

Fig. 31—Theoretical attenuation of copper-shielded strip transmission line in dielectric medium ϵ_r . Courtesy of Transactions of the IRE Professional Group on Microwave Theory and Techniques.

picofarads/axial foot.

$$Z_0 = (L'/C')^{1/2} \times 10^3 \text{ ohms}$$

$$T = (L'C')^{1/2} \times 10^{-3}$$

microseconds/axial foot.

$$\alpha_{dB} = 4.34R/Z_0 + 27.3F_p f T$$

decibels/axial foot where R = total conductor resistance in ohms/axial foot, f = frequency in megahertz, F_p = power factor, and ϵ_r = relative dielectric constant of medium between spiral and outer conductor.

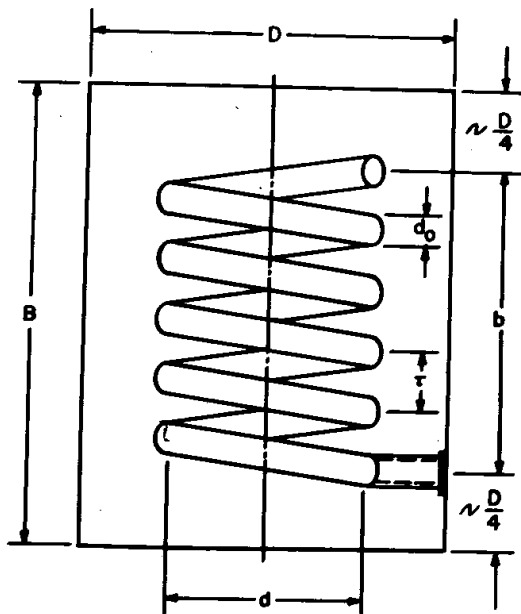


Fig. 32—Outline sketch of resonator. W. W. Macalpine and R. O. Schildknecht, "Coaxial Resonators with Helical Inner Conductor," Proceedings of the IRE, vol. 47, no. 12, p. 2100; December 1959. © 1959 Institute of Radio Engineers.

HELICAL RESONATOR*

Symbols

- b = axial length of coil, inches
- B = inside length of shield, inches
- d = mean diameter of turns, inches
- D = inside diameter of shield, inches
- d_0 = diameter of conductor, inches
- f_0 = frequency of resonance, megahertz
- n = turns per inch
- N = total number of turns of winding
- Q_u = unloaded Q

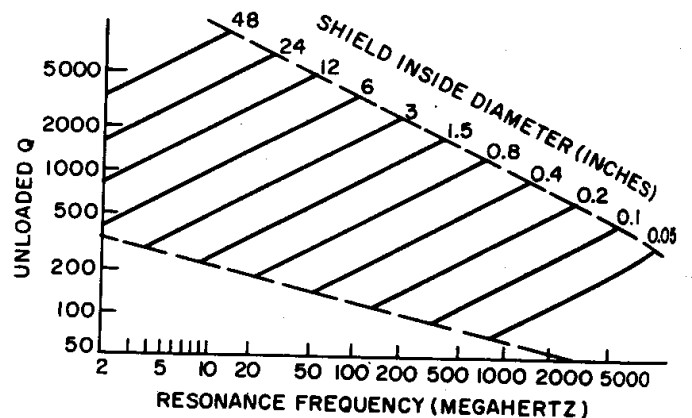


Fig. 33—Unloaded Q of helical resonator. W. W. Macalpine and R. O. Schildknecht, "Coaxial Resonators with Helical Inner Conductor," Proceedings of the IRE, vol. 47, no. 12, p. 2100; December 1959. © 1959 Institute of Radio Engineers.

* W. W. Macalpine and R. O. Schildknecht, "Coaxial Resonators with Helical Inner Conductor," Proceedings of the IRE, vol. 47, no. 12, pp. 2099-2105; December 1959. W. W. Macalpine and R. O. Schildknecht, "Helical Resonator Design Chart," Electronics, p. 140; 12 August 1960.

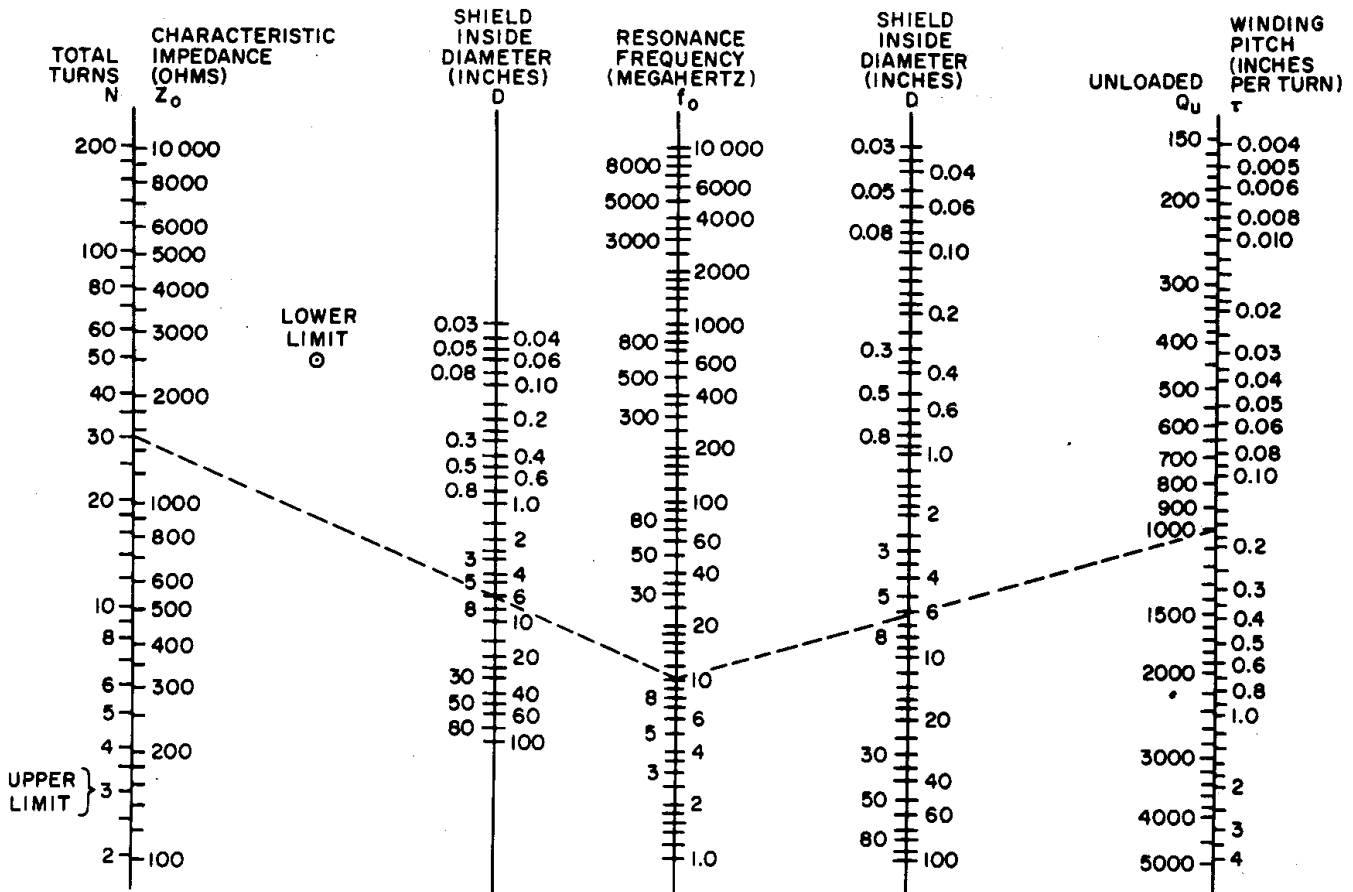


Fig. 34—Design chart for quarter-wave helical resonators. W. W. Macalpine and R. O. Schildknecht, "Coaxial Resonators with Helical Inner Conductor," *Proceedings of the IRE*, vol. 47, no. 12, p. 2101; December 1959. © 1959 Institute of Radio Engineers.

δ = skin depth, inch
 $\tau = 1/n$ = pitch of winding, inches.

Other symbols have the usual meanings, page 22-1.

The helical resonator shown in Fig. 32 consists of a shield (outer conductor) enclosing a coil (inner conductor). One end of the coil is solidly connected to the shield and the other end open-circuited, except possibly for a trimming capacitor. It operates as a distributed-parameter system equivalent to a quarter-wave coaxial transmission-line resonator. Probe, loop, or aperture coupling can be used for input and output circuits, or between adjacent coupled resonators.

Unloaded Q versus resonance frequency and shield diameter is shown in Fig. 33. The region plotted is where the helical resonator gives better Q for a given volume than other types. For higher Q and frequency, a conventional coaxial-line resonator is preferable. When the Q and frequency are lower than the plotted region, a lumped LC resonant circuit is indicated. These conditions are marked on Fig. 34 as "upper limit" (3 turns) and "lower limit," respectively.

Figure 34 is usually accurate to within ± 10 percent. It is plotted from the following equations and is limited by the conditions noted.

Unloaded Q is given for a resonator that consists of a single-layer coil of copper conductor on a low-loss form and is enclosed in a shield of seamless copper tubing. A shielded coil below its resonance

frequency also has ideally a true Q predicted by this equation. The equation gives a practical working value of Q somewhat below the theoretical maximum.

$$Q_u = 50Df_0^{1/2}$$

provided:

$$0.45 < d/D < 0.6$$

$$b/d > 1.0$$

$$0.4 < d_0/\tau < 0.6 \text{ at } b/d = 1.5$$

$$0.5 < d_0/\tau < 0.7 \text{ at } b/d = 4.0$$

$$d_0 > 5\delta.$$

Total number of turns

$$N = 1900 / (f_0 D) \text{ turns}$$

for $d/D = 0.55$, and $b/d > 1.0$.

Pitch of winding and characteristic impedance:

$$\tau = 1/n = (f_0 D^2) / 2300 \text{ inches per turn}$$

$$Z_0 = 98\,000 / (f_0 D) \text{ ohms}$$

for $d/D = 0.55$, and $b/d = 1.5$.

General conditions for all equations:

$$B \approx (b + D/2)$$

$$\tau < d/2.$$

Simplified and empirical equations from which