11. TUNING

11.3 The signal after the integrator is

$$\square\ y = \int_0^{2\pi} \left(\sin[\omega]\sin\left[\varepsilon + \omega + \tfrac{1}{2}\pi\right]\right) d\omega$$

$$\triangle\ y = \int_0^{2\pi} \left(\sin[\omega]\left[\cos\left\{\varepsilon + \tfrac{1}{2}\pi\right\}\sin\{\omega\} + \cos\{\omega\}\sin\left\{\varepsilon + \tfrac{1}{2}\pi\right\}\right]\right) d\omega$$

$$\triangle\ y = \int_0^{2\pi} \left(\cos\left[\varepsilon + \tfrac{1}{2}\pi\right][\sin\{\omega\}]^2 + \cos[\omega]\sin[\omega]\sin\left[\varepsilon + \tfrac{1}{2}\pi\right]\right) d\omega$$

$$\triangle\ y = \int_0^{2\pi} \left([-\sin\{\varepsilon\}][\sin\{\omega\}]^2 + \cos[\omega]\sin[\omega]\sin\left[\varepsilon + \tfrac{1}{2}\pi\right]\right) d\omega$$

$$\triangle\ y = \int_0^{2\pi} \left([-\sin\{\varepsilon\}][\sin\{\omega\}]^2 + \cos[\omega]\sin[\omega]\cos[\varepsilon]\right) d\omega$$

$$\triangle\ y = \int_0^{2\pi} \left(\cos[\omega]\cos[\varepsilon]\sin[\omega] - [\sin\{\omega\}]^2\sin[\varepsilon]\right) d\omega$$

$$\triangle\ y = -\pi\sin(\varepsilon)$$

Hence, $y \approx -\pi\,\varepsilon$