



Figure 1.32 Determining the Q, or quality factor, of an LC tank.

*** Figure 1.32 ***

```

*#destroy all
*#run
*#plot db(vout)

```

```
.AC lin 100 400MEG 600MEG
```

```

lin Vout 0 DC 0 AC 1
R1 Vout 0 1k
L1 Vout 0 10n
C1 Vout 0 10p

```

```
.end
```

Frequency Response of an Ideal Integrator

The frequency response of the integrator seen in Fig. 1.33 can be determined knowing the op-amp keeps the inverting input terminal at the same potential as the non-inverting input (here ground). The current through the resistor must equal the current through the capacitor so

$$\frac{V_{in}}{R} + \frac{V_{out}}{1/j\omega C} = 0 \quad (1.13)$$

or

$$\frac{V_{out}}{V_{in}} = \frac{-1}{j\omega RC} = -\frac{1+j \cdot 0}{0+j\omega RC} \quad (1.14)$$

The magnitude of the integrator's transfer function is

$$\left| \frac{V_{out}}{V_{in}} \right| = \frac{\sqrt{(1)^2 + (0)^2}}{\sqrt{(0)^2 + (2\pi f RC)^2}} = \frac{1}{2\pi RCf} \quad (1.15)$$

while the phase shift through the integrator is

$$\angle \frac{V_{out}}{V_{in}} = - \left(\underbrace{\tan^{-1} \frac{0}{1}}_0 - \underbrace{\tan^{-1} \frac{2\pi RCf}{0}}_{\pi/2} \right) = +90^\circ \quad (1.16)$$

Note that the gain of the integrator approaches infinity as the frequency decreases towards DC while the phase shift is constant.

Unity-Gain Frequency

It's of interest to determine the frequency where the magnitude of the transfer function is unity (called the unity-gain frequency, f_{un}). Using Eq. (1.15), we can write