

OPERATING MANUAL



EMTRON DX-4

HF LINEAR AMPLIFIER

Jan. 2007



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DX-4, Serial No.....

INITIAL SETTINGS FOR PLATE AND LOAD CAPACITORS

TEST FREQUENCY	BAND	FACTORY SETTINGS 50 OHM LOAD		USER SETTINGS ANTENNA	
		PLATE	LOAD	PLATE	LOAD
28.600 MHz	10m				
24.900 MHz	12m				
21.200 MHz	15m				
18.100 MHz	17m				
14.200 MHz	20m				
10.125 MHz	30m				
7.070 MHz	40m				
3.600 MHz	80m				
1.800MHz	160m				
1.850 MHz	160m				
1.900 MHz	160m				

TABLE 1

TABLE OF CONTENTS

1	GENERAL DESCRIPTION.....	5
1.1	DX-4 – INTERNAL VIEW	6
2	TECHNICAL SPECIFICATIONS.....	7
3	UNPACKING	11
3.1	OPENING THE CARTON	11
3.2	OPENING THE DX-4 COVER.....	12
3.3	INSTALLING THE TRANSFORMER	ERROR! BOOKMARK NOT DEFINED.
4	INSTALLATION ENVIRONMENT.....	12
4.1	REQUIRED ENVIRONMENT	12
4.2	POWER REQUIREMENTS.....	12
5	REAR PANEL.....	13
5.1	POWER / EARTH CONNECTIONS	13
5.2	RF CONNECTIONS.....	13
5.3	TRANSCEIVER CONTROL.....	13
6	FRONT PANEL	14
6.1	CONTROLS	14
6.2	DISPLAYS.....	14
7	ELECTRICAL CONNECTIONS.....	19
7.1	CONNECTIONS TO TRANSCEIVER / EXCITER	19
7.2	EARTH AND MAINS CONNECTIONS.....	19
7.3	TERMINATING THE POWER CABLE (EXPORT VERSION).....	ERROR! BOOKMARK NOT DEFINED.
7.4	OPERATION AT 230V, 220V, 200V (EXPORT VERSION).....	19
8	DX-4 DESCRIPTION	20
8.1	RF SECTION	20
8.2	MAINS TRANSFORMER.....	21
8.3	H. V. POWER SUPPLY	ERROR! BOOKMARK NOT DEFINED.
8.4	SOFT START MODULE	18
8.5	SENSOR MODULE.....	21
8.6	ANTENNA RELAY / QSK MODULE	21
8.7	DISPLAY BOARD.....	21
8.8	CONTROLLER BOARD	21
9	POWERING UP.....	23
10	OPERATION.....	23
10.1	TUNNING PROCEDURE	23
10.1.1	<i>General.....</i>	23
10.1.2	<i>Preliminary tuning.....</i>	23
10.1.3	<i>Final tuning.....</i>	24
10.1.4	<i>Potential problems during tuning.....</i>	25
10.2	ALC ADJUSTMENT	25
10.3	USING YOUR DX-4.....	26
10.3.1	<i>CW / RTTY and all digital modes.....</i>	26
10.3.2	<i>Voice modes (SSB).....</i>	26
10.3.3	<i>Hints on good linearity and efficiency.....</i>	26
11	SWITCHING THE POWER OFF.....	27
12	TROUBLESHOOTING - IF SOMETHING GOES WRONG.....	27
12.1	NO POWER.....	27
12.2	FAN NOT WORKING.....	27
12.3	IF THE FAULT LIGHT TURNS ON	28

12.4	OVER-TEMPERATURE CUT-OFF	28
12.5	OVER-CURRENT CUT-OFF	28
12.6	IG2 BLINKS FAST - NO PLATE VOLTAGE	28
12.7	SPARKS / DISCHARGES IN RF AREA	28
12.8	SWR CUT-OFF	29
12.9	FREQUENT OVER-DRIVE PROTECTION CUT-OFF	29
12.10	TUBE REPLACEMENT	29
13	WARRANTY / SERVICE	29
14	GLOSSARY	29
15	APPENDIX 1: SCHEMATIC DIAGRAMS	31
15.1	DX-4 BLOCK DIAGRAM	31
15.2	CIRCUIT DIAGRAM – HIGH VOLTAGE POWER SUPPLY	32
15.3	CONTROL BOARD AND ADJUSTMENT POINTS.....	33
15.4	CIRCUIT DIAGRAM – AC INPUT AND WIRING DIAGRAM – STANDARD	ERROR! BOOKMARK NOT DEFINED.
15.5	CIRCUIT DIAGRAM – AC INPUT AND WIRING DIAGRAM – U.S. VERSION	34
15.6	CIRCUIT DIAGRAM – SOFT START (200 TO 240 V OPERATION)	37
15.7	CIRCUIT DIAGRAM – QSK	39
15.8	CIRCUIT DIAGRAM – RF MODULE.....	40
15.9	CIRCUIT DIAGRAM – CONTROL BOARD	42
15.10	CONTROL BOARD – COMPONENT LEGEND (SILKSCREEN TOP)	43
	CONTROL BOARD – SOLDER SIDE TRACK WORK.....	44
16	APPENDIX 2: WAVEFORMS	45
16.1	QSK (OPTIONAL MODULE) SWITCHING.....	45
16.2	LINEARITY	45
17	APPENDIX 3: ADJUSTMENTS	46
17.1	CONTROL BOARD	46
17.1.1	<i>PRE-BIAS ADJUSTMENT (Adjustment: POT7, marked PRE_BIAS)</i>	46
17.1.2	<i>BIAS ADJUSTMENT (Adjustment: POT3, marked BIAS)</i>	46
17.1.3	<i>SWR Protection adjustment</i>	48
17.1.4	<i>EBS ADJUSTMENT (Adjustment: POT4, marked EBS)</i>	48
17.1.5	<i>SCREEN VOLTAGE ADJUSTMENT (Adjustment: POT2, marked SCREEN)</i>	48
17.1.6	<i>SCREEN CURRENT LIMIT ADJUSTMENT (Adjustment: POT1, IG2LIMIT)</i>	49
17.1.7	<i>IPTRIP ADJUSTMENT (Adjustment: POT6, marking: IP TRIP)</i>	49
17.2	DISPLAY BOARD ADJUSTMENTS	51
17.2.1	<i>PLATE CURRENT (Adjustment: VR4, Marked: AMP)</i>	51
17.2.2	<i>PLATE VOLTAGE (Adjustment: VR2, marked: VOLT)</i>	51
17.2.3	<i>REFLECTED POWER (Adjustment: VR3, marked: RF R)</i>	51
17.2.4	<i>FORWARD POWER (Adjustment: VR1, marked: RF F)</i>	51
17.2.5	<i>SCREEN CURRENT (Adjustment: VR6, marked IG2+, VR5, marked IG2-)</i>	51
17.3	RF SENSOR ADJUSTMENT	52

DX-4 LINEAR AMPLIFIER

Serial No

OPERATING MANUAL

Jan. 2007

CAUTION

The DX-4 has been designed for 100% safe operation and long life. Interlocking sensing circuitry constantly monitors conditions inside the amplifier and the power supply. It must be noted however, that the high voltages present inside the DX-4 system are EXTREMELY DANGEROUS. Do not remove the top covers under any circumstances if any leads are still plugged into the rear of the amplifier and especially if the AC lead is plugged in the power outlet.

Before any component inside the high voltage, power supply or output section is touched, unplug the power cable all rear panel leads and allow at least 5 minutes of 'off time'.

After that, you should further check this by momentarily shorting the tube anode to the chassis with a suitable insulated lead.

1 GENERAL DESCRIPTION

The Emtron DX-4 Linear Amplifier is a 4000 watt average output power, for the 160m through 10m amateur bands (9 bands), housed in a desk-top cabinet with self-contained cooling system and separate power supply. The power supply can be single phase or three-phase, this has to be specified when the DX-4 is ordered.

It utilises two high performance tetrodes, type GU84 (4CX2500), a ceramic metal tube with a plate dissipation of 2500W. The tubes are air cooled by a commercial grade forced air turbine blower system and two computer type fans sucking air and positioned above the tubes. All fans operate at two speeds, controlled by 2 temperature sensors.

Tetrodes offer exceptionally stable operation and levels of quality performance far exceeding that which can be expected from triodes. The harmonic output and intermodulation distortion achieved with this tube are exceptionally low. This is especially important when dealing with a high output power.

The Emtron DX-4 is supplied as standard with a host of features including solid state metering, comprehensive protection systems and very long duty cycle (continuous commercial service).

In addition, a unique Emtron QSK module is installed as standard. It allows for extremely rapid switching times between transmit and receive, with consequent advantages when using CW or the digital modes.

Operation of the DX-4 is greatly simplified by the absence of meter switching and of front panel level setting controls. The front panel moving LED display systems indicate simultaneously: the output forward and reverse power, screen grid current (positive and negative), the plate voltage and the plate current, while 5 single LED's indicate: Ready, Overdrive warning, High SWR cut-off indication, On Air and Fault.

The Emtron Electronic Bias Switch (EBS) automatically switches the standing current (typically 0.75 A) off when there is no modulation. This reduces the average tube dissipation.

On initial switch on, the unique Emtron "soft start" circuitry ensures that no damaging AC surge currents are generated.

Professional, fine output tuning adjustment is possible, due to the 6: 1 reduction mechanism fitted.

1.1 DX-4 – Internal View

The main components of a DX-4 amplifier are shown in the picture below.

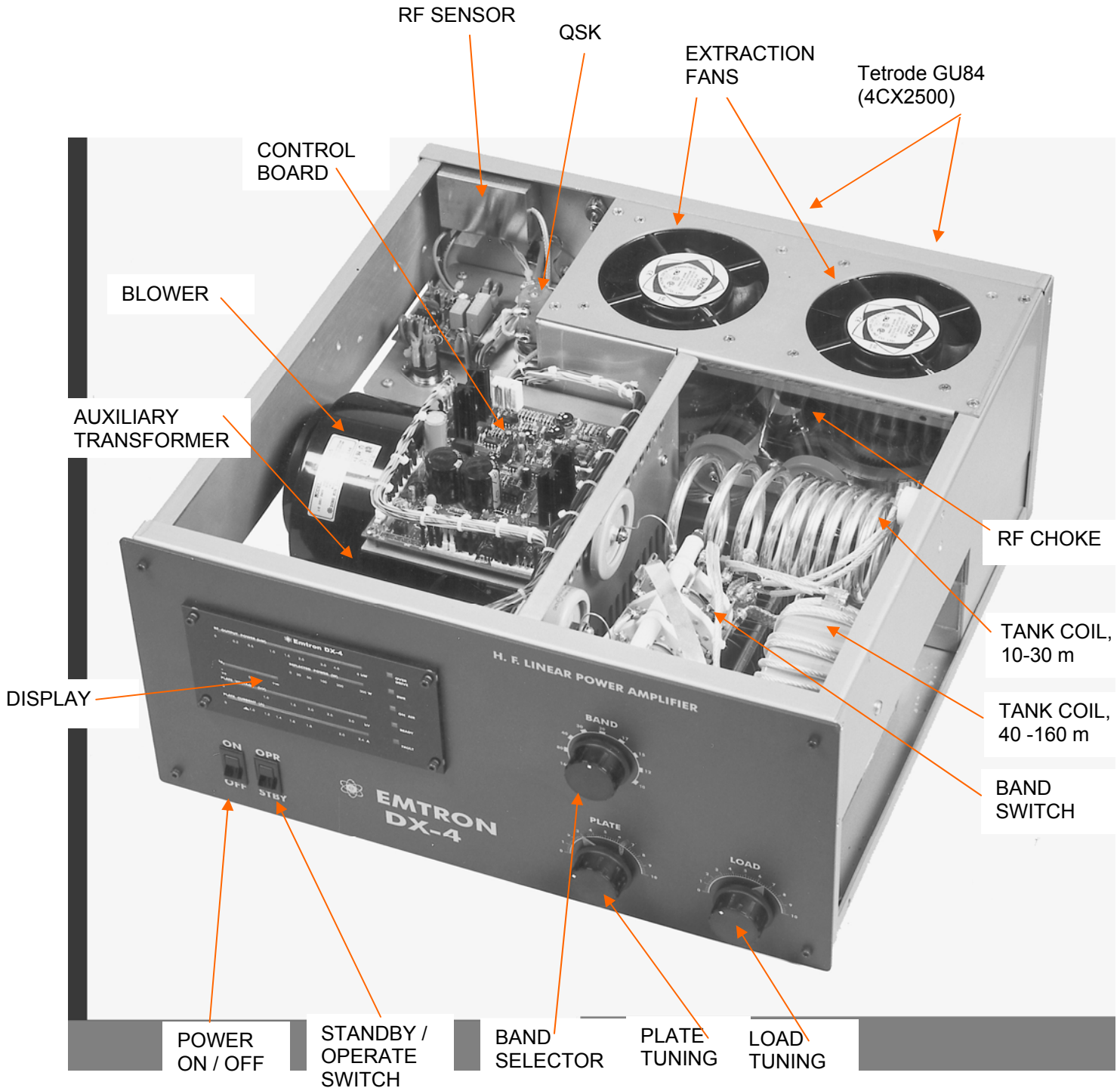


Figure 1 – Internal View

2 TECHNICAL SPECIFICATIONS

2.1 Amplifier

FREQUENCY COVERAGE: Complete (manually tuned) coverage of the nine HF amateur bands:

1.800 – 1.900 MHz
3.500 – 4.000 MHz
7.000 – 7.500 MHz
10.000 – 10.300 MHz
14.000 – 14.350 MHz
18.000 – 18.500 MHz
21.000 – 21.500 MHz
24.000 – 24.500 MHz
28.500 – 29.990 MHz

TRANSMITTING MODES: Both continuous and low duty cycle modes are supported. That is, the DX-4 supports SSB, CW, AM, FM, RTTY and SSTV. II

OUTPUT POWER: Typical 4000 W carrier or up to 5000 W PEP except 12 m band (2500 W) and 10 m band (2000 W CW)

DRIVE POWER: Nominal 60-90 watts for full rated output.

INPUT IMPEDANCE: Nominal 50 ohm passive impedance, unbalanced. VSWR 1.5:1 or less.

OUTPUT IMPEDANCE: Nominal 50 ohm passive impedance, unbalanced. VSWR 2.6:1 or less.

DISTORTION: Third order intermodulation products are more than 35 dB below rated output.

HARMONICS: Harmonic output is better than 50dB below the rated output.

FAULT PROTECTION: The comprehensive fault protection system include circuitry to monitor:

- *plate current:* should the plate current exceed a safe value, the amplifier goes to standby mode for 2 minutes.
- *screen grid over-current:* Absolute tube protection is offered with visual warning and a reduced power level being enabled if the screen current exceeds a pre-set limit.
- *temperature:* Should the tubes' temperature exceed a specific level, amplifier operation is suspended until the temperature drops to a safe level.

OPERATIONAL PROTECTION

- *Overdrive protection:* Should the DX-4 be overdriven, a LED warning indicator will light up when the linearity limit is reached. If the drive is increased further, a 2 second cut off (by-pass) will follow.
- *SWR protection:* Should the DX-4 sense an SWR exceeding 2.6:1, a LED warning indicator will light up, simultaneously with a 3 second cut off.

METERING: The front panel moving LED display systems indicate:

“Moving light” LED indicators:

- output power
- reflected power
- screen grid current (positive / negative)
- plate voltage

- plate current

Five single LED's:

- on air
- ready
- fault
- overdrive warning
- SWR cut-off indicator

ALC (if fitted): Negative going, adjustable output level.

EBS: Electronic Bias Switch - automatically switches the standing current (about 1 A) to a lower ("pre-bias") value - when there is no input drive.

PRE-BIAS: A small current will flow in the tube when the amplifier is keyed on, but there is no modulation. This will prevent a harsh sound at the beginning of each word, when the EBS is activated and the tube goes through a non-linear zone, before reaching the correct initial bias.

QSK: makes possible the antenna switching at very fast rate - typically 3ms switching time in each direction.

COOLING: forced air cooling.

OPERATING TEMPERATURE: 0 to 40° Celsius

DIMENSIONS:

470mm wide, 230mm high, 500mm deep (18.5" x 9" x 18.5")

WEIGHT:

35 kg (77 lb) unpacked

2.2 Power supply single phase:

INPUT POWER: 200, 220, 230, 240 V selectable by re-soldering transformer tap

FUSING: Two 40 A normal acting fuses on the rear panel

SOFT START: when switched on, the mains power is gradually applied to the transformer, over a period of about 5 seconds, to avoid the high in-rush current typical for such high loads. Uses one standard (240 V) soft start module.

HIGH VOLTAGE SUPPLY: 2 modules in parallel with a total capacity of 117 μ F.

Current sensing resistor: 0.5 Ω .

LOW VOLTAGE SUPPLY: The power supply box only contains the main transformer, with a single secondary winding: the high voltage. All other voltages required for filament, bias, screen, logic, QSK are derived from a small auxiliary transformer located in the amplifier

SAFETY INTERLOCK: micro-switch activated by the power supply cover; this switch is in series with the interlock switch in DX-4 (also activated by the DX-4 cover) and the DX-4 front panel ON/OFF switch.

COOLING: natural (no fan).

OPERATING TEMPERATURE: 0 to 40° Celsius

DIMENSIONS:

470mm wide, 230mm high, 500mm deep (18.5" x 9" x 18.5")

WEIGHT: 45 kg (99 lbs)

2.3 Power supply three-phase (Europe):

INPUT POWER: 400 V between phases (based on 230V/398V European)

FUSING: Three 20 A normal acting fuses on the rear panel

SOFT START: when switched on, the mains power is gradually applied to the transformer, over a period of about 5 seconds, to avoid the high in-rush current typical for such high loads. Uses 3 high voltage (400 V) soft start modules.

HIGH VOLTAGE SUPPLY: one module with a capacity of 58 μ F.

Current sensing resistor: 1 Ω .

LOW VOLTAGE SUPPLY: The power supply box only contains the main transformer, with a single secondary winding: the high voltage. All other voltages required for filament, bias, screen, logic, QSK are derived from a small auxiliary transformer located in the amplifier. This transformer has primary taps for single phase (240 V) and 3-phase operation (400 V). This is a SINGLE PHASE transformer, but when used with a European 3-phase power supply, the primary tap must be 400 V since it is connected between 2 phases.

SAFETY INTERLOCK: micro-switch activated by the power supply cover; this switch is in series with the interlock switch in DX-4 (also activated by the DX-4 cover) and the DX-4 front panel ON/OFF switch.

COOLING: natural (no fan).

OPERATING TEMPERATURE: 0 to 40° Celsius

DIMENSIONS:

470mm wide, 230mm high, 500mm deep (18.5" x 9" x 18.5")

WEIGHT: 45 kg (99 lbs)

2.4 Power supply three-phase (North America):

INPUT POWER: 230 V between phases

FUSING: Three 30 A normal acting fuses on the rear panel

SOFT START: when switched on, the mains power is gradually applied to the transformer, over a period of about 5 seconds, to avoid the high in-rush current typical for such high loads. Uses 3 standard (240 V) soft start modules.

HIGH VOLTAGE SUPPLY: one module with a capacity of 58 μ F.

Current sensing resistor: 1 Ω .

LOW VOLTAGE SUPPLY: The power supply box only contains the main transformer, with a single secondary winding: the high voltage. All other voltages required for filament, bias, screen, logic, QSK are derived from a small auxiliary transformer located in the amplifier. This transformer has primary taps for single phase (240 V) and 3-phase operation (400 V). For operation with a North American 3-phase power supply, this transformer has to have the primary set to 230 V.

SAFETY INTERLOCK: micro-switch activated by the power supply cover; this switch is in series with the interlock switch in DX-4 (also activated by the DX-4 cover) and the DX-4 front panel ON/OFF switch.

COOLING: natural (no fan).

OPERATING TEMPERATURE: 0 to 40° Celsius

DIMENSIONS:

470mm wide, 230mm high, 500mm deep (18.5" x 9" x 18.5")

WEIGHT: 45 kg (99 lbs)

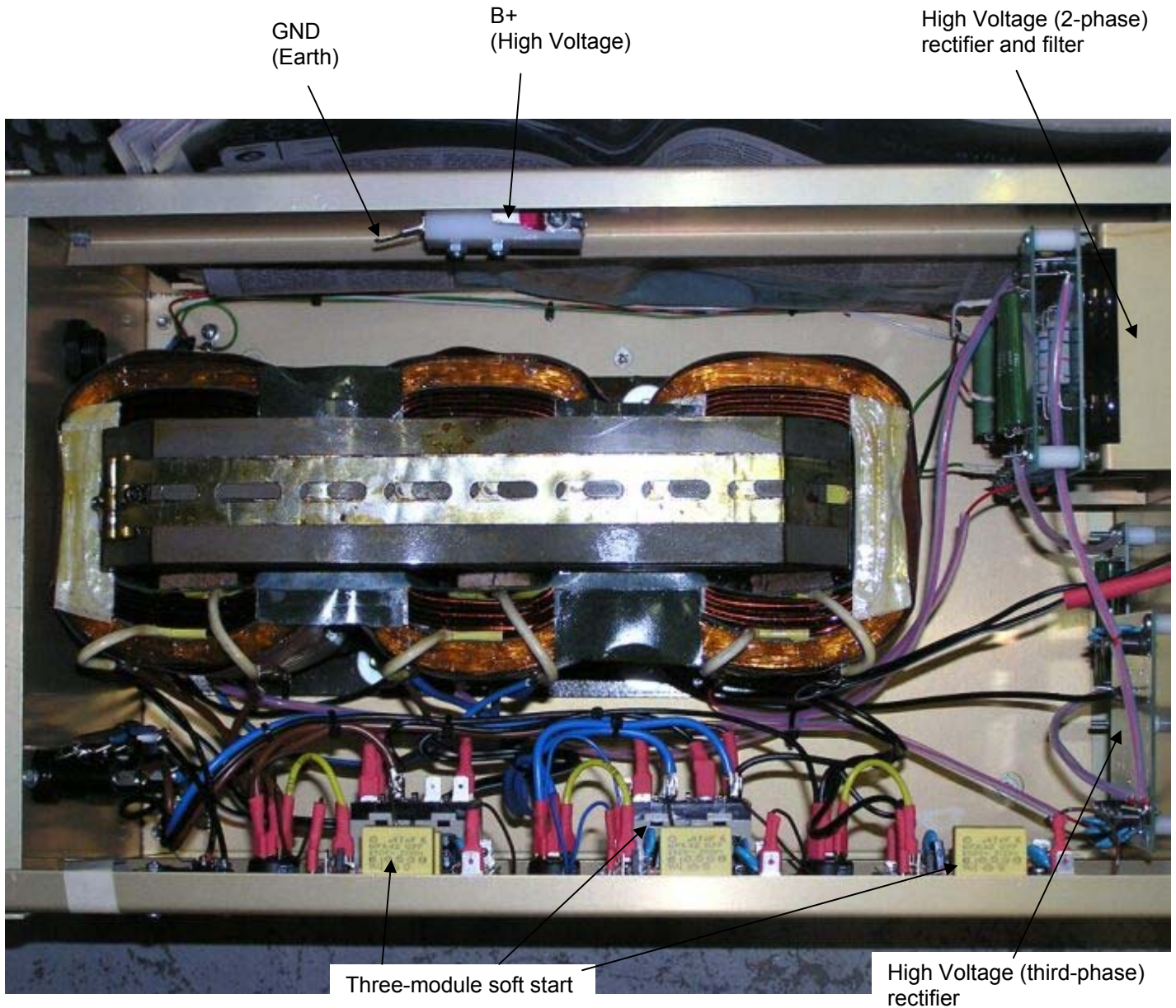


Figure 2 – 3-Phase Power Supply - Internal View

HINT: The side panel holding the soft start system can be removed for easy access. Remove the 4 screws, then lift the panel enough to clear the front and rear panel. Then the wires are long enough to allow the panel to be laid down on the bench with the components facing up.

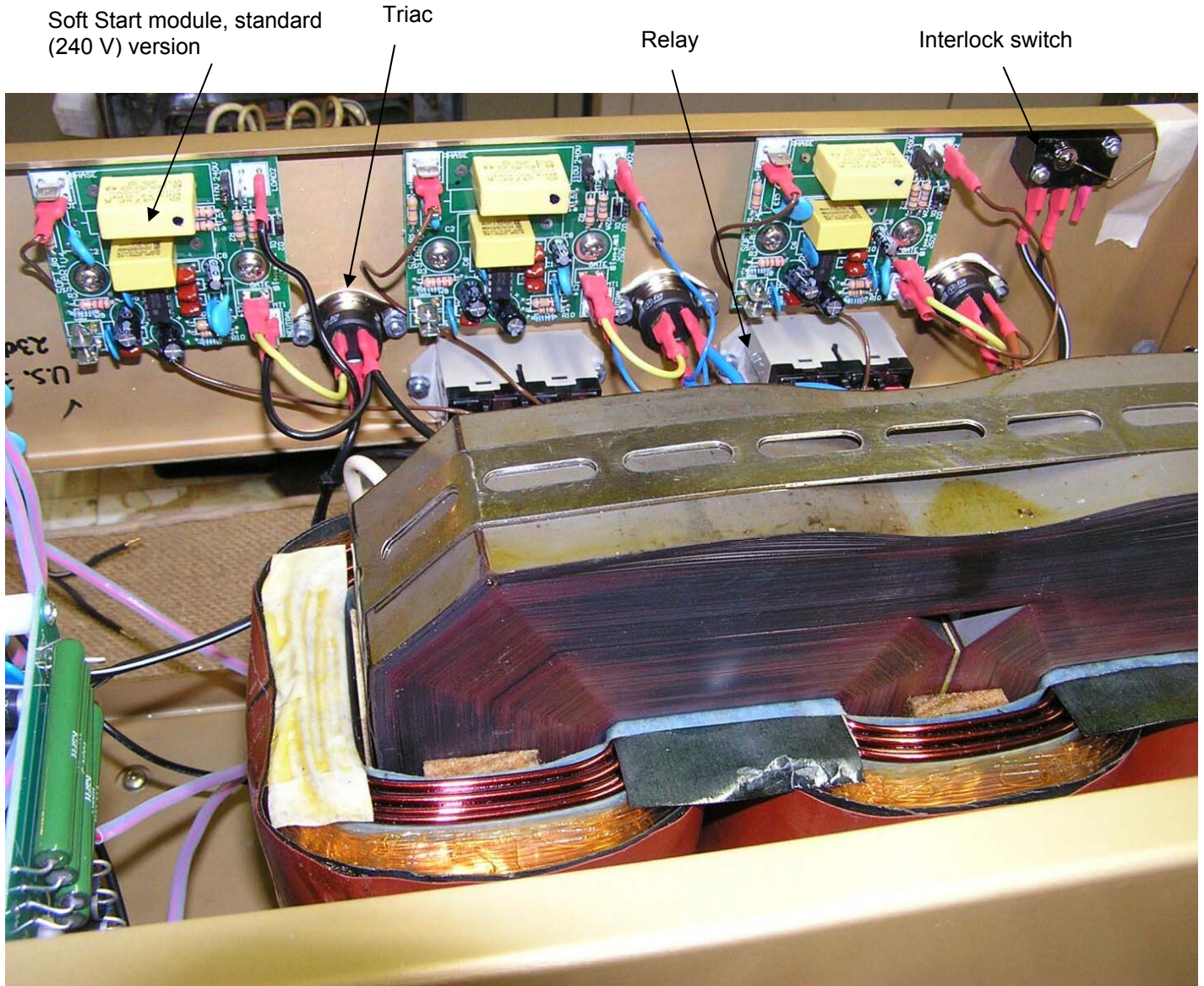


Figure 3 – 3-Phase soft start, North American version

3 UNPACKING the DX-4

The DX-4 is packed in a heavy duty package easily sufficient to protect the amplifier during transportation, even in case of fairly rough handling. The weight of the amplifier or the mains transformer in the power supply does mean, however, that dropping the amplifier or the power supply would without doubt result in some damage. The power supply is shipped in a heavy duty wooden crate.

3.1 Opening the carton

When opening the packing, do not cut the carton and do not destroy the wooden box. Save the packing material for possible further re-use. Shipment of your DX-4 in other than factory packing may result in non-warranty damage. To unpack the power supply, remove the screws on the top and remove the cover, then the power supply can be taken out.

3.2 Opening the DX-4 cover

An inspection of the interior of the amplifier and the power supply should reveal no damage or adversely affected components. Remove the 4 screws on each side and remove the amplifier cover. Should there be any form of problem, notify your supplier immediately. Check especially if the tubes are correctly positioned in place. To do this, look through the clear partition and through the fans at the top.

To open the power supply, remove 6 screws, also on the 2 sides of the box. Inspect for any possible damage.

3.3 Connecting the power supply

Remove the 3 screws on each side and remove the power supply cover. After visually inspecting for any possible shipping damage, connect the high voltage wire between the amplifier and the power supply. Remove the gland cover on the rear panel of the power supply (marked "High Voltage") and insert the end of the amplifier high voltage cable into the gland cover and the into the gland. Plug the 2 quick-connect ends into the ground and high voltage contacts positioned on the big, white isolating block. Make sure the polarity is respected, with the wire insulated in red connecting to the B+ (High Voltage) contact.

Push the cable a bit further in, to ensure it is not stretched and install and tighten the gland cap. Make sure it is tight enough so that the cable cannot be accidentally pulled out.

Make sure the transformer is wired for the nominal mains voltage in your area. See 7.4

Connect the auxiliary power and control cable between the amplifier and the power supply.

Put the cover back and the installation is complete.

4 UNPACKING the POWER SUPPLY

The DX-4 power supply is shipped in a heavy duty wooden crate.

To open the box, remove the screws holding the cover and remove the wooden cover.
etc

5 INSTALLATION ENVIRONMENT

5.1 Required environment

The DX-4 amplifier can be operated at an ambient temperature between 0 and 40° Celsius. It should be installed in a place with good ventilation and protected from the direct sunlight. At least 5 cm (2" of free space must be left at the left and right of the amplifier for ventilation. Do not place any object on top of the amplifier, especially above the ventilation opening.

An environment free of dust, smoke and high humidity is required, as for any high powered RF amplifier. Dust or particles resulting from burning fire wood or coal could be responsible for sparks or electrical discharges between the capacitor plates, or in other parts of the RF section.

Place the power supply box at some convenient location, within the available length of the cables. The power supply also requires reasonable ventilation space.

5.2 Power requirements

See also Chapter 8

5.2.1 Single phase

When operating at full power, up to 38A from the 240 VAC, single phase mains is required. Ensure that the AC supply you intend to use is fully rated and properly fused. The Emtron "soft start" circuitry ensures that

there are no momentary surges of current at power-up, therefore the fuse does not need to be over-rated. However, the wiring of the mains supply for the amplifier should be able to handle the power at full load with minimal drop in the voltage, to insure the performance of your DX-4 does not suffer.

5.2.2 Three Phase US

In North America, with 230 V between phases the current per phase at full power is about 22 A

5.2.3 Three Phase Europe

In countries using 220 V – 240 V single phase, the voltage between phases is 381 V, 398 V and 415 V respectively. For all these cases the transformer has a nominal voltage of 400 V and the current at full power is about 18 A.

6 REAR PANEL

The following connectors and controls are present on the rear panel of the DX-4

6.1 Power / Earth connections

A wing-nut Earth connection is provided at the rear of DX-4. A good Earth link must be provided here. Connect this first, before making any other connection to the amplifier.

A nine-way connector allows connecting the auxiliary power and control cable between the DX-4 and the Power Supply. The fully detachable cable is reversible, any end can be used.

The auxiliary power and control cable carries 240 VAC and low voltage signals between the amplifier and the power supply.

There is a high voltage cable, attached to the amplifier, with heavy duty lugs to be connected to the High voltage power supply. The high voltage cable carries a DC voltage of about 3100V and currents up to 2.5 A.

6.2 RF connections

RF INPUT

The RF input is an SO-239 female connector. A 50 ohm coaxial cable line of good quality terminated with a PL-259 coaxial connector is required to connect the transceiver or exciter output to the input connector of your DX-4 amplifier.

RF OUTPUT

The RF output is also a female SO-239 connector. The use of a high quality RG-8A/U, RG-213 or similar 50 ohm coaxial cable line terminated with a 'VHF' type PL-259 connector is essential. Similarly, a VSWR of 2.6: 1 or better is mandatory. Remember too, that the EMTRON DX-4 amplifier can deliver 4000 W continuously and up to 5000 W PEP in the SSB mode. Not all antennas can handle such power.

6.3 Transceiver control

ALC (if fitted)

The ALC output is via a black female RCA connector.

This is an ALC system for use with transceivers or transmitters having a negative-going ALC system and possessing an external ALC input jack. A shielded patch lead with an appropriate connector at one end and a male RCA connector for the DX-4 at the other end is required. Check the specifications of your transceiver for a suitable connection.

ALC CONTROL (if fitted)

This is a user-accessible control for setting the negative voltage at the ALC output. Further details are given in section 10.2

PTT

The PTT input is a female RCA connector (red). This line controls the transmit / receive switching system. This jack must be connected to transceiver or exciter relay contacts which are open on RECEIVE and closed on TRANSMIT. The PTT input presents an open circuit voltage of +27 to +36 V with respect to the chassis. When this contact is grounded, about 120 mA of DC current will flow to ground.

7 FRONT PANEL

The following controls and indicators are present on the front panel:

7.1 Controls

BAND SWITCH

A nine position switch selects the desired frequency range. The operating bands are indicated in metres.

PLATE TUNE

Tunes the amplifier operating frequency. A chart of approximate starting settings is given in Table-1

LOAD TUNE

Tunes the amplifier output loading. A chart of approximate starting settings is given in Table-1

ON/OFF

Switches the AC power on and off. On initial switch on, the standby mode is enabled. Note also the appropriate switch down sequence, given in Section 11.

OPR/STBY

Enables the amplifier once it has warmed up. In STANDBY mode, the screen voltage is removed and any RF power applied to the input, is bypassed to the output. If this switch is changed to OPERATE before the READY light comes on, the FAULT light will turn on. This is not a fault, but it is better to leave the switch in STBY position until the amplifier is ready to operate.

7.2 Displays

All the DX-4 indicators are concentrated in a single, “moving light” display (*See Fig. 1*). The following values are displayed (top to bottom):

Output Power - Scale up to 5 kW, non linear.

Reflected Power - Scale up to 500W, non linear.

Plate Voltage - Scale up to 4kV

I_{g2} - Zero-centred display. The left (green) side has a full scale of about 25 mA of negative screen current. The right (red) side has a full scale of about 80 mA of positive screen current. Above this value, the red LEDs will flash, warning you to increase the loading, or reduce the drive. At about 100 mA, the protective current limiting will cut in.

Plate Current - Scale up to 4 A.

ON Air - single LED, green. When pressing PTT, this LED turns on (while in OPERATE)

READY - single LED, yellow. Turns on at the end of warm-up period, when the mains power to DX-4 is switched on. It turns off for about 2 minutes if the plate current protection is triggered. In this case, the FAULT light also turns on.

FAULT - single LED, red. Turns on in 3 situations:

- when the over-temperature protection is triggered, the FAULT turns on until the tube cools to a safe level. During this time, the operation of the amplifier is disabled, the screen voltage is off and any RF power applied to the input is bypassed directly to the output.
- when the over-current protection is triggered, FAULT turns on for 2 minutes, while READY turns off

- at DX-4 power up, if the OPR/STBY switch on the front panel is left in OPR position. The FAULT light will go off when the DX-4 is ready for operation, after warm-up.

SWR - single LED, red. A three second cut-off will happen if your antenna has a SWR worse than 2:1 (typical 2.6:1) at the operating frequency. During the cut-off, the RF from the input is directly by-passed to the output.

OVER-DRIVE - single LED, yellow. Flashes when the input drive is exceeding the linear operation level. If even more drive is applied, the overdrive protection will cut off the operation for about 2 seconds.

NOTE: the input drive at which the indicator turns on depends on a certain extent on the tuning of the amplifier.

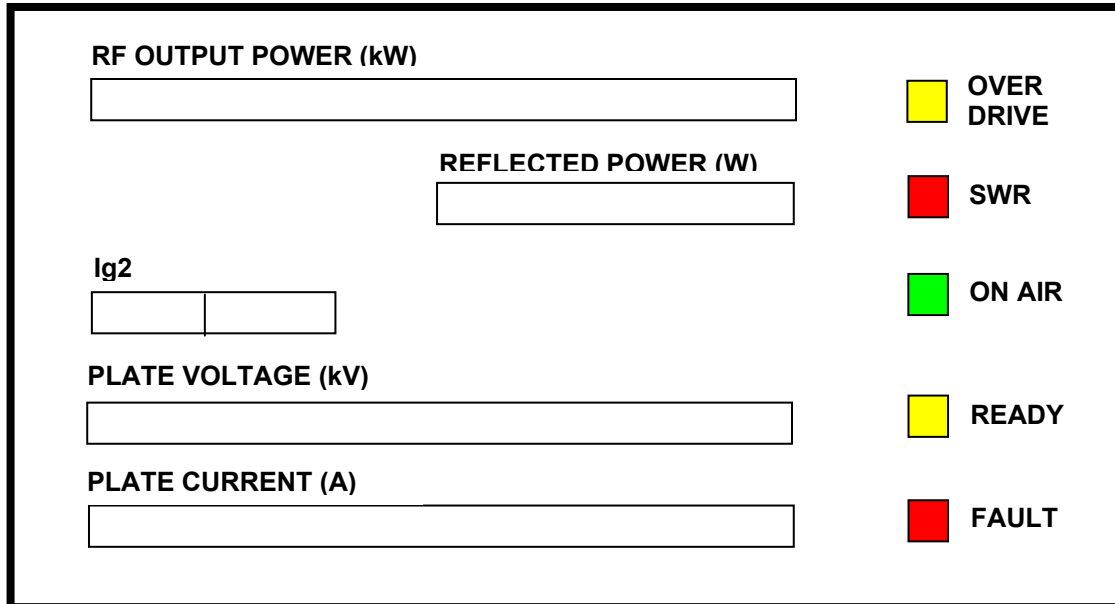


Figure 4. Front Panel Display

8 POWER SUPPLY (external)

WARNING:

Extreme care is required when handling the power supply since, apart from being very heavy, it delivers deadly high voltage and power. Even after switching the power off and unplugging the mains cable, the capacitors will store charge for some time and therefore opening the cover should be done with caution, after allowing sufficient discharge time.

Unlike the smaller Emtron amplifiers, DX-4 has an external power supply box. This box is fairly compact in size, but heavy and this is why a convenient place to put it is under the bench where the amplifier itself is installed. There are only 2 cables connected between the power supply and the amplifier: one is the power and control cable, the other one is the high voltage cable.

The mains cable has to be connected to a single or three phase power outlet. There is no mains cable on the DX-4.

8.1 Front panel

The front panel of the DX-4 power supply has only one large LED which turns on as soon as the power is switched on.

8.2 Back panel

The back panel has a mains cable entry and above that there are 2 (single phase) or 3 (3-phase) fuse holders. There is a square 9-way connector for the auxiliary power and control. The 2 m long control cable can be plugged in here, with the other end going to a similar connector on the DX-4 back panel. The cable is symmetrical, any end can be plugged into the power supply and it is fully detachable.

There is a high voltage cable entry, where the high voltage cable is put in and connected inside. The high voltage cable can be disconnected from the power supply box, but it is permanently attached to the amplifier.

8.3 Connections to DX-4

It is recommended to first place the power supply in its position (e.g. under the bench). Sufficient space is required around it, both for access during installation and for ventilation during operation.

- fit the mains plug, but do not connect to power
- open the cover, remove the gland at the high voltage inlet and put through the high voltage cable from the amplifier
- connect the Earth lug (external shield), then connect the high voltage lug (the centre wire)
- make sure the cable is not stretched (allow for some slack) and tighten the gland to prevent the cable being accidentally pulled out
- replace the cover and the screws
- connect the auxiliary cable to the white, square, 9-way connector
- move the power supply in the final position if necessary
- finish the DX-4 connections if not already done (auxiliary cable, antenna, transceiver, PTT cable)
- make sure the DX-4 front switches are in OFF and STBY position and connect the mains cable to the power outlet

8.4 Single Phase and Three-Phase power supply

When an order is placed for a DX-4 power supply (usually when a DX-4 is ordered), the user needs to specify if a single or a three-phase model is required.

If there is a choice, 3-phase operation is always preferred (apart from cost considerations) because:

- the 3 phases are evenly loaded, which becomes important at such heavy loads
- the current at 415 V 3-phase and full power is about 25 A per phase, while a single phase model draws about 38 A from 240 single phase, at full power
- the ripple frequency after the 3-phase rectifier is 300 Hz, compared with 100 Hz single phase, which means the plate voltage is better filtered, with less ripple
- the difference between the no-load and full-load plate voltage is less in a 3-phase system, which means lower standing plate voltage is required and higher operating voltage is available at full load

- higher CW and slightly higher PEP power can be obtained from the same DX-4 when using a 3-phase power supply, for the reason shown above. For the same reason, tube flash-overs are less likely

There are few external differences between the 2 types. The mains cable is different and it requires different type of plug. The single phase model has 2 fuses on the back panel, the 3-phase model has 3 fuses. The fuse rating is different: 40 A and 30 A respectively.

8.5 Terminating the Mains Cable

Since different countries use different types of plugs, the power supply is normally shipped without a mains plug. Depending on the model (single or 3 phase), you need first to fit a suitable power plug to the free end of the mains cable. The other end is permanently attached to the power supply.

8.5.1 Single phase

The single phase model has a 3-core cable:

- Yellow/green is the safety Earth, it should be connected to the Earth pin of the mains plug. This wire is connected to the power supply chassis.
- Brown is the "Active" wire (or "Line 1" in the US)
- Blue is the "Neutral" wire (or "Line 2" in the US)

Correct wiring of the brown and blue wire is recommended to the plug pins, although this is not important since the 2 wires go to the transformer primary, with symmetrical input.

There are 2 fuses, with a rating of 40 A

The transformer in the power supply has taps for 200 V, 220 V, 230 V, 240 V.

The correct tap has to be selected before installing the power supply in place and making the connections. The tap needs to match the local nominal mains (single phase) voltage. The power outlet must be able to handle the required power (about 40 A) with minimal voltage drop in order to allow the DX-4 to deliver its full power. If the mains voltage sags under load, the DX-4 will not reach the specified maximum power.

The power outlet must be correctly fused (40 A or more), but the fuse does not need to be over-rated, due to the efficient soft start fitted in the power supply, which prevents any in-rush current or "transformer bong" at power up.

Please note that the power and current taken by the single phase DX-4 are close to the practical limit of a single phase circuit and the wiring gauge and fusing need to be adequate to prevent the wires from over-heating or the voltage to drop too much under load.

It is not recommended to move the transformer tap in order to compensate for the mains voltage sag under load. This would increase the filament voltage too much and the tubes will suffer. Also, the high voltage will become higher than normal. Instead, the power circuit should be rated and wired correctly for minimal voltage drop.

See Figure 6 for transformer tap wiring.

This only applies to the main transformer in the power supply box. There is an auxiliary transformer in DX-4, which always gets the correct primary voltage, since this is derived from the 240 winding of the main transformer and if the tap is moved on the main transformer, the 240 V tap will always have the correct voltage as long as the selected tap matches the local voltage and this voltage does not sag too much under load.

8.5.2 Three phase (Europe)

The 3-phase model has a 4-core mains cable:

- Yellow/green is the safety Earth, it should be connected to the Earth pin of the mains plug. This wire is connected to the power supply chassis.
- The other 3 wires are: red, blue, white (or yellow) and they are phases: A, B, C. They are connected via 3 fuses and the soft start system to the 3-phase transformer in star connection and as such, the exact phasing is not important. Alternative colours in the cable could be brown, blue, white.
- There are 3 fuse holders with fuses rated at 30 A

The 3-phase model has a combined system of 3 soft start modules which ramp up the power over a time of about 5 seconds, preventing any in-rush current or "transformer bong". The 3-phase soft start modules (Europe) are different from the single phase modules – they can't be interchanges, for example when repairing.

The European 3-phase power supply works on a nominal 230/400 V and it can be used for 220/380V as well as 240/415V. It is not suitable for use in North America with the low voltage (230V) 3-phase (see below).

8.5.3 Three phase (North America)

It is identical to the European system except that the transformer primary is made for 230 V between phases. It also has 3 soft start modules, but these modules are identical to the single phase (240 V) modules (they are different to the European 3-phase soft start modules – care needs to be exercised when spare parts are used !)

8.6 Mains transformer

There are two transformers: the main transformer in the power supply box and a smaller, auxiliary transformer in the amplifier.

The main transformer, placed in the power supply box is the heart of the amplifier, a high performance type, designed to reduce the size and weight. It is built with a generous reserve of power, handling easily the DX-4 requirements in continuous operation. This transformer only delivers the high voltage required by the amplifier. In single phase version, the primary can be wired for 200VAC, 220VAC, 230VAC or 240VAC operation. *See Figure 7.*

The three-phase transformer has fixed voltage, country dependent (USA or Europe).

8.7 H. V. Power Supply

Single phase

A full wave bridge rectifier and filter converts the high voltage AC into high voltage DC with a huge reserve capacity of 116 microfarads. (Two high voltage power supply modules are used in parallel).

The current sensing resistor is 0.5 ohm.

Three phase

Three “Star” connected high voltage rectifiers supply a bank of capacitors with a total capacity of 58 microfarads. A single high voltage power supply is used, but there is an extra high voltage rectifier board, connected to the third phase (Phase 1 and 2 are connected to AC1 and AC2 of the power supply module).

8.8 Soft start system

At power up, the mains power is gradually applied to the transformer by the soft start system. The power is gradually applied over a time of about 5 seconds, avoiding the high inrush current typical for such big loads.

The single phase soft start has one standard (240 V) soft start module, one triac and one relay.

The three-phase supply has 3 soft start modules driving 3 triacs and it has 2 relays.

The European 3-phase system (400 V) has the 2 relay coils connected in series, while the soft start modules are the high voltage (400 V) model.

The North American 3-phase system has the 2 relay coils in parallel and the soft start modules are standard, 240 V type.

9 ELECTRICAL CONNECTIONS

9.1 Connections to Transceiver / Exciter

Signal connections

Before making any connections, ensure that DX-4 is not connected to AC power, and the transceiver is not transmitting. Connect the antenna first to the DX-4 output. Then connect the transceiver output to the DX-4 RF input. Plug the PTT lead into the RCA socket marked PTT on the rear panel. If required, connect the ALC.

The most appropriate interconnection layout is shown in Figure 1 below. In this set-up, the transmit/receive relays in the DX-4 are controlled directly by the transceiver or exciter.

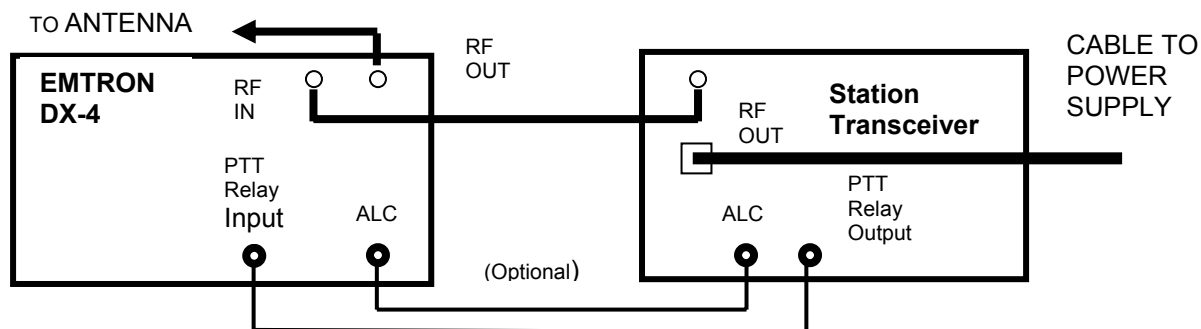


Figure 5. Connections between DX-4 and Station Transceiver

9.2 Earth and mains connections

Power connections

Before connecting any power to the amplifier, make a good Earth connection to the screw with wing nut at the rear of DX-4 and also at the rear of the power supply.

Connect the high voltage cable between the DX-4 and the power supply, as previously explained. Connect the control cable between the DX-4 and the power supply. The control cable is terminated at each end with a square 9-way connector. The cable is reversible, any end can be used to connect to DX-4. The connector is keyed and locked. Make sure the POWER switch on the front panel of the power supply box is in the OFF position. Then plug the power cable into the power outlet.

9.3 Operation at 230V, 220V, 200V (Single phase, export version)

The Emtron DX-4 will normally arrive pre-set for the power source of the country the amplifier has been sold to. However if operation to another mains voltage is required, the appropriate connection changes will be needed.

Figure 7 shows the transformer connections for 200V, 220V, 230V and 240V operation. If a change is required, this should be done only by a qualified technician, after taking all the necessary safety precautions. See CAUTION on page 5.

The wire to be moved to a different tap is brown and is identified by a yellow or white marking (ring).

PLEASE NOTE: The DX-4 should not be connected to a mains supply of less than 200VAC!

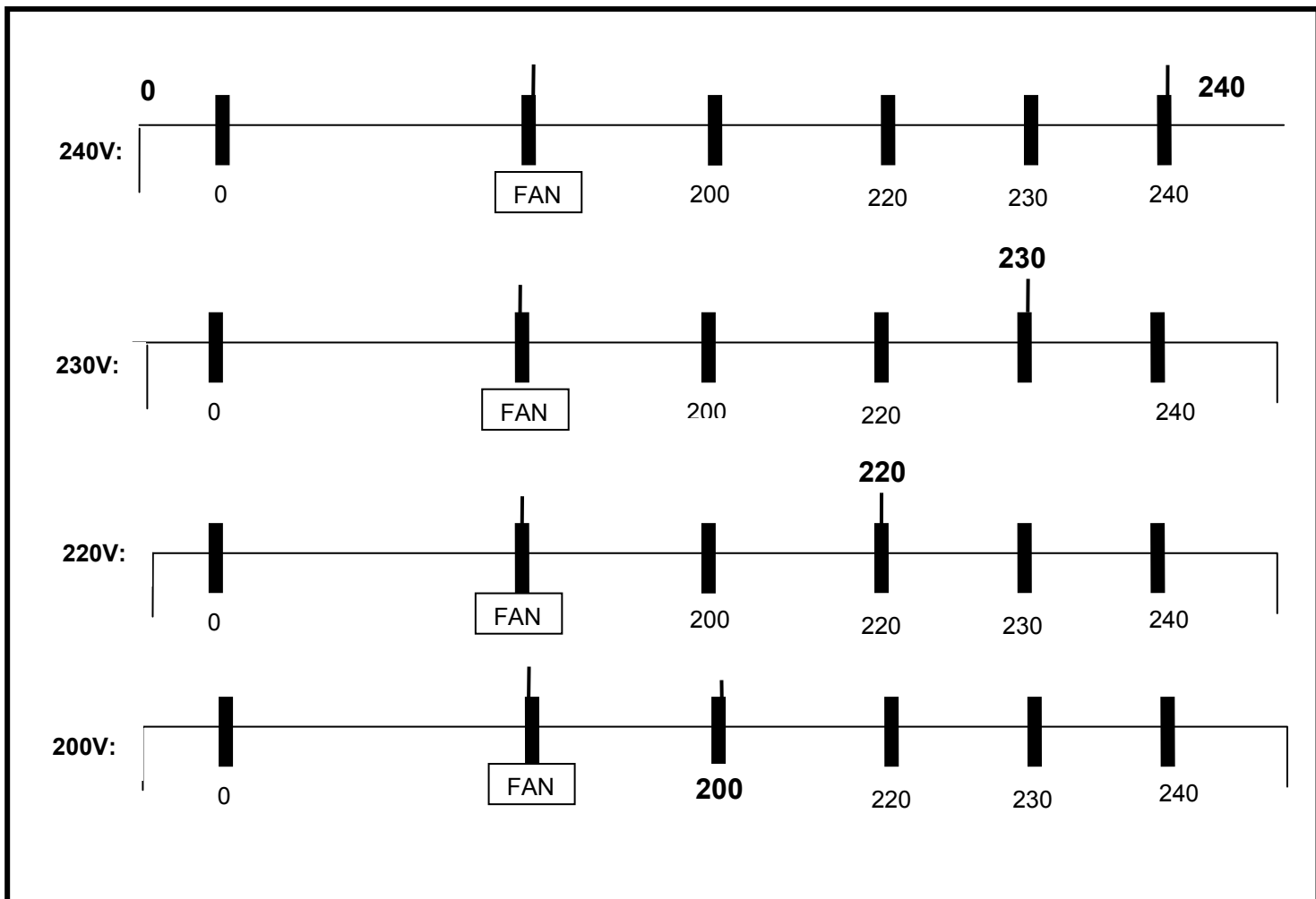


Figure 7: TRANSFORMER AC INPUT CONNECTIONS

10 DX-4 DESCRIPTION

10.1 RF Section

The RF section occupies the right hand side of the DX-4 (looking from the top - front). See picture in 1.1.

RF Switch and tuned circuits

At the front of the amplifier are two variable capacitors, for plate and load tuning. A 9-position ceramic switch is employed for the 9 operating bands. Next to the switch is the 40 to 160 metre tank coil (the large toroid). The silver plated, large diameter copper tube is the 15 to 30 metre tank coil. The single turn is for 12 and 10 m.

RF Sub-chassis

The GU84 (4CX2500) tubes are positioned on a separate RF sub-chassis. All the connections to the tubes, except for the plate, are under this sub-chassis. A 9-way heavy duty connector is used for the outside connections. The fan blows air into this sub-chassis, which is forced out through the ventilation fins of the tubes. The air temperature is sensed by sensors placed above the tubes. The sensors must stay in a position close to horizontal. In the case of ever removing the 2 fans above the tubes, which exposes the temperature sensors, make sure you are not pushing them down, too close to the tube, as high voltage exists between them. The plates are connected to the RF network and to the choke supplying the 3100VDC voltage to the plate of the GU84 tubes.

10.2 Auxiliary transformer

The auxiliary transformer inside the amplifier, supplies all the voltages other than the plate (high) voltage, as follows.

- Filament supply
- Low voltage supply to the controller board
- QSK module supply
- Bias supply
- Screen grid supply

10.3 RF Sensor module (Bi-directional coupler)

A small metal box positioned at the output of the DX-4. It detects the forward and reverse power, for measurement and display.

10.4 QSK module

The QSK module is controlled by the transceiver, via the control board. It switches the antenna between the transceiver, during reception, and amplifier, during transmission. It is also used to bypass the RF from the transceiver, directly into the antenna, when the amplifier is in standby mode, or during special conditions like overdrive, bad SWR or other error conditions.

The QSK module uses two very fast, high power vacuum relays, and their control circuitry. The purpose of QSK is to allow very fast switching between transmit and receive, during digital communications. See Appendix 2 showing oscilloscope displays of fast switching times and contact bounce-free operation of the QSK module.

10.5 Display board

This board has a number of inputs where various voltages to be measured are connected. The board converts these voltages into a "moving LED" type of display. Two of these displays have flashing light indication (Ig2 and plate current).

10.6 Controller board

The brain of the amplifier is the Controller Board. The following circuitry is part of this board:

- Bias voltage regulator, also incorporating a sensitive grid current detector for overdrive detection . Adjustable pre-bias, removes the distortion at the beginning of the word, when EBS is activated.
- Screen voltage regulator, with adjustable voltage and adjustable current limiting, for tube protection.
- Overdrive protection and timer - based on detecting grid current, it initially gives visual warning and, at higher level of overdrive, it cuts off the amplifier for 2 seconds. It ensures a clean signal, making it virtually impossible to overdrive the DX-4
- SWR detector and timer - switches the amplifier to bypass mode for about 3 seconds when high SWR is detected. Adjustable SWR level. Factory adjusted to about 2.6: 1
- EBS - the Electronic Bias Switch - senses the presence of RF input power and turns on the bias to start transmission. Factory adjusted for about 0.5W. When the input power exceeds this limit, the plate current starts flowing. When there is no speech, even for a very short time, the tube dissipation is cut to a low value, as set by the pre-bias adjustment.
- Interlocking, timer for filament warm-up
- Relay control: ready relay, SWR relay, over-drive relay, antenna relay

- QSK switching control
- Display control: Ig2 measurement and display, SWR cut-off display, overdrive warning display, READY display, FAULT display
- Logic circuitry, low voltage supply to the various electronic circuits

11 POWERING UP

Before switching the power on, check all the necessary connections: Earth, High Voltage Cable, Control cable, Mains cable, Antenna, Transceiver, PTT, ALC. Make sure the 2 switches on the front panel are in the positions: OFF, STBY.

Switch now the mains power ON (The power switch to ON position). The "soft start" system will take about 5 seconds to fully turn the power on. SWR light will turn on briefly, then off. The large red LED on the front panel of the power supply turns on. The display shows the high voltage value. You can hear the air in the cooling system.

Wait for the DX-4 to warm up, until the READY light turns on.

This takes about 2 - 3 minutes. This is a minimum time. It is a good practice to give it another minute after READY turning on.

WARNING !

**WHEN YOU SWITCH THE POWER ON, YOU MUST HEAR AIR FLOW NOISE.
IF THERE IS NO AIR FLOW NOISE, SWITCH THE POWER OFF IMMEDIATELY
AND CONTACT YOUR SUPPLIER.**

12 OPERATION

12.1 TUNNING PROCEDURE

12.1.1 General

For each band and operating frequency, the transceiver settings must match the position of the BAND switch on the front panel of the DX-4, while the PLATE and LOAD knobs must be adjusted for optimum operation which gives – in conjunction with the input drive level, the maximum output power that can be obtained for that input power. When the tuning is correct, this will also result in a minimum plate current, minimum plate dissipation and good linearity.

12.1.2 Preliminary tuning

- Turn the BAND switch to the same band setting as the transceiver.
- Put LOAD and PLATE knobs in the initial positions given in Table 1.
- DX-4 must be powered ON and "Ready", with the OPR/STBY switch in OPR position.
- Start with the transmitter at minimum power, in a "carrier" mode e.g. RTTY or CW - key down.
- Key the transceiver ON and gradually apply power to the DX-4. When 0.5 to 1 W of drive is reached, the EBS is activated and the plate current jumps from zero to about 1 A.
- Increase the drive until there is some output power indicated. If the current plate I_p reaches about 1.5 A and there is still no output indication, turn PTT off and check the connections, the band and the initial settings.
- As soon as there is any power indication, tune PLATE for maximum output (and minimum plate current).
- Apply more drive and adjust PLATE again for maximum output. Keep PTT ON for short time only (about 10 seconds). Go gradually, in several steps. When about 2000W output is reached, adjust LOAD for maximum output. If there is no red I_{g2} indication, it is likely that LOAD needs to be turned clockwise, towards higher numbers on the dial.

- Apply more drive and adjust both knobs again. When screen current appears (red Ig2 indication), increase loading by turning anti-clockwise the loading knob. (LOAD towards lower numbers on dial) until Ig2 drops almost to zero. Then adjust PLATE for maximum output power and maximum Ig2. **At this point, Ig2 is the most sensitive indicator of resonance on the working frequency.** If Ig2 goes too high (e.g. starts blinking), increase the loading again, then tune PLATE.
- Repeat the above steps, while gradually increasing the input drive power, until the overdrive indicator just starts turning on. Now the DX-4 is tuned for operation at full power on that particular operating frequency.

NOTES:

1. The maximum power is obtained from a DX-4 when:

- onset of the overdrive indication
- PLATE is tuned for maximum output power, maximum screen current Ig2 and minimum plate current, Ip
- Ig2 indicator shows 2 to 4 red LEDs.

2. The above conditions will also give the best linearity.

3. During the preliminary tuning, switch PTT on and off several times, to allow time for tube cooling. The tube dissipation (at a given drive level) is minimum when tuning is optimum. In short, be brief, with tuning "bursts".

4. Preliminary tuning, as described above, is only necessary when operating for the first time in a certain band. When the final settings for PLATE and LOAD have been found for the particular working conditions - especially the antenna used, note your settings on Table 1. The new settings will normally differ to some extent from the ones indicated, depending on the "purity" of your antenna load.

12.1.3 Final tuning

Once the preliminary tuning has been done for each band / antenna combination, the values found for PLATE and LOAD can be used for final tuning, with no need to repeat the preliminary tuning every time.

Tuning for full power

- Start with low drive level and the PLATE and LOAD knobs in the known initial positions
- Put PTT ON and increase the power (fairly quickly), to the onset of the overdrive indication. If the screen current (red Ig2) goes too high, adjust LOAD, by turning the knob to the left – towards lower numbers on the dial (increasing the load).
- Adjust the drive level and LOAD until the overdrive indicator is just about to turn ON, and at the same time Ig2 shows two or three red LED's ON.
- Fine tune PLATE for maximum output and maximum Ig2. Repeat the step above if required.

NOTE: A flashing red Ig2 indicator, even for a long time, is not harmful to the tube, since Ig2 is limited to a safe value.

Tuning for less than full power

- Start at low power, with the initial values for PLATE and LOAD
- Put PTT ON and apply drive until the output is about 1/2 of the desired power.
- Adjust LOAD for maximum output. Most likely, the knob will have to be rotated to the right, towards higher numbers on the dial.
- Adjust PLATE for maximum output
- Apply more power

- Repeat the 3 steps above until the required power is achieved. If screen current is indicated by Ig2, it should display two to four red LED's. Maximise this Ig2 indication (and the output power at the same time), by tuning PLATE

Please note that the tuning at lower power is different from the setting at full power (especially LOAD).

- If the output goes higher than desired, reduce the drive *and re-tune*. **Never reduce the output by de-tuning the amplifier!**

NOTE: If the output is low (say, less than about 2000W), Ig2 will never show any screen current at all. Ig2 might even indicate a negative current, in green - this is normal and is no cause for concern.

However, if there is (green) negative current indication, usually this will go away with better tuning of the PLATE control.

If there is no Ig2 red indication, simply rotate LOAD to the right in small steps, and each time maximise the output by turning PLATE, until the highest possible maximum in the output power is achieved.

10.1.4. Potential problems during tuning

The tuning operation should be completed fairly quickly. If the tuning process takes a longer time, it should be done by switching the transmission on and off several times, to allow the tube time to cool.

- If the FAULT light comes on, it is possible that the plate current has reached too high values due to incorrect plate tuning. In this case, reduce the excitation power, wait for the FAULT light to turn off (about 2 minutes) and resume tuning.
- If the overdrive protection is activated, by cutting off the amplifier for 2 seconds. It is likely in this case that you are applying too much power at the input. Reduce the power and watch the "overdrive" LED. Increase the power only until this light starts flashing.
- If the overdrive protection is activated at low power – this could be due to incorrect loading. Turn the LOAD control clockwise and tune PLATE. Increase the drive and repeat in small steps. A lack of screen current (red Ig2 display) is an indication that the loading is incorrect.
- If the SWR protection cuts in - it is likely that your antenna is not a good 50 ohm match at the operating frequency. In principle, the SWR protection level in DX-4 is adjustable, but it is far preferable for you to fix your antenna.

12.2 ALC ADJUSTMENT

The DX-4 can be operated without any ALC connection (most model don't even have an ALC fitted). However, if it is fitted and if you wish to use it, and your transceiver has an ALC input, then the potentiometer on the rear panel must be adjusted. This adjustment is not critical, since its voltage output is zero under normal operation and it increases sharply (towards a negative value - up to -11 V), when the overdrive limit is approached. The ALC in DX-4 amplifier is not a conventional design, this circuit operates for only one reason - to prevent overdriving and to keep the signal clean.

To adjust the ALC potentiometer:

Turn the potentiometer initially all the way to the left (minimum ALC voltage)

In CW mode, after tuning, apply increasingly higher drive, until the "overdrive" LED just starts to turn on

Increase the drive slightly more, to have the light fully on, but make sure the DX-4 overdrive protection does not cut you off. At this power level, adjust the ALC potentiometer to the right, until the transceiver drops its power output.

Alternatively, in voice mode, increase the RF gain or the microphone gain until the overdrive led is flashing at peak of modulation. Then, increase ALC (rotate potentiometer to the right) until the transceiver begins to limit the drive to DX-4.

NOTE: Some types of transceivers (e.g. YAESU FT100MP, FT920 and others) are not compatible with this type of ALC. They require an ALC signal proportional with the output power. DX-4's ALC is zero until the drive reaches the over-drive limit, when the negative voltage increases sharply. YAESU operating manual indicates that this type of ALC might not work well with their transceivers, since grid current could be generated by amplifier mis-tuning not related to excessive drive conditions. If this is the case, simply do not connect it.

12.3 USING YOUR DX-4

While tuning and adjusting the amplifier, a CW mode is normally used. When these operations are finished, you can change to the operating mode you wish to use and start operating.

12.3.1 CW / RTTY and all digital modes

In CW, the setting up of the amplifier is similar to that of the tuning mode. After adjusting the input power level to the amplifier, according to the desired output level, and tuning the plate and load capacitors, you can simply start operating by applying the same carrier level as during tuning. If the amplifier is set to deliver full output power, or close to, then screen current will be present. As in the case of tuning, the best operation is achieved when there is a certain amount of screen current flowing, corresponding to two to four red LED's turning on in the Ig2 display.

12.3.2 Voice modes (SSB)

When a voice modulation is applied to the amplifier, the drive level is not precisely defined, as in the case of tuning with continuous carrier. If there is screen current flowing, or an input overdrive, they will be indicated only at peak of modulation, by the respective indicators flashing. You will have to adjust the microphone gain, or the RF drive, or both, in an attempt to achieve input driving conditions similar to those you have used while tuning. Occasional flashing of the overdrive indicator is acceptable. If the over-driving is severe, a momentary cut-off will occur.

12.3.3 Hints on good linearity and efficiency

Operating with good efficiency: If you are watching the plate current indicator, you must be aware that the total power the amplifier is drawing from the mains is proportional to the plate current. Power that is not sent to antenna, is dissipated by the tube. As explained in the Tuning section, the best tuning achieves a maximum power output at the same time with a minimum plate current, drastically minimising the tube dissipation. Be aware that at a low power level, slightly different tuning is required than is for full power.

Achieving the best linearity: The amplifier must be tuned and operated all the time in the linear mode. This is important because a non-linear operation will generate harmonics which will disturb RF communications in other bands and frequencies.

We must distinguish two situations:

Less than full power.

With less than full power (say 2000W or less), correct tuning, no screen current and no input overdrive indication, you will *always have your DX-4 operating with a good linearity and clean signal.*

Full power operation.

At full power, there are two things that must be watched to see when you reach the limit of linear operation: the screen current, Ig2, and the grid current, indicated by the "Over-drive" LED.

In this case a good linearity is maintained up to the moment when the screen current is approaching the full scale value of the Ig2 indicator and it starts flashing, or when the overdrive indicator fully turns on.

A high screen current, indicated by 4 LED's on in the Ig2 display, will create a moderate level of distortion.

Even a small amount of grid current will cause severe distortion. When the "Over-drive" indicator just begins to turn on, there is a very small amount of distortion, created by a grid current of about 150 microamperes.

With this indicator flashing, you are at the limit of the RF carrier clipping. This is probably more acceptable in a voice mode of operation. In CW or digital modes, the best is to slightly reduce the drive, just below this level. A severe level of over-driving is not possible anyway, due to the cut-off protection. The cut-off will happen at about 400 microamperes of grid current. See *Appendix 2: Waveforms* - and *Section 12: Troubleshooting* for oscilloscope displays showing examples of a two tone generator driving the DX-4 in linear mode, and an overdrive situation, when a DX-4 with the overdrive protection disabled is being overdriven by the two-tone generator.

The Ig2 indicator should have three to four LED's flashing on at peak of modulation. This (combined with a correct plate tuning), indicates an optimum loading, good efficiency and good linearity. A lower screen current, due to excessive loading, will reduce the output power, with an equal amount of extra power dissipated by the tube. A higher screen current, making all four LED's in the Ig2 flashing, will increase the distortion.

Please note: occasional flashing of Ig2 indicator should not be a cause for concern in regard to the tube protection. The screen protection system is so good that even Ig2 flashing indefinitely is safe for the tubes.

NOTE ON EFFICIENCY: Because it operates in class AB1, the DX-4 has a plate current of about 0.75 A and a plate dissipation close to 2000 W when there is little output. As the drive is increased, more power is sent to the antenna and the tube dissipation is reduced. The highest efficiency is obtained at (or close to) full power, while the tube dissipation (and temperature) has a minimum around 3500 W in the case of DX-4. See table ... and curves....

13 SWITCHING THE POWER OFF

When you have finished using the amplifier and you want to switch it off, the following procedure is recommended: Stop transmitting. Put the switch on STBY. Leave the DX-4 running idle for a few minutes to cool the tubes, then switch the power off.

14 TROUBLESHOOTING - If something goes wrong

14.1 No power

When you switch on a DX-4, it takes about 3 - 5 seconds for the lights on the front panel display to come on and the fan to start.

This is due to the "soft start" circuit. If nothing happens after turning the power on, switch off at the front panel, then check the following:

- make sure the power point has power
- make sure the power plug is fully pushed in into the power outlet
- check that the auxiliary power and control cable is properly connected at both ends

If it is still not working, unplug the power cord from the mains, then remove the fuses from the fuse holders on the rear panel of the power supply and check them with an ohmmeter. If a fuse is blown, replace it with a fuse of the same type and try again. If the fuse blows again, or if the fuses were not blown in the first place, contact your supplier.

14.2 Fan not working

As soon as you switch the power on, you should notice two things about your DX-4: the display should indicate about 3200V of plate voltage and you should be able to hear the fan running. The amplifier is not supposed to be powered without the fan, even in idling mode. If the fan does not operate when you power up, or if it stops while using the amplifier, switch the mains power off immediately and contact your supplier.

14.3 If the FAULT light turns on

The FAULT (red) light turns on in two situations:

- Over-current in the plate circuit

This could happen due to a flash-over in the tube, or as a result of a momentary high plate current during tuning. This completely disables the amplifier for about 2 minutes. The same timer is activated as when the amplifier is switched on, causing the READY light to turn off. If the OPR/STBY switch on the front panel is put on STBY, the FAULT will turn off, but the READY will be also off. When the READY comes on again, the FAULT will disappear (if the amplifier was left in OPR), and the DX-4 is ready to operate again.

- Over-temperature cut-off. *See below.*

14.4 Over-temperature cut-off

The operation of the amplifier is disabled, but the timer is not activated. The READY light remains on, along with the FAULT light. When the tube cools down, the FAULT turns off and the operation can resume. This type of fault should never happen. DX-4 has a very efficient air cooling system. When the ventilation is not restricted, in normal ambient conditions, when properly tuned, a DX-4 can operate at full power for extended periods of time, with the fan not even going to high speed. The temperature cut-off happens when the tubes reach 150° Celsius, with ample safety margin to the specified limit of 200° for the GU84 tube.

One reason for over-temperature cut-off could be tuning with too much loading. At full power it is recommended to allow a screen current close to the maximum value, when the Ig2 red LEDs are close to full scale and about to start flashing. This can be obtained by rotating the LOAD knob slightly clockwise (higher numbers on the dial) and re-tuning PLATE. The same output power can be obtained this way with less input power drawn from the mains (as indicated by a lower plate current), better efficiency and less tube dissipation.

14.5 Over-current cut-off

If the plate current exceeds even for a brief time a pre-set safe limit, an over-current detector will activate the power up timer, disabling the amplifier for about 2 minutes. During this time the READY light is off, and the FAULT light is on, if the amplifier is left in OPR mode, as explained under 12.3, "If the FAULT light turns on".

14.6 Ig2 blinks fast - No plate voltage

If the high voltage is lost due to a fault in the amplifier, the screen current tends to reach very high values. This is an unlikely situation, but if did happen, this would normally guarantee a tube failure in unprotected amplifiers that do not have a current limiting circuit. The screen current limiting in DX-4 is so efficient, that the tubes are fully protected even in such a situation and test bench DX-4's have been extensively run with no plate voltage and maximum screen voltage, with no effect on the tubes. If this loss of high voltage should happen to your DX-4, the Ig2 display will have the red LEDs flashing, due to the screen current exceeding the pre-set limit, with no input power applied to the amplifier, while switched to OPR.

In such a case, it is possible that the high voltage is still shown on the meter, but it does not reach the tube. In any case, this is a major fault. Put the amplifier on STBY and the flashing will stop. Then switch the power off and contact your supplier.

14.7 Sparks / Discharges in RF area

Very high RF voltages are present in the amplifier during the operation at high power. Incursion of dust or even suicidal insects can cause such temporary problems.

14.8 SWR cut-off

The factory adjustment for SWR protection is about 2.6: 1. This adjustment can be changed, but the best is to operate with a properly matched antenna. Should your DX-4 'see' bad SWR, it will shut down for 3 seconds (in bypass mode).

14.9 Frequent over-drive protection cut-off

As previously described in the tuning and operation sections, there is a protection system acting on DX-4 input overdrive. When the drive reaches the limit where signal distortion begins to occur, the overdrive indicator on the front panel will warn you to reduce the drive. If you increase the drive even further, a cut-off protection is activated.

After about 2 seconds of amplifier bypass, the operation is resumed, but if you have not reduced the drive, the protection will be activated again. To stop it, you must reduce the input power drive. This protection is not adjustable - you must not exceed the limit. If this happens too often, you obviously do not have a fine control over the transmit level of your transceiver. In this case, try using the ALC, See section 10.2.

14.10 Tube replacement

It is very unlikely that you will ever need to replace the GU84 (4CX2500) tube(s). If there is a need for that, the tube is easy to replace. However, contact your supplier, because a bias adjustment is required for the new tube. *See also Appendix 3.*

15 WARRANTY / SERVICE

The full FOUR YEARS warranty for DX-4 amplifiers covers all parts and labour, except for the tubes.

The tubes are under a limited warranty, for ONE YEAR.

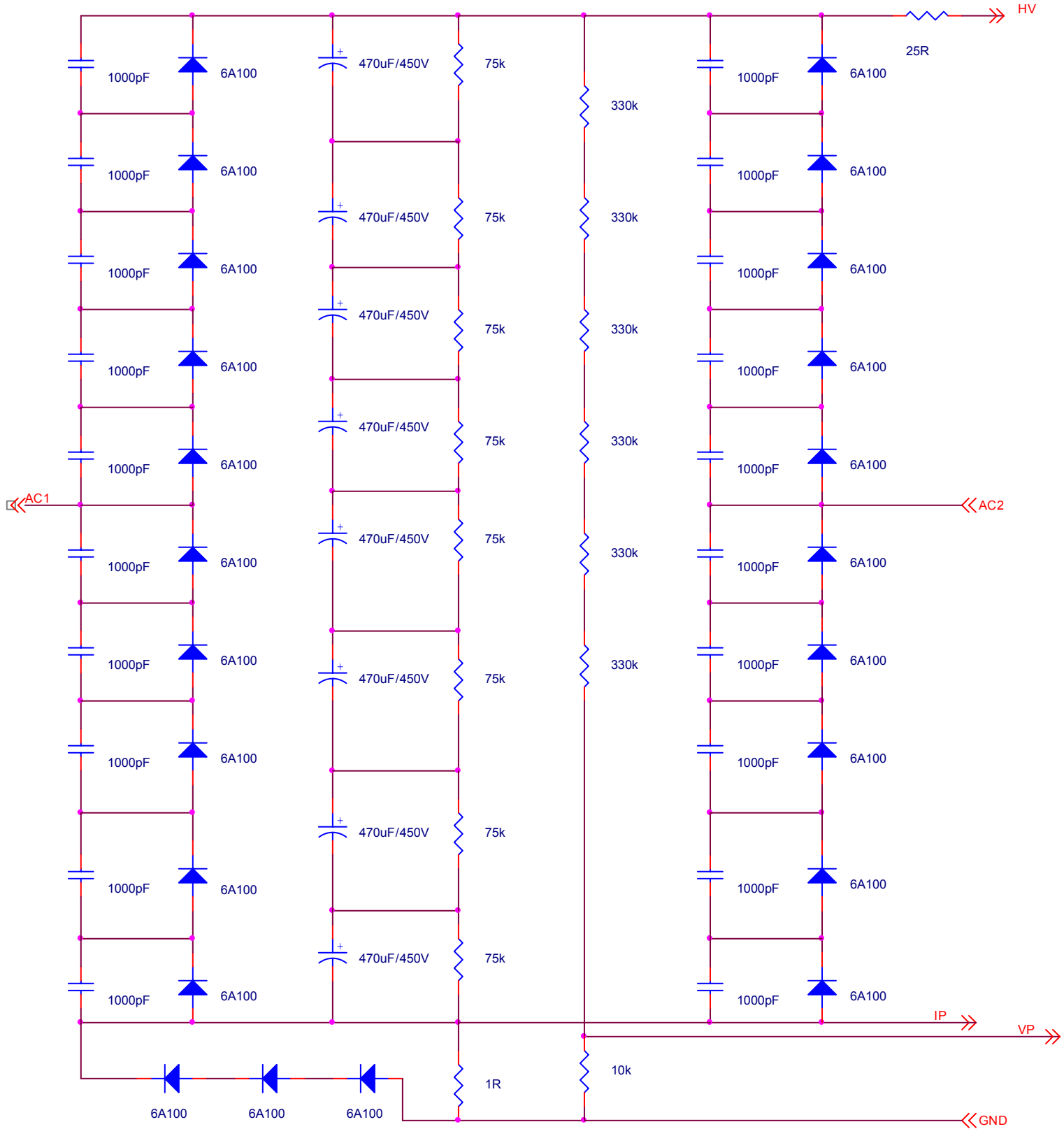
16 GLOSSARY

AC	Alternating Current
ALC	Automatic Level Control
AM	Amplitude Modulation
BALUN	Balanced / Unbalanced Transformer
BNC	Bayonet Neil-Concelman Connector
CW	Continuous Wave
dB	decibel
DC	Direct Current
EBS	Electronic Bias Switch
FM	Frequency Modulation
HF	High Frequency
HV	High Voltage
IEC	International Electro-technical Commission
IMD	Inter-Modulation Distortion
LED	Light Emitting Diode
PEP	Peak Envelope Power

RF	Radio Frequency
RTTY	Radio Tele Type
SSB	Single Side Band
SSTV	Slow Scan Tele Vision
SWR	Standing Wave Ratio
VAC	Volts, Alternating Current
VDC	Volts, Direct Current
WARC	World Administrative Radio-communications Conference
VSWR	Voltage Standing Wave Ratio

17.2 Circuit Diagram – HIGH VOLTAGE POWER SUPPLY

(Two identical modules are used in parallel)

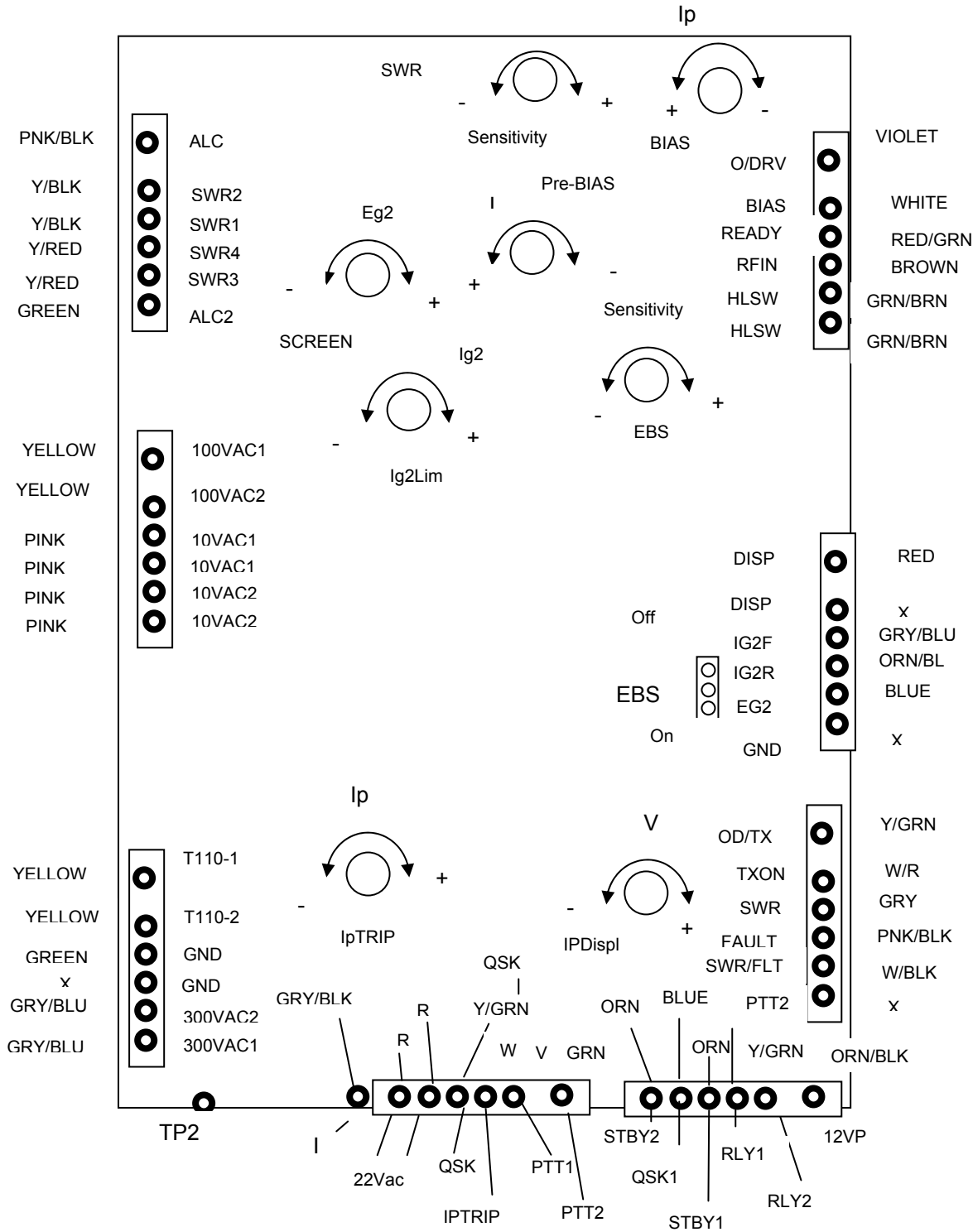


17.3 Control Board and Adjustment Points

COMPONENT SIDE VIEW

The drawing below shows all the connections to the control board and the adjustment points.

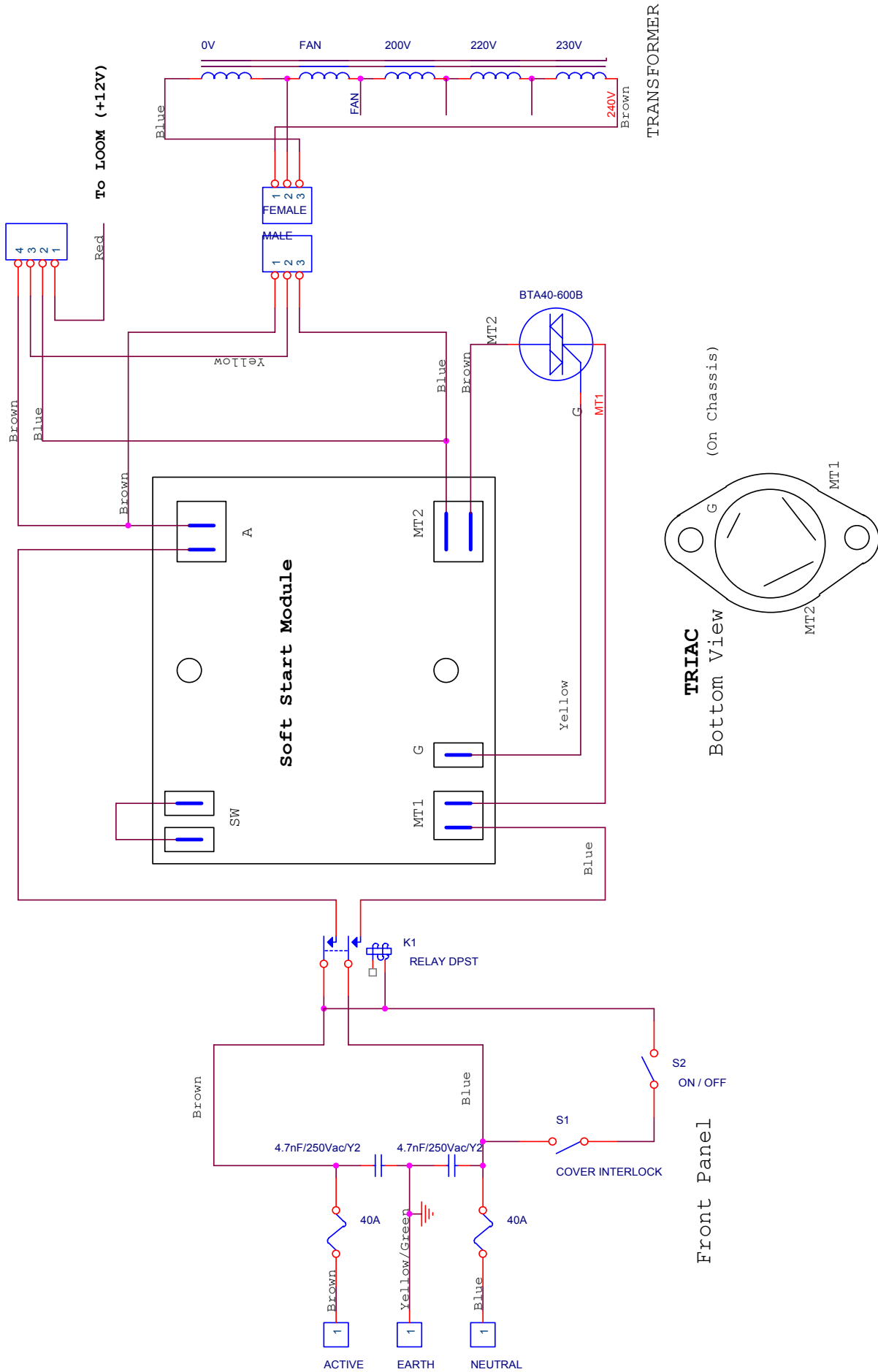
Unless you know very well what you are doing and you have a reason to do it, **do not modify any adjustment!**



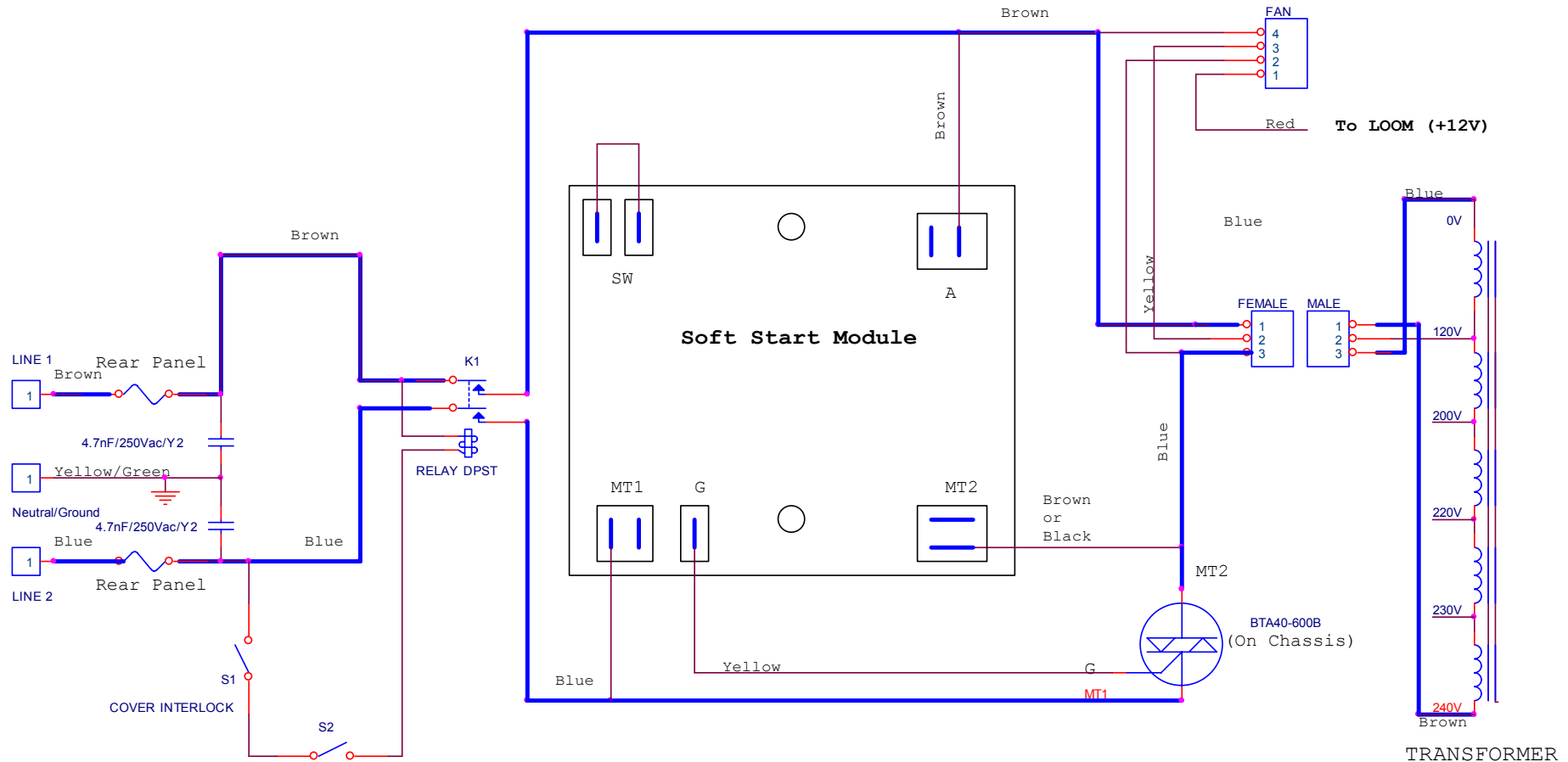
LEGEND:

GRY – grey GRN – green W – white V – violet Y – yellow PNK - pink
 BLU – blue R – red BLK – black ORN - orange

17.4 EPS4-1P Power Supply – AC INPUT AND WIRING DIAGRAM

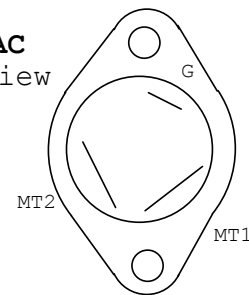


17.6 EPS4-3P 3Phase Power Supply U.S. version – AC INPUT AND WIRING DIAGRAM



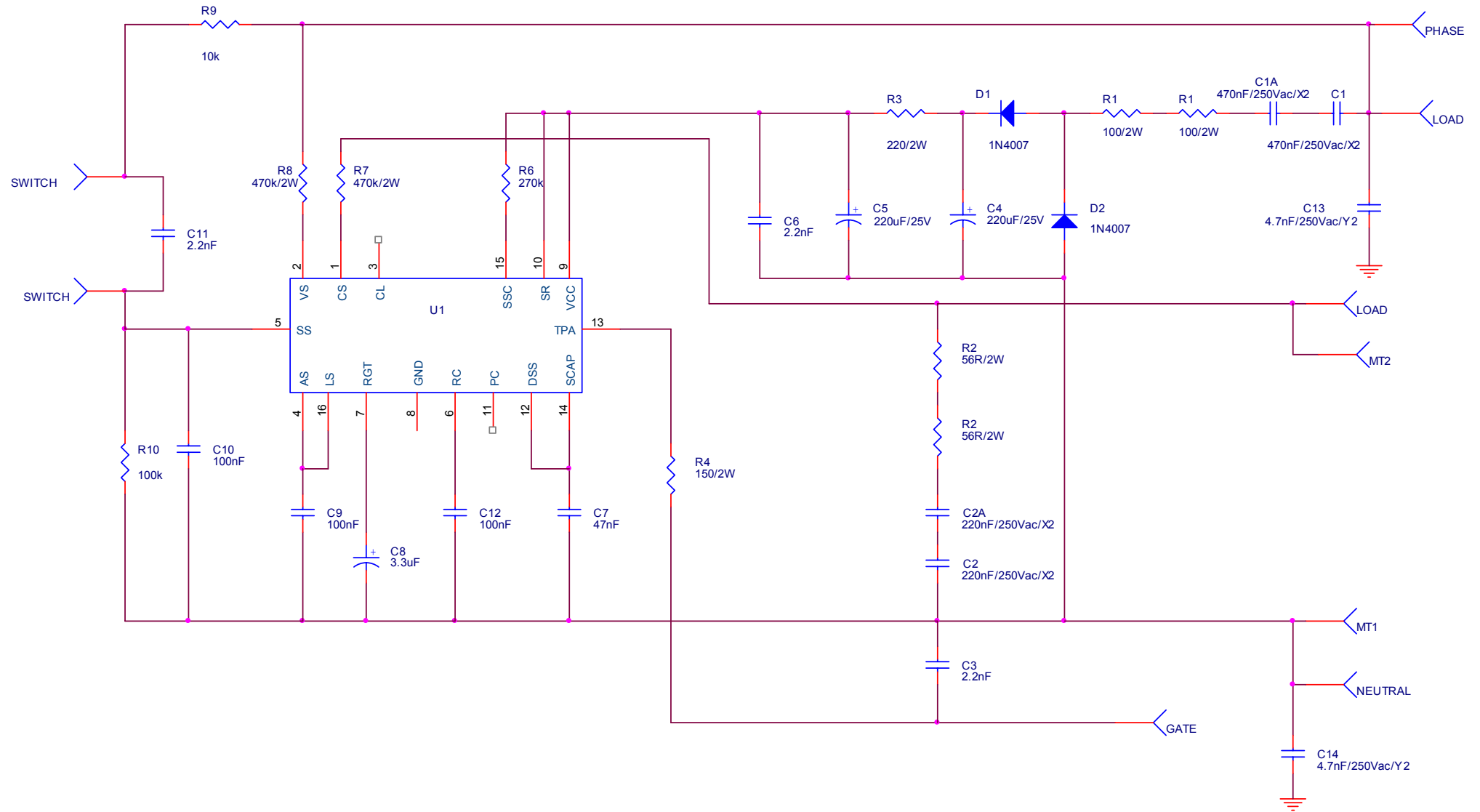
ON / OFF
Front Panel

TRIAC
Bottom View

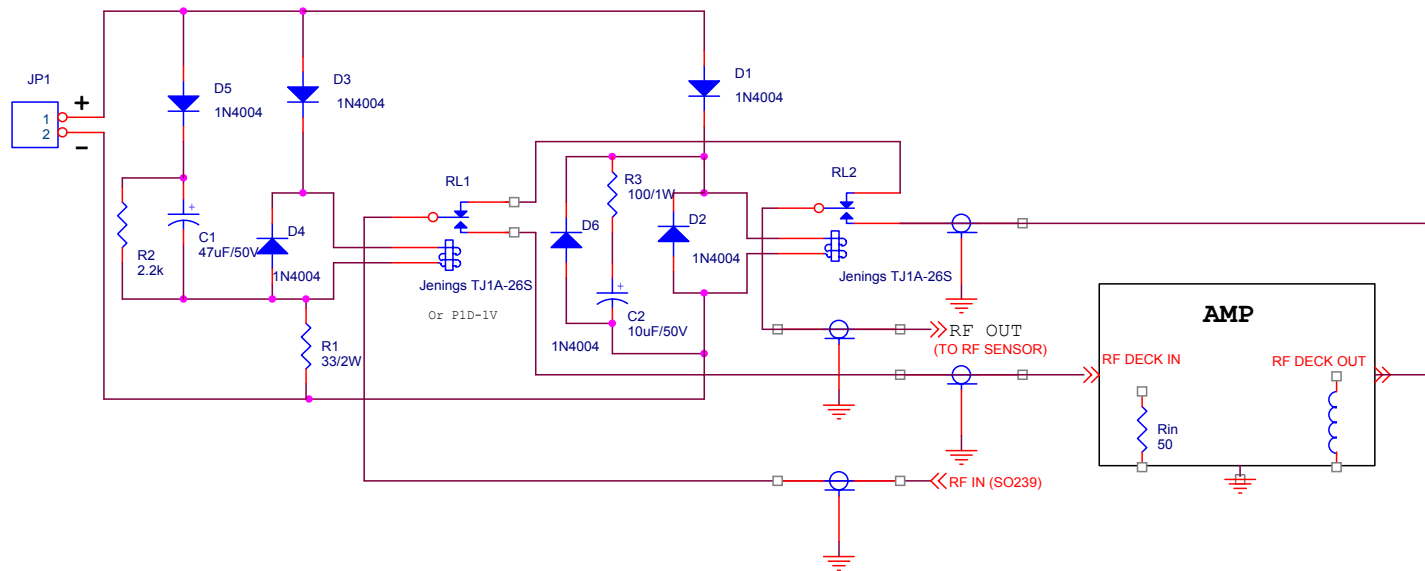


EMTRON		
Title SOFT START WIRING U.S. Version		
Size A4	Document Number SoftStartWiring US	Rev 3
Date: Thursday, July 06, 2006	Sheet 1	of 1

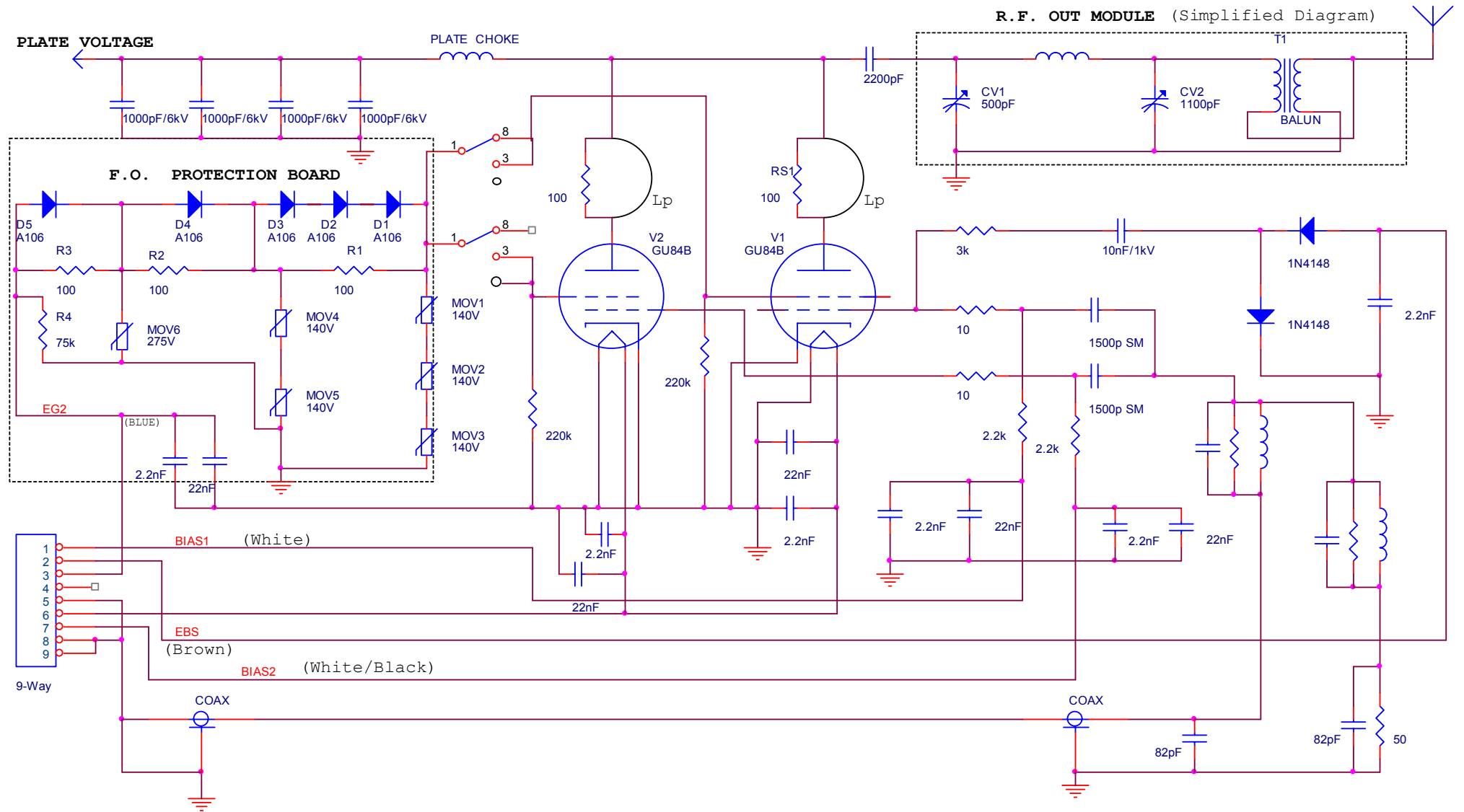
17.8 Circuit Diagram – SOFT START 3 PHASE Europe (380 - 415 V)



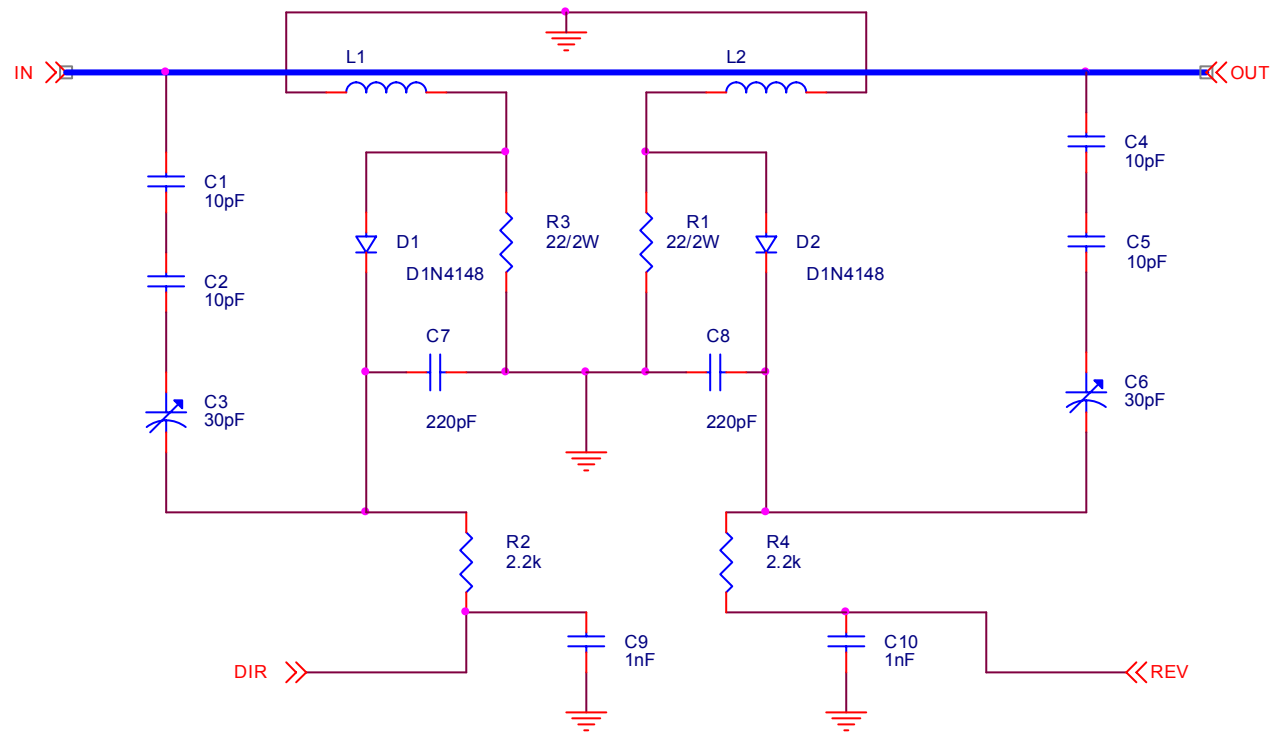
17.9 Circuit Diagram – QSK



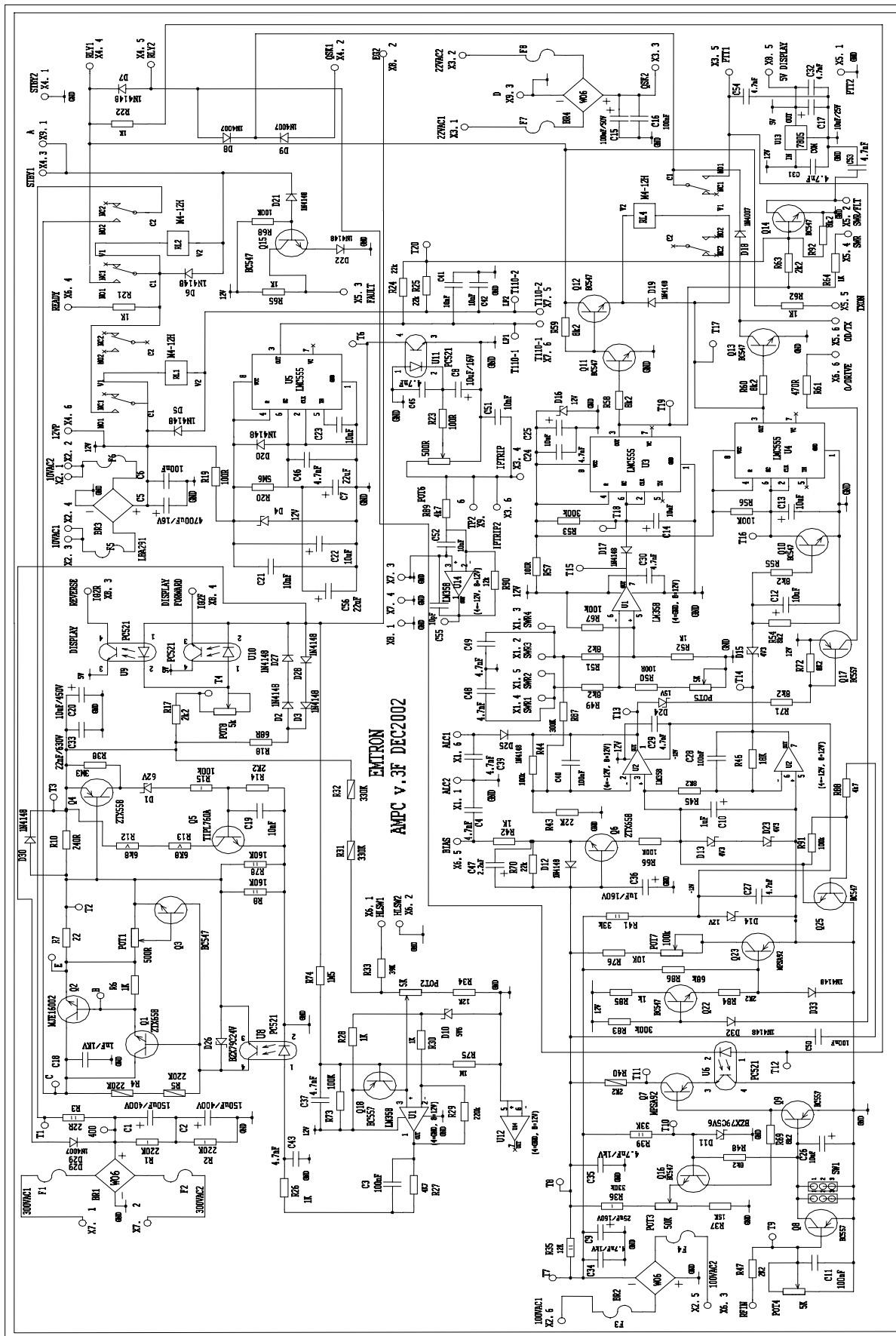
17.10 Circuit Diagram – RF MODULE



17.11 Circuit Diagram – RF SENSOR (Bi-Directional Coupler)



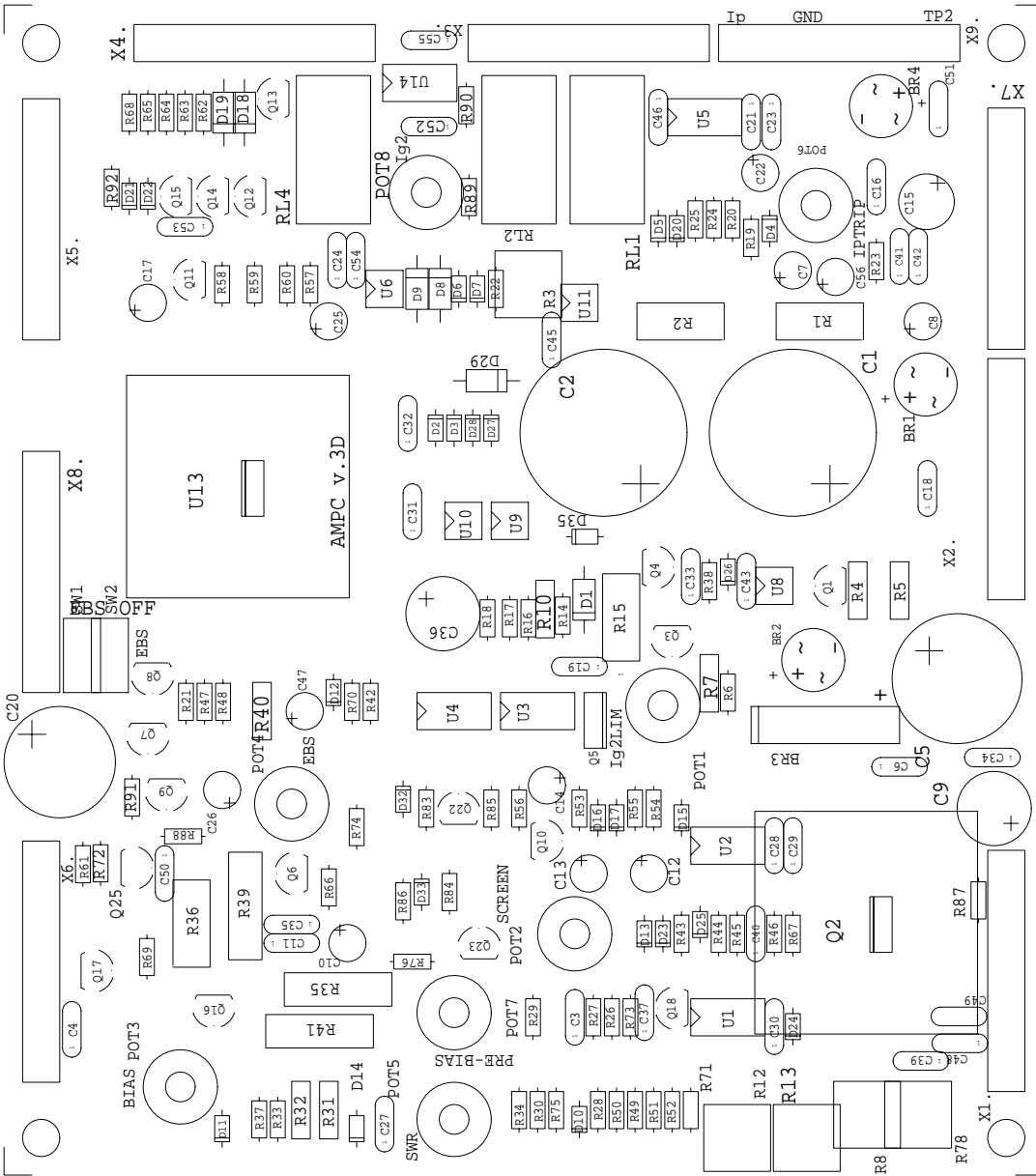
17.12 Circuit Diagram – CONTROL BOARD



17.13 CONTROL BOARD – Component Legend (Silkscreen TOP)

AMPC V.3E

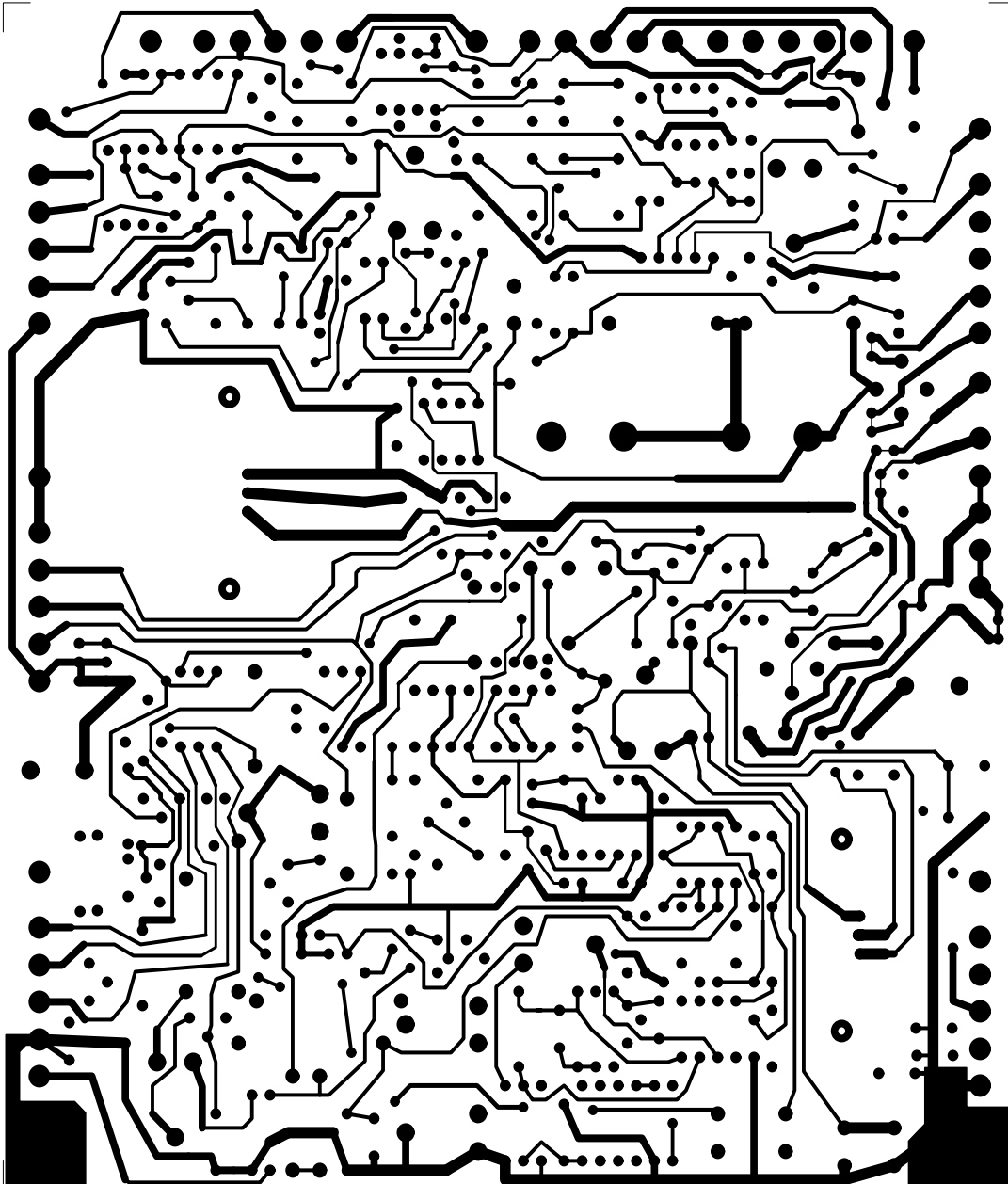
SILK SCREEN LAYER COMPONENT SIDE



Control Board – Solder Side Track work

AMPC V.3E

СОББЕК П'ААЕК ЗОГДЕК ЗIДЕ



18 APPENDIX 2: WAVEFORMS

18.1 QSK Switching

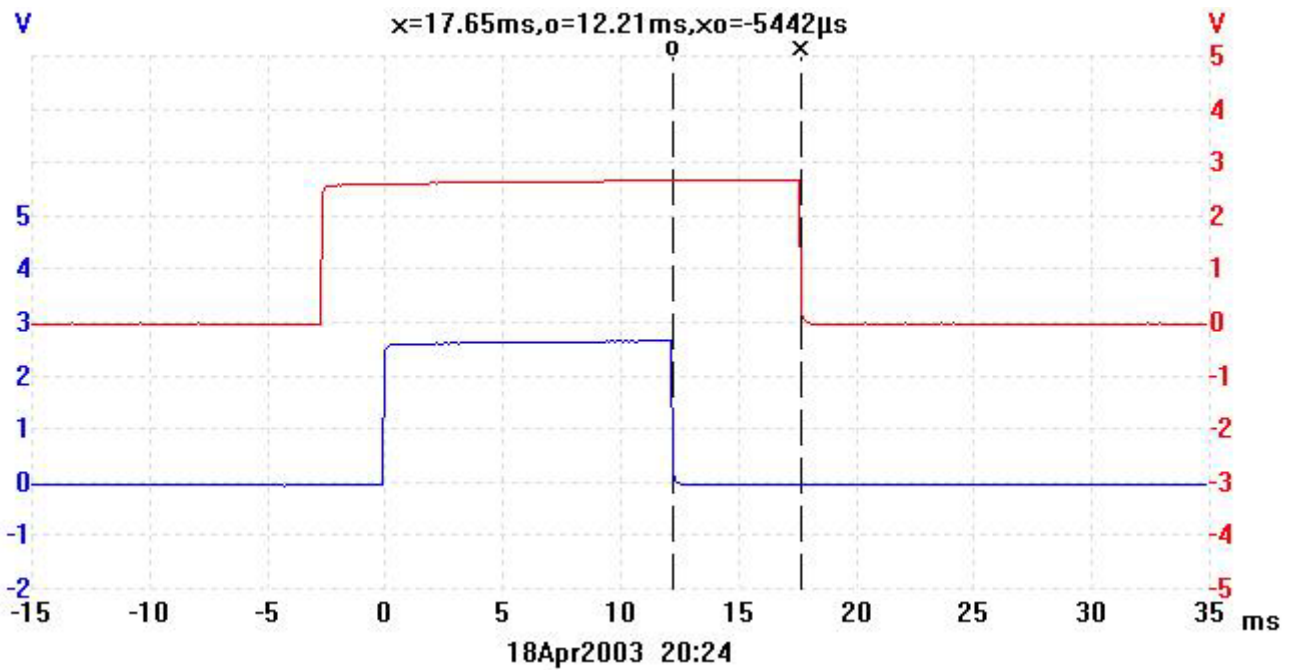


Fig. 4 No “Hot switching”: The output relay (Top trace) switches first, then the RF drive is applied (Bottom trace)

18.2 Linearity

Fig. 5 Sample of linearity curve obtained on a DX-4 at 4000 W PEP output, by using a two-tone generator and a PC oscilloscope in XY mode.

19 APPENDIX 3: ADJUSTMENTS

ADJUSTMENTS TO EMTRON “DX” AMPLIFIERS

CAUTION

Most of the following adjustments require the amplifier to be open and powered up. This also implies defeating the mains interlock safety switch, which is extremely dangerous since high voltage / high power DC and AC and RF voltages are exposed. **We do not recommend anyone to do this**, since extreme precaution and safety measures are required.

If however, this is attempted, it should be only by technical people qualified and experienced in working with high voltage and high power circuits, including RF.

19.1 CONTROL BOARD

This procedure refers to adjustments made to the board already installed in the amplifier.

This would be required, for example, after replacing the tube or after certain repairs.

After a tube replacement only one or two adjustments are required: BIAS and (if EBS used): PRE-BIAS

19.1.1 PRE-BIAS ADJUSTMENT (Adjustment: POT7, marked PRE_BIAS)

The pre-bias is required when the Electronic Bias Switching (EBS) is used. If the EBS link is kept in OFF position, the pre-bias does not need to be adjusted. PRE-BIAS must be adjusted before BIAS.

When EBS is activated (the default situation), keying the amplifier causes the plate current to stay cut off (as if the PTT was off), until a small amount of drive is applied. The “Pre-bias” establishes a small plate current as soon as PTT is on. The transition to full on is then less abrupt, while the tube dissipation is still reduced by using EBS.

PTT Off: $I_p = 0$
PTT On (no drive) and EBS on: $I_p = I_{pb}$ (pre-bias current)
PTT On (no drive) and EBS off: $I_p = I_{p0}$ (standing current)

PROCEDURE:

Remove the cover and connect a voltmeter (+) to the test point TP2 (top corner). (-) to the chassis.

Make sure the EBS link is in the lower (vertical board) or rear position (horizontal board) - (EBS ON).

See also Pictures in Fig. 6 and 7.

With the amplifier running, wait the warm-up time.

When READY, put OPR switch on and key the amplifier with NO INPUT DRIVE.

Read the voltage at TP2.

Adjust POT7 (PRE-BIAS) to obtain the desired pre-bias current.

Recommended pre-bias currents (POT 7, PRE_BIAS):

DX-1b, DX-1d	10 to 30 mA	10 to 30 mV on the voltmeter	Clockwise to reduce current	Vertical board
DX-2:	15 to 40 mA	15 to 40 mV on the voltmeter	Clockwise to reduce current	Vertical board
DX-2SP:	15 to 40 mA	15 to 40 mV on the voltmeter	Clockwise to increase current	Horizontal board
DX-3 (0.5 ohm)	20 to 60 mA	10 to 30 mV on the voltmeter	Clockwise to increase current	Horizontal board
DX-3 (1 ohm)	20 to 60 mA	20 to 60 mV on the voltmeter	Clockwise to increase current	Horizontal board
DX-4 (1 phase)	30 to 80 mA	15 to 40 mV on the voltmeter	Clockwise to increase current	Horizontal board
DX-4 (3 phase)	30 to 80 mA	30 to 80 mV on the voltmeter	Clockwise to increase current	Horizontal board

NOTE: the pre-bias current is not critical.

19.1.2 BIAS ADJUSTMENT (Adjustment: POT3, marked BIAS)

Adjust Pre-Bias before adjusting Bias.

This adjusts the plate **standing current**, with the EBS Off and the amplifier keyed with NO INPUT DRIVE.

PROCEDURE:

Remove the cover and connect a voltmeter to the test point TP2 (top corner).
Put the EBS link is in the upper (vertical board) or forward position (horizontal board) - (EBS Off).
With the amplifier running, wait the warm-up time.
When READY, put OPR switch on and key the amplifier with NO INPUT DRIVE.
Read the voltage at TP2.
Adjust POT3 (BIAS) to obtain the desired bias current.

CAUTION: With a new tube, start at a low plate current.

Single tube amplifiers (DX-1, DX-2SP, DX-3):

Rotate POT3 for minimum current before keying the amplifier.

With the adjustment in the wrong position, the plate current could reach very high values.

During this adjustment there is no output power. All the power taken from the high voltage supply is dissipated by the tube. Be brief and quick. Put PTT on for a few seconds, then off. Repeat several times until the desired standing current is achieved.

Dual tube amplifiers (DX-2, DX4):

There is a switch on the sub-chassis which allows switching off the screen voltage at any of the 2 tubes. When turned to the left, the left hand side tube is operational and the other disabled. In the middle, both tubes are operational. When turned to the right, the right hand side tube is operational the left tube is disabled.

There are 2 or 3 bias adjustment potentiometers: POT3 on the control board, affecting both tubes and 1 or 2.

The potentiometers on the small bias board attached to the heat sink, adjusting the bias individually for each tube. (There are 2 models of bias board, with one or two potentiometers).

Two potentiometer bias board:

With the PTT off, adjust these 2 potentiometers to have about (-130) V on the 2 bias pins (the white and white/black wires).

Disable tube No. 2 and adjust the standing current for tube No. 1 to about 1/2 of the required total value. Use POT3 (on the main board to adjust).

Disable tube No. 1 and use the respective potentiometer on the small bias board to adjust the standing current of tube 2 to the same value as for the tube No. 1

Enable now both tubes by putting the switch in the middle position and check the total current. Repeat the 2 steps above if necessary until the desired total standing current is achieved and at the same time the current is equally shared by the 2 tubes.

One potentiometer bias board:

In this case the main adjustment (POT3) is used to adjust the bias for the tube requiring a more negative voltage and the blue potentiometer on the bias board adjusts the tube requiring less bias. The reason is: the small board takes the main bias and divides it down to a lower voltage. It can reduce but it can't increase the voltage.

This is why balancing the tubes is not always possible. In this case the tubes should be swapped, but it is easier to swap the 2 bias wires: white and white / black.

Start with the blue potentiometer on the bias board at the fully anti-clockwise position, then rotate it about 20-30 degrees to the right. Select one tube and slightly change the blue potentiometer to see if the plate current changes. If it does, switch to the other tube. If the blue potentiometer does not change the plate current, adjust the main bias (POT3) for about 1/2 of the required total current. Switch now to the other tube and adjust the blue potentiometer to read the same current as for the first tube. Put the switch in the middle and check the total plate current. Try again each tube separate to check the balance. A few mA of difference between the 2 tubes is acceptable.

Recommended bias currents (Total standing current, POT3, BIAS and potentiometer(s) on the bias board):

DX-1b, DX-1d	290 to 310 mA	290 to 310 mV on the voltmeter	Clockwise to reduce current	Vertical board
DX-2	370 to 380 mA	370 to 380 mV on the voltmeter	Clockwise to reduce current	Vertical board
DX-2SP:	370 to 380 mA	370 to 380 mV on the voltmeter	Clockwise to increase current	Horizontal board
DX-3 GU78 (0.5 ohm):	740 to 760 mA	370 to 380 mV on the voltmeter	Clockwise to increase current	Horizontal board
DX-3 GU84: (0.5 ohm)	480 to 520 mA	240 to 260 mV on the voltmeter	Clockwise to increase current	Horizontal board
DX-3 GU84: (1 ohm)	480 to 520 mA	480 to 520 mV on the voltmeter	Clockwise to increase current	Horizontal board
DX-4: (1 phase)	740 to 760 mA	370 to 380 mV on the voltmeter	Clockwise to increase current	Horizontal board
DX-4: (3 phase)	740 to 760 mA	740 to 760 mV on the voltmeter	Clockwise to increase current	Horizontal board

NOTE: After adjustment, move the EBS link back in the ON position (default) if EBS is desired.

The above 2 adjustments are required when changing the tube or when changing the control board.
The remaining following adjustments are pre-adjusted with a new control board and normally there is no need to change them. A possible exception could be the SWR protection which might require some fine tuning after changing the control board or the RF sensor module, but usually the factory pre-adjustment is close enough. Also EBS might need adjustment depending on the personal preference of the operator (See 17.1.4)

19.1.3 SWR Protection adjustment

Adjustment: POT5, marked SWR.

This adjustment requires a special jig with a load made of 2 non-inductive, high power resistors (at least 300W). They can be switched between 130 ohm and 140 ohm. With a 50 ohm output these 2 loads give an SWR of 2.6:1 and 2.8:1 respectively. The adjustment is nominally for a ratio of 2.7:1 to trigger the protection in the form of antenna by-pass.

Usually this adjustment is performed on 20m (14.200 MHz) at full power.
With a 50 ohm dummy load, transmit and adjust for full power (or close to full power).
Stop transmitting and replace the 50 ohm dummy load with the special dummy load described above.
Switch the dummy load to 140 ohm and key the amplifier for just one second.
If the protection wasn't activated immediately, increase the sensitivity (Rotate clockwise for DX-1, DX-2 and anti-clockwise for DX-4 and DX-3, which have horizontally installed boards – access on the component side).
Repeat applying power for a short time only, until the protection is triggered.

Switch the special dummy load to 130 ohm and repeat. This time the protection should not trigger. If it triggers, reduce the sensitivity. Try several times using 130 and 140 ohm load. The protection threshold should be between these 2 values (135 ohm, corresponding to 2.7:1 SWR).

19.1.4 EBS ADJUSTMENT (Adjustment: POT4, marked EBS).

Usually this adjustment is performed on 20m (14.200 MHz), but it can be done on any band.

Transmit into a dummy load or antenna.

Apply very low input drive.

With the EBS activated (with the EBS jumper in the lower position, or ON):

Checking the existing adjustment: increase slowly the input drive, starting from zero, until the EBS system activates the amplifier. This can be checked by watching the plate current or the RF output power or the current or power taken from the AC mains. Any one of these can be monitored and a jump in reading happens when EBS switches.

Check that this happens for an input drive between 0.5 – 1 Watt.

Adjusting EBS: if the adjustment is not correct or you prefer a lower or higher setting, apply the desired amount of power and then adjust POT6 until you find the limit where the EBS activates.

NOTE 1: a higher threshold is likely to give reports of the beginning of the words being cut off. If this is the case, a lower threshold (higher sensitivity) can be used.

A low threshold can make the EBS activate erratically, for example due to the ambient noise of in the room, or even due to the noise generated by the fan. This is not a problem in itself, except that the tube will dissipate extra power during the times when you hold the key down but do not speak (eg between the words, while speaking). However, these moments are usually brief and it won't make much difference.

NOTE 2: for factory adjustment, a negative voltage with the value of 1.6 V is applied to the RFIN pin on the control board when this board is checked, then when the amplifier is tested the adjustment is only checked with RF, but not changed.

19.1.5 SCREEN VOLTAGE ADJUSTMENT (Adjustment: POT2, marked SCREEN)

The screen voltage can be measured on the pin marked EG2 on the control board (close to the jumper EBS, this pin has a blue wire connected to it; in DX-3 it is easier to measure on either side of R18). The amplifier must be READY and on OPR for the screen voltage to be present.

The nominal adjustment is 356V unloaded.

NOTE: the screen voltage does not need adjustment unless the value was altered by somebody.

19.1.6 SCREEN CURRENT LIMIT ADJUSTMENT (Adjustment: POT1, IG2LIMIT)

Do not adjust this potentiometer, it has been factory adjusted and there is no need to change.

With the amplifier switched off or on STANDBY, remove the blue wire on pin EG2.

Connect an analogue mA-meter with a 100 mA full scale range (+ to the control board) and then (-) to an adjustable resistive load with a range from 3-5 kohm to about 20 kohm (this jig is also required for the display board adjustment, it is convenient to adjust the ig2 indicator at the same time). The other end of the resistor goes to the chassis.

The power rating must be 20 – 25 W (short time loading only).

Connect also a voltmeter to measure the screen voltage.

Put the front panel switch on OPR.

Start with a higher value (20 kohm) of the resistor and reduce the resistance gradually. At 10 kohm the reading will be about 35 mA.

Continue reducing the resistance until the current reaches about 60 – 70 mA. The screen voltage must drop to about 300 V or less under this load.

If not, adjust POT1.

The above values are for DX-1

For other amplifiers the limits need to be adjusted to values similar to those shown in 17.2.5

NOTE 1: While adjusting ig2 limit, the ig2 indicator on the display board can also be checked / adjusted at the same time.

NOTE 2: IG2 LIMIT can be checked / adjusted also by simply putting a mA-meter in series with the blue wire connected to the EG2 pin on the control board. While operating the amplifier at full load, by rotating the LOAD knob, IG2 can be varied and the screen voltage can be measured. This way the current limit of the screen regulator and the ig2 indicator on the front panel can be checked quickly, without the need for a special load.

However, the amplifier has to be opened and wires used to extend the screen voltage connection to the blue wire to an external current meter and volt meter.

19.1.7 IPTRIP ADJUSTMENT (Adjustment: POT6, marking: IP TRIP)

This is the sensitivity of the high plate current protection (cut-off).

When the plate current exceeds the adjusted limit, even for a very short time, the start-up timer is reset. The screen voltage is cut off and the FAULT light turns on. To make FAULT light go off, the amplifier must be put on STANDBY. If left on OPR, the operation will resume automatically at the end of the (about) 2 minutes warm-up time. During this time, any RF power applied to the input is bypassed into antenna.

Connect a DC supply to pin TP2 on the control board (in the top corner).

With the amplifier powered and the READY light on, put the front panel switch on OPR.

Apply a current gradually increasing from zero and check that the protection is triggered at about 2.5 A of current. When this happens, the FAULT light will turn on.

If the current value found is much different from 2.5 A, adjust POT6.

To repeat the adjustment or checking, you need to wait every time for the READY light to turn on again (about 2 minutes).

To speed up, the resistor R20 (5.6 Mohm) can be paralleled briefly with a lower value resistor (1k – 100k). Touch R20 with, say 10 kohm in parallel and the Ready light will turn on immediately.

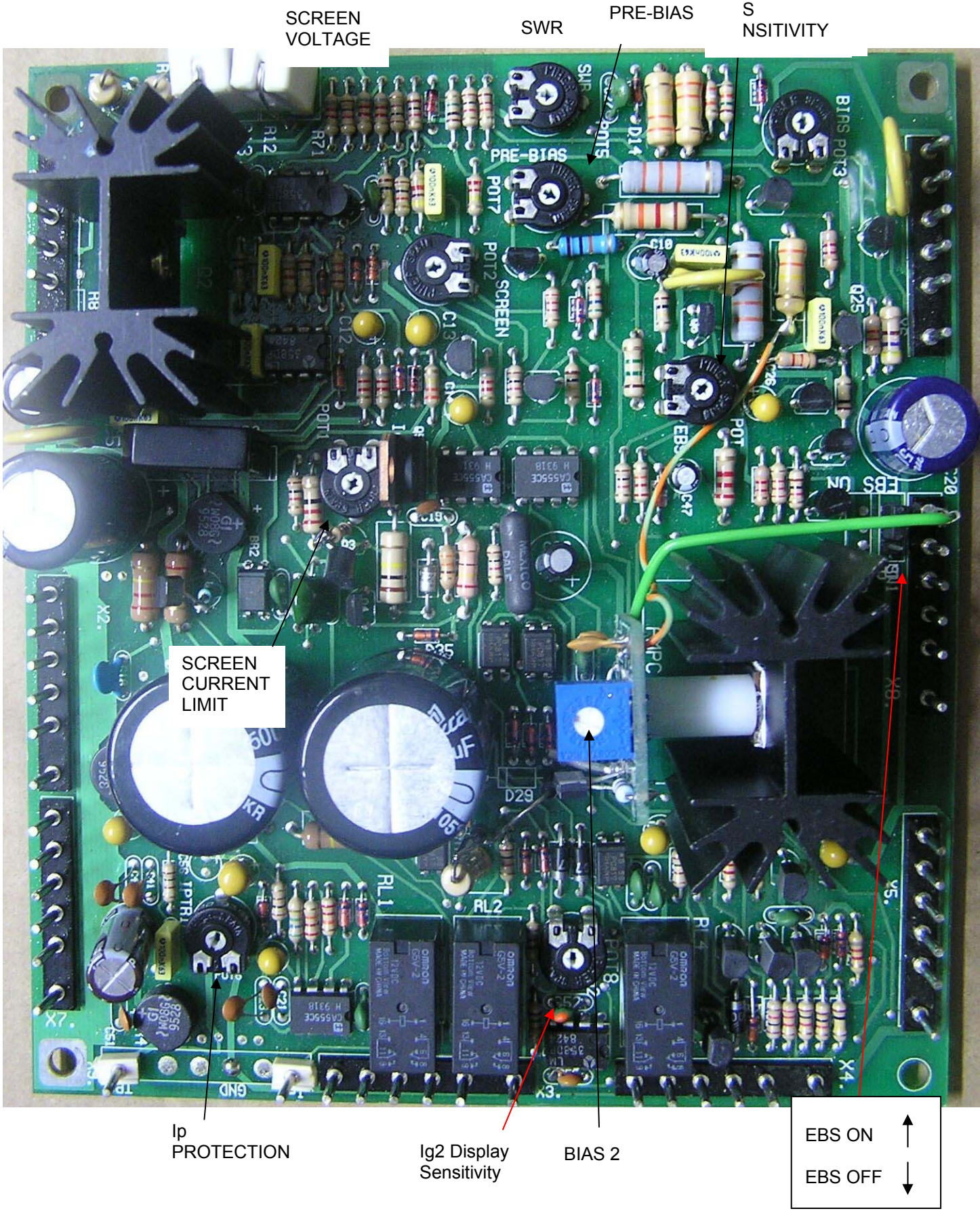


Figure 8

19.2 DISPLAY BOARD ADJUSTMENTS

The display board is pre-adjusted during testing. However, when installed in the amplifier, most adjustments need to be fine-tuned. Remove the front panel glass to gain access to adjustments.

19.2.1 PLATE CURRENT (Adjustment: VR4, Marked: AMP)

Connect a power supply to pin TP2 on the control board: negative to TP2, positive to the chassis.

Apply a current with a value between 1 A and 2 A. Choose a convenient value close to the full scale on the Ip LED row on the display board.

Adjust potentiometer AMP for correct indication.

19.2.2 PLATE VOLTAGE (Adjustment: VR2, marked: VOLT)

Using a voltmeter with a high voltage probe, measure the plate voltage.

Adjust potentiometer VOLT for correct indication on the display.

19.2.3 REFLECTED POWER (Adjustment: VR3, marked: RF R)

Reverse the input and output RF connections:

- connect the transceiver or exciter to the output
- connect the dummy load to the input of the amplifier

Apply 100W drive and adjust "RF R" for 100W indication

Reverse again the RF cable - connect them the right way.

19.2.4 FORWARD POWER (Adjustment: VR1, marked: RF F)

On 20m, operate the amplifier at the full nominal power, as indicated by an external power meter:

750W for DX-1

1500W for DX-2

2000W for DX-2SP

3000W for DX-3

4000W for DX-4

Adjust potentiometer "RF F" for correct display indication

19.2.5 SCREEN CURRENT (Adjustment: VR6, marked IG2+, VR5, marked IG2-)

ig2-: put VR5 in the middle position

ig2+: connect a mA meter in series with the screen supply, between the control board pin EG2 and the blue screen wire. (See also the control board adjustment for IG2 LIMIT).

Generate a current in the mA meter, either by connecting a load, or by operating the amplifier close to full power.

Adjust VR6 for 4 LED's on, at the limit of starting to flash, for a current ig2+ of about:

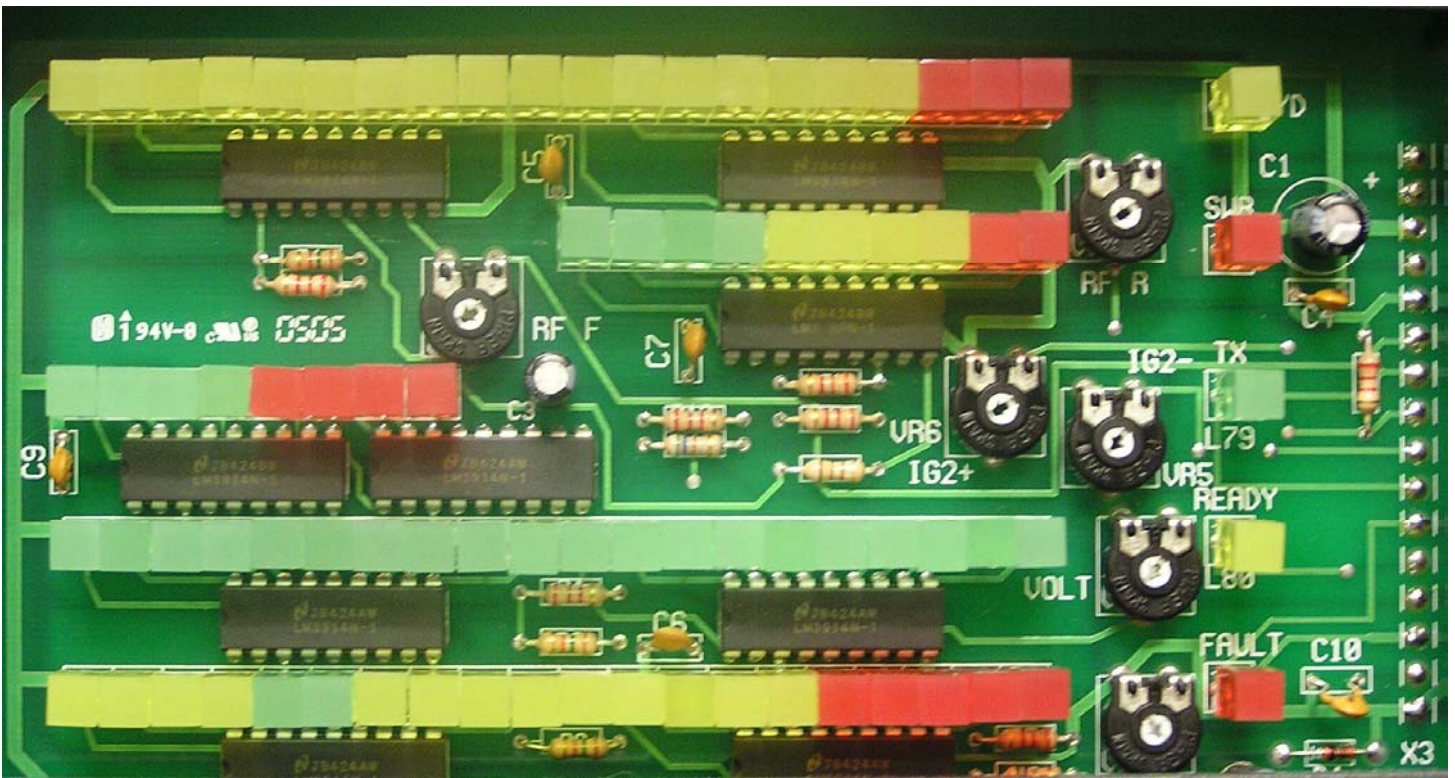
40mA for DX-1

60mA for DX-2

60mA for DX-2SP

60mA for DX-3

80 – 100mA for DX-4



19.3 RF SENSOR ADJUSTMENT

The amplifier is switched off for this adjustment.

Check if adjustment is required as per following procedure, before opening the sensor.

Unsolder and remove the metal cover.

Connect a transceiver to the input and a dummy load to the output of the amplifier.

Connect a voltmeter to pin SW1 or SW2 on the control board (with yellow/black wires).

Apply 30-50W RF on 20m (14.2MHz) and read the voltage.

Move the voltmeter on pin SW3 or SW4 (red/black wires) and read the voltage.

Typical readings:

- Yellow / black wires: 1 – 1.5 V
- Yellow / red wires: 100mV or less

Adjust the trimmer on the output side (left hand side) in the RF sensor for minimum reading on the yellow / red wires. (Use an RF screwdriver).

Reverse the 2 RF cables: apply power to the output of the amplifier and put the dummy load on the input.

Apply power again.

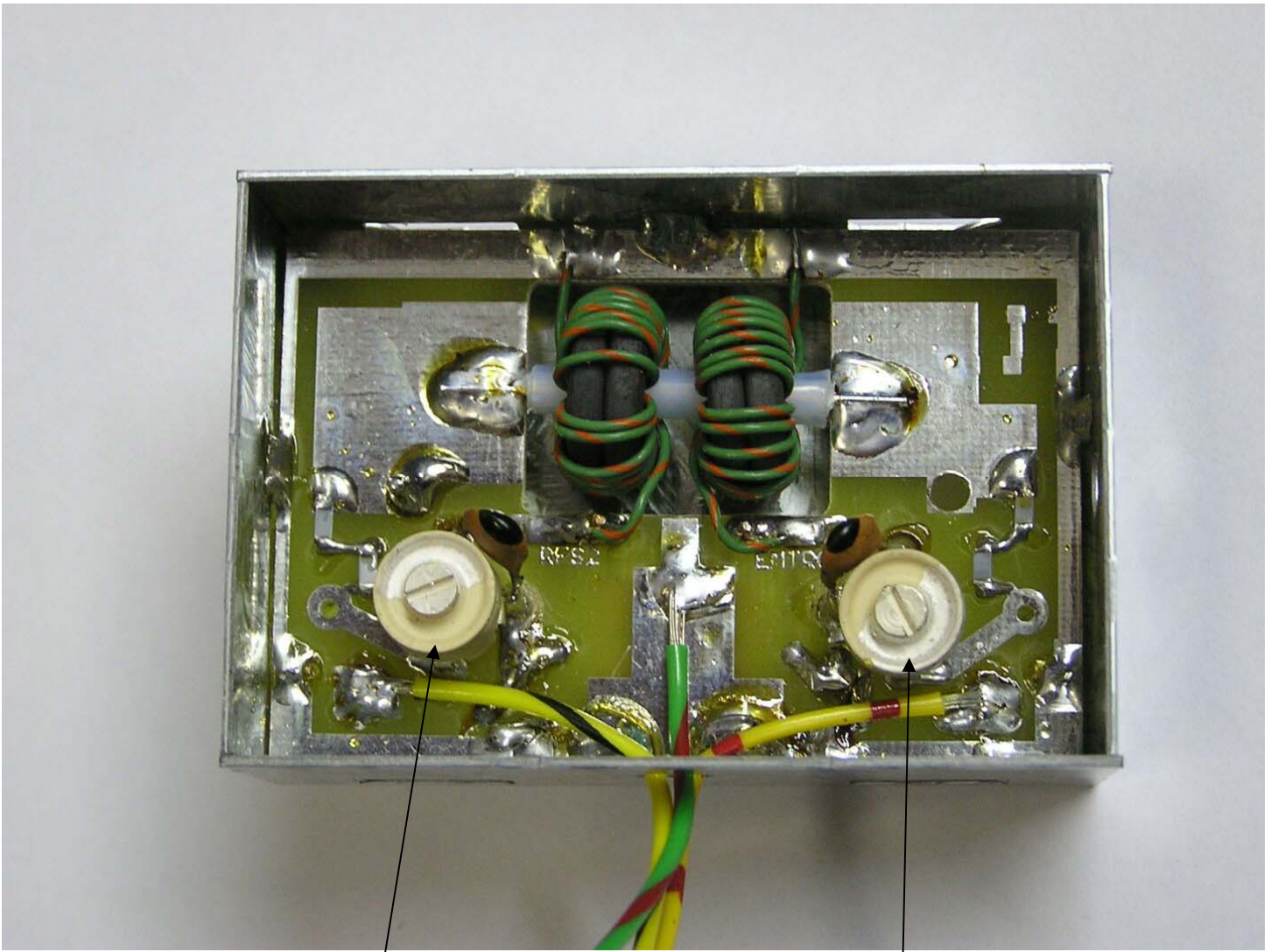
The typical readings are the same, but reversed:

- Yellow / black wires: 100mV or less
- Yellow / red wires: 1 – 1.5 V

Adjust the trimmer on the input side (right hand side) in the RF sensor for minimum reading on the yellow / black wires.

Re-position the RF sensor cover and solder.

NOTE: the above voltages can be measured as explained above and if the readings are correct, no adjustment is necessary (the sensors are pre-adjusted before being installed).

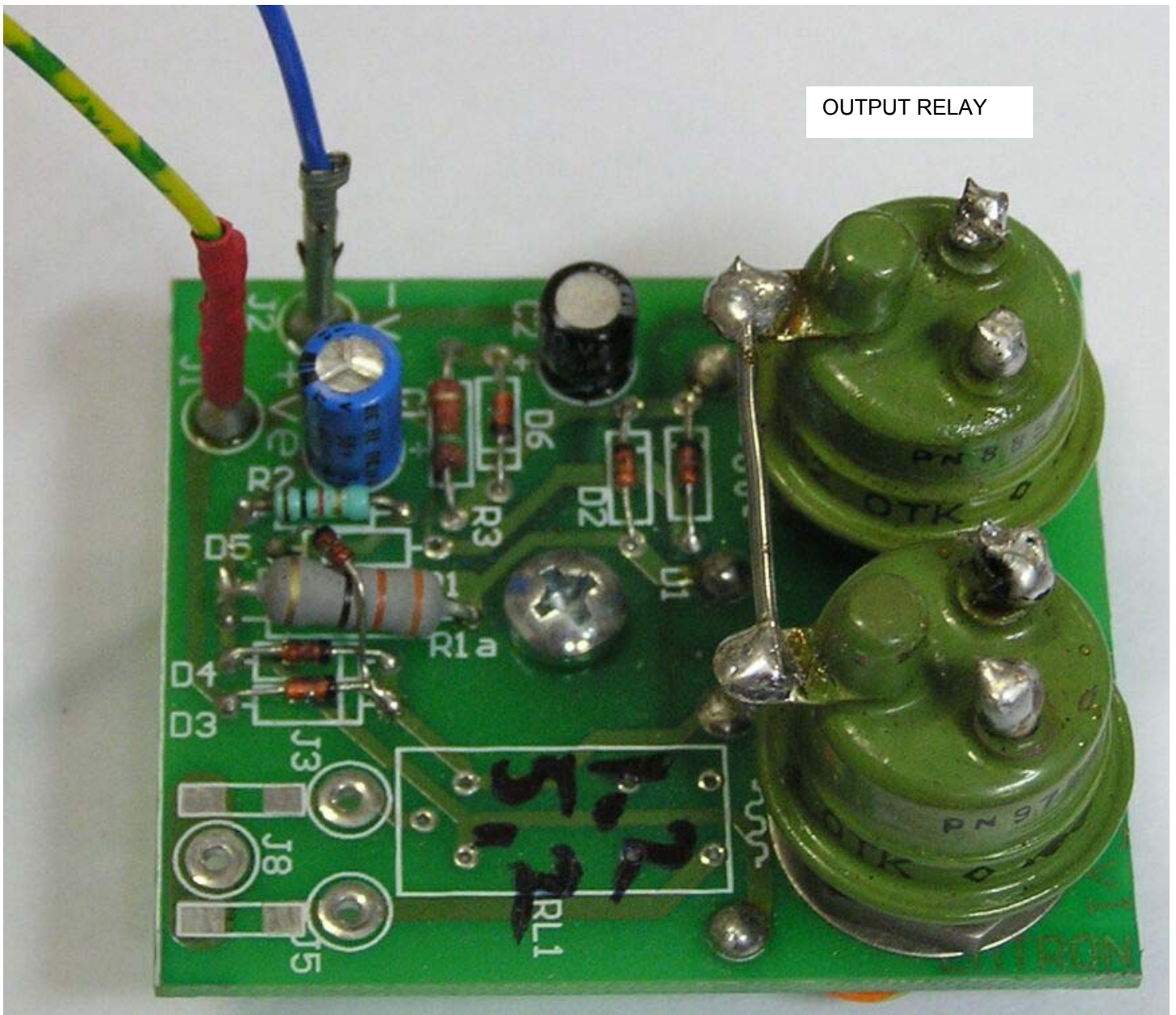


OUTPUT
SIDE
TRIMMER

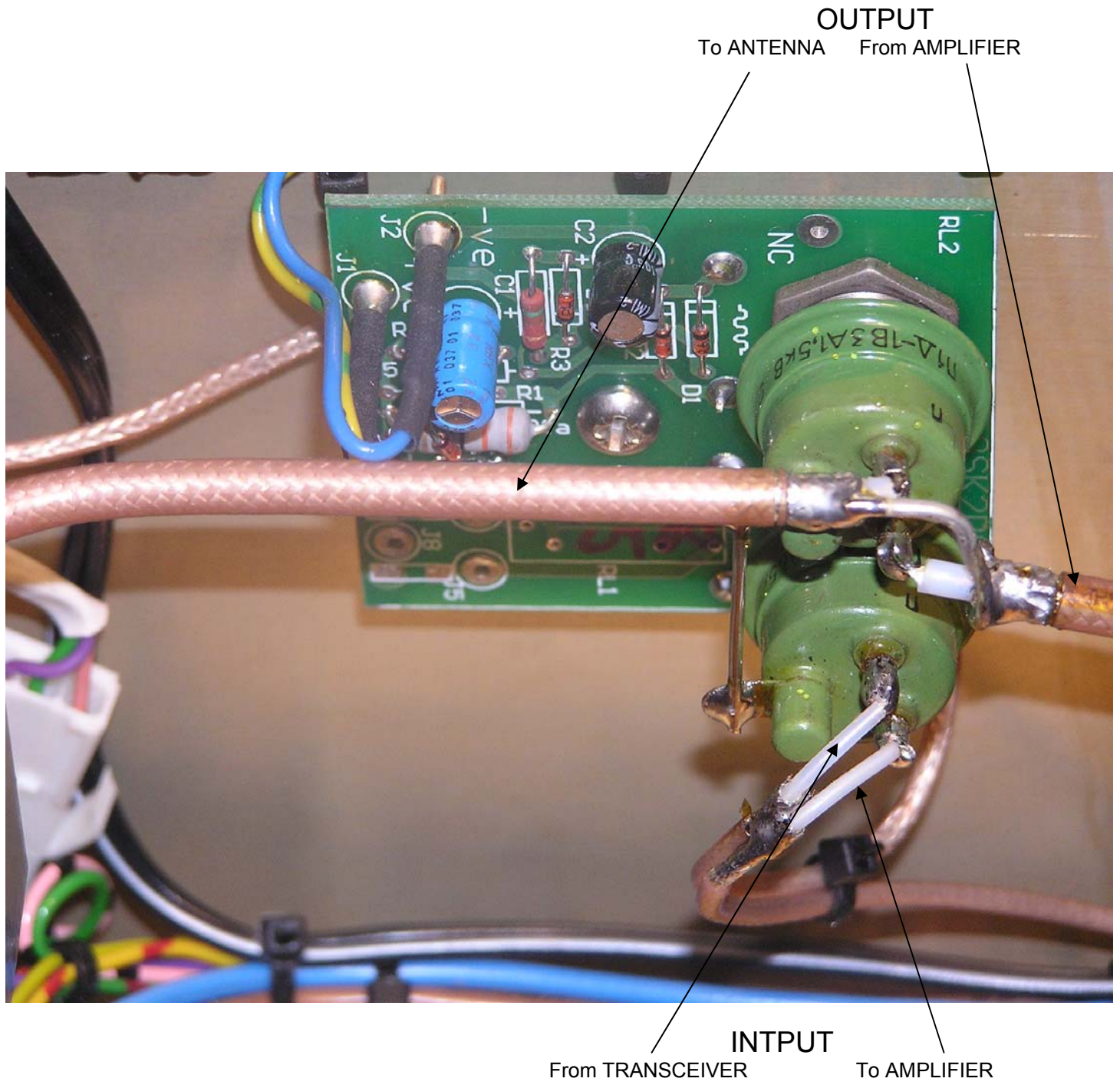
INPUT
SIDE
TRIMMER

20 APPENDIX 4: OTHER MODULES

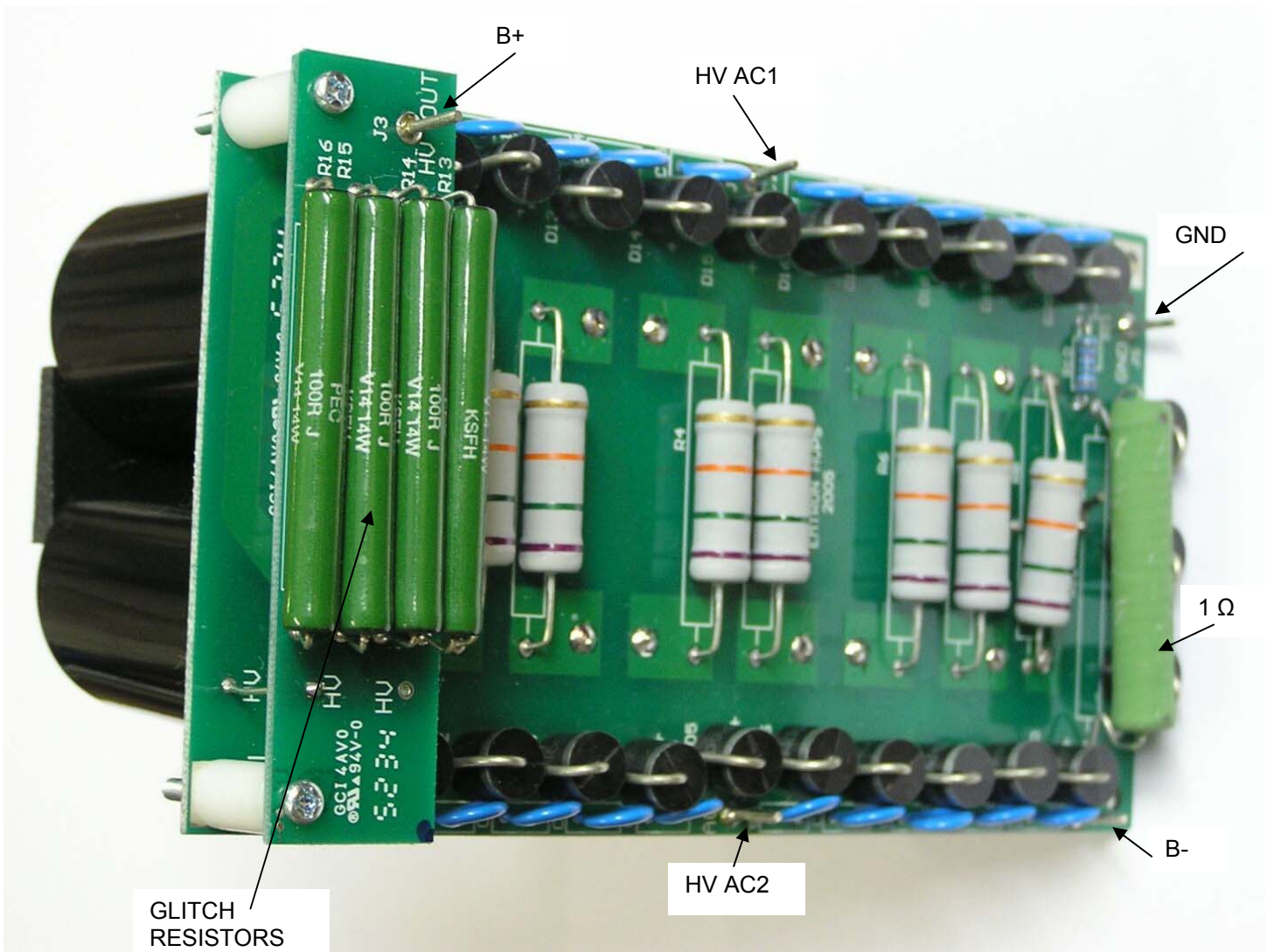
QSK



INPUT RELAY



HIGH VOLTAGE POWER SUPPLY



GLITCH RESISTORS



SOFT START MODULE, 400 V (3-PHASE EUROPE)

