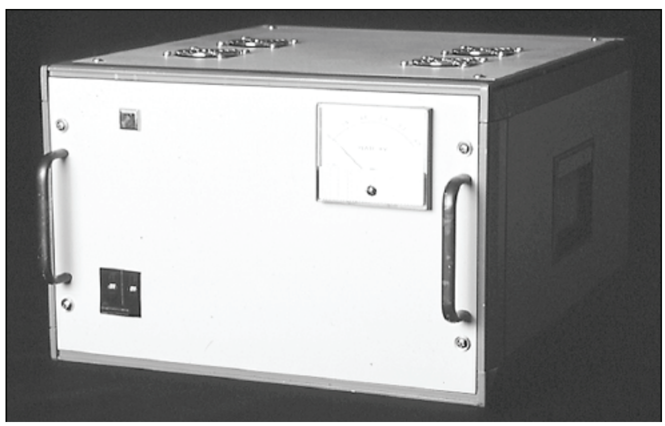
The Sunnyvale/Saint Petersburg Kilowatt-Plus

This article describes a modern 1500-W output linear amplifier for the amateur HF bands. It uses a relatively recent arrival on the transmitting tube scene in the US, a 4CX1600B power tetrode made by Svetlana in Saint Petersburg, Russia. The amplifier was designed and constructed by George T. Daughters, K6GT, who lives in Sunnyvale, California—hence the name "Sunnyvale/Saint Petersburg" for this project. **Fig 18.28** shows the completed amplifier and the power supply cabinet.

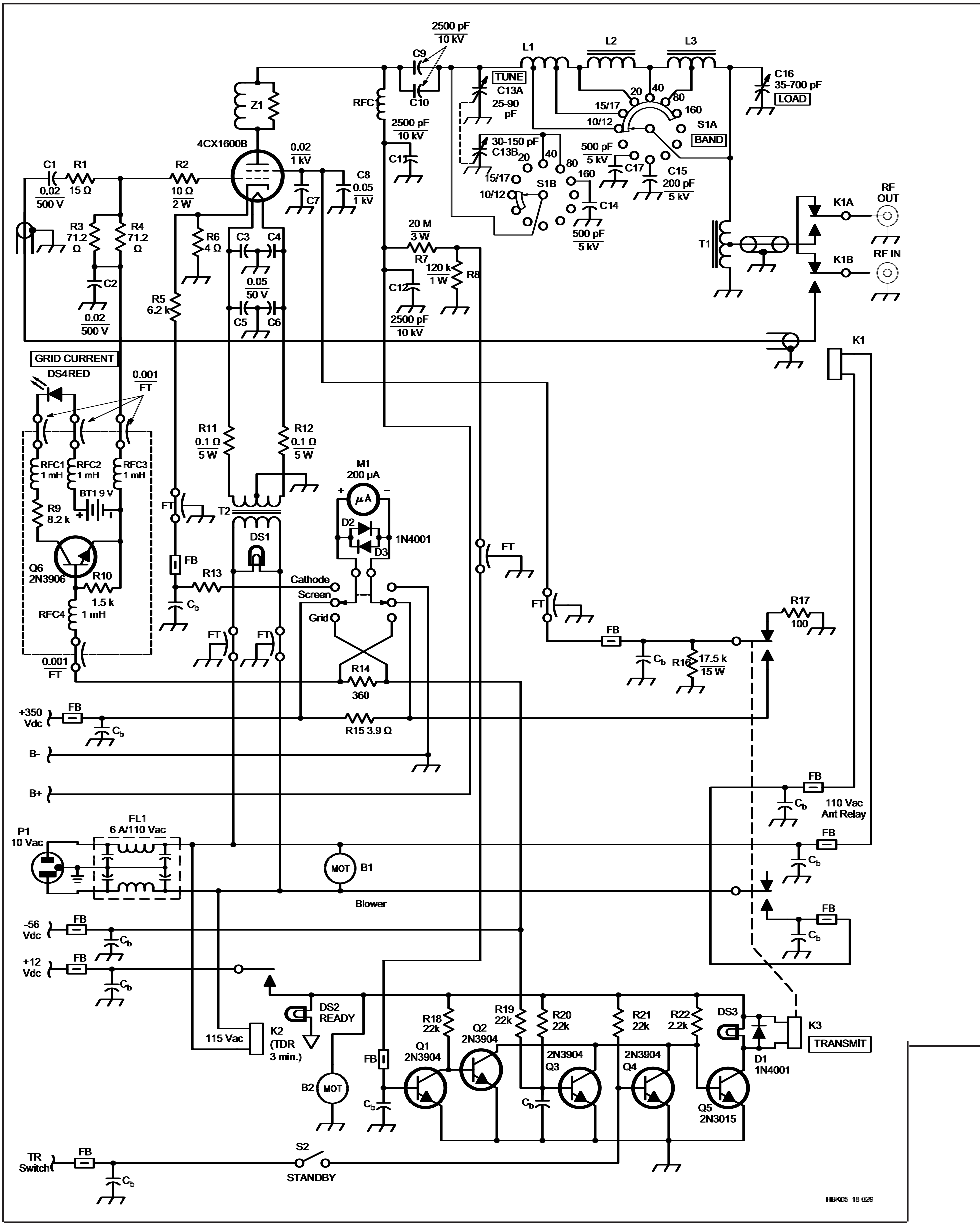
Power tetrodes such as the 4CX1600B feature higher power gain than do the power triodes (such as the 3-500Z or 8877) often used in linear amplifiers. The increased power gain gives the designer additional flexibility, at the expense of a

(A)



(B)

Fig 18.28—At A, photo of Sunnyvale/Saint Petersburg Kilowatt-Plus amplifier RF Deck. At B, the Power Supply cabinet.



2500 pF
10 kV
C9
C10
RFC
L1
L2
L3
TUNE
C13A
25-90
pF
C16
35-700 pF
LOAD
20
40
80
15/17
160
10/12
S1A
BAND
Z1
4CX1600B
2500 pF
10 kV
C11
30-150 pF
C13B
500 pF
5 kV
C17
C15
200 pF
5 kV
0.02
1 kV
C8
0.05
1 kV
C7
C1
R1
0.02
500 V
15 Ω
R2
10 Ω
2 W
S1B
C14
500 pF
5 kV
RF
OUT
K1A
RF IN
K1B
T1
R3
71.2
Ω
R4
71.2
Ω
R6
4 Ω
C3
C4
0.05
50 V
C5
C6
C2
0.02
500 V
R5
6.2 k
20 M
3 W
R7
120 k
1 W
R8
C12
2500 pF
10 kV
K1
GRID CURRENT
DS4RED
0.001
FT
R11
0.1 Ω
5 W
R12
0.1 Ω
5 W
M1
200 μA
μA
RFC1
1 mH
RFC2
1 mH
RFC3
1 mH
BT1 9 V
R9
8.2 k
T2
FT
D2
D3
1N4001
DS1
FB
Q6
2N3906
R10
1.5 k
R13
Cathode
Screen
Grid
RFC4
1 mH
FT
FT
FT
R17
100
FB
Cb
R16
17.5 k
15 W
0.001
FT
R14
360
+350
Vdc
FB
Cb
R15 3.9 Ω
B-
B+
FB
Cb
110 Vac
Ant Relay
P1
10 Vac
FL1
6 A/110 Vac
MOT
B1
Blower
FB
Cb
-56
Vdc
FB
Cb
+12
Vdc
FB
Cb
FB
Cb
DS2
READY
115 Vac
K2
(TDR
3 min.)
R18
22k
R19
22k
R20
22k
R21
22k
R22
2.2k
DS3
K3
TRANSMIT
Q1
2N3904
Q2
2N3904
2N3904
Q3
2N3904
Q4
D1
1N4001
Q5
2N3015
B2
MOT
FB
Cb
Cb
TR
Switch
FB
Cb
S2
STANDBY
HBK05_18-029

Fig 18.29—Schematic diagram of the RF Deck of the 4CX1600B linear amplifier. Resistors are 1/2 W unless noted. Capacitors are disc ceramic unless noted and those marked with a + are electrolytic.

B1—Squirrel-cage blower capable of 36 cfm at 0.4 inches of water back pressure (Dayton 4C753 or similar).
B2—"Biscuit" blower, 12 V dc, 130 mA (Rotron BD12A3 or similar) mounted inside the pressurized RF deck to aid cooling the input grid resistor R1.
BT1—9 V transistor radio battery.
C1, C2—0.02 µF, 500 V disc ceramic.
C3, C4, C5, C6—0.05 µF, 50 V disc ceramic.
C7—Screen bypass capacitor (0.02 µF, 1 kV disc ceramic at the screen terminal on the socket in parallel with the internal bypass capacitor, which is part of the Svetlana SK-3A socket).
C8—0.05 µF, 1 kV disc ceramic.
C9, C10—Parallel 2500 pF, 10 kV ceramic doorknob.
C11, C12—2500 pF, 10 kV ceramic doorknob.
C13—Plate tuning capacitor; front section is 30-150 pF; rear section is 25-90 pF (Command Technologies P/N 73-2-100-41).
C14, C17—500 pF, 5 kV ceramic doorknob.
C15—200 pF, 5 kV ceramic doorknob.
C16—Plate loading capacitor, 35-700 pF (Command Technologies P/N 73-1-45-65).
D1—1N4001.
DS1, DS2, DS3—Indicator lamps (green: 120 V ac; amber: 12 V; and red: 12 V).
DS4—Jumbo red LED.
FL1—IEC 110 V ac connector with 6 A line filter.
FT—0.001 µF, 1000 V feedthrough capacitors.
FB, —RF decoupling components used in multiple places; ferrite beads FB-43-1801 and 0.01 µF, 1 kV disc-ceramic capacitors.
K1—110 V ac DPDT antenna changeover relay.
K2—115 V ac 3-minute time delay (Macromatic SS-6262-KK).
K3—12 V dc relay, DPST.
L1—Plate tank inductor; 1/4-inch diameter, silver-plated copper tubing, 6 turns with inside diameter of 1 1/4 inches, followed by 4 1/2 turns with inside diameter of 1 3/4 inches. Tap for 10 (and 12) m is 4 turns from small-diameter end; tap for 15 (and 17) m is 2 turns further down. All of L1 is used for 20 m.
L2—Toroid coil; 5 turns #10 PTFE wire (40 inches long, overall) on two T-225-8 cores.
L3—Toroid coil; see text; 3 each #10 PTFE wires (150 inches long, overall) on three T-225-28 cores.
M1—200 mA meter movement, internal resistance 2000 Ω.
P1—IEC power cable to J1 on Fig 18.30.
Q1 to Q6—2N3904 or similar (Silicon, general purpose, NPN).
Q5—2N3015 or similar (Silicon, low (Sat), NPN).
R1—15 Ω, Caddock MP-850, mounted on heat sink with R3 and R4.
R2—10 Ω, 2 W composition.
R3, R4—71.2 Ω Caddock MP-850, mounted on heat sink with R1.
R5, R13—6.2 kΩ, 1 W. (R5 is part of the cathode current meter multiplier, as is R13. Their values were chosen to provide 1.3 A full-scale reading on the meter used.)
R6—4 Ω, 12 W (4 each 16 Ω , 3 W, noninductive metal-oxide-film, in parallel on 4CX1600B tube socket).
R7—20 MΩ, 3 W (Caddock MX430).
R8—120 kΩ, 1 W composition.
R11, R12—Filament dropping resistors; 0.1 Ω, 5 W.
R16—Screen bleeder; 17.5 kΩ, 15 W (two 25 kΩ, 5 W in parallel, in series with 5 kΩ, 5 W).
RFC—1 mH RF choke.
RFC1—Plate choke, 91 turns #26 enamel on 1-inch diameter × 3.75 inch Delrin form (Command Technologies P/N RFC-1).
T1—Broadband 2:1 transformer; 13 bifilar turns #12 PTFE (120 inches, overall) on three FT-240-61 cores. Note that plate tank inductors, bandswitch, plate RF choke, and toroidal RF transformer are part of Command Technologies HF-2500 plate tank circuit.
T2—Filament transformer, 12.6 V ac (center-tapped), 6A (Triad F-182).
V1—Svetlana 4CX1600B power tetrode in modified Svetlana SK-3A socket. The anode connector is a Svetlana AC-2, and the chimney and the chimney extension are each a Svetlana CH-1600B.
Z1—Parasitic suppressor; two turns of tinned copper strap (0.032-inch thick × 0.313-inch wide) over three 91 Ω, 2 W composition resistors in parallel.

somewhat more complex dc supply design. This amplifier operates in the grounded-cathode configuration, with a 50-Ω resistor from control grid to ground. This provides a good load for the transceiver driving the amplifier, promotes amplifier stability and also eliminates the need for switched-input tuned circuits. The advantages of such a passive-grid, grounded-cathode design outweigh the cost and complication of the screen-grid supply needed by the tetrode tube.

The Svetlana 4CX1600B is designed with a "striped-cathode," where emission takes place mainly in the spaces between parallel control-grid wires. This reduces the number of electrons intercepted by the control grid under normal drive conditions. (The Eimac 4CX1500B is also designed this way.) However, the linearity of such a high-gain tetrode falls off rapidly if the control grid is allowed to draw any current at all. Even a small positive voltage at the control grid can cause a large current to flow in the grid.

Note that the control grid in this type of high-gain tetrode is only rated at 2 W dissipation. (The first versions of the data sheet for the 4CX1600B specified the grid dissipation as 100 milliwatts!) By comparison, the control grid dissipation of the venerable, but much lower-gain, 4-1000A tetrode is 25 W. Any circumstance where measurable control grid current flows in the 4CX1600B will result in nonlinear operation, resulting not only in splatter, but also in possible damage to the control grid. It is thus important to provide some sort of grid current prevention scheme or, at the very least, a grid current warning alarm, for an amplifier using the 4CX1600B.

The grid of the 4CX1600B in this amplifier is tapped down on the input resistor. With 100 W of drive, the grid voltage cannot swing positive enough to result in significant grid current. Deliberate cathode degeneration (negative feedback) is also used to help prevent grid-current flow. This is accomplished by placing a noninductive resistor between the cathode and ground. In addition, a sensitive grid-current meter is provided, reading 1.3 mA at full-scale deflection. Finally, a simple, yet sensitive, grid-current-activated warning is also included in this design, using a red LED on the front panel as a warning lamp.

In receive, a 100 Ω resistor is switched into the screen grid circuit to chassis ground. This removes the screen voltage and keeps the tube cut off to avoid the generation of any shot noise. In transmit, a 17.5-kΩ, 15-W resistor to ground is switched into the screen grid circuit to keep a constant load of 20 mA on the series regulator. This allows the regulator to function properly with up to –20 mA of screen current. (Negative screen current is a condition common to these types of power tetrodes under some load conditions.) The 20-mA constant load is indicated on the screen-current meter as "zero," so that the meter reads actual screen current from –20 to + 80 mA.

Building It

The heart of the amplifier consists of the RF deck, the control and metering circuitry and the cooling system. These are

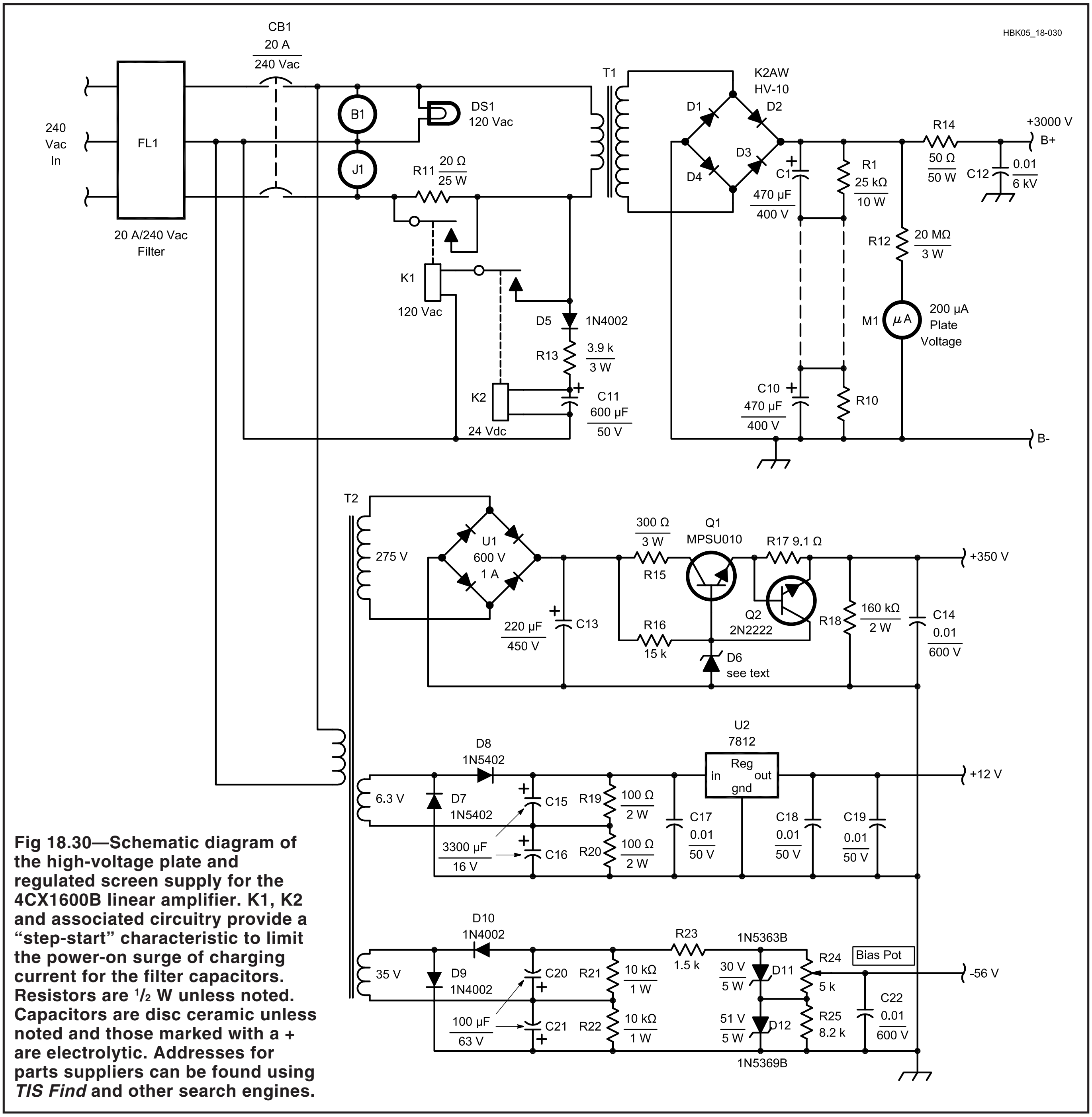


Fig 18.30—Schematic diagram of the high-voltage plate and regulated screen supply for the 4CX1600B linear amplifier. K1, K2 and associated circuitry provide a "step-start" characteristic to limit the power-on surge of charging current for the filter capacitors. Resistors are 1/2 W unless noted. Capacitors are disc ceramic unless noted and those marked with a + are electrolytic. Addresses for parts suppliers can be found using *TIS Find* and other search engines.

B1—Muffin fan (Rotron SU2A1 or similar).
C1 to C10—Filter capacitors; 470 µF, 400 V electrolytic.
C11—600 µF, 50 V electrolytic.
C12—0.01 µF, 6 kV disc ceramic.
C13—220 µF, 450 V electrolytic.
C14, C22—0.01 µF, 600 V disc ceramic.
C15, C16—3300 µF, 16 V electrolytic.
C17, C18, C19—0.01 µF, 50 V disc ceramic.
C20, C21—100 µF, 63 V electrolytic.
CB1—2 Pole, 20 A, 240 V ac circuit breaker.
D1 to D4—K2AW's HV-10 rectifier diodes.
D5—1N4002.
D6—Zener diodes, three 1N4764A and one 1N5369B to total approximately 350 V dc.
D7, D8—1N5402.
D9, D10—1N4002.
D11—Zener diode, 1N5363B (30 V, 5 W).
D12—Zener diode, 1N5369B (51 V, 5 W).
DS1—120 V ac indicator lamp (red).
FL1—240 V ac/20 A EMI filter.
J1—110 V ac, 15 A receptacle for plug P1 on Fig 18.32.
K1—120 V ac DPDT relay; both poles of 240 V ac/15 A
(Figure 18.30 continued)
contacts in parallel.
K2—24 V dc relay; 120 V ac/5 A contacts.
M1—200 mA meter movement.
Q1—MPSU010.
Q2—2N2222.
R1 to R10—Bleeder resistors; 25 kΩ, 10 W.
R11—20 Ω, 25 W.
R12—20 M Ω, 3 W (Caddock MX430).
R13—3.9 k Ω, 3 W.
R14—50 Ω, 50 W mounted on standoff insulators.
R15—300 Ω, 3 W.
R18—160 k Ω, 2 W composition.
R19, R20—100 Ω, 2 W composition.
R21, R22—10 k Ω, 1 W composition.
R24—5 kΩ potentiometer; sets control grid bias for desired no-signal cathode current.
T1—Plate transformer (Peter W. Dahl No. ARRL-002).
T2—Power transformer, 120 V / 275 V at 0.06 A, 6.3 V at 2 A, 35 V at 0.15 A.
U1—600 V, 1 A rectifier bridge.
U2—7812, +12 V IC voltage regulator.

all mounted in a surplus 19-inch rack-mount cabinet of the sort picked up at surplus stores and hamfests. The power supply is built into another cabinet.

Fig 18.29 shows the schematic diagram of the RF deck. The 4CX1600B is mounted in the Svetlana SK-3A socket, modified as described below (to allow the cathode to operate above ground potential for negative feedback). Svetlana's CH-1600B chimney routes the cooling airflow through the anode cooling fins. An additional CH-1600B acts as a chimney extension, discharging the air through the top of the RF deck's cabinet. The cooling fan is a squirrel-cage blower. According to the 4CX1600B data sheet at 1600 W of plate dissipation, the blower should deliver at least 36 cfm (cubic feet per minute) of cooling air at an ambient temperature of 25°C, at a back pressure of 0.4 inches of water.

The low-cost filament transformer specified in Fig 18.29 produces 18.5 V ac (with nominal mains voltage), so two 0.1-Ω, 5-W resistors were added to drop the voltage at the filament terminals of the 4CX1600B to the 12.6 V ac recommended by the tube manufacturer.

The input grid resistor is 51.6 Ω, with a dissipation capability exceeding 100 W. It consists of three Caddock MP850 resistors—two 71.2-Ω resistors in parallel, in series with 15 Ω, all mounted on a surplus heat sink (5.0 × 5.5 × 0.75 inch or 12.7 × 14.0 × 2.0 cm). This passive grid resistor is mounted below the chassis, near the SK-3A socket, and has its own small cooling "biscuit" fan. While the air below the chassis is pressurized by the main blower to provide cooling of the tube, the auxiliary fan cools the input resistors and keeps the air stirred up to prevent any stagnant hot air below the chassis.

The grid of the 4CX1600B is tapped at the 35.6-Ω point of the input resistive divider. As a further aid to stability, a 10-Ω, 2-W composition resistor is placed in series with the control-grid lead. This arrangement results in an input SWR of 1.0:1 at 1.9 MHz, increasing to just over 1.6:1 at 29.6 MHz, mainly due to the reactance of the 86 pF input capacitance of the 4CX1600B. No frequency compensation was deemed necessary. The cathode resistor is made up of four 16-Ω, 3W non-inductive metal-oxide film resistors from the cathode terminal ring on the socket to each of the four socket mounting screws.

The plate tank circuit components include a heavy-duty bandswitch, a silver-plated inductor for the high bands, powdered iron toroidal inductors for the low bands and a plate choke wound on a Delrin form. These components are those used in a Command Technologies HF-2500 amplifier but other suitable components could be utilized. (As it is currently configured, the plate tank cannot be tuned to 30 m. Operation at full power on this band would require another position on the bandswitch and another tap on the tank coil or compromises on other bands. These are options that the author considered to be unnecessary and undesirable, since US hams have a power limit of 200 W on 30 m.)

To construct L3, stack the three T-225-28 cores, side-by-side and hold them together with Teflon tape, making a really thick core. Start with a 150-inch long piece of Teflon-insulated #10 stranded wire and begin to wind the core with close-wound turns. When you have three turns in the first "group" of turns, leave a space (about 20º of the circle) before winding the fourth turn. Then wind the next three turns, making the second group of three turns. Make another blank space of 20º and then continue in this fashion until you have six groups of three turns spaced evenly around the core. The tap for the 80-meter position is at nine turns—halfway around.

The anode connector is a Svetlana AC-2, and the plate parasitic choke is two turns of tinned copper strap (0.032-inch thick × 0.188-inches wide, or 0.8 mm × 4.8 mm) over three 91-Ω, 2-W composition resistors in parallel. (Any value from 47 to 100 Ω will be satisfactory.) The antenna change-over relay has a 115 V ac coil (12 V dc would be fine also). The author's relay had wide, gold-plated contacts.

Control Circuitry

The control circuitry is shown in Fig 18.29. The amplifier is turned on with the main switch/breaker on the power-supply cabinet. When the switch is thrown, all voltages are ready (after the step-start delay in the plate supply). The 4CX1600B filament begins to heat; the cooling fans go on; the time delay starts and anode voltage is applied to the 4CX1600B. After the mandatory three minutes for filament warm up, the +12 V dc control voltage is enabled by the time-delay relay. At this time, the control circuitry (consisting of transistors Q1 to Q5) determines whether screen voltage can be applied to the 4CX1600B and whether to activate the antenna changeover relay. Q5 is the main switch activating T/R relay K2 whenever 12 V is available (that is, after the 3-minute warm up period). Screen voltage will thus be supplied to the tube only when all of the following conditions are met:

1. The anode voltage for the 4CX1600B is available. This is sensed in the RF deck by the resistive divider R7/R8 shown in Fig 18.29. If the HV sense line is low, then Q1 and Q2 hold the base of Q5 at a low level.
2. The negative control-grid bias is present. If this voltage is near zero, transistor Q3 is saturated, and again Q5 is turned off.
3. The T/R switch from the exciter has pulled the base of Q4 low, allowing its collector to rise.

The Power Supply

Remember that almost every voltage inside a power supply for a high-power linear amplifier is lethal! Turn it off, unplug it, and short it out before you touch anything! Always apply the "one hand in the pocket" principle when working on anything above 24 V!

The high-voltage power supply uses a Peter W. Dahl ARRL-002 transformer, weighing 46 pounds. As shown in **Fig 18.30**, a simple step-start circuit using K1 and K2 limits the current surge charging the filter capacitors when power is first applied. The transformer's output is rectified by a bridge of K2AW's Silicon Alley 10-kV diode arrays, and the filter capacitor is made up of a string of ten 470 µF, 400-V electrolytic capacitors. These were removed from a laser power supply board, which was available at a local surplus store (Alltronics, Santa Clara, CA) for $14.95. The voltage is divided equally across the capacitor string by 25-kΩ, 25-W resistors that also serve as the power supply bleeder. (This divider results in a considerably higher bleeder current than the typical 100 kΩ resistors often seen. The result is a stiffer power supply, but more heat is generated.)

The author's junk box produced a transformer with output windings of 275 V ac at 60 mA, 6.3 V ac at 2 A, and 35 V ac at 150 mA. These windings were dedicated to a regulated 350-V screen supply, a regulated 12-V dc supply for relay and indicator lamps (using a full-wave doubler and a three-terminal IC regulator), and the control-grid bias supply. The circuitry for these supplies is very straightforward. These supplies were built in the same cabinet as the plate high-voltage supply.

All power supplies are cooled by a muffin fan on the rear panel of the cabinet. Although the fan probably isn't necessary, cool components are sure to last longer. The major source of heat in this cabinet is the bleeder-resistor chain, which dissipates about 36 W when the plate voltage is 3000 V. High voltage is monitored with a 200 mA surplus meter movement through a Caddock MX430 20-MΩ multiplier

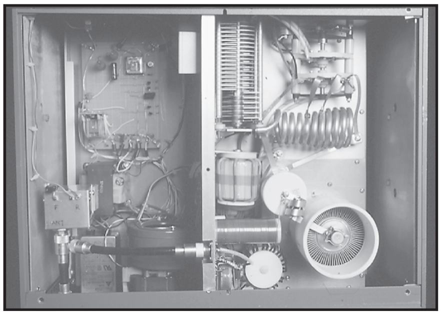


Fig 18.31—Inside view of RF deck. Tank components are from a Command Technologies HF-2500 amplifier.

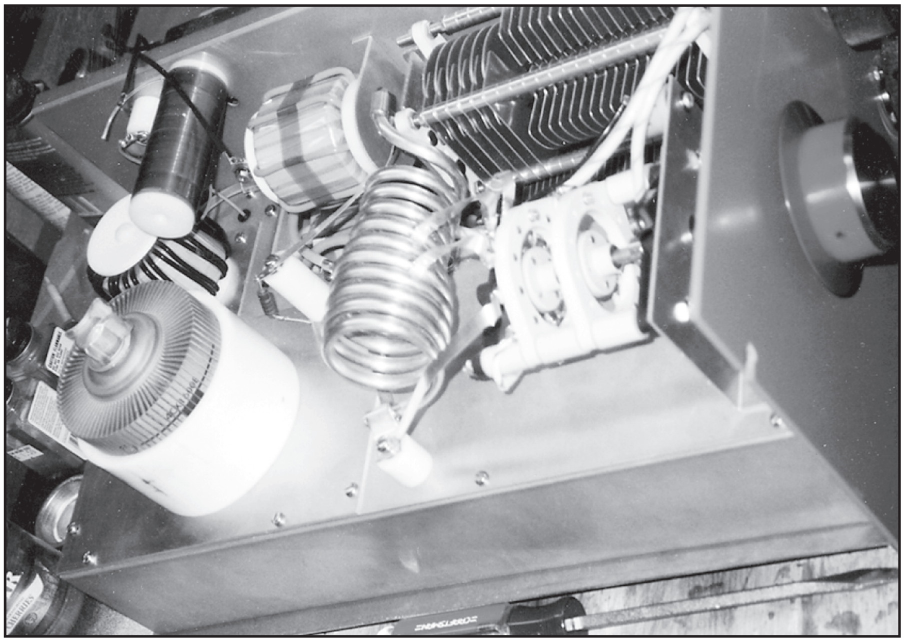


Fig 18.32—Another view of RF deck during construction.

resistor.

All power to the RF deck is supplied from the power supply cabinet. There is a standard IEC 120-V ac cable for the 4CX1600B filament transformer and the antenna changeover relay, an auxiliary power cable and a high-voltage line for the anode voltage. The shielded auxiliary power cable carries the screen and control-grid bias voltages and the 12-V dc and the ground. The high-voltage line is a 40-kV #18 wire obtained from a local surplus store, with Millen 37001 connectors at each end.

In this design it is possible to plug in and turn on the HV supply without any connection to the RF deck. If you should forget to connect the ground wire and only connect the HV cable by itself, then a potentially unsafe condition exists, with high voltage on the RF deck chassis with respect to the power supply chassis. You can avoid this in several ways: Use a special high-voltage cable/connector that incorporates a chassis ground connection together with the HV lead. Or you could use an interlock system, with an additional high-current relay in the 240 V ac line that is activated only when an interlock cable is connected. (The interlock cable would contain a direct inter-chassis ground connection.) Finally, a simple but effective approach is to bundle the HV cable with the other inter-cabinet cables, with a distinctive bright warning label to remind the operator to make sure all connections are made between the power supply and the RF deck.

Because no control-grid current flows, the control-grid bias voltage (nominally –56 V) is provided by a simple half-wave voltage doubler, with low-power zener diodes and a potentiometer to allow grid bias adjustment for the desired no-signal cathode current. The common practice of using a zener diode in the cathode circuit to provide operating bias was rejected because of the need for actual resistance between the cathode and ground for negative feedback.

The screen supply provides a dc voltage of 350 V by means of a series electronic regulator. The regulator has a current-limiting feature, where the output voltage falls if the screen draws more than 60 mA. This prevents the screen grid dissipation from exceeding its maximum rating of 20 W.

Again, please take the time to review the *Safety* chapter in this *Handbook* to familiarize yourself with the lethal dangers present in any high-powered amplifier—and the proper procedures to use in accessing such equipment.

Modifying the SK-3A Socket

Because the stock Svetlana socket has the cathode tied directly to chassis ground (through the socket's mounting plate) and because an internal bypass capacitor for the screen grid is placed between the screen grid and the cathode, you must modify the socket for this application. You will need four insulating shoulder washers (Teflon or other insulating material), made for 4-40 screws.

1. Drill out the four rivets holding the screen ring to the screen contactors at the very top of the socket.
2. At the bottom of the socket, remove the four nuts from the machine screws holding the socket assembly together.
3. Disassemble the socket:
   a) First remove the cathode contact ring. Be sure to mark its position relative to the underlying bakelite layer.
   b) Remove the bakelite socket layer, which has the factory markings and serial number, also marking its position relative to the socket mounting plate. (This is the 0.060-inch [1.5-mm] silver-plated brass plate.)
   c) Carefully remove the screen contactor assembly, freeing the contactor "ears" by springing them outward. Don't drop the screen capacitor! It is the ceramic annulus with silver plating on each side, and it is very brittle.
   d) Finish removing the spring plate, the capacitor and the other spring plate, if they didn't already come out with the screen contactor assembly in step (c) above.
   e) Remove the mounting plate assembly, marking its position relative to the remaining socket assembly.
4. Drill out the four holes in the mounting plate assembly using a #14 drill (0.180 inches). These are the second set of holes in from the outer edge, through which the socket assembly screws pass. (The screws should still be in the top layer of the socket, with heater, grid, and cathode contactors.)
5. Put the new Teflon shoulder washers on the screws. When the socket is reassembled, the cathode will be isolated from the main mounting plate and the screen bypass capacitor.
6. Replace the capacitor assembly in the following order: spring, capacitor and spring. Now replace the screen contactor assembly and the bakelite bot-

tom section, taking care to align this section with your previous mark. Carefully guide the socket solder tabs through the bakelite bottom without bending them.

7. Cut the outer tabs off the cathode ring contact. After all of this work, you don't want this ring (the cathode terminal) to be grounded when you mount the socket in the chassis! Place the modified cathode contact ring over the screws.
8. Replace the washers and nuts on the socket assembly machine screws and tighten each a little at a time, until the assembly is snug.

This completes the socket conversion. The screen ring on the 4CX1600B is contacted exactly as before. The internal screen bypass capacitor still appears between the screen grid and ground (through the socket mounting plate). The heater, control grid, and screen contacts function exactly as in the original.

The cathode annulus on the 4CX1600B is contacted exactly as before, but the electrical connection for the cathode is now isolated from the chassis. The cathode contact on the socket is now made through the thin cathode ring on the bottom of the socket. (The ring is silver-plated and easily soldered, convenient for an application like the present one, which requires multiple contacts.)

Metering

The author obtained some attractive meters with 200 µA movements from a local surplus store. The internal resistance was 2000 Ω. One meter became a voltmeter on the anode power supply (0 to 4 kV); one became a triple-purpose multimeter to measure anode current (0 to 1.3A), screen-grid current (–20 to +80 mA), and control-grid current (0 to 1.3 mA). The third meter, not shown in the schematic, indicates forward (0 to 1500 W) and reflected power (0 to 150 W) at the output connector. After dc calibration against a digital multimeter, he carefully removed the cover and face of each movement and attached a homemade laser-printed scale.

Grid Current Warning

The circuitry for the grid-current warning indicator light is very simple and is shown in Fig 18.29 also. When control-grid current flows, it develops a voltage across R10. This causes the collector current of Q6 to light a red LED indicator brightly when grid current is about 1.0 mA. (Although the battery is always connected to the circuit of transistor Q6, the current drain due to collector-emitter leakage current is negligible, so battery life should be very long. If you don't like the floating 9-V battery, a small dc power supply could be included or a small "wall-wart" type of dc supply could be built right into the cabinet. It must however, be capable of floating at the grid potential, about 60 V away from chassis ground potential.)

When the grid-current warning LED flickers on voice peaks, it's time to back off the transceiver's RF output control to reduce the drive. In CW mode, many transceivers will put out a high-power spike on initial key closure, even when the RF output control is set to quite low values. If this happens with your transceiver, the warning blink from the LED will alert you to the problem. The circuitry for the grid-current warning indicator is built into a small aluminum minibox that uses feedthrough capacitors and RF chokes to eliminate stray RF.

Results

The zero-signal plate current is about 280 mA, resulting in a zero-signal plate dissipation of about 900 W. At full 1.5 kW output on 40 m, the plate current is about 0.8 A and the anode dissipation is less than 1000 W. (Until the TR switch is activated, the screen voltage is zero and the tube is effectively cut off, so there is no plate dissipation except during transmit periods.) After a heavy period of operating the amplifier, let the fan run for a few minutes in standby mode to cool the tube before turning the amplifier off.

Performance figures for the amplifier are presented in **Table 18.7**.

Table 18.7
4CX1600B, Class AB1, Passive Grid-Driven Service

	Zero Signal	*Maximum Signal*
Plate Voltage	3200 V	3040 V
Control Grid Bias Voltage	–56 V	–56 V
Screen Grid Voltage	350 V	350 V
DC Plate Current	280 mA	800 mA
Approx. Plate Load	—	2400 W
Drive Power	0 W	66 W
Power Output	0 W	1500 W
Intermodulation Distortion Products		
3rd order	—	–35 dB
5th order	—	–43 dB
7th order	—	–47 dB