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External Anode Tetrode Tubes

Developed by Eimac in 1947, the 4X150A external anode tetrode is the forerunner of a whole family of novel and highly efficient transmitting tubes. Now manufactured by a host of companies, the original 4X150A design is still going strong and is a favorite tube-type with many VHF-minded radio amateurs.

In the past dew years a bewildering number of "4X-variety" tubes have appeared on the market, each type having slightly different characteristics than "grandpappy 4X150A." The purpose of this article is to tabulate these tubes and to note basic characteristics of each type.

The Original 4X150A

The nomenclature of the 4X150A briefly describes the tube. The "4" signifies four active elements (a tetrode), the "X" indicates the external anode (forced-air cooled), "150" indicates 150 watts plate dissipation, and the final "A" indicates this is the first production version of the tube. Recent productions of the 4X150A have included a radically new brazed anode structure having complex cooling fins that allow increased plate dissipation ratings to be achieved. The new 4X150A is operationally equivalent to the 4CX250B for frequencies below 150 Mc. The different versions of the 4X150A are not easy to tell apart, as some transitional "150 watt" tubes have the improved cooling fins but do not have the brazed anode structure. In general, the "old-style" and "new-style" 4X150A tubes may be separated by weight: the 150 watt anode tube weighs approximately 5.2 ounces and the 250 watt anode tube weighs approximately 4 ounces. In addition, the center anode (plate) diameter of the older tube is 15/16" and that of the newer tube is 13/16".

High-voltage heater versions of the 4X150A were subsequently introduced as the 4X150D and 4X150S (ruggedized). These new tubes, plus the redesigned descendants of the 4X150A bear alternate Electronic Industries Association (E.I.A.) nomenclature consisting of four-digit numbers in the seven- and eight-thousand series. Thus, the E.I.A. 7034 is the 4X150A, etc.

The 4X150G (2.5 volt heater) and its offspring (4CX250K) have coaxial terminations and are designed for internal cavity operation at frequencies into the gigacle (kilo-megacycle) region.

The 4X250B Family

The 4X250B external anode tetrode is an evolutionary design featuring ceramic insulation and evolving from the glass-insulated 4X150A. Early 4X250B's were made with a ceramic outer cylinder and a glass base. Later versions are all ceramic. These "4X-series" tubes are rated at 250 watts plate dissipation and a maximum potential of 2000 volts.

The 4CX250B Family

The "4CX family" unilaterally replaces the "4X" ceramic tubes having a glass base. The all-ceramic 4CX250B tube has a plate dissipation rating of 250 watts and is manufactured in several versions as shown on the chart at the end of this article. Lesser known tubes in this family are the 4W300B (a water-cooled tetrode of interest to mobileers) and the Y-210 (a limited production tube having no anode cooler, intended for heat-sink or liquid immersion operation). The 4CX350A is a heavy-duty version of the 4CX250B having 350 watts plate dissipation and higher transconductance. The tube is particularly well suited for Class AB1 rf service.

The 4CX300A Family

The latest offspring of the 4X150A is the popular, rugged 4CX300A. This ceramic and metal, ruggedized tetrode is capable of operation at plate potentials up to 2500 volts. Special purpose versions of the 4CX-300A are currently in production and among these is the 4CX300Y which should be of considerable interest to "side-banders" and others contemplating new equipment. The 4CX300Y resembles the 4CX300A in appearance but has a heavy-duty heater (6.0 volts at 3.4 amperes) which permits unusually high values of plate current to be drawn.

Grounded Grid Operation of External Anode Tetrodes?

Modern, high-gain external anode tetrodes do not perform well when connected in the common "grounded grid" configuration. This family of tubes is charactdrized by high perveance, together with extremely small spacing between the grid bars, and between the grid structure and the cathode. Thus, while performing in an excellent fashion as grid-driven, high-gain tetrodes, these tetrodes are unsuited for pure grounded grid operation.

For proper operation of the external anode tetrode, the screen requires much larger voltages than the control grid. Older tetrodes having lower gain figures tend to have more equal balance between absolute grid and screen currents. When these electrodes of the newer, high perveance, external anode tetrode tubes are tied together, the control grid tends to draw tremendous currents and there is grave risk of destroying it. Peak grid current, for example, in a 4X150A operated in grounded grid configuration, can easily be twice the value of the peak plate current.

It is permissible, however, to operate the external anode tube as a cathode-driven tetrode, with the grid and screen elements at rf ground potentials, but operating at the normal dc potentials. Grid dissipation is minimal and stage gain is greatly increased. Screen dissipation is nearly the same as in the tetrode connection. Greater stage gain can be obtained with this circuit because the driver does not have to supply large screen and grid losses. If it is desired to dissipate some excess of driving power, it should be absorbed in a resistive load.

The Tube Socket

The tube socket for the external anode tube serves a triple purpose. It permits connections to be made to the elements of the tube, it serves to conduct heat away from the stem of the tube and (in some cases) the socket serves as a capacitive bypass for the screen of the tube. Complete Air-System socket assemblies for all non-coaxial based external anode tubes are available, consisting of socket and air chimney, and these are tabulated at the end of this article. These sockets permit air to be blown axially on the base of the tube, past the base to the envelope, and then over the plate cooler. Use of other than an air socket with external anode tubes is not recommended, as tube temperatures cannot be adequately controlled. Use of a receiving-type loctal socket with 4X150A-style external anode tubes is emphatically not recommended. Dangerously high stem temperatures will be generated from the heat of the filament unless the base structure is cooled by an air blast, as the solid construction of the simple loctal socket blocks the normal flow of air about the tube stem.

It should be emphasized that the heater voltage on the "six volt" family of external anode tetrodes is 6.0 volts, plus or minus five percent, and not 6.3 volts. The operational range of heater voltage is 5.7 to 6.3 volts and for longest heater life, it is recommended that the heater voltage not exceed 6.0 volts.

The user of these tubes (or any other transmitting tubes) should check his heater voltage with a meter calibrated against a 1 percent laboratory meter of known accuracy. Monitoring voltage to five percent with a "garden variety" five percent ac meter proves nothing other than the fact the filament transformer is operating.

The Figure of Merit

A graphical presentation of the mutual conductance for common external anode tubes operating at various plate current levels is given at the end of this article. It can be seen that the 4CX350A and 4CX350F have about twice the transconductance of other various tubes, the 4CX300Y has approximately 30% higher transconductance, while the 7580 and the 7580/4CX259R are about 20% higher than the "common" 4X150A. Transconductance is a useful yardstick in determining the figure of merit of a particular tube (sometimes called the gain-bandwidth factor). It is calculated from:

$$\text{Figure of merit} = \frac{\text{Transconductance}}{2\pi C_t}$$

where C_t is the sum of the imput and output capacitance of the tube.

The figure of merit is a comparative figure and should not be interpreted as an absolute number. The input and output capacitances used in the calculation are average values taken from a number of typical tubes. Highest figure of merit vakues are reached by a combination of high transocnductance and low interelectrode capacitances. The 4CX350A and 4CX350F, having the highest transconductance and reasonably low interelectrode capacity, have the highest figure of merit, while the coaxial and breechblock-based tubes (with their higher capacitances) appear to have lower merit values. However, the coaxial-based tubes perform more efficiently at higher frequencies and are especially designed for cavity operation.

4CX300A FAMILY

EIMAC	EIA	P_o Watts	E_p Volts	F_{max} Mc	Heater V/A	Base	Figure of Merit	Notes
4CX300A	8167	300	2500	500	6.0/2.7	Breech-block	52	Ceramic-metal ruggedized
Y-180	-	300	2500	500	6.0/2.7	Breech-block	52	Nickel-Rhodium plated 4CX300A
4CX300Y	-	-	2500	500	6.0/3.4	Breech-block	53	High Plate current version of 4CX300A
4CX350A	8321	350	2000	500	6.0/3.0	9-pin	143	High transconductance, high current 4CX250B
4CX350F	8322	350	2000	500	26.5/0.57	9-pin	143	Aircraft version of 4CX350A
4CX125F	-	125	2000	500	26.5/0.57	9-pin	52	Aircraft version of 4CX125C

SPECIAL VERSIONS

4CN15A	-	15	2500	500	6.0/3.0	Breech-block	52	Low-duty pulse work, or heat sink cooling
4CN15L	-	15	2000	-	2.1/7.5	9-pin	-	Quick heat cathode
4CS100L	-	100	2000	-	2.1/7.5	9-pin	85	Quick heat cathode Heat sink cooling
4CX125C	-	125	2000	500	6.0/2.7	Breech-block	52	Horizontally finned 4CX300A
4CX125F	-	125	2000	500	26.5/0.56	Breech-block	52	Identical to 4CX125C except for Filament Voltage
4CX250L	-	250	2000	-	2.1/7.5	9-pin	-	Quick Heat Cathode
4CPX250K	-	250	5500	500	6.0/2.7	Coaxial	85	Pulse rated 4CX250K

4X150A FAMILY

EIMAC	EIA	P_o Watts	E_p Volts	F_{max} Mc	Heater V/A	Base	Figure of Merit	Notes
4X150A (old)	-	150	1250	500	6.0/2.6	9-pin	86	Old style anode Weight: 5.2 oz.
4X150A	7034	250	2000	500	6.0/2.6	9-pin	86	New style anode Weight: 4 oz.
4X150D	7035	250	2000	500	26.5/0.55	9-pin	86	Aircraft version of 4X150A
4X150G	8172	150	1250	1200	2.5/6.25	Coaxial	56	UHF and video service
4X150R	8296	250	2000	500	6.0/2.7	9-pin	73	Ruggedized 4X150A/7034
4X150S	8297	250	2000	500	26.5/0.56	9-pin	73	Ruggedized 4X150D/7035

4X250B FAMILY

4X250B	-	250	2000	500	6.0/2.6	9-pin	85	Ceramic shell, glass based 4X150A
4X250F	-	250	2000	500	26.5/0.56	9-pin	85	Aircraft version of 4X250B
4CX250F	7204	250	2000	500	26.5/0.56	9-pin	85	All-ceramic 4X250F
4CX250B	7203	250	2000	500	6.0/2.6	9-pin	85	All-ceramic 4X250B
4CX250K	8245	250	2000	1200	6.0/2.6	Coaxial	54	UHF and video service
4CX250M	8246	250	2000	1200	26.5/0.56	"	54	Aircraft version of 4CX250K
4CX250R	7580W	250	2000	500	6.0/2.6	9-pin	81	Ruggedized 7580
7580W	7580	250	2000	500	6.0/2.6	9-pin	82	High perveance 4CX250B
4W300B	8249	300	2000	500	6.0/2.6	9-pin	85	Water-cooled 4X250B