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CONTROL OF MULTI-CONVERTER UNIFIED POWER QUALITY CONDITIONER TO IMPROVE POWER QUALITY IN THE POWER SYSTEMS

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***Abstract*- Power quality became a major concern in power system due to increase use of power electronics devices.so in order to meet power quality standard limits to include some sort of compensation like voltage,current interfections.Improve the power quality FACTS devices is also used.Specifically, MC-UPQC is a FACTS device which is combination of one shunt voltage source converter and two or more series voltage source converters, connected back to back on the dc side and shares common dc link.Voltage and current defficiency like (harmonic,sag,and swell),is main feeder and full compensation of supply voltage deficiency(harmonics,sag, swell and interruption) on other feeder by MC-UPQC only.MC-UPQC performance as well as adopted control algorithm is illustrated by simulation.Due to implementation of this algorithm there is improvement in power quality.**

***Index Terms*- Power quality (PQ).MATLAB,Multi converter unified power quality conditioner (MC-UPQC),Voltage source inverter (VSC)**

I. INTRODUCTION

Along with the rapid development of technology and national economy, the demands of electric energy largely increase; correspondingly the power quality becomes more and more important. Power quality issues have become a serious concern by both electric industry and consumers. Power quality problems can be defined as:Any power problem that results in failure or misoperation of customer equipment manifests itself as an economic burden to the user, or produces negative impacts on the environment.'[1]- [2]The basic problems of power quality [1] are as follows:

• Power Factor

• Harmonic Distortion

• Voltage Transients

• Voltage Sags or Dips

• Voltage Swells

The AC and DC variable speed drives utilized in industries are significant contributors to total harmonic current and voltage distortion. [2].The fifth harmonic voltage distortion causes serious problems in three phase motors as it a negative harmonic. When applied to induction motor it produces negative torque [2]. The seventh harmonic creates a rotating field beyond the motors synchronous speed. The resulting torque pulsations cause wear and tear on coupling and bearings [3]. Another major power quality issue is voltage sag which is caused due to abruptincrease in the loads such as motor starting [4].Voltage sag when last longer than a cycle, many AC contactors will fall out disconnecting the motor from the supply. Another aspect of power quality issue is voltage swell. This is caused due to line to ground faults making the unfaulted phases to depend on the zero sequence impedance [5].

The provision of both DSTATCOM and DVR can control the power quality of the source current and the load bus voltage. The primary function of the DVR is to rapidly boost up the load side voltage in the event of a disturbance in order to avoid any power disruption tothat load [6] where as the DSTATCOM can compensate for distortions and unbalance in a load such that a balanced sinusoidal current flows through the feeder [7]. DSTATCOM can also regulate the voltage of a distribution bus [8]. A combination of DVR and DSTATCOM is termed as Unified Power Quality Conditioner (UPQC).An extensive study has been made and results have in obtained using PSCAD/EMTDC software in reference [9].

II. BACKGROUND SURVEY

A. UPQC TOPOLOGY AND POWER FLOW STRATEGY

A UPQC consists of voltage source inverters connected in cascade as shown in Fig. 1. Inverter 1 (Series Inverter SE) is connected in series with the incoming utility supply through a low pass filter and a voltage injecting transformer. Inverter 2 (Shunt Inverter SH) is connected in parallel with the sensitive load, whose power quality needs to be strictly maintained. The main purpose of SH is to provide required VAR support to the load, and tosuppress the load current harmonics from flowing towards the utility and it is operated in current controlled mode. SE is responsible for compensating the deficiency in voltage quality of the incoming supply, such that the load end voltage remains insensitive to the variation of utility supply.

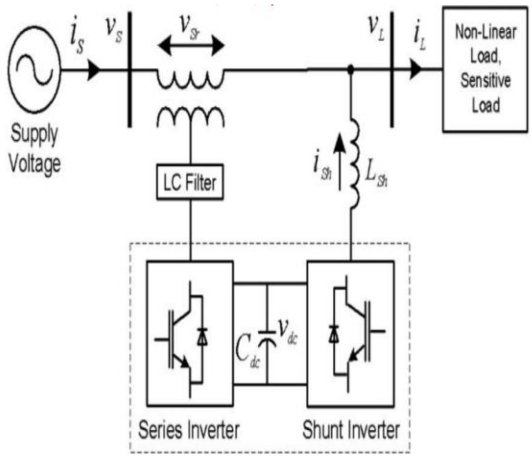

Fig. 1 UPQC General block diagram representation

The major types of power quality problems are: Interruption, Voltage-sag, Voltage-swell, Distortion, and Harmonics.

An interruption is defined (Fig 2) as complete loss of supply voltage or load current. Interruptions can be the result of power system faults, equipment failures, and control malfunction. Voltage sags (dips) are short-duration reductions in rms voltage caused by short-duration increases of the current.

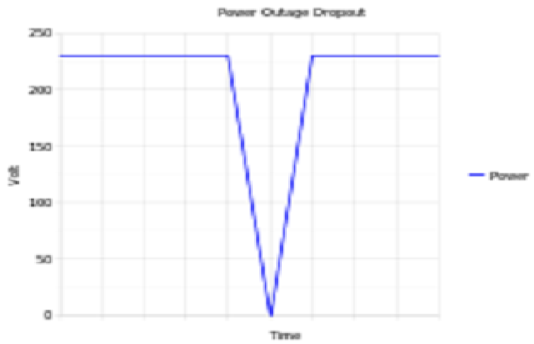

Fig 2 : Power Interruption

Voltage sags are usually associated with system faults but can also caused by energisation of heavy loads at starting of large motors (Fig 3).

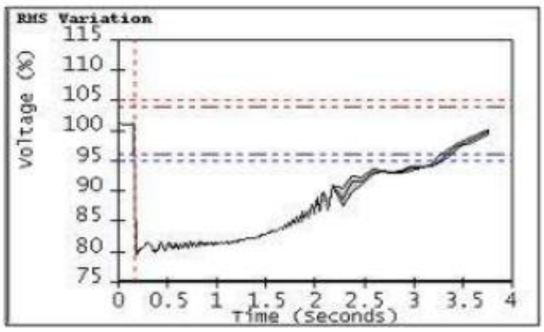

Fig 3: Voltage Sag

Voltage swell is an rms increase in the ac voltage, at the power frequency, for duration from a half cycle to a few seconds. As shown in Fig 4.,Voltage can rise above normal level for several cycles to seconds. Voltage swells will normally cause damage to lighting, motor and electronic loads and will also cause shutdown to equipment.

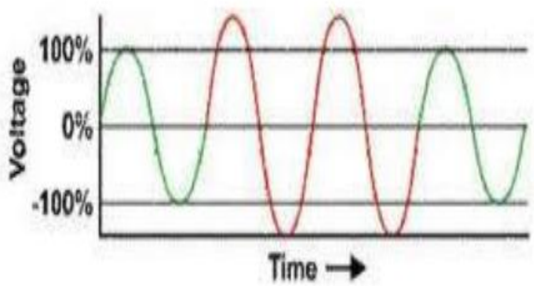

Fig 4: Voltage Swells

III. PROPOSED SYSTEM COFIGURATION

As shown in this Figure 5, two feeders connected to two different substations, supply the loads L1 and L2. The MC-UPQC is connected to two buses BUS1 and BUS2 with voltages of

Ut1and Ut2, respectively. It consists of three VSCs (VSC1, VSC2, and VSC3) which are connected back to back through a common DC-link capacitor.

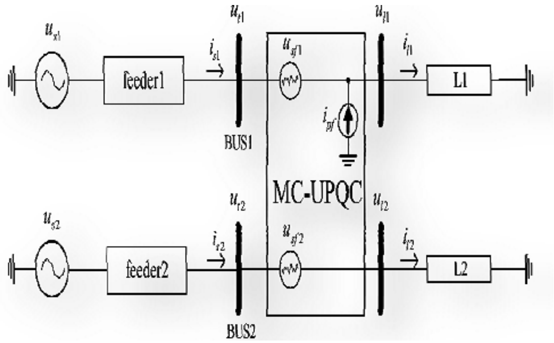

Fig.5. Single-Line Diagram of a Distribution System with an MC-UPQC.

The aims of the MC-UPQC are:

A. To regulate the load voltage (ul1) against sag/swell and distortions in the system to protect the NonLinear/sensitive load L1 i.e. the three phase induction motor.

B. To regulate the load voltage (ul2) against sag/swell and distortions in the system caused due to upstream fault on feeder2 to protect the sensitive / critical load L2.

C.To compensate for the reactive and harmonic components of nonlinear load current (il1) as shown in fig .6.

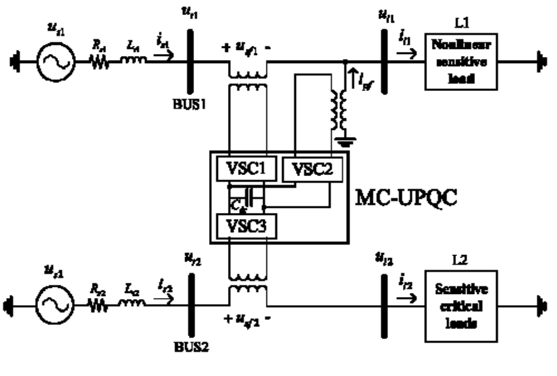

Fig.6: Typical MC-UPQC used in a distribution system.

The load L1 is a three phase induction motor which needs a pure sinusoidal voltage for proper operation while its current is non-sinusoidal and contains harmonics. The load L2 is a sensitive/critical load which needs a purely sinusoidal voltage and must be fully protected against distortion, sag/swell and interruption. These types of loads include production industries and critical service providers, such as medical centres, airports, or broadcasting centres where voltage interruption can result in severe economic losses or human damages.

Four cases have been taken up to analyses the performance of UPQC.1. Sag/swell and distortion on the bus voltage infeeder-1.
2. Upstream fault on feeder 2
3. Load change
4. Current compensation in feeder-1

A. Series VSCs:

The function of series VSC is to mitigate voltage sag and swell, voltage harmonics and current compensation during interruption. The control algorithm used is based on d-q method. The control block of series VSC is shown in fig.7. It consists of abs to dq0 transformation block which computes the three phase quantities to the direct axes, quadrature axes and zero sequence voltages, in the rotating reference frame using Park's Transformation.

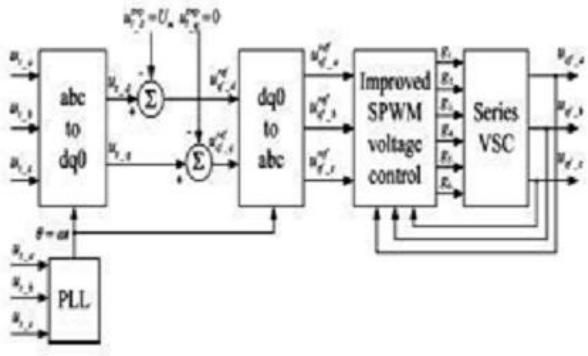

Fig.7 Control block of series VSC

The controlling is based on comparison of a voltage reference and measured terminal voltage ***ut-abc***. The PLL block is used to synchronies three phase terminal voltages on a set of frequency. The resultant signals are again transformed back to three phase quantities. This will be a victories signal consisting of three phase sinusoidal quantities. These are given to the PWMgenerator which generates pulses for the converter. The converter produces the three phase voltage signals***usf-abc*** which is free from distortions and is fed to then on-linear load.

B. Shunt VSC:

The function of shunt VSC is to compensate for their active and the harmonic components of the load currents of non-linear load shown in fig.8. It should also regulate the voltage of common DC-link capacitor. Here the three phase load currents are converted to dq0 quantities and harmonics are eliminated to obtain three phase victories currents.

These currents are used as carrier signals in the PWM hysteresis current control method to generate pulses for the shunt converter which produces distortions less currents for the load. PI controller is used maintain the DC-link voltage at the reference value ***udc-ref***.

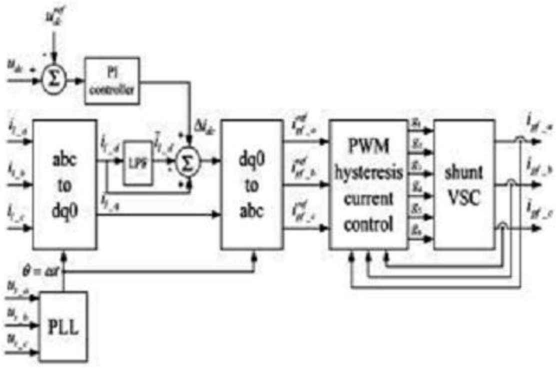

Fig.8 Control block of shunt VSC

C. Induction Motor Load:

Induction motor finds application in production industries. It requires pure sinusoidal AC supply for proper operation and for a larger lifetime. The fifth harmonic voltage distortion causes serious problems in three phase motors as it a negative harmonic. It produces negative torque which attempts to drive the motor in a reverse direction and slows it rotation. Motor draws more current to offset the reverse torque and regain its normal operating speed. This results in over current in the motor. The seventh harmonic creates a rotating field beyond the motors synchronous speed. The UPQC presented in this paper is capable of providing distortion less three phase input to the induction motor

IV. SIMULATION RESULTS

The simulation block for UPQC is shown in fig4. The simulation results obtained in MATLAB/SIMULATION show the effectiveness of the system. Fig.9 The simulation block of UPQC

A. SAG/SWELL AND DISTORTION ON THE BUS VOLTAGE IN FEEDER-1

Let us consider that the power system in Fig. 6 consists of two three-phase three-wire 380(v) (RMS, LL), 50-Hz utilities.

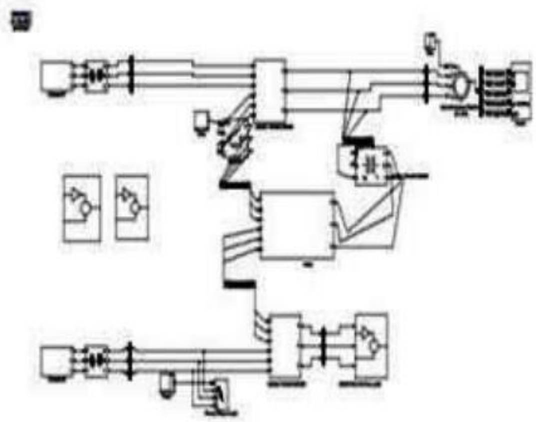

Fig. 9 The simulation block of UPQ**C**

The BUS1 voltage (ut1) contains the seventh-order harmonic with a value of 22%, and theBUS2 voltage (ut2) contains the fifth order harmonic with a value of 35%. The BUS1 voltage contains 25%sag between 0.1s<t<0.2s and 20% swell between0.2s<t<0.3s. The BUS2 voltage contains 35% sag between 0.15s<t<0.25s and 30% swell between0.25s<t<0.3s.

The load L1 is a three-phase Induction motor load with configuration mechanical input torque (Tm), Squirrel-cage rotor type with a reference frame and the machine ratings of nominal power 50H.P, 400V line voltage with frequency 50HZ. The critical load L2contains a balanced RL load of 10Ω and 100mH. The MC–UPQC is switched on at t=0.02s.The simulink model for distribution system with MC-UPQC is shown in figure 4. The BUS1 voltage, the corresponding compensation voltage injected byVSC1, and finally load L1 voltage is shown in Figure 10.

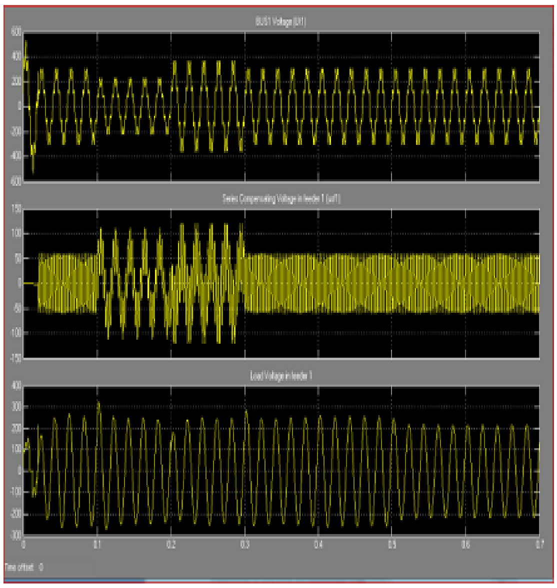

Fig 10 . Simulation Result for BUS1 voltage, series compensating voltage, and load voltage in Feeder1.

Similarly, the BUS2 voltage, the corresponding compensation voltage injected by VSC3, and finally the load L2 voltage are shown in figure 11.

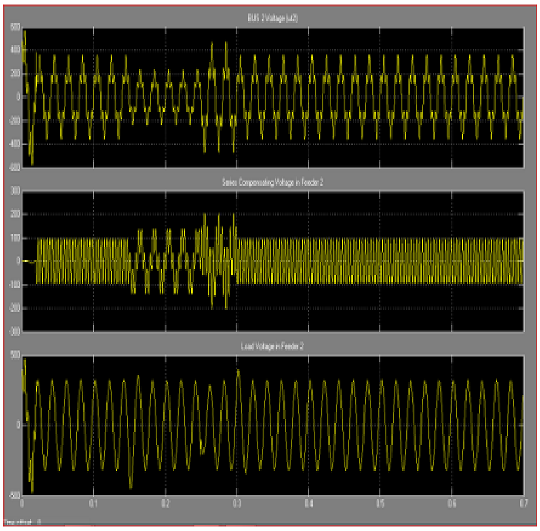

Fig 11. Simulation Result for BUS2 voltage, series compensating voltage, load voltage in Feeder 2.

Also, the DC voltage regulation loop has functioned properly under all disturbances, such as sag/swell in both feeders.

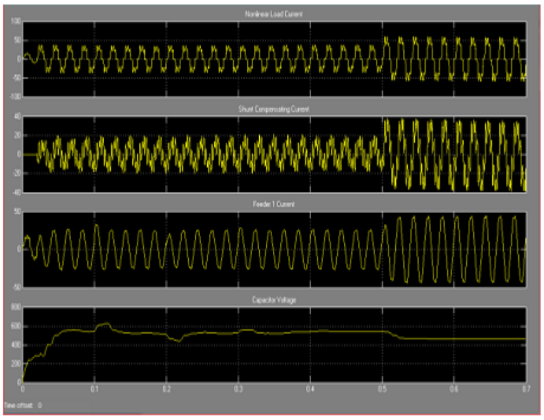

Fig 12 .Simulation Result for Nonlinear load current, compensating current, Feeder1 current, and capacitor voltage.

B. UPSTREAM FAULT ON FEEDER2

When a fault occurs in Feeder2 (in any form of L-G, L-L-G, and L-L-L-G faults), the voltage across the sensitive/critical load L2 is involved in sag/swell or interruption. This voltage imperfection can be compensated for by VSC2. In this case, the power required by load L2 is supplied through VSC2 and VSC3. This implies that the power semiconductor switches of VSC2 and VSC3 must be rated such that total power transfer is possible. The performance of the MC-UPQC under a fault condition on Feeder2 is tested by applying a three- phase fault to ground on Feeder2 between 0.3s<t<0.4 s. Simulation results are shown in Fig.13.

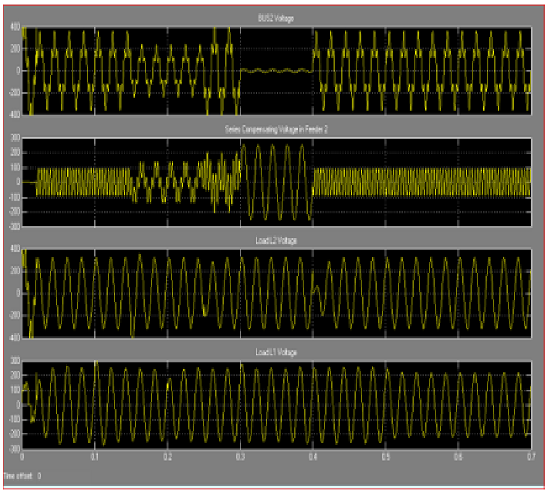

Fig 13 .simulation results for an upstream fault on Feeder2: BUS2 voltage, compensating voltage, and loads L1 and L2 voltages.

C. LOAD CHANGE

To evaluate the system behavior during a load change, the nonlinear load L1 is doubled by reducing its resistance to half at 0.5 s. The other load, however, is kept unchanged. In this case load current and source currents are suddenly increased to double and produce distorted load voltages (Ul1 and Ul2) as shown in Fig 14 .

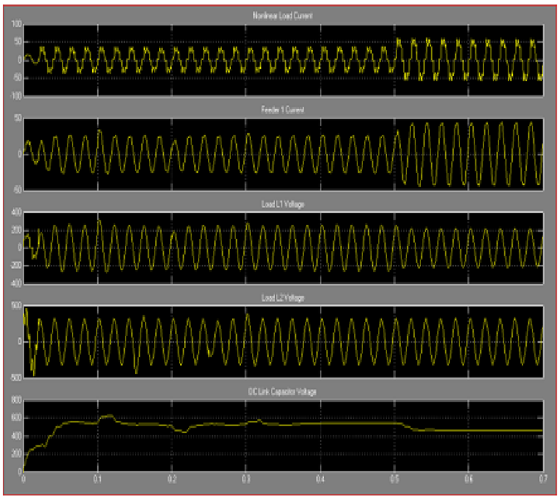

Fig 14 .Simulation results for load change: nonlinear load current, Feeder1 current, load L1 voltage, load L2 voltage, and dc-link capacitor voltage

V. CONCLUSION

The present topology illustrates the operation and control of Multi Converter Unified Power Quality Conditioner (MC-UPQC). The system is extended by adding a series VSC in an adjacent feeder.The device voltage deficiency(harmonics,sag, swell and interruption) on other feeder by MC-UPQC only.MC-UPQC performance as well as adopted control algorithm is illustrated by simulation.

REFERENCES

[1] Flory, J.E.; Key, T.S.; Smith, W.M.; Statford, R.P.; Smith, J.C.; Clemmensen, J.M.; Saunders, L.F.; Potts, C.D.; Emmett, G.L.; Moncrief, W.A.; Singletary, The Electric utility-industrial user partnership in Solving Power quality problems." Power Systems, IEEETransactionsVolume: 5, Issue: 3 page(s): 878- 886

[2] Electricity Distribution, 2001. Part 1Contributions.CIRED. 16th International Conference and Exhibition on (IEE Conf. Publ No.482) Date of Conference: 2001 Author(s): El Mofty, Alexandria Electr. Co. Youssef, K. Volume: 2.

[3] Power System Technology, 2002. Proceedings.Power Con 2002. International Conference Date of Conference: 2002 Author(s): Lumyong, P. Dept.of Electr. Eng., King Mongkut's Inst. ofTechnol.,Bangkok, Thailand Chatuthai CVolume :2Page(s) : 1190 - 1194 vol.2

[4] Electrical Insulation, 2004 conference record of the 2004 IEEE International Symposium Conference: 19, 22 sept. 2004 Author(s): Siddique, Indian Inst.of Technol., New Delhi, India. Yadava,G.S.; Singh.B, page(s):26-29

[5] "Working group, Recommended Practice forMonitoring Quality, IEEE Std, 1995, pp.1159-1995[6] Performance Of DVR Under Different Voltage Sag& Swell Conditions" APRN Journal of engineering & applied sciences VOL 5, NO.10, OCT 2010

[7] F.Z.Peng & J.S.Lai, "Generalized Instantaneous Reactive Power Theory for Three Phase Power System", IEEE TRANS.INSTRUM.MEAS., VOL. 45, NO.1 PP. 293-297, FEB.1996.

[8] G.Ledwich and A.Ghosh, "A Flexible DSTATCOMOperating Voltage and Current Control Mode" Proc.Inst.Elect. Eng., Gen., Transm. Distrib. Vol. 149 , No. 2, Pp.215-224, 2002

[9] Hamid Reza Mohammadi, Ali Yazdian Varjani, and Hossein Mokhtari, "Multiconverter Unified PowerQuality Conditioning System: MC-UPQC"IEEE Transactions on Power Delivery, Vol.24, No.3, July2009.

[10] V. Khadkikar, A. Chandra, A. O. Barry and T. D. Nguyen "Application of UPQC to Protect a Sensitive Load on a Polluted Distribution Network" IEEE, Power Engineering Society General Meeting, 2/06/2006

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