

EX752M

75V/150V
Multimode Power Supply
Service Manual

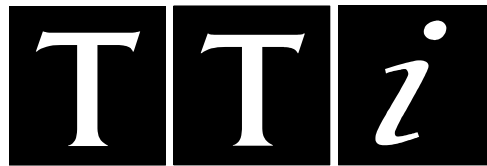


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Specification

OUTPUTS

Voltage Range:	0V to 75V minimum, Modes A and B. 0V to 150V minimum, Mode C.
Current Range:	0A to 2A minimum, Modes A and C. 0A to 4A minimum, Mode B.
Output Voltage Setting:	By coarse and fine controls.
Output Current Setting:	By single logarithmic control.
Operating Mode:	Constant voltage or constant current with automatic cross-over.
Output Switch:	Electronic. Preset voltage and current displayed when off.
Output Terminals:	4mm safety terminals on 19mm (0.75") pitch.
Output Impedance:	Typically $<5\text{m}\Omega$ in constant voltage mode. Typically $>50\text{k}\Omega$ in constant current mode (voltage limit at max).
Output Protection:	Output will withstand forward voltage of up to 85V (Modes A and B) or 170V (Mode C). Reverse protection by diode clamp for reverse currents up to 3A.
Load & Line Regulation:	$<0.01\%$ of maximum output for a 90% load change or 10% line change; $<0.1\%$ load regulation for Mode C (150V/2A).
Ripple & Noise (20MHz bandwidth):	Typically $<2\text{mVrms}$, $<15\text{mV}$ pk-pk, constant voltage mode.
Transient Response:	$<200\mu\text{s}$ to within 50mV of set level for 90% load change.
Temperature Coefficient:	Typically $<100\text{ppm}/^\circ\text{C}$
Status Indication:	Output on lamp. Constant current mode lamp.

OPERATING MODES

Mode Selection:	By front panel rotary switch.
Mode A:	Independent outputs each capable of 0-75V at 0-2A.
Mode B:	Output 2 only active, 0-75V at 0-4A. Output 1 disabled.
Mode C:	Output 2 only active, 0-150V at 0-2A. Output 1 disabled.

METER SPECIFICATIONS

Meter Types:	Dual 3 digit meters with 14mm (0.56") LEDs. Reading rate 4 Hz.
Meter Resolutions:	100mV, 10mA
Meter Accuracies:	Voltage 0.3% of reading \pm 1 digit, Current 0.6% of reading \pm 1 digit
Operating Modes:	Output 1 meters are blanked in Modes B and C.

GENERAL

AC Input:	110V-240V AC \pm 10%. Installation Category II.
Power Consumption:	500VA max.
Operating Range:	+5°C to +40°C, 20% to 80% RH.
Storage Range:	-40°C to + 70°C.
Environmental:	Indoor use at altitudes up to 2000m, Pollution Degree 2.
Safety:	Complies with EN61010-1.
EMC:	Complies with EN61326.
Size:	260 x 160 x 320mm (WxHxD).
Weight:	4.3kg

This power supply is a Safety Class I instrument according to IEC classification and has been designed to meet the requirements of EN61010-1 (Safety Requirements for Electrical Equipment for Measurement, Control and Laboratory Use). It is an Installation Category II instrument intended for operation from a normal single phase supply.

This instrument has been tested in accordance with EN61010-1 and has been supplied in a safe condition. This instruction manual contains some information and warnings which have to be followed by the user to ensure safe operation and to retain the instrument in a safe condition.

This instrument has been designed for indoor use in a Pollution Degree 2 environment in the temperature range 5°C to 40°C, 20% - 80% RH (non-condensing). It may occasionally be subjected to temperatures between +5°C and -10°C without degradation of its safety. Do not operate while condensation is present.

Use of this instrument in a manner not specified by these instructions may impair the safety protection provided. Do not operate the instrument outside its rated supply voltages or environmental range.

WARNING! THIS INSTRUMENT MUST BE EARTHED

Any interruption of the mains earth conductor inside or outside the instrument will make the instrument dangerous. Intentional interruption is prohibited. The protective action must not be negated by the use of an extension cord without a protective conductor.

When the instrument is connected to its supply, terminals may be live and opening the covers or removal of parts (except those to which access can be gained by hand) is likely to expose live parts. The apparatus shall be disconnected from all voltage sources before it is opened for any adjustment, replacement, maintenance or repair. Capacitors inside the power supply may still be charged even if the power supply has been disconnected from all voltage sources but will be safely discharged about 10 minutes after switching off power.

Any adjustment, maintenance and repair of the opened instrument under voltage shall be avoided as far as possible and, if inevitable, shall be carried out only by a skilled person who is aware of the hazard involved.

If the instrument is clearly defective, has been subject to mechanical damage, excessive moisture or chemical corrosion the safety protection may be impaired and the apparatus should be withdrawn from use and returned for checking and repair.

Make sure that only fuses with the required rated current and of the specified type are used for replacement. The use of makeshift fuses and the short-circuiting of fuse holders is prohibited.

Do not wet the instrument when cleaning it.

The following symbols are used on the instrument and in this manual:-



Earth (ground) terminal.



mains supply OFF.



mains supply ON.



alternating current (ac)



direct current (dc)



CAUTION – refer to accompanying documentation; incorrect operation may damage the power supply.

Service Handling Precautions

Service work or calibration should only be carried out by skilled engineers using high quality test equipment. If the user is in any doubt as to his competence to carry out the work, the instrument should be returned to the manufacturer or their agent overseas for the work to be carried out.

The tracks on the printed circuit boards are very fine and may lift if subjected to excessive heat. Use only a miniature temperature-controlled soldering iron and remove all solder with solder wick or suction before attempting to remove a component.

Dismantling the instrument

WARNING!

Disconnect the power supply from all voltage sources before it is opened for adjustment or repair. Capacitors inside the supply may still be charged even if the supply has been disconnected from all voltage sources but will be safely discharged about 10 minutes after removing power.

If any adjustment or repair of the opened supply under voltage is inevitable it shall be carried out only by a skilled person who is aware of the hazard involved. The incoming AC supply to the unit under test should be isolated for safety by means of a 1:1 isolation transformer of at least 700VA. High voltages (up to 400V) are always present in the primary-side circuitry which lies in a clearly defined area at the rear of the main printed circuit boards.

1. Remove the 6 side screws and front handle screw to release the top cover.
2. Unplug the 3 connector assemblies linking the main pcb to the front panel control pcb, noting their orientation (brown wire to pin 1 corner marker).
3. Unplug the mains connection at the rear of the pcb and remove the chassis safety earth connection.
4. Undo the 10 screws which secure the main pcb support pillars to the chassis (i.e. the screws accessible **underneath** the chassis) and lift out the pcb with its mounting pillars attached.
5. To remove the control pcb on the front panel first remove the main pcb. Pull off the 6 control knobs and the mode knob, then undo the 5 screws which retain the pcb to the moulding and the 4 nuts which connect the pcb to the output terminals. The control pcb can then be lifted clear.
6. Reassemble in the reverse order taking great care to ensure that all connections are exactly as before dismantling and that no insulation creepage and clearance distances have been compromised. Ensure that only the correct fastenings have been used otherwise earthing, and hence EMC and safety performance, may be impaired.

Circuit Description

Main Pcb

Mains Input, Filtering and Rectification

The AC input is via a pcb mounted IEC plug, PJ3.

X-capacitors C1, C9 and C47, together with the Y-capacitors C6, C7 and common mode inductors L1 and L2 comprise an input filter which ensures that the supply meets both conducted emission and conducted immunity EMC requirements.

VDR1 clips mains spikes for component protection, while R1 discharges the X-capacitors after removal of the mains supply.

Pcb mounted fuse FS1 limits damage on boost-stage or forward converter failure. The front panel mains switch is connected via PJ4.

The bridge rectifier BR1 has C11 and C12 connected across it to bypass noise signals and to snub reverse recovery transients in the bridge rectifier.

C89 further decouples the input filter and rectifier from the boost converter, while R113 discharges C89 after removal of the mains supply.

RT1 is an NTC which limits the initial inrush current into the boost stage output capacitor C88.

Primary Control

The primary control is by means of IC8.

This contains all the processing circuitry to shape the current taken by the power supply from the mains supply to be sinusoidal and in phase with the voltage.

Initial start-up is via R79 and R80 which charge C32. When the voltage on C32 exceeds the under voltage lockout level of 16V, IC8 starts up and supplies drive pulses to the boost MOSFET Q5. The gate drive pulses to Q5 are given a slight negative offset by C94, D52, D53 and R112 to give extra noise immunity.

C117 provides a degree of soft start.

Once the boost converter is running, the supply to IC8 is derived from an auxiliary winding on the boost inductor L3, rectified and filtered by D7, C2 and C15 and also from a power back winding on the main converter transformer, rectified and filtered by D6, C87 and C93.

R131, R132, R133, R71, C4, and C34 form a two stage RC filter to feed a voltage proportional to the mains voltage to pin 7 which, after a $1/V^2$ transformation, is fed to the multiplier. For a universal mains input, the voltage at this pin will vary between 1.5V and 5.5V.

R135 and R136 supply a current derived from the full wave rectified mains voltage to pin 4 to be used by the internal multiplier.

Also fed to the multiplier is the output of the voltage error amplifier of pin 13. The input to the error amplifier at pin 14 is from potential divider R74, R75 and R93. This potential divider monitors the voltage on the boost stage output capacitor C88 and this is compared to an accurate internal reference voltage. Thus a steady voltage of about 380V is maintained across C88.

Another potential divider R81, R82, R98 monitors the voltage across C88 and feeds into pin 3 of IC8 which is the over voltage shutdown.

Pin 8 is the output of the multiplier and is the programming current for the internal current error amplifier. This signal is taken to the mains supply side of the current sense resistor R83 via R8. The other input of the current error amplifier is taken to the other side of R83 via R72. The current error amplifier thus compares the signal across the current sense resistor R83 with the programming current and adjusts the PWM drive to the boost MOSFET Q5 accordingly. R73 and C86 with R72 form the compensation network around the current error amplifier.

When the mains supply falls below about 85Vrms, the circuit comprising of long tail pair Q6 and Q10 and Q1 act on the soft start input of IC8 to curtail operation.

Boost Stage and Forward Converter

Q5 and boost inductor L3 raise the incoming, full wave rectified, sinusoidal mains voltage to a value some 20V higher than the peak of the maximum rms input voltage. This is achieved by storing energy in L3 when Q5 is conducting and transferring it to C88 via boost diode D54 when Q5 is turned off.

When Q5 next turns on, D54 is still conducting current. To prevent large switch on losses in Q5, a delay inductor L9 is placed in series with Q5. This ensures that the current in the boost diode D54 is reduced at a gradual rate and the reverse recovery time is minimised at the same time as Q5 drain voltage is allowed to fall rapidly.

The energy stored in L9 is stored in C119 via D67 and dissipated in R92 and R95.

A dual ended forward converter comprising of Q4, Q7 and TX2 converts the boost voltage across C88 to provide two isolated low voltage secondaries and also the required secondary auxiliary voltages.

TX2 leakage energy is returned to the high voltage supply rail via D2, D3 and D4, D5. The turnoff voltage rise is controlled by 'loss less' snubber network C27, C28, D61, D63, D69, L10. R20 damps any oscillation across L10.

The gate drive to Q4 and Q7 is by means of a gate drive transformer TX1.

The drive signal is generated by an oscillator IC1A and IC1B. This is converted into two square waveforms by D-types IC7A and IC7B.

The square waveform from IC7A is 'duty cycle reduced' by R9, D39, IC1D then buffered by IC1E and IC1F and is used to drive Q2 and Q3.

The current in the forward converter is monitored by R16 and, if excessive, activates latch Q22, Q23 to provide a pulse-by pulse current limit.

The square waveform from IC7B is processed by Q19 to provide a synchronisation pulse for IC8.

Main Outputs

The component references given refer to Channel A, the left-hand (slave) channel which is marked Output 1 on the front panel. Channel B, the right-hand (master) Channel is identical except for Q15 and L7 which are up-rated components because Channel B supplies 4 Amps in the 75V/4A mode; refer to the circuit diagram and parts lists for details.

The voltage on the secondary winding is rectified and L-C filtered and fed to a linear regulator. To minimise power dissipation in the linear regulating element, the voltage across it is maintained at about 1V by means of a magamp.

The linear regulation is performed by MOSFET Q14 which receives gate drive from the front panel pcb. The voltage across Q14 is monitored by Q11 which generates reset current to the magamp whenever the voltage across Q14 forward biases the base-emitter junction of Q11.

D24 is the main rectifier and flywheel diode. The rectified pulse is filtered by L6 and C33.

Q8 minimises parasitic reset of the magamp by bypassing D24 reverse leakage currents during the fly back period.

D44, D47, D48, R111 and C76 generate a negative rail to sink the base bias current of Q11 which would otherwise cause the output to remain slightly positive when 0V was set on the front panel.

In the event of a fault where control of the magamp is lost and the voltage across the filter capacitor C33 rises above 88V, the opto isolator IC13 is activated and causes primary side thyristor SC1 to discharge the primary control power rail. This is followed by a normal restart. If the fault persists, the PSU will continue to 'hiccup'.

Secondary Auxiliary Power Supply

The power rails for the control electronics of the two main outputs are generated from auxiliary windings on the main converter transformer.

Again referring to channel A, the +15V is peak rectified by D40 and zener regulated by D42.

The +5V rail is rectified by D18, D19 and filtered by L4 and C23. The inductor L4 is held in continuous conduction and thus the voltage at the input to the three terminal regulator IC2 is maintained at low value.

The -5V rail is peak rectified by D13 and zener regulated by D20.

Mode Switching

The opto-isolators IC14 – IC16 and associated components which provide control signal isolation between the two channel are described in the Control Board section.

Control Board

Component references are given for Channel A, the left-hand (slave) channel viewed from the front; components of Channel B, the right-hand (master) channel, are all numbered from 100 upwards, e.g. RP3, C9 and R24 on Channel A are RP103, C109 and R124 on Channel B.

The linear regulator is in series with the positive output but, because of the way in which the control and metering works, it is convenient to consider the regulator output (OP) as 0V and to regard the negative output as the controlled output voltage (-V).

Supply rail and signal names on the schematics are followed by /A or /B for Channels A and B respectively, e.g. OP/A.

Voltage Control

IC7C buffers the voltage control potentiometers VR1 and VR2; VR5 sets the maximum output voltage. D6 provides the reference (V_{REF}) which is nominally 2.45V.

IC7A is a differential amplifier with a voltage gain of 14.7; for an output voltage of 75V the voltage at IC7C pin 8 will be 5.1V. VR9 trims differential gain to ensure good voltage regulation, see Calibration section.

The output of IC7C drives the input of IC7A when the ON-OFF switch, SW1B, is in the ON position. When SW1B is in the OFF position the input of IC7A is grounded via R50, setting the output volts to zero.

The output of IC7A provides the gate drive (GATE) to the regulating MOSFET Q14 (Q15) on the main pcb via D3.

Current Control

IC7D is the error amplifier which compares the voltage on the wiper of VR3, the current limit control with the voltage generated across the current sense resistor R21. When the output current reaches the set limit IC7D takes control via D4, changing the supply from constant voltage to constant current mode. At the same time Q1 is turned on by IC7D, making ILIMIT go high; this is read by the microcontroller IC3 which turns on the constant current lamp, LED2.

VR4 sets the maximum output current; VR8 adjusts the output current to be the same as the preset current at low levels, see Calibration section.

Measurement and Display

The measurement and display is controlled by a microcontroller, IC3. IC5, IC2 and associated components, together with IC3, form a dual slope A-to-D converter. Multiplexer IC4, under the control of IC3, selects the signals to be measured. The status line SW1 from the output ON/OFF switch is read by IC3 to determine which signals are measured, as follows:

Status	Voltage Measurement	Current Measurement
Output Off	Preset Volts (VPRT & ILO)	Preset Current (IPHI & ILO)
Output On	Output Volts (+SENSE & VOLO)	Output Current (IOHI & ILO)

IC3 processes the measurement and drives the two multiplexed 3-digit, 7-segment, LED displays via digit driver IC1 and segment latch IC6. Individual segment current limit is provided by RP1 and RP2. The constant current lamp, LED2, is part of this multiplexing scheme; the output on lamp, LED1, is driven directly from the +5V auxiliary rail via R2 when the dc output switch SW1-A is closed.

Mode Control

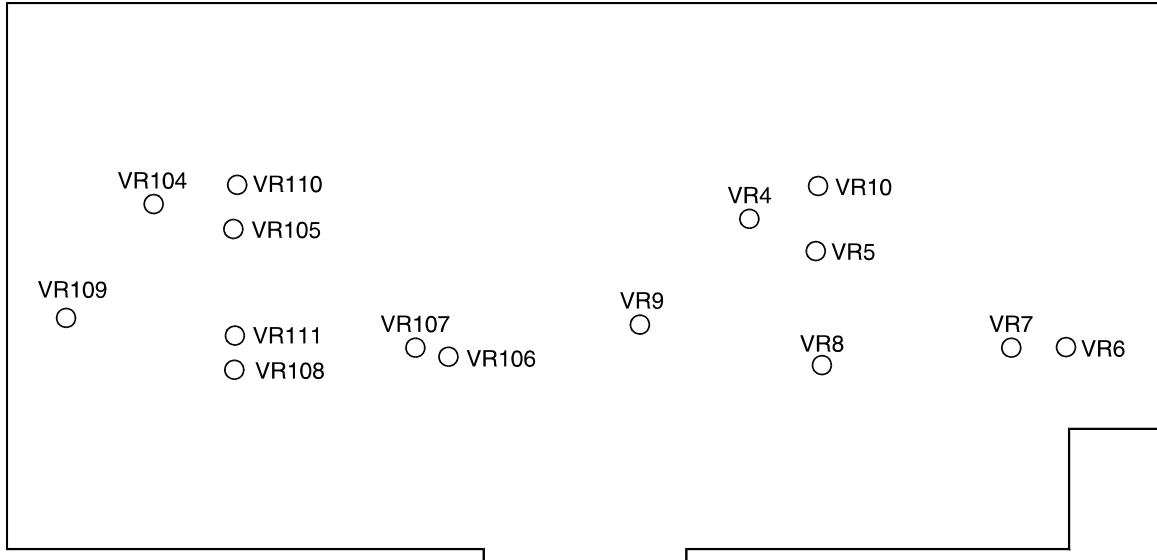
The three operating modes are selected by a 4-pole 3-way break before make switch, SW2. Opto-isolators IC14, 15 and 16 on the Main pcb provide isolation of the control signals between the 2 channels.

- Isolated:** The two channels operate independently and are isolated.
- Parallel:** The slave side is turned off and the control of the master is changed such that it can supply up to 4 Amps. SW2-C disconnects the voltage setting controls from the voltage error amplifier IC7-A of the slave, forcing the slave output to 0V. Signal X is high on IC8-A turning off the slave display. Signal P is low on IC108-B doubling the master current limit. Whenever the parallel mode is exited the PAR signal goes high pulsing the MUTE signal low via IC6 on the Main board, turning off both outputs momentarily. At power-on C52 and Q25 on the Main board also mute the outputs momentarily.
- Series:** The two channels are connected in series and to the master terminals. SW2-B disconnects the master negative terminal from its own supply and connects it to the slave negative terminal. SW2-A disconnects the slave positive output from its terminal and connects it to what was the master negative terminal supply thus putting the supplies in series. Relay RL1 switches the sense connections. SW2-C switches the input to the slave error amplifier to the master positive terminal forcing the slave to track the master. Signal X is high on IC8-C forcing the slave current limit to a little over 2 Amps so that the master current limit is always in control. Signal Y is low on IC108-A doubling the preset voltage measurement. Signal X is high on IC8-A turning off the slave display.

Calibration

Refer to the General section for dismantling instructions and safety precautions. Component adjustment references are given as Channel A/ Channel B, e.g. VR5/VR105; Channel A is the left-hand output. All adjustments are on the front panel control board unless otherwise stated.

Allow 5 minute warm-up before commencing calibration.



Control pcb calibration points (viewed from rear)

Equipment Required

A 5½ digit multimeter with better than 0.05% accuracy on dc volts and better than 0.1% accuracy on dc current (to 4A); alternatively use a precision shunt for current measurement.

Rheostat or other high power load arrangement to provide up to 4A load at 75V.

Mode A (75V/2A x 2)

Adjust Channel A and Channel B independently as follows.

Voltage Calibration

Connect the DMM (set to Volts) across the output. Set voltage and current controls to minimum. Switch output ON (Check LED is on) and check for a reading of $00.0V \pm 0.1V$ on the Volts display and DMM; check the Amps display reads $0.00 \pm 0.01A$.

Set voltage and current controls to maximum. Adjust VR5/VR105 (maximum output volts) for a reading of 75.35V to 75.45V on the DMM. Adjust VR6/VR106 (measured output volts) until the Volts display matches the reading on the external DMM.

Switch output OFF. Adjust VR10/110 (preset volts) until the Volts display shows 75.4.

Current Calibration

Switch output OFF. Set output voltage to nominally 2V. Set current control to minimum. Connect the DMM (set to Amps) and load in series across the output. Switch output ON.

Adjust VR8/108 (offset compensation of current control error amp) for a reading of $0.003A \pm .001A$ on the DMM. Check that the CC LED is ON.

Increase voltage controls and current control to maximum. Adjust load until the DMM reads $2.00A \pm 0.02A$. Adjust VR7/107 (measured output current) until the Amps display matches the DMM reading.

Reduce load until the CC LED is ON. Adjust VR4/104 (maximum output current) until the Amps display shows 2.05.

Voltage Regulation

Connect the DMM (set to Volts) across the output, no load, output ON.

Adjust voltage controls for a reading of 18.xxxx on the DMM; note exact reading.

Connect load and adjust it to give an output current of 2.00A on the Amps display. Adjust VR9/109 (differential voltage gain) until the external DMM matches the previous reading.

Mode B (75V/4A)

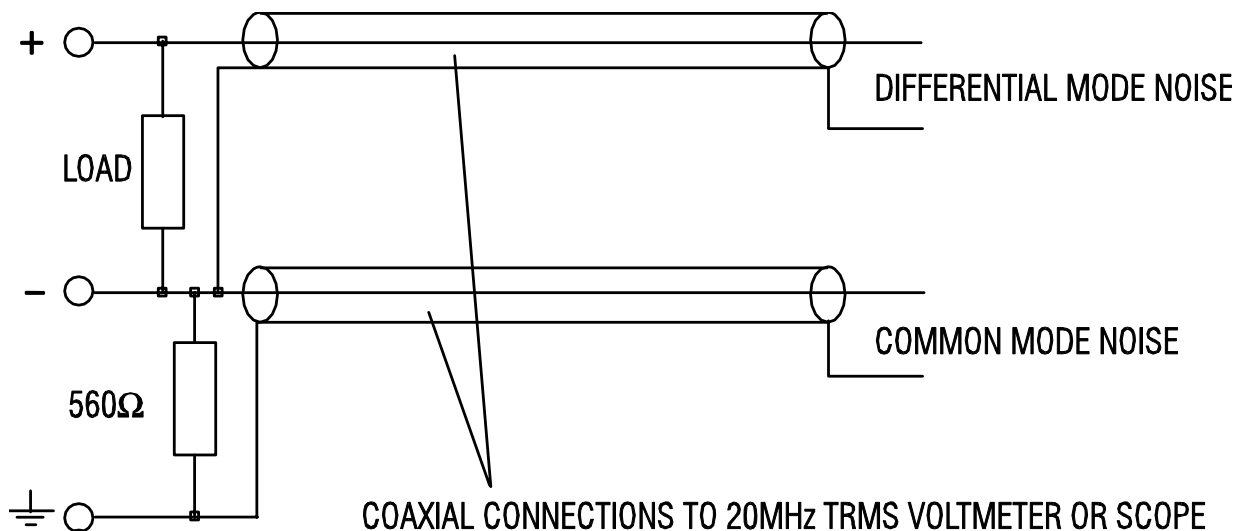
With both outputs OFF select Mode B (75V/4A). Set the voltage and current controls to maximum and check that the current display (preset maximum current) reads ≥ 4.05 Amps. Connect the rheostat, switch the output ON and adjust the load until the CC LED is just ON; check that the current display (measured output current) matches the preset current ± 0.05 Amps.

Mode C (150V/2A)

With no loads connected and both outputs OFF select Mode C (150V/2A). Switch the output ON and check that the reading on the Volts display (measured output volts) is ≥ 150.1 V. Switch the output OFF and adjust VR111 to give the same reading on the Volts display (preset output volts).

Noise Measurements

Differential and common-mode noise checks can be made using the arrangement below. Keep all unshielded connections as short as possible.



Make measurements with the output fully loaded. Measure differential and common-mode noise one at a time on a 20MHz TRMS voltmeter or use a 20MHz bandwidth-limited scope for peak-to-peak measurements.

Parts List

PCB ASSY – MAIN (44115-0960)

Part Number	Description	Position
20030-0263	WASHER M3 ZPST	SPACERS, BR1
20037-0301	WASHER M3 SHK/PROOF I/T ZPST	SPACERS TO UNDERSIDE OF PCB
20038-9501	WASHER M3 Spring	SPACERS, BR1
20210-0101	NUT M3 ZPST	BR1
20234-0011	SCREW M3 X 10 PNHDPZ ZPST	
20234-0027	SCREW M3 X 6 PNHDPZ ZPST	SPACERS
20613-0007	WASHER (SIL-PAD) TO220 PLAIN	SKD24,SKD26,SKD54,SKQ4,SKQ7, SKQ14
20613-0018	WASHER SIL-PAD TO-3P/247 PLAIN	SKQ5,SKQ15
20661-0225	SPACER Hex M3 x 12 NPBR	PCB
20670-0135	CLIP GP02 FOR PCB MTG H/SINKS	SKD24,SKD26,SKD54,SKQ4,SKQ7, SKQ14,SKQ15
20670-0300	HEATSINK PCB MTG 63MM PLAIN	SKD24,SKD26,SKD54,SKQ4,SKQ7, SKQ14,SKQ15
20670-0340	HEATSINK TO220 CLIP-ON 29DEG/W	SKIC2, 3
20670-0400	HEATSINK PCB MTG 3.7DEG C/W	SKQ5
20670-0401	CLIP FOR 20670-0400	SKQ5
20670-0410	HEATSINK – BOLT ON – 7DEG C/W	HSBR1
22040-0940	BEAD (DOUBLE) – FERRITE	FB1-5, 8
22109-0130	TRANSFORMER GATE DRIVE	TX1
22109-0180	TRANSFORMER HF POWER	TX2
22154-0160	CHOKE 1mH AXIAL 1.3 OHMS	L4, 5
22154-0180	CHOKE 350uH/4A	L6
22154-0181	CHOKE 350uH/4A LOW LOSS	L7
22154-0230	CHOKE 1.8mH/6A COMMON MODE	L1, 2
22154-0240	BOOST INDUCTOR	L3
22154-0390	CHOKE 4uH	L9
22154-0400	CHOKE 1mH	L10
22154-0520	MAGAMP 75V/4A	MA1, 2
22312-0242	FUSE CLIPS PCB MTG	FS1
22315-0248	FUSE 10A ANTISURGE (T) HBC CER	
22455-0040	TAB 4.8MAX 0.8MM STR PCB MTG	PJ4
22520-0190	AC RECEP 10AMP R/A SOLDER MTG	PJ3
22573-0041	HEADER 2WAY STR SIL STD/GOLD	TP1, 2
22573-0208	HEADER 8 WAY STRAIGHT .156P	PJ5
23185-0000	RES ZERO OHM	LK1-26,28,32,35
23202-0100	RES 10R0F W25 MF 50PPM	R61

PCB ASSY – MAIN (44115-0960) continued/...

Part Number	Description	Position
23202-0220	RES 22R0F W25 MF 50PPM	R13,67,68,69,70,105,120,121
23202-0330	RES 33R0F W25 MF 50PPM	R127
23202-0470	RES 47R0F W25 MF 50PPM	R11,15,122
23202-1100	RES 100RF W25 MF 50PPM	R44,106
23202-1220	RES 220RF W25 MF 50PPM	R84
23202-1330	RES 330RF W25 MF 50PPM	R89
23202-1470	RES 470RF W25 MF 50PPM	R2,10,85,123
23202-2100	RES 1K00F W25 MF 50PPM	R77,112,118
23202-2220	RES 2K20F W25 MF 50PPM	R14,40,41,47
23202-2270	RES 2K70F W25 MF 50PPM	R9
23202-2330	RES 3K30F W25 MF 50PPM	R8,72
23202-2390	RES 3K90F W25 MF 50PPM	R5
23202-2470	RES 4K70F W25 MF 50PPM	R33,34,55
23202-3100	RES 10K0F W25 MF 50PPM	R43,45,144,146
23202-3110	RES 11K0F W25 MF 50PPM	R93
23202-3220	RES 22K0F W25 MF 50PPM	R35,65,66,73,98
23202-3270	RES 27K0F W25 MF 50PPM	R12
23202-3330	RES 33K0F W25 MF 50PPM	R71,147-150
23202-3470	RES 47K0F W25 MF 50PPM	R6
23202-4100	RES 100KF W25 MF 50PPM	R18,19,36,48-52,57,78,140,141,143, 145
23202-4360	RES 360KF W25 MF 50PPM	R133
23202-4390	RES 390KF W25 MF 50PPM	R74,75
23202-4470	RES 470KF W25 MF 50PPM	R53
23202-4620	RES 620KF W25 MF 50PPM	R131,132,135,136
23202-4820	RES 820KF W25 MF 50PPM	R81
23202-4910	RES 910KF W25 MF 50PPM	R82
23206-2100	RES 1K00F W60 MF 50PPM	R25,26
23206-5680	RES 6M80F W60 MF 50PPM	R96,97
23206-5680	RES 6M80F W60 MF 50PPM	R91,101
23209-4220	RES 220KF W75 MF 100PPM	R1,113
23210-1100	RES 100RJ 2W MF 250PPM	R90,129
23210-1220	RES 220RJ 2W MF 250PPM	R27,30
23210-1470	RES 470RJ 2W MF 250PPM	R92,95
23210-2470	RES 4K70J 2W MF 250PPM	R42,46,86,87
23210-3220	RES 22K0J 2W MF 250PPM	R3,4
23210-3330	RES 33K0J 2W MF 250PPM	R79,80
23210-3390	RES 39K0J 2W MF 250PPM	R39,63,64,94

PCB ASSY – MAIN (44115-0960) continued/...

Part Number	Description	Position
23222-0047	RES 4R70J W33 MF FUSIBLE NFR25	R7,21,22,23,24,54
23222-0220	RES 22R0J W33 MF FUSIBLE NRF25	R17,110,111
23222-1100	RES 100RJ W33 MF FUSIBLE NRF25	R37,38
23222-1220	RES 220RJ W33 MF FUSIBLE NFR25	R99,100,102,103
23222-1470	RES 470RJ W33 MF FUSIBLE NFR25	R29,32
23222-2100	RES 1K00J W33 MF FUSIBLE NFR25	R56,62
23271-0020	RES 0R047J 2W MR	R83
23274-0005	RES 0R22K 2W5 WW	R16
23274-0136	RES 100RJ 4W WW	R28,31
23274-0310	RES 10K0J 4W WW	R20
23386-0010	VARISTOR V275LA20A	VDR1
23386-0060	THERMISTOR INRUSH LIMIT 6A 10R	RT1
23424-0443	CAP 10NZ 1KV CER D10 P5	C5
23424-0459	CAP 4N7 250V AC CER STR/LNG Y	C6,7,11,12
23424-0466	CAP 1N0K 1KV CER P5	C82-85
23424-0468	CAP 470PK 1KV CER P5	C20,21,58,59
23424-0469	CAP 220PK 1KV CER P5	C22,29,118,121
23424-0472	CAP 2N2K 1KV CER P5/P7.5	C27,28
23427-0388	CAP 220PK 100V CER P2.5	C68
23427-0389	CAP 2N2K 100V CER MED K P2.5	C17
23427-9211	CAP 470PK 100V CER MED K P2.5	C8,10,49
23557-0610	CAP 100U 50V ELEC RE2 P3.5	C32
23557-0612	CAP 1U0 100V/50V ELEC RE2 P2	C50,52
23557-0661	CAP 470U 25V ELEC RE2 P5	C23,25
23557-0673	CAP 22U 35V ELEC RE2 P2	C18,19
23557-0681	CAP 220U 100V ELEC P5/P7.5	C70,71
23557-0693	CAP 2U2 160V ELEC P2.5	C30
23557-0820	CAP 10U 50V ELEC LOW ESR P2	C15,72,73,93
23557-0827	CAP 470U 100V LOW ESR P7.5	C33,37
23557-0950	CAP 470U 400V ELEC S/I P10	C88
23620-0236	CAP 1N0K 100V P/E P5	C3,86
23620-0246	CAP 100NK 63V P/E P5	C2,13,24,26,41,42,44,45,69,74,75,80,81,87, 92,102,107-110,111,115,117,120
23620-0247	CAP 220NK 63V P/E P5	C4,34
23620-0252	CAP 2N2K 63V P/E P5	C48
23620-0264	CAP 100NK 400V P/E 368 SER P15	C51,54,76,77
23620-0267	CAP 100NK 100V P/E P5	C31,35,61,62

PCB ASSY – MAIN (44115-0960) continued/...

Part Number	Description	Position
23620-9007	CAP 10NK 100V P/E P5	C90,91,101
23621-0314	CAP 1UOK 400V P/E P27.5	C14
23684-0016	CAP 220NM 250VAC MIN X2 P22.5	C89
23684-0020	CAP 1UM 250VAC X2 P/P P27.5	C1,9,47
23685-0013	CAP 330NK 160V P/P P15	C16,94,119
25021-0901	DIO 1N4148 B/R	D8,11,13,14,25,27
25021-0910	DIO BAV21	D39,40,41,53,56,57,68,77
25031-0060	DIO BYV27	D6,7,18,19,21,22
25031-0100	DIO BAX12A	D1
25031-0110	DIO BYV26C	D44,45,50,61,63,69
25031-0120	DIO BYM26C	D2,3,4,5
25031-0140	DIO DUAL MURH860CT	D24,26,54,67
25031-0150	DIO UF4006	D9,10,15,16,30,31
25115-0910	DIO 1N4007 B/R	D78
25130-0207	DIO ZEN 15V W4	D42,43
25130-0246	DIO ZEN 22V W4	D66
25130-0903	DIO ZEN 5V1 W4	D20,23
25130-0915	DIO ZEN 75V W4	D58,60
25130-0916	DIO ZEN 3V3 W4	D52
25130-9209	DIO ZEN 12V W4	D62,64
25130-9210	DIO ZEN 18V W4	D33,34,59
25131-0230	DIO ZEN 75V 1W3	D47,48,49,51
25210-0050	THYRISTOR 2N5064	SC1
25211-0301	RECTIFIER BRIDGE D20XB60	BR1
25349-3500	TRAN PNP MJE350	Q11,12
25349-4210	RAN PNP BF421	Q8,9
25349-5560	TRAN PNP BC556	Q23
25349-7510	TRAN PNP ZTX751	Q3
25349-7580	TRAN PNP ZTX758	Q6,10
25381-0404	TRAN NPN 2N3904	Q19
25383-0506	TRAN NPN BC337	Q22
25383-0507	TRAN NPN BC546	Q1,25
25388-0211	TRAN NPN ZTX651	Q2
25601-0510	TRAN MOSFET N-CHAN 500V 20A	Q5
25601-0570	TRAN MOSFET N CHAN IRF540	Q14
25601-0600	TRAN MOSFET N CHAN IRFP250	Q15
25601-0610	TRAN MOSFET N CHAN IRFB11N50A	Q4,7

PCB ASSY – MAIN (44115-0960) continued/...

Part Number	Description	Position
27001-0060	OPTO-COUPLER SFH615A-3	IC12-16
27160-0009	IC V/REG 7805	IC2,3
27160-0013	IC V/REG 7815	IC4
27168-0040	IC L4981A	IC8
27226-0130	IC 4013B	IC7
27226-0690	IC 4069UB	IC1
27226-0930	IC 4093B	IC6
35515-1620	PCB - MAIN	

PCB ASSY - CONTROL (44115-0970)

Part Number	Description	Position
20661-0851	SPACER .56 INCH 7-SEG LED	DIS1,2,101,102
22220-0011	SWITCH ROTARY 4P3W SPLINE SHAFT	SW2
22225-0220	SWITCH PUSH/PUSH SPPH11470B	SW1,101
22240-0070	RELAY TYPE 47 (12VDC)	RL1
22573-0209	HEADER 9 WAY STRAIGHT .156P	PJ1,101 (SOLDER SIDE)
22575-0208	SKT 8W .156 20AWG (YELLOW)IDT	CONTROL TO MAIN PJ5
23202-0100	RES 10R0F W25 MF 50PPM	R50,150
23202-0220	RES 22R0F W25 MF 50PPM	R25,125
23202-1100	RES 100RF W25 MF 50PPM	R40,55,140
23202-1330	RES 330RF W25 MF 50PPM	R22,122
23202-1470	RES 470RF W25 MF 50PPM	R45,145
23202-1680	RES 680RF W25 MF 50PPM	R2,102
23202-2100	RES 1K00F W25 MF 50PPM	R10,11,12,23,48,110,111,112,123,148
23202-2360	RES 3K60F W25 MF 50PPM	R147
23202-2390	RES 3K90F W25 MF 50PPM	R46,146
23202-2470	RES 4K70F W25 MF 50PPM	R38,39,138,139,157
23202-2499	RES 4K99F W25 MF 50PPM	R34,134
23202-2820	RES 8K20F W25 MF 50PPM	R18,118
23202-3100	RES 10K0F W25 MF 50PPM	R5,14,15,17,24,28,30,32,41,43,44,47, 51,58, 105,114,115,117,124,128,130, 132,141,143, 144,151,158
23202-3127	RES 12K7F W25 MF 50PPM	R103
23202-3143	RES 14K3F W25 MF 50PPM	R4,35,135
23202-3150	RES 15K0F W25 MF 50PPM	R33,104,133
23202-3240	RES 24K0F W25 MF 50PPM	R27,127,152,153
23202-3330	RES 33K0F W25 MF 50PPM	R6,7,8,106,107,108
23202-3560	RES 56K0F W25 MF 50PPM	R31,131

PCB ASSY - CONTROL (44115-0970) continued/...

Part Number	Description	Position
23202-3866	RES 86K6F W25 MF 50PPM	R156
23202-4100	RES 100KF W25 MF 50PPM	R3,59,61,159
23202-4180	RES 180KF W25 MF 50PPM	R1
23202-4210	RES 210KF W25 MF 50PPM	R54
23202-4220	RES 220KF W25 MF 50PPM	R36,37,42,136,137,142
23202-4270	RES 270KF W25 MF 50PPM	R101
23202-4470	RES 470KF W25 MF 50PPM	R29,129
23202-5100	RES 1M00F W25 MF 50PPM	R19,60,119,160
23202-6100	RES 10M0F W25 MF 50PPM	R13,26,113,126
23301-0415	RES NETWK SIL 1K0 X 4S	RP3,103
23301-0464	RES NETWK SIL 56R X 4S	RP1,2,101,102
23320-0003	RES R10 - FERRYALLOY	R21,121
23347-0330	POT 10K LIN SPLINE SHAFT 25MM	VR1,2,101,102
23347-0340	POT 10K LOG SPLINE SHAFT 25MM	VR3,103
23385-1100	RES PS/H 100R CF 6MM	VR7,107
23385-2220	RES PS/H 2K2 CF 6MM	VR4-6,9,10,104-106,109,110
23385-2470	RES PS/H 4K7 CF 6MM	VR111
23385-4100	RES PS/H 100K CF 6MM	VR8,108
23388-0030	THERMISTOR PTC 100 OHM 265V	PTC1,2
23424-0443	CAP 10NZ 1KV CER D10 P5	C30,130
23427-0323	CAP 22PJ 100V CER NPO P5	C4,5,38,104,105
23427-0329	CAP 47PG 63V CER N150 P5	C15,17,29,42,115,117,129,142
23427-0353	CAP 220PG 100V CER N750 P5T	C19,119,41,141
23427-9205	CAP 47PJ 100V CER NPO P2.5	C39,139
23557-0612	CAP 1U0 100V/50V ELEC RE2 P2	C18,23,37,118,123,137
23557-0647	CAP 10U 35V ELEC RE2 P2	C25,26,125,126
23557-0665	CAP 2U2 50V ELEC RE2 P2	C16,116
23557-0668	CAP 220U 10V ELEC RE2 P2.5	C21,121
23557-0826	CAP 22U 100V LOW ESR P3.5	C20,22,120,122
23620-0246	CAP 100NK 63V P/E P5	C3,6,8,9,12,27,28,32,33,35,103,106,108, 109,112,124,127,128,134,135
23620-0247	CAP 220NK 63V P/E P5	C1,101
23620-0249	CAP 330NK 63V P/E P5	C10,11,110,111
23620-0252	CAP 2N2K 63V P/E P5	C40,140
23620-0264	CAP 100NK 400V P/E 368 SER P15	C36,136
23620-0267	CAP 100NK 100V P/E P5	C31,131
23620-9007	CAP 10NK 100V P/E P5	C13,14,113,114

PCB ASSY - CONTROL (44115-0970) continued/...

Part Number	Description	Position
23685-0007	CAP 100NK 160V P/P MKP4 P10	C2,102
25021-0901	DIO 1N4148 B/R	D1,2,3,4,5,7,8,9,11,12,13,101,102,103,104, 105,107,108,109,113
25061-0200	LED - T1 ROUND (3mm) - RED	LED1,2,101,102
25061-0519	DISPLAY 3 DIG .56 LED 9MM LEG	DIS1,2,102
25061-0520	DISPLAY 4 DIG .56 LED 9MM LEG	DIS101
25115-0907	DIO 1N4002 B/R	D114,115
25117-0020	DIO 1N5401	D10,110
25336-5590	TRAN PNP BC559C	Q1,101
25377-5490	TRAN NPN BC549C	Q2,102
27106-0506	IC LM324N 14 PIN	IC7,107
27106-0646	IC LF347 BI-FET OP AMP	IC5,105
27161-0120	IC V/REF ZRA245(ZR404) 2.45V	D6,106
27164-0507	IC ULN-2003A	IC1,101
27226-0520	IC 4052B	IC4,104
27226-0530	IC 4053B	IC2,8,102,108
27231-5740	IC 74HC574	IC6,106
27250-2001	IC MCU8 PIC16C55A-04/P ROM	IC3,103
28502-0010	RESONATOR CER 4MHZ	XTAL1,101
35555-2910	PCB - CONTROL	

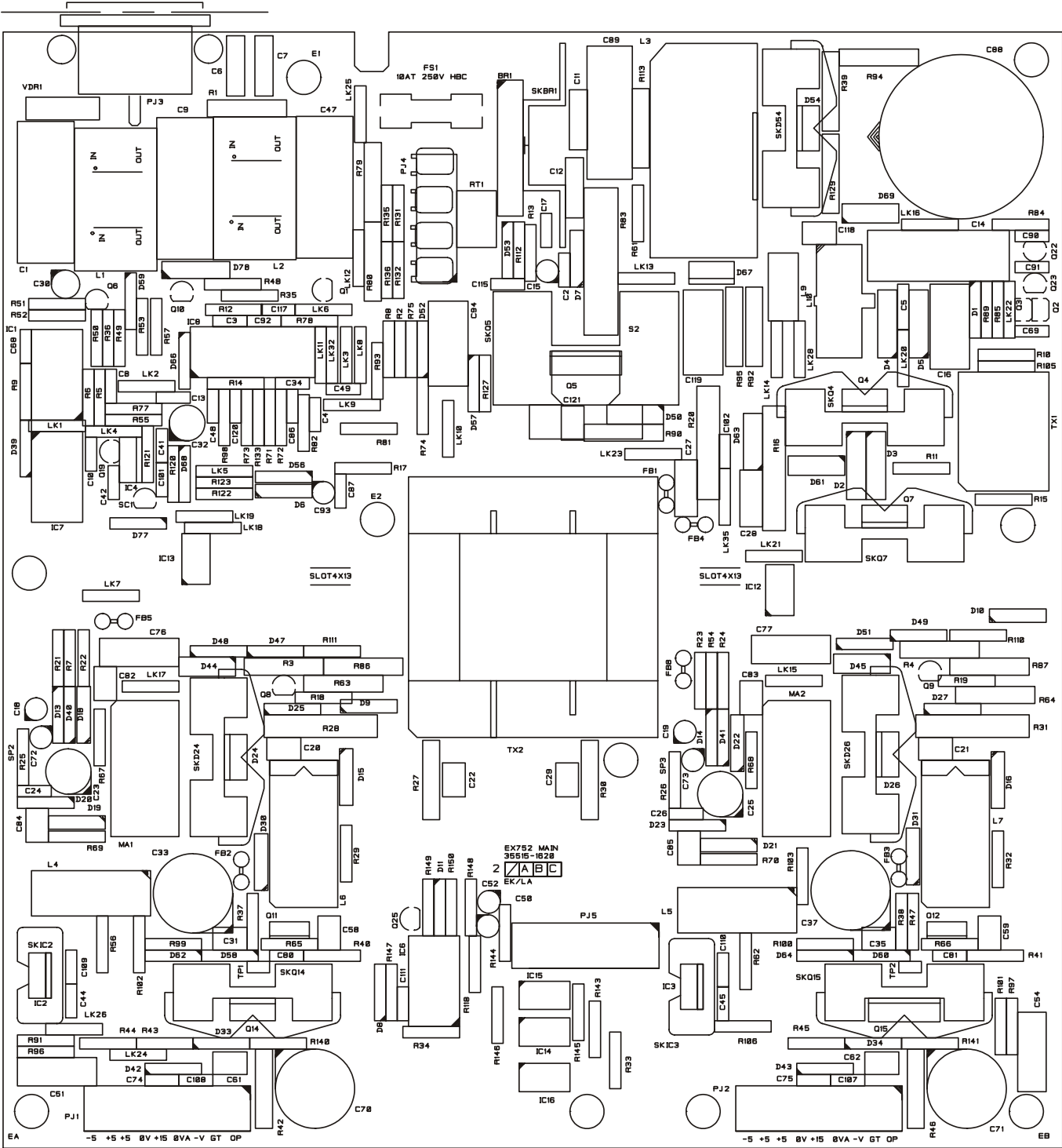
MECHANICAL ITEMS

Part Number	Description	Position
10232-0425	SLEEVING H/SHR 19MM BR RED	FERRITE SLEEVES
20030-0263	WASHER M3 ZPST	CONTROL PCB TO GROUND, STANDOFFS, BRACKET TO MOULDING
20030-0264	WASHER M2.5 ZPST	CONTROL PCB
20030-0266	WASHER M4 ZPST	EARTH
20037-0247	WASHER 4BA SHK/PROOF I/T ZPST	EARTH TERMINAL
20037-0301	WASHER M3 SHK/PROOF I/T ZPST	CHASSIS TO MAIN PCB SPACERS, GROUND STANDOFFS
20037-0305	WASHER 5/16in.SHK/PRF I/T ZPST	GREY TERMINAL
20037-0401	SOLDER TAG SHAKEPROOF - 4BA	EARTH
20038-9502	WASHER M4 SPRING	EARTH
20062-9501	SCREW No.6x3/4in RAISED CKHDPZ	HANDLE TO COVER , HANDLE TO L BRACKET
20063-0010	SCREW NO6 X 3/8 NIB HDPZ ST/AB	COVER TO CHASSIS, FRONT PANEL TO CHASSIS
20065-0020	SCREW 2-28 X 5/16PLAS PNHDPZ	CONTROL PCB & L BRACKET TO MOULDING

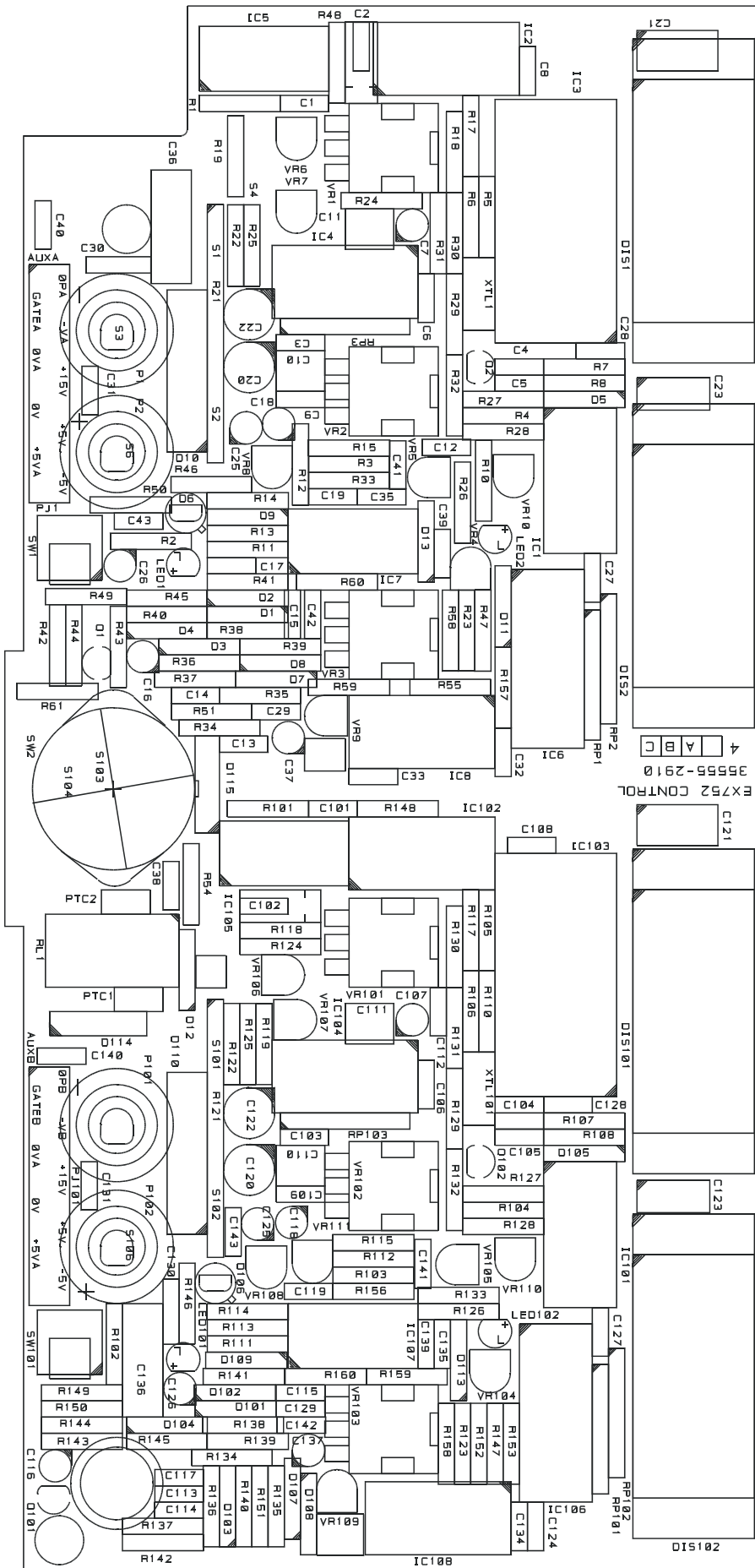
MECHANICAL ITEMS continued/...

Part Number	Description	Position
20210-0102	NUT M4 ZPST	EARTH
20213-0040	CAPTIVE NUT SPIRE NO.6	COVER TO CHASSIS, HANDLE TO COVER, HANDLE TO L BRACKET
20234-0024	SCREW M3 X 16 PNHDPZ ZPST	
20234-0027	SCREW M3 X 6 PNHDPZ ZPST	MAIN PCB SPACERS
20236-0010	SCREW M4 X 12 TAMPERPROOF	EARTH
20612-0011	WASHER FIBRE M3	CONTROL PCB
20653-0204	CABLE TIE 100 X 2.5MM	MAINS HARNESS TO CHASSIS
20662-9301	SELF-ADHESIVE FEET	
22040-0030	FERRITE SLEEVE APPROX 8/16/14L	OUTPUT A, OUTPUT B, OUTPUT C, MAINS
22219-0090	SWITCH ROCKER DPST GREY 12	
22225-0222	PUSHBUTTON PB10/50/000 BLACK	
22491-0120	MAINS LD 2M ST IEC/UK PLUG 5A	230V UK
22491-0270	MAINS LD 2M ST IEC/EURO PLUG	230V EURO
22491-0040	MAINS LD 2M ST IEC/USA PLUG	115V USA
22571-0691	WASHER ALUMINIUM FOR TP2E TERM	GREY TERMINAL
22571-0696	TERMINAL TP/2 GREY/GREY 12	
22571-0740	TERMINAL TP/44 GREY/RED	
22571-0741	PIN ANTI-ROTATION (TP/44&244L)	
22571-0750	TERMINAL TP/44 GREY/BLACK	
22575-0209	SKT9W .156 20AWG (YELLOW) IDT OUTPUT	
29211-0110	HANDLE EC254-OZ 6in BLACK/NICK	
31512-0710	BRACKET FRONT PANEL	
33111-0220	BRACKET HANDLE SUPPORT	
33147-0140	FRONT MOULDING	
33331-5860	OVERLAY NAME AND LOGO	
33331-5870	OVERLAY TERMINAL AREA	
33533-0370	OVERLAY DISPLAY WINDOW	
33533-0400	OVERLAY DISPL WINDOW	
33536-4090	CHASSIS	
33536-4220	COVER	
37151-0470	KNOB 21MM SPLINE L/GREY F/R	
37151-0331	KNOB - MACHINED - 21MM SPLINED	
44115-0960	PCB ASSY - MAIN	
44115-0970	PCB ASSY - CONTROL	
48511-0350	INSTRUCTION BOOK - EX752M	

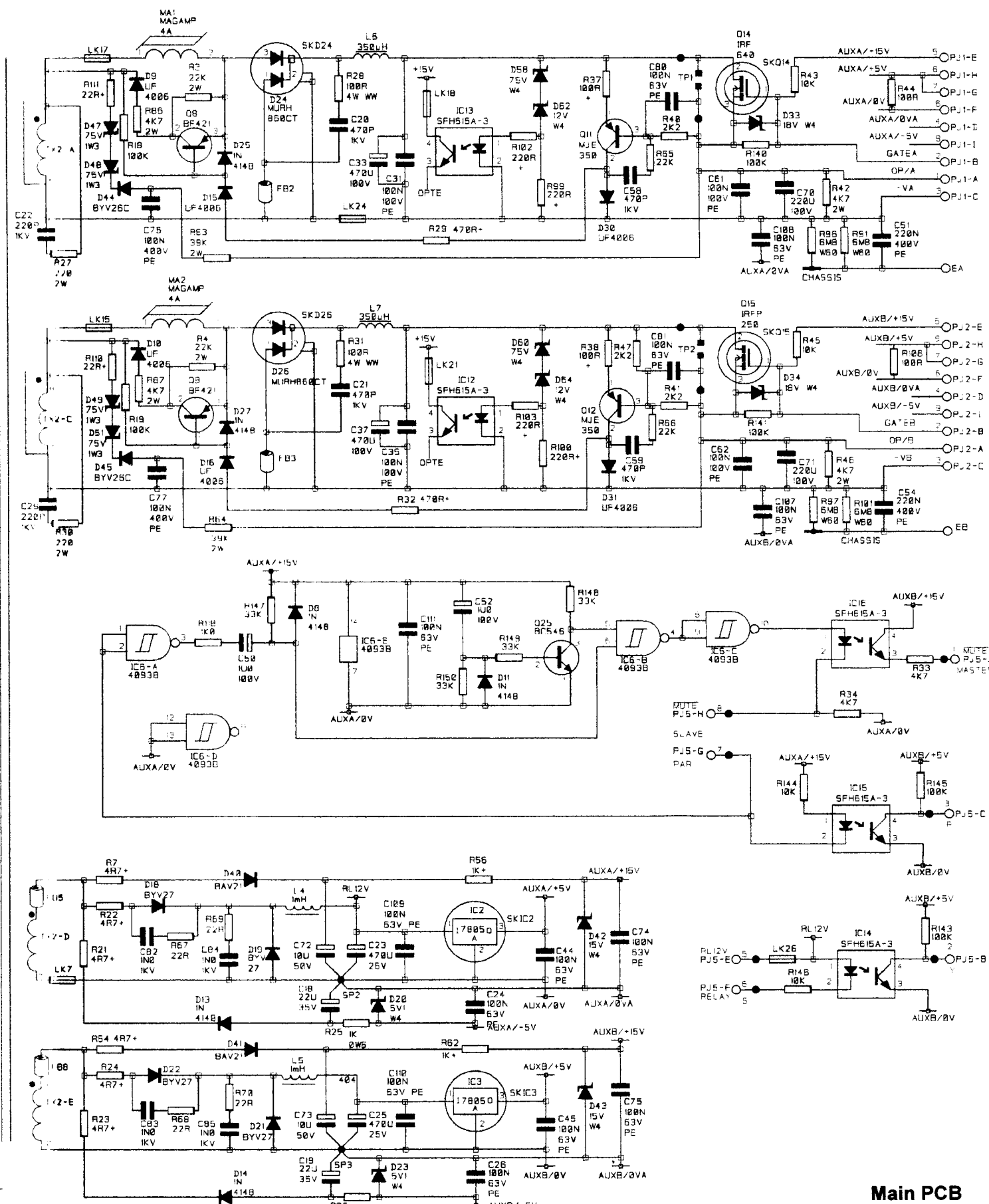
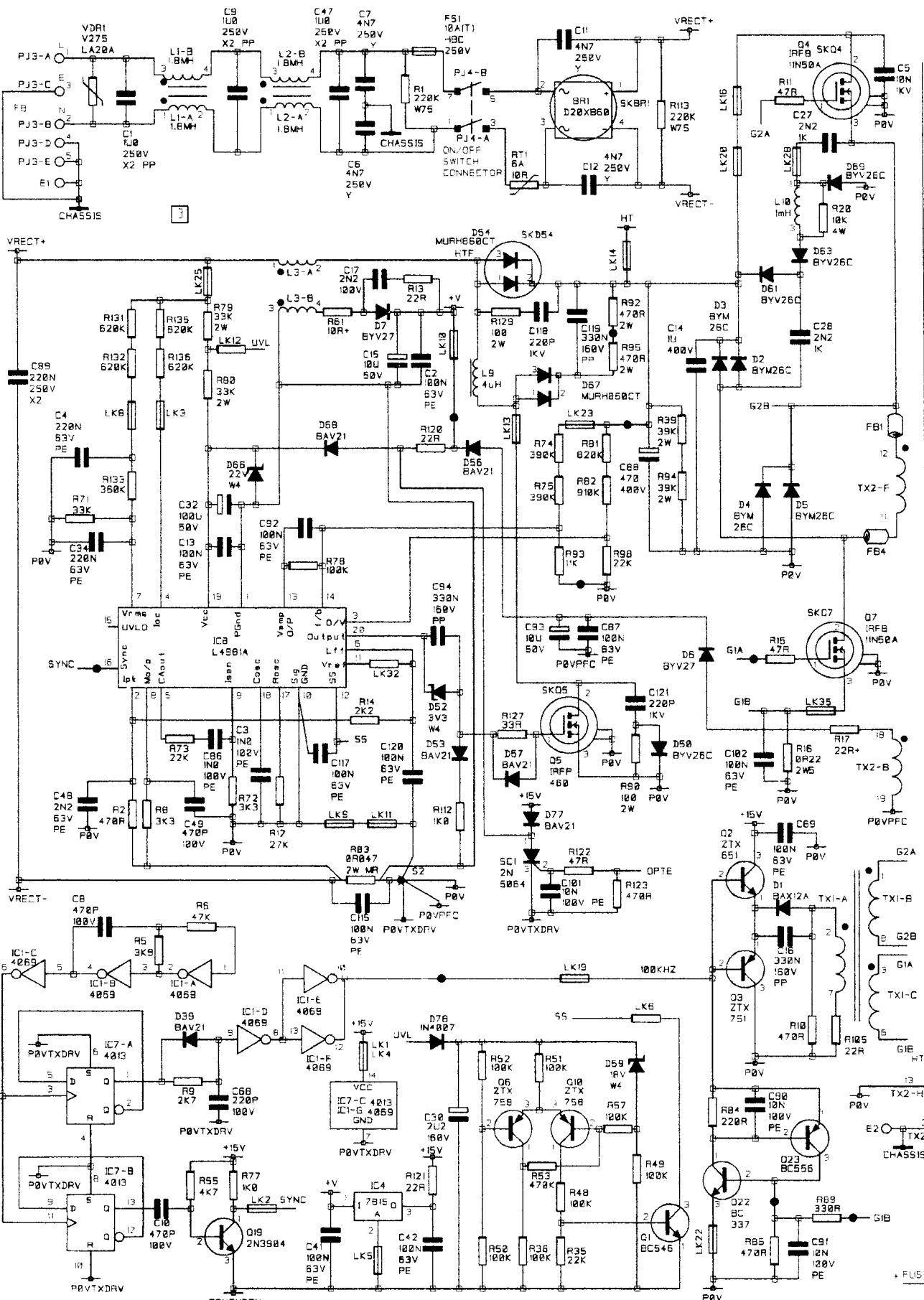
Component Layouts



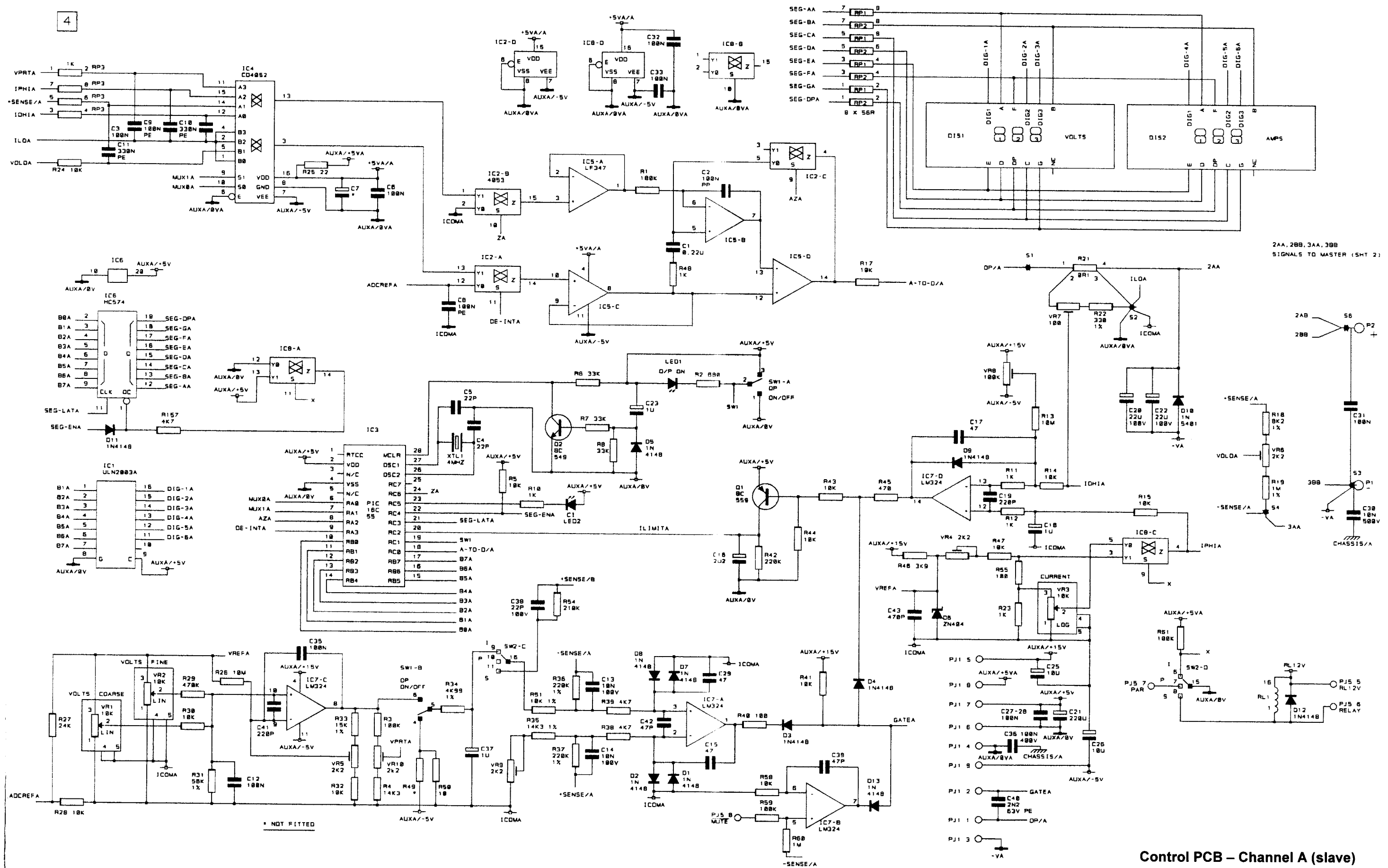
Main Board



Control Board



Main PCB

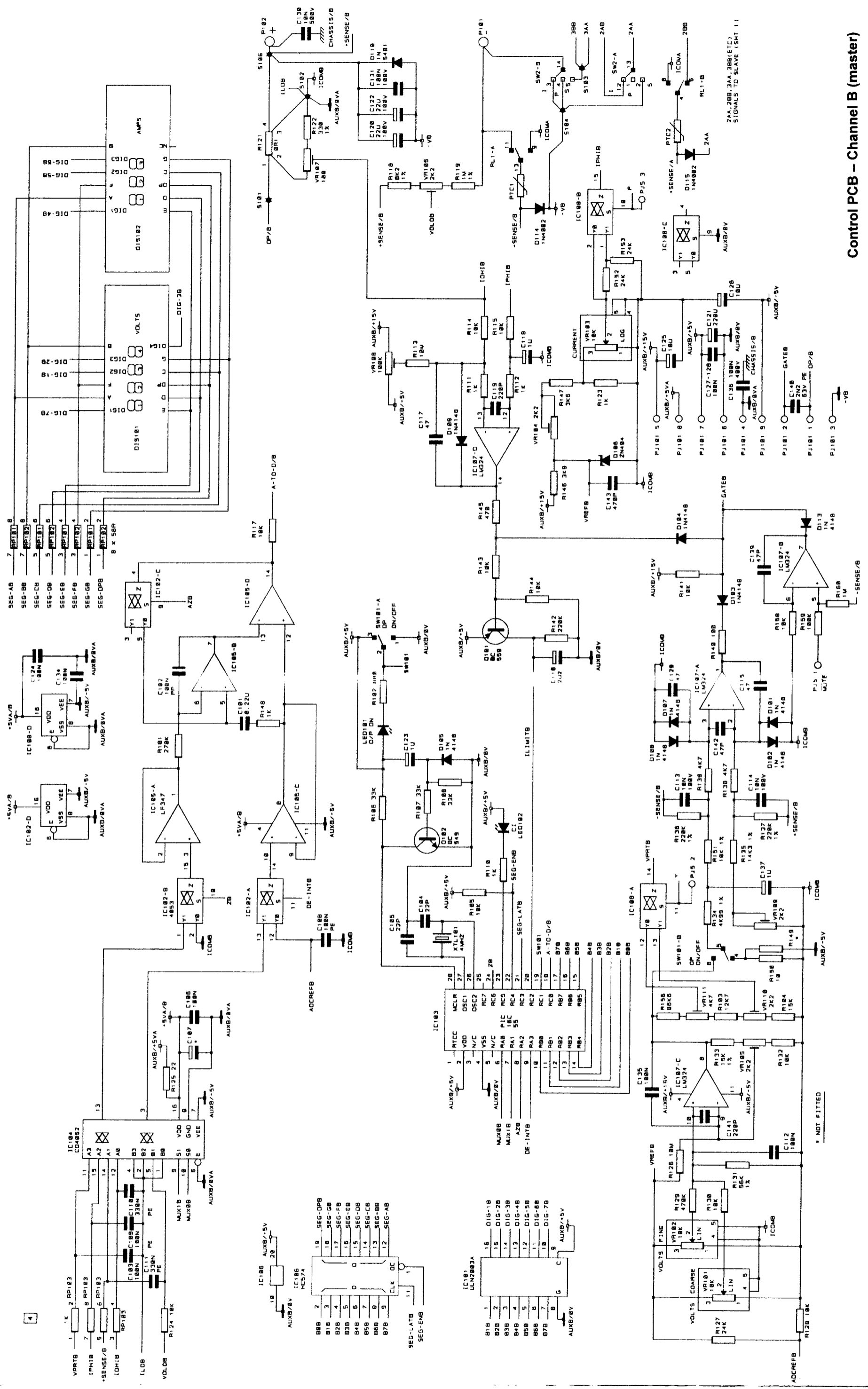


2AA, 2BB, 3AA, 3BB
 SIGNALS TO MASTER (SHT 2)

* NOT FITTED

Control PCB - Channel A (slave)

- PJ1 5 ○ AUX+/+5V
- PJ1 8 ○ AUX+/+5V
- PJ1 7 ○ AUX+/+5V
- PJ1 6 ○ AUX+/+5V
- PJ1 4 ○ AUX+/+5V
- PJ1 9 ○ AUX+/+5V
- PJ1 2 ○ GATEA
- PJ1 1 ○ DP/A
- PJ1 3 ○ -VA



Control PCB - Channel B (master)

* NOT FITTED



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