1. Discuss the effects of harmonics on synchronous machines.

There is distortion of Resultant Flux when Resistive Load is connected to Synchronous Generator. Flux is also distorted due to other reasons e.g. Slot Harmonics. Distortion in Flux distorts EMF induced and creates Harmonics in EMF Wave. Harmonics mean EMF has higher Frequency components. Harmonics increase Losses in Transmission Line due to Skin Effect and Iron Loss in Transformers connected to Generator. 5th Harmonic produces retarding Torque in Induction Motor. 7th Harmonics may produce Crawling in Induction Motor i.e. Induction Motor may start running at 1/7th Speed. In synchronous machines, voltages and currents are induced, which are in sinusoidal

waveforms.But in practice, these sinusoidal waveforms will deviate to form non?sinusoidal waveforms. These non-sinusoidal waveforms are expressed in terms of Fourier

transforms which are the sum of series of sinusoidal waveforms.

These harmonic components can be represented as follows.

Fundamental: e1 = Em1 Sin ( t ± θ1)

2nd Hermonic e2 = Em2 Sin (2 t ± θ2)

3rd Harmonic e3 = Em3 Sin (3 t ± θ3)

5th Harmonic e5 = Em5 Sin (5 t ± θ5) etc.

In case of alternators as the field system and the stator coils are symmetrical the induced

emf will also be symmetrical and hence the generated emf in an alternator will not

contain any even harmonics.

* -Slot Harmonics:

 As the armature or stator of an alternator is slotted, some harmonics

are induced into the emf which is called slot harmonics. The presence of slot in the stator

makes the air gap reluctance at the surface of the stator non uniform. Since in case of

alternators the poles are moving or there is a relative motion between the stator and rotor,

the slots and the teeth alternately occupy any point in the air gap. Due to this the

reluctance or the air gap will be continuously varying. Due to this variation of reluctance

ripples will be formed in the air gap between the rotor and stator slots and teeth. This

ripple formed in the air gap will induce ripple emf called slot harmonics.

* Effect of Harmonics on induced emf:

The harmonics will affect both pitch factor and distribution factor and hence the induced

emf. In a well designed alternator the air gap flux density distribution will be symmetrical

and hence can be represented in Fourier series as follows.

The RMS value of the resultant voltage induced can be given as

Eph2 = [(E1)2+ ....+ …………… (En)2]

\*\*(A)2 Means A Square

* Effect of Harmonics of pitch and distribution Factor:

The pitch factor is given by Kp = cos /2, where is the chording angle.

For any harmonic say nth harmonic the pitch factor is given by Kpn = cos n α/2

The distribution factor is given by Kd = (sin mβ /2) / (m sin β/2)

For any harmonic say nth harmonic the distribution factor is given by

Kdn = (sin mn β/2)/(m sin nβ/2)

This is the detailed info about Harmonics In Synchronous Machines,Minimization

Methods of Harmonics.Effect of Harmonics on induced emf.

* - Increased Heating

General

Iron losses such as eddy current and hysteresis losses, are produced in the core of motors

and generators due to the alternating magnetic field. The amount of eddy current loss

varies as the square of the frequency, while hysteresis loss is directly proportional to

frequency. Thus, higher frequency voltage components (i.e. harmonic voltages) generate

additional losses, which result to higher operating temperature of the core and the

surrounding windings. Nevertheless, winding losses are of more concern than iron losses.

Basically, I2R losses in the machine windings vary as the square of the RMS current.

Therefore, an increase in the RMS current due to harmonics should be minimized since it

will lead to higher winding losses. Moreover, actual losses would be slightly higher than

calculated values because of skin effect. Furthermore, stray losses - winding eddy current

losses, high frequency rotor and stator surface losses, and tooth pulsation losses will

increase due to harmonic voltages and currents.

Motors

Core and stray losses may become significant for an induction motor with skewed rotors.

Single-phase motors are the most affected.

Generators

The heating effect of nonlinear loads on generators is greater compared to transformers.

This is because a generator has higher reactance and impedance, that when paired with

high frequency flux changes could cause stator heating. Also, high frequency currents

will induce currents in the pole faces and hunting winding and hence cause rotor heating.

Subsequently, generators supplying nonlinear loads should be derated based on the

generator reactance.

1. Justify technically why the stator windings of large generators are star connected.
* The phase voltage is 0.577 times the line voltage which results in lesser voltage stress and hence lesser insulation cost.
* The availability of the neutral point which can be grounded and thus provide a path for circulating current in case there is any unbalance in the load end or some fault occurs.
* In star connection there is a neutral availability if there is any problem. And another one is it reduces the high voltage values.
* The armature winding of alternator have a six output terminal, in which three terminal short (make neutral point) and remaining three gives output which are possible only in star connection. So we are connected in star
1. Why is it that the armature for large machines is stationary?

Answer:

1. It is easier to collect current through brushes from stationary armature in case of generators.

2. When armature winding is stationary and field winding rotates we get more output as field

winding is quite lighter than armature winding.

3. There is less chances of sparking in stationary arm. Winding comparatively to stationary

rotor.

4. Commutation is a problem in rotatory armature.

5. As armature winding is stationary the natural cooling is more effective.

6. As rotating winding is field winding which is comparatively light so chances of wear and tear

is less.

1. The brushless technology does not have a contact zone, which considerably reduces wearing and maintenance. Less brushes, abrasion of brushless generator is mainly on bearings, from the view of a mechanical point, brushless generator is almost a maintenance-free motor, when necessary, just need to do some dust removal maintenance. Brush generator has excellent low-speed torque performance and high torque characteristics, which are irreplaceable.