Name : .....

Roll No. : .....

Invigilator's Signature : .....

CS/M.Tech (EE)/SEM-3/PEM-301 (A)/2012-13

2012
POWER QUALITY MANAGEMENT

Time Allotted : 3 Hours *Full Marks* : 70

The figures in the margin indicate full marks.
Candidates are required to give their answers in their own words as far as practicable.

Answer any *five* questions. 5 × 14 = 70

1. A distorted supply voltage $v(t)$ is applied to a load resulting a nonlinear current $i(t)$ given by the following :

$$v(t) = V_{dc} + \sum_{n=1}^{\infty} \frac{\sqrt{2V_n}}{n^2} \sin(n\omega t - \varphi_{vn})$$

with $V_{dc} = 10V$, $\frac{V_n}{n^2} = \frac{230\sqrt{2}}{n^2}$ and $\varphi_{vn} = 0$ for n = 1,3,5,7

and $i(t) = I_{dc} + \sum_{n=1}^{\infty} \frac{\sqrt{2I_n}}{n} \sin(n\omega t - \varphi_{in})$

with $I_{dc} = 2A$, $\frac{I_n}{n} = \frac{20}{n}$ and φ_{in} = n × 30° for n = 1,3,5,7

Compute the following :

a) Active Power, P, Active Power related to Fundamental Component, P_1 and Active Power for Harmonic Components, P_H.

b) Reactive Power, Q, Reactive Power related to Fundamental Component, Q_1 and Reactive Power for Harmonic Components, Q_H.

c) Apparent Power, S, Apparent Power related to Fundamental Component, S_1 and Apparent Power for Harmonic Components, S_H.

d) Non-active Power, N and Distortion Power, D.

e) Displacement Power factor and Power factor.

f) Total Harmonic Distortion (THD) of voltage and current.

3 + 3 + 2 + 2 + 2 + 2

2. A power supply has the following data :

Phase to neutral voltage = 10 kV

Short circuit level = 250 MVA

$\frac{X_s}{R_s} = 5$

It is supplying a star connected inductive load whose mean power is 25 kW and reactive power varies from 0 to 50 MV Ar, all quantities are on the basis of per phase.

a) Find the load bus voltage and voltage drop in the supply feeder. Thus determine load current, power factor and system voltage.

b) It is required to maintain the load bus voltage to be same as supply bus voltage i.e., V = 10 kV. Calculate the reactive power supplied by the compensator.

c) What should be the load bus voltage and compensator current if it is required to maintain the unity power factor at the supply ? 4 + 5 + 5

3. a) Show that the compensator affects the no load supply voltage and voltage sensitivity of supply point voltage to the variation in the load reactive power.

b) Consider a three-phase system with line-line voltage 11 kV and short circuit capacity of 480 MVA. With compensator gain of 100 pu determine voltage sensitivity with and without compensator. For each cash, if a load reactive power changes by 10 MVAr, find out the change in load bus voltage assuming linear relationship between V-Q characteristics. Also find relationship between compensator and load reactive powers. 7 + 7

4. For a star connected 3-phase, 3-wire system, 3-phase voltages are balanced sinusoids with RMS value value of 230 V at 50 Hz. The load is unbalanced and star connected and load impedances are $Z_a = 3 + j4\Omega$, $Z_b = 5 + j12\Omega$, $Z_c = 12 - j5\Omega$. Compute the following :

   a) The line currents

   b) The active (P) and reactive (Q) powers of each phase.

   c) The compensator susceptances so that the supply sees the load balanced and unity power factor.

   d) For case (c), compute the source, load, compensator active and reactive powers (after compensation).

3 + 3 + 4 + 4

5. a) Draw the schematic of Voltage Source Inverter compensator and explain its working.

   b) Develop a state space model of the compensator. 6 + 8

6. a) What are the components of a DVR System ? Show a scheme for a DVR.

b) With suitable schematic diagram explain the working of DVR based compensation in a distribution system. 7 + 7

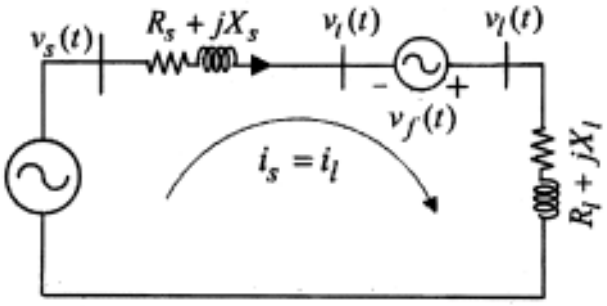
7. Consider a system with supply voltage 230 V = 1·0 pu, 50 Hz as shown in the Figure given below and feeder impendance as Z_s = 0·05 + j 0·3 pu and load impendance Z_l = 0·5 + j 0·3 pu.

a) Compute the load voltage without DVR.

b) Compute the current and DVR voltage such that $V_l = V_s$

c) Compute the effective source voltage including DVR. Explain the power flow in the circuit.

d) Compute the terminal voltage with DVR compensation.



3 + 3 + 4 + 4

8. A DVR is shown in Figure given below. The feeder impendance of the line is 0·1 + j 0·5 pu.

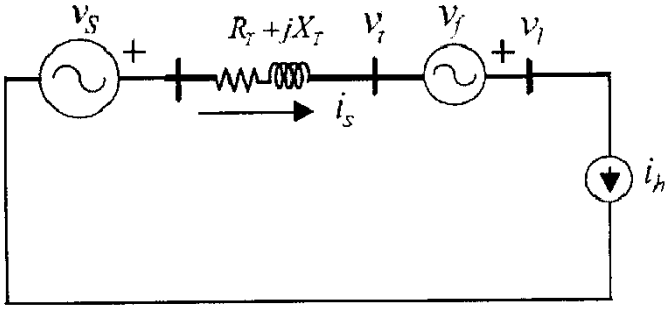
Assume i_h to be load current represented by square waveform approximated by the following expression :

i_h = 1·0 sin (ωt – 30°) + 0·3 sin (sin (3ωt – 90°) pu

a) Find the load voltage v (t) without DVR compensation i.e., $v_f = 0$

b) Is it possible to maintain load voltage, V_l to be 1·0 pu sinusoidal waveform ? If yes what is the DVR voltage, $v_f(t)$?

c) If no, how much maximum voltage can be maintained at load terminal with the DVR without taking any real power from the dc bus ?



4 + 5 + 5

9. Write short notes on any *four* of the following : $4 \times 3\frac{1}{2}$

a) Power factor and its correction using compensator

b) Improvement of voltage regulator using compensator

c) Scheme for Realization of DVR voltage using VSI

d) Theory of Instantaneous symmetrical component

e) Power Quality.