RF Power Amplifier (RFPA)
Grounded Grid (GG) Cathode Driven (CD) Configuration

By Larry E. Gugle K4RFE, RF Design, Manufacture, Test & Service Engineer (Retired)

The design and operation of a Power Triode, Tetrode or Pentode RF Power Amplifier (RFPA) in Grounded Grid (GG), Cathode Driven (CD), configuration is perhaps the easiest to build, and operationally the most stable available to the homebrew builder.

The 'B+' is applied to the Anode (Plate) and 'B-' to the Cathode. Both the Control Grid (CG) and Cathode are at DC ground potential (which also means that the 'B-' terminal of the supply is attached to ground). The schematic diagram in **Figure-1** below shows this configuration.

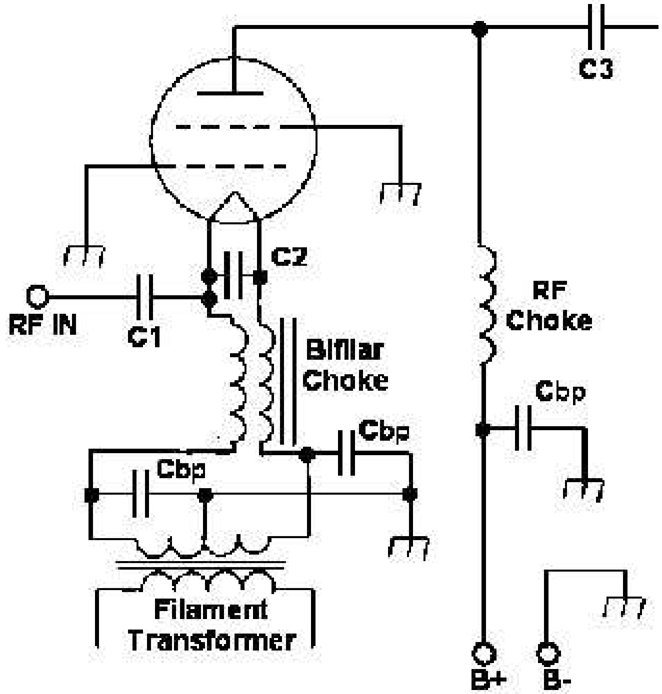

Figure-1

In **Figure-1** above the tube illustrated is a Tetrode configured in GG. The Control Grid (CG) and Screen Grid (SG) are connected directly to ground.

In a RF Power Amplifier (RFPA) with a Tetrode configured conventionally as a Grounded Cathode (GC), Grid Driven (GD) circuit, the Screen Grid (SG) aids in maintaining high current levels, despite fluctuations in the Plate Voltage when a constant voltage is applied to it. If the Tetrode is configured, like a Triode in Grounded Grid (GG), Cathode Driven (CD), the Screen Grid (SG) function is no longer necessary. Consequently the Screen Grid (SG) is simply tied to ground like the Control Grid (CG).

With using a Electron tube with a directly heated Cathode, the Cathode acts as both Filament (Heater) and Cathode. The Filament / Cathode combination is heated and produces thermionic emissions by application of AC Voltage from the Filament Transformer. At the same time, the operational Cathode is at DC ground potential via the centertap of the Filament Transformer. This is not to say, however, that it is at ground potential for RFAC, a Bi-Filar Choke between the Transformer and the Tube raises it above ground for RFAC, but permits it to remain at ground potential with respect to DC. In the case of a **4-400C,** with no RFAC signal voltage applied to the Cathode, a maximum idling **quiescent current** of approximately **35ma** will flow between the Cathode and Plate.

When using a Zero Bias Triode or Tetrode in Grounded Grid (GG), Cathode Driven (CD) configuration, the input RF AC signal voltage applied to the Cathode, will have peak current flow from the Cathode to Plate during the negative half of the input cycle, and will have minimum current flow between the Cathode and Plate during the positive half of the input cycle. This makes the input and output RF AC signal voltages 180 degrees out of phase with each other and prevents coupling between the output and input stages, thereby eliminating much of the potential for self-oscillation.

When using a **single 4-400C**, the **Filament Voltage** requires **5.0 VAC at 14.5 Amps**. **Plate Voltage** maximum is **4,000VDC**, with **typical Voltage Operation at around 3,000 VDC**. The maximum **Plate dissipation is 400 Watts.** If the tube will be running **Class AB,** the Plate will be required to dissipate **40%** of the power consumed in the process of amplification. To calculate the amount of **Plate current** (**Ip**), the total **Power Input ('Pi'n)** to the tube must be calculated first:

1. **To obtain the Power Input (Pin), divide (/) the Plate dissipation in watts (400 Watts), by the highest percent of power consumed in the process of amplification for Class AB tube operation (40%):**
    a. **Pin = Pd / % = 400 Watts / 40% = 1,000 Watts.**
2. **To obtain the Plate Current (Ip) divide (/) the Power In (Pin) by the Plate voltage of 3000 VDC:**
    a. **Ip = Pin / Ep = 1,000 Watts / 3000 VDC = .333 Amps (333mA)**.

It is important to understand at this point that with a given Plate voltage, the load we place on the tube will determine the amount of current it draws, and as such the amount of power that will be dissipated by the Plate and the amount of power that will be transferred to the antenna. **The goal is to maximize the amount of power we are able to deliver to the antenna without melting down the tube plate in the process**. **Consequently, our design load resistance becomes relatively important.**

Single Side Band Suppressed Carrier - Amplitude Modulation (SSBSC - AM) Telephony and Continous Wave (CW) 'On' and 'Off' Keying Telegraphy service are both intermittent and in the case of SSBSC-AM it is syllabic in nature. This means that neither mode has a solid, uninterrupted RF carrier for any prolonged period of time. ***There is an average that takes place - half above the tubes maximum rating and half below. Consequently, the tube can be loaded to deliver 'twice' the amount of current at signal peaks, understanding that the lulls will fall far below the tubes dissipation ratings. In this way, the average amount of power the tube will be called upon to***

dissipate will not exceed its ratings. **Therefore, the formula for computing the best load resistance is:**

$$R_L = Ep / K \times Ip$$

Class A Operation (K = 1.3 ~ 1.4): R_L = Ep / (1.3 ~ 1.4) x Ip
Class AB Operation (K = 1.5 ~ 1.7): R_L = Ep / (1.5 ~ 1.7) x Ip
Class B Operation (K = 1.8 ~ 1.9): R_L = Ep / (1.8 ~ 1.9) x Ip
Class C Operation (K = 2.0): R_L = Ep / 2.0 x Ip

Running One Tube Single Ended

In the case of **one 4-400C** Electron Tube, running **Class AB**, the best plate load resistance (R_L) which will transfer the maximum amount of available power to the antenna is;

R_L = Ep / K x Ip = Ep / 1.5 x Ip = 3,000 VDC / 1.5 x 333 ma = 6006 Ohms

With the RF Plate Load Resistance calculated for the specific tube, it is now possible to calculate the required values for the "Pi" Output-Coupling Network for C4, L1 and C5 for each given band we intend to operate on.

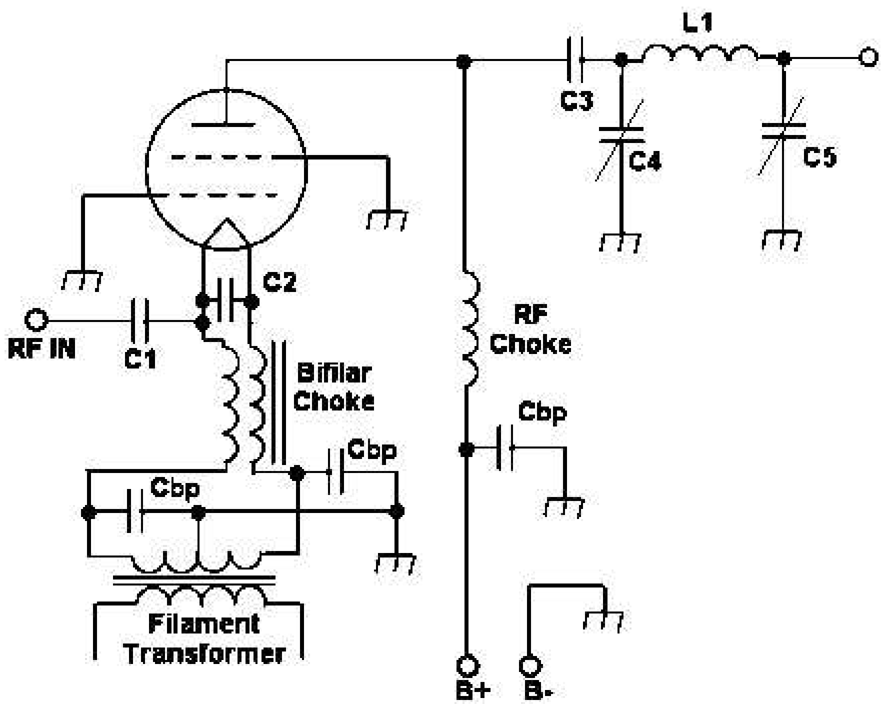

Figure-2

In Figure-2 above:

1. The **Bifilar Choke** isolates the Cathode / Filament from the Filament transformer, as well as aids in preventing RFAC from entering the DC circuit from its feed point at C1.
2. **Cbp** are Cathode By-Pass capacitors between each side of the Bifilar Choke and ground, on the choke's transformer end, which are intended to bypass any RFAC that appear on that end of the choke to ground. Nominal values for the **Cbp** capacitors are

.01uf, and may be **disc ceramic type capacitors, although silver mica capacitors are preferred.**

3. **C1** is the Cathode capacitor. Nominal value for **C1** capacitor is **.01uf** disc ceramic type.
4. **C2** is the Filament capacitor. Nominal value **C2** capacitor is **.01uf** disc ceramic type. ***This capacitor serves to equalize both sides of the Filament with respect to RF***.
5. **C3** is the Plate DC blocking capacitor at a Nominal value of approximately **500pF disc ceramic type.** ***C3 should be 2 or 3 times the Plate voltage.*** Example: **for 3000 VDC x 2 = 6000 VDC or 3000 VDC x 3 = 9000 VDC**.
6. **When using one Electron Tube, the *quiescent idling current* can be reduced, permitting the Electron Tube(s) to run cooler, by connecting a 25K Ohm or 30K Ohm, 10 Watt resistor in line with the Filament transformer center tap and ground (as shown in Figure-3 below); when switched to transmit, an unused relay pair of K1a could then be engaged to short out the resistor, bringing the center tap directly to ground.**

Running Two Tubes In Parallel

In the case of **two 4-400C** Electron Tubes, running **Class AB**, the best plate load resistance (R_L) which will transfer the maximum amount of available power to the antenna is;

R_L = Ep / K x Ip = Ep / 1.5 x Ip = 3,000 VDC / 1.5 x 666 ma = 3003 Ohms

Note:

1. **Load Resistance (RL) will be half that of a single tube.**
2. **Power output (Po) will be double that of a single tube.**
3. **Power input ('Pi'), Cathode to Plate will be double that of a single tube.**
4. **Plate idling (quiescent) current will be double that of a single tube. (I.e. 35mA to 70mA)**

With the RF Plate Load Resistance calculated for the specific tube, it is now possible to calculate the required values for a "Pi" Output-Coupling Network for C4, L1 and C5 for each given band we intend to operate on.

***To employ two Electron Tubes in parallel, simply parallel all connections.* Use as short a lead as possible between them, and pay particular attention to the gauge of wire used for the Filament connections.**

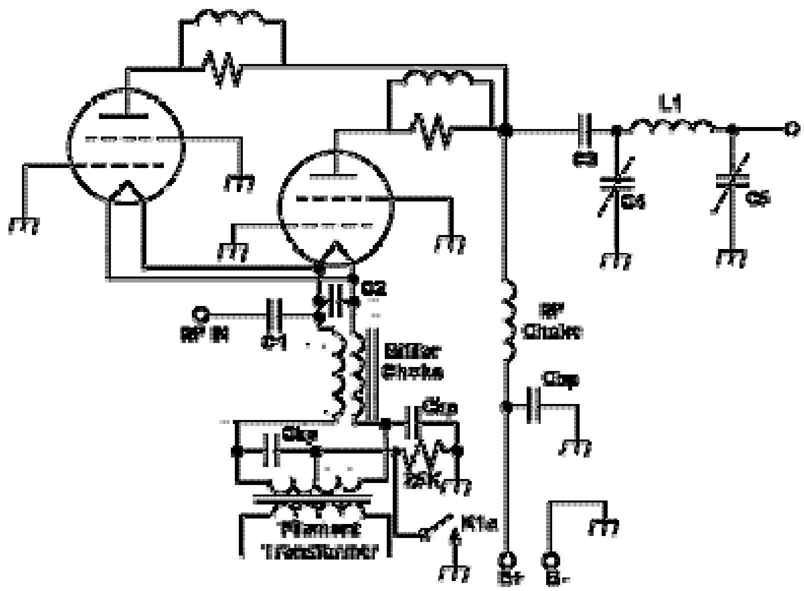

Figure-3: Two Electron Tubes in Parallel

In Figure-3 above:

1. The **Bifilar Choke** isolates the Cathode / Filament from the Filament transformer, as well as aids in preventing RFAC from entering the DC circuit from its feed point at C1.
2. **Cbp** is a Cathode By-Pass capacitor between each side of the Bifilar Choke and ground, on the choke's transformer end, which are intended to bypass any RF that appears on that end of the choke to ground. Nominal values for the **Cbp** capacitors are **.01uf**, and may be **disc ceramic type capacitors, *although silver mica capacitors are preferred.***
3. **C1** is the Cathode capacitor. Nominal value for **C1** capacitor is **.01uf** disc ceramic type.
4. **C2** is the Filament capacitor. Nominal value **C2** capacitor is **.01uf** disc ceramic type. ***This capacitor serves to equalize both sides of the Filament with respect to RF.***
5. **C3** is the Plate DC blocking capacitor at a Nominal value of approximately **500pF disc ceramic type.** ***C3 should be 2 or 3 times the Plate voltage.*** Example: **for 3000 VDC x 2 = 6000 VDC or 3000 VDC x 3 = 9000 VDC**.
6. **When using two Electron Tubes, the *quiescent idling current* can be reduced, permitting the Electron Tube(s) to run cooler, by connecting a 25K Ohm or 30K Ohm, 10 Watt resistor in line with the Filament transformer center tap and ground (as shown in Figure-3 below); when switched to transmit, an unused relay pair of K1a could then be engaged to short out the resistor, bringing the center tap directly to ground.**

RF Tank Circuit
"Pi" or "'Pi'-L" Configured Output-Coupling Network

The RF Tank Circuit places both a load on the tube(s) and transforms the output impedance to match the line. Prior to the popularity of the "Pi" and "'Pi'-L" Output-Coupling Networks and coaxial cable feedline, Amateur Radio Operators utilized air wound transformers to match the output impedance of their tubes to balanced Feedlines such as twin-lead and ladder line. Air wound transformers work well, however they were bulky and most often single banded. Amateur Radio Operators often used plug-in sections that required changing out when ever they would change from one band to another. In addition, neither twin-lead, nor ladder line "jumpered" very well.

"Pi" Network (C1, L1 & C2 only) and becomes a "'Pi'-L" Network

(with L2 added)

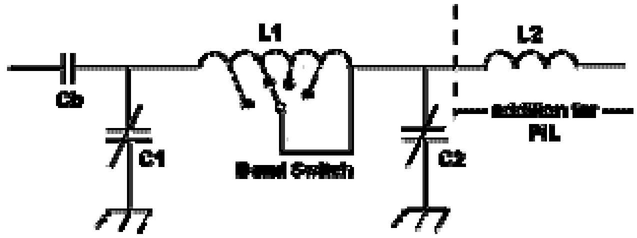

Figure-4

With the advent of lower loss coaxial cable and advancements in feeding balanced antennas with unbalance line, the "Pi" and "'Pi'-L" Output Coupling Networks have become the RF Tank Circuit of choice. In Figure-4 above, **both the "Pi" and "'Pi'-L" Networks use C1 in conjunction with L1 to properly match the Plate Load Resistance (RL). From there C2 works with L1 (and L2 in the "Pi'-L') to match the Load of the RF Transmission Feedline (normally 50 Ohm characteristic impedance coaxial cable). *The values of C1, L1, C2 and L2 should be selected for the lowest band of intended operation*. *Remember that the caps are adjustable from near zero to their maximum value.*** L1 becomes adjustable with the introduction of a rotary switch used to tap and short portions of L1, reducing its operational inductance in the process. In the "Pi'-L' network, L2 is normally a fixed inductor.

The advantages of using a "'Pi'-L" network are its ability to provide a greater transformation ratio (feed line impedance), and provide better harmonic suppression. Keep in mind; however, the voltage handling capacity of C2 will be somewhat higher with the addition of L2. C2 should be a large variable capacitor with the same size and type as C1 if building a "Pi'-L' network.

The rating of the blocking capacitor (Cb)and the 'air space' and 'insulation' of the Plate Tuning Capacitor (C1) should be rated for at least 2.0 ~ 3.0 times the voltage applied to the Plate. Example: **for an Ep of 3000 VDC x 2.0 = 6000VDC or Ep of 3000 VDC x 3.0 = 9000VDC**.

In the case of a 'Pi' network, C2 can be simply a broadcast receiving type in good condition. In the case of a "Pi'-L' network, C2 should have the same rating as C1. **The switch used to short out portions of L1 should be a ceramic wafer switch, although it need not be particularly heavy provided it shorts from the feedline side in, rather than from the Plate side.**

For a two 4-400C Electron Tube RFPA running in Class-AB, the values needed for C1, L1 and C2, for operation on 160 Meters, may be found in the chart below. For a Load Resistance (R_L) of 3003 Ohms, use the 3000 Ohms column. The values of C1 = 324 pF, L1 = 26.2 uH and C2 = 1793pF respectively. Since all other bands (80, 75, 40, 20, 17, 15, 12 and 10 Meters) are above 160 meters, these represent the maximum values that will be required to construct the 'Pi' Output Coupling Network. A transmitting type variable Capacitor with greater plate spacing should be employed for C1, whereas, a receiving type variable Capacitor will be sufficient in most instances for C2.

Class-AB
('Pi' Coupling Network Values)
C1 (pf)

Plate Load F (MHZ)	1000	1500	2000	2500	3000	3500	4000	4500
1.8	883	612	470	383	324	281	248	223
3.5	450	300	225	180	150	128	112	100
4.0	395	260	200	160	130	115	100	88
7.0	225	150	112	90	75	64	56	50
14.0	112	75	56	45	37	32	28	25
21.0	75	50	38	30	25	21	19	17
28.0	56	37	28	23	18	16	14	13

L1 (uH)

Plate Load F (MHZ)	1000	1500	2000	2500	3000	3500	4000	4500
1.8	10.5	14.6	18.6	22.4	26.2	29.8	33.4	36.9
3.5	5.4	7.9	10.1	12.5	14.7	17.0	19.0	21.0
4.0	4.7	6.8	9.0	11.0	13.0	14.5	16.5	18.0
7.0	2.7	4.0	5.0	6.3	7.3	8.5	9.5	10.5
14.0	1.4	2.0	2.5	3.1	3.6	4.2	4.7	5.3
21.0	0.9	1.3	1.7	2.1	2.4	3.2	3.2	3.5
28.0	0.7	1.0	1.3	1.5	1.8	2.3	2.3	2.6

C2 (pf)

Plate Load F (MHZ)	1000	1500	2000	2500	3000	3500	4000	4500
1.8	3554	2865	2408	2067	1793	1562	1358	1172
3.5	1850	1420	1100	900	710	580	470	340
4.0	1650	1250	980	780	620	510	410	270
7.0	925	710	550	450	355	290	235	170
14.0	460	355	275	225	175	145	117	85
21.0	310	238	183	150	120	97	78	57
28.0	230	180	138	112	87	72	58	42

To monitor Plate current, a 0 ~ 100 ma meter, properly shunted to read 0 amp full scale, should be placed inline with the with the B- supply, between the power supply terminal and its connection to ground.

In regard to the Filament voltage and current ratings, Electron Tubes using thoriated tungsten Filaments must be held to within .1% of the specified voltage, as measured at the tube socket. If you elect to wind you own Filament transformer, be sure to adjust the windings to ensure that the voltage under load is within that tolerance. If you must be on one side or the other, it is best to be slightly low, rather than slightly high. Aside from adjusting the secondary windings, you may wish to start with a transformer core with primary windings tapped to permit voltage adjustment. Another approach is to employ a Variac.

Although it would be advisable to bring the Filament voltage up slowly, such as using a Variac, once the Filaments are at full voltage, the B+ High Voltage (HV) may be applied. This, however, is not the case with ceramic tubes, which require a period for the Filament to adequately heat the Cathode.

'Pi' or ''Pi'-L' Configured Input-Coupling Networks

When dealing with a Alternating Current (AC) Signal Voltage, fed to the input of a RF Power Amplifier (RFPA), placed in-line after a Transmitter, there is primarily AC Impedance (electronic symbol 'Z') measured in Ohms (electronic symbol 'Ω'), not just DC Resistance (electronic symbol 'R', symbol 'Ω'), measured in Ohms with a Volt/Ohm meter.

Alternating Current (AC) Impedance (Z), measured in Ohms (electronic symbol 'Ω'), is made up of a combination of different Characteristic Component Values which are:

a. Capacitive Reactance (electronic symbol 'Xc') of Capacitors.
b. Inductive Reactance (electronic symbol 'XL') of Inductors.
c. Alternating Current (AC) Resistance (electronic symbol 'R').
d. Alternating Current (AC) Frequency (electronic symbol 'F').

When any one of the Characteristic Component Values of the RF Alternating Current (AC) signal voltage change, the value of the AC Impedance (Z) will also change.

Solid-state RF Power Amplifier stages in the Transmitter output and Receiver input portions of modern Amateur Radio Service Transceivers, have a designed 50Ω fixed output 'source' and input 'load' Impedance (Z), that require a 50Ω 'load' or 'source' Impedance (Z) for a maximum transfer of power.

A Grounded Grid (GG), Cathode Driven (CD), configured Triode Electron Tube RF Power Amplifier (RFPA), does not normally have a Cathode Impedance (Z) that is 50Ω. Because of this a Low Pass Filter (LPF) in a constant 'K', 'Pi'' or 'L' configuration Impedance (Z) matching network is required:

e. If there is no 'Pi' or 'L' configured Low Pass Filter (LPF) Impedance (Z) Matching Network between the Cathode of a Electron Tube RF Power Amplifier (RFPA), Triode configured in Grounded Grid (GG), Cathode Driven (CD), it will permit input driving RF AC signal voltage ***waveform distortion***, resulting in;
    i. A higher degree of Intermodulation Distortion (IMD).
    ii. A higher Voltage Standing Wave Ratio (VSWR) on the connecting 50□ Characteristic Impedance (Z) RF Coaxial Transmission Feedline.
    iii. 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 RF Power Amplifier (RFPA).
f. A Transmitter has a designed output 50Ω Impedance (Z) which is the 'source' Impedance for the connected RF Transmission Feedline 50Ω Characteristic Impedance (Z) 'load'.
g. The RF Transmission Feedline 50Ω Characteristic Impedance (Z) becomes the 'source' Impedance (Z) for the RF Power Amplifier (RFPA) input 'Pi' or 'L' configured Low Pass Filter (LPF) Network Impedance (Z) 'load'.

h. The RF Power Amplifier (RFPA input 'Pi' or 'L' configured Low Pass Filter (LPF) Network becomes the 'source' Impedance (Z) for the Electron Tube RF Power Amplifier (RFPA) Cathode Impedance (Z) 'load'.

The RF Power Amplifier (RFPA) input 'Pi' or 'L' configured Low Pass Filter (LPF) Impedance matching network, does the same function as adding an 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'.

The tuned-cathode input circuit coupled by a length of coaxial cable from the 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. Omission of the cathode-tuned circuit can lead to distortion of the driving signal, increased Intermodulation distortion, reduced amplifier efficiency, and driver loading problems.

Examples of some electron tube cathode input Impedance (Z) ohmic (Ω) values:

i. 3-500Z
    i. One tube = 115Ω
    ii. Two tubes in parallel = 57.5Ω
    iii. Three tubes in parallel = 38.3Ω
    iv. Four tubes in parallel = 28.8Ω
j. 572B
    i. One tube = 215Ω
    ii. Two tubes in parallel = 107.5Ω
    iii. Three tubes in parallel = 71.7Ω
    iv. Four tubes in parallel = 53.75Ω
k. 811A
    i. One tube = 320Ω
    ii. Two tubes in parallel = 160Ω
    iii. Three tubes in parallel = 106.7Ω
    iv. Four tubes in parallel = 80Ω

Figure-1 below is an example schematic diagram of the RF section in a Henry 3K-A RF Power Amplifier (RFPA) showing the tuned input 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. Components values may be either fixed or variable/adjustable.

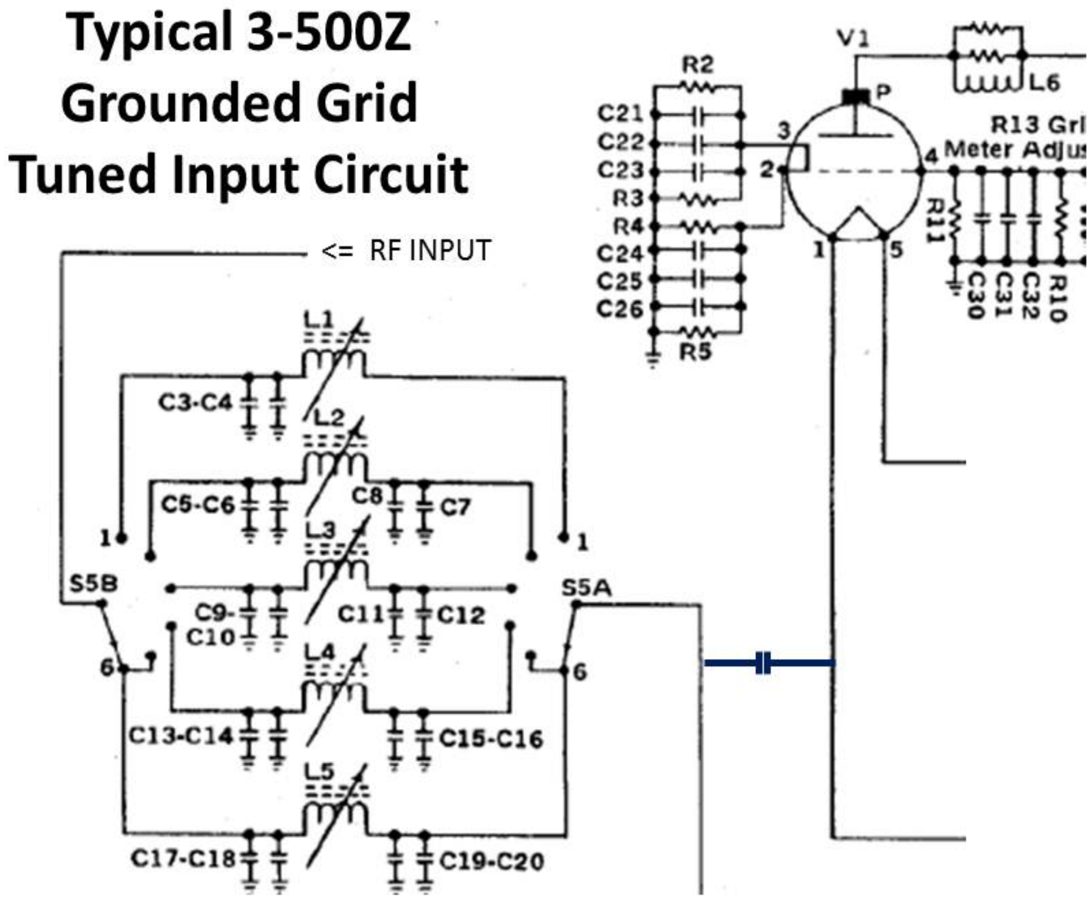
Typical 3-500Z
Grounded Grid
Tuned Input Circuit
<= RF INPUT
V1
P
R2
C21
C22
C23
R3
R4
C24
C25
C26
R5
L6
R13 Gri
Meter Adju
R11
C30
C31
C32
R10
L1
L2
L3
L4
L5
C3-C4
C5-C6
C8
C7
C9-
C10
C11
C12
C13-C14
C15-C16
C17-C18
C19-C20
S5B
S5A

Figure-1

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

Parasitic Suppression

To reduce parasitic oscillations, which occur in the amplification process and appear as a spurious component of the output signal, a parasitic suppressor should be employed between the Plate cap of each tube and the supply voltage. ***A capable parasitic suppressor can be fashioned by connecting three 150 ohm, 2 watt carbon resistors in parallel (equals 50Ω) and winding a coil of no. 12 wire approximately 4.5 turns at 1.5 inches in***

diameter by 2 inches in length in parallel and around the resistors as illustrated. The resulting unit should be connected as close to the tube plate cap as possible, kee'Pi'ng the remaining leads to the choke and blocking capacitor as short as possible.

Selecting the Right Tube

When selecting an Electron Tube, take time to study the specifications contained in the appropriate datasheet. Information provided on Triodes generally includes a set of operational values for Grounded Grid, however, not so with Tetrodes. To arrive at the operating parameters for a Tetrode used in Grounded Grid, utilize the Class B values as a starting point. While selecting a tube, around which to build a amplifier, may seem the logical way to go about it, more often than not, amplifiers are designed around a Electron Tube or Tube pair that we already have. For example, while a pair of 3-500Zs makes a great pair of Triodes around which to build an amp, a pair of 4-400C Tetrodes can be utilized to provide very close to the same amount of power at often less than a quarter of the cost of the Triodes.

When selecting an Electron tube for Grounded Grid (GG), Cathode Driven (CD), service, it is important to choose one that is a '<u>High mu</u>' tubes. The term '<u>mu</u>' refers to the interelectrode relationships that determine its ability to amplify a signal. A 'High mu' tube will generally have a high amplification factor and a 'Low mu' Tube an insufficient amplification factor for Grounded Grid service.

Commercial broadcast stations across the country routinely change out their 4-400Cs when their output level drops around 10 percent - these are called 'pulls' and most often find their way to the Amateur Radio Service Market at a small fraction of their original cost. In order to accommodate routine change out, broadcast stations often maintain a small stock. What do you suppose happens when they update equipment? Answer - the unused stock again finds its way onto the market, consumed by both other broadcast stations and amateurs alike, at a portion of their original cost. Finally, consider which would be more difficult to produce, a triode or a Tetrode with its additional grid? Yet, go to any site that offers both and you will find that tubes such as the 3-500Z sell for more than heavily consumed tetrodes such as the 4-250 or 4-400C.

Transformer Power Capabilities

The power transformer often constitutes a major portion of the cost of home brewing a MF / HF RFPA. This, however, needn't be the case. Relatively small power transformers of modest capability may be used for <u>I</u>ntermittent <u>V</u>oice <u>S</u>ervice (IVS) and CW service at a worthwhile saving in weight and cost.

The duty cycle or ratio of duration of maximum power output to total time power that is applied to the primary windings of a power supply is what determines the transformers required power capability. In SSBSC-AM and CW service the duty cycle is much smaller then that of a supply used for DSBFC-AM, FSK and SSTV operation. While the power supply must be capable of supplying peak power equal to the PEP input for a short duration, ***<u>the average power demanded by SSBSC-AM is generally only about one half or less of the total PEP requirement.</u>*** The syllabic rate, or interval between words, of SSBSC-AM provide periods of low duty, similar to the way in which CW permits the power supply to rest during the non-keydown portions of a transmission. For this reason, the average power capability of a supply designed for IVS can be as low as 25 percent of the PEP level. CW, on the other hand, runs somewhat higher with the average at close to 50 percent of the peak level for short transmissions.

Winding a 'PLATE CHOKE'

RF Chokes for the Plate circuit of power amplifiers may be very easily constructed. Finding a sufficient form will in every event represent the biggest obstacle. Use a 'Ceramic' form or a 'Phenolic' form. If Ceramic or Phenolic cannot be located, consider a 'Glass Dowel' the same dimensions. If a Glass Dowel is employed use one made from Frosted Glass would be far preferable to polished glass, because the porosity of the frosted surface will aid in retaining the windings. **The use of 'PVC' or 'Other Plastic' Materials that become unstable when heated should be avoided at all cost.**

Amplifiers operating in the 1.5 KW range, will almost universally require a 32 uH choke, resonant at 43 MHZ. To accomplish these values, the form required for this choke would need to be a 6" by ¾". Once the form is in hand, begin by close winding it with 89 turns of #18 Formex (enameled wire), or equivalent. The completed length of the coil will be around 4 1/8" long of the 6" form. . Once wound, tightly secure the wire ends and use fingernail polish to hold the turns in place. When the polish dries, remove one of the wires and unwind it from the form, being a careful as possible not to disturb the second winding that's been left in place. Reapply the fingernail polish to seal the turns to the form. Utilize the mounting hardware discussed above to attach the choke to the chassis. Secure the ends carefully. A nylon screw type conduit clamp may then be employed to secure the form to the chassis. A good rule of thumb for the approximate value of the plate choke is that it should be about '10' times the plate load resistance (reactance).

Amplifiers operating above the 1.5 KW range will require a choke of about 78 uH, series resonant at 28 MHZ. To accomplish these values, the form required for this choke would need to be a 6" by ¾". Once the form is in hand, begin by close winding it with bifilar winding (two wires wound right next to each other in parallel) of #26 Formex (enameled wire), or equivalent. The completed length of the coil will be around 4" long of the 6" form. Once wound, tightly secure the wire ends and use fingernail polish to hold the turns in place. When the polish dries, remove one of the wires and unwind it from the form, being a careful as possible not to disturb the second winding that's been left in place. Reapply the fingernail polish to seal the turns to the form. Utilize the mounting hardware discussed above to attach the choke to the chassis. Secure the ends carefully. A nylon screw type conduit clamp may then be employed to secure the form to the chassis.

Winding a Bifilar 'CATHODE CHOKE'

Locate a 4.5 – 6.0" length of 3/8" to ½" ferrite rod. If you don't already have one in your junk box, stop by your neighborhood Good Will, or Salvation Army store, or hit the garage sales on Saturday and spend some time peering into the backs of old clock radios that may be offered for sale. You should be able to spot a rod if the manufacture utilized one as part of the internal antenna. While you're at it, see if you can find a radio with not only a ferrite rod, as described above, but a large three section tuning capacitor as well. You can salvage the tuning capacitor as well.

Once you've secured a ferrite rod, as described, 'Pi'ckup about a 10-foot stretch of 3 conductor, 12 Gauge interior electrical wire (if you're planning to use the choke for anything above 15 amps, use 10 Gauge). Strip off the plastic jacket, and you should have a black and a white insulated lead, as well as a bare copper wire the same length. Put the bare copper wire in your junk box for some other project.

Next, locate a wooden dowel the same diameter as the ferrite rod. Straighten and place the black and white wires next to each other and tape one end together. Leaving about two inches, begin winding the wires together, as tightly as possible, onto the wooden dowel. Try to wrap the turns as perpendicular to the dowel as possible - this will permit as many turns per inch as will be possible. Wrap 14 turns. When you are done winding, it should look like a candy-cane stick - black, white, black, white, etc. Now carefully slip the coil off the wooden dowel and slip it onto the ferrite rod. Once on the rod, twist the turns carefully to tighten and take up the slack. While applying tension to tighten the coil, wrap silk tape, available at most drug stores, over the coils to ensure that they remain in place. No mount will be needed - once soldered in place; the wire leads will very capably support the choke.

To design and build a home-brew amplifier from scratch, begin by:

1. **Sketch a basic schematic, utilizing the tube or tubes you've selected, and assigning values to each component part of the circuit.**

2. **Collect the required parts for each section you already have and purchase the parts you do not have.**

3. **Once the necessary parts for each section have been obtained, begin assembling them and test the result. Make corrections as needed and move on to building the next section as parts are available.**

4. **Before you know it, you will be applying the B+ to the Plate of your tube(s) and making final adjustments.**

5. **Just take it a step at a time, think about what you're doing, research what you're not sure of and you will not be disappointed with the outcome.**