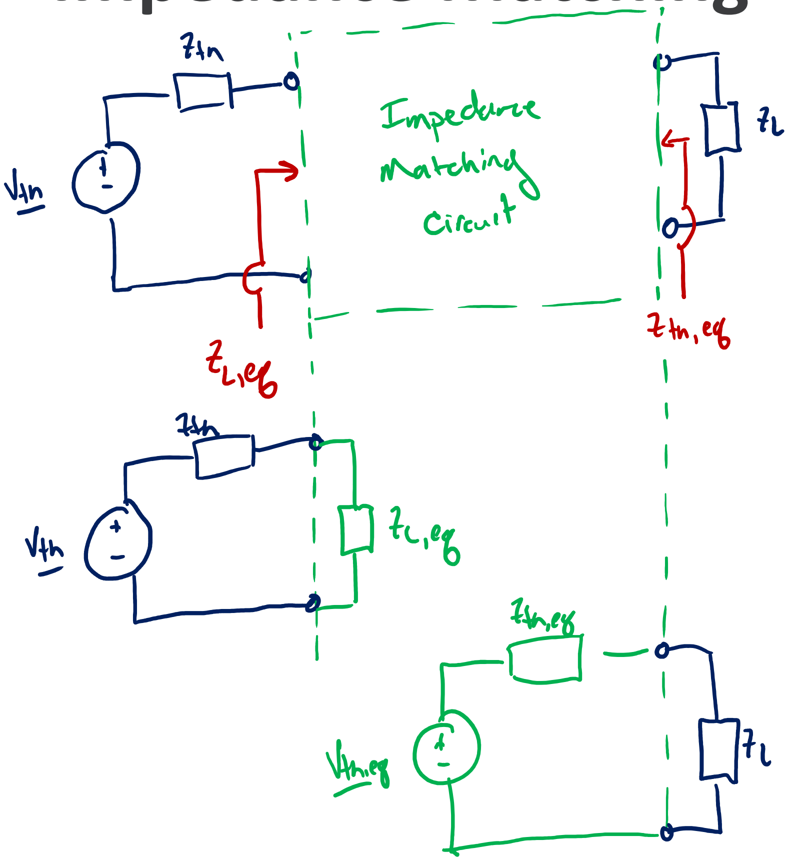
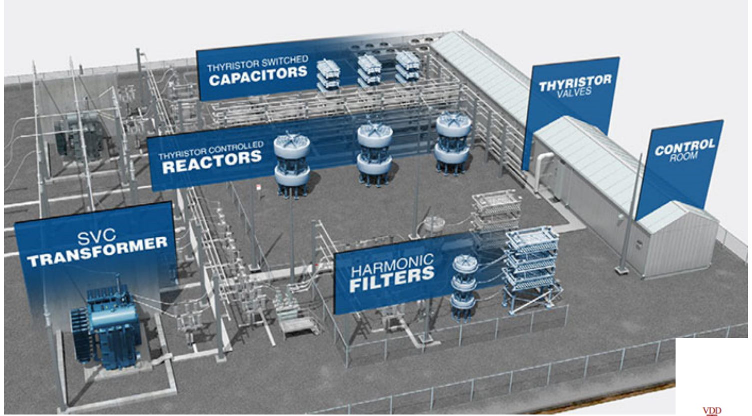
Impedance Matching

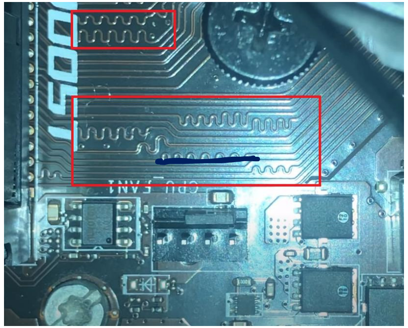


Impedance matching goals

- Maximize power transfer → $Z_L = Z_{th,eq}^*$
- Minimize distortion → $Z_L = Z_{th,eq}$
- Maximize efficiency → $Re\{Z_{th,eq}\} \ll Re\{R_L\}$
- Maximize Quality Factor → $Im\{Z_{L,eq}\} = \emptyset$

Example Matching Applications





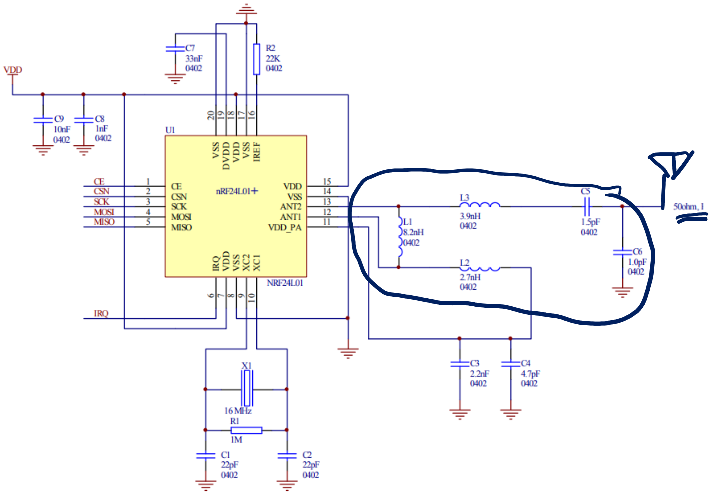
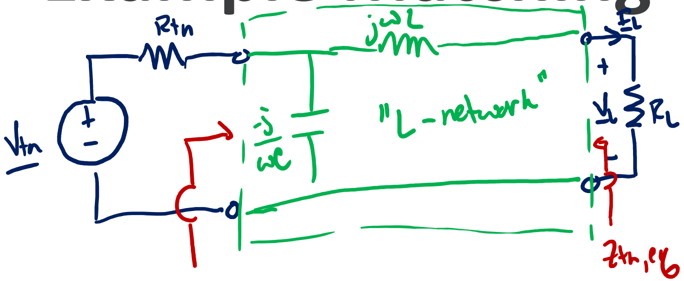


Figure 29. nRF24L01+ schematic for RF layouts with single ended 50Ω RF output

Example Matching Circuits

$R_{th} > R_L$, but want maximum possible power to R_L



Using "L-network" set $Z_L = Z_{th,eq}^*$ or $Z_{L,eq} = Z_{th}^*$

$Z_L = j\omega L = jX_L$, $X_L = \omega L$ | $Z_C = \frac{-j}{\omega C} = -jX_C$, $X_C = \frac{1}{\omega C}$

$$Z_{th,eq} = (R_{th} \| -jX_C) + jX_L$$

$$= \frac{-jX_C R_{th}}{R_{th} - jX_C} \cdot \frac{(R_{th} + jX_C)}{(R_{th} + jX_C)} + jX_L$$

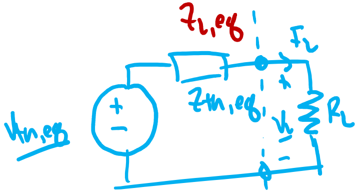
correct

$$= \frac{-jX_C R_{th}^2 + X_C^2 R_{th}}{R_{th}^2 + X_C^2} + jX_L$$

Note: In lecture, the line below was copied incorrectly. Rth is squared, not Xc, in the imaginary term

$$Z_{th,eq} = \frac{X_C^2 R_{th}}{R_{th}^2 + X_C^2} + j\left[X_L - \frac{X_C R_{th}^2}{R_{th}^2 + X_C^2}\right]$$

$Re\{Z_{th,eq}\} = R_L$ $Im\{Z_{th,eq}\} = 0$

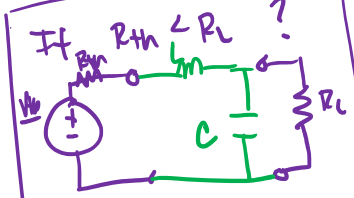


$$V_{th,eq} = \frac{V_{th}}{R_{th}}(R_{th} \| -jX_C)$$

$$X_C = \sqrt{\frac{R_L R_{th}^2}{R_{th} - R_L}}$$

$$X_L = \frac{X_C R_{th}^2}{R_{th}^2 + X_C^2}$$

If $R_{th} < R_L$?



Just flip the two ports

transformer can be used for scaling

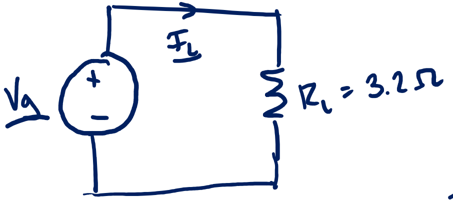
$X_C \to \infty$ $Re\{Z_{th,eq}\} \to R_{th}$
$X_C \to 0$ $Re\{Z_{th,eq}\} \to 0$
} this circuit reduces Rth

Matching Example

$\omega = 2\pi 60\,Hz$

$V_g = 170 \angle 0° \; V$

residential wall outlet is
120 V_{rms} = 170 V_{pk} @ 60 Hz



with $R_L = 3.2\,\Omega$ ≈ equivalent model of plugged-in load

$I_L = \frac{V_g}{R_L} = \frac{170 \angle 0°}{3.2} = 53 \angle 0° \; A$

$S_g = \frac{1}{2} V_g I_L^* = \frac{1}{2}(170 \angle 0°)(53 \angle 0°) = 4.5\,kW + j0\,VAR = 4.5 \angle 0° \; kVA$