EMTRON DX-1 - CIRCUIT DESCRIPTIONS

The input RF stage.

The input circuit of the Emtron DX-1d linear amplifier utilises a 50 ohm passive "L Pad" network with SWR compensation. This network consists of two non-inductive power resistors, an inductor and a capacitor.

The input signal is coupled to the control grid via a coaxial cable, passive input network, 1500pF silver mica capacitor and a 10 ohm resistor. A portion of the input signal is also being rectified in a voltage doubling circuit C13, D1, D2 and C7 and the generated –ve DC output signal is controlling the Electronic Bias Switch (EBS) on the control board.

The Control Board

1. Screen supply

Refer to the top left part of the circuit diagram.
Nominally 300 Vac is applied to the bridge BR1, creating about 420 Vdc on C1 and C2.
When the relay RL2 (OPR/STBY) is activated, this voltage is applied to the series pass transistor Q2. Otherwise, when the amplifier is not READY, or it is in STANDBY, there is no screen voltage.
The voltage is regulated by U1 via the optocoupler U8 and op-amp Q1. U1A will maintain the voltage on the POT2 wiper equal to the reference given by D10. POT2 is the screen voltage adjustment.
R7 and Q3 provide the current limiting. The current limit is adjusted by POT1. This circuit is intended to limit the screen current during the normal tube operation, preventing it from going over 40 mA. In short circuit, Q2 dissipation could reach 16W. To avoid Q2 overheating in case of a permanent short circuit, Q18 will turn off the screen voltage, as soon as a very low output voltage is detected.
The series pass regulator can only source, but not sink current. When a negative screen current is generated by the tetrode, R8 and R78 will sink a certain amount of current, creating a negative voltage drop on R10. This will turn on Q4, which will proportionally drive Q5. This will create sufficient current in R12, R13 to load down the screen voltage and maintain the voltage regulation. At all other times Q5 is off and it does not load the screen regulator unnecessarily.

The optocouplers U9 and U10 transmit the screen current information to the display board, for negative and positive currents, respectively. R18 and the diodes D2,D3, D27, D28 create a shunt. They pass most of the screen current, with only a fraction going into R16 or R17.

The regulated 350 Vdc screen supply is being applied to the screen of the GU74B (4CX800) tube via the Flash-over protection circuit. The purpose of this protection circuit is to dissipate the energy stored in the HV power supply when released to the screen, in case of a tube flash-over and consequently protecting the tube as well as the 350Vdc regulated screen power supply on the control board.

2. Bias circuit

This is at the bottom left side of the circuit diagram.
The bridge BR2 gets 100 Vac, charging C9 to about (- 120) Vdc. Since this circuit needs to deliver only a very small current, a simple shunt regulator is used. R35 and R40 form a voltage divider, with Q7 conducting just enough current to maintain the bias voltage constant.
The voltage reference is D11, which keeps the base of Q16 at - 5.6V. POT3 is the bias adjustment.
For Q7 to conduct, 2 conditions are required:

- The optoclupler U6 must be activated by the PTT contact.
- Q9 must be off, either due to the EBS link in the lower position, or a negative voltage present on the RFIN pin.

3. Electronic Bias Switch

Q9 is off only when either the EBS is disabled by the link on SW1 placed in the upper position, or (with the link in the lower position), there is a negative voltage at point RFIN, which turns Q8 ON and Q9 OFF.
POT4 is the sensitivity adjustment for the EBS circuit.

4. Pre-Bias

The pre-bias circuit is made up of Q22 and Q23. When the amplifier is keyed but there is no audio signal to turn on the bias, the negative voltage is prevented to completely cut off the tube, by maintaining a small plate current, adjusted by POT7.
With PTT off, Q7 and Q23 are off and there is no plate current.
With PTT on, but no input RF drive, Q7 is off, while Q23 is on just enough to reduce the bias voltage (in absolute value), to the level required by the pre-bias current previously adjusted. With PTT on and RF drive present, there is normal operating plate current.
With PTT on and the link in the lower position there is standing plate current.

5. 12Vdc supply

BR3 rectifies the 10Vac and charges C5 to 12 - 14 V. At power up, this voltage is initially applied only to the timer U5, the +5V regulator U13, the timers U3, U4 and the operational amplifiers U1 and U2.

6. +5Vdc supply

All the time while the power is on, U13 supplies +5V regulated to the display board.

7. Warm-up timer
The timer IC 555 gives about 2 minutes of warm up time when the power is turned on. This is the time required by C7 and C23 to charge to about 3.33 V.
When the time is up, pin 3 of U5 goes low, activating RL 1 (the READY relay) via the PCB pins X7.6 and X7.5, connected to the 110ºC sensor (normally closed), located above the tube. At this moment, RL1 applies 12V to RL2 and R21, turning on the READY LED.

8. Operate
With the STBY (front panel) switch open, RL2 is not powered. When the switch is closed, RL2 is energized. This causes the screen voltage to turn on and 12V to be applied to the antenna relay RL Y1 and to other circuits.

9. Antenna relay / QSK activation

While in OPERATE mode, closing PTT1 point (X3.5 - bottom right hand corner of schematic) to ground will cause either the antenna relay, or the QSK module to energize. In normal operation RL4 is energized (See below. - Also note: there is no RL3). The joint point of Q8 and Q9 is grounded and so is RL Y2 (X4.5) and QSK1 (X4.2). The pin QSK2 (X3.3) supplies the QSK module with about 30 Vdc, via BR4.

PTT on also pulls low Q13 collector and X5.6 (OD/TX), causing the "ON AIR" LED connected to TXON (X5.5) to turn on.

10. Grid current detector and overdrive protection

Q6 is a current mirror circuit. Any grid current flowing in its emitter will be effectively diverted to ground, charging C10. The voltage is limited by the Zener diode D13, D23. The negative voltage on C10 is amplified by U2A, generating at output the ALC voltage, with values between 0 and - 11 V. When U2A output, normally 0, goes negative by more than about 3V, D24 will conduct, turning Q17 on and turning the Overdrive LED on. This happens at about 100 microamperes of grid current.

When the overdrive is more severe (about 0.4 mA), U2B (with a lower gain) will output a positive voltage sufficient to exceed the D15 (4.3V) threshold and turn Q10 on. This will discharge C13 and cause the pin 3 of timer U4 to go high. This pin normally keeps RL4 activated. By going high, it

toggles RL4 which opens the antenna relay circuit, and the amplifier goes in bypass mode for a short time. As soon as the overdrive condition disappears, there is no grid current, Q10 turns off and C13 charges again. It takes about 2 - 3 seconds before the pin 3 of U4 goes low again and the normal operation is resumed. If the input drive is not reduced, the cycle will repeat.

11. SWR protection

U1B compares two voltages fed from the RF sensor. The 2 voltages are proportional with the forward and the reverse power. POT5 is typically adjusted for U1 pin 7 to go low when the SWR is 2.7: 1.

When this happens, C14 is discharged and the pin 3 of U3 goes high. This drives Q11 on and Q12 off, removing the 12V power from RL4. U3 pin 3 also drives the SWR LED on, via R64 and the FAULT LED on via R63 and Q14. RL4 switching causes the antenna relay to switch to bypass. After 3 - 4 seconds C14 charges again and U3 / 3 goes low, enabling the normal operation. Then the cycle will repeat until the cause that created the high SWR condition is removed.

12. Plate over-current protection

If the plate current exceeds the pre-set limit of about 1.8 A, due to a tube flash-over, or while tuning, the voltage drop on the 1 ohm resistor in the high voltage power supply module will drive the optocoupler U11. This voltage is connected to IPTRIP (X3.6) and the trip voltage is adjusted by POT6. The factory adjustment value is 1.85 V. When this protection is triggered, C7 and C23 are discharged and U5 will put the amplifier in Standby. It will take about 2 minutes to come back to the READY condition. During the 2 minutes the FAULT light will stay on (unless the front panel switch is changed to STANDBY). U3 pin 3 being high will turn Q14 on and the pin SWR/FL T (X5.2) becomes low.

The FAULT light also comes on if the temperature sensor reaches the limit when its contacts open. This will open the circuit between X7.5 and X7.6, deactivating the relay RL 1 and turning the FAULT light on. However, in this case the 2-minute timer is not involved and the operation returns to normal as soon as the temperature drops enough for the temperature sensor contacts to close.

The Display Board

The DX-2 amplifier uses a solid state display with "moving LED's", which imitate an analog display. Six voltages are input into the Display board:

- Plate voltage information, from a resistive divider in the plate circuit

- Plate current information, from a 1 ohm resistor in the plate circuit

- Forward power, from the RF power sensor

- Reverse power, from the RF power sensor
- Positive screen current
- Negative screen current

Each one of these 6 voltages reaches an adjustment potentiometer and then an LM3914 LED driver. Horizontal light bars are displayed, proportional to the values measured.

The High Voltage Power Supply

A full bridge rectifier is fed the 1900 Vac from the transformer. The bridge is made of 4 x 5 diodes, with a rating of 1000V / 6A each.

Eight electrolytic capacitors (470 uF / 450V) are connected in series to filter the high voltage DC. Each capacitor has in parallel a 75 kohm resistor, which equalizes the voltage across each capacitor and ensures the capacitors are discharged in a short time after switching the power off.

The negative side of the bridge is connected to ground via a 1 ohm resistor, used to pick up the voltage drop for current measurement and over-current detection.

The positive side is connected to the tube via a 25 ohm group of resistors and the RF choke. A chain of resistors is used as a divider for high voltage measurement.

The Soft Start Circuit

A triac is phase-controlled to ramp up the AC supply voltage, over a time of about 5 seconds.

When the power is applied, C8 is starts charging gradually, and the control I.C. starts shifting the phase from an initial zero, to almost 180 degrees, when the full mains power is applied to the transformer.

The AC Input Circuit

The mains voltage is applied to a double pole 240 Vac relay, via 2 fuses with a rating of 15 A each. The relay is activated when the front panel switch is closed, and it applies the mains voltage to the soft start module.

The transformer takes 240 V in primary and delivers in secondary all the required voltages:

- 12.6 Vac for the tube filament
- 10 Vac for the control circuitry
- 100 Vac for bias
- 300 Vac for screen supply
- 22 Vac for the QSK module.

The transformer primary has a center tap where the cooling fan is connected. A relay switches the fan from 120 V to the full 240 V when the temperature sensor detects the tube temperature reaching a certain limit.

The RF Sensor

The sensor is using a current transformer, with the RF current feeding the antenna passing through a torroid with 2 secondary windings. The output of one winding is rectified and provides a DC voltage proportional with the forward power. The other winding is connected to a capacitor which cancels the voltage created in the winding by the forward power, but add up in phase with the voltage created by the reflected power.

These two outputs are rectified and then used for the power indicator, as well as for the SWR protection circuit in the Control Board, which is adjusted to cut off if a certain ratio between these 2 voltages is exceeded.

The RF Output Circuit

The tube plate is AC coupled into the PI output circuit made of one switched inductor and 2 variable capacitors, which is coupled into the antenna via a 4:1 impedance transformer (Balun) with an unbalanced primary and balanced secondary.