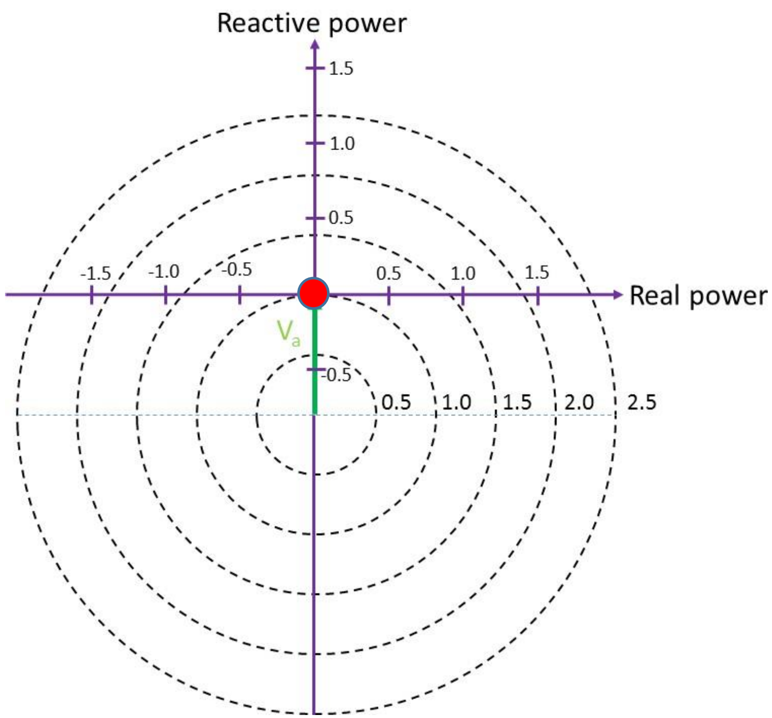
Numerical example

Consider a 3-phase, 1.5MW, 50Hz, 8-pole, non-salient synchronous machine with a synchronous reactance of 1.25 per unit. The machine is connected to 6.6kV (rms) infinite busbars. Using the electrical diagram drawn previously for a machine with 1.25 per unit reactance.

Using a load diagram approach estimate the load angle, the real and reactive power for the following conditions:

a) On no load with 1.0 per unit excitation



On no-load, the generator does not supply or draw any net real or reactive power.

Operating point

Load angle = 0°
Real power = 0 per unit
Reactive power = 0 per unit

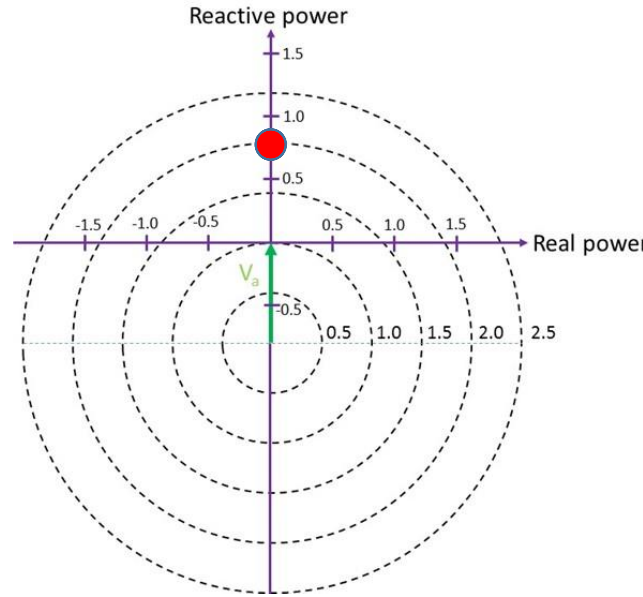
Although this can be solved in per unit, given that the question defines 1.0 per unit at 1.5MW, i.e the rated power, then we can equate per unit values with actual real and reactive powers

b) As a compensator with 2.0 per unit excitation

When acting as a compensator, the machine supplies +ive reactive power. Hence:

● Operating point

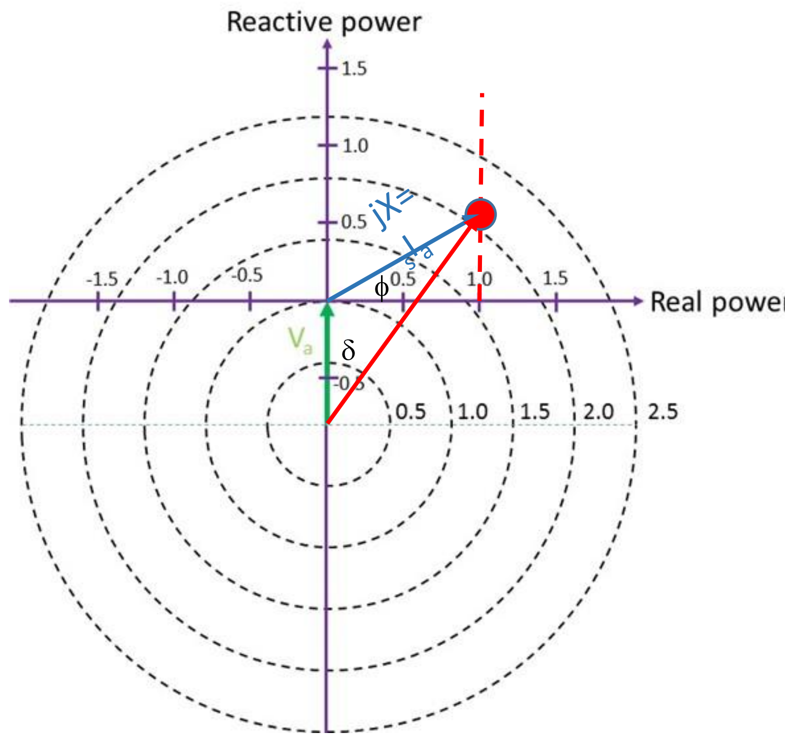
The load angle is 0°
Real power = 0 per unit
Reactive power = 0.8 per unit (=1.2 MVAr)



c) As a motor on full-load (1.0 per unit) operating at leading power factor of 0.87

$\phi = \cos^{-1}(0.87) = 29.4°$

Draw a construction line at 29.4 ° for which intersects the 1.0 per unit real power contour at the operating point. We can then draw in E to establish load angle.
From load diagram:
δ = -36° (note polarity from earlier definition)
Real power = 1.0 per unit = 1.5MW
From diagram:
Reactive power: 0.57 per unit = 0.8MVAr



d) As a generator delivering a real power of 0.75 per unit at a power factor of 0.78 leading

$$Apparent\ power(VA) = \frac{Real\ power}{Power\ factor} = \frac{0.75}{0.78} = 0.961\ per\ unit$$

$$Reactive\ power = 0.862 \sin\phi = +0.68\ per\ unit$$

Draw construction lines for real and reactive power
Intersection gives operating point. Draw E from origin gives:

δ = +28° (note polarity from convention)

The actual real and reactive powers are:

P = -0.75 ×1.5 = -1.12MW
Q = 0.6 ×1.5 = +0.9MVAr