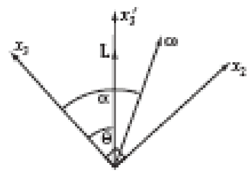
11-27.



Initially:

$$L_1 = 0 = I_1\omega_1$$

$$L_2 = L\sin\theta = I_1\omega_2 = I_1\omega\sin\alpha$$

$$L_3 = L\ xos\ \theta = I_3\omega_3 = I_3\omega\cos\alpha$$

Thus

$$\tan\theta = \frac{L_2}{L_3} = \frac{I_1}{I_3}\tan\alpha \qquad (1)$$

From Eq. (11.102)

$$\omega_3 = \dot{\phi}\cos\theta + \dot{\psi}$$

Since $\omega_3 = \omega\cos\alpha$, we have

$$\dot{\phi}\cos\theta = \omega\cos\alpha - \dot{\psi} \qquad (2)$$

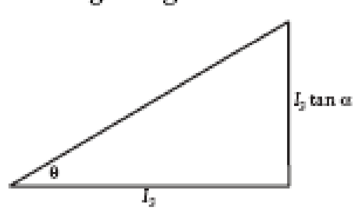
From Eq. (11.131)

$$\dot{\psi} = -\Omega = -\frac{I_3 - I_1}{I_1}\omega_3$$

(2) becomes

$$\dot{\phi}\cos\theta = \frac{I_3}{I_1}\omega\cos\alpha \qquad (3)$$

From (1), we may construct the following triangle



from which $\cos\theta = \dfrac{I_3}{\left[I_3^2 + I_1^2\tan^2\alpha\right]^{1/2}}$

Substituting into (3) gives

$$\dot{\phi} = \frac{\omega}{I_1}\sqrt{I_1^2\sin^2\alpha + I_3^2\cos^2\alpha}$$