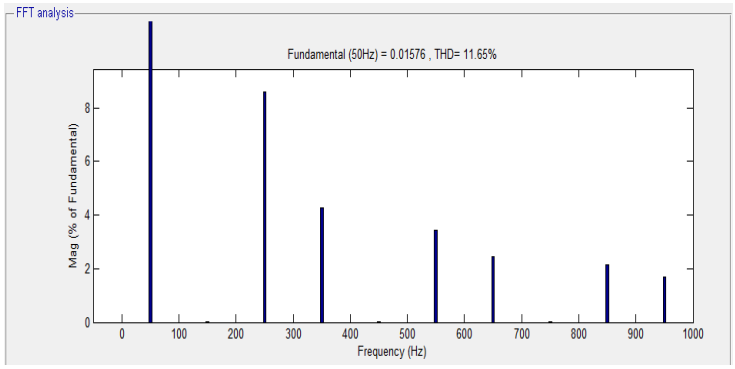

Figure 6: THD of model without filter

VII. RESULT AND CONCLUSION

This paper gives the information of effect of nonlinear load on the power system. The simulation result shows the effect of nonlinear load on source current. The THD is found to be 11.65%.

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