From December 2007 *High Frequency Electronics*

DESIGN NOTES

Those 'New' DIN 7-16 Connectors

The 7-16 connector has become a worldwide industry standard for wireless infrastructure site installations. This connector has been popular in Europe, but it's use in the U.S. is a relatively recent phenomenon. Previously, EIA flanged connectors were typical in applications with higher power than could be handled by a type N, LC, or similar connector.

The name comes from the sizes of the inner conductor (7 mm) and outer conductor (16 mm). The connector is weather sealed, impedance-matched, and can be mated and unmated with those adjustable wrenches that are present in every technician's toolbox!

Installation on cables is more complicated, given the variation in size, material and construction among cable manufacturers. However, each company either provides appropriate connectors or cooperates with a connector manufacturer to develop the appropriate construction and installation methods.

Materials are the same as any typical connector, typically silver plated brass bodies, beryllium copper spring-loaded mating surfaces, PTFE insulation and silicone rubber gaskets. Performance is excellent for a high power connector. Most models are rated for operation to 7.5 GHz with a maximum return loss at 2 GHz in the range of 20 dB. With robust construction and impedance-matched design, the passive IMD performance is excellent. At the highest frequencies (7.5 GHz), manufacturing tolerances result in some variation in published specifications, but SWR performance can be as low as 1.1:1 with shielding (leakage) performance in the 125 to 128 dB range.

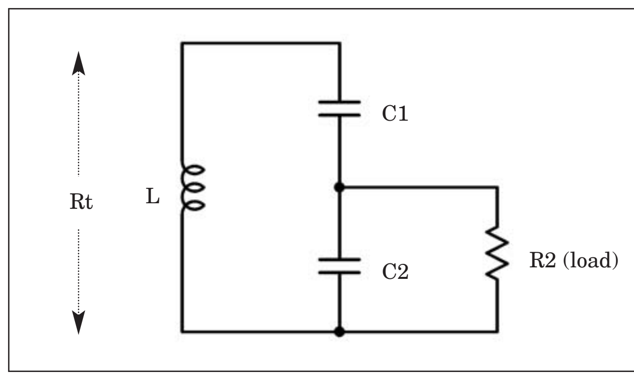
With widespread use in wireless base stations, the prices tend to be lower than other connectors in the same power and frequency range. Thus, the 7-16 is finding its way into more applications, such as satellite earth stations, broadcasting, and other high power systems operating from low RF frequencies to the mid-GHz range.

Some Useful LCR Circuits and Formulas for Their Calculation

The following notes are from a collection submitted by Ain Rehman. They describe various useful LCR circuits and the methods for calculating component values and operating parameters. We will include more of Mr. Rehman's notes in the next issue, covering basic LC matching networks

Tapped Capacitor Tuned Circuit

Tapped capacitor circuits are used extensively in the design of Colpitt's oscillators as well as in other tuned frequency applications where impedance transformation is needed, such as top-coupled filters. The circuit is shown below:



Here, R2 is the load across the tap. What is required is to find the values of L, C1, C2 when given R2, Rt, f_0 and B. f_0 is the resonant frequency, R2 is the load, Rt is the tank or terminal impedance and B is the bandwidth.

Note that this circuit acts as a transformer in that, it transforms the values of R2 into a value of Rt given by: $Rt/R2 = N^2$ where N is normally associated with the turns ratio of a transformer. This expression also describes the impedance transforming property of the tapped capacitor circuit.

The following formulas are approximate:

(For Qp = 10)

$$Qp = Qt/N \quad (1)$$

$$C2 = NC \quad (2)$$

$$C1 = C2/(N-1) \quad (3)$$

(For Qp<10)

$$Qp = \{[(Qt^2 + 1)/N^2\ ] - 1.0\}^{1/2} \quad (4)$$

$$C2 = Qp/\omega_0 R2 \quad (5)$$

$$Cse = C2(Qp^2 + 1)/Qp^2 \quad (6)$$

$$C1 = CseC/(Cse - C) \quad (7)$$

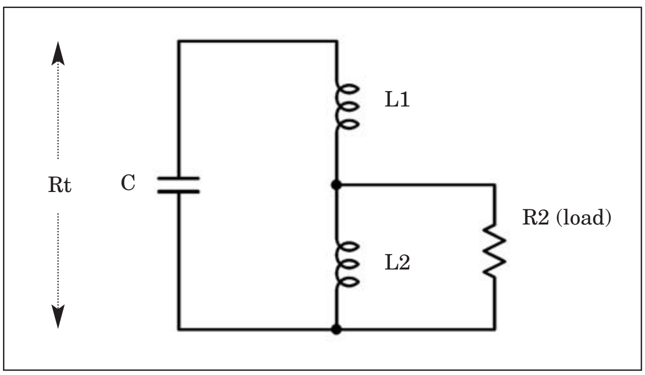
(continued on page 72)

The following are the definitions of the various quantities above.

$Qt \approx f_0/B$ (8)
$C \approx 1/2\pi B Rt$ (9)
$L \approx 1/\omega_0^2 C$ (10)
$N = (Rt/R2)$ (11)
$Qt / N \approx Qp$ (12)

Tapped Inductor Circuits

Tapped inductor circuits are circuits where the inductor is divided into two parts with a tap. This is shown below:



Since it is a complementary configuration, the analysis of the tapped inductor circuit is similar to that for the tapped capacitor circuit. It should be noted that a tapped inductor is really an autotransformer and as such has the properties of impedance transformation.

The following formulas are approximate.

(For Qp = 10)
$Qp = Qt/N$ (1)
$L2 = L/N$ (2)
$L1 = L2(N - 1) = L - L2$ (3)

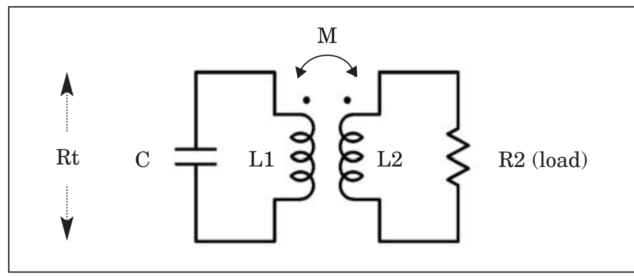
(For Qp< 10)
$Qp = \{[(Qt^2 + 1)/N^2] - 1.0\}^{1/2}$ (4)
$L2 = R2/\omega_0 Qp$ (5)
$Lse = L2\ Qp^2/(Qp^2 + 1)$ (6)
$L1 = L - Lse$ (7)

The following are the definitions of the various quantities above.

$Qt \approx f_0/B$ (8)
$C \approx 1/2\pi B Rt$ (9)
$L \approx 1/\omega_0^2\ C$ (10)
$N = (Rt / R2)$ (11)
$Qt/N \approx Qp$ (12)

Single Tuned Transformer ("Link Coupling")

The single tuned transformer provides a way to do impedance matching and isolation between input and output and a phase reversal if required. The design formulas include primary and secondary inductance (L1 and L2), mutual inductance M, coupling coefficient k and tuning capacitance C that satisfies the specified values for Rt, R2, f_0 and B. The schematic is shown below:



Experienced engineers may recognize this as "link coupling," which was commonly used in years past, and has been rediscovered for some integrated circuit applications.

The following formulas are approximate.

(For Qp = 10)
$k = (Qp/Qt)^{1/2}$ (1)
$L2 = R2/\omega_0 Qp$ (2)
$L1 = Lt$ (3)
$M = L1/N$ (4)

(For Qp< 10)
$k = \{(Qp^2 + 1)/(QpQt + 1)\}^{1/2}$ (5)
$L2 = R2/\omega_0 Qp$ (5)
$L1 = Lt\ [(Qp^2 + 1)/(Qp^2 + 1 - k^2)]$ (6)
$M = k(L1L2)^{1/2}$ (7)

Q factor

By definition, Q is the energy stored in the circuits divided by the average power dissipated by the circuit. This definition applies to all systems, not just LCR circuits.

$Q = R/\sqrt{(L/C)}$ [parallel RLC circuit]
$Q = \sqrt{(L/C)}/R$ [series RLC circuit]

There is also a one-to-one relationship between Q and the bandwidth of a tuned circuit:

$BW/\omega_0 = 1/Q$

Thus, higher Q means smaller bandwidth.