ISSN 2348 – 8034
Impact Factor- 3.155

GLOBAL JOURNAL OF ENGINEERING SCIENCE AND RESEARCHES

DESIGN OF DYNAMIC REACTIVE POWER COMPENSATOR (DRPC) FOR THREE PHASE UNBALANCED LOAD

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ABSTRACT
Unbalance in power system could be caused by the addition of single phase loads and dynamically varying loads which are unavoidable. It is because of this reason that the load reactive power is no longer balanced, which might result in voltage fluctuation, line overloads and high transmission line losses in the system. To minimize these effects, network operators might charge for kVA demands, which would force the customers to reduce the reactive power consumption in the line. This paper discusses about the Dynamic Reactive Power Compensator (DRPC). The smooth and continuous reactive power compensation will improve the power system performance. This will bring down voltage fluctuations, power loss in the transmission line system and threat on instability while reducing the kVA demand charges at the same time. A control system for DRPC has been developed and simulated using MATLAB and results are provided. This paper presents a complete preliminary simulation & study of a DRPC controller.

Keywords: *DRPC,TCR,BSC,Unbalanced Load, reactive power, voltage profile, power system & MATLAB.*

I. INTRODUCTION
Increase in the usage of industrial and home appliances had created higher demand of electricity in many countries all over the world. Industries are mainly equipped with usually large number of heavy rotating machines, which will consume huge amount of reactive power. Because of these reasons the power factor at the load centre is degraded quickly and it also reduces the power transfer capability of the transmission line while causing under voltage problems simultaneously. Much higher growth in power electronics field has created several opportunities to achieve good & reliable power system performances. There are many FACTS as well as CUSTOM power devices which have been developed to enhance the power system performances by compensating and controlling reactive power. Static VAr Compensators (SVCs) are most widely used as one of the shunt connected type FACTS device to improve the power system performance.
Voltage control is complicated by two factors. Firstly, the transmission system itself is a nonlinear consumer of reactive power, which depends on system loading. At very light loading the system generates reactive power which must be absorbed, while at heavy loading, the system consumes a large amount of reactive power that must be replaced and must be supplied somehow. It means, the system is designed to withstand a single contingency or multiple. At least a portion of the reactive power supply should be capable of responding quickly to changing reactive power demands in the system and to maintain acceptable voltages i.e. flat voltage profile throughout the system.The voltage needs to be maintained in between 95% and 105% of the nominal voltage.

II. DYNAMIC REACTIVE POWER COMPENSATOR
Dynamic Reactive Power Compensator is a controller which is used to compensate the reactive power in the transmission line which leads to the imbalance in the voltage profile. When the reactive power demand in the system increases the controller will increase the firing angle from 90 to 180 degrees, which reduces the TCR contribution and thus allow the supplying of reactive power demand from DRPC. Here the controlled element is reactor & controlling element is opposite poled thyristor or bidirectional thyristor valve, which conducts in the alternate half cycles of supply frequency. When voltage is at the peak and thyristor is turned ON than the reactance offered by the reactor is minimum . As a result of which the value of inductance is also minimum and the value of current is maximum. So, maximum amount of reactive power is absorbed by the reactor. When the delay angle increases from 90 to 180 degrees than the reactance offered by the reactor is maximum & inductance is also maximum. As a result of which the value of current is minimum, so minimum amount of reactive power is absorbed by the rector of DRPC. The anode current must be greater than the minimum value of current known as the latching current, in order to turn ON the thyristor & must be below minimum value of current known as holding current to turn OFF the thyristor. If the thyristors fire at same delay angle than harmonic currents are introduced in the system, which are very harmful

for the system preferably third harmonics. So DRPC if connected in delta so as to get rid of 3rd harmonics because these harmonic currents circulate in the delta connection and are not allowed to escape into the transmission line.

III. DESIGNING OF DYNAMIC REACTIVE POWER COMPENSATOR (DRPC)

Dynamic reactive power compensator (DRPC)consists of Thyristor Controlled Reactor (TCR) and Breaker Switched Capacitor (BSC). Thyristor firing angles were controlled to achieve smooth variation of the reactive power supplied by the DRPC. The power rating of a single phase TCR was set to be equal to any one of the three BSCs connected to that phase. When a BSC is switched on the TCR is set to its maximum to fully compensate that BSC.

1. Thyristor Controlled Reactor (TCR)

We need to control thyristor firing angles to achieve the smooth variation of reactive power supplied by the DRPC. When the reactive power demand increases the controller will increase the firing angle, which reduces the TCR contribution and thus allow supplying the reactive power demand from DRPC.

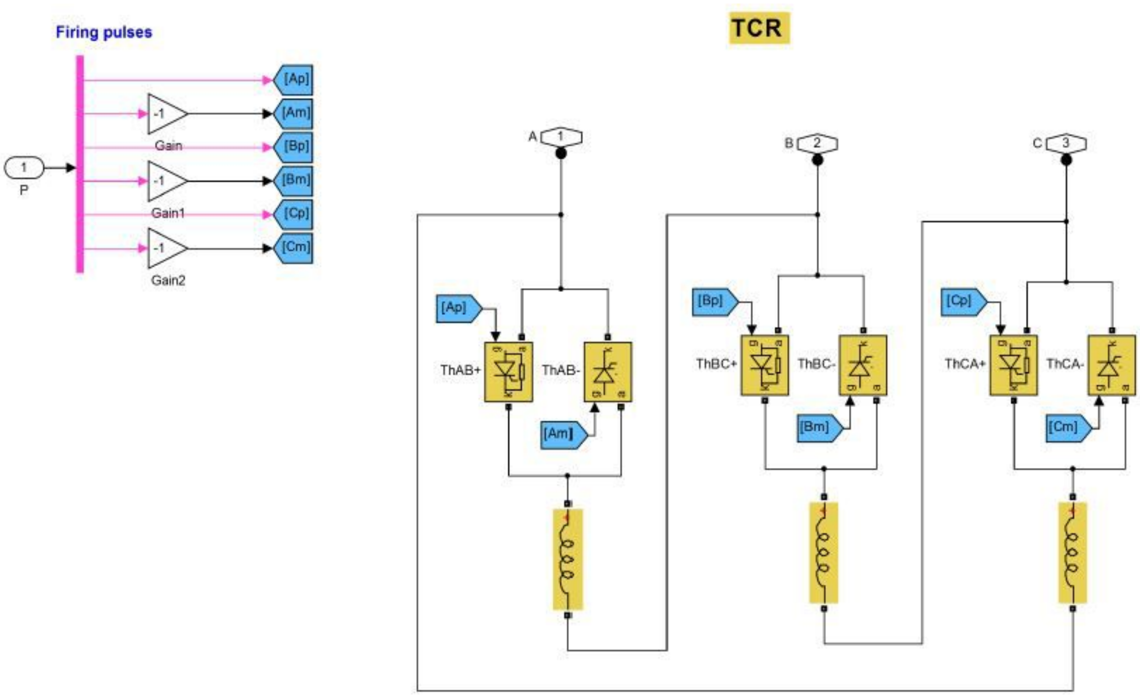

Figure1. Design of Thyristor Controlled Reactor (TCR).

PARAMETERS	TCR
TCR Inductance (H)	100 H
Quality Factor	100
Thyristor snubber: [R (ohm) C (F)]	[500 250e-9]
Thyristor data: [Ron (ohm) Vf (volt)]	[1e-3 1*15]

The value of Inductor used in TCR is calculated by the formula given below.

$$L = 2^{*}10^{-7}LOG(D/R^{1})$$

Where, D is the distance between the conductor used in transmission line.

$$R^{1}=0.7788R$$

 ISSN 2348 – 8034
Impact Factor- 3.155

Where R is the radius of the conductor used in transmission line.

2. Breaker Switched Capacitor (BSC).

Breaker Switched Capacitor is connected in parallel to TCR and load. It has a shunt connected capacitor which is used to supply required amount of reactive power as demanded by the dynamic load.

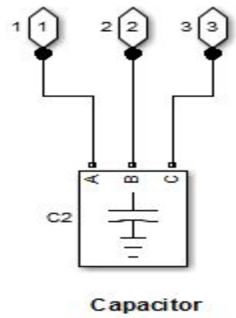

Figure2. Design of Breaker Switched Capacitor (BSC).

The value of capacitor used in BSC is calculated by the formula given below.

$Q = 2\pi f^{*}C^{*}V^{2}$ & $Xc = 1/2\pi fC$

Where Q is the reactive power in the system, f is the frequency, C is the capacitor & V is the voltage to be transmitted.

IV. SIMULINK MODEL OF UNBALANCED LOAD CONNECTED TO LONG TRANSMISSION LINE

Unbalanced three phase load is connected to 300 km long transmission line. MATLAB / SIMULINK software is being used for the modelling of this model. It is one among the various simulation tools used for this study, its analysis and development of application which uses the functional commands along with the block sets for designing of the above system. Sim Power Systems is one its designing tools which is being used for modelling and simulation of electric power systems in MATLAB software. Also this software provides wider range of flexibility in modifying all the block sets according to the user needs & requirements. The complete precise modelling of the power circuit along with their mechanisms are explained in detail as follows below.

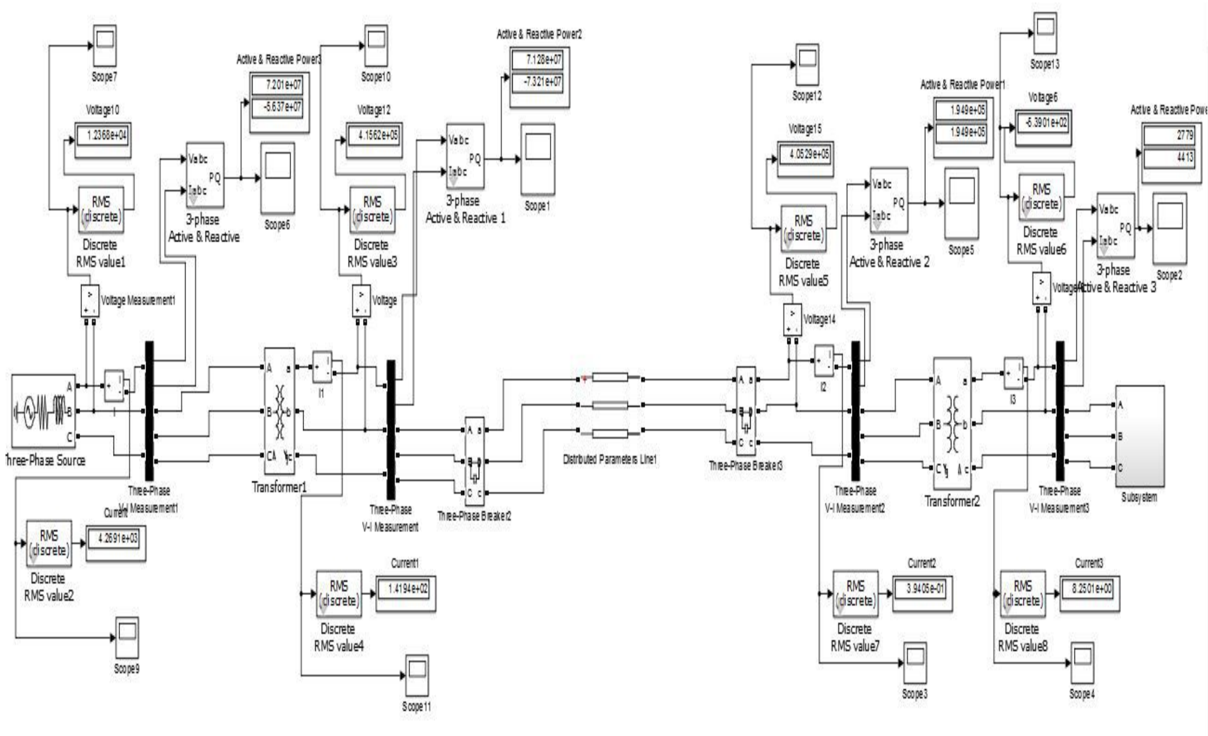

Figure3. Modelling & Simulation of 3phase Unbalanced Load Connected to Long Transmission line.

Table showing Simulation Results.

PARAMETERS	SENDING END	RECEIVING END
Voltage	415 KV	405 KV
Active Power	72 MW	195 KW
Reactive Power	56.37 MVAR	195 KVAR
Current	141.9 A	39.4 A

Voltage drop of approximately 10 KV was found at the receiving end of transmission line. This drop in voltage is due to the dynamically varying loads or unbalanced loads. These loads consume large large amount of reactive power because of their inductive nature. A Dynamic Reactive Power is designed to minimize reactive power flow & improve voltage profile. DRPC can be used to improve power quality in the city area, where low voltage problems are being addressed. Furthermore this can also be effectively used to enhance the power transfer capability of the transmission lines up to a large extent. Dynamic reactive power compensation improves the power system performance in several ways such as improving the load power factor, boosting voltage profile, enhancing power transfer capabilities, controlling and minimising power oscillations and improving system stability.

V. COMPENSATION RESULTS AFTER CONNECTING DRPC

A MATLAB Simulink model is developed to study the Compensation provided by DRPC to 3 phase Unbalanced Load connected to 300 KM Long Distributed Parameter Transmission Line.

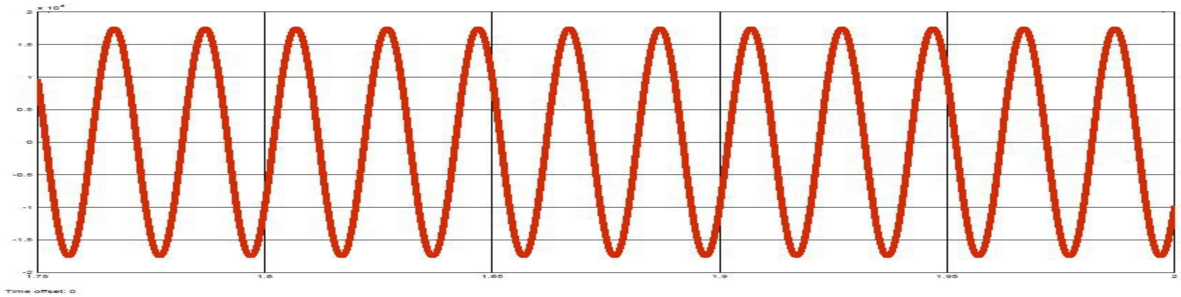

Figure4. Voltage Waveform at Generator Side of 13.8KV.

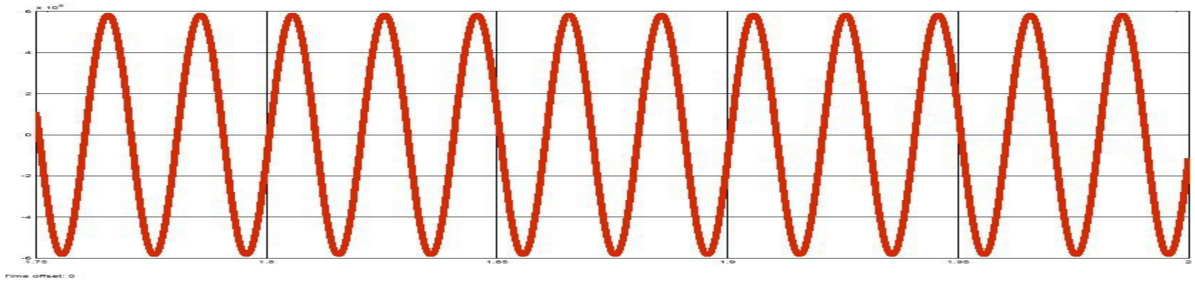

Figure5. Voltage Waveform at Sending End after being Stepped Up to 415 KV.

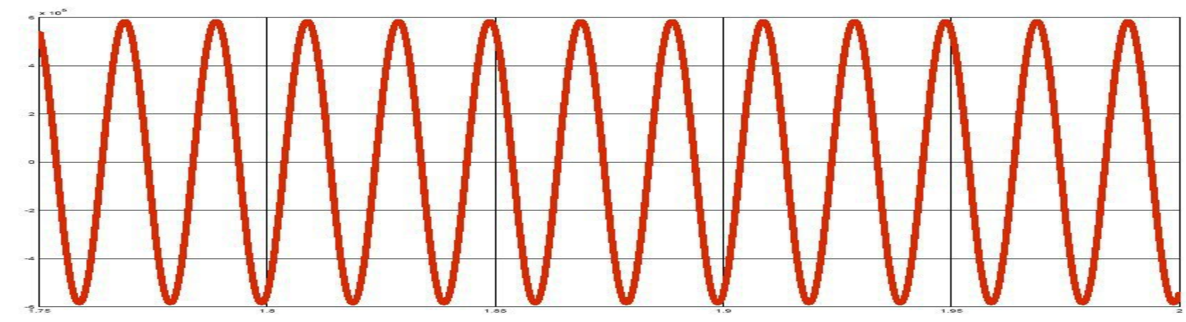

Figure6. Voltage Waveform at Receiving End to 415 KV.

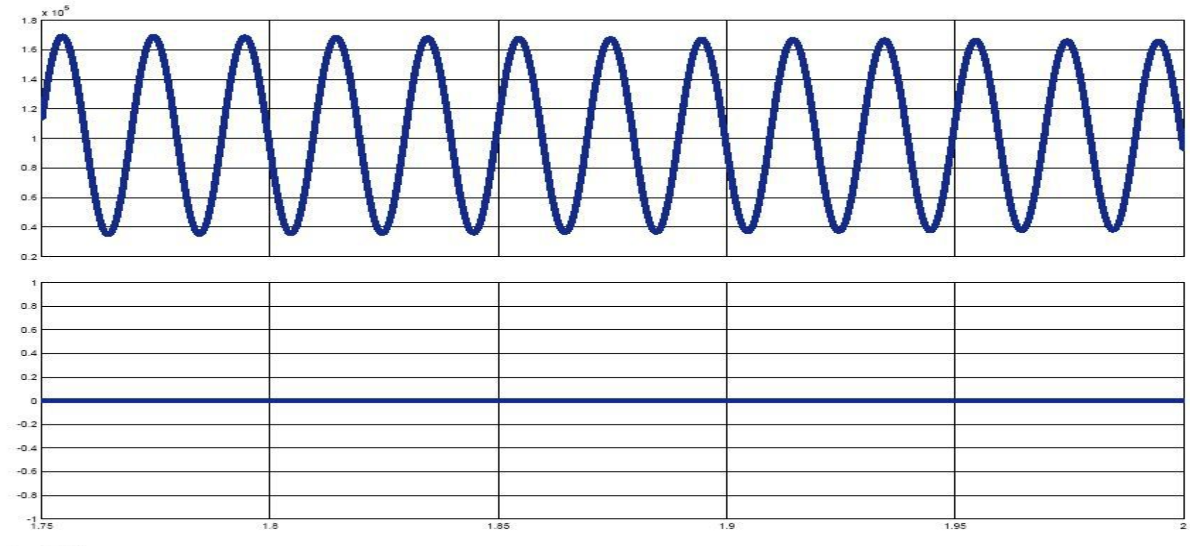

Figure7. Active & Reactive Power Waveforms at Receiving End on the Load side.

ISSN 2348 – 8034
Impact Factor- 3.155

Table showing Simulation Results.

PARAMETERS	SENDING END	RECEIVING END
Voltage	415 KV	415 KV
Active Power	72 MW	92 KW
Reactive Power	53.84 MVAR	0 MVAR
Current	138 A	40 A

VI. CONCLUSION

Voltage drop of approximately more than 10 KV was found at the receiving end of transmission line. This drop in voltage is because of dynamically varying loads or unbalanced loads. These loads consume large amount of reactive power. This voltage drop was compensated by the dynamic reactive compensator (DRPC) and equal voltages are maintained at both the sending end & receiving end. The Simulation results confirm that the reactive power drawn from the source is kept at zero by the controlled DRPC injection method. In addition to the power factor improvement, always a reactive power compensator is used which boosts the bus bar voltage. Since the kVA charges are high, reduction in kVA demand will decrease the electricity bill by a considerable amount. The peak shaving of the kVA demand helps the utility to supply power with comparatively less line losses and higher efficiency. Thus the above proposed technique helps us to compensate reactive power of unbalanced load centres and improve the power factor close to unity at the steady state. Still some research work is left as the instantaneous transient measurement of unbalanced reactive power flowing through each phases to be studied and it is a challenging task for protection systems.

REFERENCES

1. *S. Arunprasanth, A. Arulampalam and P.J. Binduhewa, "Dynamic Reactive power (DRPC) for Unbalance load reactive power compensation", in 2013 IEEE 8th International Conference on Industrial and Information Systems, ICIIS 2013, Aug. 18-20, 2013, Sri Lanka.*
2. *S. Arunprasanth, R.W.K.M.R.K.D. Bandara, R.M.R. Tharaka, A. Atputharajah, M.A.R.M. Fernando, S.G. Abeyrathne, D.N. Navarathne, A.P. Tennakoon and S. Alagoda "Design of Dynamic Reactive Power Compensator (DRPC) to improve power factor of a load centre", IESL Centre, Central Province Annual Session & AGM 2011.*
3. *S.RAO, EHV-AC, HVDC transmission & distribution engineering," third edition, Khanna Publishers.*
4. *N. G. Hingorani, FACTS Technology - State of the Art, Current Challenges and Future Prospects, IEEE Power Engineering Society General Meeting, June 2007, pp. 1-4.*
5. *K.R.Padiyar, —HVDC power transmission systems," second edition, New age international publishers.*