TCET Formula Sheet

Decibel Formulas

Relative Power Gain

$$A_P = \frac{P_O}{P_I}$$

where P_O and P_I are defined as the following:

$$P_I = \frac{V_I^2}{R_I}$$

$$P_O = \frac{V_O^2}{R_O}$$

Relative Voltage Gain

$$A_V = \frac{V_O}{V_I}$$

Relative Power Gain in dB

$$A_P(db) = 10\log_{10} A_P$$

Given that $R_O = R_I$

If $R_O \neq R_I$ then the general form is given by the following:

$$A_P(db) = 10\log_{10}\left(\frac{\frac{V_O^2}{R_O}}{\frac{V_I^2}{R_I}}\right)$$

Relative Voltage Gain in dB

$$A_V(db) = 20\log_{10}\left(\frac{V_O}{V_I}\right) = 20\log_{10} A_V$$

If $R_O \neq R_I$ then the general form is given by the following:

$$A_V(db) = 20\log_{10}\left(\frac{V_O}{V_I}\right) - 10\log_{10}\left(\frac{R_O}{R_I}\right)$$

Absolute Power Gain dBm

$$A_{P(dBm)} = 10\log_{10}\left(\frac{P}{1\ \text{mW}}\right),\ \text{dBm}$$

Absolute Power Gain dBw

$$A_{P(dBw)} = 10\log_{10}\left(\frac{P}{1\ \text{W}}\right),\ \text{dBw}$$

Signal-to-Noise Ratio

$$\text{SNR} = 10\log_{10}\left(\frac{\text{Signal Power}}{\text{Noise Power}}\right)$$

And given that $R_O = R_I$,

$$\text{SNR} = 10\log_{10}\left(\frac{V_S^2}{V_N^2}\right)$$

$$\text{SNR} = 20\log_{10}\left(\frac{V_S}{V_N}\right)\text{dB}$$

Impulse Noise

$$dB_S = 20\log_{10}\left(\frac{P}{0.0002\bar{\mu}}\right), \text{ where P is sound pressure in } \bar{\mu}$$

$$\bar{\mu} = 1\frac{\text{dyne}}{\text{cm}^2} = 10^{-6} \text{ of atmospheric pressure at sea level}$$

Convert Parallel to Series Resonant Circuits

$$R_s = \frac{R_p * X_p^2}{R_p^2 + X_p^2} = \frac{R_p}{Q^2+1}$$

$$X_s = \frac{R_p^2 * X_p}{R_p^2 + X_p^2} = \frac{X_p * Q^2}{Q^2+1}$$

Convert Series to Parallel Resonant Circuits

$$R_p = \frac{R_s^2 + X_s^2}{R_s}$$

$$X_p = \frac{R_s^2 + X_s^2}{X_s}$$

Impedance Matching

$R_{src} = R_L,$ for DC sources.

$Z_{src} = Z_L,$ for AC sources.

Source Resistance = Load Resistance

$P_I = P_O$

Key Points L-Pad Networks

1. The primary applications of L-networks involve impedance matching in RF circuits, transmitters, and receivers.
2. L-networks are useful in matching one amplifier output to the input of a following stage.
3. Any RF circuit application covering a narrow frequency range is a candidate for an L-network.
4. There are four basic versions of the L-network, with two low-pass versions and two high-pass versions.
5. Most widely used since they attenuate harmonics, noise, and other undesired signals.
6. **The impedances that are being matched determine the Q (quality factor) of the circuit, which cannot be specified or controlled.****
7. **There are limits to the range of impedances that it can match.****

Key Points Pi-Pad Networks

1. The π-networks primary application is to match a high impedance source to lower value load impedance
2. It can also be used in reverse to match a low impedance to a higher impedance.
3. The π-network also can be considered two back-to-back L-networks with a virtual impedance between them.
4. To use the L-network procedures, you need to assume an intermediate virtual load/source resistance $R_V = \frac{R_H}{Q^2+1}$
5. R_H is the higher of the two design impedances R_{src} and R_L
6. **The resulting R_V will be lower than either R_{src} or R_L depending on the desired Q.**
7. **Typical Q values are usually in the 5 to 20 range.**

Key Points T-Pad Networks

1. The main reason to employ a T-network like the π-network, is to get control of the circuit Q.
2. Like the π-network, it's used when you need to limit the bandwidth to reduce harmonics or help filter out adjacent signals without the use of additional filters.
3. The T-network also can be considered two cascaded L-networks. **This is equivalent to the π-network above.**

L-Pad Formulas (Low Pass 1)

$$Q = \sqrt{\frac{R_L}{R_{src}} - 1}$$

$$X_L = QR_{src}$$

$$L = \frac{X_L}{2\pi f}$$

$$X_C = \frac{R_L}{Q}$$

$$C = \frac{1}{2\pi f X_C}$$

$$BW = \frac{f}{Q}$$

L-Pad Formulas (Conversion Series-Parallel)

$$R_s = \text{ series resistance } = \frac{R_p}{Q^2+1}$$

$$R_p = \text{ parallel resistance } = R_s(Q^2+1)$$

$$X_s = \text{ series reactance } = \frac{X_p Q^2}{Q^2+1}$$

$$X_p = \text{ parallel reactance } = \frac{X_s(Q^2+1)}{Q^2}$$

$$Q = \sqrt{\frac{R_p}{R_s 1}} = \frac{X_L}{R_s} = \frac{R_p}{X_C}$$

If $Q > 5, y$ you can use the simplified approximations:

$$R_p = Q^2 R_s$$

$$X_p = X_s$$

L-Pad Formulas (Low Pass 2)

$$Q = \sqrt{\frac{R_{src}}{R_L} - 1}$$

$$X_L = QR_L$$

$$L = \frac{X_L}{2\pi f}$$

$$X_C = \frac{R_{src}}{Q}$$

$$C = \frac{1}{2\pi f X_C}$$

$$BW = \frac{f}{Q}$$

$$R_R = \frac{L}{CR} = R(Q^2+1) = \text{ resonant equivalent resistance}$$

Pi-Pad Formulas (Low Pass)

$$BW = \frac{f}{Q}$$

$$R_V = \frac{R_H}{Q^2+1}$$

$$X_L = QR_L;\ \text{use this formula for } X_{L_1} \text{ and } X_{L_2}$$

$$L = \frac{X_L}{2\pi f};\ \text{use this formula for } L_1 \text{ and } L_2$$

$$X_{C_1} = \frac{R_{src}}{Q}$$

$$X_{C_2} = \frac{R_L}{Q}$$

$$C = \frac{1}{2\pi f X_C};\ \text{use this formula for } C_1 \text{ and } C_2$$

$$Q = \sqrt{\frac{R_{src}}{R_L} - 1}; R_{src} = R_V$$

Add $L_1 + L_2$ to get total inductance.

T-Pad Formulas (LCC Method)

1. Select the desired bandwidth and calculate Q.
2. Calculate: $X_L = QR_{src}$ 3. Calculate $X_{C_2} = R_L\sqrt{R_{src}\frac{Q^2+1}{R_L}1}$
4. Calculate $X_{C_1} = R_{src}\frac{Q^2+1}{Q}\frac{QR_L}{QR_LX_{C_2}}$
5. Calculate the inductance $L = \frac{X_L}{2\pi f}$
6. Calculate the capacitances $C = \frac{1}{2\pi f X_C}$

Resonance

Etc.

Telecommunications (Chapter 11)

Etc.