A Comparitive Study of DSTATCOM & DVR For Power Quality Improvement

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Abstract- *A Power quality problem is an occurrence manifested as a nonstandard voltage, current or frequency that results in a failure or a mis-operation of end user equipments. In order to maintain the power system quality some devices are used (stated below) which will absorb and provide reactive power to mitigate voltage sag, swell, interruption and improve power factor in various conditions. Utility distribution networks, sensitive industrial loads and critical commercial operations suffer from various types of outages and service interruptions which can cost significant financial losses. With the restructuring of power systems and with shifting trend towards distributed and dispersed generation, the issue of power quality is going to take newer dimensions. Thus improvement of power quality is a serious question, it is very vital to take positive steps in this direction. There are various devices which are present which can be used to improve the power quality for the transmission line like,*

SVC (STATIC VAR COMPENSATOR), DSTATCOM (DISTRIBUTED STATIC COMPENSATOR), DVR (DYNAMIC VOLTAGE RESTORER). The present work is to identify the better option which can be used from DSTATCOM or DVR for power quality improvement by comparing both devices.

Keywords- D STATCOM, DVR, SVC, Voltage sag, Interruption, Voltage swell.

I. INTRODUCTION

Power distribution systems, ideally, should provide their customers with an uninterrupted flow of energy at smooth sinusoidal voltage at the contracted magnitude level and frequency. However, in practice, power systems, especially the distribution systems, have numerous nonlinear loads, which significantly affect the quality of power supplies. As a result of the nonlinear loads, the purity of the waveform of supplies is lost. This ends up producing many power quality problems. Apart from nonlinear loads, some system events, both usual (e.g. capacitor switching, motor starting) and unusual (e.g. faults) could also inflict power quality problems. Power quality phenomenon or power quality disturbance can be defined as the deviation of the voltage and the current from its ideal waveform.

Faults at either the transmission or distribution level may cause voltage sag or swell in the entire system or a large part of it. Also, under heavy load conditions, a significant voltage drop may occur in the system. Voltage sag and swell can cause sensitive equipment to fail, shutdown and create a large current unbalance. The voltage dip magnitude is ranged from 10% to 90% of nominal voltage and with duration from half a cycle to 1 min and *swell* is defined as an increase in rms voltage or current at the power frequency for durations from 0.5 cycles to 1 min. typical magnitudes are between 1.1 and 1.8 p.u.

To overcome the problem related to the power quality custom power device is introduced. A number of power quality problem solutions are provide by custom devices. At present, a wide range of flexible AC controller which is capitalized on newly available power electronic components is emerging for custom power application. There are different types of Custom Power devices used in electrical network to improve power quality problems. Each of the devices has its own benefits and limitations.

In this paper we are discussing only two types of such devices (i) DSTATCOM (ii) DVR which are explained respectively.

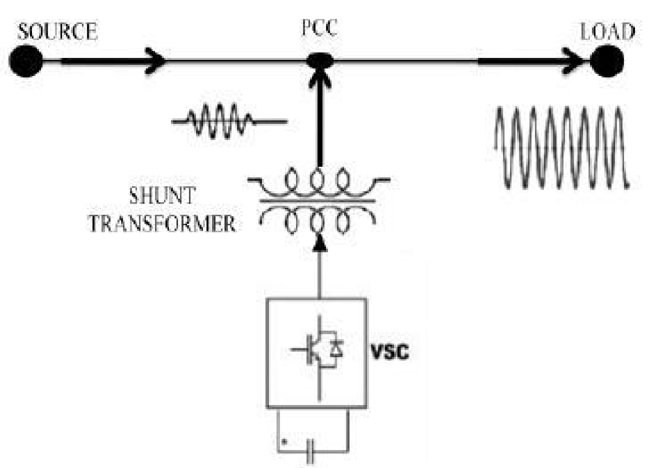
II. DISTRIBUTED STATIC COMPENSATOR (D-STATCOM)

D-Statcom basically VSC (voltage source converter) based FACTS controller. It is employed at distribution level or at load side also behaves as shunt active filter. It works as the IEEE-519 standard limit. Since the electrical power distribution system it is very important to balance the supply and demand of active and reactive power in the electrical power system. Incase if the balance is lost the frequency and voltage excursion may occur result in collapse of power system. So we can say that the key of stable power system. The distribution system losses power quality problems are increasing due to reactive power. The main application of D-

Statcom exhibit high speed control of reactive power to provide voltage stabilization in power system.

The D-Statcom protect the distribution system from voltage sags, flicker caused by reactive current demand. DSTATCOM employs a voltage source converter (VSC) and generates capacitive and inductive reactive power internally. Its control is very fast and has the capability to provide adequate reactive compensation to the system. DSTATCOM can be effectively utilized to regulate voltage for one large rating motor or for a series of small induction motors starting simultaneously. Induction motor loads draw large starting currents (5- 6times) of the full rated current and may affect working of sensitive loads[3].

D-Statcom (Distributed static compensator) is a parallel voltage controller, which is schematically depicted in figure-1, consists of a filter, Voltage source converter, a dc energy storage device, a coupling transformer connected in shunt to the distribution network through a coupling transformer. The voltage source converters the dc voltage across the storage device into a set of three-phase ac output voltages. These voltages are in phase and coupled with the ac system through the reactance of the coupling transformer.



Suitable adjustment of the phase and magnitude of the D-Statcom output voltages allows effective control of active and reactive power exchanges between the D-Statcom and the ac system. Such configuration allows the device to absorb or generate controllable active and reactive power. The VSC connected in shunt with the ac system provides a multifunctional topology which can be used for up to three quite distinct purposes:

1. Voltage regulation and compensation of reactive power;
2. Correction of power factor; and
3. Eliminating of current harmonics.

Here, such device is employed to provide continuous voltage regulation using an indirectly controlled converter. The shunt injected current h corrects the voltage sag by adjusting the voltage drop across the system impedance h. The value of h can be controlled by adjusting the output voltage of the converter. The shunt h can be written as,

$$h = - = -\left(h - \right) \frac{}{h} \qquad (1)$$

$$h\angle = \angle - \quad - \quad \angle - + \angle - \qquad (2)$$

The complex power injection of the D-Statcom can be expressed as,

$$h = * \; h“ \qquad (3)$$

It may be mentioned that the effectiveness of the D-Statcom in correcting voltage sag depends on the value of h or fault level of the load bus. When the shunt injected current h is kept in quadrature with, the desired voltage correction can be achieved without injecting any active power into the system. On the other hand, when the value of h of minimized, the same voltage correction can be achieved with minimum apparent power injection into the System[5].

III. RESULTANT WAVEFORM WITH & WITHOUT USING DSTATCOM

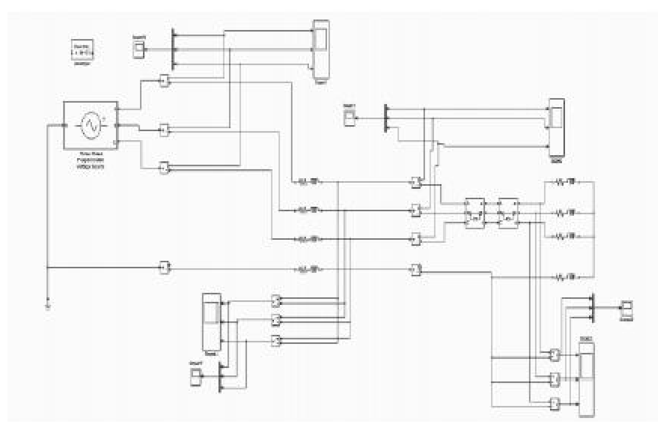


Fig. 2 Simulation model without D-Statcom

MATLAB/SIMULINK modelling of three phase loads without D-Statcom as shown in Fig.2. The fault is created in source side, the corresponding waveform as shown in Fig.3. and fault time is mentioned as given below,

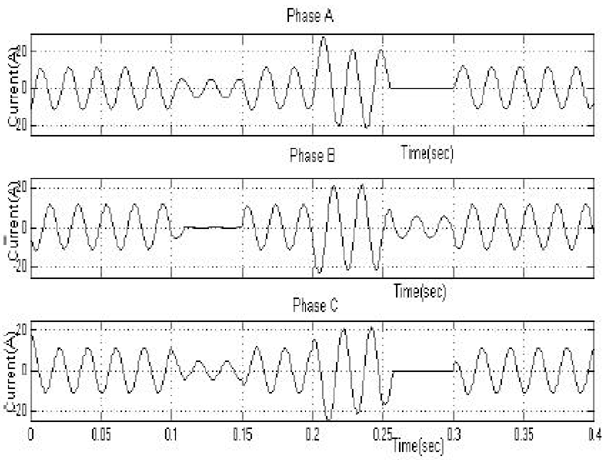


Fig. 3 Current waveform without D-Statcom

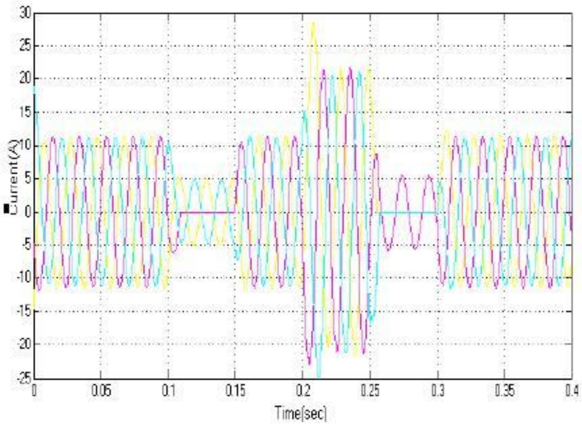


Fig .4.Three phase Current waveform without D-Statcom

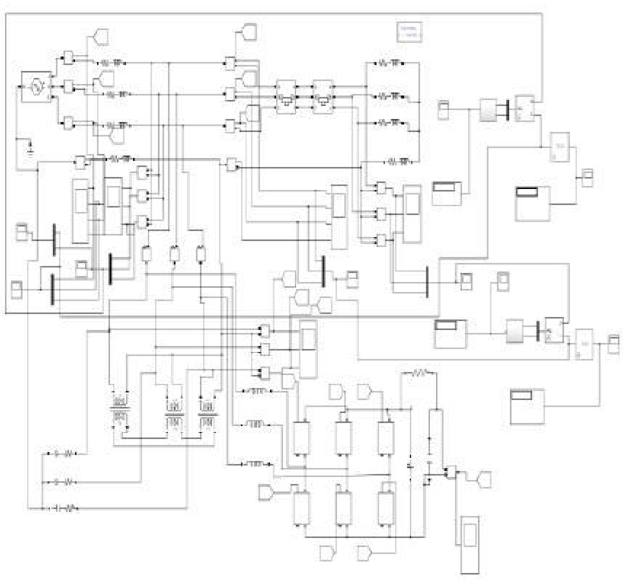


Fig.5 Simulation model with D-Statcom

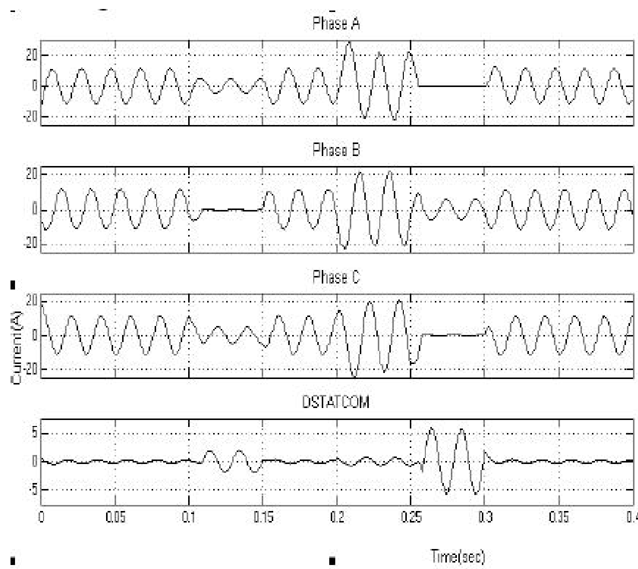
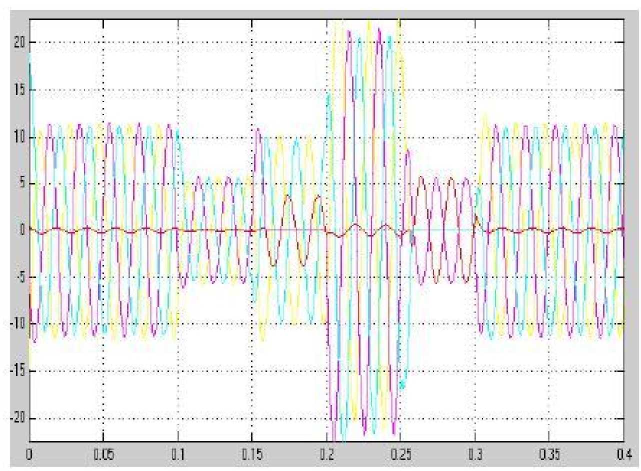


Fig.6 Current waveform with D-Statcom

The three phase current waveform as shown in Fig.4. The three single phase signals are combined by using multiplexer to create the three phase signal as mentioned above



The faults time periods like sag from 0.1 to 0.15 sec, swell from 0.2 to 0.25 sec and interruption from 0.25 to 0.3 sec. These above faulting periods to damage utility side loads, Hence to compensate these problems, we are used in DStatcom.The corresponding three phase loads with D-Statcom as mentioned above Fig.7. In transient condition fault current is produced, that fault current to affect or damage the voltage source converter. Hence to product the voltage source converter in D-Statcom by using space vector pulse width modulation (PWM). The three phase current waveform as shown in Fig.7

IV. DYNAMIC VOLTAGE RESTORER (DVR)

DVR is a Custom Power Device used to eliminate supply side voltage disturbances. DVR also known as Static Series Compensator maintains the load voltage at a desired magnitude and phase by compensating the voltage sags/swells and voltage unbalances presented at the point of common coupling.

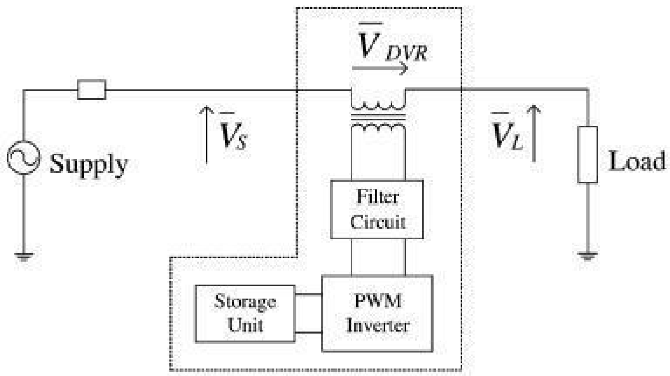


Figure-8: DVR series connected topology

The power circuit of the DVR is shown in Fig. 8.The

The star/open winding allows injection of positive, negative and zero sequence voltages whereas delta/open winding only allows positive and negative sequence voltage injection.

c) Passive Filters

Passive filters are placed at the high voltage side of the DVR to filter the harmonics. These filters are placed at the high voltage side as placing the filters at the inverter side introduces phase angle shift which can disrupt the control algorithm.

d) Energy storage

Batteries, flywheels or SMEs can be used to provide real power for compensation. Compensation using real power is essential when large voltage sag occurs.

e) Capacitor

DVR has a large DC capacitor to ensure stiff DC voltage input to inverter.

f) By-Pass Switch

If the over current on the load side exceeds a permissible limit due to short circuit on the load or large inrush current, the DVR will be isolated from the system by using the bypass switches and supplying another path for current[6].

V. CONTROL & OPERATION OF DVR USING 3 PHASE TRANSMISSION LINE

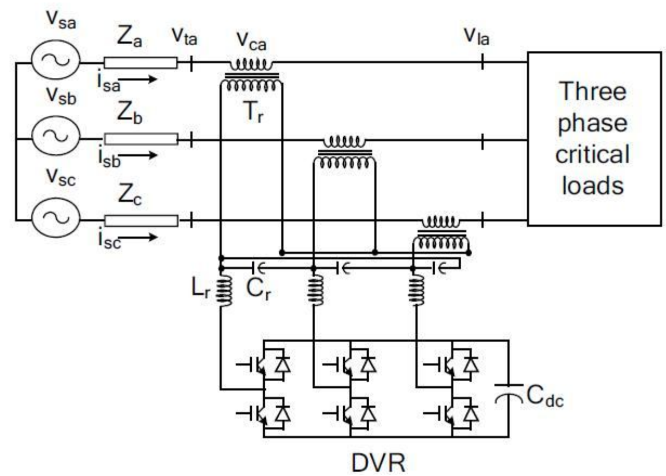


Figure-9: DVR connected 3 phase line

The compensation for voltage sags using a DVR can be performed by injecting/absorbing reactive power or real power.

When the injected voltage is in quadrature with the current at the fundamental frequency, compensation is achieved by injecting reactive power and the DVR is self-supported with dc bus. But, if the injected voltage is in phase with the current, DVR injects real power and hence a battery is required at the dc side of VSI. The control technique adopted should consider the limitations such as the voltage injection capability (inverter and transformer rating) and optimization of the size of energy storage.

Figure-4 shows the control block of the DVR in which the synchronous reference frame (SRF) theory is used for the control of self-supported DVR. The voltages at PCC (Vt) are converted to the rotating reference frame using the abc-dqo conversion. The harmonics and the oscillatory components of voltages are eliminated using low pass filters (LPF). The components of voltages in d-axis and q-axis are,

Vsd = Vsd dc + Vsd ac

Vsq = Vsq dc + Vsq ac

The compensating strategy for compensation of voltage quality problems considers that the load terminal voltage should be of rated magnitude and undistorted[7].

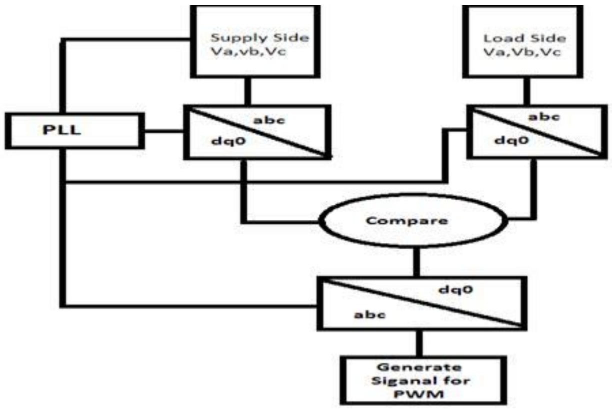


Figure-10: Control Block of DVR

The dqo transformation or Park's transformation is used to control of DVR. The dqo method gives the sag depth and phase shift information with start and end times. The quantities are expressed as the instantaneous space vectors. Firstly convert the voltage from a-b-c reference frame to d-q-o reference. For simplicity zero phase sequence components is ignored.

Fig. 10 illustrates a flow chart of the feed forward dqo transformation for voltage sags/swells detection. The detection is carried out in each of the three phases. The control is based on the comparison of a voltage reference and the measured terminal voltage (Va, Vb, Vc).The voltage sags is detected when the supply drops below 90% of the reference value whereas voltage swells is detected when supply voltage increases up to 25% of the reference value. The error signal is used as a modulation signal that allows generating a commutation pattern for the power switches (IGBT's) constituting the voltage source converter. The commutation pattern is generated by means of the sinusoidal pulse width modulation technique (SPWM); voltages are controlled through the modulation.

VI. RESULTANT WAVEFORM WITH & WITHOUTUSING DVR

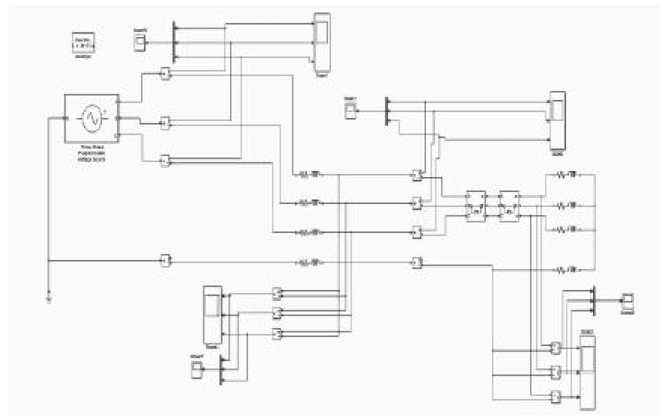


Fig. 11 Simulation model without DVR

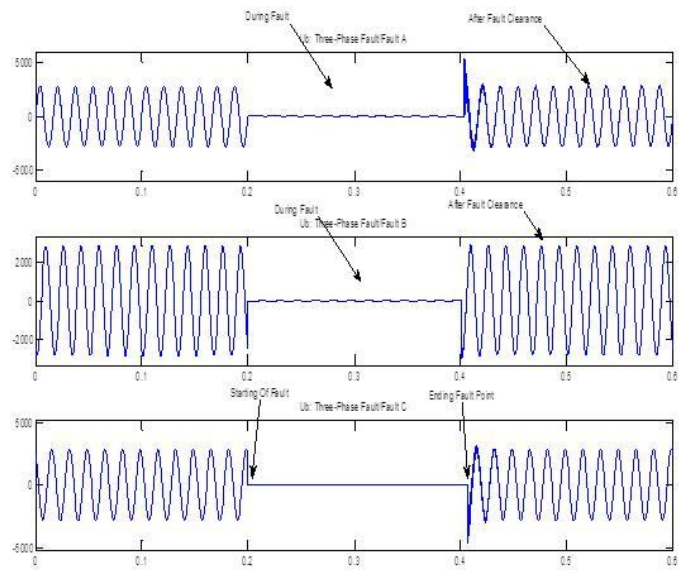


Fig.-12 Three phase fault without DVR with a 3 phase fault

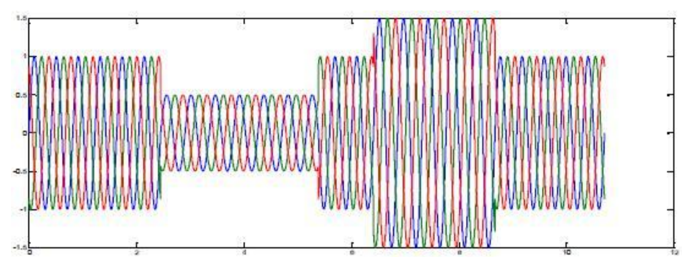


Fig .13.Three phase Current waveform without DVR with 3 phase fault with 50% voltage Sag and 50% voltage Swell

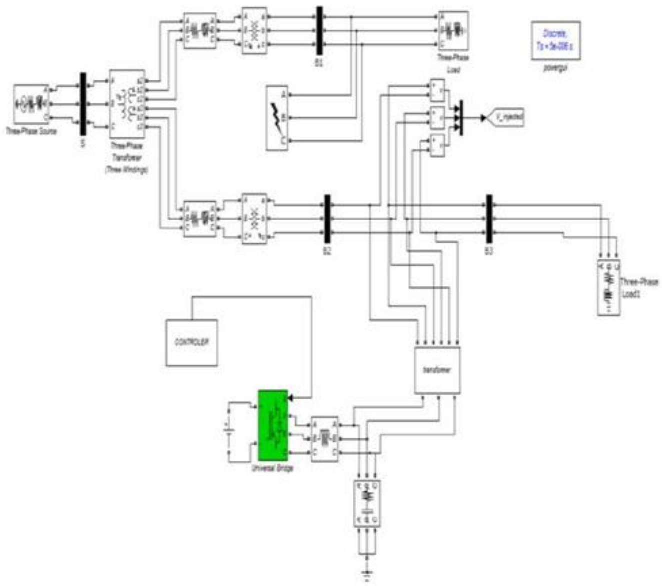


Fig. 14 Simulation model with DVR

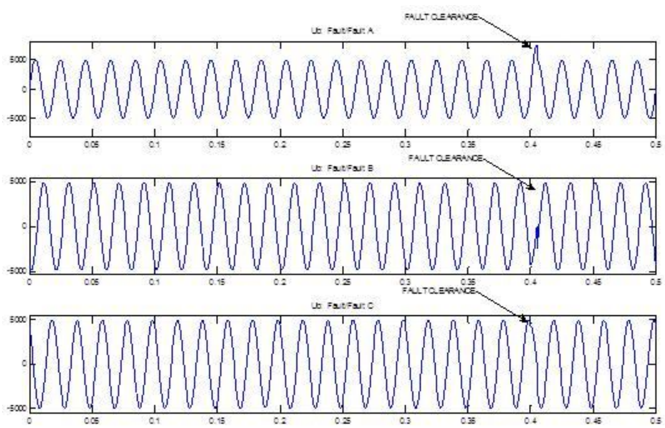


Fig.-15 Three phase fault with DVR with a 3 phase fault

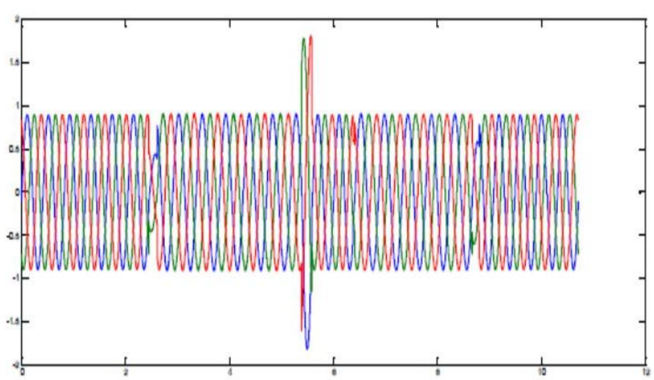


Fig .16.Three phase Current waveform with DVR with 3 phase
fault after clearing the Voltage Sag and Swell

Figure-12 shows the first simulation was done with no DVR and a three phase fault is applied to the system at point with fault resistance of 0.66 Ω for a time duration of 200 ms. Figure-15 shows the second simulation is carried out at the same scenario as above but a DVR is now introduced at the load side to compensate the voltage sag occurred due to the three phase fault applied.

VII. CONCLUSION

From the above two waveforms we have studied that the clearing of sags and swells in the 3 phase system (by taking a faulty condition as an example) is very much clean and approx completely removed by using DVR. And also it has the ability to control the active power flow. So from the above study we can say that DVR is clearly considered to be one of the best economic solutions for its size and capabilities.

REFERENCES

[1] V.Malathi, “Power quality improvement of grid interconnecteddistribution system FSS-LMS algorithm”, VOL.02, Issue.06,ISSN: 2319-1163, Jun.2013.

[2] D.Bhanumurthy and Prashanth, “Power quality improvement at distribution level”,Proc.IJERA,vol.2,Issue.3,pp.970-975,Jun.2012

[3] Dr.S.R.Paranjothi and A.Selvaraj “Voltage Sag Mitigation onFig.-15 Three phase fault with DVR with a 3 phase fault ASD”, Proc.IJEST,vol.3,no.02,ISSN:0975-5462,Feb.2011

[4] R Chiumeo and C Gandolfi, “Simulations of a possibleconfiguration of Premium Power Park”, International Conferenceon Renewable Energies and Power Quality (ICREPQ’10) Granada(Spain), 23-25th March, 2010.