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Power Quality Improvement by D-STATCOM in Distribution under Various Fault Conditions

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ABSTRACT
Now A Day, Power Quality Is Important Factor In Electrical Power. We Used Different Type Of Electronic Device For Power Quality Improvement Means Improvement Of Voltage Sag /Dips, Fluctuation Of Current And Harmonic.For Improvement Of Power Quality We Used Different Type Of Shunt Compensating Power Electronics Device (I.E D-STATCOM).D-STATCOM Generally Connected At Common Coupling Point (PCC) For Overcome PQ Type Problem, D-STATCOM Is Used In Different Type Of Fault,(Such As Single Line To Ground Fault (SLG), Line To Line Fault (LL),Double Line To Ground Fault (DLG),Three Phase Fault (LLL),Three Phase To Ground Fault (LLLG).We Also Know, Operating Time Period Of D-STATCOM Is Very Small So It Is Most Efficient Shunt Connected Device.D-STATCOM Contain Different Type Of Controller For Control The Operation In Such A Way That Overall Power Quality Of System Improved.In This Paper We Design And Simulate The D-STATCOM With PI Controller For Power Quality Improvement Under Different Fault Condition.
Keywords-D-STATCOM,LCL Passive Filter,Power Quality, Total Harmonic Distortion(THD), Vsc, Voltage Sag, Voltage Dip.

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I. INTRODUCTION

Now A Day Distribution System Suffering From Poor Power Quality Problem Such As Poor Power Factor ,Unbalanced Loading Of Three Phase System, Voltage Drop And Total Harmonic Distribution . The Cause Of Poor Power Quality Is Reactive Power Mismatching And Nonlinear Load (Like Induction Motor, Adjustable Speed Device (ASD), Power Electronics Device, Variable Frequency Device (VFD)) Used In Distribution System.

Mismatching Of Reactive Power Flow Also Effect The Active Power Flow And Voltage Drop At Load Side[1].Nonlinear Load (Like Motor, Three Phase Generator , Variable Frequency Device ,Power Electronics Device) Inject Harmonic In System So, Distorts The Voltage At Coupling Point And Also Effect The Performance Of Other Load Which Is Connect At Coupling Point.D-STATCOM Is Category Of Custom Power Device For Power Quality Enhancement. Actually , D-STATCOM Improve Voltage Profile By Controlling Reactive Power Flow In To System.Reactive Power Flow Can Be Controlled By Controlling The Firing Angle Of Solid State Switch That Used In Convertor Of D-STATCOM.So By Controlling Switch Of VSC We Can Controlled Reactive Power Flow Of D-STATCOM [9,10].

II. STRUCTURE

D-STATCOM Is Most Usable Shunt Compensating Custom Power Device That Used For Power Quality Improvement. This Device Generally Connected At Load End Where Power Quality Improvement Is Needed.

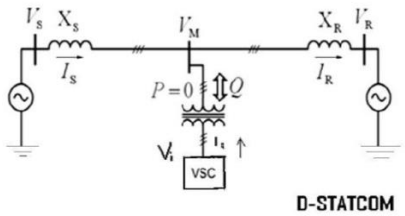

Fig 1 . D-STATCOM Structure.

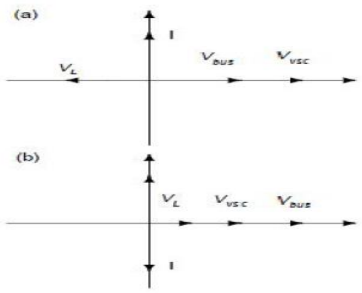

Fig 2. Vector Diagram Of DSTATCOM (A) Capacitive Mode,(B) Inductive Mode.

In The Above Figure 1, We Need Enhanced Voltage Profile At Mid Point Then We Connected D-STATCOM At Mid Point And By Controlling The Magnitude Of The Iqof D-STATCOM, We Can Controlled Voltage Profile At Mid Point . Iqcontrolled By Controlling Output Voltage Of VSC.

Output Voltage Of VSC Can Be Controlled By Controlling Firing Angle Of Switch Of Convertor. So Finally We Can Say That By Controlling The Firing Angle Of Convertor We Can Improve Voltage Profile At Mid Point [2].

From Figure 2 We See That D-STATCOM Can Operate In Two Mode (1). Capacitive Mode (2) Inductive Mode

Under Capacitive Mode D-STATCOM Deliver Reactive Power To The System So It Behave Like Capacitor , This Mode Are Used When Voltage Dip Take Place In System.

Under Inductive Mode D-STATCOM Behave Like Pure Inductor So It Absorb Reactive Power From System , This Method Used When Voltage Swell Occurs In System[3].

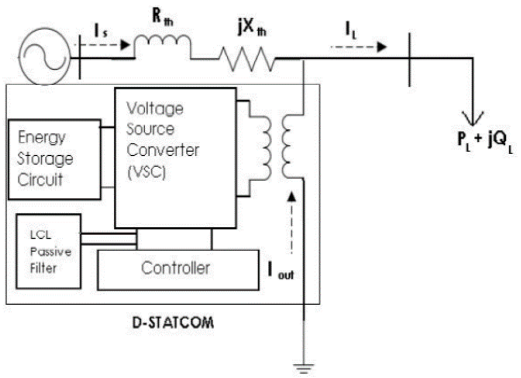

Fig 3 . Block Diagram Of D-STATCOM

III. COMPONENT OF D-STATCOM

A. Voltage Source Invertor (VSC)

Voltage Source Convertor Is Power Electronics Based Device That Connected Either In Series Or Parallel With System .VSC Consist Of Storage Deviceand Power Electronics Switch. Generally Used IGBT As Switch . VSC Used For Generate Sinusoidal Voltage Of Required Magnitude, Phase And Frequency . It Used For Generate Voltage Or Manage The Mismatching Of Voltage At Desired Location.

We Know D-STATCOM Can Deliver Reactive Power To The System Or Absorb Reactive Power From System. When Output Voltage Of VSC Greater Than System Voltage Than It Deliver Reactive Power To The System .Under This Condition It Manage The Voltage Dip Problem [4,5] .

When Output Of VSC Is Less Than System Voltage Than It Absorb Reactive Power From System Under This Condition D-STATCOM Work As Inductor .This Condition Is Generally Used When Voltage Swelling Occur In System .

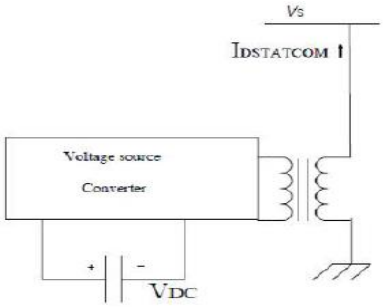

Fig 4 Voltage Source Convertor.

B. COUPLING TRANSFORMER

Coupling Transformer Is Used For Connect D-STATCOM With Distribution Network In Shunt Connected Mode. It Used For Maintain Isolation Between D-STATCOM Circuit And Distribution System.

C. ENERGY STORAGE CIRCUIT.

There Are Different Type Of Energy Storage Device Are Available But Generally Used Dc Source Or Dc Capacitor.

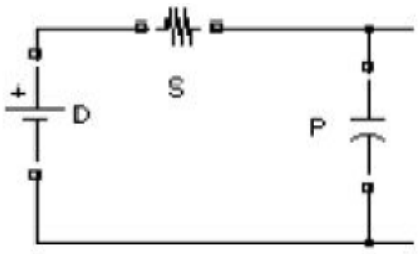

Fig 5 Energy Storage Circuit

Here We See Dc Battery Connected With Capacitor. Capacitor Is Used For Isolate Ripple From Input Of Convertor. Charging Of Battery Take Place When VSC Work Like Convertor And Discharging Of Battery Take Place When VSC Work Like Invertor[11].

D. HARMONIC FILTER

Filter Is Connected At Output Of VSC. Harmonic Filtor Is Used For Filterout The Unwanted Signal At Output Of Convertor. LCL Passive Filter Is Most Effective Filter For Isolate The Harmonic.To Design It, Equation (1), (2) And (3)Are Used[12].

$$L_g = \frac{E_n}{2\sqrt{6} i_{ripm} f_{sw}} \quad (1)$$

$$C_f = \frac{L + L_g}{LL_g(2\pi f_{res})^2} \quad (2)$$

For Most Effective Filter

$$10 f_n \le f_{res} \le 0.5 f_{sw}, \quad (3)$$

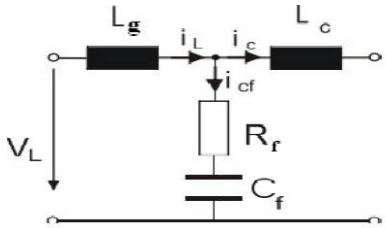

Fig 6. LCL Passive Filter Circuit Diagram.

E. CONTROLLER

Generally Used PI Type Controller Ind-STATCOM. Controller Is Used For Maintain Constant Voltage At Load End Under Different Situation.

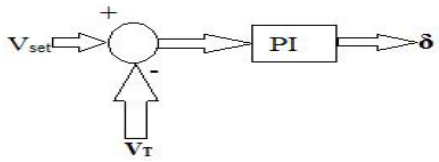

Fig 7 PI Controller

Here Difference Between Reference Voltage And Load End Voltage Is Called Error Signal[7]. This Error Signal Fed Into PI Controller And After Processing It Give Required Anglefor Making Error Is Zero.It Means Load End Voltage Is Equal To Reference Voltage [6,8].

IV. SIMULATION MODEL.

In This Model A Generating Station Is Devided Into Two Parallel Feeder Of 11kv. One Of The Feeder Connected With D-STATCOM And Other Feeder Is Without D-STATCOM. Then We Create Different Type Of Fault For 0.15 To 0.3 Sec In The Following Simulation Model.

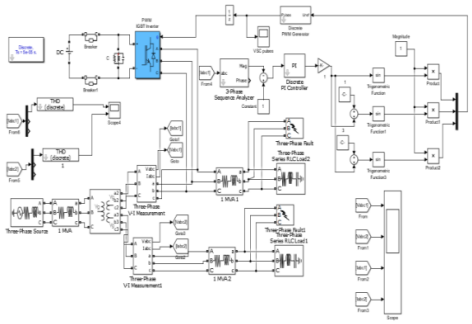

Fig 8. Simulation Model

Single Line Fault Creates On Phase A. Double Line To Ground Fault Create On Phase A And B. Three Phase To Ground Fault Create On All Three Phase.

SIMULATION RESULT.

CASE 1. **Single Line To Ground Fault.**

Sigle Line To Ground Fault Creates On Phase A For Duration 0.15 To 0.30 Sec. Now Compare The Result Without And With Using D-STATCOM.

(a) Load Current

We Know During Short Circuit Fault Current Flow Through Phase Is Very High. Here Fault Create On Phase A So Current Through Phase A Is High During Fault Duration (0.15 To 0.30 Sec).

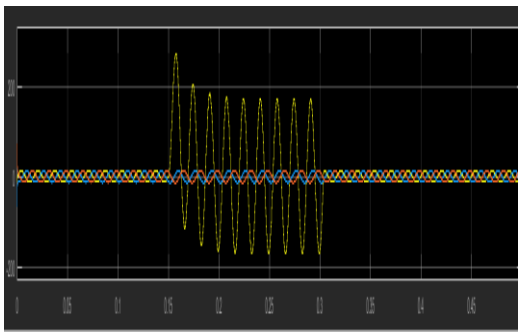

Fig 9 Load Current Without Using D-STATCOM

Then Use D-STATCOM For Compensate High Current Value. After Using D-STATCOM Current In Three Phase Are Balanced.

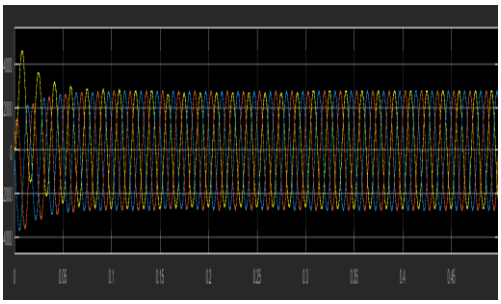

Fig 10. Load Current With Using D-STATCOM

(b) Voltage Waveform.

We Know During Short Circuit Fault Voltage Dip Occure . Here Fault Create In Phase A So Voltage Dip Occure In Phase A During Fault Duration (0.15 To 0.30 Sec).

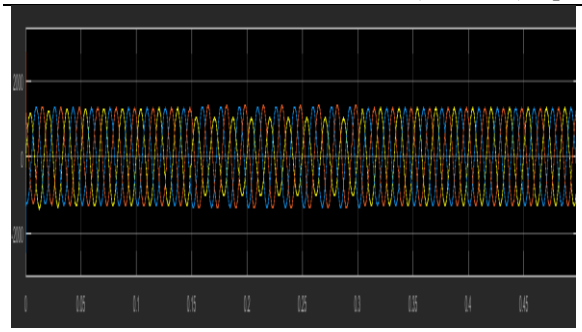

Fig 11 . Voltage Waveform (Without Using D-STATCOM)

For Making Balance Three Phase Voltage Use D-STATCOM. Voltage Waveform After Using D-STATCOM

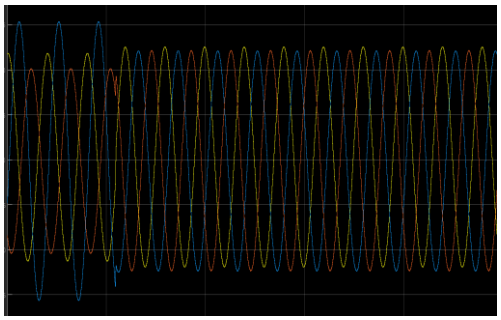

Fig 12. Balanced Three Phase Voltage (With D-STATCOM)

(c) Total Harmonic Distortion

Total Harmonic Distortion Without Using D-STATCOM Is 37.67 % And After Using D-STATCOM Total Harmonic Distortion Is 25.66 % . So After Using D-STATCOM Total Harmonic Distortion Is Reduced.

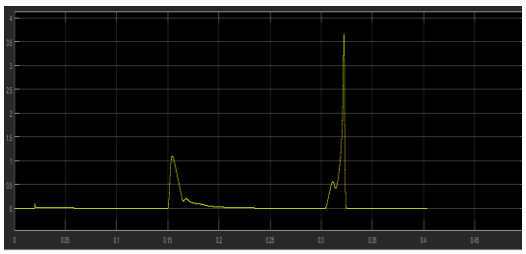

Fig 13. Total Harmonic Distortion (Without D-STATCOM)

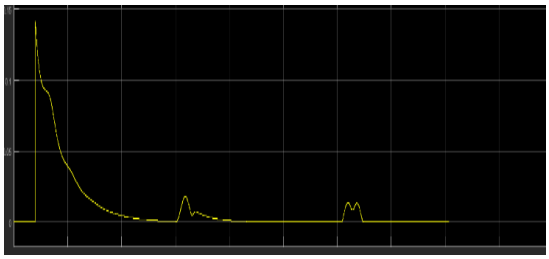

Fig 14. Total Harmonic Distortion (With D-STATCOM).

Case 2**. Double Line To Ground Fault**

In This Case Double Line To Ground Fault Create On Phase A And B For Duration 0.15 To 0.30 Sec. Here We Compare Different Parameter With And Without Using D-STATCOM.

(a) Load Current

We Know During Short Circuit Fault Current Flow Through Phase Is Very High. Here Fault Create On Phase A And B So Current Through Phase A And B Is High During Fault Duration (0.15 To 0.30 Sec).

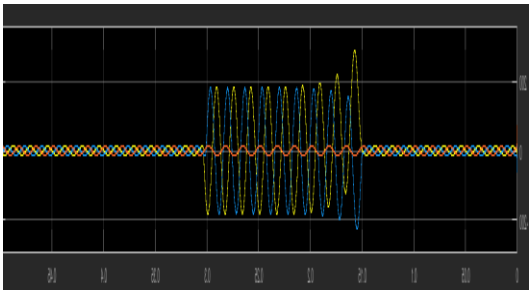

Fig 15 Load Current (Without D-STATCOM)

Now Use D-STATCOM For Compensate This High Phase Current.So After Using We Achieve Balance Three Phase Current.

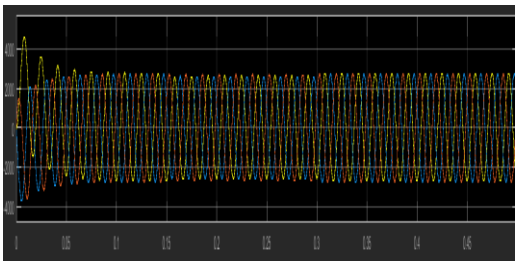

Fig 16 Load Current (With D-STATCOM)

(b) Voltage Waveform.

We Know During Short Circuit Fault Voltage Dip Occur .In This Case Fault Create In Phase A And B. So Voltage Dip Occur In Phase A And B .For Make Healthy We Used D-STATCOM. So After Using D-STATCOM We Get Balanced Three Phase Voltage.

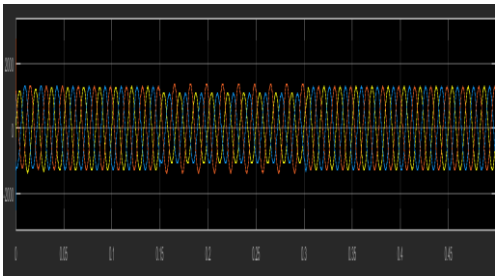

Fig 17 Voltage Waveform (Without D-STATCOM)

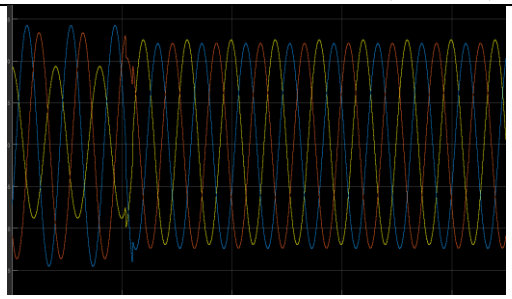

Fig 18 Voltage Waveform (With D-STATCOM)

(c) Total Harmonic Distortion

Total Harmonic Distortion Without Using D-STATCOM Is 37.67% But After Using D-STATCOM Total Harmonic Distortion Is 25.66%. So After Using D-STATCOM Total Harmonic Percentage Is Reduce.

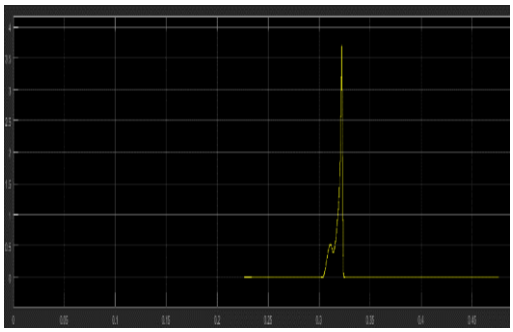

Fig 19. Total Harmonic Distortion (Without Using D-STATCOM)

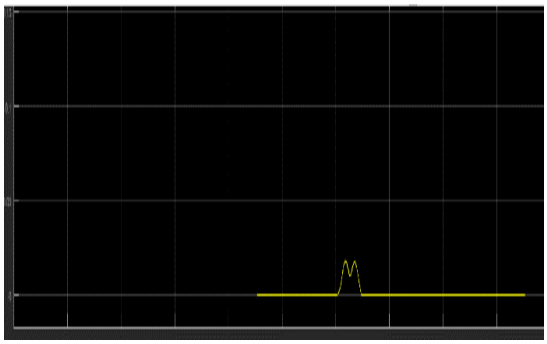

Fig 20. Total Harmonic Distortion (With Using D-STATCOM)

Case 3. **Three Phase To Ground Fault**.

In This Case Fault Create On Three Phase For Duration 0.15 To 0.30 Sec. After Fault Create We Compare Different Parameter With And Without D-STATCOM.

(a) Load Current.

We Know During Short Circuit Fault Current Flow Through Phase Is Very High. Here Fault Create On Phase A ,B And C So Current Through Phase A , B And C Is High During Fault Duration (0.15 To 0.30 Sec).

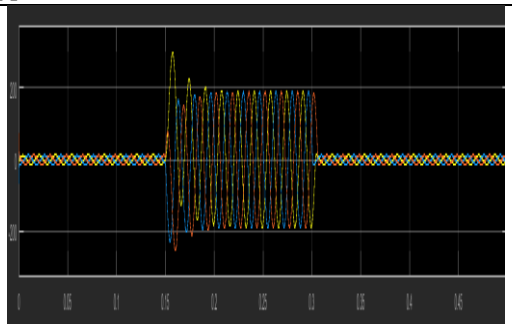

Fig 21. Load Current (Without D-STATCOM)

Now Use D-STATCOM For Compensate This High Phase Current.So After Using We Achieve Balance Three Phase Current.

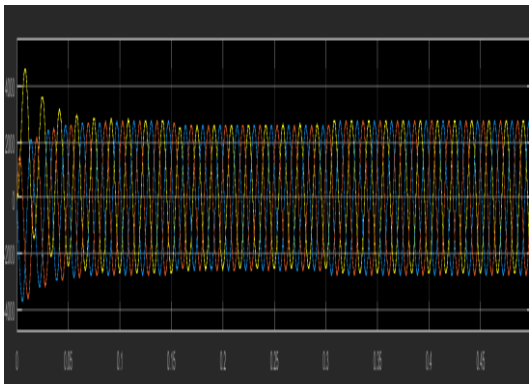

Fig 22 Load Current (With D-STATCOM)

(b) Voltage Waveform.

We Know During Short Circuit Fault Voltage Dip Occur .In This Case Fault Create In Phase A ,B And C. So Voltage Dip Occur In Phase A ,B And C .

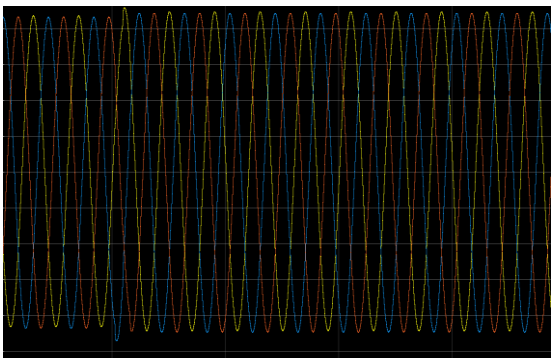

Fig 23 Voltage Waveform (Without D-STATCOM)

For Make Healthy We Used D-STATCOM. So After Using D-STATCOM We Get Balanced Three Phase Voltage.

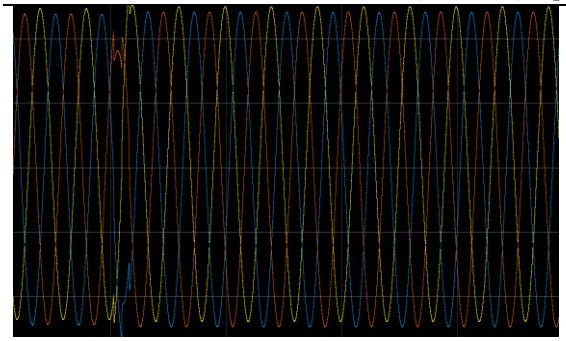

Fig 24 Voltage Waveform (With D-STATCOM)

(c) Total Harmonic Distortion

Total Harmonic Distortion Without Using D-STATCOM Is 37.67% But After Using D-STATCOM Total Harmonic Distortion Is 25.66%. So After Using D-STATCOM Total Harmonic Percentage Is Reduce.

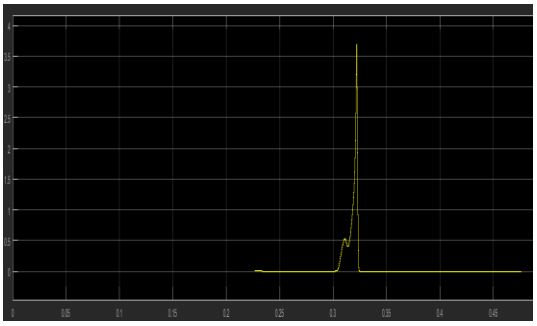

Fig 25. Total Harmonic Distortion (Without Using D-STATCOM)

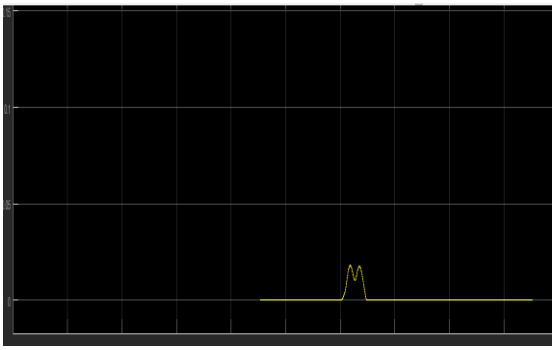

Fig 26. Total Harmonic Distortion (With Using D-STATCOM)

V. CONCLUSION

This Paper Deal With Power Quality Means Voltage Dip, Current Unbalanced, Total Harmonic Distortion . In This Paper We See That With The Help Of D-STATCOM We

Can Improve Power Quality Of Distribution Network In Static Linear And Non Linear Load Under Different Fault Condition.

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