Simulation of D-STATCOM and DVR for Power Quality Enhancement in Distribution Network under Various Faults Conditions

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Abstract— The concept of Flexible Alternating Current Transmission Systems (FACTs) and Custom Power has been researched extensively by researchers throughout the world and the studies suggest out that power quality is widely studied by the researchers. On the whole FACTs uses Power electronic devices and methods to control the high voltage side of the network for improving the flow of power. Custom Power Devices are mainly for low-voltage distribution, and improving poor quality of power and reliability of supply affecting entities such as factories, offices and homes. The quality of Power and Reliability are becoming important issues for critical and sensitive loads. DSTATCOM is mainly used to mitigate different faults such as Single Line to Ground (SLG) fault and Double Phase to Ground (LLG) fault and three-phase fault (LLLG). The fast Response of DSTATCOM makes it the efficient solution for enhancing the power quality of the distribution system.

Key words: D-STATCOM, Power Quality Enhancement, Distribution Network

I. INTRODUCTION

Power quality improvement has always been the main concern of the power engineers and in the recent year with the increased usage of the digital equipments the power quality has brought the power quality improvement to a centre stage. In the present times almost all the industries use electronic controllers which are extremely sensitive to the quality of the power to be used. A minor variation would also lead to serious aberration and may cause the system to fail.

Much of this modern load equipment itself uses electronic switching devices which then can contribute to poor network voltage quality. The beginning of competition into electrical energy supply has created greater commercial awareness of the issues of power quality while equipment is now readily available to measure the quality of the voltage Waveform and so quantify the problem.

Along with advancement in technology, the worldwide economy organization has evolved towards globalization and the profit margins of many activities tend to decrease. The increased sensitivity of the vast majority of processes like (industrial, services and even residential) to PQ problems turns the availability of electric power with quality a crucial factor for competitiveness in every sector of activity. The nonstop process industry and the information technology services are most significant area. In a event of even a minor disturbance the results would lead to a huge amount of financial loss and consequent loss of productivity and competitiveness.

II. TEST SYSTEM

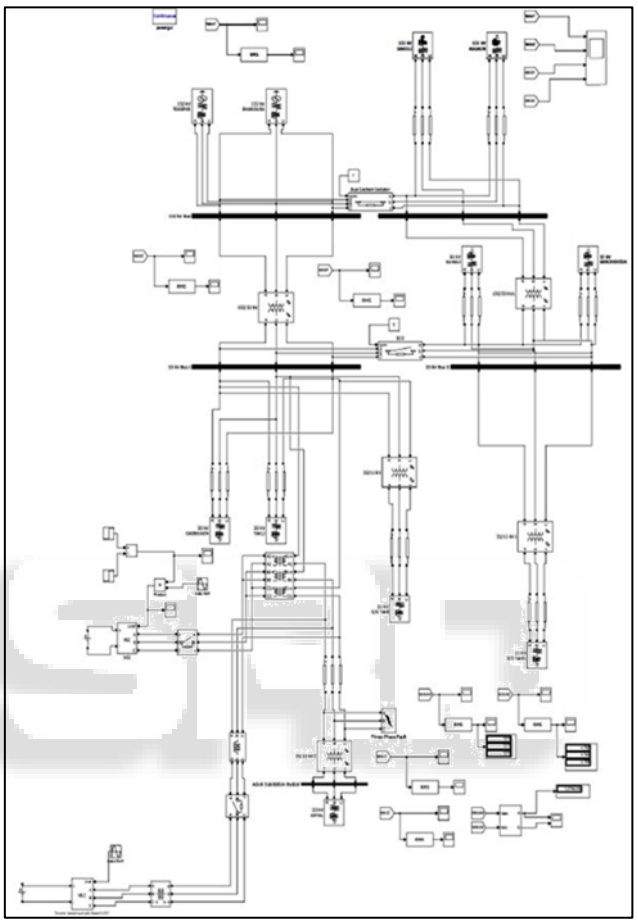

Fig. 1: System with DSTATCOM and DVR

In this system both DSTATCOM and DVR is connected. And simulation results on power devices and without power devices are shown here.

III. RESULT ANALYSIS OF TEST SYSTEM

A. Result Analysis for LG Fault

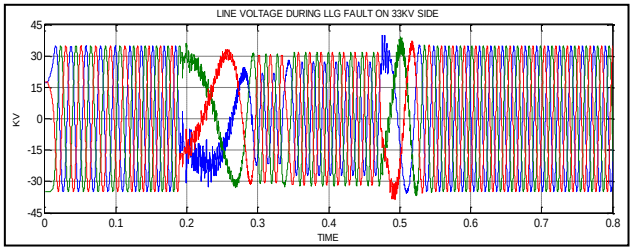

Fig. 2: Line Voltage of System during LLG Fault on 33kv Side with DSTATCOM

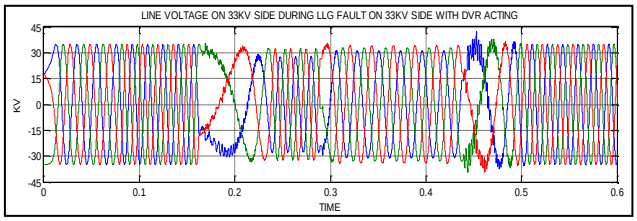

Fig. 3: Line Voltage of System during LLG Fault on 33kv Side with DVR

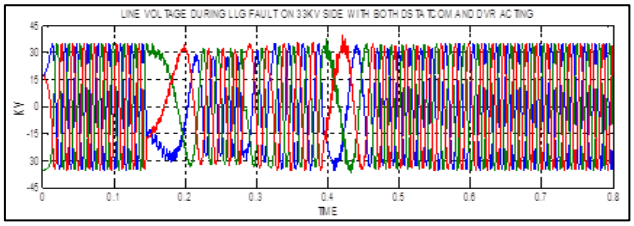

Fig. 4: Line Voltage of System during LLG Fault on 33kv Side with both DSTATCOM and DVR

From the above all four figures, from 2 to 4 represent the system with LLG fault and respective voltage level during fault conditions. In all the results fault time is constant that is from 0.2 to 0.5. During LLG fault voltage of all the one phase gets reduced more compared to other two phases. There is voltage sag during 0.2 to 0.5 for without power devices.

In fig 2, DSTATCOM is acting between 0.3 to 0.5, during that timing voltage of system get improved but not totally maintain up to line voltage.

In fig 3, DVR is acting between 0.3 to 0.5, during that timing voltage of system get improved but not totally maintain up to line voltage.

In fig 4, both DSTATCOM and DVR are acting. DVR is acting between 0.3 to 0.5, and DSTATCOM is acting between 0.4 to 0.5. Timing of 0.4 to 0.5 is the schedule in which both the devices are in acting condition system voltage get approximately equal to line voltage. Since it is LLG fault conditions, hence all the three phase voltages gets improves simultaneously. Hence from whole diagrams' it can be clear that voltage of the system gets totally compensated when both the devices are acting in the system.

B. Result Analysis for Current Compensation during LLG Fault

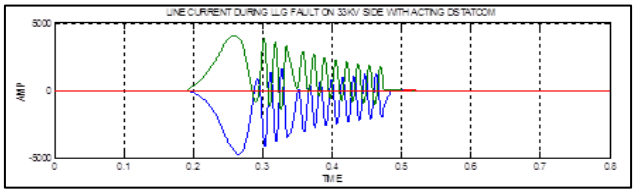

Fig. 5: Line Current of System during LLG Fault on 33KV Side with DSATATCOM

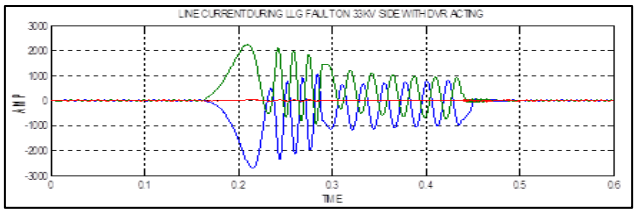

Fig. 6: Line Current of System during LLG Fault on 33KV Side with DVR

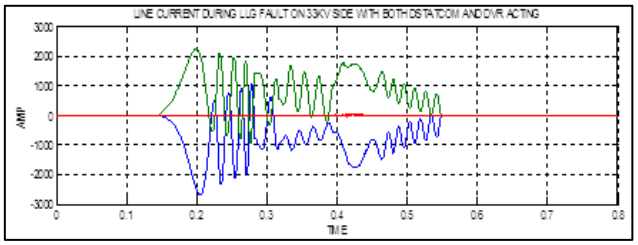

Fig. 7: Line Current of System during LLG Fault on 33KV Side with both DSTATCOM and DVR

From the above all four figures, from 5 to 7 represent the system with LLG fault and respective voltage level during fault conditions. In all the results fault time is constant that is from 0.2 to 0.5. During LLG fault voltage of all the one phase gets reduced more compared to other two phases. There is voltage sag during 0.2 to 0.5 for without power devices.

In fig 5, DSTATCOM is acting between 0.3 to 0.5, during that timing current of system get reduced but not totally maintain up to line current.

In fig 6, DVR is acting between 0.3 to 0.5, during that timing current of system get improved but not totally maintain up to line current.

In fig 7, both DSTATCOM and DVR are acting. DVR is acting between 0.3 to 0.5, and DSTATCOM is acting between 0.4 to 0.5. Timing of 0.4 to 0.5 is the schedule in which both the devices are in acting condition system current get not near to line current. Since it is LLG fault conditions, hence faulted phase current gets reduced.

C. Result Analysis for Voltage Compensation during LLLG Fault

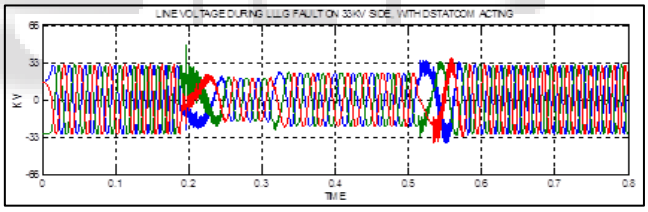

Fig. 8: Line Voltage of System during LLLG Fault on 33kv Side with DSTATCOM

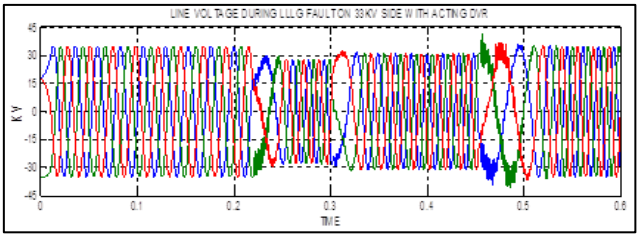

Fig. 9: Line Voltage of System during LLLG Fault on 33kv Side with acting DVR

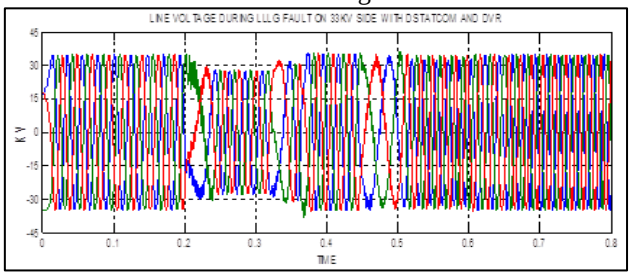

Fig. 10 Line Voltages during LLLG Fault on 33kv Side with DSTACOM and DVR

From the above all four figures, from 8 to 10 represent the system with LLLG fault and respective voltage level during fault conditions. In all the results fault time is constant that is from 0.2 to 0.5. During LLLG fault voltage of all the three phases gets reduced. There is voltage sag during 0.2 to 0.5 for without power devices.

In fig 8, DSTATCOM is acting between 0.3 to 0.5, during that timing voltage of system get improved but not totally maintain up to line voltage.

In fig 9, DVR is acting between 0.3 to 0.5, during that timing voltage of system get improved but not totally maintain up to line voltage.

In fig 10, both DSTATCOM and DVR are acting. DVR is acting between 0.3 to 0.5, and DSTATCOM is acting between 0.4 to 0.5. Timing of 0.4 to 0.5 is the schedule in which both the devices are in acting condition system voltage get approximately equal to line voltage. Since it is LLLG fault conditions, hence all the three phase voltages gets improves simultaneously. Hence from whole diagrams' it can be clear that voltage of the system gets totally compensated when both the devices are acting in the system.

D. Result Analysis for Current Compensation during LLLG Fault

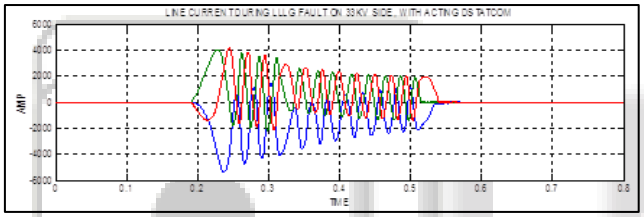

Fig. 11: Line Current of System during LLLG Fault on 33kv Side with DDSTATCOM

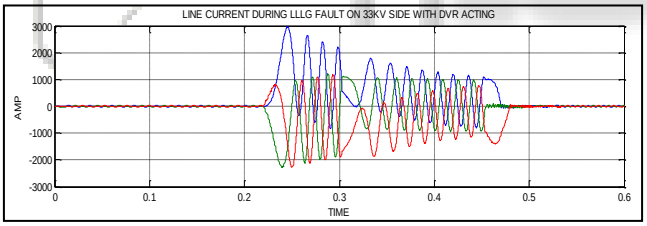

Fig. 12: Line Current of System during LLLG Fault on 33kv Side with DVR

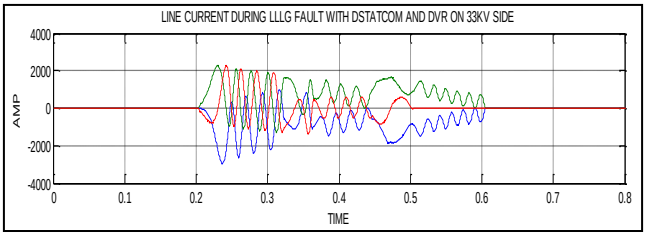

Fig. 13: Line Current of System during LLLG Fault on 33kv Side with DSTATCOM and DVR

From the above all four figures, from 11 to 13 represent the system with LLLG fault and respective voltage level during fault conditions. In all the results fault time is constant that is from 0.2 to 0.5. During LLLG fault voltage of all the one phase gets reduced more compared to other two phases. There is voltage sag during 0.2 to 0.5 for without power devices.

In fig 11, DSTATCOM is acting between 0.3 to 0.5, during that timing current of system get reduced but not totally maintain up to line current.

In fig 12, DVR is acting between 0.3 to 0.5, during that timing current of system get improved but not totally maintain up to line current.

In fig 13, both DSTATCOM and DVR are acting. DVR is acting between 0.3 to 0.5, and DSTATCOM is acting between 0.4 to 0.5. Timing of 0.4 to 0.5 is the schedule in which both the devices are in acting condition system current get not near to line current. Since it is LLLG fault conditions, hence faulted phase current gets reduced.

IV. LOAD CONDITION

Three Phase RLC Series load
ACTIVE POWER=0.6875MW=687.7KW
REACTIVE POWER=0.2489VAr=248.9VAr

Sr. No	Faults Condition	Normal cndition voltage(KV)	System Voltage During Fault Condition(KV)	Voltage Compensation During Fault Condition (KV)
1	LLG	33	22.5	Approx. 33kv
2	LLLG	33	18	Approx. 33kv

Table 1: Voltage Compensation when both Devices Act

Sr. No	Faults condition	Normal cndition current(AMP)	System Current During Fault Condition(A)	Current Compensation During Fault Condition (A)
1	LLG Fault	16.8	Up to 2700A	UP TO 2000A
2	LLLG Fault	16.8	Up to 3000A	UP TO 2200A

Table 2: Current Reduction when both Devices act

Line voltage on 33kv side	33KV
Line current on 33kv side	11.9A (approx. 12A)
Load in MW handled(ACTIVE POWER)	0.68MW
REACTIVE POWER	0.2489MVAr
Load in MVA handled	0.724121MVA
Power Factor	0.93
Line voltage on 11kv side	11KV

Table 3: Data of Adyad Substation
Date: 16 May, 2017

Breaker resistance Ron (Ohm)	0.001
Snubber resistance Rs (Ohm)	1×10^{6}
Snubber capacitance Cs (F)	Infinite

Table 4: Three Phase Breaker

Nominal power and frequency [Pn(VA) , fn(Hz)]	[5×10^{6} , 50]
Winding-1 Connection	Yg Grounded
Winding-1 Connection	Yg Grounded
Winding 1 parameters [V1 Ph-	[33×10^{3} , 0.002

Ph(Vrms), R1(pu), L1(pu)]	, 0.08]
Winding 2 parameters [V2 Ph-Ph(Vrms), R2(pu), L2(pu)]	[11×10^3 , 0.002 , 0.08]
Magnetization resistance Rm (pu)	500
Magnetization inductance Lm (pu)	500

Table 5: 33/11KV Transformer

Configuration	Yg
Nominal phase-to-phase voltage Vn	11kv
Nominal frequency fn (Hz)	50
Active power P (W)	0.6875×10^6
Inductive reactive power QL (positive var)	0.2489×10^6
Capacitive reactive power Qc (negative var)	0
Load type	Constant Z

Table 6: Three Phase Series RLC Load (ADYAD)

Winding 1 connection (ABC terminals)	Yg Grounded
Winding 2 connection (abc terminals)	Yg Grounded
Nominal power and frequency [Pn(VA) , fn(Hz)]	[50×10^6 , 50]
Winding 1 parameters [V1 Ph-Ph(Vrms) , R1(pu) , L1(pu)]	[132×10^3, 0.002 , 0.08]
Winding 2 parameters [V2 Ph-Ph(Vrms) , R2(pu) , L2(pu)]	[33×10^3 , 0.002 , 0.08]
Magnetization resistance Rm (pu)	500
Magnetization inductance Lm (pu)	500

Table 7: Three Phase Transformer (Two Winding)

Sr. No	Faults Condition	System normal voltage (KV)	System Voltage During Fault Condition(KV)	Voltage Compensation During Fault Condition (KV)
1	LLG	33	22.5	6.5KV (22.5+6.5=29KV)
2	LLLG	33	18	8.25KV (18+8.25=24.75KV)

Table 8: Voltage Compensation During Different Fault Condition with DSTATCOM

Sr. No	Faults condition	System Current During Normal Condition(A)	System Current During Fault Condition(A)	Voltage Compensation During Fault Condition (A)
2	LLG Fault	16.8	1200-4000A	UPTO 2500A reduced from fault current
3	LLLG Fault	16.8	1500-5600A	UPTO 3200A reduced from fault current

Table 9: Current Reduction during Different Fault Condition with DSTATCOM

V. CONCLUSION

It can be clear that from the above tables 1 and 2. When both devices are act approximate total faulted voltage gets compensated. Table 3, shows data of adyad Substation which it is used in project. Table 4 to table 7, shows parameters of substation. Table 8. And table 9. Shows voltage compensation and current reduction respectively during LLG and LLLG fault conditions by using DSTATCOM. full compensation can be obtained by using only both the devices like DSATATCOM and DVR. DSTATCOM and DVR are playing vital role for compensation.

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