$$= 1386 + 1396 \underline{|90^\circ - 36.87^\circ}$$

$$= 1386 + 838 + j1117 \text{ V}$$

$$= 2224 + j1117 = 2489 \underline{|26.66^\circ} \text{ V}$$

5. $I_f = \dfrac{2489}{m'} = \dfrac{2489}{10.28} = 242 \text{ A}$ ■

FOR FURTHER STUDY

THE POTIER METHOD OF MEASURING x_1

When a synchronous machine is operating as a generator with a zero power factor inductive load, the phasor/vector diagram looks like Figure 2.69. Note that all MMFs lie along the d axis and that $|E_\phi|$ is the arithmetic sum of $|V_1|$ and $|I_1|\, x_1$.

The situation relative to the OCC is shown in Figure 2.70, where point P represents the actual terminal line-to-line voltage and the actual field current required to produce that voltage at zero power factor and the particular value of armature current $|I_1|$. Noting that $I_f = F_2 / N_f$, the MMF vector diagram may be laid off along the field current axis, if all vector magnitudes are scaled by dividing by N_f. Corresponding to the resultant R, the induced voltage on a line-to-line basis ($\sqrt{3}E_\phi$) is found on the OCC. From Figure 2.69, the difference between $|E_\phi|$ and $|V_1|$ is $|I_1|\, x_1$. Therefore the difference on the voltage axis of the OCC between $\sqrt{3}\,|E_\phi|$ and $\sqrt{3}\,|V_1|$ is $\sqrt{3}\,|I_1|\, x_1$. The shaded triangle is called the *Potier triangle* after the inventor of this method. Note that the sides of this triangle are proportional to $|I_1|$.

Consider the situation at short circuit, illustrated in Figure 2.71. Here we see the Potier triangle is located on the field current axis. Note the auxiliary triangle A. The attitude of A is $\sqrt{3}\,|I_1|\, x_l$ and its hypotenuse is the air gap line. This is the clue to finding x_1 by Potier's method.

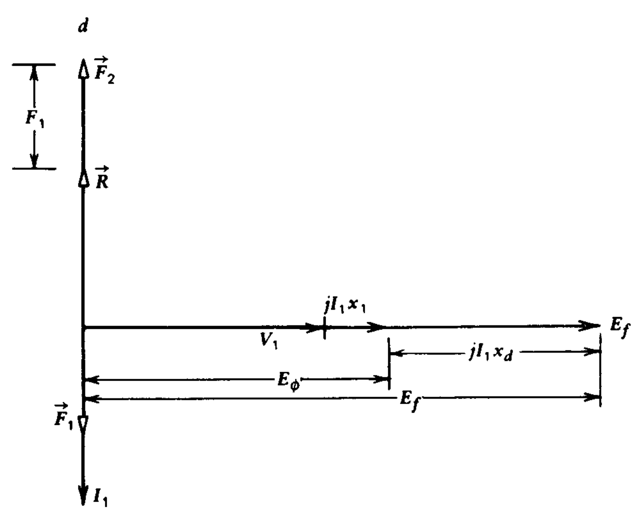

FIGURE 2.69 Phasor/vector diagram of a synchronous machine at zero power factor lagging.

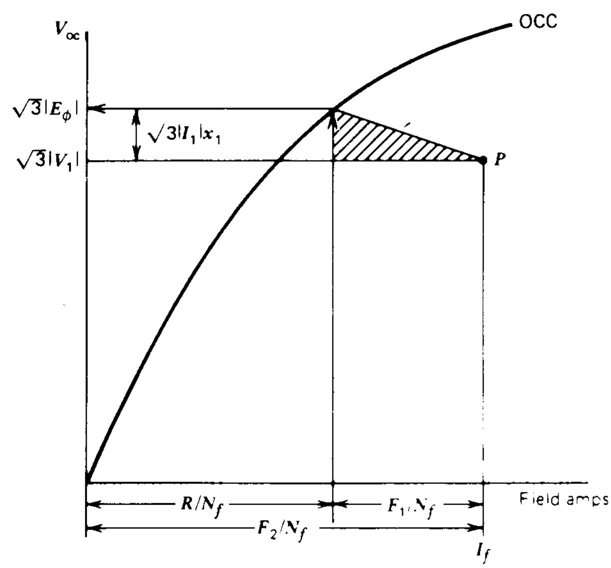

FIGURE 2.70 The Potier triangle.

Procedure

Refer to Figure 2.72.

1. With an adjustable, balanced, three-phase inductive load connected to its terminals, drive the machine at rated speed. Adjust I_f for **rated voltage** and the load inductance for **rated current.** Record the field current required to produce rated terminal voltage at rated current, zero power factor, lagging (I_{fo}).
2. Draw a horizontal line through rated volts on the OCC. Locate the point P corresponding to the field current of the zero power factor test.

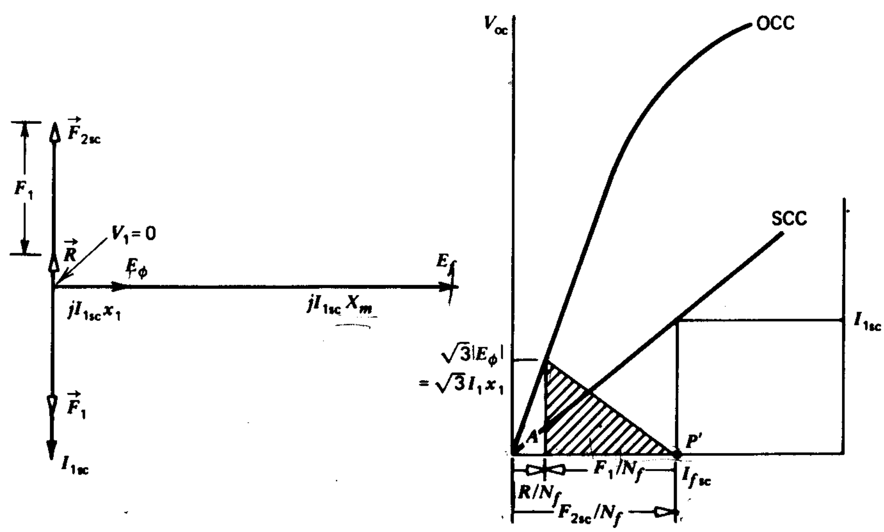

FIGURE 2.71 Conditions at short circuit.

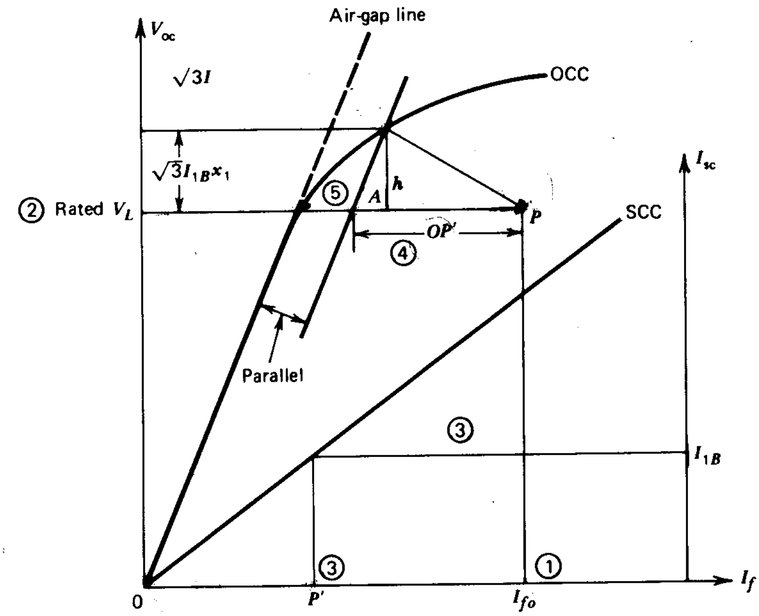

FIGURE 2.72 The Potier method of evaluating x_1.

3. Locate P' corresponding to rated current (same current used in zero power-factor test) on the SCC. The field current OP' is F_{2sc}/N_f of Figure 2.71.
4. Lay off the distance OP' to the left on P on the rated voltage line.
5. Through the point just located, draw a line parallel to the air gap line until it
6. intersects the OCC. This establishes the auxiliary triangle A of altitude h.

$$x_1 = \frac{h}{\sqrt{3}I_{1B}}$$

The reactance thus found is often called the Potier reactance rather than the leakage reactance. For cylindrical-rotor machines, it is a very good approximation for x_1. Some error arises from the fact that r_1 is neglected and that the Potier reactance does not include effects of harmonic fields.

The Potier reactance is not a very good measure of the leakage reactance of salient-pole machines. However when it is used as the value of x_1 to calculate excitation requirements by the saturated synchronous reactance method, the results are fairly good.

Approximate I_f Calculation

An often used approximate method for determining the field current employs the approximate saturated synchronous reactance x_{da} found by Equation 2.99 and further assumes that $|E_\phi|$ never varies much from the rated voltage of the machine. The process in finding I_f by this method is as follows:

1. Using $x_d = x_{da}$, apply Kirchhoff's voltage law to the circuit model to calculate E_f.
2. Taking $|E_\phi| = V_{1B}$, use the open-circuit characteristic to find the m' in Equation 2.78.