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ELECTRICAL AND ELECTRONICS ENGINEERING

III YEAR / VI SEMESTER

EE 8006 – POWER QUALITY

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CONCEPTS OF COMPENSATORS

UNIT -4 INTRODUCTION TO PASSIVE POWER COMPENSATORS
LECTURE 01
CONTENTS

• Operation of passive shunt and series compensators.
• Analysis and Design of passive shunt compensators.
• Performance of passive power filter.
• Limitations of passive filter.
• Parallel Resonance of passive filters
• Load compensation – Voltage Regulation and Power factor correction
PASSIVE COMPENSATION

• The reactive-power control for a line is often called reactive-power compensation and external devices or subsystems that control reactive power on transmission lines are known as “compensators”.

• A compensator mitigates the undesirable effects of the circuit parameters of a given line
PASSIVE COMPENSATION TYPES

1. Shunt Compensation

2. Series Compensation
SHUNT COMPENSATION

• Shunt compensation can also be employed as a ‘local’ remedy against voltage collapse which can occur when large induction machines are connected to the system.

• After system faults the machines load the power system heavily with high reactive power consumption
The reactive current is injected into the line to maintain voltage magnitude and transmittable active power (P) is increased but more reactive power (Q) is to be provided.

The remedy for such fault is strong capacitive power injection for example by using an either SVC or STATCOM or just switched capacitors.
Figure 3: Single-line diagram of a shunt compensated transmission line and its phasor diagram.
SERIES COMPENSATION

• The Series Compensation is a well established technology that primarily used to transfer reactance most notably in bulk transmission corridors.

• The result is a significant increase in the transmission system transient and voltage stability
SERIES COMPENSATION

• Series Compensation is self regulating in the sense that its reactive power output follows the variations

• In transmission line current that makes the series compensation concept extremely straightforward and cost effective
SERIES COMPENSATION

• This principle can also be applied in meshed systems for balancing the loads on parallel lines

• The simplest form of series compensation is the fixed series compensator for reducing the transmission angle thus providing stability enhancement.
SERIES COMPENSATION CIRCUIT
SERIES COMPENSATION CIRCUIT

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Performance of passive power filter

Series active filter and parallel passive filter
Performance of passive power filter

• It is constituted by a series active filter and a passive filter connected in parallel with the load.

• The control strategy is based on the vectorial theory dual formulation of instantaneous reactive power.

• The filter impedance has to be smaller than the source impedance in order to eliminate source current harmonics.
Performance of passive power filter

• Not suitable for variable loads & Resonant drawback

• An active power filter in series to the ac source impedance improves the compensation characteristics of the passive filters in parallel connection.
Performance of passive power filter

- Generation of a voltage proportional to the source current

- Harmonics is used for elimination of series and parallel resonances with the rest of the system.

- Simulations on the MATLAB-Simulink platform.
Performance of passive power filter

• Traditionally a passive LC power filter is used to eliminate current harmonics when it is connected in parallel with the load.

• This compensation equipment has some drawbacks.

• So active power filter, typically consists of a three-phase pulse width modulation voltage source inverter is used.
Performance of passive power filter

• Harmonic current drawn from a supply by the nonlinear load results in the distortion of the supply voltage waveform at the point of common coupling (PCC) due to the source impedance.

• Both distorted current and voltage may cause end-user equipment to malfunction, conductors to overheat and may reduce the efficiency and life expectancy of the equipment.
Performance of passive power filter

• A passive LC power filter is used to eliminate current harmonics when it is connected in parallel with the load.

• It has some drawbacks like overheating, bulk in size

• Resonant drawback and required maintenance due to which the passive filter cannot provide a complete solution.
Series active power and passive filter topology
The vector transformations

•The vector transformations from the phase reference system a-b-c to α- β-0 coordinates can be obtained, thus

\[
\begin{align*}
\begin{bmatrix} v_0 \\ v_\alpha \\ v_\beta \end{bmatrix} &= \sqrt{2\over 3} \begin{bmatrix} 1/\sqrt{2} & 1/\sqrt{2} & 1/\sqrt{2} \\ 1 & -1/2 & -1/2 \\ 0 & \sqrt{3}/2 & -\sqrt{3}/2 \end{bmatrix} \begin{bmatrix} v_\alpha \\ v_\beta \end{bmatrix} \\
\begin{bmatrix} i_0 \\ i_\alpha \\ i_\beta \end{bmatrix} &= \sqrt{2\over 3} \begin{bmatrix} 1/\sqrt{2} & 1/\sqrt{2} & 1/\sqrt{2} \\ 1 & -1/2 & -1/2 \\ 0 & \sqrt{3}/2 & -\sqrt{3}/2 \end{bmatrix} \begin{bmatrix} i_\alpha \\ i_\beta \end{bmatrix}
\end{align*}
\]

•The instantaneous real power in the α- β-0 frame is calculated as follows:

\[ p_{3\phi}(t) = v_\alpha i_\alpha + v_\beta i_\beta + v_0 i_0. \]
What more in feasibility analysis?

• Software

• Simulations have been carried out on the MATLAB-Simulink platform with different loads and with variation in the source impedance.

• This analysis allowed an experimental prototype to be developed. Experimental and simulation results are presented.
Output waveform
Limitations of passive filter.

• Capacitors and Reactors are to be specially designed.

• Every filter in the scheme has to be provided with protection and control arrangement.

• The scope for possible series / parallel resonance exists and should be avoided by careful study before implementation.
Limitations of passive filter

• These do not offer 100% solution for harmonic suppression similar to active filters.

• Their performance is subject to parameter variations, ageing etc.
Parallel Resonance of passive filters

• A filter is a passive filter if it consists of only passive elements R, L, and C.

• It is said to be an active filter if it consists of active elements (such as transistors and op amps) in addition to passive elements R, L, and C.
Parallel Resonance of passive filters

• The maximum gain of a passive filter is unity.

• To generate a gain greater than unity, one should use an active filter.

• There are other ways to get the types of filters.

• The filters discussed here are the simple types.

• Many other filters have sharper and complex frequency responses.
Voltage Regulation and Power factor correction

• Transferring reactive power into electrical energy supply equipment results in a considerably higher absorption of current that results from simply transferring active power, see diagram below.

• This in turn results in unnecessary losses in power transmission and the need to oversize electrical equipment.
Voltage Regulation and Power factor correction
Power factor correction

• Using compensation systems in plant grid can also make a positive difference because transfer losses can be minimized, transformer

• Line loads can be reduced and oversizing can be avoided.

• This improves the operating reliability of the energy supply grid, extends the equipment's service life.

• Reduces investments in equipment.