Test and Calibration Procedure

IMPORTANT ELECTRICAL SAFETY CONSIDERATIONS

A substantial proportion of the power supply main PCB is occupied by primary side circuitry comprising tracks, terminals and components (including one of the large heat sinks) which normally operate at AC mains potential.

The incoming AC supply to the PCB or PSU under test must be isolated by means of a 1:1 isolation transformer of at least 700VA rating for safety and noise control.

High voltages (up to 400V peak) are always present in the primary side circuitry. Note that removing bridging connector PJ4 disconnects HV only from the power FETs.

Components at high voltage lie within a well defined area of the main PCB which includes the large heat sink SK1. The operator should familiarise himself with the boundaries of this area and avoid contact within it.

Primary side earthing - Earthing of the Y filter capacitor at GND3, at the hex spacer, is desirable to control noise effects.

HV Capacitor Discharging - Allow 6 mins for HV reservoirs C9,10 to discharge from 400V to 40V via R5,6. Alternatively discharge <u>both</u> capacitors with 100R 5W resistor.

TEMPORARY EARTHING FOR PRIMARY SIDE MEASUREMENTS

Voltage checks and CRO measurements on the main PCB primary side circuit are only carried out with 60 VDC maximum applied to the switching power FETs. Primary side node VRECT- must be well grounded (e.g. at Q1,2 mount bolts) to protect the user and the external PSU during these measurements. Not that this negates the protection normally provided by the isolation transformer and earths the particularly easily touched heat sink SK1.

ORDER OF CHECKS AND ADJUSTMENTS

The power supplies comprise a switchmode pre-regulator operating at mains (primary) potential which feeds a (secondary) linear regulator. The latter must be working properly for proper operation or testing of the former. Both regulators obtain their auxiliary supplies from 50Hz auxiliary transformer T1 the primary of which is fed from the mains potential (primary) section of the PCB which is therefore energised during all tests. The order of checks and adjustments reflects these dependencies and should be followed after any repair work.

DIRECTIONS FOR DIFFERENT TYPES

The directions are written as far as possible to cover normal (non-programmable) and programmable versions. Settings and other values which vary between 35V/10A and 18V/20A versions are respectively separated by an oblique stroke.

Figures referred to in the text appear on a fold-out sheet immediately before the Circuit Diagrams.

TEST EQUIPMENT REQUIRED FOR RECALIBRATION ONLY

Rheostat or other high power load arrangements to provide 3.5 & 2.75/0.9 & 0.6Ohms at 10/20A for 35V/10A and 18V/20A respectively at 400W dissipation.

10Ohm 10W wirewound resistance.

Common mode rejection test network according to Fig 3.

Digital voltmeter with 100uV resolution and 1mV accuracy.

Current meter 20A maximum, 2mA accuracy, or equivalent shunt and voltmeter arrangement.

TEST EQUIPMENT FOR MAIN PCB TESTING

100Ohm 5W wirewound resistance for discharging HV reservoirs.

Power supplies: 60VDC 2A limited, 5VDC 2A limited, 3VDC 1.5A limited. A single 60V 2A dual lab supply should meet all requirements. A 4700uF 63V electrolytic capacitor is required across the 60V output while checking overcurrent tripping.

A 4-pin 0.156" pitch socket with leads carefully wired for safe connection of external 60V PSU to header PJ4 according to Fig 1.

A 2 pin 0.156" pitch polarised socket for connection of output terminals to sense input header PJ3 according to Fig 2.

A lead for earthing node VRECT-.

A light lead with an EZ clip at each end.

A light lead with a clip and pointed probe for tripping.

Oscilloscope, 20 MHz bandwidth with x10 HV probes.

General purpose multimeter suitable for HV use.

REPAIRS FOLLOWING POWER FET FAILURE

Q1,Q2 must both be replaced. Survival of gate drive components, particularly R18,22 should be checked. Triac TC1 should be checked for short circuit failure.

PREPARATION FOR MAIN PCB TESTING

Set mains voltage selector switch to 230 or 115VAC position to suit local supply.

Visual Inspection. C9,10 electrolytic polarities; all power semiconductors properly mounted and correctly torqued.

Remove HV bridging connector from PJ4.

Earth primary side circuitry at Q1,2 mounting screws on SK1.

Link sense input from PJ3 to its corresponding output terminal using 2-pin polarised connector lead as shown in Fig 2.

Connect EZ clip lead to link from 0V to C69 +ve to inhibit apparent primary overtemp trip.

If preset potentiometer settings are suspect, centralise all presets except VR10 (fully CW) and VR9 (fully ACW).

Connect the Control Board via PJ1.

Connect the isolated AC supply to the main PCB pins P100,101.

Connect DVM to output terminals.

Preliminary Checks

1. **Check Inrush Control and HV Rectification** - This should be carried out if this section is suspect. Adjust the Variac for about 15 percent of the voltage selector indication. Switch on. Check that voltage across C9 and C10 are both about 25/50VDC for selector on 230/115V and that voltage across PTC1 exceeds 3 VAC (meter on AC mains voltage range). Then increase Variac to about 60 and then 100 per cent of the voltage selector setting. At each voltage, check for equal DC voltage across C9 and C10 and that voltage across PTC1 is less than 1.5 VAC (meter on AC mains range).

2. **Check Auxiliary Supplies** - The voltages from 0V to IC4 pin 3 and IC3 pin 3 should be +5V and -5VDC within 0.25V. Note that the Control board draws approx 280 mA from the +5V rail. The primary side auxiliary voltage between VRECT- and IC2 pin 3 should be 12V within 0.6V.

Linear Regulator Checks

1. **Check/Preadjust Voltage Zero** - Connect an external +5VDC, 2A limited power supply between DCVOUT (+ve) and VOUT- (access top R55 and D37 respectively). Set Voltage control(s) to minimum and Current control to maximum. Switch Output on. Switch supplies on. CV LED should come on. Adjust VR3 for zero output voltage within 5 mV.

2. **Check/Preadjust Current Zero** - Connect 10Ohm 10W load to output terminals. Set Voltage control(s) to maximum and Current control to minimum. Adjust VR8 for zero output voltage within 20 mV. CI LED should be on. Note and avoid saturated region below about -20 mV.

3. **Check All Series Pass Transistors Active** - Short circuit output. Set current control to maximum. Check that voltage across each emitter resistor R38- 39/R38-41 is at least 10mV.

4. **Check Linear Reg Shutdown** - Trip the supervisory logic trip by momentarily connecting 0V to IC9 pin 13 with pointed probe lead. The output voltage should fall below -20mV. Reset the logic by momentarily connecting 0V to PJ1- 27.

5. **Check Output Off Level.** Switch Output off. Disconnect load. Output voltage should lie between -0.25V and -0.15V. Disconnect +5V external supply.

Testing Main PCB with LV on HF Switching Section

1. **Preparation** - Allow time or discharge HV reservoirs C9,10 then connect external 60V 2A limited PSU to switchmode section via connector lead of Fig 1 to PJ4. Connect 3.75Ohm load. Switch PSU off.

2. **Check Switchmode Master/Clock Waveform** - Connect CRO via x10 probe between VRECT- (common) and IC1 pins 6,7. Check ramp waveform against Fig 4 observing:

   (i) Basically saw tooth of period of 5.9 to 6.7 usec.

   (ii) Downward stroke duration approx 0.7 usec.

   (iii) Voltage swinging between approx +0.9V and +2.8V.

   (iv) Fast rising section over first approx 0.7 usec of ramp.

3. **Check Power On Soft Start** - Connect CRO via X10 probe to IC1 pin 8. Turn mains supply to board off and on. The soft-start voltage should fall immediately to less than +1V then rise slowly (about 0.5 sec) to about +4.5V.

4. **Check Demand and Gate Waveforms** - Turn voltage and current controls to maximum. Q1 gate drive waveform should be an almost square, approximately 20V pk-pk waveform swinging symmetrically about 0V. Q2 drive waveform may also be checked if node HF is **momentarily** linked to VRECT-. Switch off.

5. **Check Power FETs Blocking** - Connect CRO between VRECT- and switchmode output point HF. Set Voltage control(s) to minimum, Current control to maximum and Output off. Switch 60V PSU on. No current should be drawn.

6. **Check Switchmode Idling Waveforms and Pre-regulator Overhead** - Switch on. Current from 60V supply should still be less than 10 mA. Waveform at point HF should show narrow symmetrical alternating pulses and very slow no-load ringing. At R10/22 junction the positive gate drive pulse should exceed +6V for 100-200ns. Linear regulator overhead voltage between 0V and DCVOUT should be 1.7 to 1.9VDC.

7. **Check Switchmode Waveforms** - Switch Output on. Waveform at point HF should not change. If Voltage control is advanced PWM duty cycle at point HF should increase with rectangular PWM pulses of about 60V pk-pk amplitude separated by a plateau at 30V as shown in Fig 5. Maximum duty cycle should occur at about 10V/5V DC output. Storage spikes at point HF are then typically 20V pk and 100ns base width.The PWM waveform edges should be stable; however instability or lack of output may be cured in the next section.Remove all instrument connections from the primary side circuitry.

8. **Check/Set Pre-regulator Gain** - Connect CRO between 0V and OPTPO1B. Reduce Voltage controls for 5.0/3.2V *? DC output. The voltage across R128 (generated by the optocoupler input current) should be 175 to 200mV; otherwise switch off, discharge HV reservoirs C9,10 and fit E12 0.25W resistor in R128 to bring the voltage into range on retest. When the Voltage control(s) are adjusted just to reach maximum duty cycle, the voltage across R128 should be +200 to 250mV.

9. **Check HF rectifier waveforms** - Connect CRO probe to DCT (D14 tab). The 160kHz rectified rectangular PWM pulses typically exhibit similarly sized ringing recovery spikes of 20V peak and 1us half cycle basewidth decaying within 2 ring cycles as shown in Fig 6.

10. **Check Switchmode Supervisory Shutdown** - Connect 0V momentarily to IC9 pin 13 (sense miswire input). Switchmode activity should cease, trip LED1 on PCB come on and the display indicate "TRIP". Reset the supervisory logic by momentarily connecting 0V to PJ1-27. Check the secondary thermostat input by momentarily connecting +5V to IC8 pin 5 which should give the same result.

11. **Check Overcurrent Trip Action** - 4700uF is needed across the output of the 60V supply to provide the necessary current surge. Set the Voltage control(s) to maximum then connect a 0.47Ohm 5W resistor **momentarily** between VOUT- and DCVOUT (access top leads of R55). PWM output should cease immediately and then soft-restart. Switch off. Remove earthing link to VRECT-.

Testing of Main PCBs at Full Voltage

1. **Preparation -** Remove VRECT- earthing link. Allow time or discharge HV reservoirs C9,10. Refit leadless bridging connector to PJ4. Connect DVM between filter output at top of R55(+ve) and D37 (VOUT-). Set the Voltage and Current controls to minimum. Switch Output off. Switch AC on. The CV and CI LEDs should be off, the Output LED on and both displays reading zero.

2. **Control Board Adjustments (non-programmable versions)** - If the control board is suspect carry out this stage as described under Calibration stage 2.

3. **Check Voltage Zero** - Set Voltage control(s) to minimum and Current control for about 0.2A. Switch Output on. The CV LED should be on and the Output LED off. The Current and Voltage displays should both read zero. Adjust VR3 until the DVM reads within 5mV of zero. Set the Current control to minimum. The DVM should read between -0.7V and -0.15V. Switch Output off. The DVM should read between -0.15 and -0.25V.

4. **Check Current Zero** - Connect 10Ohm 10W load to output terminals. Set Voltage control(s) to display about 4V and Current control to minimum. The CI LED should come on. Adjust VR8 for zero DVM reading within 20mV. Note and avoid saturated region below about -20mV. Disconnect load after test.

5. **Check Maximum Voltage** - Set Voltage control(s) to maximum. Switch Output on. The CV LED should be on. The Voltage display should read 35.3/18.15V. Adjust VR2 until the DVM reading matches the Voltage display. Switch Output off.

6. **Check Measured Current Display** - Connect 3.75/0.9Ohm load in series with the current meter. Set preset VR9 fully ACW. Set the Current control to maximum. Switch Output on. Adjust VR9 until the current display reading matches the current meter. The CV LED should remain on. Switch output off.

7. **Check HF Power Filtering** - CRO check that 160 kHz ripple voltage between 0V and DCVOUT (top R55) is less than 50 mV pk-pk. Switch Output off.

8. **Check Measured Voltage Display -** Connect 2.75/0.6Ohm load in series with the current meter. Switch Output on. The CI LED should be on. Adjust VR4 until the Voltage display matches the DVM reading. Switch Output off. Disconnect the load.

9. **Check OVP Trip** - Set preset VR10 fully CW. Set Current control to about 0.5A display. Set Voltage control(s) for about 34V display. Set the user OVP preset (VR3 on the control board) for about 34V OVP display. Rotate VR10 fully ACW. The display should indicate "TRIP". Switch off. Allow time or discharge HV reservoirs C9,10.

RECALIBRATION OF ASSEMBLED POWER SUPPLIES

1. **Preparation** - Ensure voltage selector is in the appropriate position and HV bridging connector present. Connect common mode test network to rear terminal block as shown in Fig 3. Close the test network switch. Set the Voltage and Current controls to minimum. Switch Output off. Switch on. The CV and CI LEDs should be off, the Output LED on and both displays reading zero. Switch Output off.

2. **Control Board Adjustments (non-programmable versions only)** - Connect the DVM between 0V and IC7-A on the main PCB pin 13. Note the DVM reading which should be within 3 mV of zero. Switch Output on. If necessary adjust VR5 on the control board to maintain the same DVM reading. SWITCH OUTPUT OFF to avoid destroying test network. Advance Voltage and Current controls to maximum. Adjust VR6 on the control board for a Voltage display of 35.3/18.15V. Adjust VR7 on the control board for a Current display of 10.2/20.2A.

3. **Set Voltage Zero** - Move DVM to rear sense terminals. Set Voltage control(s) to minimum and Current control for about 0.2A. Switch Output on. The CV LED should be on and the Output LED off. The Current and Voltage displays should both read zero. Adjust VR3 until the DVM reads within 5mV of zero. Set the Current control to minimum. The DVM should read between -0.7V and -0.15V. Switch Output off. The DVM should read between -0.15 and -0.25V.

4. **Set Current Zero** - Connect 10Ohm 10W load to output terminals. Set Voltage control(s) to display about 4V and Current control to minimum. The CI LED should come on. Adjust VR8 for zero DVM reading within 20mV. Note and avoid saturated region below about -20mV. Disconnect load after test.

5. **Adjust CMRR** - Set the Current control for about 0.2A. Note the DVM reading. Open the switch on the test network and if necessary adjust VR1 to remove about half the difference. Close the switch and repeat the process until the DVM reading is the same for both switch positions. Switch Output off. Disconnect the test network and link adjacent sense and output terminals.

6. **Set Maximum Voltage** - Set Voltage control(s) to maximum. Switch Output on. The CV LED should be on. The Voltage display should read 35.3/18.15V. Adjust VR2 until the DVM reading matches the Voltage display. Switch Output off.

7. **Adjust Measured Current Display** - Connect 3.75/0.90hm load in series with the current meter. Set preset VR9 fully ACW. Set the Current control to maximum. Switch Output on. Adjust VR9 until the current display reading matches the current meter. The CV LED must remain on. Switch output off.

8. **Adjust Measured Voltage Display** - Connect 2.75/0.60hm load in series with the current meter. Switch Output on. The CI LED must remain on. Adjust VR4 until the Voltage display matches the DVM reading. Switch Output off. Disconnect the load.

9. **Adjust OVP Trip** - Set preset VR10 fully CW. Set Current control to about 0.5A display. Set Voltage control(s) for 34.00V display. Set the user OVP preset (VR3 on the control board) for near 34V OVP display. Now slowly adjust preset VR10 ACW until the display indicates "TRIP". Reduce the Voltage control(s) by about 5 per cent and turn the supply off briefly to reset the supervisory logic. Then recheck the trip point by increasing the Voltage control(s) gradually until OVP trip occurs.