HAM TIPS

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Components for Pi-Coupled Amplifiers

By

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Most of the references on this subject present data for the determination of values of the components for pi-coupled amplifiers in terms of curves or formulas. To simplify the design procedure for the amateur, W2RYI has compiled this data in easy-to-use tabular form.

The use of a pi network to couple the plate of an rf amplifier tube to the antenna provides several advantages over the use of a conventional parallel-tuned, inductively-coupled tank circuit. The ease with which a multiband transmitter employing a pi-network tank circuit with rotary or tapped coils can be operated on several bands, in addition to its harmonic-attenuation feature, has made this circuit appealing to designers of amateur transmitters. The circuit is also popular because front-panel controls can be used to compensate for reasonably large variations in transmission-line reactance.

The function of the pi network is to match a transmission line having relatively low characteristic impedance to the plate of a tube which must "see" a relatively high resistive load to produce optimum power output. *Table I* lists the estimated plate loads for the various operating conditions of several popular tubes used in amateur transmitters. To determine the plate load for a given tube type, refer to *Table I* and select the operating condition that most closely fits your requirements; the estimated plate-load value for that operating condition is given in the last column in the table. The exact load for tubes not listed in *Table I* can be determined from a set of complicated calculations; however, a good approximation can be made with the formula:

$$\text{Estimated Plate Load (ohms)} = \frac{E_b}{2I_b}$$

where E_b is the plate supply voltage, and I_b is the dc plate current in ma.

The estimated plate load is then used as the key to *Table II*. This table lists the actual values of the pi-network components for the estimated plate loads; *Fig. 1* shows the location of these components in the circuit.

Example

An RCA 6146 is to be used in a 7-Mc, cw transmitter with 750 volts on the plate, and the signal is to be fed to a 50-ohm, coaxial line. *Table I* shows the estimated plate load to be 3,100 ohms. As shown in the 3,000-ohm column of *Table II*, 7-Mc operation requires 90 $\mu\mu$f for C_1, 6.2 μh for L, and 700 $\mu\mu$f for C_2.

When a 50-ohm, non-reactive load is applied to the coax output connector, optimum loading at 7 Mc will occur with components

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approximating the above values. In a practical transmitter, a capacitor of 1,000 $\mu\mu$f should be used for C_2 so that the loading can be reduced when desirable, and so that compensation can be made for variations in antenna reactance. Capacitor C_1 should be capable of tuning through resonance at 7 Mc; all variations in reactance considered, a capacitance of 150 $\mu\mu$f would be considered to be a safe design value for C_1.

Recommendations

Design and constructional details for pi-coupled finals are amply covered in the articles listed in the accompanying bibliography. These articles should be examined thoroughly for ideas and suggestions before construction is begun.

In addition to the many valuable suggestions in the literature on the design of multi-band rigs using pi-coupled finals, there are two precautions to be observed: (1) The driver should be a straight-through amplifier employing a conventional tuned tank circuit. (2) The final amplifier should not be operated as a doubler. These recommendations are important because the pi-coupled amplifier, in addition to attenuating harmonics effectively, will pass signals at frequencies below the fundamental more readily than an amplifier employing a parallel-resonant plate circuit. If the low-frequency signals from preceding multiplier stages are not permitted to reach the control grid of a pi-coupled final amplifier, successful operation will be assured.

Table I

Estimated Plate Loads for Typical Operating Conditions

Tube Type	Service	Emission	E_b volts	E_{c_2} volts	I_b ma	P_o watts	Plate Load ohms
813	ICAS	CW	2,250	400	220	375	5,100
	CCS	CW	2,000	400	180	275	5,500
	CCS	CW	1,500	300	180	210	4,200
	ICAS	Phone	2,000	350	200	300	5,000
	CCS	Phone	1,600	300	150	180	5,300
813's (Parallel)	ICAS	CW	2,250	400	440	750	2,600
	ICAS	Phone	2,000	350	400	600	2,500
807	ICAS	CW	750	250	100	54	3,700
	CCS	CW	600	250	100	40	3,000
	CCS	CW	500	250	100	32	2,500
	ICAS	Phone	600	300	100	44	3,000
	CCS	Phone	475	250	83	28	2,900
807's (Parallel)	ICAS	CW	750	250	200	108	1,900
	ICAS	Phone	600	300	200	88	1,500
6146	ICAS	CW	750	160	120	70	3,100
	ICAS	CW	600	180	150	66	2,000
	CCS	CW	600	150	112	52	2,600
	ICAS	Phone	600	150	112	52	2,600
	CCS	Phone	475	135	94	34	2,600
812-A*	ICAS	CW	1,500	—	173	190	4,300
	CCS	CW	1,250	—	140	130	4,500
	ICAS	Phone	1,250	—	140	130	4,500
	CCS	Phone	1,000	—	115	85	4,300
4-65A**	CCS	CW	1,500	250	150	170	5,000
	CCS	CW	600	250	140	54	2,100
	CCS	Phone	1,500	250	120	145	6,200
	CCS	Phone	600	250	117	50	2,500
4-125A/4D21	CCS	CW	2,500	350	200	375	6,200
	CCS	CW	2,000	350	200	275	5,000
	CCS	Phone	2,000	350	150	225	8,200
	CCS	Phone	2,500	350	152	300	6,700
4-250/5D22	CCS	CW	3,000	500	345	800	4,300
	CCS	CW	2,500	500	300	575	4,100
	CCS	Phone	3,000	400	225	510	6,700
	CCS	Phone	2,500	400	200	375	6,200
2E26	ICAS	CW	600	185	66	27	4,500
	CCS	CW	500	185	60	20	4,200
	ICAS	Phone	500	180	54	18	4,600
	CCS	Phone	400	160	50	13.5	4,600

*Grid Neutralization.

**Typical operating conditions at higher plate voltages are published, but plate impedances are too high for convenient pi-network operation.

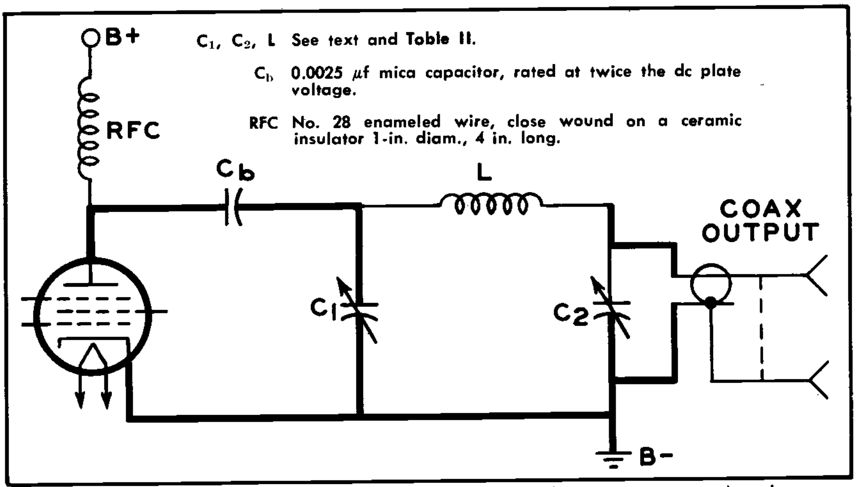

Fig. 1. Plate circuit for the pi-coupled final. Mount the components so that the connections and "chassis" paths, shown as heavy lines, will be as short as possible.

Table II Components for Pi-Coupled Final Amplifiers*

Estimated Plate Load (ohms)	1,000	1,500	2,000	2,500	3,000	3,500	4,000	4,500	5,000	6,000*	NOTES
C_1 in μμf, 3.5 Mc	520	360	280	210	180	155	135	120	110	90	The actual capacitance setting
7	260	180	140	105	90	76	68	60	56	45	for C_1 equals the value in this
14	130	90	70	52	45	38	34	30	28	23	table minus the published tube
21	85	60	47	35	31	25	23	20	19	15	output capacitance. Air gap
28	65	45	35	26	23	19	17	15	14	11	approx. 10 mils/100 v E_b.
L in μh, 3.5 Mc	4.5	6.5	8.5	10.5	12.5	14	15.5	18	20	25	Inductance values are for a
7	2.2	3.2	4.2	5.2	6.2	7	7.8	9	10	12.5	50-ohm load. For a 70-ohm
14	1.1	1.6	2.1	2.6	3.1	3.5	3.9	4.5	5	6.2	load, values are approx. 3%
21	0.73	1.08	1.38	1.7	2.05	2.3	2.6	3	3.3	4.1	higher.
28	0.55	0.8	1.05	1.28	1.55	1.7	1.95	2.25	2.5	3.1	
C_2 in μμf, 3.5 Mc	2,400	2,100	1,800	1,550	1,400	1,250	1,100	1,000	900	700	For 50-ohm transmission line.
7	1,200	1,060	900	760	700	630	560	500	460	350	Air gap for C_2 is approx. 1
14	600	530	450	380	350	320	280	250	230	175	mil/100 v E_b.
21	400	350	300	250	230	210	185	165	155	120	
28	300	265	225	190	175	160	140	125	115	90	
C_2 in μμf, 3.5 Mc	1,800	1,500	1,300	1,100	1,000	900	800	720	640	500	For 70-ohm transmission line.
7	900	750	650	560	500	450	400	360	320	250	
14	450	370	320	280	250	220	200	180	160	125	
21	300	250	215	190	170	145	130	120	110	85	
28	225	185	160	140	125	110	100	90	80	65	

* Values given are approximations. All components shown in Table II are for a Q of 12. For other values of Q, use $\frac{Q_a}{Q_b} = \frac{C_a}{C_b}$ and $\frac{Q_a}{Q_b} = \frac{L_b}{L_a}$. When the estimated plate load is higher than 5,000 ohms, it is recommended that the components be selected for a circuit Q between 20 and 30.

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7. "A Wide-Range, High-Power, Pi-Network Final," Farrar, **QST**, Oct., 1953.
8. "Simplified Pi-Network Solutions," Hoefer, **CQ**, Nov., 1953.

NEW RCA TYPE 80

The RCA type 80 full-wave vacuum rectifier was recently changed over from a size ST-14 bulb to a T-9 bulb, like that used for the 5Y3-GT. This was done in order to utilize RCA's modern tube manufacturing techniques and equipment more effectively, despite declining replacement demand for the type 80.

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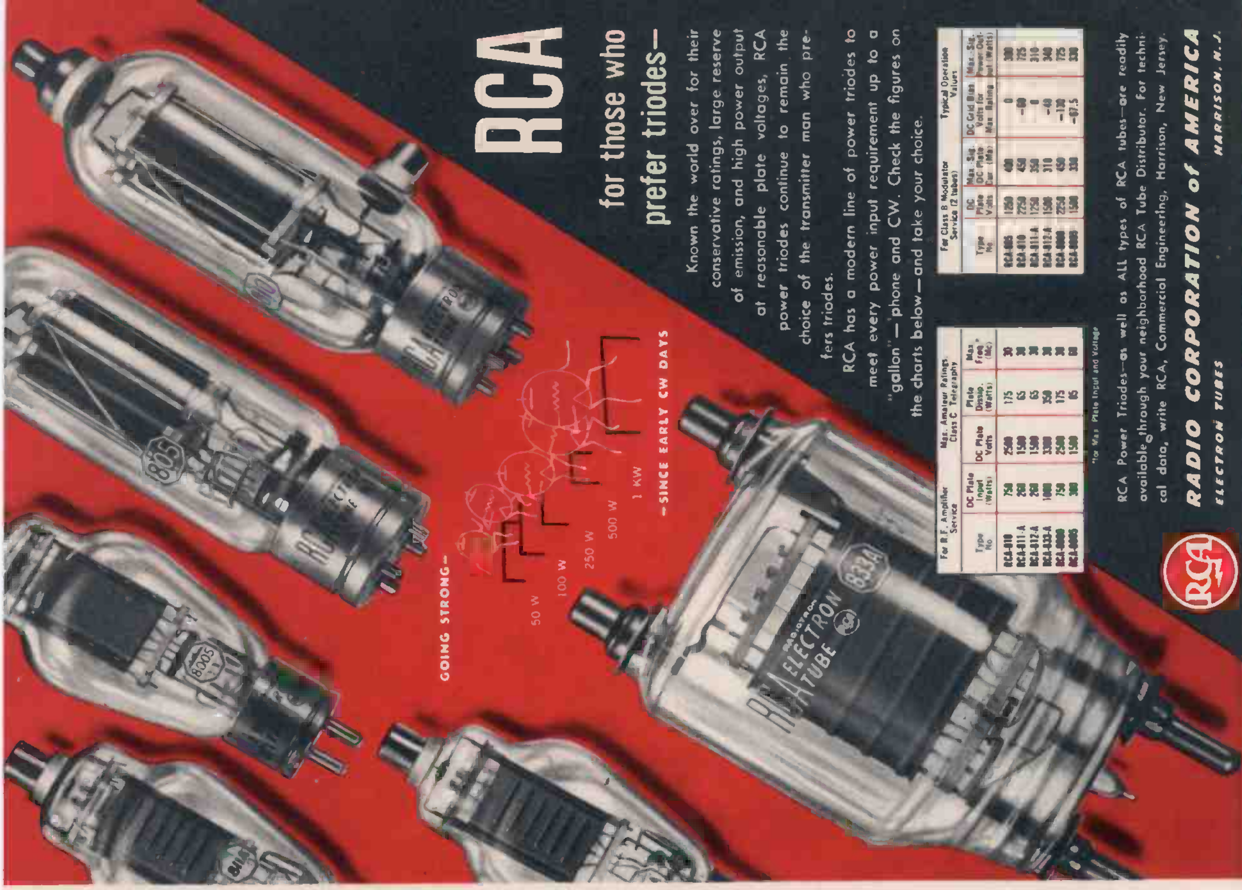

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RCA-811-A	260	1500	65	30
RCA-812-A	260	1500	65	30
RCA-833-A	1000	3300	350	30
RCA-8000	750	2500	175	30
RCA-8005	300	1500	85	60

*for Max. Plate Input and Voltage

For Class B Modulator Service (2 tubes)			Typical Operation Values	
Type No.	DC Plate Volts	Max.-Sig. DC Plate Cur. (Ma)	DC Grid Bias Volts for Max. Rating	Max.-Sig. Power Output (Watts)
RCA-805	1250	400	0	300
RCA-810	2250	450	−60	725
RCA-811-A	1250	350	0	310
RCA-812-A	1500	310	−40	340
RCA-8000	2250	450	−130	725
RCA-8005	1500	330	−87.5	330

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