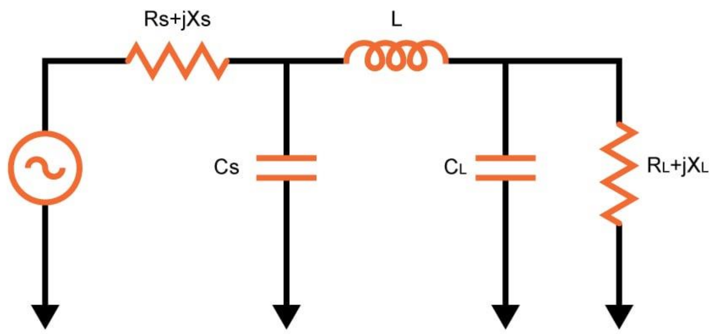
The Pi-Matching Network

You will probably notice on transmitter schematics, the familiar Pi-Match Network, it looks like the Pi symbol, hence its name. Here is an example:



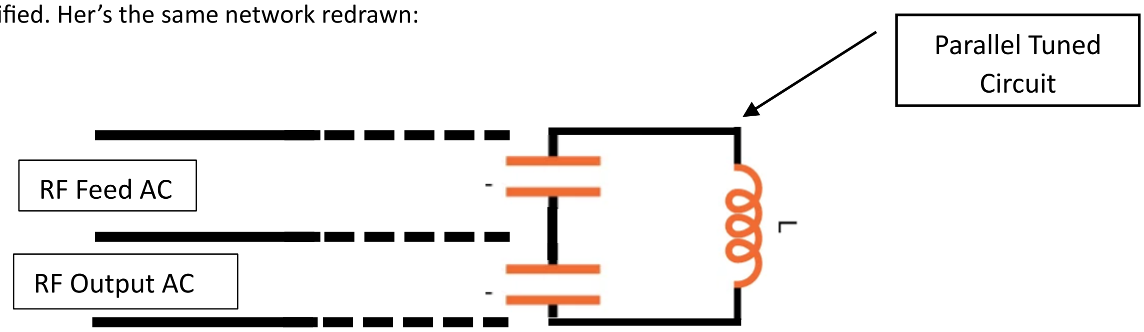
The AC generator on the left represents the transmitter output circuit, with a typical output impedance of a few ohms, up to typically 50ohms.

The left-most series impedance represents the output stage to matching circuit impedance. Then there are two shunt capacitors C-source and C-load and a series inductor L followed by the antennae impedance RL+jXL, or it could br RL + jXC depending on how the antenna is tuned, that means physically too long (XL) or too short (XC).

Therefore, in most cases there needs to be a match between the transmitter output stage and the attached antenna, the latter can also vary from a few-ohms up to many 000's of ohms, but ideally 50-ohms for a perfect match.

Cables used in RF systems have a typical characteristic impedance of 50-ohms. I'll use R for ohms from now on.

To the beginner the Pi-Match network can look daunting, but by some simple manipulation of the network, it can be simplified. Her's the same network redrawn:

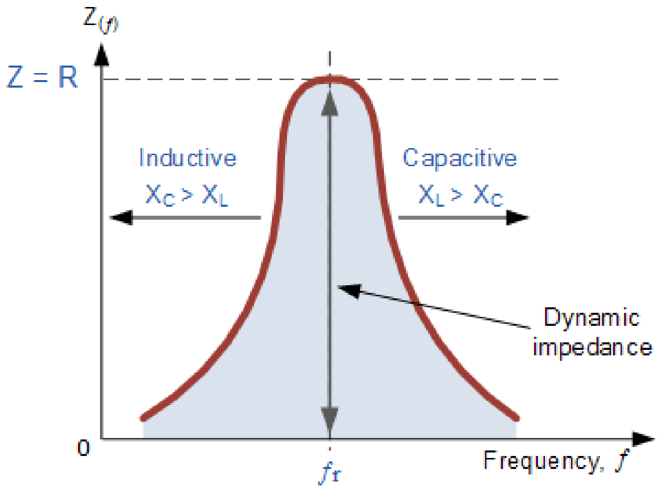


Now we have the same matching network, but re-arranged into a more familiar shape, that of a parallel tuned circuit, which is exactly what it is!

Now, we can conduct some simple analysis of the tuned circuit, to then see how it can be used for an RF Output stage to Antenna matching method.

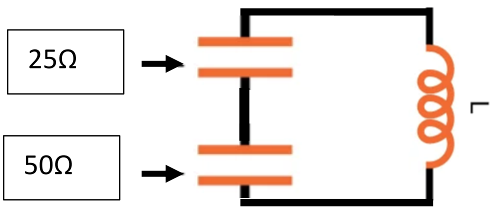
Let's assume the RF Transmitter output impedance is 25R and the antenna impedance is 50R and the frequency is 10MHz, derived form an inductor value of 2.5nH and a 'total' capacitance of 100nF, note in this instance the total capacitance is derived from two series capacitors, meaning two 200nF capacitors in-series:

1. First, we need to calculate the circuit impedance at resonance, which happens when the Inductive impedance equals the capacitor impedance:



Parallel Resonance

2. The actual resonant frequency is derived from the fact that the inductive and capacitive reactance values become equal, this occurs when:
    a. XL = 1/XC
    b. Or when:
        i. XL = 1 / (ωXC) where ω=2πF
        ii. Rearranging:
            1. ω^2 = 1 / LC, then ω = SQRT(1/LC)
            2. F = 1 / 2π$\sqrt{LC}$
            3. Frequency of resonance = 10.06MHz
3. Now let's determine the parallel impedance of the circuit at resonance, which will be the what's termed dynamic impedance or the remaining resistive component of the circuit at resonance:
    a. Rd = L/RC
    b. Therefore, in this example Rd = 0.0025Ω
4. Now let's consider the tuned circuit again, this noting that we can apply determine the ratio of impedance of the whole tuned circuit, then apport impedance based on the input/output impedance ratio:
    a. The input/output impedance ration (that needing to be matched) is 25Ω/50 or 0.5



    b. The required input circuit impedance of 25Ω can now be transformed up to 50Ω through transformer action and the ratio of impedances.
5. The RF output stage is now matched to the antenna input impedance.
6. In practice, the two shunt capacitors are typical variable, allowing for a precise match to be obtained.