2-8 Parallel operation of alternator:

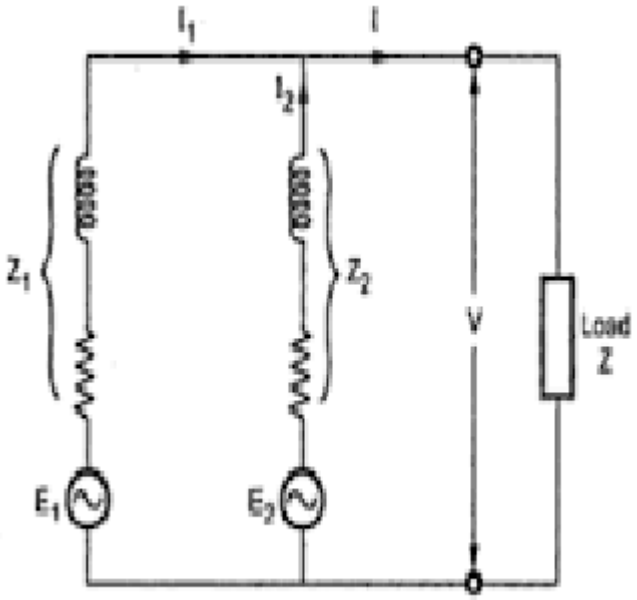
The operation of connecting an alternator in parallel with another alternator or with common bus bars is known as a synchronizing. Generally, alternators are used in power system where they are in parallel with many other alternators. It means that the alternator is connected to alive system of constant voltage and constant frequency.

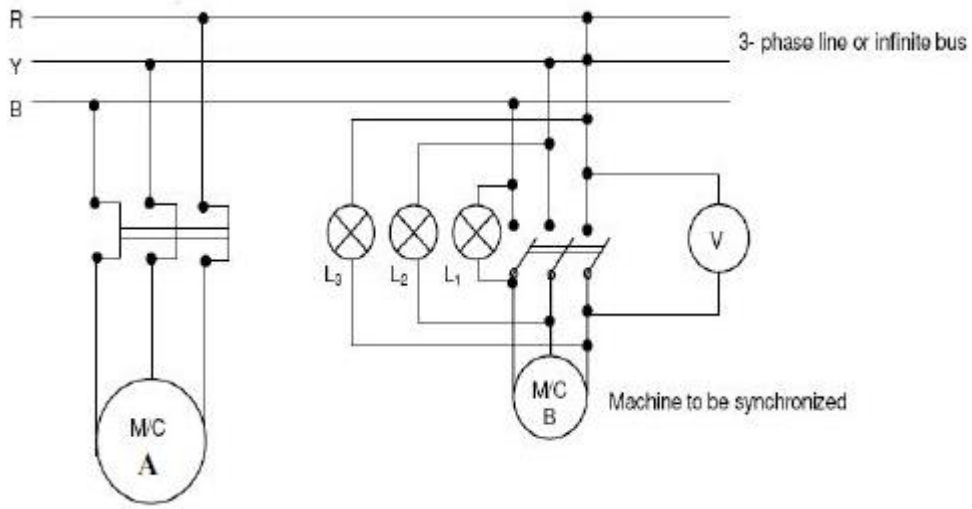
There are three conditions must be satisfied when connect the alternators in parallel:

1-The terminal voltage of incoming alternator must be the same as bus- bar voltage

2-the speed f the incoming machine must be such that its frequency ($f = \frac{P_o}{60}$) equals bus-bar frequency.

3-the phase of the alternator voltage must be identical with the phase of the bus-bar voltage.




R
Y
B
3- phase line or infinite bus
L3
L2
L1
V
M/C
A
M/C
B
Machine to be synchronized


SLOW
FAST
SYNCHROSCOPE
GENERAL ELECTRIC


FREQUENCY (Hz)
BUS
GEN
SYNCHROSCOPE
VOLTAGE (kV)
BUS
GEN
TOO SLOW
TOO FAST
SYNC
SELCO
SPEED RAISE
LOWER
CIRCUIT BREAKER OPEN
VOLTAGE RAISE

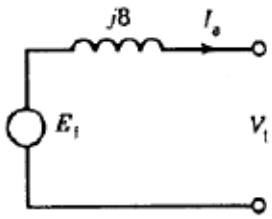
EXAMPLE

A 3ϕ, 5 kVA, 208 V, four-pole, 60 Hz, star-connected synchronous machine has negligible stator winding resistance and a synchronous reactance of 8 ohms per phase at rated terminal voltage.

Determine the excitation voltage and the power angle when the machine is delivering rated kVA at 0.8 PF lagging. Draw the phasor diagram for this condition.

Solution

The per-phase equivalent circuit for the synchronous generator



$$V_t = \frac{208}{\sqrt{3}} = 120 \text{ V/phase}$$

Stator current at rated kVA:

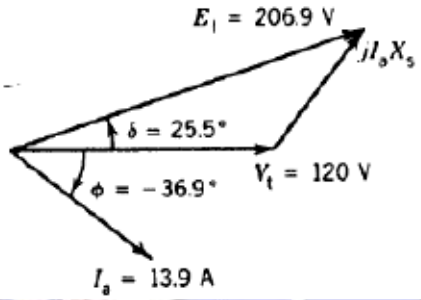
$$I_a = \frac{5000}{\sqrt{3} \times 208} = 13.9 \text{ A}$$

$\phi = -36.9°$ for lagging pf of 0.8

$$E_f = V_t \angle 0° + I_a jX_s$$
$$= 120\angle 0° + 13.9\angle -36.9° \cdot 8\angle 90°$$
$$= 206.9\angle 25.5°$$

Excitation voltage $E_f = 206.9$ V/phase

Power angle $\delta = +25.5°$



H.W

Q1) A four pole, three-phase synchronous generator is rated 250 MVA, its terminal voltage is 24 kV, the synchronous reactance is: 125%.

- Calculate the synchronous reactance in ohm.
- Calculate the rated current and the line to ground terminal voltage.
- Draw the equivalent circuit.
- Calculate the induced voltage, E_f, at rated load and pf = 0.8 lag.

(Ans: X_{syn}=2.88Ω, I_g=6.01∟-36.87°KA, E_{gn}=27.93∟29.74KV)

Q2) A3-phase, star connected alternator is rated at 1600Kva, 3500V. the armature effective resistance and synchronous reactance are 1.5Ω and 30Ω respectively per phase. Calculate the

percentage regulation for a load of 1280Kw at power factor of a) 0.8 lagging b) 0.8 leading c) unity.

(Ans. 18.6, -11.99, 3.227)

Q3) A 3-phase, 120kV, 1.5 MVA, alternator, its star connected armature winding has 1Ω effective resistance and 10Ω synchronous reactance per phase find VR% at full load at: a) unity power factor, b) 0.8 lagging, c) 0.8 leading. (Ans. 1.56%, 7.36%, -5%)

Q4) A 3-phase, 0.8MVA, 3.3Kv, 50Kz, SG, its armature winding star connected and its iron and mechanical losses are 20kW, having 0.5Ω/phase armature resistance. When a 150V is applied to the excitation winding Ie=100A at cosφ=1 and Ie=120A at cosφ=0.8lagging. find the efficiency at rated load and unity power factor and 0.8 lagging. (Ans. 9205%, 90.46%)

Q5) A 3-phase, delta connected, 15MVA, 10kV alternator has an armature resistance of 0.4Ω/phase and syncronouse reactance of 1.2Ω/phase. Find the full load voltage regulation at 0.8 power factor leading and lagging. (Ans. -1.82%, 5.26%)