Impedance Matching Network (IMN)

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*An **Impedance Matching Network (IMN)**, is commonly called an **'Antenna Coupler'**, **'Antenna System Coupler'**, **'Antenna Tuner'**, **'Antenna System Tuner'**, **'Transmatch'** or just **'Tuner'**.*

Most of the time an IMN is normally located inside a building at the Amateur Radio Service, Primary Station Operating Position with the Active Antenna's RF Feedline hooked to its output.

If the IMN is located 'inside' the building, the name ' Antenna Coupler' or 'Antenna Tuner' are inaccurate, because it does not Couple or Tune just the 'Active Antenna'.

'Antenna System Coupler', 'Antenna System Tuner' or 'Transmatch' are more accurate terms if the IMN is located inside the building at the Amateur Radio Service Primary Station Operating Position because, it Tunes, Couples or Matches the 'Entire Antenna System', which includes the 'Active Antenna' and the 'RF Feedline' connected to it.

If the IMN is located 'outside' the building hooked directly to the Active Antenna's feedpoint it would be an 'Antenna Tuner'.

An IMN is one piece of equipment that usually finds its way at one time or another into almost every Amateur Radio Station, operating on any of the Amateur Radio Service Bands of Medium Frequency [MF] (160 Meters), High Frequency [HF] (80 Meters - 10 Meters), Very High

Frequency [VHF] (6 Meters - 1.25 Meters) and Ultra High Frequency [UHF] (.70 Meters - .23 Meters).

<u>Why should a IMN be used?</u> Because many Amateur Radio Stations have limited Active Antenna choices, which have many various feedpoint impedances and the need to operate on frequencies other than where the Active Antenna is resonant, or use a non-resonant Multiband Active Antenna, all of which necessitate the use of an IMN.

An IMN is an Electrical Transformer that contains Inductors and Capacitors which form a Parallel Inductive-Capacitive (LC) Network either in a 'Hi-Pass Filter "T" Configuration' or a 'Low-Pass Filter "Pi" Configuration'.

These LC Networks can be adjusted to transform mismatches of impedances between the various different types of Active Antenna feedpoint Impedances (Z) and the connecting RF Feedline Characteristic Impedances (Zo). These necessary adjustments will provide the station's Equipment, inline before the IMN, in both the Transmit and Receive modes, with a proper circuit impedance of 50Ω.

Impedance mismatches are caused when an Active Antenna's feedpoint Impedance and the connecting RF Feedlines Characteristic Impedance are not of an equal value and do not provide a required circuit impedance of 50Ω.

In the 'Classical AC Generator', the condition required for a Maximum Power delivery from a Source to a Load, is when the Load Impedance (Z_L) equals the Source Impedance (Zs) of the AC Generator. This condition is called a **'*conjugate match*'**. *The term 'conjugate match' means that if in one direction from a junction the impedance (Z) is R + jX, then in the opposite direction the impedance (Z) is R – jX.*

Some but not all modern Transceiver's provide as a standard feature or an optional feature, an Internal 'Automatic Tune' IMN. These Internal Automatic Tune IMNs can usually transform an impedance mismatch of up to approximately a 3.0:1 Voltage Standing Wave Ratio (VSWR) to a 1.0:1 VSWR on a RF Feedline, but beyond that point either an 'External Automatic Tune' or 'Manual Tune' IMN will be needed.

A measure of an IMN ability to transform impedances efficiently is energy loss*.** Under extreme conditions an IMN can get quite hot or arc over at power levels well under the manufacturers rating. With the wide range of radio frequencies in the electromagnetic spectrum and with the huge diversity of antenna types in use, an IMN is expected to perform under an incredible number of possible combinations. Some IMNs are more efficient at this than others and ***heat in an IMN is a product of energy loss. ***RF energy being dissipated as heat is lost power that will not find its way to your Active Antenna and into the air***.

IMN energy losses generally get higher as the impedance of the load decreases. **Most of the power losses (Lost Power = I^2R) in an IMN primarily occur in the 'Coil', and no coil can withstand high power for very long.** If the maximum RF Peak Envelope Power (PEP) 'output' from the Transmitter and / or External Inline RF Power Amplifier (RFPA) is more than the IMNs designed maximum RF Peak Envelope Power (PEP) 'output' handling capability, than there is a possibility of damaged to the IMN coil. **Power that is not dissipated by the load is wasted power and will be dissipated as heat.**

1. As an example, 1500 Watts PEP output power being transmitted from a 50Ω output impedance External Inline RF Power Amplifier into a 50Ω input impedance IMN, which is properly adjusted to transform a 50Ω scorce impedance to a 5Ω load impedance, would have approximately 90% to 98% of the power delivered into a 5 ohm load impedance, consequently, there will be some power loss in the form of heat dissipated in the IMN. This loss will primarily occur in the coil of the Impedance IMN. In this example there could be as much as 30~150 watts of lost power dissipated in the IMN coil. 1500W PEP x 90%~98% = 30~150W lost power.

2. A good 'Rule of Thumb' to use when deciding on what power handling capability a IMN should have, is one with a Peak Envelope Power (PEP) ‘output' rating of at least 'Two 1/2 (2.5)' to 'Three (3)' times the PEP output rating of the transmitters internal RF Power Amplifier Stage, or External inline RF Power Amplifier (RFPA).

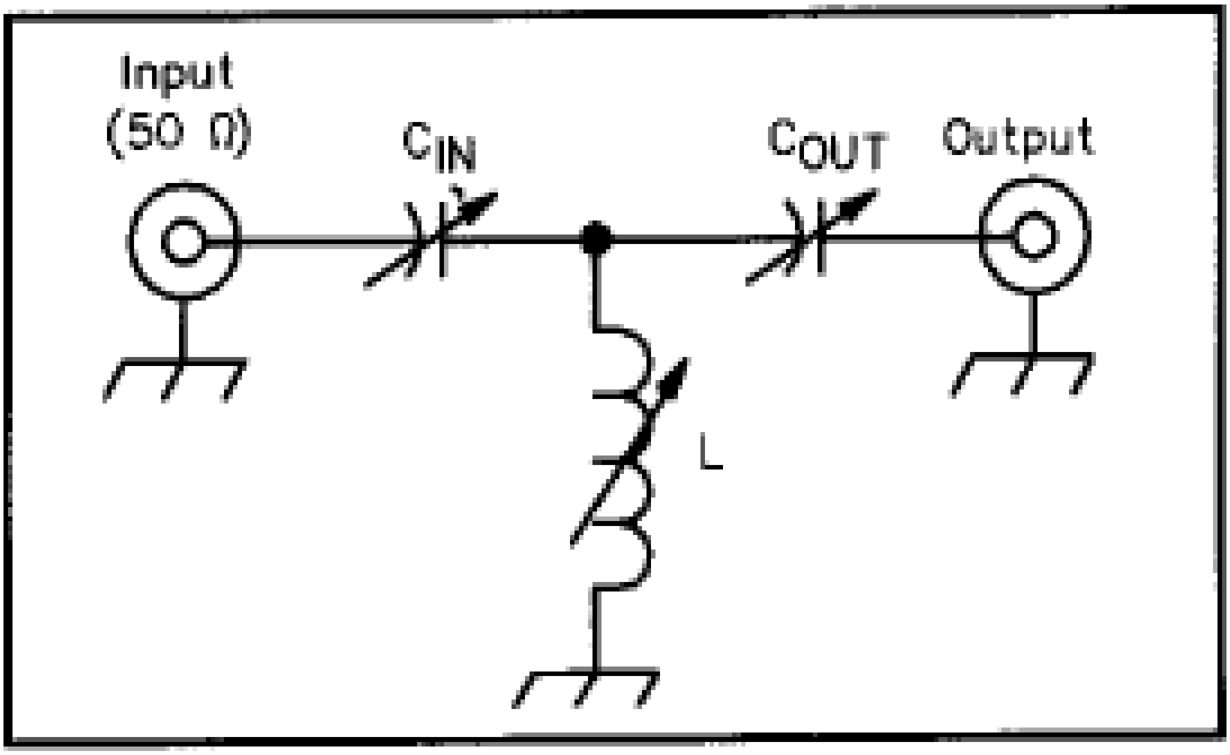
    a. Examples:

        i. 100 Watts PEP 'Output' Transmitter should use a 250 ~ 300 Watt PEP 'Output' IMN.

        ii. 200 Watts PEP 'Output' Transmitter should use a 500 ~ 600 Watt PEP 'Output' IMN.

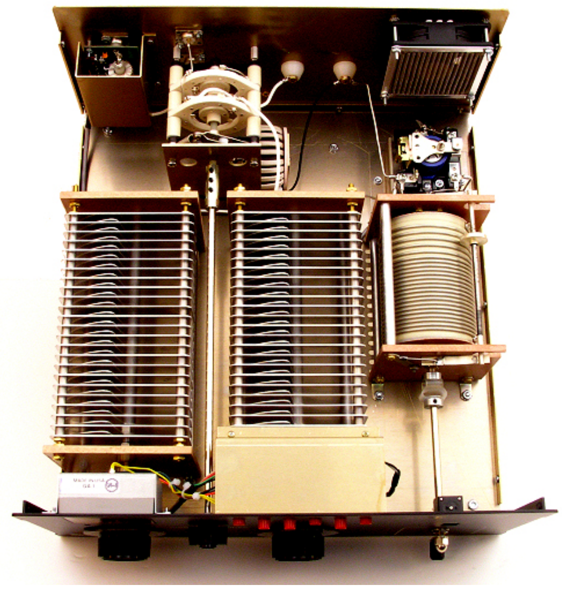
        iii. 800 Watts PEP 'Output' RF Power Amplifier should use a 2000 ~ 2400 Watt PEP 'Output' IMN..

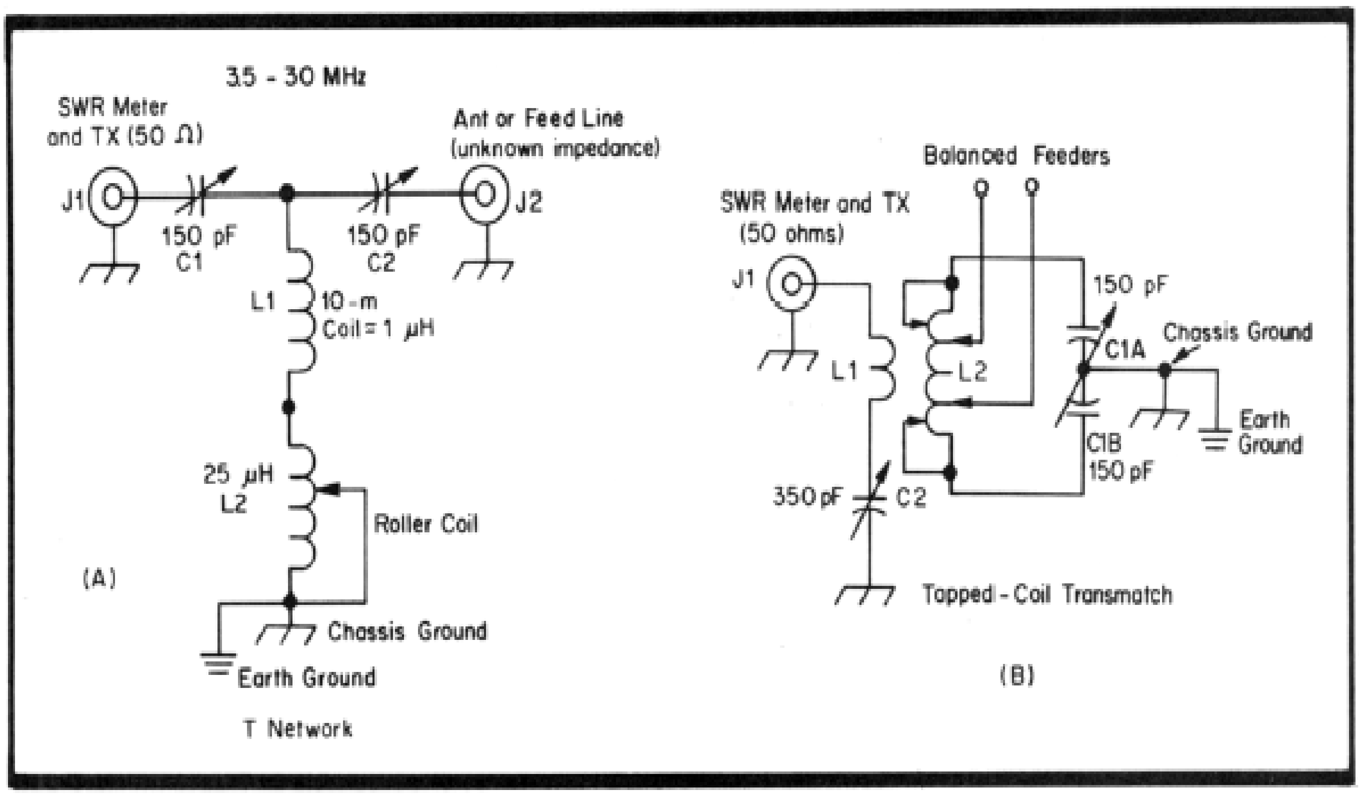
        iv. 1500 Watts PEP 'Output' RF Power Amplifier should use a 3750 ~ 4500 Watt PEP 'Output' IMN.



The above 'Generic' circuit shows a 'T' Hi-Pass Filter Network, so called because the capacitor and inductor setup look like the letter 'T' of the alphabet. Most modern transceivers have a built-in Automatic Tune IMN and most modern External Automatic Tune and Manual Tune **IMN** using this type of circuit.

1. In the 'Automatic' Tune IMN, there are motors, which adjust the circuit’s tuning capacitors ('Cin or C1' and 'Cout or C2'), and relays ground various 'L' taps to vary the network’s inductance. (Relays may switch in additional inductance or capacitance to extend the network’s tuning or matching range.)
2. In the 'Manual' Tune IMN, there are front-panel controls labeled ‘Transmitter' [Cin or C1]’ and ‘Antenna' [Cout or C2]’, which adjust the capacitors, and the 'L' may be a front-panel-adjustable roller inductor adjusted by a hand crank or a multiple tapped coil with a rotary switch.
3. The 'T' network’s 'Cin or C1' and 'Cout or C2' normally have a capacitance range of 20 pF – 300pF and the 'L' has an inductance range of 0.1 μH – 35 μH.





The above schematic diagram shows two example circuits for a Manual Tune IMN.

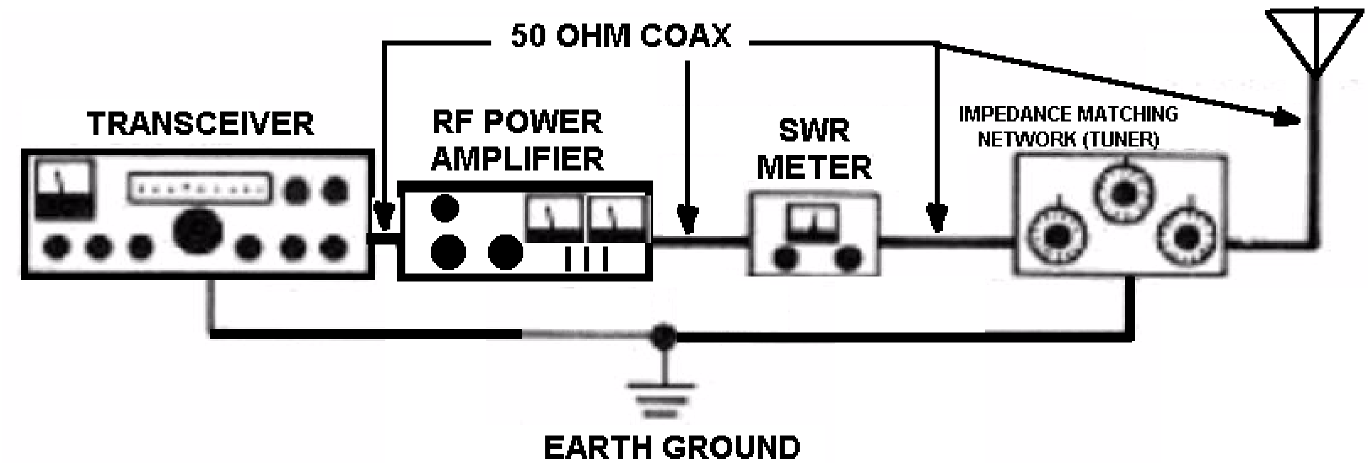
1. The circuit at (A) is a 'T' Hi-Pass Filter Network, which is a popular version used by most manufacturers. 'C2' is adjusted along with 'C1' to obtain an SWR of 1.0:1.

    a. 'L1' is usually included to improve the circuit 'Q' at 10 and 15 meters, because some roller inductors do not have a tapered coil pitch at one end of the inductor.

    b. *Increasing the capacitance of this sample circuit's air variable capacitors 'C1' and 'C2' to 300 pF will enable the circuit to work from 1.8 – 30 MHz.*

2. Circuit (B) has a tapped coil and the outer taps are adjusted to change the coil inductance. The inner taps are moved equally from the ends of 'L2' to obtain a matched condition for balanced feed lines. 'C2' is adjusted along with 'C1' to obtain an SWR of 1.0:1. 'L1' is a small link over the center of 'L2'.

    a. A single-wire antenna may also be tuned with this circuit by connecting it to one of the inner coil taps.



The above figure shows the correct way to connect a Transceiver, RF Power Amplifier, SWR Meter and IMN. Some IMN contain a built in SWR Meter and if this is the case, the external SWR Meter shown between the RF Power Amplifier and IMN may be eliminated. Some IMN are equipped with a built in Balun Transformer to allow the use of Balanced RF Feedlines (Twin Lead Line, Window Line or Ladder Line). Terminals for balanced lines are located on the rear of the IMN.