Operator's Handbook

ISS10

(20 amps, 10 channels)

Superconducting Shim Power Supply

Revision 7

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OXFORD INSTRUMENTS

Contents

1 Warnings

1. ***High Voltage Hazard. Isolate this equipment by switching off the external AC electrical supply, disconnecting and removing the external supply cable. Always position the equipment so that disconnection from the mains is not impaired during use.***

2. ***Maintenance: Only qualified and authorised persons should carry out servicing and repair work on this equipment.***

3. ***High Voltage Hazard: High voltages are present inside this equipment. Isolate this equipment by switching off the external AC electrical supply, disconnecting and removing the external supply cable before any covers are removed.***

4. ***Heavy Load Hazard. Care must be taken when moving the unit. Always use appropriate lifting equipment, which must be positioned under the unit.***

5. ***High voltage Hazard: Capacitors inside the equipment may remain temporarily charged after removed of the AC power. Wait at least one minute after disconnecting the AC supply before any work is done inside the unit.***

6. ***The equipment has the following AC Mains input voltage setting options 200 V, 215 V and 230 V. Please make sure the equipment is set to the value nearest to the nominal local mains voltage.***

7. ***If the equipment is used in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired.***

8. ***The equipment is not suitable for use with explosive or flammable gases. The equipment is not suitable for use in explosive, flammable or hazardous environments.***

9. ***The equipment does not provide protection against the ingress of water. The equipment should be positioned so that it will not be exposed to water ingress.***

10. ***Grounding. The ISS10 is provided with a protective earth stud that must be connected to a permanently protective earth cable. The cable must be green with a yellow stripe and have an area of cross section not less than 10 mm SQ (8 AWG) and terminated in a UL listed ring crimp. Each cable must be connected to the installation protective earth circuit in accordance with the applicable local and national wiring codes of the country of installation.***

2 Cautions

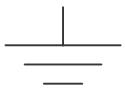
1 ***ELECTROSTATIC HAZARD: This equipment contains Electrostatic Sensitive Devices (ESSD). ESSD protective procedures in accordance with BS CECC00015 Part 1 and American National Standard EIA-541-1988 must be applied when installing or maintaining this product. Refer to guidelines in the preliminary pages.***

2. ***COOLING HAZARD. Internal components are air-cooled. Ensure the front lower ventilation space is not obstructed.***

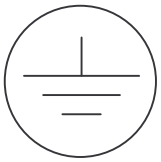
3. ***This equipment has been tested and found to comply with the limits for Medical Devices in IEC 60601-1-2. These limits are designed to provide reasonable protection against harmful interface in a typical medical installation. This equipment generates used and radiate radio frequency energy and if not installed and used in accordance with the instructions, may cause interference to other devices in the vicinity.***

Explanation of symbols used in the Instrument

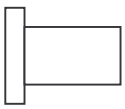
Attention; please refer to the manual



Functional earth



Protective earth



OFF

ON

3 Introduction

3.1 Use of this Manual

This manual provides operating and service information for the Oxford Instruments Superconducting Shim Power Supply model ISS10. Sections 1-4 provide essential information and should be read before operating the instrument for the first time. The remainder of the manual provides more detail on specific aspects and may be referred to as required.

3.2 Description of Equipment

The ISS10 shim power supply is designed for energising superconducting shim magnets. The supply delivers a maximum shim current of 20 amps (positive or negative). In addition to the main magnet switch heater, a matrix of up to 10 superconducting switches can be addressed, so ten superconducting shim coils can be set to different currents.

A set of Oxford Instruments shim coils are connected in series. The heaters for all the switches have one side connected together. All these connections go to a shim power supply via a (demountable) lead. An ISS10 can address each shim channel individually and set it to the required current.

The shim power supply will automatically handle many of the tasks of addressing a set of shim coils and establishing different currents in them. The operator simply sets the required shim current and the instrument does all sweeping, opening and closing the superconducting switch and pausing for states to become established.

The power supply is a microprocessor based instrument and is controlled by an operating program contained in a programmable memory chip (EPROM). This program is referred to as the **firmware**. The firmware is coded with two letters followed by a two part number (for example SH1.01), the first digit indicates a major revision and the second two digits cover minor revisions. The firmware version is displayed on the front panel whenever the instrument is turned on.

Manual operation is by means of front panel push buttons and associated status lamps. Remote computer control and monitoring is possible by means of built-in RS232 (serial) or GPIB (IEEE-488) interfaces.

3.3 Warning

Before you operate this equipment for the first time, please make sure that you are aware of the precautions, which you must take to ensure your own safety. In particular please read the Safety section (4) of this manual.

3.4 Disposal and re-cycling

Before disposing of this equipment, it is important to check with the appropriate local organisations to obtain advice on local rules and regulations about disposal and recycling.

You **must** contact Oxford Instruments NanoScience Customer Support (giving full product details) before any disposal begins.

4 Safety

The following general safety precautions must be observed during the operation, service and repair of this instrument.

4.1 Protective Ground

To minimise shock hazard the instrument must be connected to an electrical ground. The ground wire (green/yellow) in the instrument AC power cable must be connected to the installation electrical ground system. Do not use extension cords without a protective earth conductor. Do not disconnect the protective ground inside or outside the instrument.

4.2 Shim Coils Connection

Under no circumstances should the "Shim Coils" connection be disconnected from the power supply or the magnet while current is flowing in the power supply. This may cause dangerously high voltages to appear on the shim cables or terminals.

4.3 Repair and Adjustment

Some internal adjustments can be made to the power supply. Although Oxford Instruments does not encourage you to make these adjustments we try to supply you with enough information to allow you to do it safely. Disconnect the AC power supply **By taking out input Mains lead** before you remove the covers or fuses, because dangerous voltages are accessible on the circuit board and other components. It is not sufficient to switch off the front panel power switch.

" No adjustment or repair allowed by user while mains connected to the system in any case".

4.4 Safety Standards

This equipment is designed to meet the following safety requirements.

IEC61010-1: 2001

EN 61010-1: 2001

IEC 60601-1:1998+A1:1991+A2:1995
"Safety requirements for electrical equipment for measurement, control and laboratory use."

5 Installation

To avoid overheating, ensure that there is sufficient space for air-flow around the power supply. There **must** be a gap of at least 100 mm behind the unit and an exit path for hot air from the cooling fan.

5.1 Supply Connection

A single phase mains supply is required for the power supply. Before connecting the supply, ensure that the voltage selector on the rear panel of the unit indicates the correct supply voltage.

The front panel switch marked ON/OFF is used to turn the unit on and off.

If the supply voltage is incorrect, open the voltage selector panel using the slot provided, withdraw the voltage selector and replace it in the correct orientation for the intended voltage. Check that the correct fuses are fitted, then close the voltage selector panel.

Supply voltage settings and the associated fuse ratings are:

- 100 Vac 4.0 Amp Type T (Slow Blow)
- 120 Vac 4.0 Amp Type T (Slow Blow)
- 220 Vac 1.6 Amp Type T (Slow Blow)
- 240 Vac 1.6 Amp Type T (Slow Blow)

5.2 Shim Magnet Connections

Connections to the shim magnets are made via the 20 way connector mounted on the rear panel and marked "SHIM COILS".

Danger **On no account should these connections be made or broken unless the shim supply is in STANDBY mode or switched off.**

When making the connections, the shim supply should be switched off to ensure that offset currents do not cause an output voltage. Current polarity is defined as positive when current flows out of the MAGNET+ terminals and returns to MAGNET-.

Pin connection on the 20 way "SHIM COILS" connector are:-

1	MAIN switch heater
2	Z0 switch heater
3	Z1 switch heater
4	Z2 switch heater
5	X switch heater
6	Y switch heater
7	ZX switch heater
8	ZY switch heater
9	C2 switch heater
10	S2 switch heater
11	Z3 switch heater
12	+12 volts switch heater common
13	MAGNET +
14	MAGNET +
15	MAGNET +
16	MAGNET +
17	MAGNET -
18	MAGNET -
19	MAGNET -
20	MAGNET -

The main magnet switch heater can be configured for a 100 or a 200 ohm load, in both cases, the output current will limit at a bit more than 120 mA. If the switch heater load is 200 ohms then a zero-ohm link should be fitted at R543 on the analogue pcb (see diagram CCB1302 page 5 of 5). If the switch heater is 100 ohms, then omit the link.

5.3 Serial Data Line Connection

An RS232C bi-directional serial data link from a computer may be connected via the 25 way D-socket labelled RS232 on the rear panel. The unit is configured as a Data Communication Equipment (DCE) and may be connected directly to a computer or a data terminal, configured as a Data Termination Equipment (DTE). If the power supply is to be connected to a computer which is itself configured as a DCE, pins 2 and 3 should be swapped in the interconnecting cable. For computers fitted with a 9 way D plug for RS232, (AT style COM port), a standard "AT lead" fitted with a 9 way socket and a 25 way plug is required.

Pin connections at the RS232 socket are:

Pin	Name	Notes
1	FG	Linked to Chassis Ground in power supply
2	TD	Received Data (From Computer)
3	RD	Transmitted Data (To Computer)
4	RTS	Linked to 5
5	CTS	Linked to 4
6	DSR	+5 V when unit is powered up
7	GND	Signal Ground
8	DCD	+5 V when unit is powered up

All other pins are open circuit.

The power supply does not require signals to be present on any of the "modem control" lines, RTS or DTR (pin 20). In other words, the power supply only requires pins 2,3 and 7 to be connected to a computer. However, to ensure maximum compatibility with any requirement of the computer, RTS is looped back as CTS and logic high levels are returned on DSR and DCD.

Voltage levels for the transmitted and received data are:

Transmitted Data High	> +5.5 V
Transmitted Data Low	< -5.5 V
Received Data High Threshold	< +2.6 V
Received Data Low Threshold	> +1.4 V
Max. Rx Input Voltage	± 30 V

Data protocols are:

Handshake	None required
Baud Rate	9600
Tx Start Bits	1
Tx Data Bits	8
Tx Stop Bits	2
Rx Start Bits	1
Rx Data Bits	8
Rx Stop Bits	1 or more

For normal ASCII exchanges the 8th data bit is treated as a parity bit. It is always set to "0" on transmitted data. It is ignored on received data.

5.4 The Oxford Instruments ISOBUS

A unique feature of this power supply and other Oxford Instruments products, is the ability to connect a number of instruments simultaneously, to a single RS232 port on a computer and to control each one independently. This is done by means of an ISOBUS cable which carries a single MASTER connector (25-way D socket) and up to eight, daisy-chained SLAVE connectors (25-way D plugs). Each slave connector incorporates full optical isolation so that the slaves are all isolated from the master and from each other. The slaves connectors draw their power from the individual instruments, via the DCD signal on pin 8. The master connector may draw its power from either DTR or RTS signals from the computer.

To use ISOBUS, a special communication protocol is required, which is part of the command structure of Oxford Instruments products and is described in section 7.5.

5.5 GPIB (IEEE-488) Connection

Connections to the GPIB are made via a standard 24 way GPIB connector on the rear panel. Assignment of the connector pins conforms to the standard IEEE-488.1. Connections should be made using a standard GPIB cable.

Caution GPIB connections should never be made or broken whilst the monitor or any of the instruments connected to the Bus are powered up. Failure to observe this precaution can result in damage to one or more instruments.

The GPIB interface complies fully with IEEE-488.1-1987 as a talker/listener, able to generate service requests and respond to serial poll and device clear commands. It does not support parallel polling and has no trigger function. Open collector drivers are used on the bus lines so it does not prevent parallel polling of other devices on the bus. Its complete GPIB capability is specified by the Capability Identification Codes:-

SH1 AH1 T6 L4 SR1 RL0 PP0 DC1 DT0 C0 E1

Two lamps are fitted to the rear panel below the GPIB connector, to assist in diagnosing any GPIB communication problems. The RED lamp lights whenever the power supply is addressed to TALK and the GREEN lamp lights whenever it is addressed to LISTEN. The behaviour of the lamps is very dependent on the GPIB monitor in use. Some controllers un-address an instrument at the end of any transaction, in which case the lamps will just blink on for each transaction. Others leave instruments addressed between transactions in which case one or other lamp may remain lit depending on whether the power supply was last addressed to talk or to listen.

Before any communication can occur, the power supply must be given a unique GPIB address. By default, the power supply is supplied with its address set to 25. If this address is already in use by another instrument on the bus, it can be changed from the front panel via the Test Mode. This is described in section 10.6.

5.6 The GPIB to ISOBUS Gateway

The power supply has the ability to act as a GATEWAY to an ISOBUS cable, allowing other instruments to be linked to the GPIB without themselves requiring GPIB interfaces. This can enable other Oxford Instruments' products, for which an internal GPIB interface is not available, to be linked. It offers the additional advantage of optical isolation between these instruments and the GPIB.

To use the gateway, all that is required is GATEWAY MASTER ADAPTOR. This allows the 25 way ISOBUS MASTER socket to be linked to the 25 way RS232 socket on the power supply. The adaptor is a symmetrical 25-way plug to 25-way plug link, with pin connections as shown below.

Beware of using 25-way plug to 25-way plug adaptors, sold as "DCE-linkers" by some suppliers. Several different conventions exist for these, not all of which will work as a Gateway Master Adaptor. The connections required are given in the table below. A Gateway Master Adaptor providing these connections may be obtained from Oxford Instruments.

25 WAY PLUG	25 WAY PLUG
1	1
2	3
3	2
7	7
6	4
4	6

Note that the connections are symmetrical and the adaptor may be plugged in either way round.

The necessary protocols for the use of a power supply as a Gateway Master are described in section 7.6.9.

5.7 Digital Interface Connections

The digital interface port is a 15 way D-type connector on the rear panel, marked "PARALLEL I/O" (which corresponds to SK2 on diagram CBL1202 sheet 2/3). It is a digital interface and provides three separate functions.

a) an input signal to force a superconducting magnet to de-energise.

b) several uncommitted input and output lines for computer control. (3 input, 8 output, see section 8.4)

c) provides an interface for the optional supplementary input device.

The outputs are open-collector transistors (specification as for ULN2803A) and can sink up to 500 mA from a supply of up to 25 volts maximum. When driving an inductive load, it is recommended that a diode is connected across the load to absorb the stored energy.

For low power loads, current may be drawn directly from pin 15, which is connected via a diode and fuse, to the internal unregulated 11 volt line. A maximum total current of 500 mA may be drawn from this source.

The input lines on the parallel interface socket are suitable for either TTL level inputs (74 series, Transistor Transistor Logic) or contact closures to +5 V. The input device is a 74HC244 and 100 kohm pull-down resistors to 0V are fitted. Pin connections at this socket are:-

Pin	Title	Function
1	Output Bit 0	(spare)
9	Output Bit 1	(spare)
2	Output Bit 2	(spare)
10	Output Bit 3	(spare)
3	Output Bit 4	(spare)
11	Output Bit 5	(spare)
4	Output Bit 6	(spare)
12	Output Bit 7	reserved
5	Input K4	Optionally for Rotary Encoder
13	Input K5	Optionally for Rotary Encoder
6	Input K6	(spare)
14	Input K7	Auto-Run-Down
7	+5V	Optionally for Rotary Encoder
15	+11V unregulated.	Driver Protection
8	0V	

5.7.1 Auto-Run-Down Input

Auto-run-down will automatically de-energise a magnet system. The function is described in section 9. Suggested wiring schematics are shown in diagram CCB0982.

To activate auto-run-down, pin 14 should be taken to logic 1 (+5 V) relative to pin 8 (0 V). The recommended means by which to achieve this is by galvanically isolated contact-closure (for example a relay) between pins 7 and 14.

For example, low helium level can trigger an auto-run-down by using an Oxford Instruments ILM200 or HLM2 helium level meter. These meters contain relays which change state when the helium level drops below a user setable level.

In the case of the ILM200, Connections should be made to a pair of terminals inside the ILM200 marked "COM" and "N/O".

In the case of the HLM2, connections should be made to a pair of terminals on the rear panel, marked "COM" and "LOW".

Refer to the relevant level meter manual for further details.

Note that if using the ISS10 in conjunction with an Oxford Instruments power supply such as the IPS120-10 or PS120-10, then the auto-run-down signal to the magnet power supply should come from the "ANALOGUE I/O" port of the shim power supply.

5.7.2 Rotary Encoder Input

Available as an optional suplimentary input device, this rotary encoder plugs in to three pins on the PARALLEL I/O port. Its function is described in section 6.1.2.

5.8 Analogue Interface Connections

The analogue interface port is a 9 way D-type connector on the rear panel, marked "ANALOGUE I/O" (see diagram CCB2902 and PL5 on CCB1302 sheet 2/5 and 5/5). It provides three separate functions.

a) an auto-run-down output signal to a magnet power supply.

b) an input to sense when the main magnet switch should be open.

c) analogue monitoring of power supply current output current.

Pin connections at this socket are:-

Pin	Function
1	Auto-Run-Down Output +ve
6	Auto-Run-Down Output -ve
2	Sense Main Heater +ve
7	Sense Main Heater -ve
3	Current Monitor
8	Current Monitor return
4	Not connected
9	Not connected
5	Not connected

5.8.1 Auto-Run-Down Output

The auto-run-down function will automatically de-energise a magnet system but only after the shim currents have been dumped. The function is described in section 9. Suggested wiring schematics are shown in diagram CCB0982.

This output is an otherwise unconnected optically-coupled Darlington transistor (device U505 on CCB1302 page 5 of 5, an H11G2), the collector is connected to pin 1 and the emitter is connected to pin 6. The device must not switch more than 150 mA or 80 V.

The output is designed to interface to the "PARALLEL I/O" port of an Oxford Instruments magnet power supply such as the IPS120-10 or PS120-10:

Connect ISS10, ANALOGUE I/O, pin 1 to IPS120-10 , PARALLEL I/O, pin 7
Connect ISS10, ANALOGUE I/O, pin 6 to IPS120-10 , PARALLEL I/O, pin 14

5.8.2 Sense Main Heater

This input is to sense when the main magnet switch heater is to be energised. It is designed to connect to the switch heater output of a magnet power supply and is intended to detect when the user wants the main magnet switch to be open. Suggested wiring schematics are shown in diagram CCB0982.

When the shim power supply senses a voltage on these terminals, two things happen:-

1. The shim power supply enters auto-dump mode and takes all shim currents to zero (see page 23).

2. The "MAIN" switch heater terminal of the SHIM COILS connector is energised so that the current for the main magnet switch can be drawn from the shim supply via the SHIM COILS cable.

   The main magnet switch heater current may still be provided by the main magnet power supply, but must be routed from power supply to magnet cryostat via a different lead. If this configuration is required then it is suggested that R544 is removed (a 1.5 kohm resistor), this reduces the current drawn from the switch heater output circuit to no more than 1 mA.

This connection should not be made if the main magnet switch heater is to be controlled from the front panel of the shim power supply.

The input is an opto-coupler (device U504 on CCB1302 page 5 of 5, a 6N139), the anode is connected via a 10 kohm resistor to pin 2 and the cathode is connected to pin 7.

To connect to an Oxford Instruments magnet power supply such as the IPS120-10 or PS120-10, link two pins from the "ANALOGUE I/O" connector of the ISS10 to the IPS120-10 switch heater terminals:

Connect ISS10, ANALOGUE I/O pin 2	to IPS120-10 , SWITCH HEATER +ve
Connect ISS10, ANALOGUE I/O pin 7	to IPS120-10 , SWITCH HEATER -ve

5.8.3 Current Monitor

This output provides a 10 V monitor of the output current, note that the monitor polarity is the inverse of the output current. A 1 kohm resistor is fitted in series with each pin.

±10 V represents an output current of ±20 A (to within ±0.1%).

6 Local Operation

6.1 Front Panel Controls

The majority of the operating controls are located on the front panel and are grouped together in logically related boxes.

6.1.1 Power

The main ON/OFF switch. When the instrument is switched on, the green POWER lamp is lit.

6.1.2 Adjust

The red RAISE and LOWER buttons are used to adjust a parameter. They have no effect on their own but are always used in conjunction with one of the other buttons (LATCH mode is an exception to this rule, no other buttons are needed). Whenever a parameter is being adjusted, its value is shown on the main display. Setting a value involves pressing RAISE or LOWER until the required value is shown.

Operation of the RAISE and LOWER controls has been designed to allow large changes to be made relatively quickly whilst at the same time enabling any value to be set exactly. Pressing RAISE or LOWER briefly will cause the value to change by one digit. If the button is held in, the last figure will start to change at about 5 units per second. After 2 seconds, an approximately 10-fold increase in rate will occur, followed after another 2 seconds by a further rate increase and so on. Altogether there are 6 different rates. Whenever RAISE or LOWER is released, the next lower speed will be selected. This allows the user to "home-in" on the required value most ergonomically.

A rotary encoder is available as an optional supplement to RAISE and LOWER. Rotating the device will cause the displayed variable to change value, as it is spun faster, the variable's rate of change will increase rapidly. Note that there is an element of 'inertia' built into the control, rotating the device moderately fast but smoothly , will achieve a high rate of change for the variable. Use of this device will not affect the use of the RAISE and LOWER buttons.

6.1.3 Control

Control of the instrument may either be LOCAL from the front panel, or REMOTE via the RS232 or GPIB interface. The LOC/REM button may be used to switch between LOCAL and REMOTE. A third mode, Auto-Run-Down, is selectable via a socket on the rear panel, see section 9.

When LOCK is lit, the instrument is locked into either local or remote control and the LOC/REM button has no effect. At power up, it is locked in LOCAL, since at that time the instrument has no way of knowing whether there is a computer connected to a digital interface.

When the instrument is in REMOTE but not LOCKed, many of the front panel controls are inoperative. Those controls which only affect the display, will still work but those which could change the operation of the instrument are disabled.

When in REMOTE and LOCKed, the front panel is completely inoperative. Auto-Run-Down locks out both LOCAL and REMOTE control. This state is indicated when the "control" lights are flashing, see section 9.

6.1.4 Shim Control

The functions contained in this box split into two sections, an upper row of eleven buttons and lamps to address (shim) magnet and a lower row of buttons and lamps to set and display the control modes of the shim supply.

MAIN

This lamp indicates when the main magnet switch heater is on. The associated button performs two functions, as an on/off control and as a means of disabling the Auto-Dump mode.

Main Heater, On/Off

Control of the main switch heater is either via the front panel button or via a separate (main) magnet power supply. In all cases, the power for the main magnet heater is provided by the ISS10.

If the main heater is configured for control by this button, then to toggle the state of the main magnet heater, press and hold MAIN then press ACTIVE.

If the front panel button has been disabled then use the button on the front of the main magnet power supply. The ISS10 looks for an external signal, from the other power supply, and immediately relays this state to the main switch heater.

Caution The ISS10 does not know if the main magnet current terminals are connected to a suitable power supply. Controlling the main magnet heater from the ISS10 may cause a quench or even some damage to the magnet system as the ISS10 will energise a main magnet switch heater without making any checks.

Note that after issuing a command to change the state of the switch heater it is necessary to wait several seconds for the switch to respond before assuming that it has changed state.

To configure the ISS10 to use the front panel button for on/off control, see Sup 05, page 52. A fuller description of the hardware connections are given in section 5.8.2.

Main Heater, Auto Dump

For normal operation, when the main magnet heater is energised and the main magnet is therefore not persistent, the ISS10 is forced into an 'Auto-Dump' mode. In this mode all the shims are dumped (held at zero current) this takes precedence over any other mode. A fuller description of this mode is given on page 23.

When the MAIN button is pressed, the numeric display may read either "**Ad On**" or "**Ad OF**" indicating that the Auto-Dump mode is on or off. To toggle between the two states, press and hold MAIN then press DUMP. When the ISS10 is switched off (and on), the machine reverts to the Auto-Dump 'On' state.

Z0, Z1, Z2, Z3, X, Y, ZX, ZY, C2, S2

These buttons and lamps address each of ten shim channels. Press a button at any time, the associated lamp will light and the numeric display shows the shim current. If the ISS10 is configured to ignore the button then there is no change in the display (see Sup 05, page 52).

When a channel is selected from the front panel, the numeric display appears to flash twice and briefly shows "- - - - -". Two numbers are shown, the first is the actual current in a shim coil, the second is the "target current". To adjust the target current use RAISE and LOWER, the starting point for adjustment will be the displayed number, so to start from the "actual current" you must be quick! The ISS10 will only update the new target value when the shim channel button is released.

Note that if a shim coil is in persistent mode, then what the ISS10 believes is the "actual current" in that coil may be slightly different. This is because of coupling between coils, changing the current from when the ISS10 last put the coil persistent.

SWEEPING & PAUSING

These lamps indicate what actions the shim power supply is performing. If the output current is changing (because of sweeping the leads or a shim magnet) then SWEEPING will be lit. If the power supply is waiting for the system to settle (for instance whilst a switch is healing) then PAUSING will be lit.

Whenever the shim supply is performing an operation, one or other of these lamps will be lit. If neither SWEEPING nor PAUSING are lit then the shim supply has no activities to perform, the machine is waiting for the operator to give a command. The SWEEPING lamp will be lit all the time that the shim supply is in LATCH mode. If both SWEEPING and PAUSING are lit then the unit is in an unstable state (for instance voltage limiting).

If the ISS10 has been asked to change a shim current then the following procedure will always be followed. The power supply will sweep the leads to the persistent current in the selected coil, open the required switch and then ramp to the new target current or if 'dumping' it will sweep to zero current. When the shim coil is at the required current then the switch heater will be de-energised, then a pause whilst the switch heals, then finally sweep to zero current if there are no more shim currents to be changed.

The following table summarises the process:-

Action	Lamp	Default Setting
Sweep leads up to match the shim current	SWEEPING	200 A/min
Pause while lead current settles	PAUSING	1 second
Switch heater on, pause for switch to open	PAUSING	2 second
Sweep shim to target current (0 if dumping)	SWEEPING	20 A/min
Pause while shim current settles	PAUSING	5 second
Switch heater off, pause for switch to close	PAUSING	5 second
Sweep leads to 0 or to match the next shim	SWEEPING	200 A/min

The default settings refer to the delay times and sweep rates for a new ISS10. These settings may well be changed for a particular project. To make a change, (see Sup 07 to Sup 11, section 10.10).

STANDBY, ACTIVE, LATCH, CYCLE & DUMP

If the ISS10 has any operations stacked up waiting to be performed, then depending on the state, one of the lamps in the SHIM CONTROL box will flash.

When the ISS10 is changing from one state to another, two lamps will flash. The lamp associated with the present state will be on most of the time and the destination state will flash briefly.

STANDBY

In the STANDBY mode all outputs are in their 'safe' states. The shim current output is clamped by an internal contactor and all switch heater outputs are turned off. When the ISS10 is first turned on, it is in the STANDBY mode.

Press a shim channel button and the (persistent) shim current will be displayed. While in this mode, no switch heaters can be energised and no target currents can be set (persistent shim currents can be set, as described later in this section). The only change of mode that is permitted is from STANDBY to ACTIVE.

Exit from any other mode to STANDBY will happen immediately if no shim channels are being adjusted. If a shim channel is being adjusted then the ISS10 will put that channel persistent in the usual way, sweep the power supply output current to zero amps and finally drop the output contactor. Any stacked changes to shim currents will be discarded.

Changing the ‘Persistent Shim Current’ can be done only from STANDBY mode. This mechanism is intended to allow users to overwrite the ‘persistent current’ records in the ISS10 with the actual persistent shim currents.

To adjust:-
Press the required shim channel button and also press STANDBY (briefly).
The message “SEt P” is displayed, followed by the persistent current.
Hold down the shim channel button and adjust the persistent current,
use RAISE and LOWER in the usual way.

ACTIVE

In active mode, the preferred state is no switch heaters energised and no current in the leads. When changing from Standby to Active the output clamp is released.

Press a channel button and the ISS10 will display the actual current then the target current for that coil. When the channel button is released, if the target current is not changed (using RAISE and LOWER) then no further action is taken. If the target current is adjusted, the power supply will put the required change onto an internal 'stack' and proceed to change the current automatically, see "SWEEPING & PAUSING" on page 20.

Whilst in Active mode, all ten shim channels may be loaded up with new target currents, the power supply will stack this information and cycle through the coils setting the required currents (in the order in which they were entered). If there are any operations stacked up then the Active LED will flash.

Whilst in Active Cycle or Dump modes, pressing the ACTIVE button will indicate on the 10 switch heater LEDS which channels have yet to be set to new target currents held on the stack.

LATCH

The usual Active function results in the last addressed channel being put persistent and the power supply current returning to zero. A mechanism is provided that will run the power supply current to the selected shim current, then energise the switch heater and remain indefinitely in this state. While in this mode, the operator can adjust the shim current directly.

To latch a selected channel, hold down the ACTIVE button then press the selected channel button. The display will show "LAtCH". If the ISS10 is adjusting a shim channel, it will finish with that channel, discard any other changes that may be on the stack and 'pick up' the latched channel.

When in this (latched) Active state, the operation of the RAISE and LOWER buttons are non-standard. If RAISE or LOWER (but not the shim channel button) are pressed then the shim current for the present shim channel is slowly ramped, at about 10 minimum counts (10 mA) per second. While in this mode, the ACTIVE lamp will flash (quickly).

To leave the latched state press the ACTIVE button without pressing a shim coil button, the display will show "UnLAt". Exit is permitted directly to Standby, Cycle or Dump.

CYCLE

The CYCLE button will initiate a sequence of addressing each coil in the order shown on the front panel and (re)affirming each target current. After a single cycle has been performed, the shim power supply returns to the normal Active mode. Whilst in the Cycle mode, the associated lamp will flash.

The automatic sequence of sweeping the leads, opening a switch, sweeping a shim coil then waiting for the switch to heal are as described in "SWEEPING & PAUSING" on page 20.

DUMP

Provides a mechanism for dumping the shim coil currents (resetting to zero) whilst sweeping the main magnet.

There are two dump functions, Manual-dump and Auto-dump. Manual-dump is triggered when the operator presses the DUMP button, auto-dump is triggered either by the main switch heater turning on or by an auto-run-down signal (from a He level meter).

On leaving Dump mode, the shim currents can be restored to the earlier target currents by pressing CYCLE. At any time whilst the ISS10 is in a dump state, the original shim target currents can be modified in the usual way.

Manual-Dump

Press the DUMP button to trigger a single dump cycle.

This function is latched. When first pressed, all the present target currents are saved, then a procedure is started that is similar to Cycle but the shim currents are all driven to zero amps.

While in Dump mode and the shim currents are being taken to zero, the dump LED will flash. When the dump process has taken all channels to 0 amps, the shim power supply will output zero amps, no switch heaters will be energised and the LED will be lit but not flash. Pressing DUMP a second time re-triggers the manual- dump function. To restore the original target currents, press CYCLE.

Auto-Dump

This function is triggered automatically by one of two causes. Either the main heater is on (regardless of whether or not the magnet is being swept) or because of an auto-run-down signal (from a He level meter). Whilst in this mode, the DUMP lamp will flash. The auto-dump process ends when the main heater or auto-run-down signal is turned off.

The process will start by taking a copy of all the present target currents, then the ISS10 sweeps the output current to zero and turns on all the controllable switch heaters, this rapidly 'dumps' **all** the shim currents. A selection of shim channel heaters remain on for the duration of the auto-dump signal (typically all the 'Z' coils), the remaining channels are then repeatedly dumped just as manual-dump.

The shim coils are held at zero current to protect them from quenching when the main magnet is swept but to reduce the 'boil off' only certain channels are energised all the time. The user may select which channels are 'always on', they should be all the coils that are closely coupled, the remaining coils are only dumped periodically. To change a channel from one group to the other see Sup 06, page 52.

Note that the Auto-Dump mode can be disabled, see the description of the MAIN button on page 19.

6.1.5 Display

Whilst no buttons are pressed, the front panel display will indicate the present output current.

Numeric Display

The numeric display normally indicates the present output current in amps.

When the power supply is in voltage limit mode (see section 24) the display will flash to warn the operator that the number displayed is not the actual output current.

"Hot" Message

It is possible that the display may read "Hot" instead of a number, this indicates that the transistor bank has overheated. The "Hot" state will cause the power supply to clamp.

The power supply should be left to cool with the power still on (thus powering the fans). Pressing the ACTIVE button will restore normal operation but only if the overheated part has cooled down.

The display may be switched to show other parameters. These are displayed whilst the appropriate button is pressed. As soon as it is released the normal display returns. Whilst a shim channel button is pressed, the actual or target current in that shim coil will be displayed.

'Err I' Message

This (Error Current) message will be displayed if the power supply is unable to deliver the current that has been asked for, see section 6.2.

OUTPUT VOLTS

The voltage across the (inductive) magnet is proportional to the rate of change of current, so depends on the magnitude and sign of the sweep rate. The displayed voltage includes the voltage drop due to the magnet cables, which is proportional to output current.

6.2 Voltage Limiting

Voltage limiting can result from several causes e.g. a magnet being swept too fast, a magnet quench or a superconducting switch breaking open.

In normal use, the power supply output voltage will stay within the voltage limits (+/-4 volts). However, if a limit is exceeded the power supply will go into "catch" mode and stabilise the magnet system by matching the power supply current to the shim magnet current. Whilst voltage limiting the display will flash as there may be a discrepancy between the actual power supply output current and the displayed current.

If the ISS10 can not stabilise the output current within a short period then the mode will automatically drop back to STANDBY and the front panel displays the message 'Err I'. This error current message will be displyed if the shim current level is not connected The time allowed for stabilising can be adjusted (see Sup 11, page 53).

7 Remote Operation

7.1 Introduction

The power supply may be remotely operated by means of its RS232 or GPIB interface. This allows a computer to interrogate the supply and if required, to take control of it.

When in control, the computer has the option of locking out all the front panel controls, or of allowing the front panel LOC/REM control to remain active, so that an operator may restore LOCAL operation if required.

7.2 Communication Protocols

The power supply is always fitted with both Serial (RS232) and GPIB (IEEE-488) interfaces. Details of the hardware communication protocols for the two interfaces are given in sections 5.3 and 5.5 respectively.

The same command protocols are used for the Serial and GPIB interfaces.

All commands consist of a string of printing ASCII characters, terminated by a Carriage Return character. A Line Feed character may optionally be sent after the Carriage Return but is ignored by the power supply.

Unless the command starts with a "$" (dollar) character, all commands will evoke a response from the power supply. The response will consist of a string of one or more printing ASCII characters and will be terminated by a Carriage Return Character. This may optionally be followed by a Line Feed character.

The response will normally be sent immediately following the command. If a front panel button is pressed when the command is received, the response may be delayed until the button is released. With the Serial Interface in use, the response will be transmitted automatically as soon as it is available. With the GPIB interface, the response will be sent when the instrument is next addressed to talk.

The power supply will accept a command string at all times. If a computer is unable to accept data from the power supply at the full rate of the 9600 baud interface, then the response may appear to be incomplete or chaotic. In this case, the "W" command may be used to instruct the power supply to send more slowly, see page 36.

If the first character of a command is a "$", the command will be obeyed but no response will be sent, see section 7.5.

7.3 Commands and Responses

Commands to the power supply all consist of a single upper-case letter, optionally followed by a numeric parameter, the whole being terminated by a Carriage Return. The response sent by the power supply varies depending on the command. Usually it consists of the command letter received, followed by the value of any data requested. Where a command instructs the power supply to carry out an action rather than to send data, the command letter alone will be returned.

If a command is not recognised, has an illegal parameter or cannot be obeyed for any reason, an error response will be sent. This consists of a "?" (question mark), followed by all or part of the command string in question. To simplify error handling in the computer, the "?" will always be the first character returned.

The most common reason for a command error is attempting to execute a control command whilst the power supply is in LOCAL control. If in doubt, the "X" command may be used to determine the current status.

7.4 Numeric Parameters

All numeric parameters are treated as signed decimal numbers and are sent as a string of decimal digits with an appropriately placed decimal point. Note that this is **not the same convention as the** PS120-10 **or ITC**4where all numbers were treated as signed integers.

The format of all numbers exactly matches that displayed on the front panel. However the resolution can be extended by an extra decade if set by the "Qn" command, see page 34.

7.5 Use of the Oxford Instruments ISOBUS

The Oxford Instruments ISOBUS allows a number of instruments to be driven in parallel from a single RS232 port on a computer, using a special cable assembly.

To allow separate instruments to be distinguished, each is allocated a unique address in the range 1 to 9, held in non-volatile memory.

When operating on ISOBUS an instrument must be able to recognise and respond to commands addressed to it, whilst ignoring commands addressed to other instruments. This is achieved by starting all commands with a special ISOBUS control character.

When more than one powered-up instrument is connected on ISOBUS, no command should be issued which does not have an ISOBUS control character as its first character. Issuing such a command would result in an unintelligible response, as all instruments would reply together. (N.B. This will only result in lost data. No hardware damage will be caused).

Following the control character and its parameter (where required), the rest of the command follows the form described above. The response of the instrument depends on the initial control character in the following manner:

@n (At)n addresses the command to instrument number n, where n is a digit in the range 0 to 9. This instrument obeys the command and returns its usual response. All other instruments ignore the command and send no reply.

$ (Dollar) instructs all instruments to send no reply. This is normally used to precede a command being sent to all instruments simultaneously, and prevents a conflict as they all echo the command together.

It may also be used in non-ISOBUS applications if the computer does not wish to receive a response.

It should be used with caution however, since all responses are suppressed, including the "?" error response. Thus the computer has no way of knowing whether a command has been received or even if the instrument is connected.

If a command is to be addressed to a specific instrument, but no reply is required, it is permissible to use "$" and "@n" together. The "$" should always come first.

& (Ampersand) instructs an instrument to ignore any following ISOBUS control characters. It is included in the ISOBUS protocol to allow instruments whose command repertoire includes "@", "$", "&" or "!" to be used on ISOBUS. The power supply does not require the use of this command.

!n (Exclamation) instructs the instrument that from now on, its address is to be n. This command is included here since it is relevant to ISOBUS operation. However for obvious reasons, it should not be sent when more than one instrument is powered up and connected to ISOBUS. (It would result in all instruments having the same address!).

The command is intended for initial setting up of instruments, one at a time. To avoid inadvertently changing addresses, the "!" command will only be obeyed following a "U" command with a non-zero password, see page 36

Note that the address set this way is the ISOBUS address, not the GPIB address. The later cannot be set via the interface, since until an address is defined, GPIB communication is not possible.

7.6 The GPIB Interface

The GPIB Interface allows the power supply to be computer-controlled by means of the General Purpose Interface Bus (GPIB), also known as HPIB and IEEE-488 interface.

The GPIB Interface supplements rather than replaces the RS232 Serial Interface. It allows an instrument to be controlled either by GPIB or RS232 (not both simultaneously). In addition when operating under GPIB control, the RS232 interface may be used as a GATEWAY to further OI instruments, not themselves fitted with a GPIB interface.

An Oxford Instruments shim power supply is normally supplied set to a GPIB address of 26. To change the address, the user must enter test mode, see section 10.6.

The instructions which follow assume some basic familiarity with the concepts of the GPIB. This will typically be provided as part of the documentation supporting a GPIB controller card for a computer etc.

Even with the GPIB interface fitted it is still possible to communicate with the instrument via the RS232 interface in the standard way. This is the default condition after power up (or a re-start when exiting test mode) and ISOBUS addressing may be used if desired.

Provided the GPIB interface has not been deliberately DISABLED by setting its address to 0, it may be switched to the GPIB IN-USE state at any time. This occurs automatically when a GPIB Controller asserts the REN line and addresses the interface either to talk or listen at the GPIB address selected. Once it has been put into the GPIB IN-USE state, it remains in that state until power down or until a re-start on exit from test mode.

7.6.1 Sending Commands via the GPIB

Commands sent via the GPIB follow exactly the same syntax as for the RS232 interface. Commands must be terminated by a Carriage Return <CR> character, (ASCII 13). A Line Feed <LF> may be sent if desired but is not needed and will have no effect. (Your GPIB controller may send <CRLF> by default). Provided it is operating (as opposed to being in TEST mode) the power supply will accept commands at all times. Where commands produce a response message, this should be read before a further command is issued.

7.6.2 Accepting Responses via the GPIB

Messages returned via the GPIB consist, by default, of an ASCII character string, terminated by a <CR>. If your controller expects <LF> as a terminating character, this may be achieved by sending an initial "Q2" command after power up. Note that the "Q2" command itself produces no response message but that all subsequent messages are terminated by the <CRLF> pair. The interface never asserts the EOI line at the end of a message, instead allowing either <CR> or <LF> to be used as the End-of-String (EOS) character.

7.6.3 The Status Byte, Use of a Serial Poll

One of the problems with a GPIB interface is knowing when a message is available to be read. If a device is addressed to TALK but has no data available, it will wait indefinitely, unless the controller includes a TIME-OUT facility (see section 7.6.10). There are a number of ways by which the controller can determine when data is available. The simplest, but least reliable way is to "know" from the command which has been sent, whether a reply is to be expected. This is fine until something unexpected happens.

A better alternative is to read a STATUS BYTE from the instrument by conducting a SERIAL POLL of it. The power supply interface will always respond to a serial poll and will return a status byte. Three bits in this byte have significance for the power supply as follows.

Bit 6 (Value 64 decimal)	RQS (Requesting Service)
Bit 4 (Value 16 decimal)	MAV (Message Available)
Bit 1 (Value 2 decimal)	BAV (Byte Available)

The bit positions for the RQS and MAV bits are as specified in IEEE-488.1 and IEEE-488.2 respectively. (Note the convention here is that the Least Significant Bit is Bit 0. This is sometimes referred to as data line D1. Thus lines D1 to D8 correspond to Bits 0 to 7.)

The BAV bit is set as soon as at least one byte is available to be read. The MAV bit is set when a complete message up to and including the <CR> or <LF> character is available to be read. The RQS bit indicates that the instrument has requested service by asserting the GPIB SRQ line true (see section 7.6.4).

The status byte may be read as many times as the controller wishes. The MAV and BAV bits will reflect the current status of the interface at the time the byte is read (but see below). Hence once set, they will remain set until the message has been read. The RQS bit behaves differently (in accordance with IEEE-488.1). The first time the status byte is read after the interface has requested service, it will be set. The act of reading the status byte clears the service request bit and at the same time allows the interface to release the Service Request Line (see below). It will not be asserted again unless a further service request is issued.

The power supply updates the status byte every millisecond. Thus if the status byte is read within 1mS of reading data from the interface, the MAV and BAV bits may not yet have been cleared, even though all available data has been read. If these bits are found to be unexpectedly set immediately after a data read, a second read of the status byte at least 1mS later will confirm whether there really is data remaining.

7.6.4 Use of the Service Request Line

The interface will issue a service request (by pulling the SRQ line), at the point a complete message becomes available to be read, (i.e. at the point at which MAV is first set), unless the interface is already addressed to TALK at that point. In the latter case no service request is required since the controller is already waiting to read the data or is in the process of doing so.

Hence use of the SRQ line allows a suitably equipped controller to handle all data from the interface on an interrupt basis. If the controller is not equipped to do this, it may simply ignore the SRQ line and poll the status byte on a regular basis until the MAV bit indicates data is available.

7.6.5 Use of the Device Clear Function

When the GPIB interface receives a Device Clear message from the controller, it responds by clearing all the communication buffers to their empty, power-up state. It does not reset any of the temperature control functions to the power-up state. Device Clear may thus be safely used to empty the buffers if these have been filled with a number of unread messages. Device Clear may be sent by either the GPIB DCL message (which clears all connected devices), or by means of the SDC message addressed specifically to its address.

Note that if an ISOBUS GATEWAY is in use, only the buffers in the MASTER instrument are cleared. If data is currently being transmitted from a SLAVE instrument to the MASTER, this will be read into the buffer after it has been cleared.

7.6.6 Use of the Interface Clear (IFC) Function

Receipt of the single line IFC message clears the GPIB interface functions as specified by IEEE-488.1. It does not clear any pending data in the buffers. Nor does it have any effect on operation of the power supply's control functions.

7.6.7 Non-Implemented Features of the GPIB

The GPIB Remote Enable (REN) line is used only to alert the interface to the presence of an active controller. It is not used for LOCAL/REMOTE switching which is carried out by the simpler "C" command, for compatibility with RS232 operation. Similarly the GPIB LOCAL LOCKOUT command and GOTO LOCAL commands have no effect. This functionality too is a part of the "C" command.

The interface does not respond to a Parallel Poll request. However since it uses open collector data buffers, it can co-exist on the GPIB with other instruments which do have a Parallel Poll facility.

7.6.8 Compatibility with IEEE-488.2

Compatibility with certain aspects of this extension to the original standard has already been mentioned in a number of places (for example the format of the Status Byte). However details of the command sequences and formats within messages, error handling and status reporting all follow the existing power supply syntax and protocols used on RS232. This precludes complete compliance with the rather more complex IEEE-488.2 syntax. In particular there is no attempt to support the "Standard Commands for Programmable Instruments" (SCPI).

7.6.9 Use of the GPIB Interface as a GATEWAY to ISOBUS

When the interface is operating in the GPIB IN-USE state, all characters received via the GPIB are echoed back out on the RS232 line. Similarly any characters received on the RS232 are made available to be read by the GPIB controller (with MAV, BAV and RQS being set appropriately as above). This allows one or more other instruments to be connected to the first instrument using the Oxford Instruments ISOBUS. These may share the benefits of being controlled by the GPIB controller, whilst at the same time enjoying the advantages of optical isolation provided by ISOBUS. To use this GATEWAY, requires only a GATEWAY MASTER ADAPTOR, as described in section 5.6.

No special command protocols are required to access the GATEWAY. All Oxford Instruments products fitted with RS232 can be accessed in this way. The command strings sent to individual instruments when used in this way are simply prefaced by their ISOBUS ADDRESSES as described above. Note the distinction between the GPIB address which is common to all the instruments on the GATEWAY and their individual ISOBUS addresses which form a part of the message string, preceded by the "@" character. The ISOBUS GATEWAY MASTER (i.e. the instrument actually fitted with the GPIB interface) always has the ISOBUS address "@0". This must be used when addressing this instrument, since a command sent with no "@" prefix would be seen by all instruments (just as for a simple ISOBUS system).

7.6.10 Writing a "Rugged" GPIB Control Program

A lot of effort has been put into making the design of the GPIB interface as tolerant as possible. However in any computer interface designed to operate unattended for periods of time, it is essential to assume that data corruption may occur at any time. Usually this is due to static, power line surges, operator error etc. Any controller program should be designed to cope with this. In particular all attempts to write data to or read data from any instrument should have a TIME-OUT facility built in. The GPIB handshake sequence makes it all too easy for lost data to result in the bus hanging indefinitely. When a time-out occurs the controller should attempt to assess what is happening. In the case of the power supply GPIB interface this is best done by means of a serial poll. If this too times out, the next recourse should be to reset the interface by means of the Interface Clear (IFC) line. If a serial poll is still unable to get a response, the controller must assume that the instrument has been switched off, failed or a connector has fallen out. As a last resort it should attempt to alert an operator and/or if possible continue operating the remaining instruments.

8 Command Syntax

For a more detailed explanation of the power supply states, the user should refer to section 6, Local Operation.

Commands fall into four categories:

Monitor Commands
which are always recognised.

Control Commands
which are only recognised when in REMOTE control.

System Commands
which are only recognised after receipt of the correct Unn command or "unlock key".

Specialist Commands
Which are all lower case letters. They are primarily for use with Oxford Instruments supplied high level system software or as an aid to control algorithm development.

In the Lists which follow "n" & "m" represent decimal digits 0-9. A number represented by “nn” is not constrained to be a single digit.

8.1 Monitor Commands

Cn Set Control

The control command sets the power supply into LOCAL or REMOTE and determines whether the LOC/REM button is LOCKED or active. At power up the power supply defaults to the C0 state. Allowed values are:

C0 Local & Locked (default state)
C1 Remote & Locked
C2 Local & Unlocked
C3 Remote & Unlocked

In the C3 state, the channel buttons can be used to examine values on the display, but RAISE and LOWER cannot be used to change these values. However the LOC/REM button is active and can be used to switch to the C2 state in order to change values. While any buttons are held pressed in the C3 state, the instrument will not respond to any remote commands. Instead these are held pending and acted upon when the button is released. Computer programs should either be written to tolerate this delay or should put the instrument into the C1 state to completely disable the front panel controls.

G Read Switch Heater Status

The read heater command returns the status of a shim channel. To select a shim channel the Channel Pointer must be set, refer to the Pnn command on page 34. Possible returned values are:

G0 Shim channel persistent, no changes required
G2 Shim channel on stack, switch heater off
G3 Shim channel on stack, switch heater on
G4 Shim channel not controllable

J Read Shim Current

The **J** command will return the current that the power supply believes to be in a shim coil. Note that the actual current in the shim coil may differ from the current that the ISS10 last put in there, this is due to coupling between the coils.

The shim current is returned in the same form as the number appears on the front panel display. An extra digit will appear if "extended resolution" has been set, see Qn on page 34. To select a shim channel the Channel Pointer must be set, refer to the Pnn command on page 34.

K Read Shim Target Current

The K command will return the target current that the user has requested for the selected shim coil.

The target shim current is returned in the same form as the number appears on the front panel display. An extra digit will appear if "extended resolution" has been set, see Qn on page 34. To select a shim channel the Channel Pointer must be set, refer to the Pnn command on page 34.

Pnn Set Channel Pointer

The Pnn command sets a channel pointer. The pointer is used by all commands that refer to data specific to a particular shim coil (such as G I J and K). The channels are numbered in the same order as on the front panel display, starting with MAIN as channel 1. The channels are listed below:

P0 Pointer off(power-up default).
P1 Main magnet
P2 Z0 shim coil
P3 Z1 shim coil
P4 Z2 shim coil
P5 Z3 shim coil
P6 X shim coil
P7 Y shim coil
P8 ZX shim coil
P9 ZY shim coil
P10 C2 shim coil
P11 S2 shim coil

Qn Set Communications Protocol

Defines the communication protocol. Currently only 4 values of n are significant:

Q0 "Normal" (Default Value)
Q2 Sends <LF> after each <CR>
Q4 Extended Resolution.
Q6 Extended Resolution. Send <LF> after each <CR>.

Note that unlike all other commands, the Q command does not produce an echoed response to the computer. (Having changed the communication protocol, it automatically clears the communications buffer.)

The <LF> option is for use with computers that require an <LF> as an input message terminator.

Extended resolution increases the resolution of the power supply's currents and associated rates by one order of magnitude. For example the shim coil current resolution is increased from 0.001 amp to 0.0001 amp.

Note that the Q command is volatile, when the power supply is switched off and on, the communication protocol reverts to the default value of Q0.

Rnn Read Parameter

The READ command allows the computer to interrogate any of a number of variables. These readings are not likely to be of use to most users. To determine the currents in individual shim coils, use the commands, J or K.

The returned value is always an integer as defined in section 7.4. Allowed values for n are listed below. The name of the parameter is followed by the units and the letters E.R. if the parameter can be sent at extended resolution, see the "Qn" command on page 34. Variables marked with a "*" are intended as service diagnostics and are unlikely to be of use to the user.

R 0	Demand current (output current)	amps	E.R.
R 1	Measured power supply voltage	volts	
R 2	Measured output current	amps	
R 3	Unused		
R 4	Target current	amps	E.R.
R 5	Lead sweep rate	amps / minute	E.R.
R 6	Magnet sweep rate	amps / minute	E.R.
R 7	Trip current	amps	E.R.
R 8 *	Scratch pad current	amps	E.R.
R 9	Unused		
R 10 *	DAC zero offset	amps	E.R.
R 11 *	Channel 1 frequency/4		
R 12 *	Channel 2 frequency/4		
R 13 *	Channel 3 frequency/4		
R 14	Unused		
R 15	Unused		

S Read List of Stacked Shims

The read stack command returns a list of all shim channels on the 'stack' (that have yet to be set to new values). The returned string is variable length and each shim coil is identified by the same number as defined by the Pnn command on page 34. Some examples are:

S	Empty stack (no shim coils to be changed)
S,02	Z0 to be changed
S,03,11	Z1 & S2 to be changed

T Read Status of State Machines

The ISS10 performs highest level operations under control of two state machines. A graphical description of the state machines is given at the back of this manual, see drawing number CCB0981.

The T command reads the state of both machines. The returned string is in the form of **T,mm,nn** the mm shows the state of the first machine and nn the state of the second machine.

At the top level is a machine to control the 'operator interface'; this controls the operation of the various modes, STANDBY, ACTIVE, CYCLE, DUMP and LATCH. The state number is T,**mm**,nn and identifies one of the 'MAS' boxes in the diagram CCB0981, page 1 of 2.

The lower level state machine controls the sequence of picking up a shim channel, taking it to a new current and putting it persistent again. The state number is T,mm,**nn** and identifies one of the 'NAS' boxes in the diagram CCB0981, page 2 of 2.

Unn Unlock System Commands

The UNLOCK command allows access to the SYSTEM commands. These commands are intended for diagnostic and configuration purposes and have the power to erase or modify the contents of the memory. The U command must be followed by the correct KEY parameter before these commands may be used. The KEY value for these commands is 9999.

A lower level of key protection is provided for the "!" command, to avoid accidental errors. Any non-zero value will unlock this command.

Two additional special key values are significant. These are intended specifically to allow a GATEWAY MASTER instrument to be used to load RAM data (via a "Y" command) to a SLAVE instrument, without the data being "obeyed" as commands, by the MASTER. A value of U1234 puts the MASTER to SLEEP, until the specific sequence U4321 is detected. Whilst it is asleep, all data received via the GPIB interface is passed on to the slave but ignored by the master.

Thus the allowed values of U are:-

U0	Locked (power-up default)
U1	"!" Command Unlocked
U1234	Sleep
U4321	Wake Up
U9999	"Y" Command Unlocked

V Read Version

The VERSION command requires no parameters. It returns a message indicating the instrument type and software version number.

For example: "ISS10 Version 1.03 ©OXFORD 1995"

Wnn Set Wait Interval

The WAIT command sets a delay interval before each character is sent from the power supply via the serial interface. This allows the power supply to communicate with a slow computer with no input buffering. The parameter nn specifies the delay in milliseconds. It defaults to zero at power-up, the maximum delay is 32767 milliseconds.

Note that the W command does not reduce the rate at which the power supply can accept data from computer.

X Examine Status

The EXAMINE command allows the computer to read the current power supply STATUS. It requires no parameters and will return a message string of the form:

XnAnCnHnMnmNnPnn

Note that the length of the returned string is fixed (at 16 characters). The digits "n" (and "m") have the following meaning:

Xn System Status
- m=0 Normal
- m=1 Over heated
- m=2 Warming up

An Activity
- n=0 Hold
- n=1 To set point
- n=2 To zero
- n=4 Clamped

Cn LOC/REM status (n as for C command)
- n=0 Local & locked
- n=1 Remote & locked
- n=2 Local & unlocked
- n=3 Remote & unlocked
- n=4 Auto-run-down
- n=5 Auto-run-down
- n=6 Auto-run-down
- n=7 Auto-run-down

Hn MAIN switch heater (n as for H command)
- n=0 Main switch heater off Auto-Dump mode on (enabled)
- n=1 Main switch heater on Auto-Dump mode on (enabled)
- n=2 Main switch heater off Auto-Dump mode off (disabled)
- n=3 Main switch heater on Auto-Dump mode off (disabled)

Mmn MODE (m & n as for M command)
- m=0 Commanded (future) state = Standby
- m=1 Commanded (future) state = Active
- m=2 Commanded (future) state = Cycle
- m=3 Commanded (future) state = Dump
- m=4 Commanded (future) state = Latch
- n=0 Actual (present) state = Standby
- n=1 Actual (present) state = Active
- n=2 Actual (present) state = Cycle
- n=3 Actual (present) state = Dump
- n=4 Actual (present) state = Latch

Nn NAC status (mimic front panel activity lamps)
- n=0 Idle
- n=1 Sweeping
- n=2 Pausing

Pnn	Pointer	(nn as for P command)
	P0	Pointer off
	P1	Main magnet
	P2	Z0 shim coil
	P3	Z1 shim coil
	P4	Z2 shim coil
	P5	Z3 shim coil
	P6	X shim coil
	P7	Y shim coil
	P8	ZX shim coil
	P9	ZY shim coil
	P10	C2 shim coil
	P11	S2 shim coil

8.2 Control Commands

Fnn Set Front Panel to Display Parameter

The FRONT PANEL DISPLAY command sets the display to show one of the internal parameters rather than the normal demanded current or field. "nn" may take the same values as for the "Rnn" command above, with the same significance. Normal display operation may be restored by sending an F0 command. The command is intended chiefly for use during test and fault diagnosis.

Hn Set Main Switch Heater

The HEATER command performs two functions, as an on/off control for the main switch heater and as a means of disabling the Auto-Dump mode.

Allowed values for n are:

H0	Main switch heater off (close switch)	Auto-Dump mode on (enabled)
H1	Main switch heater on (open switch)	Auto-Dump mode on (enabled)
H2	Main switch heater off (close switch)	Auto-Dump mode off (disabled)
H3	Main switch heater on (open switch)	Auto-Dump mode off (disabled)

Control of the main switch heater is either directly from the ISS10 or via a seperate (main) magnet power supply. If the main heater is not configured for control by the ISS10 then the part of the command that controls the main heater on/off will be ignored (H0, H1 are identical, as are H2, H3).

Note that after issuing a command to change the state of the switch heater it is necessary to wait several seconds for the switch to respond before assuming that it has changed state.

Caution The ISS10 does not Know if the main magnet current terminals are connected to a suitable power supply. Controlling the main magnet heater from the ISS10 may cause a quench or even some damage to the magnet system as the ISS10 will energise a main magnet switch heater without making any checks.

The second function controlled by the H command is the disabling of the Auto-Dump function.

For normal operation, when the main magnet heater is energised and the main magnet is therefore not persistent, the ISS10 is forced into an 'Auto-Dump' mode. In this mode all the shims are dumped (held at zero current) this takes precedence over any other mode. When the ISS10 is switched off (and on), the machine reverts to the Auto-Dump ‘On’ state. A fuller description of this mode is given on page 23.

Inn Set Target Current

The I command sets the target current for the shim coil pointed to by the Channel Pointer. To select a shim channel the Channel Pointer must be set, refer to the Pnn command on page 34. The command will not be accepted if the power supply is in STANDBY mode.

The parameter nn is the required current sent as a number in accordance with section 7.4. The resolution of the set current is 0.001 amp, or 0.0001 amp if Extended Resolution has been selected, see Qn on page 34.

Lnn Set Persistent Current

The L command sets the persistent current for the shim coil pointed to by the Channel Pointer. To select a shim channel the Channel Pointer must be set, refer to the Pnn command on page 34. The command will only be accepted if the power supply is in STANDBY mode.

The parameter nn is the required current sent as a number in accordance with section 7.4. The resolution of the set current is 0.001 amp, or 0.0001 amp if Extended Resolution has been selected, see Qn on page 34.

Mn Set Mode

The MODE command sets the required operating mode for the ISS10. Mn may take the following values:

M0	Standby
M1	Active
M2	Cycle
M3	Dump
M4	Latch

8.3 System Commands

Yn Load RAM Contents

The Y command allows the entire contents of the RAM memory to be loaded in binary, via the serial or GPIB interface. It is not intended as a user command and will only be obeyed after a correct "U" password. If n is omitted or has the value 2, only the first 2 kilobytes of the memory will be loaded. If n has the value 8, the entire 8 kilobytes are loaded. Note that after loading the memory in this way, the new content will be lost at power-down, unless it has been saved by a STORE sequence as described in section 10.3.

Zn Dump RAM Contents

The Z command allows the entire contents of the RAM memory to be dumped in binary, via the serial or GPIB interface. It is not intended as a user command. Like the Y command, omitting n or setting it to 2 results in a 2 kilobyte dump. Setting n to 8 gives a full 8 kilobyte dump.

! Set ISOBUS Address

See section 7.5

8.4 Specialist Commands

In general the commands in this section are not intended for customer use. They have been provided for engineering use during algorithm development and to interface with certain Oxford Instruments application software. The details which follow are provided for interest only. They are correct for this version of firmware but future versions will not necessarily retain the commands in the same form. A command letter followed by ".." indicates that a numeric value should be appended to the command.

g Send Hex Reading

Send the internal value of a displayable variable. This allows the user to inspect the value of an variable to the full 24 bit resolution of the power supply. The x pointer should be set to "nn" where "Rnn" is the equivalent READ PARAMETER command. The y pointer must be set to 99. The response is sent as an (unsigned) 6 digit hexadecimal number.

h.. Set Hex Variable

Set the internal value of a displayable variable. This allows the user to set the value of a variable to the full 24 bit resolution of the power supply. The x pointer should be set to "nn" where "Rnn" is the equivalent READ PARAMETER command. The y pointer must be set to 99. The number must be sent as an (unsigned) 6 digit hexadecimal number.

Caution This command must be used carefully. As well as the numbers being difficult to relate to actual currents etc., the power supply makes no checks (such as current limits) before accepting the new value.

r Read Parallel Interface Port

Read the state of the 3 "free" input lines to the PARALLEL I/O port. This command allows digital signals to be passed transparently through the power supply to the communication interfaces.

The response is in the form of an integer in the range 0 to 7. The decimal number corresponds to the binary number presented to the bit 0 to bit 2 input pins of the Parallel I/O Port.

Note that the first two bits of this port are used by the optional suplimentary input device (or rotary encoder), see section 5.7.2. Therefore, in combination with this device, only bit 2 is available as a user input line.

s.. Set Parallel Interface Port

Set the state of the 7 "free" output input lines to the PARALLEL I/O port. This command allows digital signals to be passed transparently through the power supply from the communication interfaces.

The command should be in the form of an integer in the range 0 to 127. The decimal number corresponds to the binary number presented to the bit 0 to bit 7 output pins of the Parallel I/O Port.

x.. Set x Pointer

y.. Set y Pointer

The x and y commands set pointers into tables for loading and/or examining data values in the table. The sequence of operations is to is load either or both pointers as appropriate, then issue the command to load or examine the data. The number following ‘x’ or ‘y’ is a decimal integer in the range 0 to 128. If a command is issued with incorrect values set for x or y, that command will not be obeyed and an error response will be returned.

At power-up x and y are set to zero. None of the tables hold data at x=0, y=0; so it is good practise to leave x and y set to zero after use. This will ensure that if one of the "table" commands is issued inadvertently, it will always be rejected and produce an error response.

9 Auto-Run-Down

Auto-run-down will automatically de-energise a magnet system in response to an external signal. It does not provide a particularly fast means of doing so. It is primarily intended for use with a helium level meter, as a means of protecting a magnet from damage should the helium level in the magnet cryostat drop too far.

Caution This function can only operate if the power supply is left switched on.

The auto-run-down function is invoked via the rear panel connector marked "PARALLEL I/O", see section 5.7.1. The signal must be passed on to the main magnet power supply, this is done via the connector marked "ANALOGUE I/O", see section 5.8.1.

While auto-run-down is active, local and remote control are locked out and the lights in the front panel section marked "CONTROL" will flash. The operator cannot regain control of the power supply until the external signal is cleared (or disconnected).

The following sequence of actions are performed automatically when auto-run-down is active:-

I) The auto-run-down signal is transmitted to the main magnet power supply. The main magnet power supply is responsible for de-energising the main magnet.

ii) The ISS10 is triggered into the auto-dump mode (due to the main magnet switch heater being turned on). All shim coil currents are dumped to zero.

iii) When the ISS10 detects the main magnet power supply turning the main magnet switch heater off, the shim power supply will turn off all the shim heaters that it controls. Thus the magnet system is left in a state of zero electrical energy.

10 Test Mode

10.1 Entry to Test Mode

When switched on, the power supply performs a basic self test of the microprocessor and memory before displaying the firmware version message e.g. "SH1.01" followed by the GPIB address "G 26". A more detailed hardware test mode is accessed by one of two methods, either press the internal RED button, SW1, on the digital circuit board; or, press LOC/REM, RAISE and LOWER all at the same time. This will result in the message "tESt", which will shortly be followed by the test menu, consisting of a letter "t" and an integer. Test routines which may be of use to the user are described below.

Selecting a given test involves using RAISE and LOWER to display the test number required, then pressing LOC/REM to activate the test. Note that "t 00" is the correct route for exit from test mode and it also provides the STORE procedure for this instrument, see section 10.3.

Caution A complete memory initialisation may be achieved by pressing the internal RED button whilst holding both RAISE and LOWER pressed. This is a drastic measure which will destroy all the calibration data held in the non-volatile memory and so necessitate a complete re-calibration of the power supply. It should be used only if the memory content is known to be corrupt.

10.2 Test Menu

On entering test mode the message "tESt" is displayed, which will shortly be followed by the test menu, consisting of a letter "t" and an integer; initially, "t 00" will be displayed. RAISE and LOWER may be used to step through the menu options, when the required option is displayed, pressing LOC/REM will select it. The menu is cyclic, so that pressing RAISE when t 07 is displayed, will cycle back to t 00.

The Test Options are:

The Test Options are:

t 00 Exit test mode (and store changes in EEPROM)
t 01 Test front panel display and lamps
t 02 Test front panel buttons
t 03 Set the GPIB address
t 04 Select "F" menu (front panel display)
t 05 Select "P" menu (power supply calibration)
t 06 Magnet system configuration
t 07 Select "S" menu (superconducting magnet calibration)

All these tests are described below.

10.3 Test 00 Exit (and Storing Calibration Data)

This option should be used for exit from test mode. On exit the user is prompted to STORE any data that has been changed in test mode.

The power supply contains several types of memory circuits. Changes to any of the parameters in test mode will be retained while the power supply is switched on. If the changes are not stored then when the unit is switched on again, the original calibration parameters will be restored.

On entry to test 0, the display reads "Stor.y" press RAISE or LOWER and the display toggles to "Stor.n". Press LOC/REM to exit test 0 and return to the normal mode. If on exit, the display reads "Stor.y", then the calibration data will be stored. If the display reads "Stor.n", then the new data will not be stored. It is unlikely that a user will require the "Stor.n" option.

If "Stor.y" has been selected, The display will briefly show "Stor" indicating that the data has been correctly stored. If instead of showing "Stor", the display shows "Prot", this indicates that the memory is protected by the hardware WRITE-ENABLE switch being in the OFF position. This is Switch 1 of a small 2 way Dual-in-Line switch SW2 on the digital circuit board (CBL1200). Set it to the "ON" position and try again. The switch need only be returned to the OFF position if it is desired to prevent any possibility of the data being changed by someone tampering with the front panel. When the power supply leaves the factory, this switch is normally ON, allowing changes to be stored.

10.4 Test 01 Test Front Panel Lamps

Lights each LED or display segment in turn, then pulls each of the auxiliary (parallel interface) output lines low in turn. When the test is complete, the unit returns to the test menu.

10.5 Test 02 Test Front Panel Buttons

Tests the control buttons. When the test is entered, the display will be blank. If the buttons are pressed, one at a time, each should light a single segment in the upper half of the display. Stuck buttons will give a permanently lit segment. If more than one segment lights for a single button, track shorts are indicated. To leave test 2, POWER must be switched off.

10.6 Test 03 Setting the GPIB address

An Oxford Instruments power supply is normally supplied set to a GPIB address of 25. On accessing Test 3, the display will now show G.nn where nn is the current GPIB address. Use RAISE and LOWER to display the desired new address, then press LOC/REM to select it. The instrument will revert to the t.00 state. Pressing LOC/REM again will restart the instrument, with the new address in operation. Any address in the range 1 to 30 may be selected. (Although 31 may be selected, it is not a valid GPIB address since it is reserved for the UNTALK, UNLISTEN functions). Setting the GPIB address to 0 has a special significance. It DISABLES the GPIB interface ensuring that only RS232 operation is possible. To ENABLE it again it is only necessary to return to the t.03 mode and select a new non-zero address.

10.7 Test 04 F (Front Panel Display) Menu

allows the front panel display to be set to indicate one of the internal parameters rather than the normal demand current. This produces the same effect as the "Fnn" command described on page 39, without the need to connect a computer.

When test 4 is selected, the display will show "F 00" RAISE and LOWER may be used to select an option in the range 0 to 15 for front panel display. The options are as given in the list for the "Rnn" command on page 34. When the required option has been selected, pressing LOC/REM will implement it. The power supply will return to normal operation but with the selected parameter on display. To restore a normal display "F 00" should be selected. The options are listed below:-

R 0	Demand current (output current)	amps
R 1	Measured power supply voltage	volts
R 2	Measured output current	amps
R 3	Unused	
R 4	Target current	amps
R 5	Lead sweep rate	amps / minute
R 6	Magnet sweep rate	amps / minute
R 7	Trip current	amps
R 8 *	Scratch pad current	amps
R 9	Unused	
R 10 *	DAC zero offset	amps
R 11 *	Channel 1 frequency/4	
R 12 *	Channel 2 frequency/4	
R 13 *	Channel 3 frequency/4	
R 14	Unused	
R 15	Unused	

Variables marked with a "*" are intended as service diagnostics and are unlikely to be of use to the user.

10.8 Test 05 PSU (Power Supply) Menu

This menu provides access to a set of operations designed to be carried out when initially setting up a power supply. The majority will not be needed thereafter unless hardware changes are made.

Caution The "Psu" menu changes the calibration of the power supply and magnet.

"Psu" is entered from test 5 in the Test Menu, resulting in "PSU" being briefly displayed followed by "P" and an integer. RAISE and LOWER may be used to step through the menu and LOC/REM used to choose an option.

Note that the power supply may prevent casual entry to the Psu menu. If the user tries to enter this mode and the power supply current is not zero, a "not 0 Error" message will be displayed and the display returns to "t 00". This check is to protect the magnet system from damage as the output will be clamped on entry to the PSU menu and this may cause problems! The safety feature may be overridden by pressing and holding LOC/REM whilst the error message is displayed.

The table which follows lists the available options.

P 00	Return to test menu
P 01	Set output current
P 02	Define power supply current range
P 03	Adjust power supply zero correction
P 04	Step through DAC outputs
P 05	Test heater outputs
P 06	Not used
P 07	Not used
P 08	Not used
P 09	Not used
P 10	Calibrate voltage monitor at negative voltage limit
P 11	Calibrate voltage monitor at positive voltage limit
P 12	Auto-calibration of current monitor
P 13	Not used
P 14	Auto-zero power supply
P 15	Not used

Psu 01 Direct Control of Output Current

This test provides direct control over the shim power supply current output. The test requires that the normal connections to the cryostat be removed. The normal operation of the unit (sweeping automatically) is disabled. The current sweep rate is set by the "sweep rate for leads", see S 03 on page 51. Four of the channel buttons are 'borrowed' for control:-

MAIN	Press to 'hold' the output at the present current. Also can be used to adjust the output current, press and hold MAIN then press RAISE or LOWER in the usual manner to adjust the output current.
Z0	Sweep to zero amps.
Z1	Sweep to maximum current limit (+20 amp).
Z2	Sweep to minimum current limit (-20 amp).

Psu 02 Define Power Supply Current Range.

Caution Oxford Instruments advises the user not to change the current range unless a precision high current shunt is available for re-calibration. Note that changing this parameter will also affect **all** other "Psu" and "Sup" calibrations. Perhaps what is required is test 7, Sup 2, define power supply current limit?

On entry, the display shows "I CAL" (current calibrate), press LOC/REM again and the power supply returns to the menu. To display or adjust the current range, display I CAL then press RAISE, LOWER and LOC/REM.

The number is set to the rated output current of the power supply, for example, 120.000 for a normal IPS120-10. Initially, RAISE and LOWER may be used to shift the decimal point to the required position. Depress LOC/REM and use RAISE and LOWER to set the number required.

Psu 03 Adjust Power Supply Zero Correction

This is a software trim for the zero current of the power supply. On entry, the present value is displayed as a number of amps, depressing LOC/REM allows this value to be adjusted over a small range. The default setting is 00.000

For the duration of this test, the output of the power supply is unclamped, thus the offset current can be measured between the power supply's magnet terminals. An easy way of doing this is to place a 1 kohm resistor across the output, and measure the voltage across it to the scale of 1 volt/mA.

Psu 04 Step Through DAC Outputs

This test is intended for checking the output of the power supply's DAC. For the duration of this test, the output of the power supply is clamped. Therefore no current will flow between the magnet terminals and the output of the DAC can be safely measured at test point TP303 on the analogue pcb (mounted upside down in the top of the power supply).

On entering Psu 04, the display will briefly read "d 00" followed by -10.0000 volts. This display indicates approximately what voltage the DAC should output. Pressing RAISE or LOWER will cycle the DAC from "d 01" to "d 16", while the button is depressed the display will read "d nn", indicating which data line to the DAC is made active. When the button is released, the calculated DAC output voltage will be displayed. To exit Psu 04, press LOC/REM.

Psu 05 Control of Switch Heater Outputs

This test provides direct control over the shim switch heater outputs. The normal connections to the cryostat be removed. Press any shim channel buttons and the corresponding switch heater output will be latched on or off. On entry the display will read "H ---", all the bars are low, as switch heaters are turned on, one or more bars will go high.

Psu 10 Calibrate Voltage Monitor at the Negative Limit

Psu 10 calibrates the measured voltage at the negative voltage limit, normally about -4 volts

Psu 11 Calibrate Voltage Monitor at the Positive Limit

Psu 11 calibrates the measured voltage at the positive voltage limit, normally about +4 volts.

Psu 10 and Psu 11

These tests calibrate the power supply voltage monitor. The normal connections to the cryostat must be removed. A voltage meter set to read at least ±10 volts should be connected from the MAGNET- to the MAGNET+ terminals.

On entry to Psu 10 or Psu 11, the power supply will display "PAUSE" as the output voltage sweeps to the (hardware) voltage limit. The display will then change to show the measured output voltage. To alter the calibration, depress LOC/REM and use RAISE and LOWER to set the display to the voltage measured on the external voltage meter. Releasing LOC/REM causes the output voltage to clamp and drop to about 1/10th of its normal value. Pressing the LOC/REM button once more to return to the "Psu" menu.

Exit from Psu 10 and Psu 11 must be via the correct route else corruption of the zero setting of the power supply will result. Pressing LOC/REM at any time will abort the test and return to the Psu menu.

If large adjustments are needed, it will probably be necessary to repeat Psu 10 and Psu 11 until both points are calibrated.

To change the hardware voltage limits, the power supply must be opened up and access obtained to the analogue pcb, CBL1300. To adjust the negative limit, enter Psu 10 as described above and adjust RV301 to set the required limit. To adjust the positive limit, enter Psu 11 as described above and adjust RV302 to set the required limit.

Psu 12 Auto-Calibration of Current Monitor

This test automatically calibrates the measured lead current of the power supply. This test requires that the normal connections to the cryostat be removed. A link capable of 20 amps should then be connected between MAGNET- and MAGNET+.

After entering Psu 12, the calibration is performed automatically but the display indicates some

i) Display measured current
ii) Sweep to the +ve current limit and allow to settle
iii) Sweep to the -ve current limit and allow to settle
iv) A gain calculation is now performed
v) Sweep to zero and allow to settle
vi) Null measured current
vii) Display measured current for 2 second
viii) Exit to "Psu" menu.

thing of what is happening:-

This calibration should only be performed when the power supply is "warm", that is, when it has been running for at least 15 minutes.

Psu 14 Auto-Zero Voltage and Current Monitors

automatically zeros the voltage and then the current measured by the power supply. This test requires existing connections to the "magnet" and "switch heater" terminals to be removed. A wire link or busbar should then be connected between MAGNET- and MAGNET+.

After entering Psu 14, the zeroing is performed automatically but the display indicates something of what is happening:-

i) Display measured voltage for 2 second
ii) Null measured voltage
iii) Display measured voltage for 2 second
iv) Display measured current for 2 second
v) Null measured current
vi) Display measured current for 2 second
vii) Exit to "Psu" menu.

This calibration should only be performed when the power supply is "warm", that is, when it has been running for at least 15 minutes.

The error message "driFt Error" will be displayed if the output voltage drifts while zeroing. Ensure that the output link is correctly placed.

10.9 Test 06 Magnet System Configuration

Configuration defines what type of magnet system will be used with the power supply. On entry to test 6, a number in the range 0 to 255 is displayed, this represents "configuration" and may be adjusted by pressing LOC/REM and using RAISE and LOWER, releasing LOC/REM returns to the test menu.

At present the only permitted value for configuration is 0.

10.10 Test 07 SUP(erconducting magnet) Menu

The "Sup" menu provides access to a set of operations designed to be carried out when initially setting up a magnet system. The majority will not be needed thereafter unless hardware changes are made.

"Sup" is entered from test 7 in the Test Menu, resulting in "Sup" being briefly displayed followed by "S" and an integer. RAISE and LOWER may be used to step through the menu and LOC/REM used to choose an option.

The table which follows lists the available options.

S 00 Return to test menu
S 01 Not used
S 02 Define power supply current limit
S 03 Define sweep rate for leads
S 04 Define sweep rate for shim coils
S 05 Define which shim channels are controllable
S 06 Define which shim channels are always on when in auto-dump
S 07 Adjust switch open time
S 08 Adjust switch close time
S 09 Adjust shim coil settle time
S 10 Adjust lead settle time
S 11 Adjust unstable output time
S 12 Not used
S 13 Not used
S 14 Not used
S 15 Not used

Sup 02 Define Power Supply Current Limit

defines the power supply current limit. On entry the present limit is displayed and may be adjusted by depressing LOC/REM and using RAISE and LOWER. It will not be possible to set a SET POINT current greater than this limit.

Sup 03 Define Sweep Rate for Leads

Sets the sweep rate for the leads (all shim coils in persistent mode). The default rate is 200.00 amps per minute.

Sup 04 Define Sweep Rate for Shim Coils

Sets the sweep rate for the shim magnets (switch heater energised). The default rate is 020.00 amps per minute.

Sup 03 and Sup 04

Set the output current sweep rates in units of amps per minute. Press RAISE or LOWER to display the maximum or minimum values for rate of change of current. Depressing LOC/REM a second time allows the user to adjust the selected sweep rate with RAISE and LOWER. The adjustment will start from whatever number is displayed when LOC/REM is pressed, this allows the numbers to be changed rapidly from one end of the range to the other. Releasing LOC/REM returns to the "S" menu.

Sup 05 Define Controllable Channels

This test defines which of the channels are controllable from the shim power supply. There are eleven channels which can be controlled, ten shim channels and the main magnet switch heater. On entry, the display reads "Cont" and the lamps will be lit for all channels that are controllable. To toggle the state of a channel, press the associated button. To exit press LOC/REM.

All shim channels that are in the cryostat should be selected. Normally the main magnet switch heater is turned off as it is controlled from the main magnet power supply and not from the front panel button. However, if the main magnet power supply has no switch heater output, then the shim power supply control will be required. Please note that if the main magnet switch heater is controlled from a separate power supply then the ISS10 must be connected in parallel (see section 5.8.2).

Sup 06 Define Always On in Auto-Dump

This test defines which of the channels are always held open (switch heaters energised) when in auto-dump mode. Only those channels which are controllable (see Sup 05) may be selected. On entry, the display reads "Ad on" and the lamps will be lit for all channels that are always on. To toggle the state of a channel, press the associated button. To exit press LOC/REM.

Normally only strongly coupled coils will be selected (such as Z0 and Z2). Note that the MAIN channel can not be turned off.

Sup 07 Define Open Spell

Displays as “OPEN SPELL”. Sets the delay time for a switch heater and switch to warm up, before making a change in the shim coil current.

Sup 08 Define Close Spell

Displays as “CLOSE SPELL”. Sets the delay time for a switch to cool down, before sweeping the leads to a new current.

Sup 09 Define Coil Spell

Displays as “COIL SPELL”. Sets the delay time at the end of sweeping a shim coil. This allows the various fields and inductive coupling to settle before closing the switch.

Sup 10 Define Lead Spell

Displays as “LEAd SPELL”. Sets the delay time at the end of sweeping the leads (does not need to be long).

Sup 11 Define Unstable (bad) Current Spell

Displays as “I bAd SPELL”. If the output becomes unstable (the current can not be controlled and it voltage limits) then after this delay time, the system drops into STANDBY. This may happen if the shim current leads not connected.

Sup 07, Sup 08, Sup 09, Sup 10 and Sup 11

defines the times for which the "Change Shim Current" state machine will wait (see diagram CCB0981 page 2 of 2, which shows all the NAS states). On entry to each of these procedures, a message such as "OPEN SPELL" is displayed, then a number. The number is the delay time and is defined in units of 1/4 second (approximately). It can be adjusted by depressing LOC/REM and using RAISE AND LOWER. The spell can be set to any value between 1 and 255 inclusive (between 1/4 second and about 1 minute), it is not possible to set a delay of 0.

The table below summarises the differences

Test	Display On Entry	Default Value	Equivalent Time	State CCB0981 2 of 2
Sup 07	OPEN SPELL	00008	2 seconds.	NAS3
Sup 08	CLOSE SPELL	00020	5 seconds.	NAS6
Sup 09	COIL SPELL	00020	5 seconds.	NAS5
Sup 10	LEAd SPELL	00004	1 second	NAS2 & NAS7
Sup 11	I bAd SPELL	00020	5 seconds	NAS8 & NAS9

11 Specification

Output Current	-20 to +20 amps DC
Voltage Compliance	+4 volts to -4 volts
Current Resolution	
Front Panel	1 mA
Computer Interface	0.1 mA
Current Stability	±1 mA per °C
over a 12 hour period	±1 mA, ambient temp. 25 ±1 °C
Current Sweep	Digitally generated
Sweep Rate	0.01 amp/min to 200 amp/min in units of 0.01 amp/min
Current Noise/Ripple	Less than 0.05% of full scale
Shim Switch Heater Output	70 mA into 100 Ohms (> 200 mA into 0 Ohms)
Main Magnet Switch Heater Output	120 mA into 100 Ohms or 120 mA into 200 Ohms
Remote Interfaces	
RS232	Configured as DCE
GPIB	To IEEE-488 standard
Connectors	
Power In	6 amp IEC
Shim Connector	20 way Cinch connector
RS232	25 way D socket
GPIB	Standard IEEE-488 connector
Digital I/O	15 way D socket
Analogue I/O	9 way D socket
Ambient Temperature	0-40 °C.
Cooling	Forced Air, 400 W maximum
Power Requirements	200-240 V 50/60 Hz or 100-120 V 50/60 Hz
Power Consumption	380 VA maximum

Dimensions			
	Free-Standing	Height	135 mm
		Width	585 mm
		Depth	530 mm
	Rack Mounted	3U high	
Weight		20 kg	

Environment

The followong operatng einviroment conditions must be observed;

Maximum magnetic field	50 GAUSS
Ambient temperature	18 to 30 Celsius
Atmospheric pressure	700 to 1060 mbar(10 to 15 psi)
Relative humidity	30% to 75% non- condensing
Vibration	10 G (20 ms)

5 G intermittent 0.5 G continous, 5 to 200 Hz broadband,with a sweep rate of octave/min

Handling and Storage Including Transport

The module may be stored for up to 15 weeks in a storage enviroment as follows;

Ambient temperature	-20 to 55 Celsius
Relative humidity	30% to 75% (non- condensing)
Atmospheric pressure	700 to 1060 mbar

If storage is for less than than 3 days then the following environmental restrictions apply;

Ambient temperature	-40 to 55 Celsius
Relative humidity	30% to 75% (non- condensing)
Atmospheric pressure	700 to 1060 mbar

Marking for packaging and handling complies with international standards ISO 780/BS2770.

Maintenance

Preventive maintenance

Warning

Access within the equipment and removal of connecting cables is restricted to suitably skilled and competent persons. See Warning and CAUTIONS.

Maintenance interval

Six months or as for cleaning if more frequent.

Cleaning

External cleaning

Interval between cleaning is as required by appearance.

Warning

Ensure that the AC supply to the equipment is isolated at the external disconnect device before cleaning. See warnings and cautions.

To remove surface dust and light markings, the equipment may be wiped down using lint free cloth, barely moistened with clean water. For removal of heavy marks, the use of a proprietary aerosol foaming cleaner is permissible. Test carefully on a small inconspicuous area to ensure that the product does not damage the surface finish.

Connections

Warning

High voltage hazard. Ensure that the AC supply to the equipment is isolated at the external disconnect switch before accessing any connection.

Check all cables and connections to the equipment for mechanical and ensure all covers are securely fixed in place.

Mains cord selection

Mains supply cord shall be rated for the maximum current for the equipment and the cable used shall meet the requirements of IEC227 or IEC245, mains cords certified or approved by any recognised national test house are regarded as meeting this requirement.

Green/Yellow covered conductors shall be used only for connection to protective conductor terminals.

Rack Mounting Instruction

When the ISS-10 is supplied as a stand-alone unit, it should be installed in a 19 –inch rack for ease of handling. When it is supplied as a part of a larger system, the units will be racked together with the remainder of the system. The rack must be earthed.

12 Quick Reference Guide

12.1 Front Panel Controls

OUTPUT VOLTS Display power supply output voltage.

STANDBY Output contactor clamped, all switch heater outputs off.

ACTIVE From STANDBY: Open output contactor, enable control of switch heaters, shim current setting and all other modes.

When in ACTIVE, CYCLE or DUMP states:
No change in mode but show any channels on the stack.

To enter LATCH mode, press and hold the ACTIVE button and press the channel button. To exit press ACTIVE again.

CYCLE Sweep to each shim magnet (in turn) and re-assert the target current.

DUMP Sweep to each shim magnet (in turn) and take the current to zero. Press CYCLE to restore shim currents.

SWEEPING
PAUSING One of these leds will be lit whilst there are changes being made to the shim currents.

MAIN + ACTIVE Energise main magnet switch heater
(may be controlled by the main magnet power supply).

MAIN + DUMP	Auto-Dump mode	Enabled	Disenable
	Display reads	Ad On	Ad OF

Z0 Z1 Z2 Z3 X Y
ZX ZY C2 S2 In STANDBY mode, display persistent current in the shim coil. Press STANDBY again to adjust persistent current.

In ACTIVE mode, display persistent current then target current for a shim coil. Adjust target current using RAISE and LOWER.

To enter LATCH mode, press and hold the ACTIVE button and press the channel button. To exit press ACTIVE again.

RAISE Increase the value of a displayed variable.

LOWER Decrease the value of a displayed variable.

LOC / REM Enter test mode.
+ RAISE + LOWER

12.2 Serial and GPIB Commands

Cn	Set Control	C0 local, C1 remote, +2 to unlock.
Fnn	Set Front Panel to Display Parameter	see section 0
G	Read Heater Information	
Hn	Set Main Switch Heater	H0 off, H1 on, +2 to turn off Auto-Dump
Inn	Set Target Current	
J	Read Shim Current (actual current)	
K	Read Shim Target Current	
Lnn	Set Persistent Current	
Mn	Set Mode	M0 Standby, M1 Active, M2 Cycle, M3 Dump, M4 Latch
Pnn	Set Channel Pointer	
	P0	Pointer off (power-up default)
	P1	Main magnet
	P2	Z0 shim coil
	P3	Z1 shim coil
	P4	Z2 shim coil
	P5	Z3 shim coil
	P6	X shim coil
	P7	Y shim coil
	P8	ZX shim coil
	P9	ZY shim coil
	P10	C2 shim coil
	P11	S2 shim coil
Qn	Set Communications Protocol	
Rnn	Read Display Parameter,	see section 0
S	Send List of Stacked Shim Channels	
T	Read State Machine Status	
Unn	Unlock System Commands	
V	Read Version	
Wnn	Set Wait Interval	
X	Examine Status:	XnAnCnHnMmnNnPnn
Yn	Load RAM Contents	
Zn	Dump RAM Contents	
!	Set ISOBUS Address	

Specialist Commands

g	Read Hex Reading
h	Set Hex Variable
r	Read Parallel Interface Port
s	Set Parallel Interface Port
x...	Set x Pointer
y...	Set y Pointer

12.3 Test Mode

Note that if any parameters are changed in test mode, then to be retained after power down, the STORE procedure must be used; see t 00, section 10.3.

t 00 Exit (& store in EEPROM)
Toggle "Stor.y" and "Stor.n" using RAISE or LOWER, exit using LOC/REM.

t 01 Test front panel display and lamps

t 02 Test front panel buttons

t 03 Set the GPIB address from 1 to 30 (0 to 31).

t 04 Select "F" menu, set front panel display, see section 0

t 05 Select "P" menu, power supply calibration

- **P 00** Return to test menu
- **P 01** Set output current: **MAIN** hold, **Z0** 0A, **Z1** +20A, **Z2** -20A.
- **P 02** Define power supply current range
- **P 03** Adjust psu zero correction
- **P 04** Step through DAC outputs
- **P 05** Test heater outputs
- **P 10** Calibrate psu voltage at negative voltage limit
- **P 11** Calibrate psu voltage at positive voltage limit
- **P 12** Auto-calibration of measured current
- **P 14** Auto-zero power supply

t 06 Magnet system configuration - No function at present.

t 07 Select "S" menu, shim magnet calibration

S 00 Return to test menu

- **S 02** Define power supply current limit
- **S 03** Define sweep rate for leads
- **S 04** Define sweep rate for shim coils
- **S 05** Define which shim channels are controllable
- **S 06** Define which shim channels are always on in Auto Dump
- **S 07** Define PAUSING time for a shim switch to open
- **S 08** Define PAUSING time for a shim switch to close
- **S 09** Define PAUSING time at the end of a shim current sweep
- **S 10** Define PAUSING time at the end of a lead current sweep
- **S 11** Define PAUSING time for unstable output to force STANDBY

12.4 Display Parameters

These numbers identify the display variables for the two computer interface commands, **Fnn** and **Rnn**. The test mode, **t 04**, sets the front panel display using the same numbers.

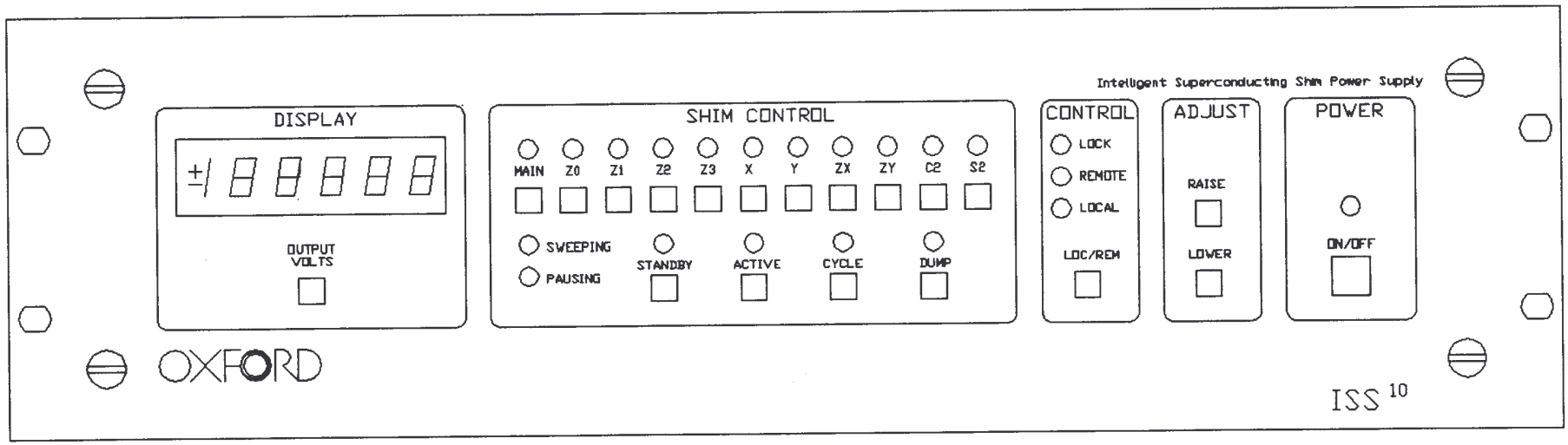
Some parameters are marked E.R., if the computer interface has been set to extended resolution mode, then the reply to the Rnn command includes an extra decade.

0	Demand current (output current)	amps	E.R.
1	Measured power supply voltage	volts	
2	Measured magnet current	amps	
3	Unused		
4	Target current	amps	E.R.
5	Leads sweep rate,	amps / minute	E.R.
6	Magnet sweep rate	amps / minute	E.R.
7	Trip current	amps	E.R.
8	Scratch pad current	amps	E.R.
9	Unused		
10	DAC zero offset	amps	E.R.
11	Channel 1 freq/4		
12	Channel 2 freq/4		
13	Channel 3 freq/4		
14	Unused		
15	Unused		

13 Circuit Diagrams

The diagrams that follow are listed below.

Drawing No.	No. of pages	Description
CCB0980	1 of 1	Front Panel Assembly
CCB0981	1 of 2 2 of 2	State Machine for Operator Interface State Machine to Change Shim Current
CCB0982	1 of 1	Connections to other units
CCB1102	1 of 1	Key / Display PCB
CBL1202	1 of 4 2 of 4 3 of 4 4 of 4	Digital PCB CPU, Memory and Timing Digital PCB Input / Output Ports Digital PCB RS232 and GPIB Interface Digital PCB De-Coupling Capacitors etc.
CCB1302	1 of 5 2 of 5 3 of 5 4 of 5 5 of 5	Analogue PCB Output Control Analogue PCB Current Control Analogue PCB Analogue / Digital Interface Analogue PCB Power Control Analogue PCB Driver / Telemetry Interface
CBI1402	1 of 1	Pass Bank Unit
CBI1602	1 of 1	Mains Wiring
CCB2902	1 of 1	Wiring Loom



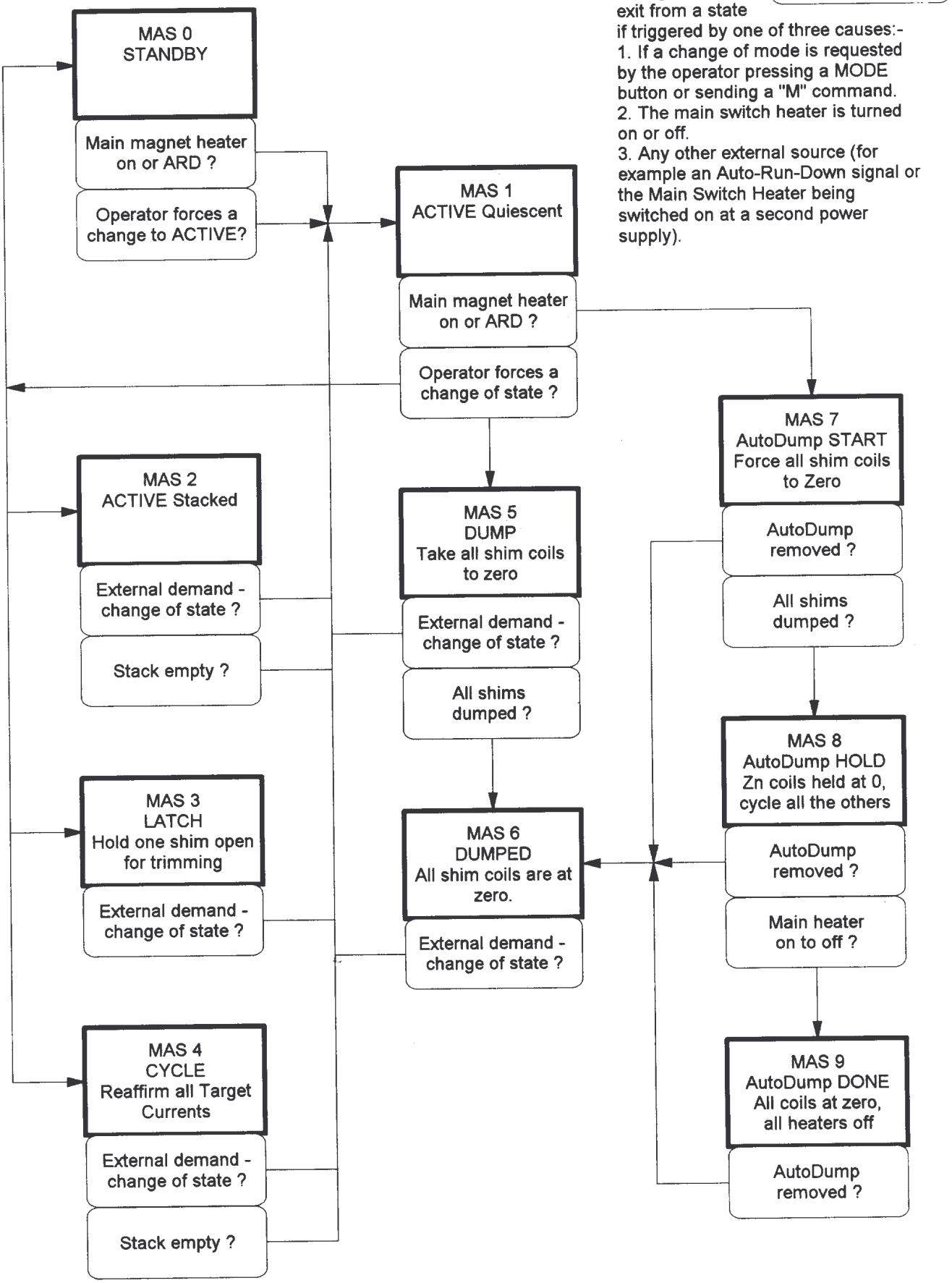
			ISS10 SHIM POWER SUPPLY FRONT PANEL ASSEMBLY
			OXFORD
			DRAWING NUMBER A4/ CCB0980
01	06/12/94		

This state diagram represents the control logic for the ISS-10 shim power supply.

At the top level, a state machine handles the operator commands such as STANDBY, ACTIVE, CYCLE and DUMP and LATCH.

External demand - change of state ?

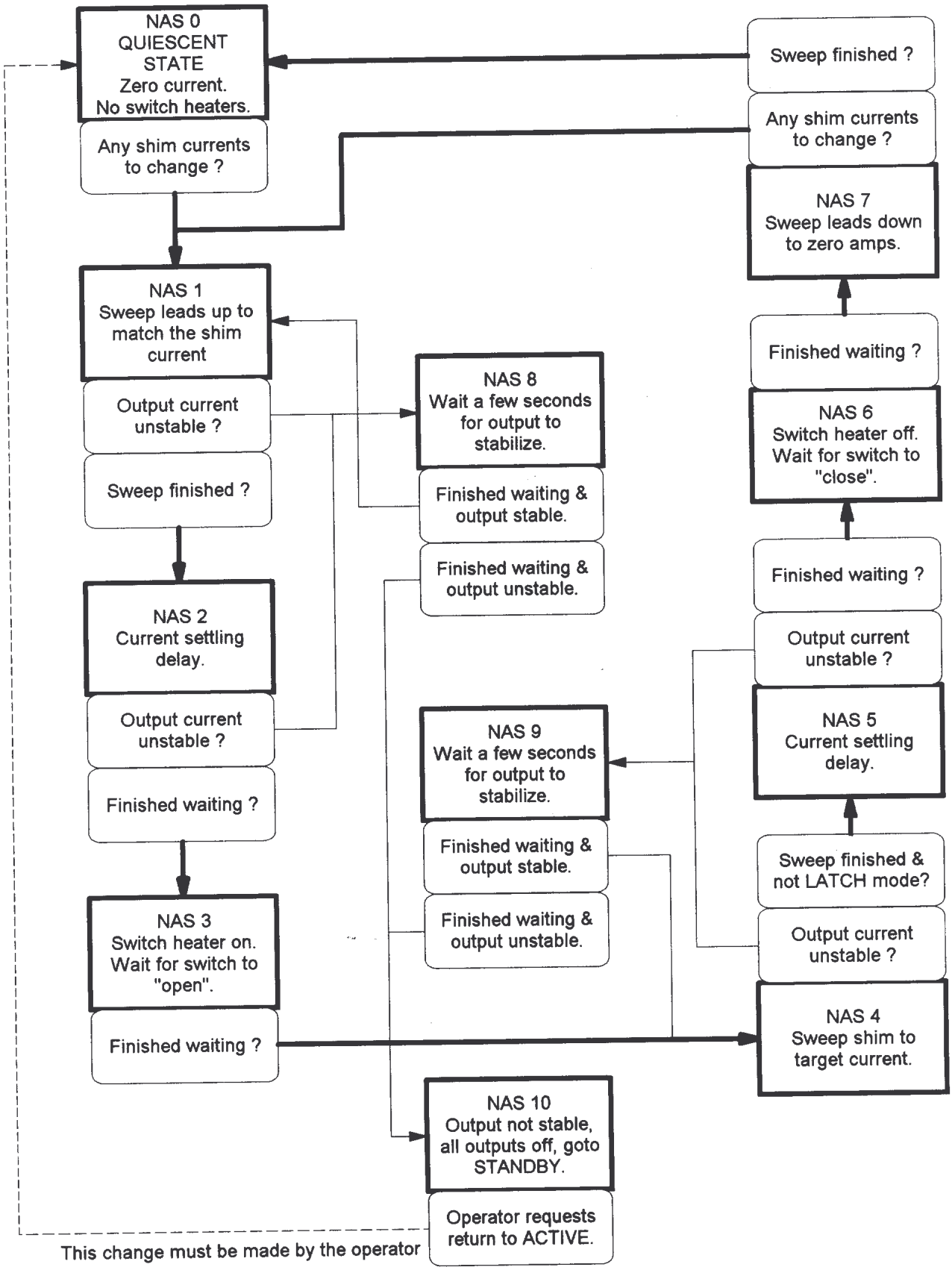
The box shown on the right causes exit from a state if triggered by one of three causes:-
1. If a change of mode is requested by the operator pressing a MODE button or sending a "M" command.
2. The main switch heater is turned on or off.
3. Any other external source (for example an Auto-Run-Down signal or the Main Switch Heater being switched on at a second power supply).

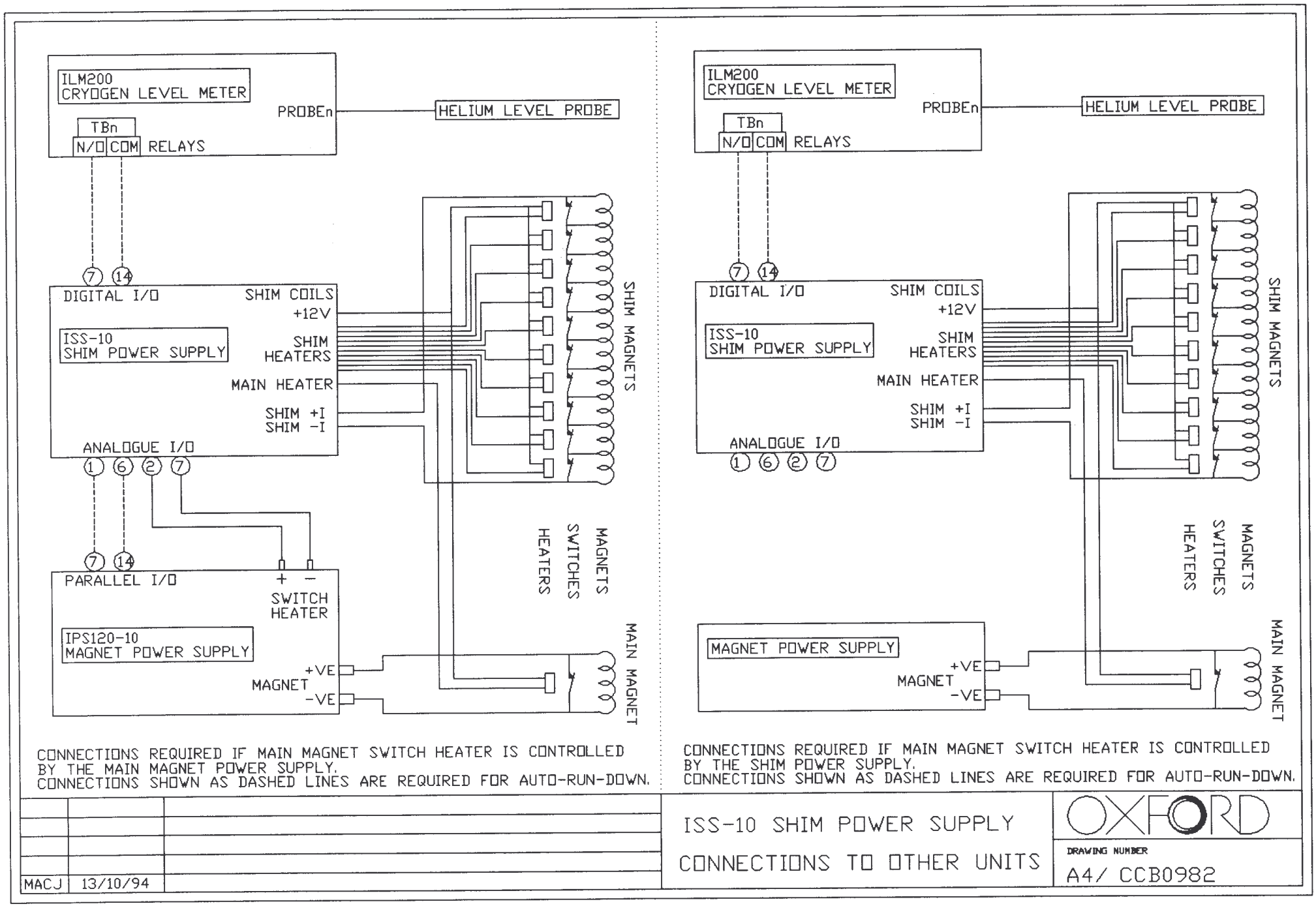


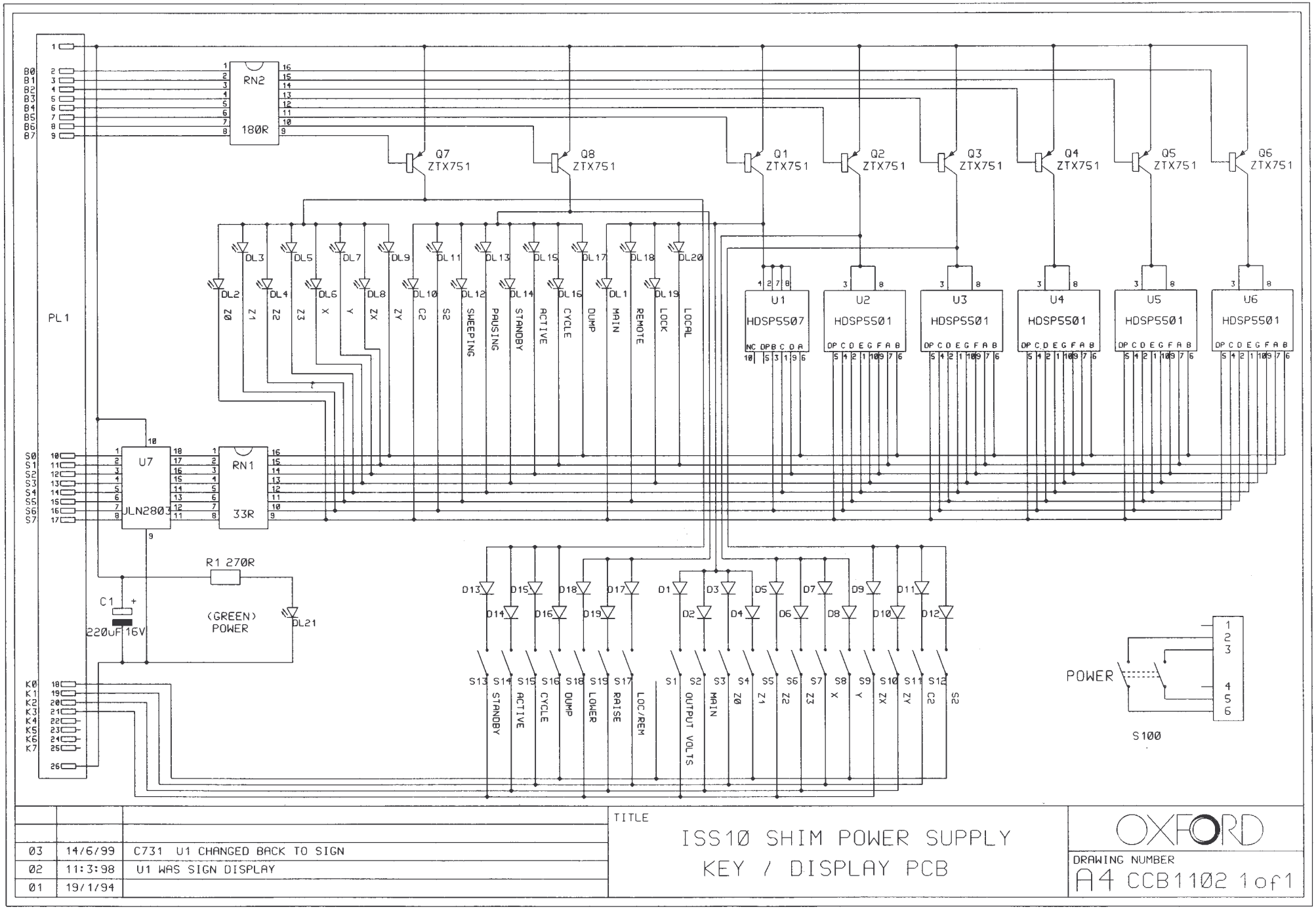
CCB0981 Revision 02 24/05/95 Diagram 2 of 2.
For SH1.03 firmware. CHANGE SHIM CURRENT

This state diagram represents the control logic for the ISS-10 shim power supply.

At a lower level a state machine controls how the power supply changes the individual shim currents. This machine can process a series of changes to any shim currents. The changes are stored on a 'stack'. The left and right columns describe the normal operation of the machine, the central column indicates the operation if the output becomes unstable.




ILM200
CRYOGEN LEVEL METER
PROBEn
HELIUM LEVEL PROBE
TBn
N/O COM RELAYS
7 14
DIGITAL I/O
SHIM COILS
+12V
ISS-10
SHIM POWER SUPPLY
SHIM
HEATERS
MAIN HEATER
SHIM +I
SHIM -I
ANALOGUE I/O
1 6 2 7
SHIM MAGNETS
PARALLEL I/O
+ -
SWITCH
HEATER
IPS120-10
MAGNET POWER SUPPLY
+VE
MAGNET
-VE
HEATERS
SWITCHES
MAGNETS
MAIN MAGNET
CONNECTIONS REQUIRED IF MAIN MAGNET SWITCH HEATER IS CONTROLLED
BY THE MAIN MAGNET POWER SUPPLY.
CONNECTIONS SHOWN AS DASHED LINES ARE REQUIRED FOR AUTO-RUN-DOWN.
ILM200
CRYOGEN LEVEL METER
PROBEn
HELIUM LEVEL PROBE
TBn
N/O COM RELAYS
7 14
DIGITAL I/O
SHIM COILS
+12V
ISS-10
SHIM POWER SUPPLY
SHIM
HEATERS
MAIN HEATER
SHIM +I
SHIM -I
ANALOGUE I/O
1 6 2 7
SHIM MAGNETS
MAGNET POWER SUPPLY
+VE
MAGNET
-VE
HEATERS
SWITCHES
MAGNETS
MAIN MAGNET
CONNECTIONS REQUIRED IF MAIN MAGNET SWITCH HEATER IS CONTROLLED
BY THE SHIM POWER SUPPLY.
CONNECTIONS SHOWN AS DASHED LINES ARE REQUIRED FOR AUTO-RUN-DOWN.
MACJ 13/10/94
ISS-10 SHIM POWER SUPPLY
CONNECTIONS TO OTHER UNITS
OXFORD
DRAWING NUMBER
A4/ CCB0982



03	14/6/99	C731 U1 CHANGED BACK TO SIGN
02	11:3:98	U1 WAS SIGN DISPLAY
01	19/1/94	

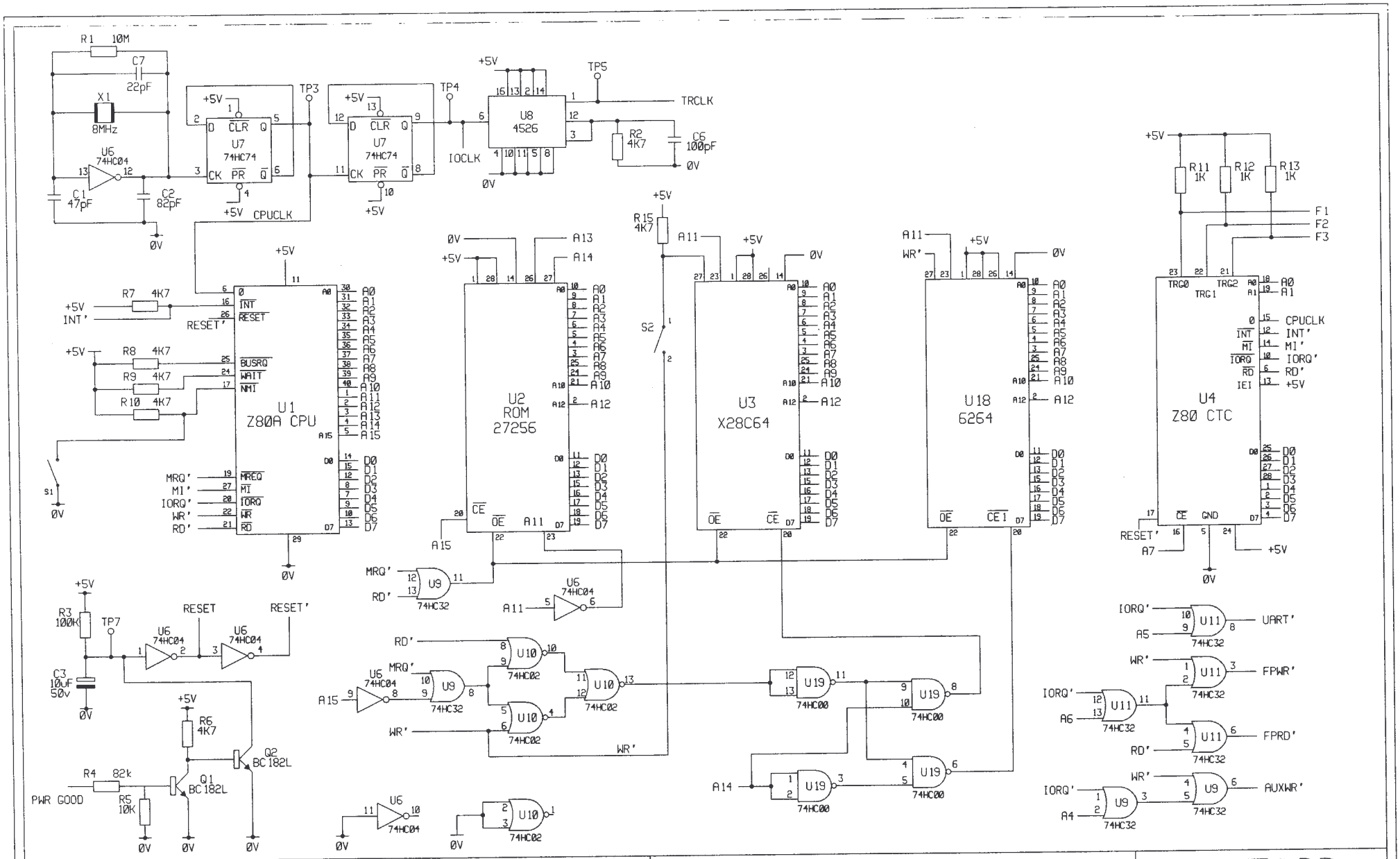
TITLE

ISS10 SHIM POWER SUPPLY
KEY / DISPLAY PCB

OXFORD

DRAWING NUMBER

A4 CCB1102 1of1



3	14/8/95	
02	17/5/94	
01	RJM	

TITLE

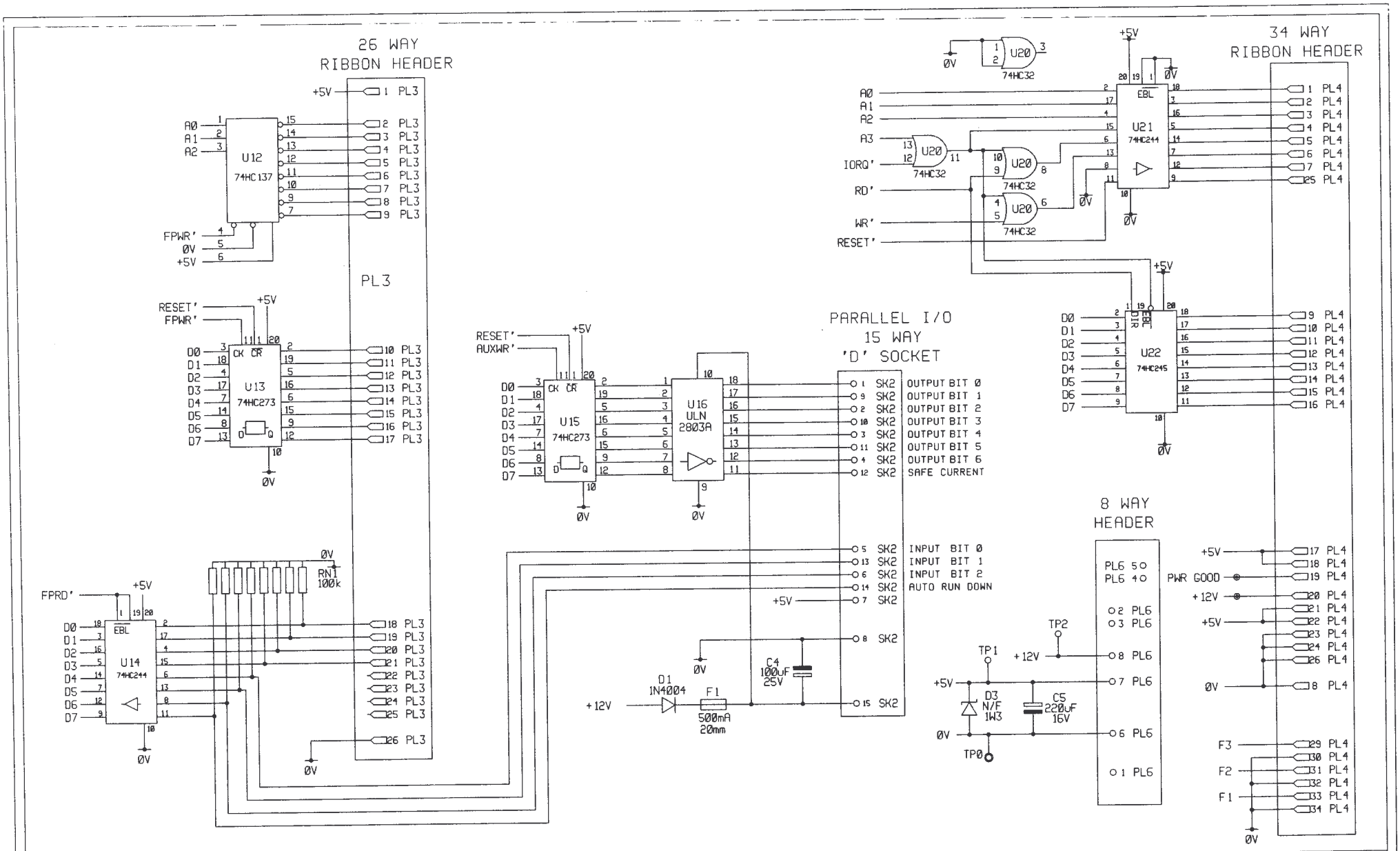
ISS10 DIGITAL PCB

CPU, MEMORY AND TIMING

OXFORD

DRAWING NUMBER

A4 CBL 1202 1 of 4



3	14/8/95	EMC MODS C9 DELETED
02	17/5/94	
01	RJM	

TITLE

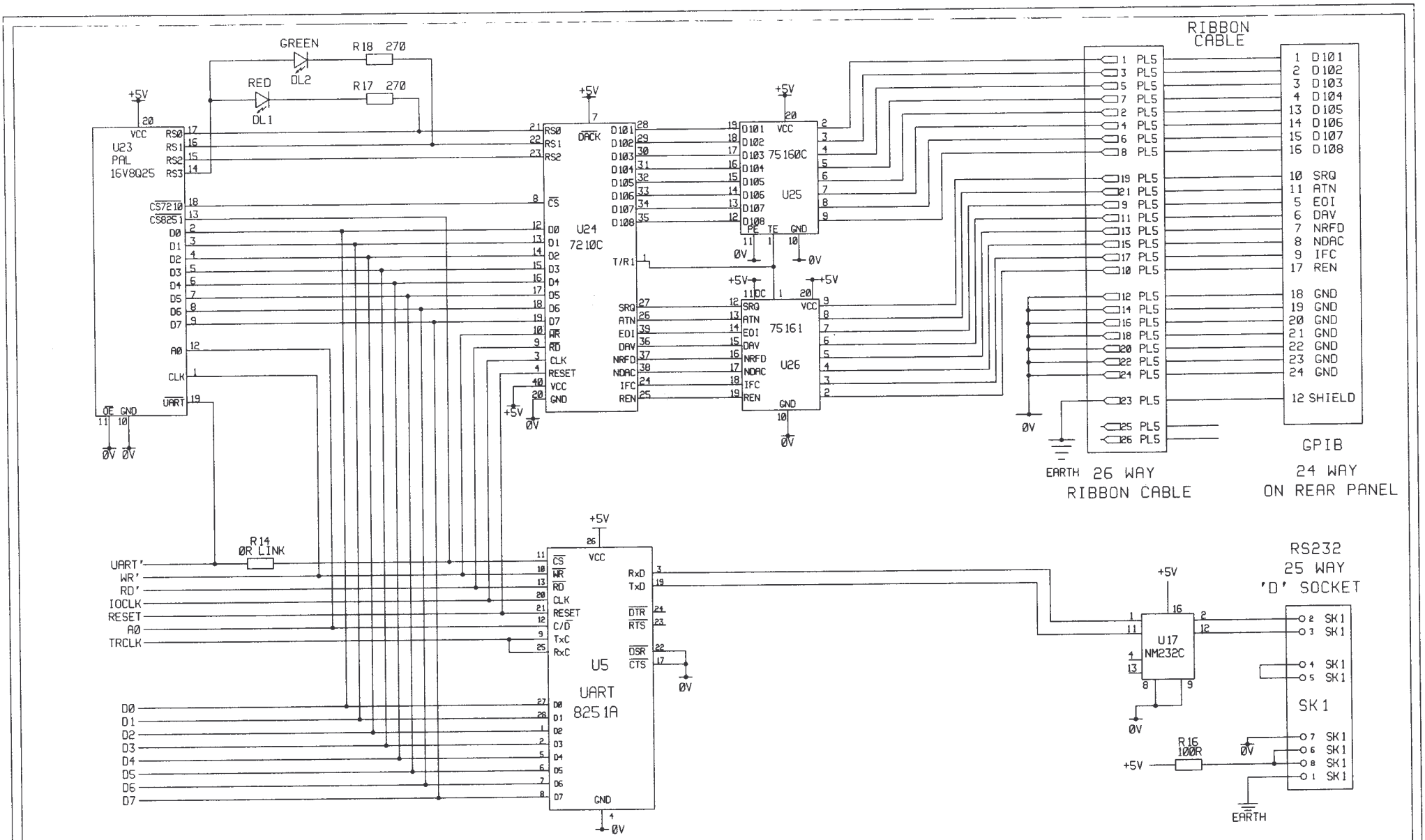
ISS10 DIGITAL PCB

INPUT / OUTPUT PORTS

OXFORD

DRAWING NUMBER

A4 CBL1202 2of4

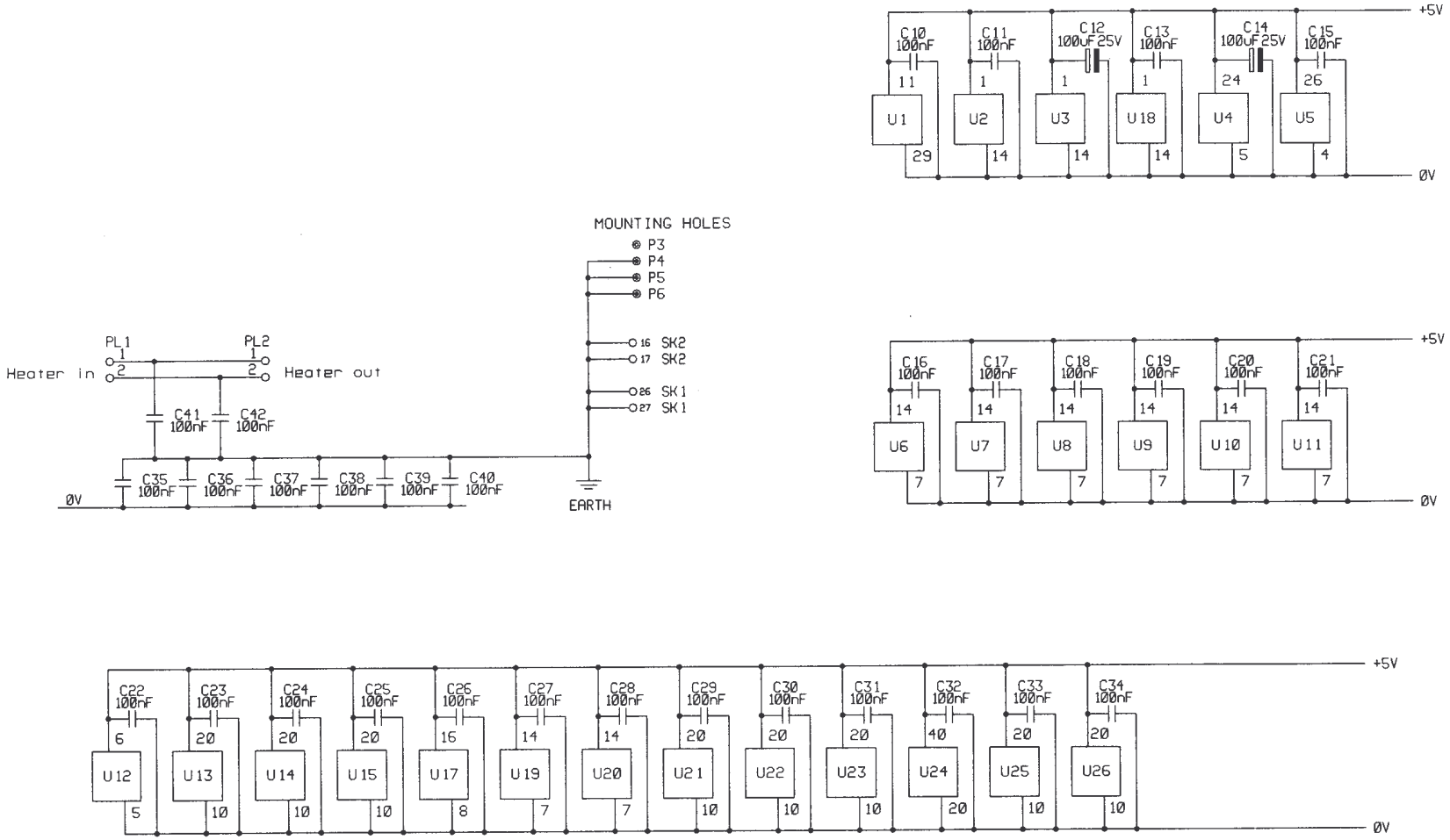


			TITLE
			ISS10 DIGITAL PCB
3	14/8/95	EMC MODS	RS232 AND GPIB INTERFACE
02	17/5/94		
01	RJM		

OXFORD

DRAWING NUMBER

A4 CBL 1202 3 of 4



3	14/8/95	EMC MODS C35-42, PL1-2
02	17/5/94	
01	RJM	

TITLE

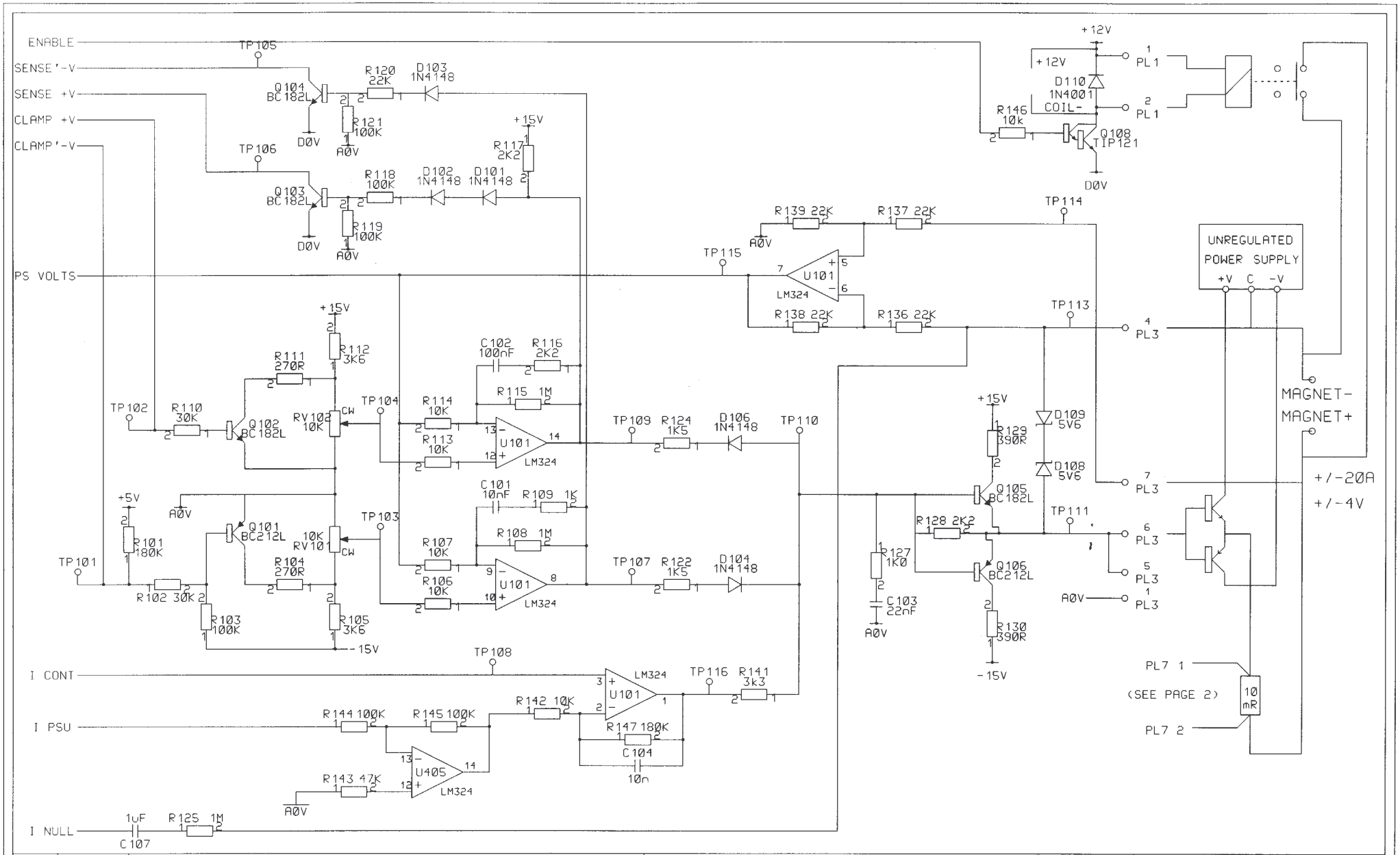
ISS10 DIGITAL PCB

DE-COUPLING CAPACITORS etc.

OXFORD

DRAWING NUMBER

A4 CBL1202 4of4

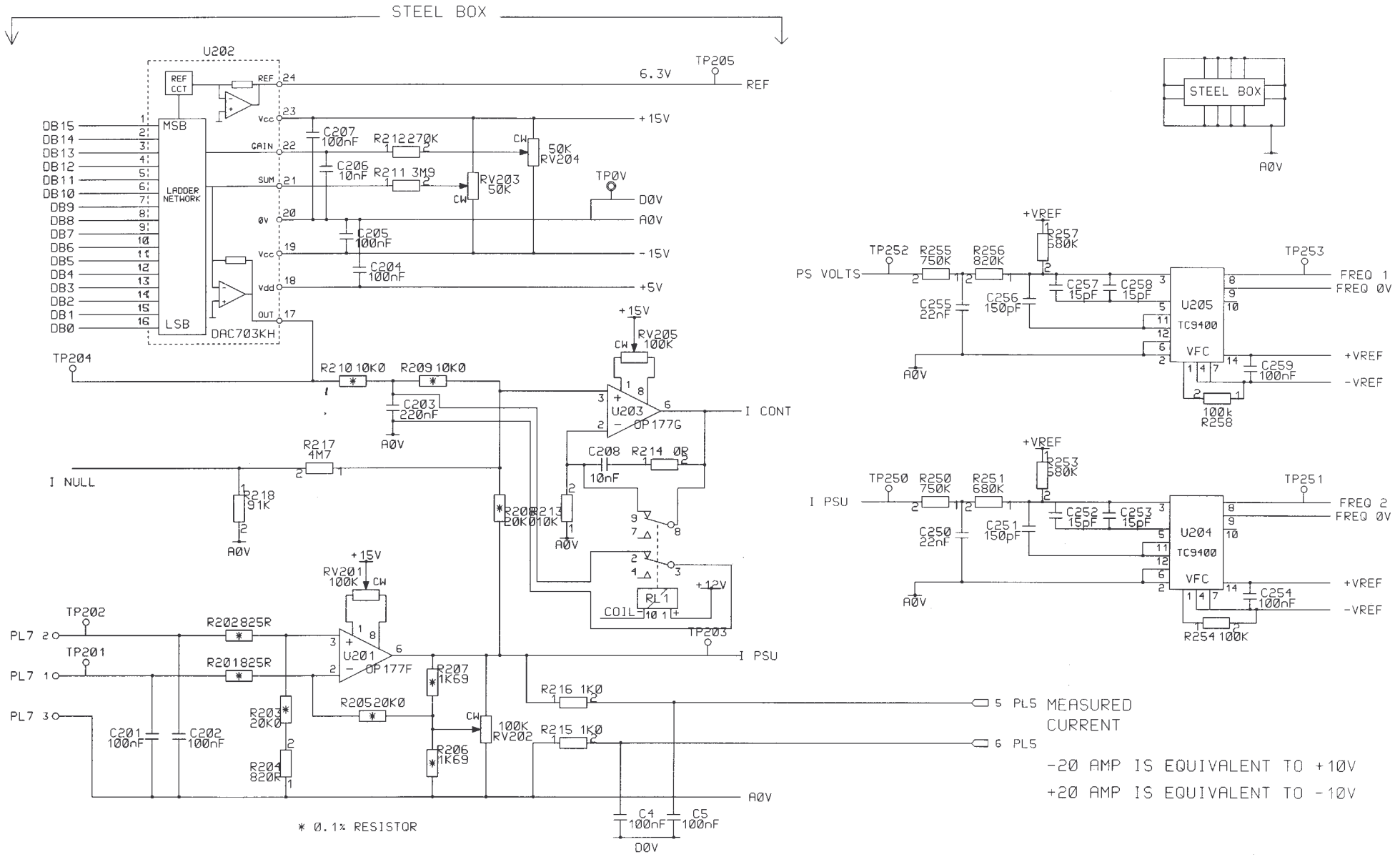


07	14/8/98	C654 RL1 ADDED
06	2/12/97	C613 R545 ADDED & D1 CHANGED TO D502
04	11/3/96	BUG FIXES & EMC MODS
03	13/12/94	PCB CCB1301 REV 03
02	15/8/94	PCB CCB1301 REV 01. SWITCH HEATERS ADDED

ISS10 SHIM POWER SUPPLY
ANALOGUE PCB
OUTPUT CONTROL

OXFORD

DRAWING NUMBER
A4 CCB1302 1of5

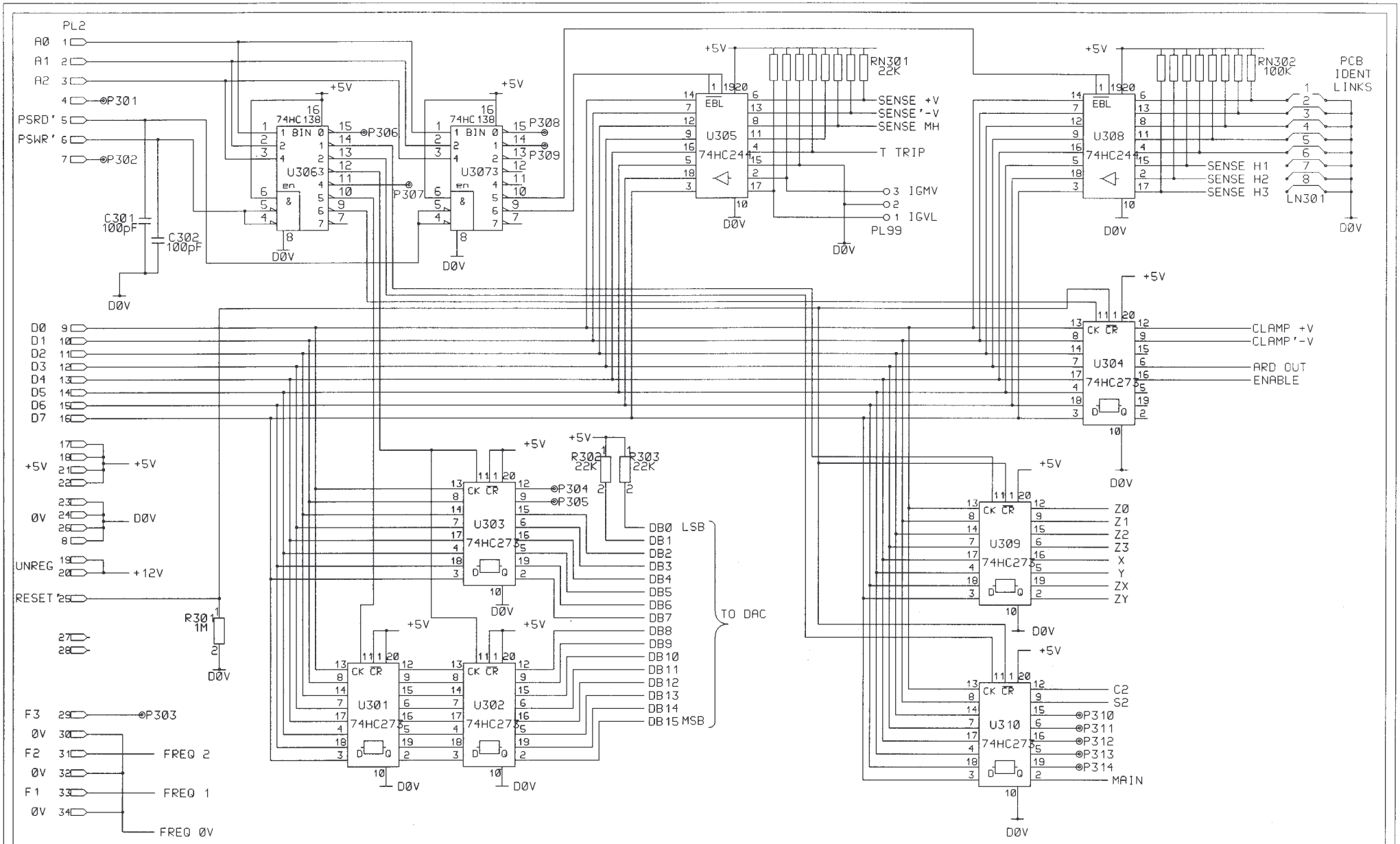


07	14/8/98	C654 RL1 ADDED
06	2/12/97	C613 R545 ADDED & D1 CHANGED TO D502
04	11/3/96	BUG FIXES & EMC MODS
03	13/12/94	PCB CCB1301 REV 03
02	15/8/94	PCB CCB1301 REV 01. SWITCH HEATERS ADDED

ISS10 SHIM POWER SUPPLY
ANALOGUE PCB
CURRENT CONTROL

OXFORD

DRAWING NUMBER
A4 CCB1302 2of5

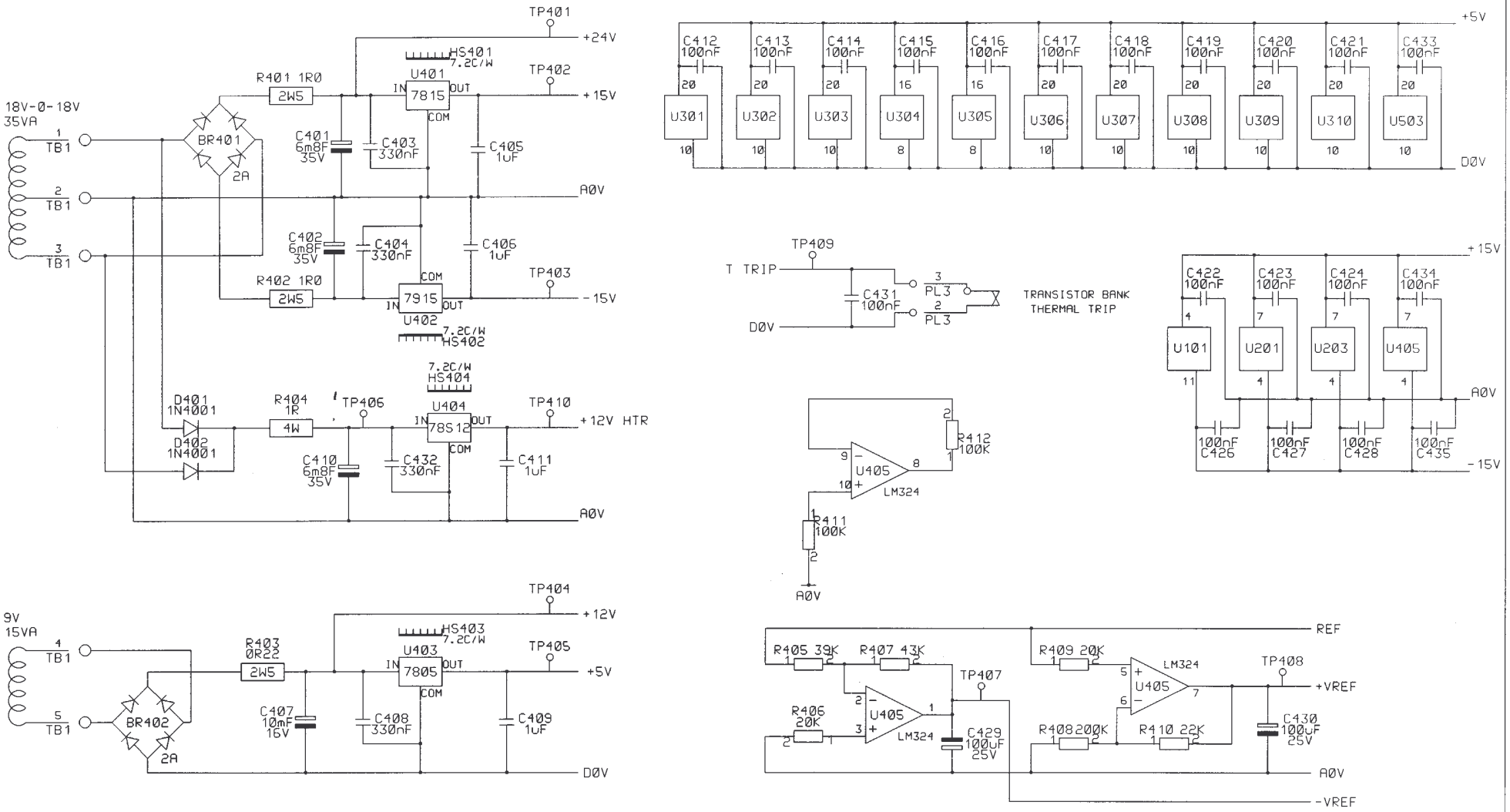


07	14/8/98	C654 RL1 ADDED
06	2/12/97	C613 R545 ADDED & D1 CHANGED TO D502
04	11/3/96	BUG FIXES & EMC MODS
03	13/12/94	PCB CCB1301 REV 03
02	15/8/94	PCB CCB1301 REV 01. SWITCH HEATERS ADDED

ISS10 SHIM POWER SUPPLY
ANALOGUE PCB
ANALOGUE/DIGITAL INTERFACE

OXFORD

DRAWING NUMBER
A4 CCB1302 3of5

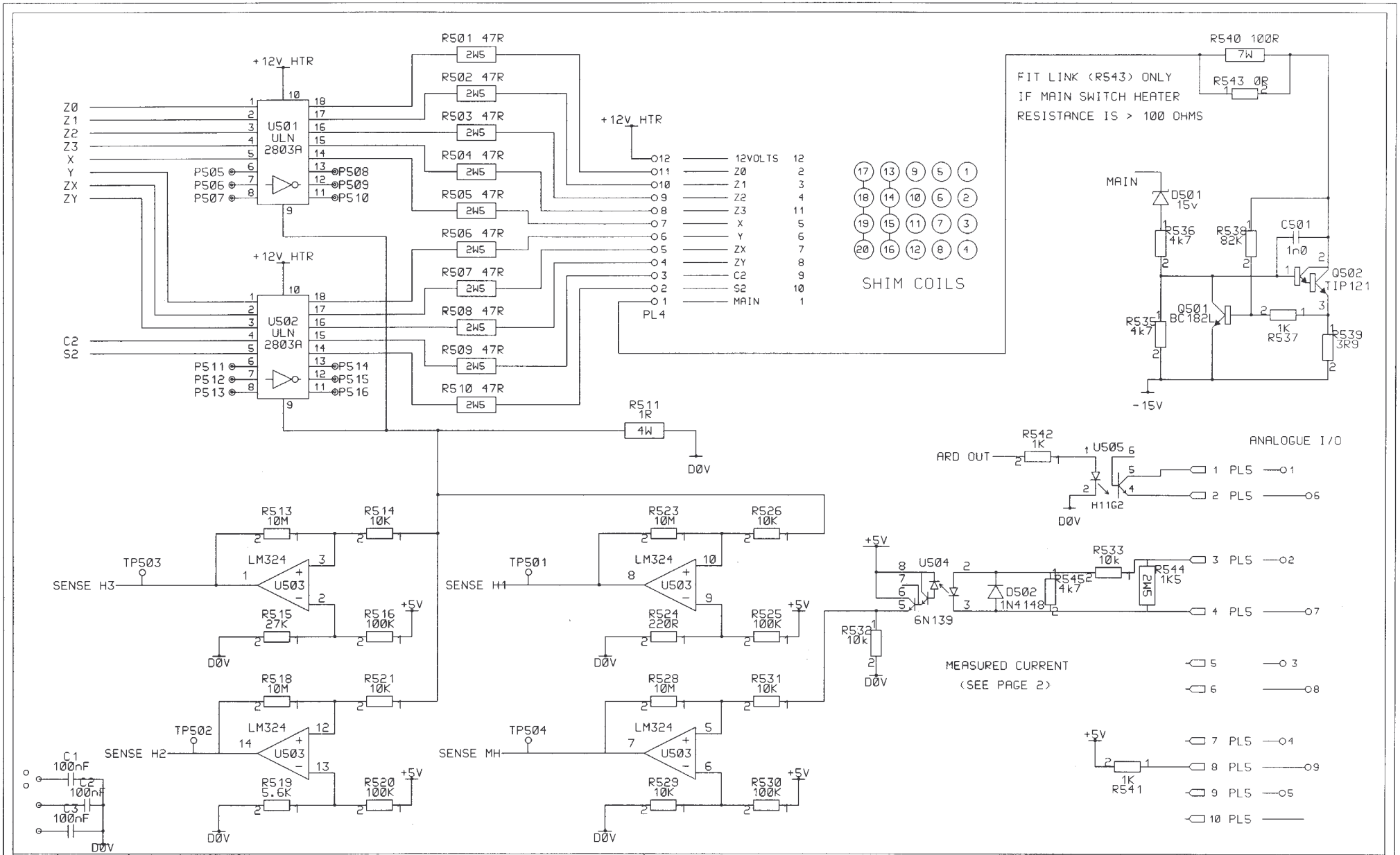


07	14/8/98	C654 RL1 ADDED
06	2/12/97	C613 R545 ADDED & D1 CHANGED TO D502
04	11/3/96	BUG FIXES & EMC MODS
03	13/12/94	PCB CCB1301 REV 03
02	15/8/94	PCB CCB1301 REV 01. SWITCH HEATERS ADDED

ISS10 SHIM POWER SUPPLY
ANALOGUE PCB
POWER CONTROL

OXFORD

DRAWING NUMBER
A4 CCB1302 4of5



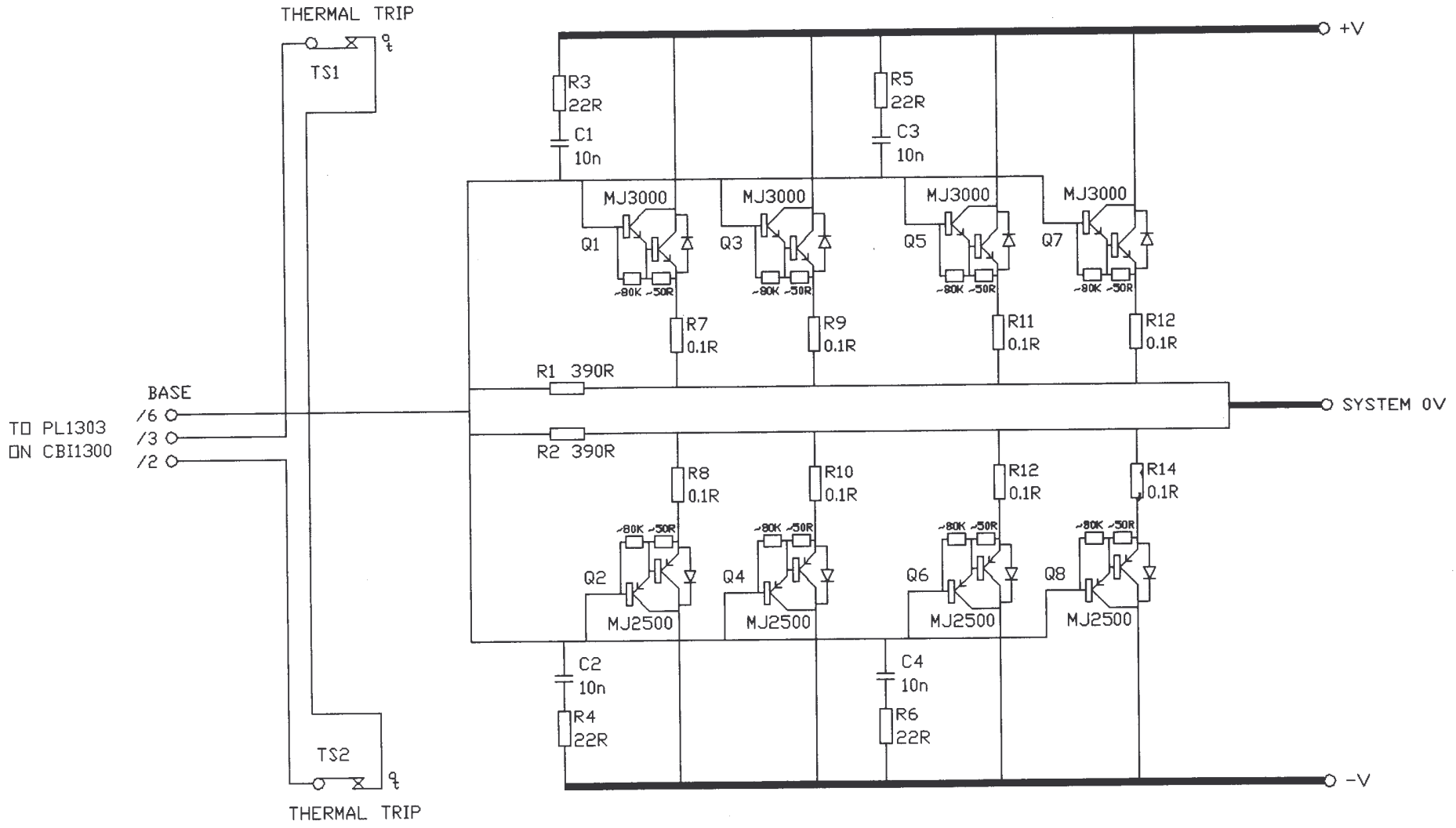
07	14/8/98	C654 RL1 ADDED
06	2/12/97	C613 R545 ADDED & D1 CHANGED TO D502
04	11/3/96	BUG FIXES & EMC MODS
03	13/12/94	PCB CCB1301 REV 03
02	15/8/94	PCB CCB1301 REV 01. SWITCH HEATERS ADDED

ISS10 SHIM POWER SUPPLY ANALOGUE PCB DRIVER/TELEMETRY INTERFACE

OXFORD

DRAWING NUMBER

A4/CCB1302 sht 5of5



MACJ	06/12/94	
MACJ	25/6/91	
WRB	20/2/91	

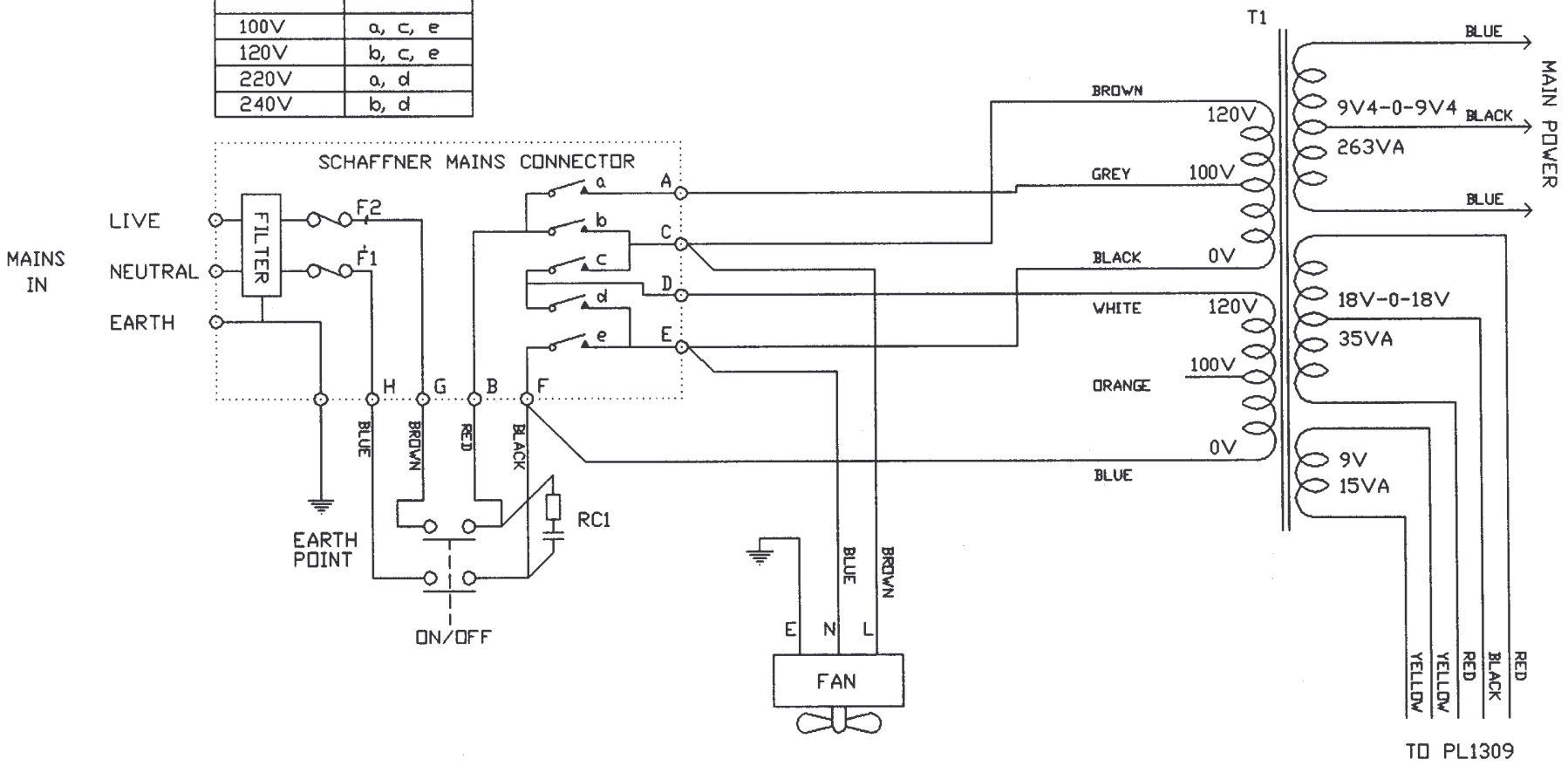
ISS10 POWER SUPPLY
PASS BANK UNIT

OXFORD

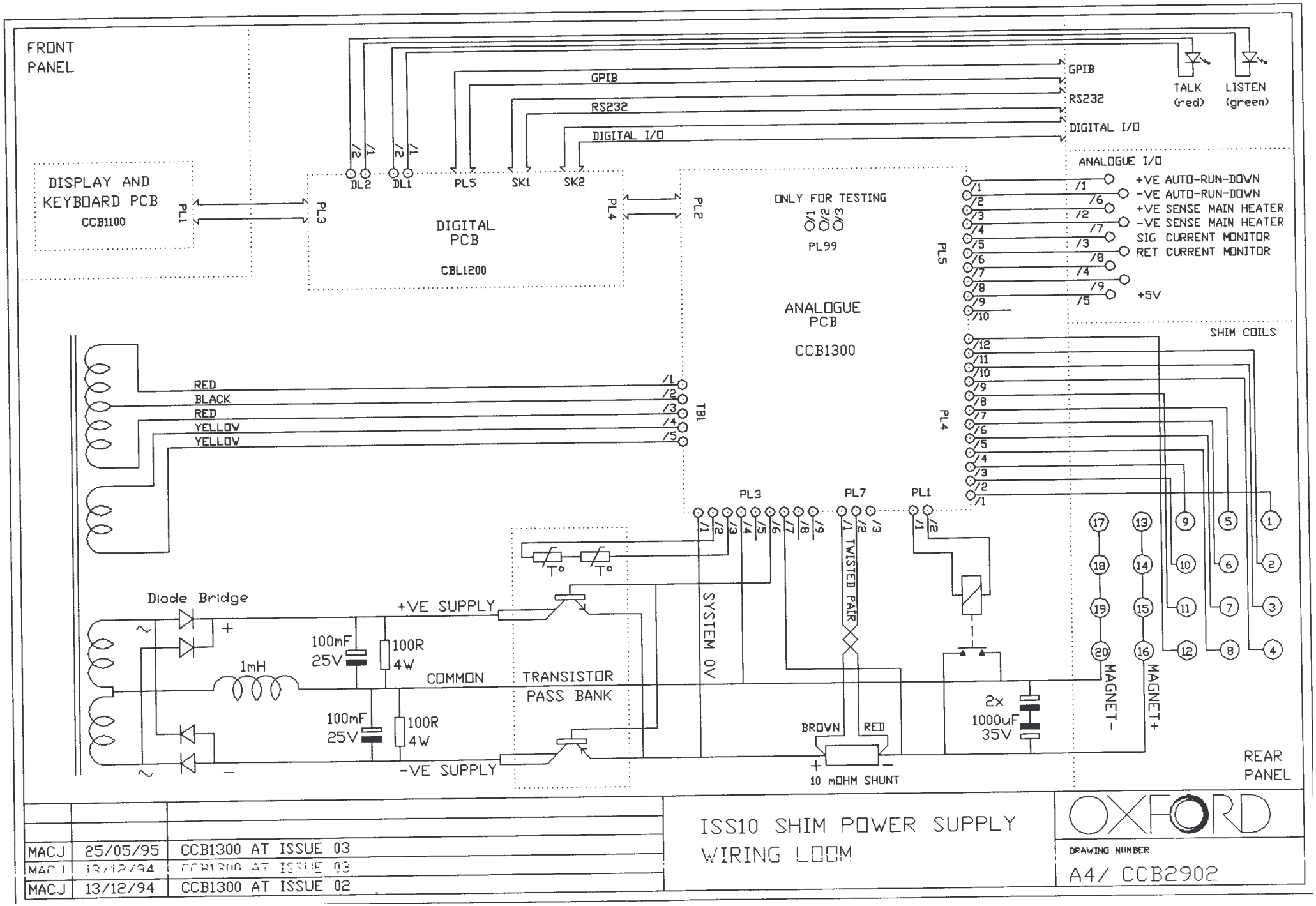
DRAWING NUMBER
A4/ CBI1402

FUSES	100 & 120Vac	220 & 240 Vac
F1 & F2	4 A (T)	1.6 A (T)

VOLTAGE	CONTACTS
100V	a, c, e
120V	b, c, e
220V	a, d
240V	b, d



MACJ	14/3/91	ISS10 POWER SUPPLY MAINS WIRING	OXFORD DRAWING NUMBER A4/ CBI1602



MACJ	25/05/95	CCB1300 AT ISSUE 03
MACJ	13/12/94	CCB1300 AT ISSUE 03
MACJ	13/12/94	CCB1300 AT ISSUE 02

ISS10 SHIM POWER SUPPLY WIRING LOOM

OXFORD

DRAWING NUMBER

A4/ CCB2902