RF Power Amplifier (RFPA)

Designing a 'Input Tank Circuit'

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Power Triode Electron Tube

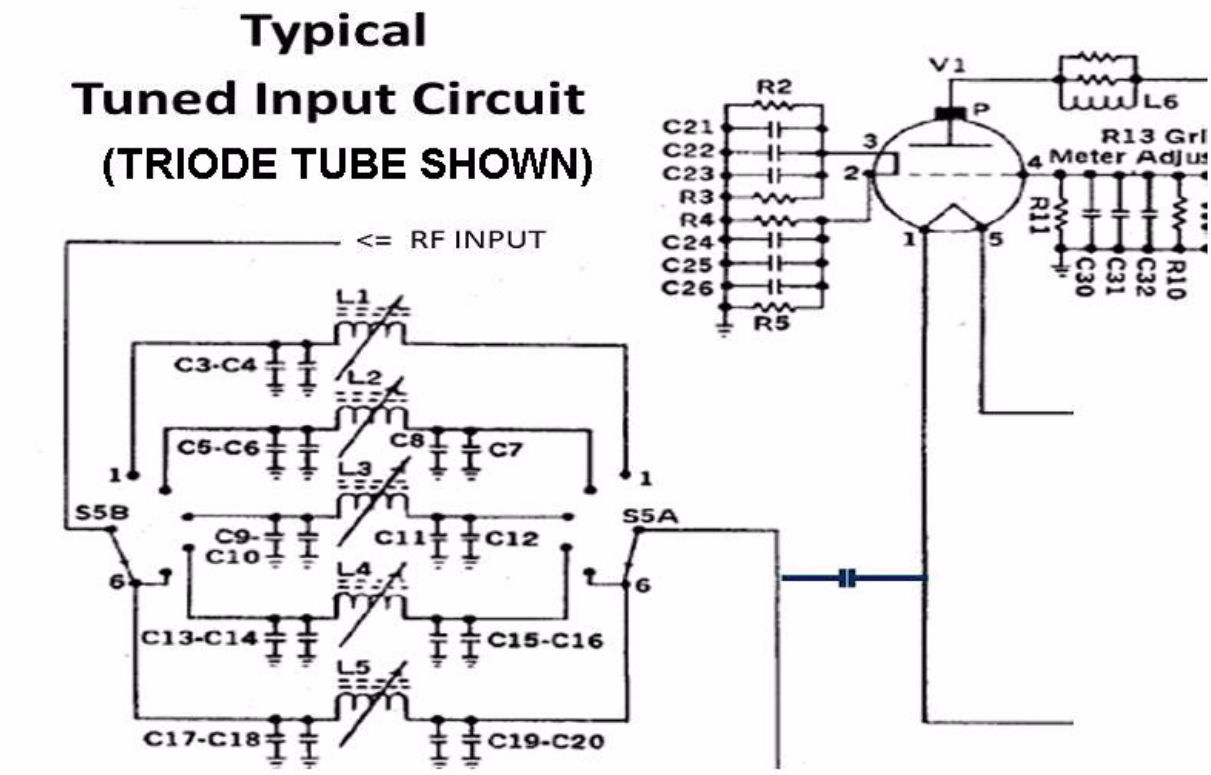


Figure-1 Input 'Tank' Circuit Network in Low-Pass Filter (LPF) 'Pi' and 'L' Configurations

1. Figure-1 above is a schematic diagram illustrating a 'Tuned Input Coupling Filter Network Circuit using a 'Pi' configuration on 15, 20, 40, 75 and 80 Meters and a 'L' configuration on 10 Meters. Most 'Pi' an 'L' configurations use fixed capacitors and variable inductors. Component may be either fixed or variable (adjustable) values.
2. When a Alternating Current (AC) Signal Voltage is fed to the input of a Electron Tube RF Power Amplifier (RFPA), AC Impedance (electronic symbol 'Z') measured in Ohms

(electronic symbol 'Ω') is the primary Characteristic, not the DC Resistance (electronic symbol 'R'), measured in Ohms (electronic symbol 'Ω) with a Volt/Ohm meter.

3. Alternating Current (AC) Impedance (Z), is made up of a combination of different Characteristic Values caused by the AC and all of the circuit Components which include:
    a. The Capacitive Reactance (electronic symbol 'Xc') of Capacitors ('C').
    b. The Inductive Reactance (electronic symbol 'XL') of Inductors ('L').
    c. The Resistance (electronic symbol 'R') of Resistors ('R').
    d. The Frequency (electronic symbol 'F') of the Alternating Current (AC).
4. When any one of these Characteristic Values change, the value of the AC Impedance (Z) will also change.
5. Most Electron Tube RF Power Amplifiers (RFPA), using a Power Triode configured in Grounded Grid (GG), Cathode Driven (CD), configuration do not normally have a Cathode Impedance (Z) that is 50Ω. Because of this an Impedance (Z) Matching, Low Pass Filter (LPF) Network, configured in a constant 'K', 'Pi' or 'L' is required:
    a. If there is no Network it will permit input driving RF AC Signal Voltage Waveform Distortion, resulting in;
        i. A higher degree of Intermodulation Distortion (IMD).
        ii. Reduced amplifier efficiency.
        iii. Driver (Exciter) loading problems.
        iv. A higher Voltage Standing Wave Ratio (VSWR) created on the connecting 50Ω Characteristic Impedance (Z) RF Coaxial Feedline between the Transmitter output and Amplifier input.
        v. The Transmitter will fold back on RF output power, reducing the drive AC signal voltage to the Electron Tube(s), which in turn reduces the RF power output from the Electron Tube(s).
6. RF Power Amplifier stages in modern Solid-State Amateur Radio Service Transceivers have a designed Fixed 50Ω Output 'Source' Impedance (Z) and a Fixed Input 'Load' Impedance (Z). This Fixed Impedance (Z) requires a 50Ω 'Load' Impedance (Z) in Transmit Mode and a 50Ω 'Source' Impedance (Z) in Receive Mode for a maximum transfer of RF Power.
    a. The RF Coaxial Cable Feedline 50Ω Characteristic Impedance (Z), connected to the Transceivers RF output connector is the Transceivers first 'Load' Impedance (Z).

b. Then the RF Coaxial Cable Feedline 50Ω Characteristic Impedance (Z) becomes the 'Source' Impedance (Z) for the RF Power Amplifier (RFPA) 'Pi' or 'L' configured Low Pass Filter (LPF) Networks 'Load' Impedance (Z).
c. The RF Power Amplifier (RFPA 'Pi' or 'L' configured Low Pass Filter (LPF) Network becomes the 'Source' Impedance (Z) for the RF Power Amplifier (RFPA) Electron Tube(s) Cathode 'Load' Impedance (Z).

7. The Tuned-Cathode input circuit coupled by a length of 50Ω Characteristic Impedance (Z) RF Coaxial Cable Feedline from a Transmitter, is recommended to be designed with a 'Q' of between 'two' (2) and 'four' (4). A simple rule of thumb is that the network circuit capacitances at resonance should be about 20 pF per meter of wavelength for one-to-one impedance transformation.
8. A RF Power Amplifier (RFPA) internal input 'Pi' or 'L' configured Low Pass Filter (LPF) Impedance matching network, does the same function as adding a separate external 'Pi' or 'L' configured Low Pass Filter (LPF) Impedance matching network (called a Tuner, Antenna Tuner, Antenna System Tuner, Antenna Tuning Unit or Transmatch) between your Transmitter's designed 50Ω Impedance (Z) RF output connector which is the 'Source' Impedance (Z) for the connecting RF Transmission Feedline's Characteristic Impedance (Z) 'Load'. Then the RF Transmission Feedline's Characteristic Impedance (Z) is the 'Source' Impedance (Z) for a Active Antenna's Impedance (Z) 'Load'.
9. Examples of some electron tube cathode input Impedance (Z) ohmic (Ω) values:
    a. 3-500Z
        i. One tube = 115Ω
        ii. Two tubes in parallel = 57.5Ω
        iii. Three tubes in parallel = 38.33Ω
        iv. Four tubes in parallel = 28.75Ω
    b. 572B
        i. One tube = 215Ω
        ii. Two tubes in parallel = 107.5Ω
        iii. Three tubes in parallel = 71.66Ω
        iv. Four tubes in parallel = 53.75Ω
    c. 811A
        i. One tube = 320Ω

ii. Two tubes in parallel = 160Ω

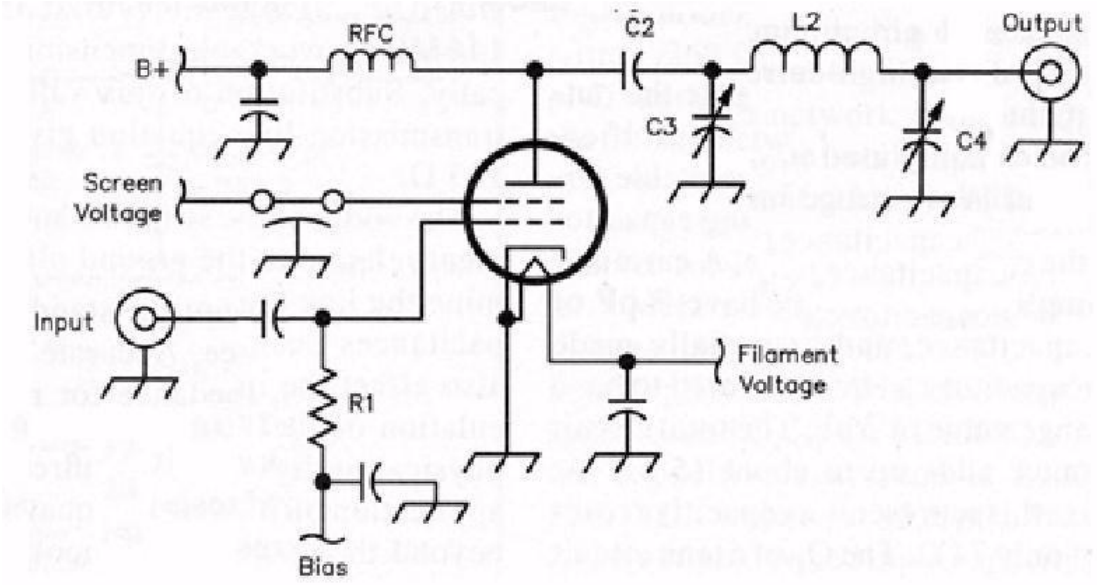
iii. Three tubes in parallel = 106.66Ω

iv. Four tubes in parallel = 80Ω

CATHODE CIRCUIT VALUES FOR GROUNDED-GRID AMPLIFIER

Cathode Z_t (Ω)	Band	C1(pF)	C2(pF)	L(μH)	Cathode Z_t (Ω)	Band	C1(pF)	C2(pF)	L(μH)
20	160	3300	4100	2.50	75	160	3300	2870	3.81
	80	1700	2120	1.34		80	1700	1540	2.05
	40	900	1120	0.68		40	900	770	1.03
	20	440	560	0.33		20	440	380	0.51
	15	300	370	0.22		15	300	250	0.34
	10	220	275	0.16		10	220	180	0.25
30	160	3300	3900	2.84	100	160	3300	2520	4.20
	80	1700	2100	1.52		80	1700	1350	2.26
	40	900	1050	0.77		40	900	680	1.14
	20	440	520	0.38		20	440	330	0.56
	15	300	350	0.25		15	300	220	0.38
	10	220	258	0.19		10	220	160	0.28
40	160	3300	3360	3.01	150	160	3300	2100	4.81
	80	1700	1800	1.62		80	1700	1130	2.59
	40	900	910	0.82		40	900	570	1.30
	20	440	450	0.40		20	440	280	0.66
	15	300	300	0.27		15	300	180	0.43
	10	220	220	0.20		10	220	138	0.32
50	160	3300	3300	3.33	200	160	3300	1800	5.32
	80	1700	1700	1.79		80	1700	980	2.86
	40	900	900	0.90		40	900	490	1.44
	20	440	440	0.45		20	440	245	0.71
	15	300	300	0.30		15	300	164	0.48
	10	220	220	0.22		10	220	120	0.35
60	160	3300	3100	3.53	250	160	3300	1640	5.78
	80	1700	1670	1.90		80	1700	880	3.11
	40	900	840	0.96		40	900	440	1.57
	20	440	417	0.47		20	440	220	0.78
	15	300	275	0.32		15	300	140	0.52
	10	220	205	0.23		10	220	100	0.38

Power Tetrode and Pentode Electron Tube



Input impedance of a Grounded-Cathode (GC) amplifier is high, complex, and also non-linear (decreases at onset of grid current).

A Grid-swamping resistor(50Ω) swamps tube input resistance and reactance, and eliminates effect of input-impedance nonlinearity. As input circuit is broadband, It need not be bandswitched. (R1 is the Grid Swamping Resistor)

Class AB1 (no grid current) most common.

Grounded-cathode amplifier has simple 50Ω resistive input circuit. As input circuit is broadband, it always matches exciter correctly, and need not be bandswitched. Note that lack of tuned input network reduces harmonic suppression, and can allow high RF energy from VHF parasitic oscillations to damage exciter.