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**Question 1:** Discuss the effects of harmonics on synchronous machines (hint” identify the harmonics, state how they affect synchronous motors; state how they affect synchronous generators)

**Ans:**

**a)** In an electric power system, a harmonic is a voltage or current at a multiple of the fundamental frequency of the system, produced by the action of non-linear loads such as rectifiers, discharge lighting, or saturated magnetic devices. Harmonic frequencies in the power grid are a frequent cause of power quality problems. Harmonics in power systems result in increased heating in the equipment and conductors, misfiring in variable speed drives, and torque pulsations in motors**.**

**b)** There are two types of harmonics and they are odd harmonics and even harmonics. Odd numbers such as 3, 5, 7, etc, are the odd harmonics while even numbers such as 2, 4, 6, etc, are the even harmonics.

**c) Effects of harmonics on Motors and generators**

Generators and motors are adversely affected by harmonics in the networks to which they are connected. Typical effects are:

Increased heating due to iron and copper losses at the harmonic frequencies

Higher audible noise emission as compared with sinusoidal excitation

Harmonic currents in the rotor

The harmonic currents noted above are caused by harmonics in the stator winding, which will produce harmonic currents in the rotor, e.g., 5th- and 7th-order stator harmonics will produce 6th-order rotor harmonics, while 11th- and 13th-order stator harmonics will produce 12th-order rotor harmonics.

These rotor harmonic currents will result in increased rotor heating and pulsating or reduced torque.

It should also be noted that system unbalance (standing unbalance or ground faults), expressed as negative-sequence currents, can also reflect into the rotor as harmonic currents, which add to those noted above.

Generators can also produce harmonics and, in particular, triplen harmonics that can circulate through adjacent Wye-grounded transformers when generators are directly connected to a load bus. The use of the Delta-connected generator transformers can control this.

**Question 2 :** Justify technically why the stator windings of large generators are star connected

**Ans:** This is because

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

**Question 3:** Why is it that the armature for large machines is stationary?

**Ans:** This is because, it is easier to collect current through bruses from stationary armature in case of generators. When armature winding is stationary and field winding rotates we get more output as field winding is quite lighter than armature winding. There is less chances of sparking in stationary arm

**Question 4:** Why do brushless generators undergo less maintenance

**Ans:**  The brushless technology does not have a contact zone, which considerably reduces wearing and maintenance.