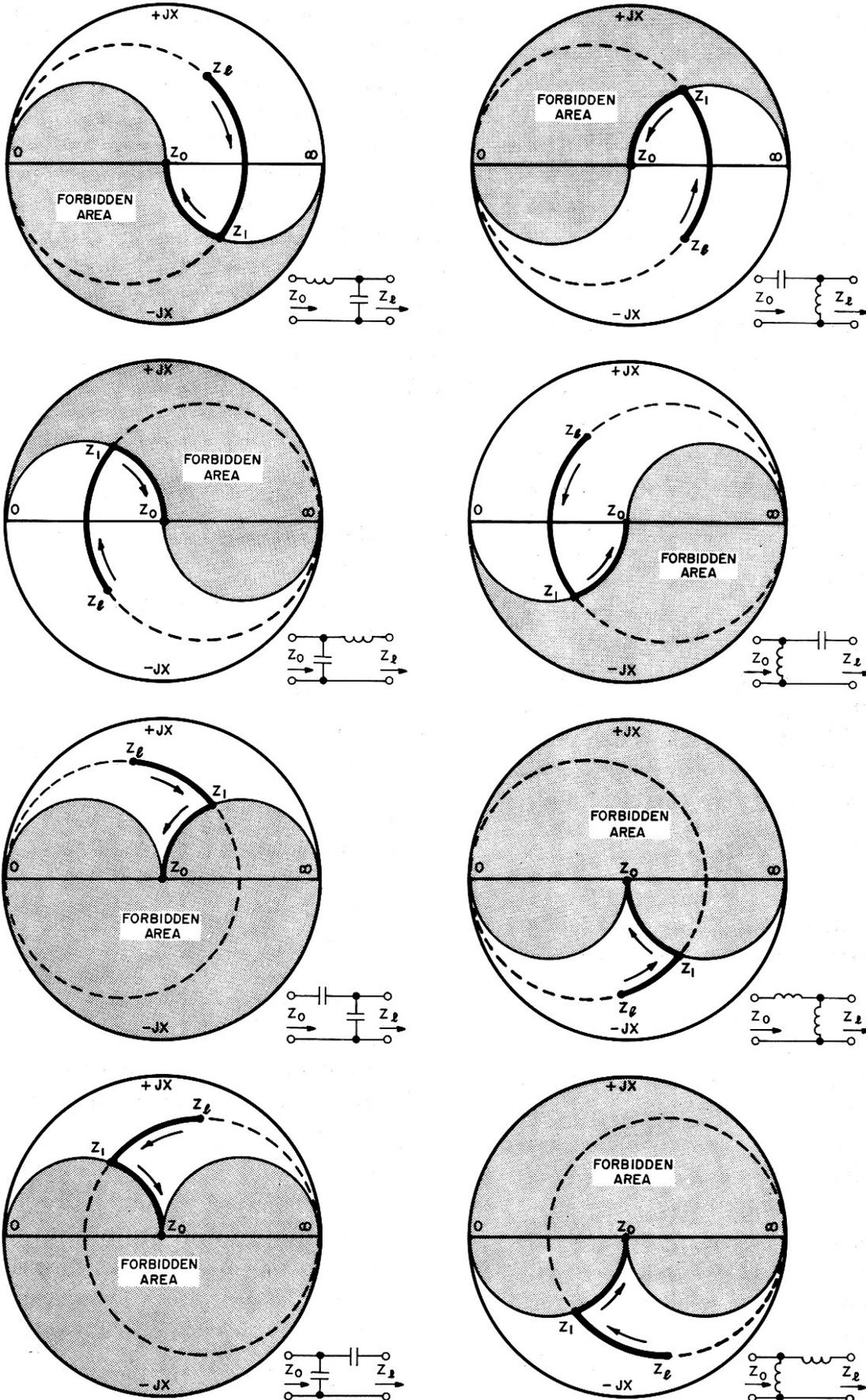
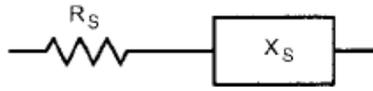


Impedance Matching Networks

Smith Chart Regions, Configurations and Equations

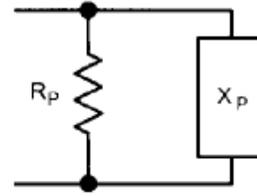
<http://www.qsl.net/va3iul>





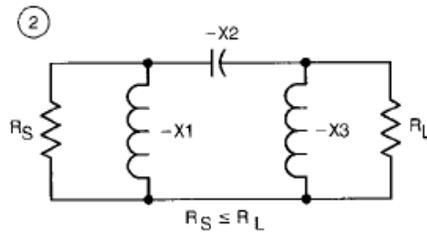
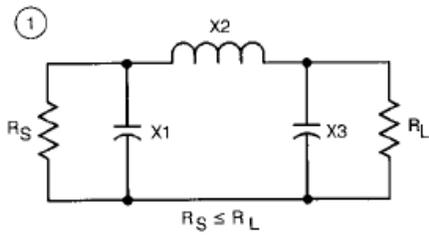
$$R_S = R_P \cdot \left[\frac{X_P^2}{R_P^2 + X_P^2} \right];$$

$$R_P = R_S \cdot \left[\frac{R_S^2 + X_S^2}{R_S^2} \right];$$



$$X_S = X_P \cdot \left[\frac{R_P^2}{R_P^2 + X_P^2} \right]$$

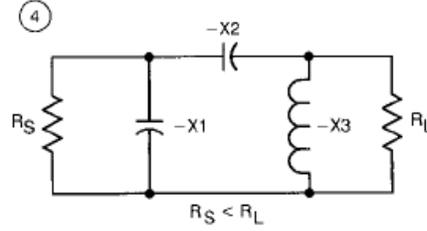
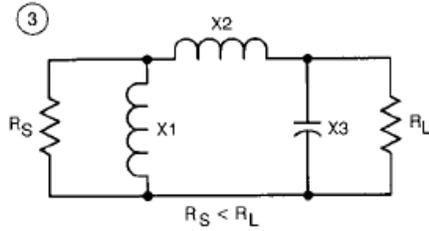
$$X_P = X_S \cdot \left[\frac{R_S^2 + X_S^2}{X_S^2} \right]$$



$$X1 = -R_S \sqrt{\frac{R_L/R_S}{Q^2 + 1} - (R_L/R_S)}$$

$$X2 = \frac{Q \times R_L - (R_S \times R_L / X1)}{Q^2 + 1}$$

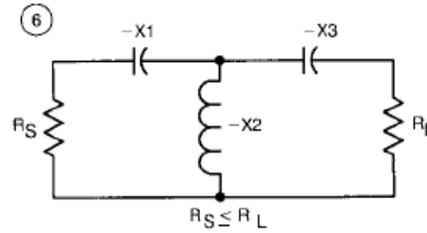
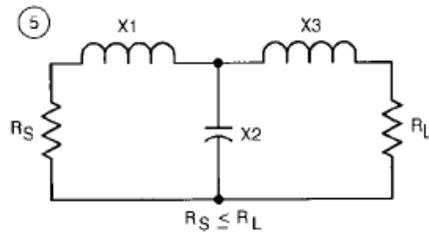
$$X3 = -\frac{R_L}{Q}$$



$$X1 = \frac{R_S}{\sqrt{\frac{R_S(Q^2 + 1)}{R_L} - 1}}$$

$$X2 = \frac{R_L \times Q}{Q^2 + 1} \left(1 - \frac{R_S}{Q \times X1}\right)$$

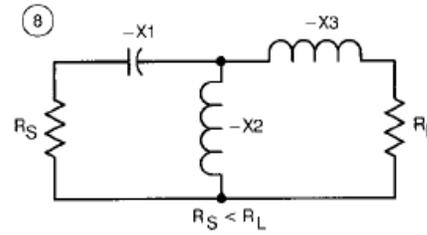
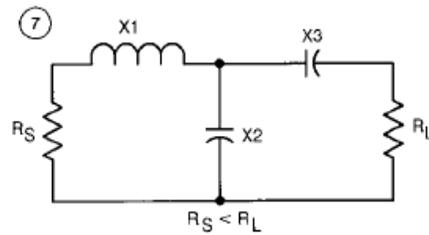
$$X3 = -\frac{R_L}{Q}$$



$$X1 = R_S \times Q$$

$$X2 = \frac{-R_S(1 + Q^2)}{Q + \sqrt{\frac{R_S(1 + Q^2)}{R_L} - 1}}$$

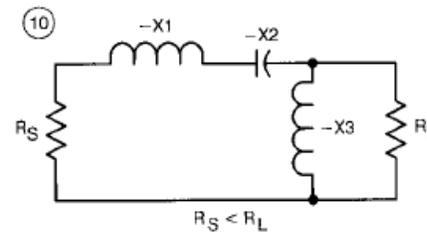
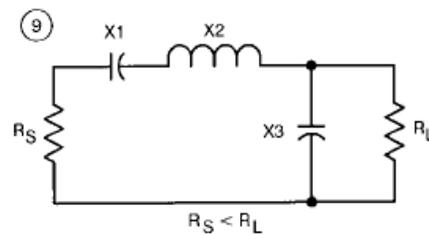
$$X3 = R_L \sqrt{\frac{R_S(1 + Q^2)}{R_L} - 1}$$



$$X1 = Q \times R_S$$

$$X2 = \frac{-R_S(1 + Q^2)}{Q - \sqrt{\frac{R_S(1 + Q^2)}{R_L} - 1}}$$

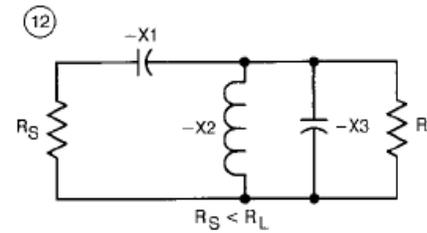
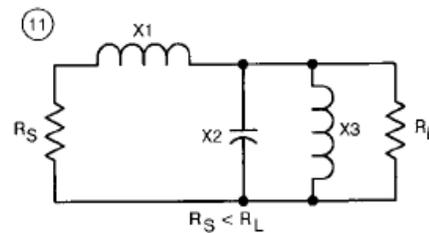
$$X3 = -R_L \sqrt{\frac{R_S(1 + Q^2)}{R_L} - 1}$$



$$X1 = -Q \times R_S$$

$$X2 = \sqrt{R_S \times R_L - R_S^2} - X1$$

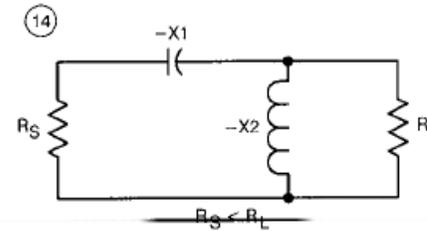
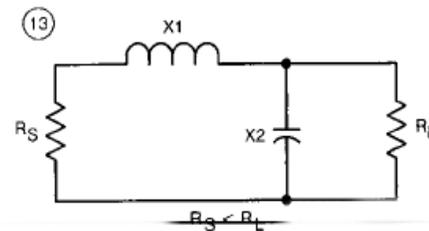
$$X3 = \frac{-R_S \times R_L}{X1 + X2}$$



$$X1 = R_S \sqrt{\frac{R_L}{R_S} - 1}$$

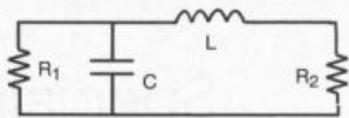
$$X3 = \frac{R_L}{Q}$$

$$X2 = \frac{-X3}{\frac{X1}{Q \times R_S} + 1}$$

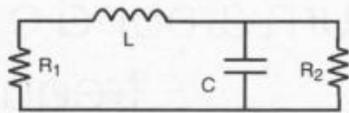


$$X1 = \sqrt{R_S \times R_L - R_S^2}$$

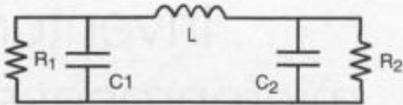
$$X2 = -\frac{R_S \times R_L}{X1}$$



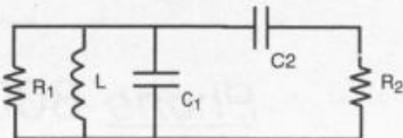
1a: L Section (a)



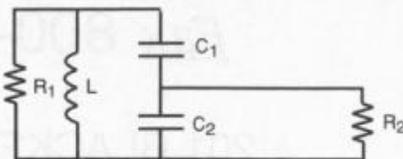
1b: L Section (b)



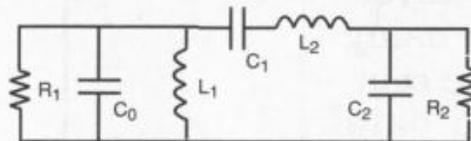
2: Pi Network



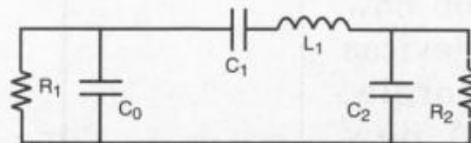
3: Gamma Network



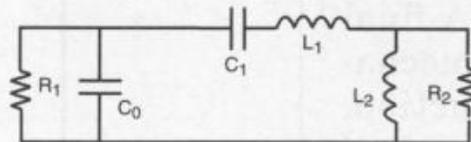
4: Tapped Capacitor



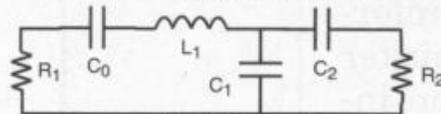
5: Modified PI Network I



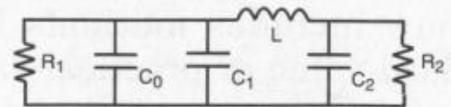
6: Modified PI Network II



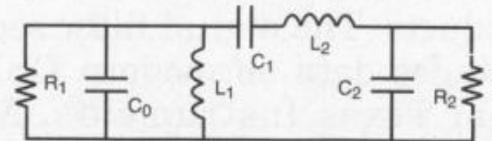
7: Modified PI Network III



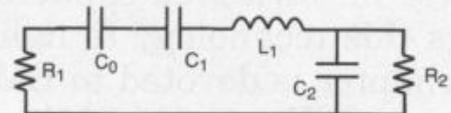
8: Modified T Network



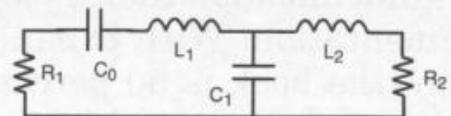
9: PI Network With Input C0



10: Modified PI Network IV



11: Modified L Network



12: T Network

1a: L section, Capacitive Input

Restriction: $R_1 > R_2$

$$X_L = \sqrt{R_1 R_2 - R_2^2}$$

$$X_C = \frac{R_1 R_2}{X_L}$$

$$Q = \frac{X_L}{R_2} = \frac{R_1}{X_C}$$

1b: L section, Inductive Input

Restriction: $R_1 < R_2$

$$X_C = R_1 \sqrt{\frac{R_1}{R_2 - R_1}}$$

$$X_L = \frac{R_1 R_2}{X_C}$$

$$Q = \frac{X_L}{R_1} = \frac{R_2}{X_C}$$

2: Pi network

Restrictions: $R_1 > R_2$, $Q > \sqrt{\frac{R_1}{R_2} - 1}$

$$X_{C1} = \frac{R_1}{Q}$$

$$X_{C2} = R_2 \sqrt{\frac{R_1 / R_2}{Q^2 + 1 - (R_1 / R_2)}}$$

$$X_L = \frac{QR_1 + R_1 R_2 / X_{C2}}{Q^2 + 1}$$

3: Gamma network

Restrictions: $R_1 > R_2$, $Q > \frac{X_{C2}}{R_2}$

$$X_L = \frac{R_1}{Q}$$

$$X_{C2} = R_2 \sqrt{\frac{R_1}{R_2} - 1}$$

$$X_{C1} = \frac{R_1}{Q} - \frac{1}{\left(1 - \frac{X_{C2}}{QR_2}\right)}$$

4: Tapped CapacitorRestrictions: $R_1 > R_2$, $Q > \sqrt{\frac{R_1}{R_2} - 1}$

$$X_L = \frac{R_1}{Q}$$

$$X_{C_1} = \frac{R_1 Q}{Q^2 + 1} \left(1 - \frac{R_2}{Q X_{C_2}} \right)$$

$$X_{C_2} = \frac{R_2}{\sqrt{\left(Q^2 + 1 \right) \frac{R_2}{R_1} - 1}}$$

5: Modified Pi networkRestrictions: $R_2 > R_1$, $\frac{R_2}{R_1} > \frac{Q^2}{Q^2 + 1}$

$$X_{C_1} = QR_1$$

$$X_{C_2} = \frac{R_2}{\sqrt{\frac{R_2(Q^2 + 1)}{R_1 Q^2} - 1}}$$

$$X_{L_1} = \frac{QR_1}{\left(\frac{QR_1}{X_{C_0}} \right) + 1}$$

$$X_{L_2} = QR_1 \left(1 + \frac{R_2}{Q X_{C_2}} \right)$$

6: Modified Pi network II

Restrictions:

$$Q > \frac{R_1}{X_{C_0}}; R_1 R_2 > X_{C_0}^2 \frac{Q^2}{Q^2 + 1}$$

$$X_{C_1} = Q \frac{X_{C_0}^2}{R_1} \left(1 - \frac{R_1}{Q X_{C_0}} \right)$$

$$X_{C_2} = \frac{R_2}{\sqrt{\frac{Q^2 + 1}{Q^2} \frac{R_1 R_2}{X_{C_0}^2} - 1}}$$

$$X_{L_1} = Q \frac{X_{C_0}^2}{R_1} \left(1 + \frac{R_2}{Q X_{C_2}} \right)$$

7: Modified Pi network III

Restrictions:

$$Q > \frac{\sqrt{R_1 R_2}}{X_{C_0}}; Q > \frac{R_1}{X_{C_0}}$$

$$X_{L_1} = Q \frac{X_{C_0}^2}{R_1} \left(1 - \frac{\sqrt{R_1 R_2}}{Q X_{C_0}} \right)$$

$$X_{L_2} = X_{C_0} \sqrt{\frac{R_2}{R_1}}$$

$$X_{C_1} = Q \frac{X_{C_0}^2}{R_1} \left(1 - \frac{R_1}{Q X_{C_0}} \right)$$

$$X_{C_2} = \frac{R_2}{Q} \left(\frac{Q X_{C_0}}{\sqrt{R_1 R_2}} - 1 \right)$$

8: Modified T network

Restrictions:

$$R_2 > R_1; Q > \sqrt{\frac{R_1}{R_2} - 1}$$

$$X_{L_1} = QR_1 + X_{C_0}$$

$$X_{C_2} = \sqrt{\frac{R_1}{R_2} (1 + Q^2) - 1}$$

$$X_{C_1} = R_1 \frac{1 + Q^2}{Q - \sqrt{\frac{R_1}{R_2} (1 + Q^2)}}$$

9: Pi network w/ input C_0

Restrictions:

$$R_1 > R_2; Q > \sqrt{\frac{R_1}{R_2} - 1}$$

$$X_{C_0} + X_{C_1} = \frac{R_1}{Q}$$

$$X_{C_2} = R_2 \sqrt{\frac{R_1 / R_2}{(Q^2 + 1) - (R_1 / R_2)}}$$

$$X_L = \frac{QR_1 + \frac{R_1 R_2}{X_{C_2}}}{Q^2 + 1}$$

10: Modified Pi network IVRestrictions: $R_2 > R_1$

$$X_{L_1} = X_{C_0}$$

$$X_{C_1} = QR_1$$

$$X_{C_2} = R_2 \sqrt{\frac{R_1}{R_2 - R_1}}$$

$$X_{L_2} = X_{C_1} + \frac{R_1 R_2}{X_{C_2}}$$

11: Modified L networkRestrictions: $R_2 > R_1$

$$X_{C_1} = QR_1$$

$$X_{C_2} = R_2 \sqrt{\frac{R_1}{R_2 - R_1}}$$

$$X_{L_2} = X_{C_1} + \frac{R_1 R_2}{X_{C_2}} + X_{C_0}$$

12: T network

Restrictions:

$$R_2 = R_1; Q > \sqrt{\frac{R_2}{R_1} - 1}$$

$$X_{L_1} = R_1 Q + X_{C_0}$$

$$X_{L_2} = R_2 \sqrt{\frac{R_1}{R_2} (Q^2 + 1) - 1}$$

$$X_{C_1} = \frac{R_1 (1 + Q^2)}{Q + \sqrt{\frac{R_1}{R_2} (1 + Q^2) - 1}}$$