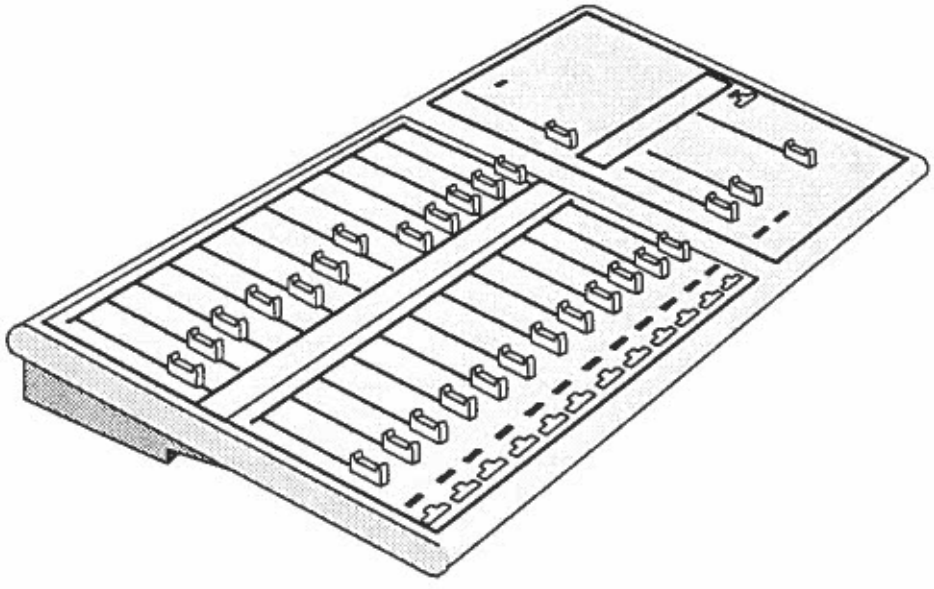
Strand Lighting

MAINTENANCE HANDBOOK

LX



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Strand Lighting

Strand Lighting Ltd.,
Grant Way,
Isleworth,
Middlesex.
TW7 5QD

Tel 081 560 3171 Fax 081 568 2103

Strand Lighting International Offices

Note: Telephone numbers exclude international and national dialling codes

Asia:	802 Houston Centre, 63 Mody Road, Tsimshatsui East, Kowloon, Hong Kong	Tel: 368 5161	Fax: 369 4890
Canada:	2430 Lucknow Drive, Unit 15, Missisauga, Ontario L5S 1V3 Canada	Tel: 416 677 7130	Fax: 416 677 6859
France:	26 Villa Des Fleurs, 92400 Courbevoie, France	Tel: 1 478 86666	Fax: 1 433 37175
Germany:	PO Box 4449, 3300 Braunschweig, Germany	Tel: 5331 30080	Fax: 331 78883
Italy:	Via delle Gardenie 33 (Pontia Vecchia Km 33,400), 00040 Pomezia-Roma, Italy	Tel: 6 919 7123	Fax: 6 919 7136
USA:	PO Box 9004, 18111 South Santa Fe Avenue, Rancho Dominguez, CA 90221 USA	Tel: 213 637 7500	Fax: 213 632 5519

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Contents

LX

1. Introduction

LX is a compact, portable, easy to use, 'manual' lighting control console.
The LX console provides analog, wire-per-dimmer control outputs, intended for connection to portable dimmer packs, but which may also be used with 'permanent' dimmer installations.

LX is supplied in five versions :–

'-10V' versions providing dimmer outputs of 0V (off) to -10V (full on) in 3 sizes – 12, 18, or 24 channels.

'+10V' versions providing dimmer outputs of 0V (off) to +10V (full on) in 2 sizes – 12 or 24 channels.

This handbook provides technical information on the LX range of control system products.
The book is aimed at experienced engineers and service personnel, who are expected to be familiar with terminology used in the electronics and lighting industries.

This handbook is divided into 10 sections.

Section 1	This Introduction.
Section 2	A brief description of LX operational controls.
Section 4	Instructions regarding installation of LX consoles.
Section 5	Instructions and hints regarding maintenance procedures.
Section 6	Instructions regarding removal and refitting of LX subassemblies.
Section 8	A description of LX electronic circuit operation.
Section 9	Block interconnection diagrams of LX consoles.
Section 10	Circuit diagrams for LX electronics.

2. Operation

Full operational details are contained in the LX User Guide (supplied with each console).
This section gives a brief description of the function of each of the front panel controls and indicators.
Refer to Figure 1 – Panel Layout diagram.

A Preset Faders

These allow control of the level of individual dimmer channels. Levels set on the A Preset faders are proportionally reduced as the **A Master Fader** is reduced from 100% to 0%.

B Preset Faders

These allow control of the level of individual dimmer channels. Levels set on the A Preset faders are proportionally reduced as the **B Master Fader** is reduced from 100% to 0%. (The B Master Fader is mounted so that 0% is at its top end, and 100% is at its lower end).

If the A and B Master Faders are moved together from one end to the other, a 'dipless' crossfade is carried out between the lighting controlled by one Preset, and the lighting controlled by the other Preset.

Time Fader

Sets times (from 0 seconds to 5 minutes) for the fades which occur whenever the Master Faders are moved. The **'Manual' Indicator** shows when the Time Fader is at its top (0 seconds) position.

Master Active Indicators

When illuminated, these show that the corresponding Master Fader is at a level greater than 10%, and may therefore be controlling 'active' lighting.

Channels Indicators

These show channel level by increasing in brightness as channel level increases.
(Indication is very dim at levels below approximately 30%).

Flash Switches

When pressed, these cause the associated channel to jump up in level to the level set on the **Flash Level Master**. (Flash level combines with current Channel level on a 'highest-takes-precedence' basis.

Blackout Switch

When pressed, causes 'Blackout' to switch on or off. When Blackout is on, all channel output levels are held at 0%, and the **Blackout Indicator** is illuminated.

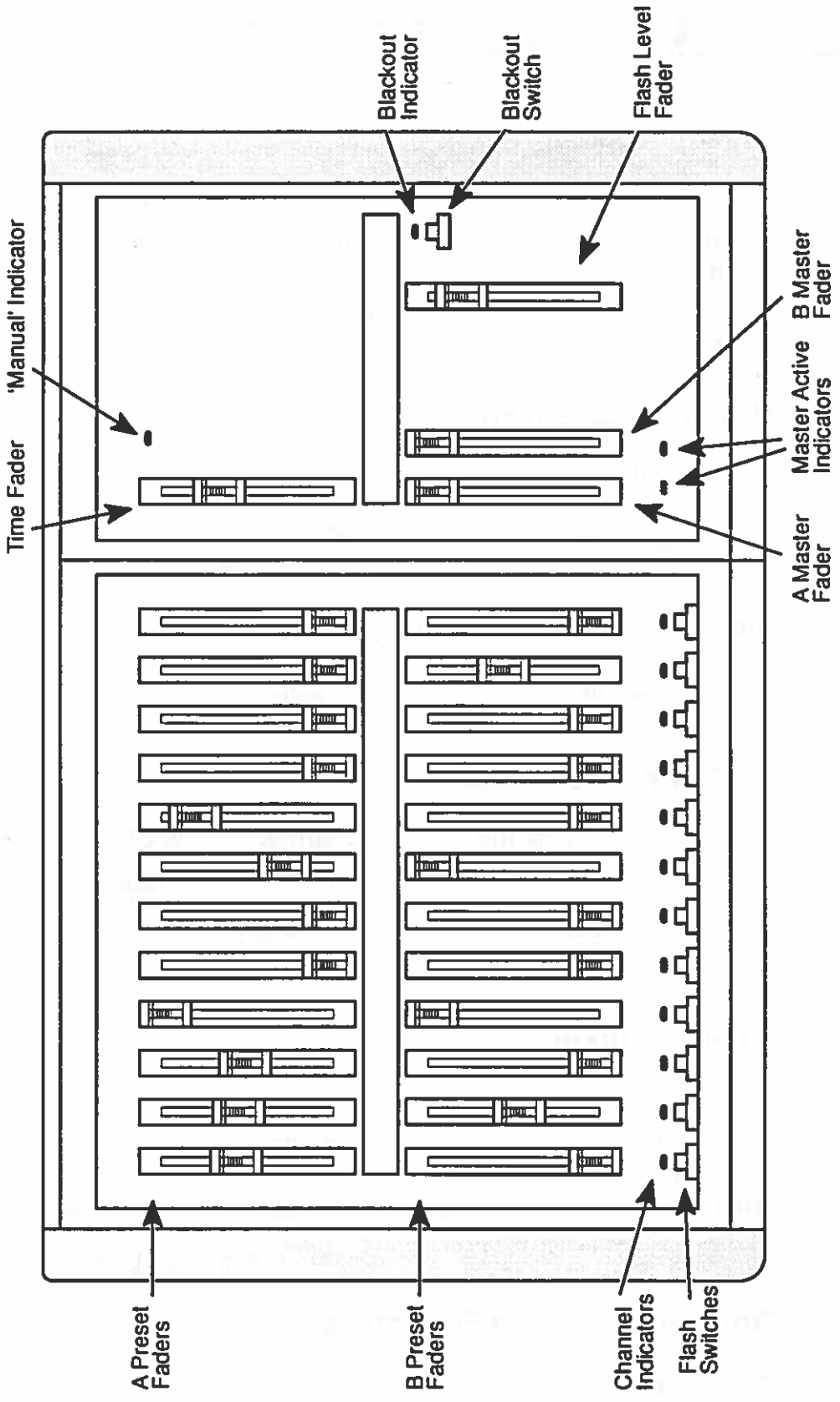


Figure 1 – Panel Layout

3. LX Console Specifications

3.1 Dimensions

	12 Channel	18 Channel	24 Channel
Width :	452mm	600mm	714mm
Depth :	285mm	285mm	285mm
Height :	65mm	65mm	65mm
Weight :	2Kg	3Kg	4Kg

3.2 Power Requirements

3.2.1 DC Voltage

From Battery Eliminator : -18V +/- 10%
From dimmer packs (-10V versions) : -15V +/- 10%

Note : Battery Eliminators supplied by Strand Lighting have a nominal output voltage of -15V, however, in practice the output voltage is slightly higher, and is sufficient to operate LX consoles.

3.2.2 DC Current Consumption

12 Channel	18 Channel	24 Channel
110mA	150mA	180mA

Note : These currents may increase slightly depending on the type of dimmers connected.

3.3 Control Outputs

-10V versions :
0V (off) to -10V (full on) via a 10KΩ resistor and a silicon diode.
+10V versions :
0V (off) to +10V (full on) via a 1KΩ resistor and a silicon diode.
Maximum control current per dimmer – 1mA.

3.4 Ambient Operating Environment

Temperature : 0°C to +35°C
Relative Humidity : 10% to 95% – Non condensing
'Office Level' Cleanliness

4. Installation

4.1 Location and Operating Environment

When selecting a location for the LX, various factors should be considered :–

- The operator should have a clear view of the performance area.
- There should be adequate space for cue sheets, scripts etc.
- Controllable, low-level lighting should be installed, or made available, to illuminate the control area.

The reliability of the LX will be enhanced if the operating environment is maintained within certain limits :–

- Ambient temperature within the range 15-25°C.
- Relative Humidity less than 90%.
- Condensation **never** allowed to form on, or inside, the equipment.
- The area must be clean and tidy to 'Office' level, with a minimum of dust. It is strongly recommended that the LX is covered when not in use.

4.2 Unpacking

After unpacking, inspect the LX console (and Battery Eliminator, if supplied) carefully to ensure that no damage has occurred during transit. Should any damage be evident, or any parts be missing, please inform the distributor or Strand Lighting Ltd. without delay. Also ensure that the correct version of LX has been supplied.

The carton should contain :–

1 LX console
1 User Guide
1 Battery Eliminator
[not included for -10V versions]

Retain the original packing materials for use should the unit have to be returned to the supplier for any reason, or for storage or transport.
If the console is to be part of a touring system, it is recommend that a suitable protective transit case be manufactured.

4.3 Control Cables, and Extensions

A range of control and extension cables is available from Strand Lighting. Alternatively, it may be required to make up such cables to suit the individual installation. It is important that an appropriate size and type of cable are chosen. Cable size is of particular importance where -10V LX consoles are to be powered from the dimmer packs, as the use of control cables which are too small may result in power losses along the cables, and in turn lead to malfunction of the overall installation.

For all installations, the cable size to be used will depend on the required length of the control cables :–
For distances up to 100 Metres, the recommended cable is PVC insulated multicore with a core size of 0.22mm^2 (7/0.2mm).
For distances up to 200 Metres, the recommended cable is PVC insulated multicore with a core size of 0.5mm^2 (16/0.2mm).
For distances above 200 Metres, it is recommended that the LX is powered from a Battery Eliminator. Alternatively, multicore [0.22mm^2 (7/0.2mm)] may be used for the dimmer control signals, but with additional separate wires for the Dimmer Common signal and the -15V power. For distances up to 500 Metres, these wires should have a core size of at least 2mm^2.
(If the LX is to be powered from a Battery Eliminator, a cable will not be required for -15V power).

4.4 Dimmers [-10V control]

Connection to the dimmers is via 8 pin DIN sockets situated on the rear of the LX console. Each 8 pin DIN connector carries six dimmer control signals, a Dimmer Common signal, and a -15V Power signal.
Pin connections for an 8 pin DIN socket are shown in Figure 2.

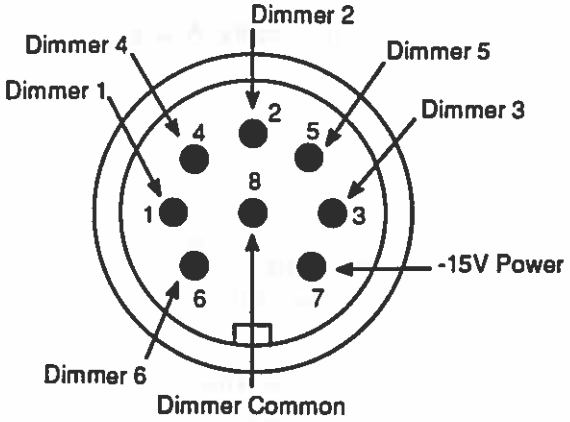


Figure 2 – Dimmer Connections – 8 pin DIN Socket

Figure 3 lists the cable colours for standard 8 core control cable.

Function	Colour	Function	Colour
Dimmer 1	Red	Dimmer 5	White
Dimmer 2	Blue	Dimmer 6	Black
Dimmer 3	Green	-15V	
Dimmer 4	Yellow	power	Brown
		Dimmer	
		Common	Violet

Figure 3 – Colours for 8 Core Cable

4.4.1 Connection to Tempus, ACT3 or ACT6 Dimmers

The control input to a Tempus, ACT3 and ACT6 dimmer pack is via an 8 pin Bleecon socket. 8 pin DIN plugs will mate correctly with these sockets, but will not latch. The LX system may be connected to the dimmers using appropriate cables fitted with 8 pin DIN plugs. Alternatively, if latching connectors are required, the cables should be fitted with an 8 pin latching DIN plug at one end, and an 8 pin Bleecon plug at the other.

Note : Unless the LX is to be supplied with power from a Battery Eliminator, it must be connected to a minimum of two Tempus, ACT3 Master, or ACT6 dimmer packs, in order to ensure that it receives sufficient power for correct operation. This is irrespective of whether the LX has 12, 18, or 24 channels.

4.4.2 Connection to Other Types of Dimmer

-10V versions of LX may be operated with other types of dimmer, provided that they will accept a 0V to -10V control voltage.
A Battery Eliminator will be required to power the LX, unless the dimmer rack(s) incorporate a suitable -15V DC power supply. This power supply (or a combination of more than one power supply from several portable dimmer packs) must be capable of supplying at least 200mA at -15V.
If there is any doubt that the dimmers on site are suitable, please contact the manufacturer of the dimmers, Strand Lighting, or an approved Strand Lighting Service Agent.

Once it has been verified that the dimmers will operate with the LX, an appropriate set of adaptor cables should be constructed and installed to connect them to the DIN sockets on the LX.

4.5 Dimmers [+10V control]

Connection to the dimmers is via 15 pin Min-D sockets.
The Min-D connector carries 12 dimmer control signals and the Dimmer Common signal.
Pin connections for Min-D type connectors are shown in Figure 4.

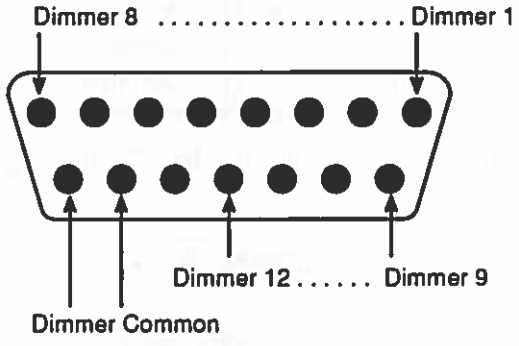


Figure 4 – Dimmer Connections – Min D-Type Socket

Figure 5 lists the cable colours for standard 18 core control cable.

Function	Colour	Function	Colour
Dimmer 1	Red	Dimmer 10	Pink
Dimmer 2	Blue	Dimmer 11	Cyan
Dimmer 3	Green	Dimmer 12	Grey
Dimmer 4	Yellow	Dimmer	
Dimmer 5	White	Common	Red/Blue
Dimmer 6	Black	Not used	Green/Red
Dimmer 7	Brown	Not used	Yellow/Red
Dimmer 8	Violet	Not used	White/Red
Dimmer 9	Orange	Not used	Red/Black

Figure 5 – Colours for 18 Core Cable

+10V versions of LX may be operated with various styles of dimmer, provided that they will accept a 0V to +10V analog control voltage. If there is any doubt that the dimmers on site are suitable, please contact the manufacturer of the dimmers, Strand Lighting, or an approved Strand Lighting Service Agent.

Once it has been verified that the dimmers will operate with the LX, appropriate wiring should be installed to connect them to the LX.

Note : +10V versions of LX require a power supply from a Battery Eliminator.

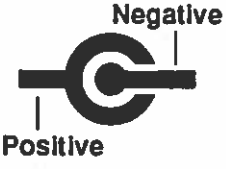
4.6 Battery Eliminator

This will not be required if the LX is a -10V version and is to be powered from the dimmer packs.
Ensure that there is a nearby mains power socket, into which the Battery Eliminator may be plugged. This socket must be positioned so that there is a free flow of air for ventilation of the Battery Eliminator, and that the power cable will reach the LX without imposing any strain on the cable or connectors.

Check that the Battery Eliminator provided is correct for the local mains voltage, – either 240V, 220V, or 120V.

Connect the Battery Eliminator to the LX console before plugging it into the mains socket.

CAUTION! **If the Battery Eliminator has not been supplied by Strand Lighting, ensure that its output connector is wired with the correct polarity – as shown in the diagram.**



4.7 Testing

Following installation and connecting, the LX and dimmers must be tested to verify that all is correct :–

Check all connections.
Connect a luminaire to each of the dimmers.
Follow the steps outlined on the first page of the Operation section in the User Guide to check that the LX console and dimmers are operating. Raise the fader for each channel in turn and check that the appropriate luminaire can be controlled.

If the dimmers do not respond correctly, switch off all equipment, re-check all connections and settings, and repeat the sequence.

5. Maintenance

5.1 Routine Maintenance

Routine preventitive maintenance is not required for LX. However, it is recommended that cleaning and inspection are carried out on a regular basis (At least once every 6 months).

5.1.1 Cleaning

Clean the surface of the console using a cloth which has been **slightly** dampened with water (and a little detergent, if necessary).

CAUTION! **Do not use solvents, abrasive cleaners, or polishes, as these may damage the surface of the LX or its printed markings.**
Do not allow any liquid to enter into the console.
Do not use spray cleaners, etc. as these may enter the faders and switches and cause malfunction or damage.

5.1.2 Inspection

Inspect the console for any signs of damage. Operate each fader and switch in turn, checking for correct function.
Inspect the cables to the dimmers, ensuring that all connectors are properly inserted, and that no physical damage has occurred to connectors or cable insulation.
Inspect the Battery Eliminator (if part of the installation), checking that no physical damage has occurred to its plug pins, the housing, or the cable and connection to the LX. Ensure that the Battery Eliminator connections are properly inserted – both into the mains power socket, and into the LX.

WARNING

As hazardous voltages are present within the Battery Eliminator, it must immediately be replaced in the event that any damage has occurred to it.

5.2 Fault Finding and Repairs

5.2.1 Equipment Required

The following equipment and provisions will be required in order to carry out maintenance on LX consoles :–

- Workarea — This must have a minimum area of at least twice that of the LX console to be repaired. Equipment required for anti-static handling techniques should be available.

- Spare Parts — The exact requirements will depend on the extent to which maintenance is to be carried out. Spare parts are available from Strand Lighting companies, and from approved Service Agents.
  A complete set of spare PCBs will be useful in some fault finding procedures.

- Multimeter — This should be capable of reading (as a minimum) DC voltages, DC current, and resistance, to an accuracy of +/- 2% or better.

- Oscilloscope — Required for component level maintenance. As LX does not incorporate complex circuitry, a basic oscilloscope will suffice.

- Tools — Including desolder tool (sucker type), soldering iron (fine tipped, temperature controlled), pliers, cutters, screwdrivers, etc.

5.2.2 Diagnostic Checks

If a problem occurs within an LX installation, some basic preliminary checks should be made, in an attempt to isolate obvious sources of trouble :–

- Ensure that the problem is not simply a question of incorrect operation. eg. Check that the Blackout switch is not 'active'. Check that the Master, Time, and Channel faders are in appropriate positions.

- Ensure that all connectors are firmly and correctly inserted.

- Ensure that mains power is applied to the dimmers.

- Ensure that mains power is applied to the Battery Eliminator, if part of the installation.

If basic checks do not identify the cause of the problem, more involved checks will be necessary. Exactly what checks are required will depend on the nature of the problem. The following list gives hints about some types of problem, their possible causes, and recommended checks.

Problem	Possible Cause	Check
1 switch / fader / LED not working.	Failed component.	Individual component in question.
	Faulty circuitry.	PCB electronics associated with non-working component.
1 channel not working.	Bad connection.	Dimmer Connections – both external & internal.
	Faulty circuitry.	Fader PCB electronics.
Group of channels not working.	Bad connection.	Dimmer Connections – both external & internal. Module interconnections.
	Channel circuitry.	Fader PCB electronics.
1 entire Preset not working.	Bad connection.	Module interconnections.
	Faulty circuitry.	Fader PCB electronics. Control PCB electronics.
1 entire Fader module not working.	Bad connection.	Module interconnections.
	Faulty circuitry.	Fader PCB electronics. Control PCB electronics.
All Fader modules not working.	Bad connection.	Module interconnections.
	Faulty circuitry.	Control PCB electronics.
LX totally inoperative.	Bad connection.	Power supply connections.
	Lack of power.	Battery Eliminator / power feed from dimmer packs.
	Faulty circuitry.	PSU Regulator PCB electronics.
	Faulty circuitry.	Control PCB electronics.

If a particular PCB is suspected of being faulty, this may easily be verified by connecting a known working PCB in place of the suspect one.

Details of electronic circuit operation are given in section 8. It is beyond the scope of this handbook to give detailed instructions regarding fault finding at component level.

5.2.3 Repairs

If repairs are to be carried out at component level, care must be taken in order to achieve a successful repair, and to prevent further damage to the equipment.

- Repairs must not be carried out by untrained, unskilled personnel.
- Do not attempt disconnection or removal of any electronic subassembly or component without first ensuring that the console is disconnected from its power source(s).
- If removing, or replacing, circuit board components, great care must be taken that the printed tracks are not damaged. The tracks are very fine in places, and may easily lose their adhesion to the circuit board if too much heat is applied with a soldering iron.
  If a track is damaged, such that its circuit is broken, do not attempt repairs at the point of the break; Find the component pins at the ends of the track, either side of the break, and attach a suitable length of fine PTFE covered wire between the component pins. If the link is more than 30mm in length, attach it to the PCB with 'wire tack' adhesive at intervals of approximately 30mm.
- Many of the Integrated Circuit components used in LX can be damaged by static-electric discharges. Anti-static handing techniques must be used when working with such components.
- The Battery Eliminator is considered as one component, to be replaced, rather than repaired, in the event of a failure.

6. Removing and Refitting Console Subassemblies

6.1 Work Area

A clear work area, of about twice the area of the LX console, will be required. It is suggested that this work area is covered with a piece of soft cloth or thin foam plastic in order to protect the LX from scratches.

6.2 Opening the LX

1) Place the LX, face down, on the work area.

2) Remove the line of module retaining screws from along the centre of the base. (5 screws on a 12 channel LX, 7 on an 18 channel LX, 8 on a 24 channel LX). [Screw type – M3 x 8mm, Pan head, Posidrive, plus M3 shakeproof washer]

3) Holding the modules into the base, turn the LX over.

4) Gently lift the front of the Control module (on the right of the console) and the adjacent Fader module.

5) Pull the Control module slightly forward, lift it slightly, and unplug the 6 way connector and 3 way connector from the Control PCB. The Control module may now be removed from the console.

CAUTION! **When unplugging the connectors from the PCBs, do not pull on the wires, as these may come away from the connector, and necessitate the replacement of the complete cable and connector assembly. If necessary, ease the latching bar(s) on the PCB mounted plug away from the socket housing using a small flat bladed screwdriver.**

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6) Unplug the 6 way connector and the dimmer cables (two 8 way connectors on -10V LXs, one 14 way connector on +10V LXs) from the right hand side of the adjacent Fader module – noting their positions. This module may now be removed from the console.

7) Similarly remove the other Fader module (if fitted).

6.3 Removing PCBs

6.3.1 Control and Fader PCBs

These PCBs form parts of the console modules.

1) Remove all fader knobs by pulling them off. The use of screwdrivers, or other tools, as levers is not recommended as these may cause damage to the plastic mouldings.
This step is probably best carried out prior to removing the module from the console.

2) Remove the self-tapping screws which hold the PCB to the plastic moulding (four screws in a Control or 6 way Fader module, five screws in a 12 way Fader module). [Screw type – self tapping No. 4 x $^1/_2$", Posidrive, plus M3 shakeproof washer].

3) Gently separate the PCB from the plastic moulding.

6.3.2 Power Supply Regulator PCB

This PCB is positioned in the base of the console. Figure 6 shows a part sectional view.

1) Remove the screw which holds the heatsink bracket to the rear of the console base. [Screw type – M3 x 10mm, Pan head, Posidrive, plus M3 nut and shakeproof washer].

2) Remove the screws which hold the PCB into the console base. [Screw type – M3 x 8mm, Pan head, Posidrive, plus M3 shakeproof washer].

3) Lift the PCB away from the console base.

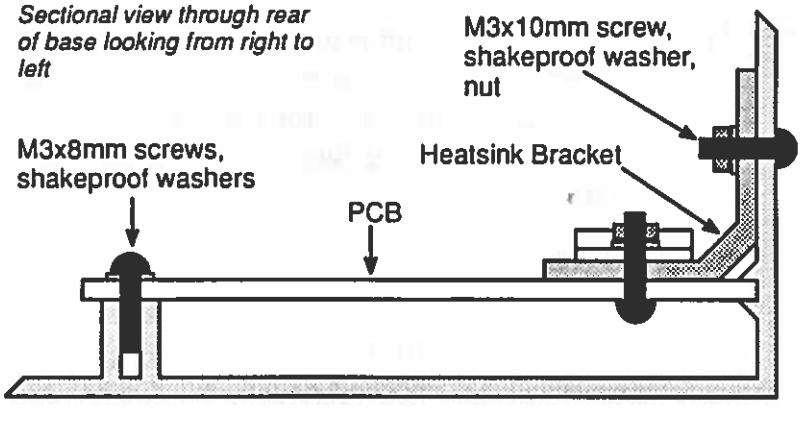


Figure 6 – PSU Regulator PCB Positioning

CAUTION! **Printed circuit boards should be handled only by their edges, and must not be allowed to come into contact with contaminants such as liquids, dust, grease, etc.**

6.4 Refitting PCBs

1) Place the PCB in its correct position, ensuring that faders, switches, and mounting holes line up as appropriate.

2) Refit all fixing screws, (and nuts and washers as appropriate) ensuring that they are tight, but not so tight as to cause damage to the PCB or the plastic moulding.

3) Refit all fader knobs. Green striped knobs are for the A Preset and Master faders, purple (lilac) striped knobs are for the B Preset and Master faders, and blue striped knobs are for the Time and Flash Level faders,

6.5 Re-assembling the LX

Follow the layout given in the appropriate Interconnection Diagram (Figures 12 – 16) for guidance on reconnecting cables.

1) If the PSU Regulator PCB has been removed, refit it into position, ensuring that all screws are tight, and reconnect the 2 way cable.

2) Refit the left hand Fader module into the base, reconnecting the 6 way module interconnection cable, and the relevant dimmer cable(s).

3) Refit the second Fader module (if part of the console), reconnecting its dimmer cable(s) and the module interconnection cable.

4) Refit the Control module, reconnecting the module interconnection cable and the cable to the PSU Regulator PCB.
Ensure that no cables become trapped or snagged.
(It will be necessary to slightly lift the adjacent Fader module during the refitting of the Control module).

5) Refit the module retaining screws.

7. Spare Parts & Accessories

The following list gives Strand Lighting product codes for accessories and packaged spare parts for LX.
The product codes should be quoted whenever items are ordered.

For details of parts not listed below, please contact a Strand lighting office or approved Service Agent.

7.1 Accessories

0700090/UK	Battery Eliminator 240V AC UK 13A plug pins
0700090/EC	Battery Eliminator 220V AC 'Schuko' plug pins (Contact Strand Lighting for details of other styles of Battery Eliminator.)
0480005	Dimmer cable 8 pin DIN – 8 pin DIN 5 metres
0480015	Dimmer cable 15 pin Min-D – open end 5 metres
8804800	User Guide leaflet

7.2 Spare Parts

0480310	Master Control Printed Circuit Board
0480306	6 Channel Fader Printed Circuit Board
0480312	12 Channel Fader (-10V) Printed Circuit Board
0480313	12 Channel Fader (+10V) Printed Circuit Board
0480314	PSU Regulator Printed Circuit Board
0480320	Control Tile moulding complete with label
0480326	6 Channel Fader Tile moulding complete with label
0490165	12 Channel Fader Tile moulding complete with labels
0490120	Faders (2)
0490122	Faders (24)
0490130	Switches (2)
0490132	Switches (24)
0490180	Fader Knobs (12 lilac, 12 green, 6 blue)
0490185	Fader Knobs (6 lilac, 6 green, 3 blue)

8. Circuit Description

It is recommended that this section be read in conjunction with sections 9 and 10 (Block Diagrams and Circuit Diagrams).

Within this section, in order to allow the reader to identify components within the circuit diagrams, components are referred to by their 'Circuit Designators'. A Circuit Designator takes the form of one or more letters, followed by a number. eg. C12 = capacitor number 12.

When it is required to specify a particular pin or connection on a component, the pin or connection number is added after the Circuit Designator, with a slash '/' to separate the two numbers.
eg. IC5/12 = pin 12 of Integrated Circuit number 5.

Where several similar but separate elements are contained within one component, a further letter may be added to the Circuit Designator to identify a specific element.
eg. IC3b = the second element within IC3

An LX console is assembled using up to four different Printed Circuit Boards (PCBs). These PCBs provide different functions, and are fitted according to the version of LX.

A total of five PCB designs may be used in LX :–

1) Control – holding overall mastering, control, and power supply circuitry.

2) 12 Way Fader (-10V) – holding faders and associated circuitry for 12 channels, with 0V to -10V outputs. (Not found in +10V versions)

3) 12 Way Fader (+10V) – holding faders and associated circuitry for 12 channels,with 0V to +10V outputs. (Not found in -10V versions)

4) 6 Way Fader (-10V) – holding faders and associated circuitry for 6 channels, with 0V to -10V outputs. (Not found in +10V versions)

5) PSU Regulator – holding a power supply regulator which provides -15V to the LX from an external Battery Eliminator.

8.1 Interconnections

8.1.1 PSU Regulator PCB to Control PCB

A 2 way cable connects -15V and 0V power rails from the PSU Regulator PCB to the Control PCB.

8.1.2 Control PCB to Fader PCBs

A six way cable connects the Control PCB to the 1 or 2 Fader PCBs.
This cable carries +15V, -15V, 0V power rails, A & B Master signals, and the Flash Master signal.

Note : If power to the LX is being supplied from dimmer packs, -15V current flows from Fader PCBs to Control PCB, rather than in the other direction.

8.2 Control PCB Ref 1963 PCB 1030

8.2.1 Power Supply.

An LX console only requires an external power input of -15V to operate. Internally, LX console circuitry requires both +15V and -15V power rails, together with an additional rail of -5V.
The additional voltages of +15V and -5V are generated in the Power Supply section of the Control PCB.

Note : CMOS logic ICs on the Control PCB are powered using -15V as V_{ss}, and 0V as V_{dd}.

8.2.1.1 +15V

+15V is derived from -15V by means of a switching regulator (IC7), used in step-up mode. IC7 operates between 0V as V_{cc}, and -15V as GND.

IC7 contains a voltage reference, a comparator, an oscillator whose mark-space ratio can be varied by the output of the comparator, and a power switching transistor which operates on the output of the oscillator.

The basic oscillator frequency is set at approximately 50KHz. by capacitor C11. As the power switching transistor switches on, it pulls current into IC7/1 via choke L1, and thus stores energy in L1. As the transistor switches off, the stored energy is transferred via diode D1 to capacitor C2, charging it with a positive voltage with respect to -15V.

The voltage on C2 is divided down by R35 and R39. The divided voltage is input into IC7/5, where it is compared against the internal reference voltage, with the result of the comparison used to control the ratio of the on and off times for the switching transistor, and as a result, the voltage on C2. The values of the resistors are such as to give a regulator output of approximately +29V against an input of -14V. ie. +15V with respect to 0V.

The current into L1 passes through the parallel connection of R12, R18, and R19. The voltage across these resistors is used as a measure of the input current of the regulator, being used via IC7/7 to inhibit regulator operation if too high. The value of the resistors is such that the maximum output current at +15V is limited to approximately 250mA.

8.2.1.2 -5V

-5V is derived from -15V by means of a small linear regulator (REG1).
This voltage is used mainly as a 'reference' and bias voltage within the Mastering and Timer circuits.

8.2.2 Dipless Crossfade Mastering.

The principle used in this circuit is one of varying the levels of 'Master' outputs by using pulse width modulation, sometimes known as 'Chop' Mastering.
The pulse width modulated signals are derived by taking the DC Master levels and comparing them against a sawtooth waveform.

8.2.2.1 Sawtooth Waveform Generator

This is formed by IC10a and IC10b, together with VT8 and associated components.
IC10a is connected as an integrator - with its input as the output of IC10b. IC10/7 is in a high condition as the integrator output moves negative. At the same time VT8 is turned on, holding IC10/6 at just above -5V. As the integrator output at IC10/1 reaches -5V, IC10/7 switches to a low condition, causing the direction of integration to change to positive going, and turning off VT8, (D17 limits the negative voltage on VT8's emitter to a safe level) thus allowing IC10/6 to be pulled to just below 0V. Once the integrator output reaches 0V IC10/7 switches high once again, and the process repeats. The output frequency is approximately 1KHz.
Waveforms are shown in Figure A7.

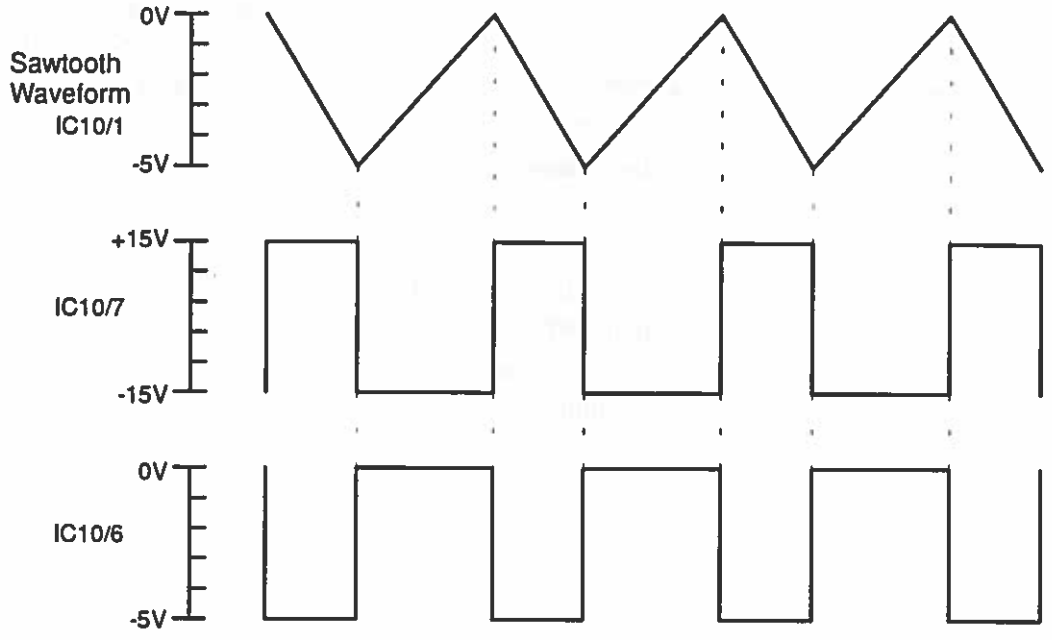


Figure A7 – Sawtooth Generator Waveforms

8.2.2.2 'Chop' Mastering

The Master levels from the Fade control circuits are compared against the sawtooth waveform in IC10c (A Preset) and IC10d (B Preset) [Refer to section 8.2.3 for the description of the Fade control circuits.] The comparator outputs are rectangular waveforms whose mark-space ratios vary according to the Master levels. With the Master levels at either 0% or 100%, the comparator outputs are 'static' at either a high or a low level.
Example waveforms are shown in Figure A8.
Note that the B Master fader is calibrated 'upside-down', and also that the two Master waveforms are 'opposite' in timing. (With both Masters at 50%, the A Master signal is high while the B Master signal is low.) This so that the the two signals 'add' correctly in the circuits on the Fader PCBs.

The comparator outputs are then 'squared', inverted, and limited to negative going signals only, by Schmitt inverters IC9c and IC9f. Diodes D23 and D24 prevent the inputs to these CMOS devices from exceeding their V_{dd} power rail (0V). The Schmitt trigger outputs are buffered by VT11 and VT12 which operate as emitter followers.
Two zener diodes (D21 and D25) provide a reference voltage of -11.2V. This voltage is used to limit the base voltages of VT11 and VT12, such that the output signals A MASTER and B MASTER have voltage limits of 0V and -11.2 V. [The magnitude of these signals is reduced to -10V in the Fader PCB circuitry.]

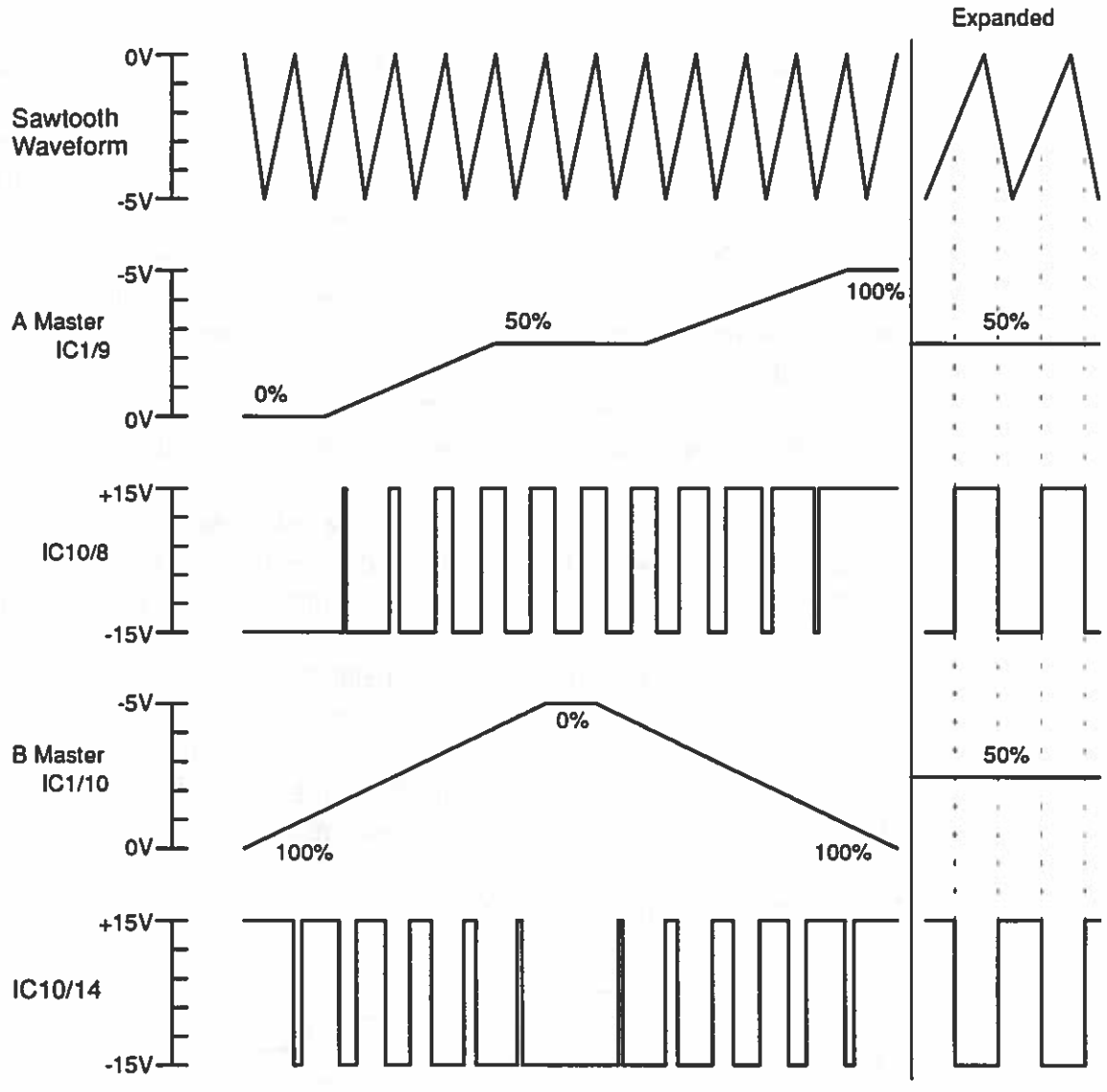


Figure A8 – 'Chop' Mastering Waveforms

8.2.3 Fade Controls

The Fade Control circuits provide the inputs to the Dipless Crossfade Mastering circuits. These inputs are derived either as the direct outputs of the two Master faders, or as automatic fades with fade times of between 0 and 300 seconds. The Time Control circuits are based on integrator circuits which are controlled by a series of pulses occurring at a frequency set by the Time fader.

8.2.3.1 Timer Control

This is a voltage controlled oscillator, with an exponential relationship between the control voltage and the oscillator frequency.
R10 and C3 form a simple capacitor charge circuit. Initially C3 is discharged. Once power is applied to the LX, C3 charges towards just below 0V via R10. IC3a operates as a comparator, comparing the voltage on C3 against the setting of the Time fader. When the voltage on C3 reaches the voltage on the fader, IC3/1 switches to a high level. This turns on VT2, which in turn discharges C5, the voltage on which is compared against -2.5V by IC2. As the voltage on C5 is -5V when it is discharged, IC2/6 will switch to a high level. This high level turns on VT3, which discharges C3, causing IC3/1 to switch low again. VT2 then turns off, allowing C5 to charge towards 0V – causing IC2/6 to switch low when the voltage on C5 reaches -2.5V.
The process repeats once the voltage on C3 once again reaches the voltage from the Time fader. This will take a time dependent on the time fader setting. The waveform at IC2/6 takes the form of a series of pulses, occurring at the repetition rate (frequency) of the oscillator circuit.
As the charging waveform at C3 is exponential in shape, the relationship between Time fader setting and oscillator frequency is exponential.
When the Time fader is in the 'Manual' position, C3 is unable to charge at all, and the high output from IC2/6 is continuous. When the Time fader is in the 5 minute position, C3 charges fully, but its voltage never reaches 0V (as set on the fader), and the output from IC2/6 is continuously low.
Waveforms are shown in Figure A9.

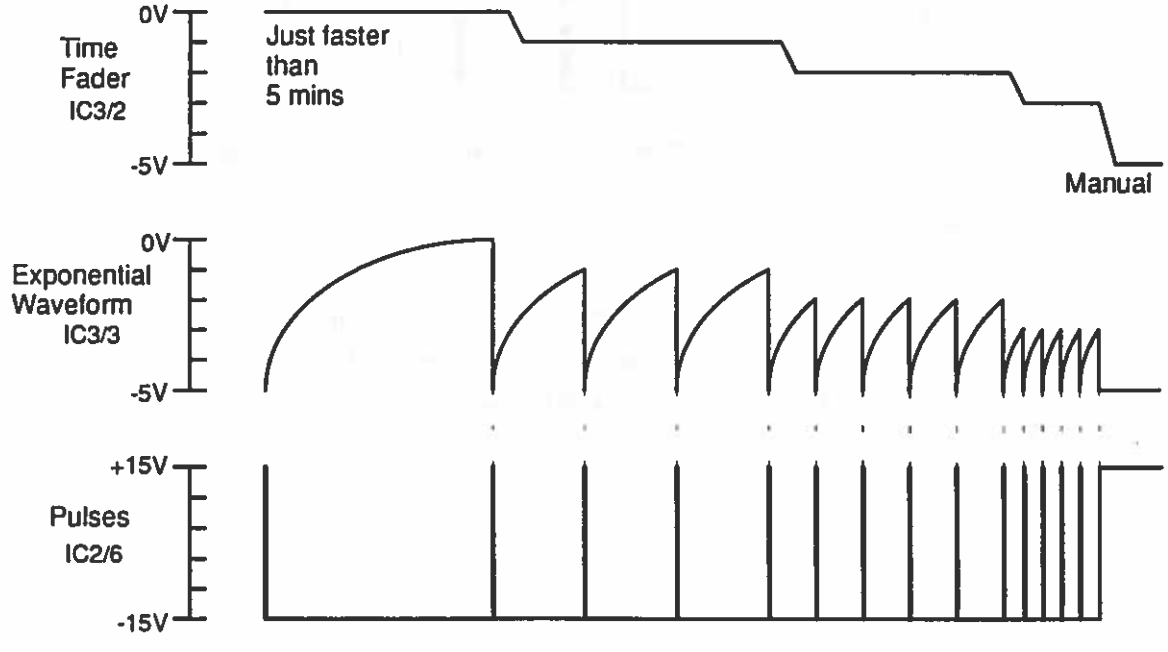


Figure A9 – Timer Control Waveforms

8.2.3.2 Fade Timers

Two separate circuits provide Master level signals from the settings / movement of the Master faders, and the output from the Timer control circuit.
The two circuits are identical in operation; only the circuit for the A Master is described.

IC6, R24, and C9 form an integrator circuit. The output from IC6/6 is compared against the setting of the A Master fader in IC3d. IC3/14 will be at a high level if the signal from IC6/6 is above the level set on the fader, and at a low level if the signal from IC6/6 is below the level set on the fader. The output from IC3/14 is passed to a limiting circuit formed by R36, R42, D12 and D13. The resulting voltage is not more than approximately 3.4V above or below -5V. As the output of IC3/14 is not 'symmetrical' about -5V, D10 is used to bypass R36 and thus keep the current through D12 and D13 approximately equal for both directions of flow. The voltage on the anode of D12 is passed into adjustment potentiometer RV4 (used to allow adjustment of the overall accuracy of the timer), and is then buffered by IC3c. The output from IC3/8 is used as the input to the integrator – via two possible routes: through analog switch IC1a – if this is turned on, and through the potential divider R2 and R3, if IC1a is not switched on.

Integration takes place with respect to -5V, and IC6/6 either moves towards 0V or towards -5V depending on whether IC3/14 is high or low. When the integrator output equals the Master fader setting, IC3/14 moves to -5V and prevents further change of the integrator output. [In practice this circuit tends to oscillate, but the magnitude of oscillation at IC6/6 is negligible]. Component values are such that if IC1a is switched on, the integrator output will move by 5V in approximately 1 second, but if IC1a is not switched on, the integrator output will take approximately 5 minutes to move by 5V.
The overall rate of change at IC6/6 is determined by the relative on and off times of IC1a. This is controlled by the output of the Timer Control circuit.

Note : IC6 (and IC5 in the B Timer circuit) have been selected as a type which has very low specified offset voltage and current, in order to reduce timing errors during slow fades. In addition to this, rings of track (guard rings) are present around the connections to the inverting inputs of IC5 and IC6, to 'protect' against the possibility of current leaking across the surface of the PCB, and causing timing errors.

8.2.3.3 'Manual'

IC3b compares the setting of the Time fader against a voltage just above -5V. When the fader output is below this voltage, ie. very close to its top end, IC3/7 switches to a high level. This in turn switches on transistor VT6, and rapidly discharges C22. IC9/8 then switches to 0V, turning on analog switches IC1c and IC1d which connect the Master faders so that they bypass the fade timers.
The timers continue to operate, catching up with any Master fader movement within 1 second.
When the Time fader is moved away from its top position, IC3/7 switches to a low level, turning off VT6. C22 charges through R57. After a delay of about 2 seconds, IC9/8 switches low, turning off IC1c and IC1d. This delay prevents a possible 'jump' in channel levels in a situation where the Time fader is brought to its top and then moved downwards immediately afterwards.

Following the application of power to the LX, C22 is discharged. This causes 'Manual' to be active (until C22 charges), and additionally, current through R6 and D3 causes the Timer Control output to be at the 1 second setting – regardless of the position of the Time fader. Thus, following power up, the actual Master level signals will move to match the settings of the Master faders.

8.2.4 Master Active Indicators

R27, R17, and R70 provide two voltages of approximately -0.5V, and -4.5V. The A & B Master levels are compared against these voltage by IC4b and IC4a. Whenever the A Master level is more negative than -0.5V (corresponding to a control level of 10%), IC4/7 switches to a low level, and switches on LED1. Whenever the B Master level is more positive than -4.5V (corresponding to a control level of 10%), IC4/1 switches to a low level, and switches on LED2.

When Blackout is active, IC4/6 and IC4/2 are switched to -15V via D8 and D26, thus ensuring that the comparator outputs are held at a high level, and that LED1 and LED2 are off.

8.2.5 Blackout Switch

The Blackout Switch is a push button type, electronically latched, with an LED indicator to show 'Blackout Active'.
The setting of Blackout is 'remembered' for approximately 5 minutes following removal of power from the console.

8.2.5.1 Switch Circuit

The Blackout switch (SW1) is de-bounced by a CR network (C21, R60, R51) and a Schmitt Trigger inverter (IC9a). The 'debounced' switch signal from IC9/2 is further inverted by IC9b and is then applied via transistor VT13 to the clock input of a D-type flip-flop (IC8a), which is connected as a 'toggle' device. Each time SW1 is operated, IC8/1 changes state – from low (Blackout off) to high (Blackout on), or from high to low.
When Blackout is active (IC8/1 at a high level), VT5 is switched on. This illuminates LED4, clamps the voltage at IC4/6 and IC4/2 at a low level – preventing the operation of the Master Active indicators, and turns on VT4 which clamps the -11.2V reference at the anode of D21 to 0V – reducing both A and B Master outputs to 0%.

8.2.5.2 Blackout Switch Circuit Power Supply

The -15V power supply for IC8 (push button latch) is taken via a Schottky diode to C20 and C25 (C25 is not normally fitted to the PCB). C20 holds sufficient energy to operate IC8 for at approximately 5 minutes.
Whilst power is applied to the LX, power for IC8 flows through D18 from the power supply, and C20 is fully charged.
When power is removed from the LX, the -15V rail will move to a zero voltage. D18 is then reversed biased. Power for IC8 flows from C20, via R67. Additionally, C20 slowly discharges through R50, VT9, and R55. If C20 has discharged to less than about -5V before power is re-applied to the console, at power up VT9 will be switched off, which will switch VT10 on and reset IC8a to the Blackout off condition.
In order to prevent current being drained from C20 unnecessarily, when power is off, IC8 is isolated from other devices. VT13 isolates IC8/3 from IC9/4, and D14 isolates IC8/1 from VT5.

8.3 12 Channel Fader PCB (-10V) Ref 1962 PCB 1029

8.3.1 Master Signals

The A and B Master signals are buffered by transistors VT1 and VT2 which operate as Emitter Followers.
The Flash Master signal is connected directly to the Flash pushes.

8.3.2 Power Supply

If power is being supplied from the dimmer packs, diodes D49 and D50 ensure that the possible sources of -15V power 'pile' together.

8.3.3 Channel Circuits

Only the circuit for Channel 1 is described, as all twelve channel circuits are identical in operation.
The buffered A Master signal is applied to the top end of fader RV1. The buffered B Master signal is applied to the top end of fader RV2. The outputs from the two faders will be reduced versions of the Master signals – depending upon the fader positions. The outputs from faders RV1 and RV2 are taken via diodes D2 and D1. The output from Flash push SW1 is taken via diode D3 to the same point.
The signal at the anodes of D1, D2, and D3 will be a combination of the outputs from the two faders and the Flash push. This combination will take the form of 'highest-takes-precedence', ie. at any one instant, the signal will be derived from whichever of the three possible sources has the greatest voltage. The waveforms in Figure A10 show an example of this style of operation.

Note : whenever the Master faders on the Control module are not at either 0% or 100%, the signals at the faders will be 'chopped' and not stable DC.

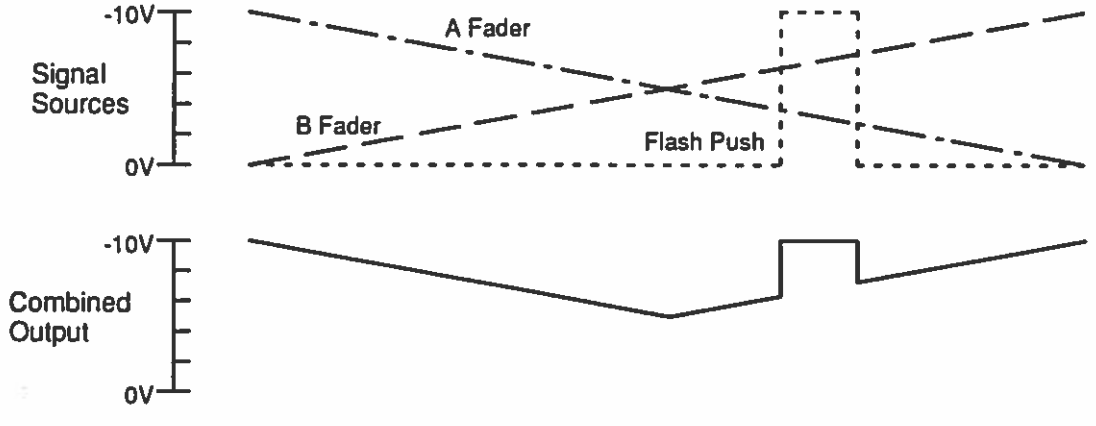


Figure A10 – 'Highest-Takes-Precedence' Waveforms

The combined output signal is fed via a simple low pass filter network, formed by R3 and C2, in order to smooth out the chop mastering waveforms. The filter time constant is approximately 1/20 second. This is long enough to provide the required level of filtering, but short enough not to affect the sensitivity of control. Figure A11 shows an example of the relevant waveforms.

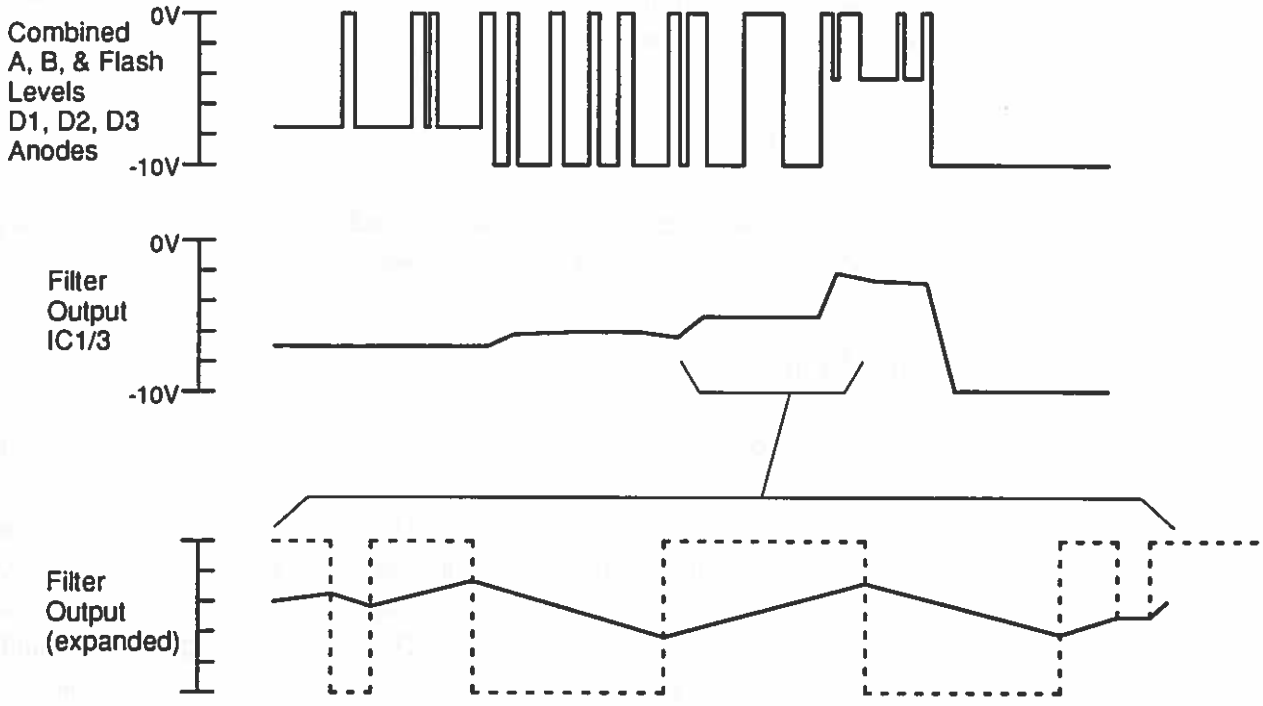


Figure A11 – Channel Output Waveforms

The filter output is buffered by an operational amplifier (IC1a) connected in voltage follower configuration. The operational amplifier output at IC1/1 then drives the channel indicator LED (LED 1), and the dimmer output at PL1/1 via a series connection of a 10KΩ resistor (R7) and a diode (D9).
Output IC1/1 is also connected to connector PL3/1. This connector is not fitted on standard PCBs.

8.4 6 Channel Fader PCB Ref 1961 PCB 1028

This design is a reduced version of that used for the 12 Channel Fader PCB.

8.4.1 Master Signals

The A and B Master signals are buffered by transistors VT1 and VT2 which operate as Emitter Followers.

8.4.2 Power Supply

If power is being supplied from the dimmer packs, diode D19 ensures that the possible sources of -15V power 'pile' together.

8.4.3 Channel Circuits

Only the circuit for Channel 1 is described, as all six channel circuits are identical in operation.
The buffered A Master signal is applied to the top end of fader RV1. The buffered B Master signal is applied to the top end of fader RV7. The outputs from the two faders will be reduced versions of the Master signals – depending upon the fader positions. The outputs from faders RV1 and RV7 are taken via diodes D4 and D3. The output from Flash push SW1 is taken via diode D1 to the same point.
The signal at the anodes of D1, D3, and D4 will be a 'highest-takes-precedence' combination of the outputs from the two faders and the Flash push.
Note : whenever the Master faders on the Control module are not at either 0% or 100%, the signals at the faders will be 'chopped' and not stable DC.

The combined output signal is fed via a simple low pass filter network, formed by R4 and C3, in order to smooth out the chop mastering waveforms. The filter time constant is approximately 1/20 second.

The filter output is buffered by an operational amplifier (IC1a) connected in voltage follower configuration. The operational amplifier output at IC1/1 then drives the channel indicator LED (LED 1), and the dimmer output at PL1/1 via a series connection of a 10KΩ resistor (R24) and a diode (D25).
Output IC1/1 is also connected to connector PL3/1. This connector is not fitted on standard PCBs.

8.5 12 Channel Fader PCB (+10V) Ref 1962 PCB 1029

8.5.1 Master Signals

The A and B Master signals are buffered by transistors VT1 and VT2 which operate as Emitter Followers.

8.5.2 Channel Circuits

Only the circuit for Channel 1 is described, as all twelve channel circuits are identical in operation.
The buffered A Master signal is applied to the top end of fader RV1. The buffered B Master signal is applied to the top end of fader RV2. The outputs from the two faders will be reduced versions of the Master signals – depending upon the fader positions. The outputs from faders RV1 and RV2 are taken via diodes D3 and D2. The output from Flash push SW1 is taken via diode D1 to the same point.
The signal at the anodes of D1, D2, and D3 will be a 'highest-takes-precedence' combination of the outputs from the two faders and the Flash push.
Note : whenever the Master faders on the Control module are not at either 0% or 100%, the signals at the faders will be 'chopped' and not stable DC.

The combined output signal is fed to the combination of IC1a, R3, R7, and C1. IC1a is configured as an Integrator, with its gain limited to a maximum of -1. This integration circuit operates as a low pass filter network with a time constant of approximately 1/20 second. The filter smooths out the chop mastering waveforms, and in addition, the inverting action of the circuit provides an output which is positive going, from the negative going Master signals.

The integrator output at IC1/1 then drives the channel indicator LED (LED1), and the dimmer output at PL2/1 via a series connection of a 1KΩ resistor (R9) and a diode (D9).

8.6 PSU Regulator PCB Ref 1967 PCB 1034

The input current from the battery eliminator is given additional smoothing by C2, and is voltage regulated to -15V by REG1. Diode D1 prevents problems if power to the LX is supplied simultaneously from dimmer packs and from a battery eliminator. D1 and diodes on the Fader PCBs combine the different power sources on a highest-takes-precedence basis.

Diode D3 protects the LX from either voltage transients above 24V in amplitude or from the connection of a supply with +ve and -ve terminals reversed. Any high currents which may flow under fault or error conditions cause R2 (a Positive Temperature Coefficient device) to heat up and change into a high resistance condition so limiting such currents to a safe level.

Should the input voltage from the battery eliminator drop below about 17V (because of low mains voltage, for example), REG1 will be unable to maintain a -15V output. However, the voltage from REG1 will simply drop in proportion to the low input voltage, and will still operate the LX correctly. (unless the voltage from the battery eliminator drops to below about 15V).

9. Block Diagrams

This section contains Block Diagrams for the five standard versions of LX. The diagrams show the printed circuit boards, together with interconnection cables. An indication of the number of wires in each cable is shown alongside the lines which represent the cables.

The layout of connectors on the PCBs is drawn such that it represents the relative positions of the connectors on actual PCBs.

The following symbols are used in the block diagrams :–

'Molex' Connector. The number represents the number of pins.

15 pin Min-D Connector.

8 pin DIN Connector.

Connection cable. The number represents the number of wires.

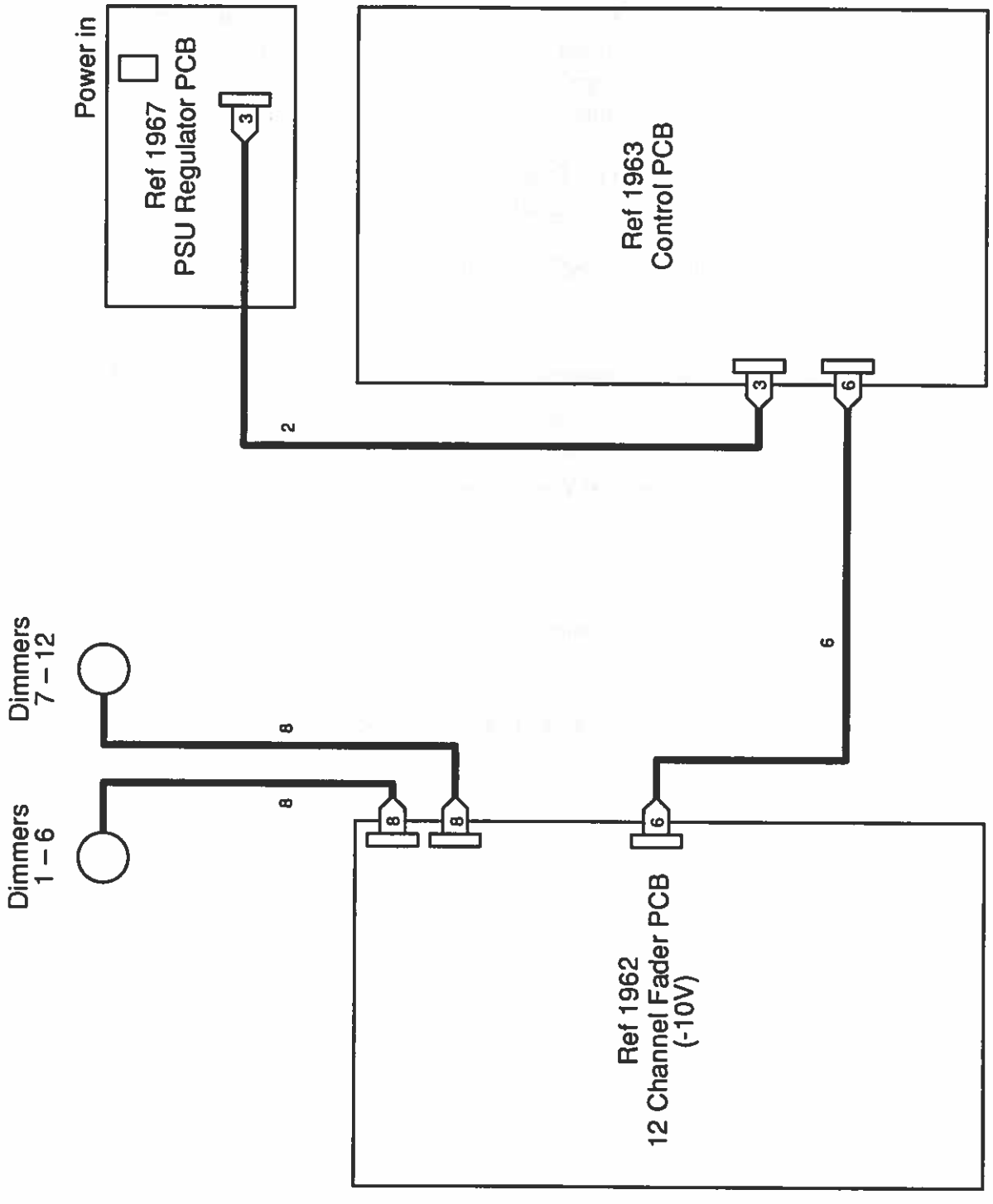


Figure 12 – 12 Channel LX -10V

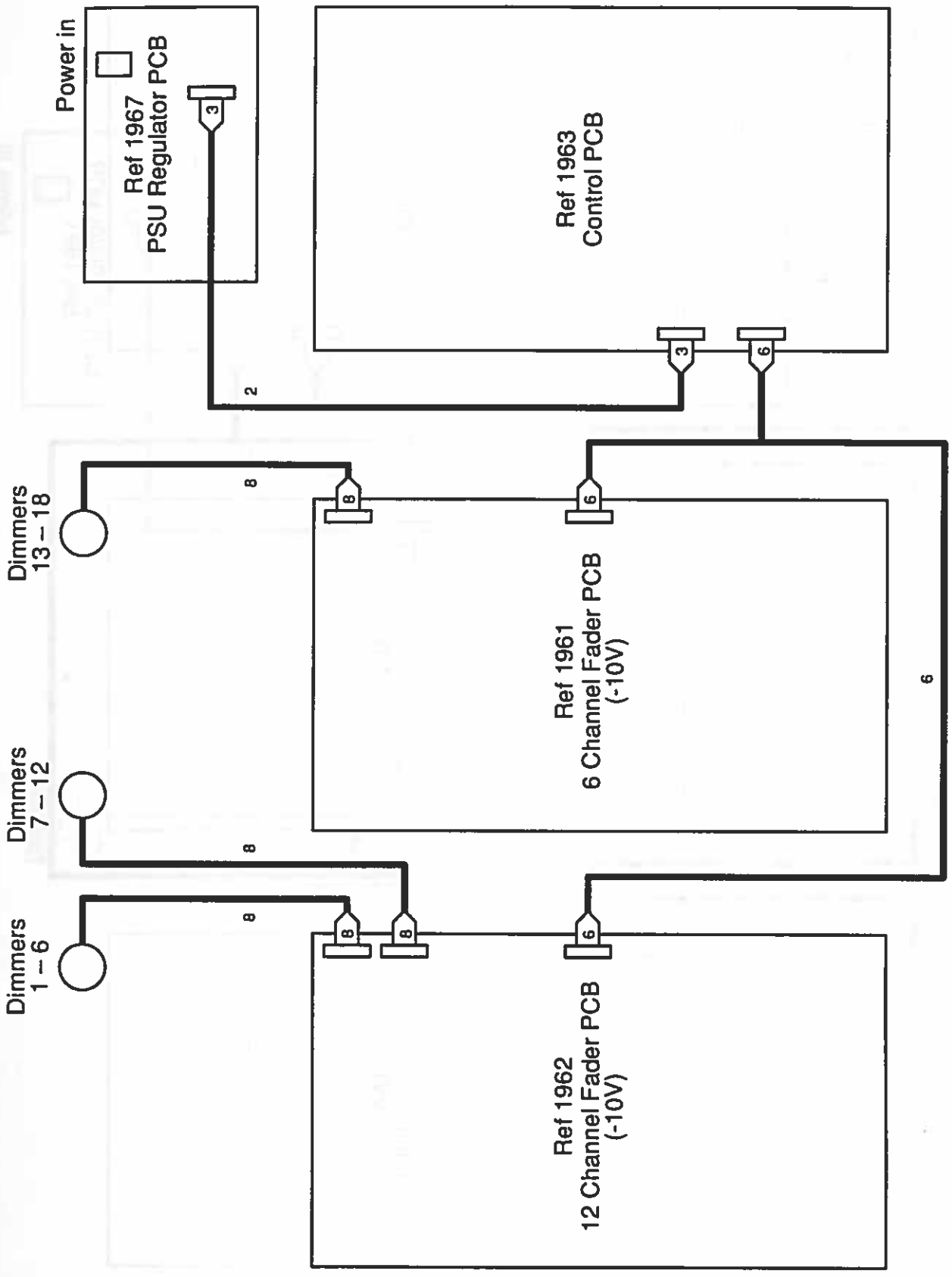


Figure 13 – 18 Channel LX -10V

LX

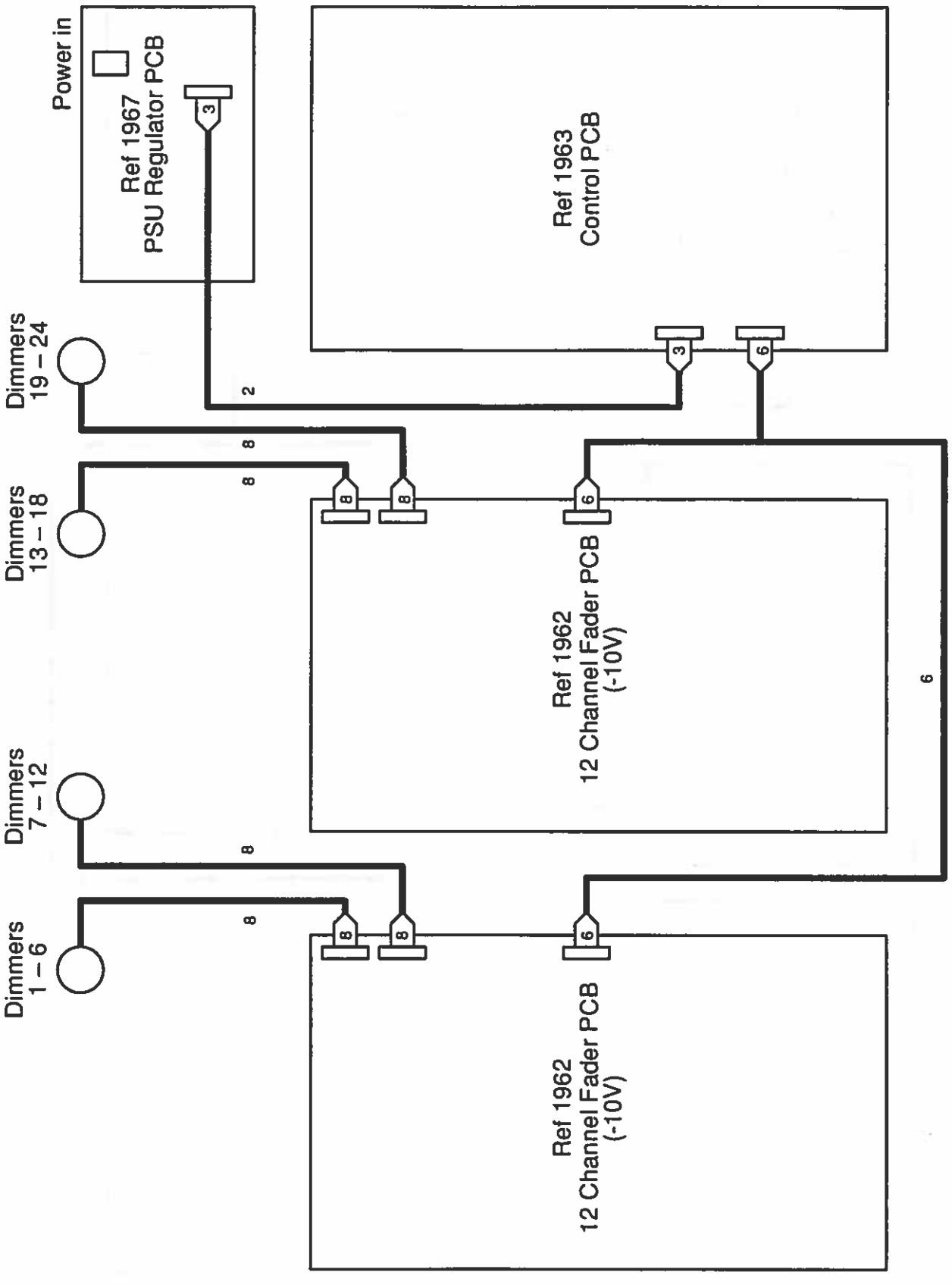


Figure 14 – 24 Channel LX -10V

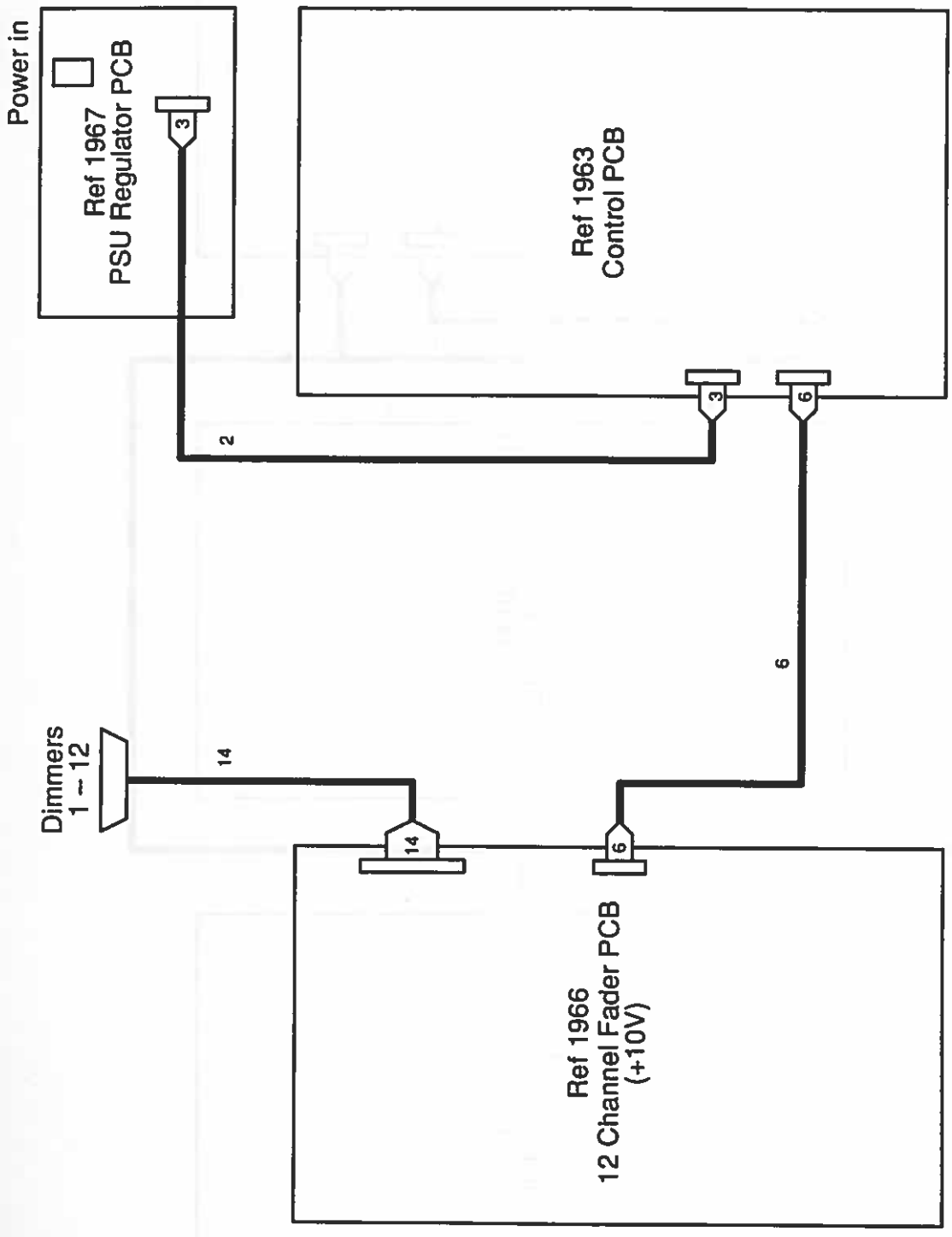


Figure 15 – 12 Channel LX +10V

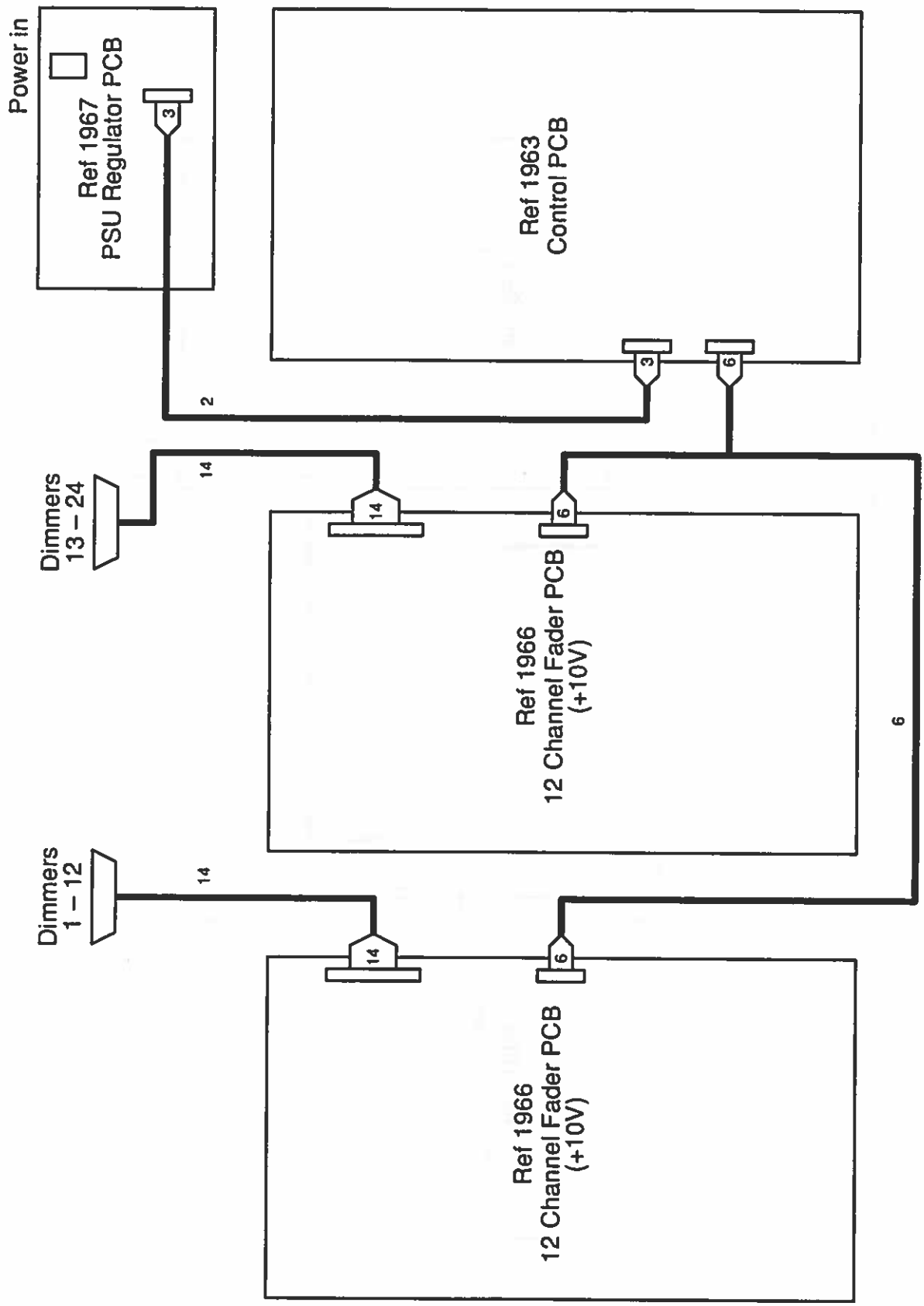


Figure 16 – 24 Channel LX +10V

10. Circuit Diagrams

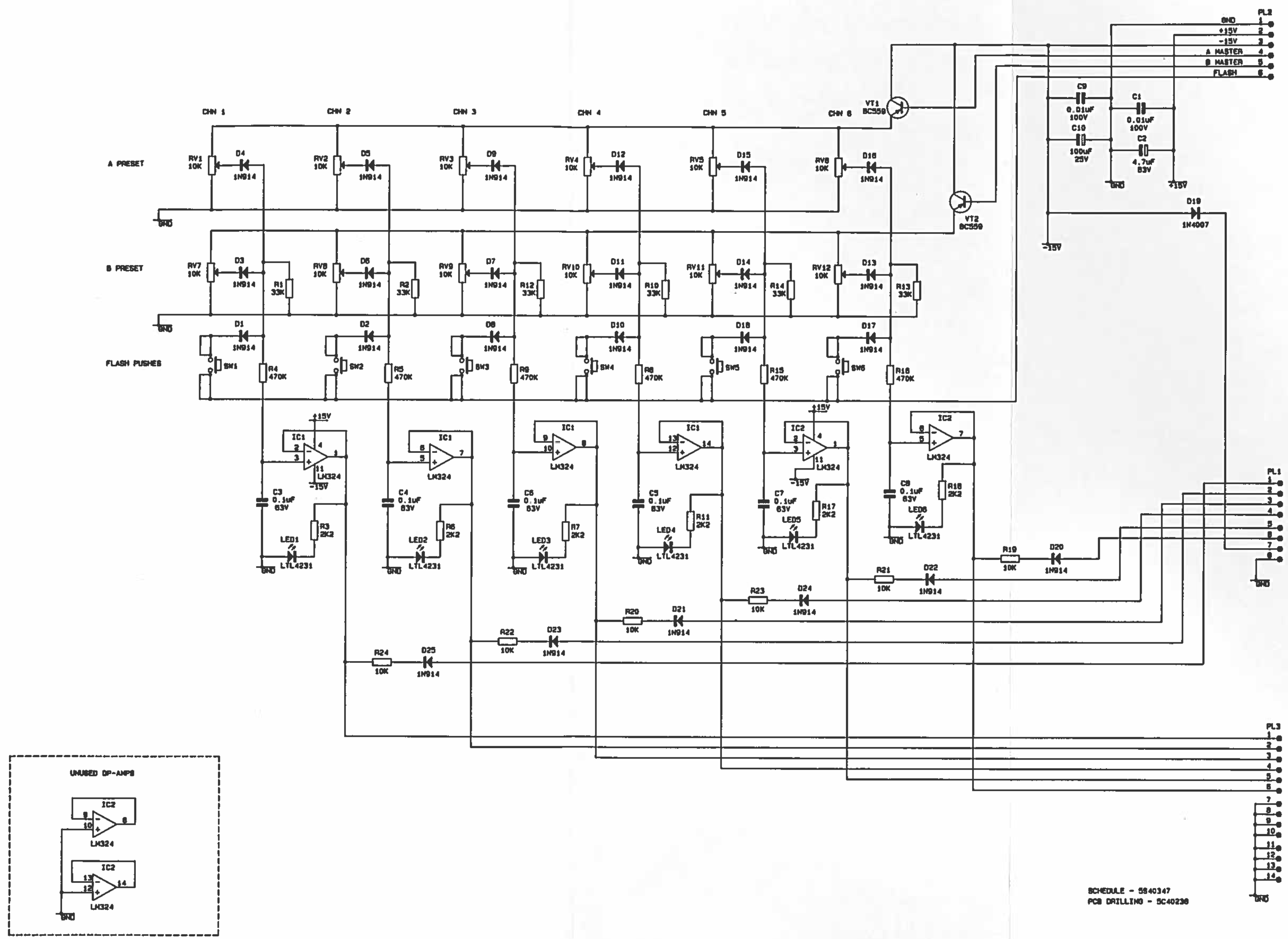
This section contains Circuit Diagrams for the five PCBs used in LX.

Drawing Number	Drawing Title	PCB Ref.
6B40237	LX 6 Way Fader Card (-10V) Circuit Diagram	1961
6B40239	LX 12 Way Fader Card (-10V) Circuit Diagram	1962
6B40241	LX Master Control Card Circuit Diagram	1963
6C40281	LX Power Supply Regulator Card Circuit Diagram	1967
6B40393	LX 12 Way Fader Card (+10V) Circuit Diagram	1966

DRG. No. 5840237 SH. 1 OF 1

3rd ANGLE PROJECTION

DO NOT SCALE
IF IN DOUBT ASK



Strand Lighting Ltd	
MATERIAL:-	
FINISH:-	
FIRST USED ON:- LX	1L40322

DIMENSIONS IN mm
TOLERANCES
1 DEC. PLACE ± 0.4mm
2 DEC. PLACES ± 0.1mm
ANGULAR ± 0.25°
UNLESS OTHERWISE STATED

SCALE		DATE
DRAWN	A.H.P.	06.08.90
CHECK'D	R.PILBRIN	17.08.91
APP'D	A.R.BROWN	17.08.91

TITLE
LX 6 WAY FADER CARD (-10V)
CIRCUIT DIAGRAM

I B

PCB1028/1 REF1961

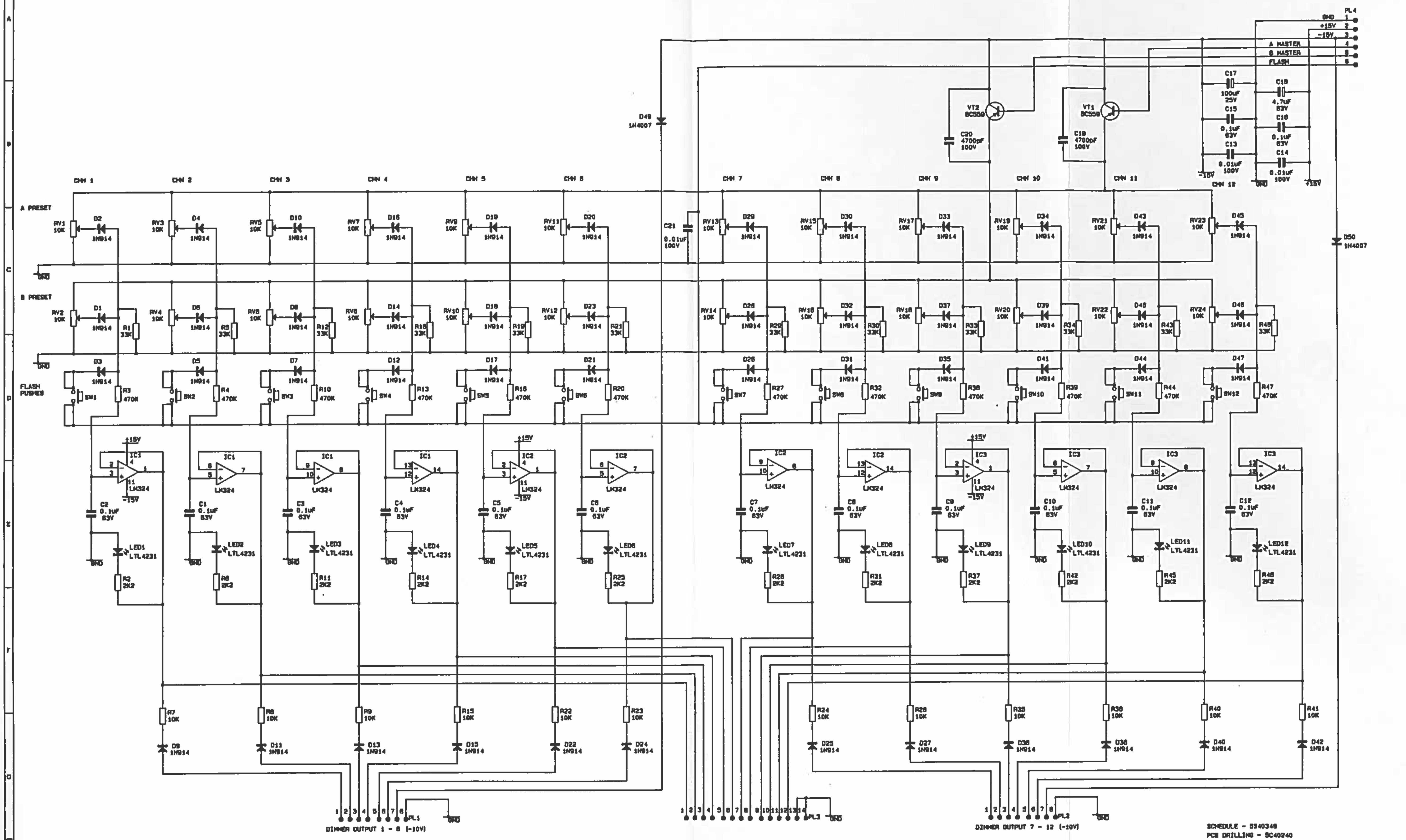
ISSUE 1

DRG. No. 5840237 SH. 1 OF 1

DRG. No.	SH. 1
6840239	OF 1

3rd ANGLE PROJECTION

DO NOT SCALE
IF IN DOUBT ASK



MATERIAL:-	DIMENSIONS IN mm TOLERANCES 1 DEC. PLACE ± 0.4mm 2 DEC. PLACES ± 0.1mm ANGULAR ± 0.25° UNLESS OTHERWISE STATED	TITLE LX 12 WAY FADER CARD (-10V) CIRCUIT DIAGRAM	I B
FINISH:-	SCALE / DATE	PCB1029/2	REF 1962
FIRST USED ON:- 1L40322 LX	DRAWN A.H.P. 18.08.88	ISSUE 1	DRG. No. 6840239 SH. 1 OF 1
	CHECK'D K.PILGRIM 17.05.91		
	APP'D A.R.BROWN 17.05.91		

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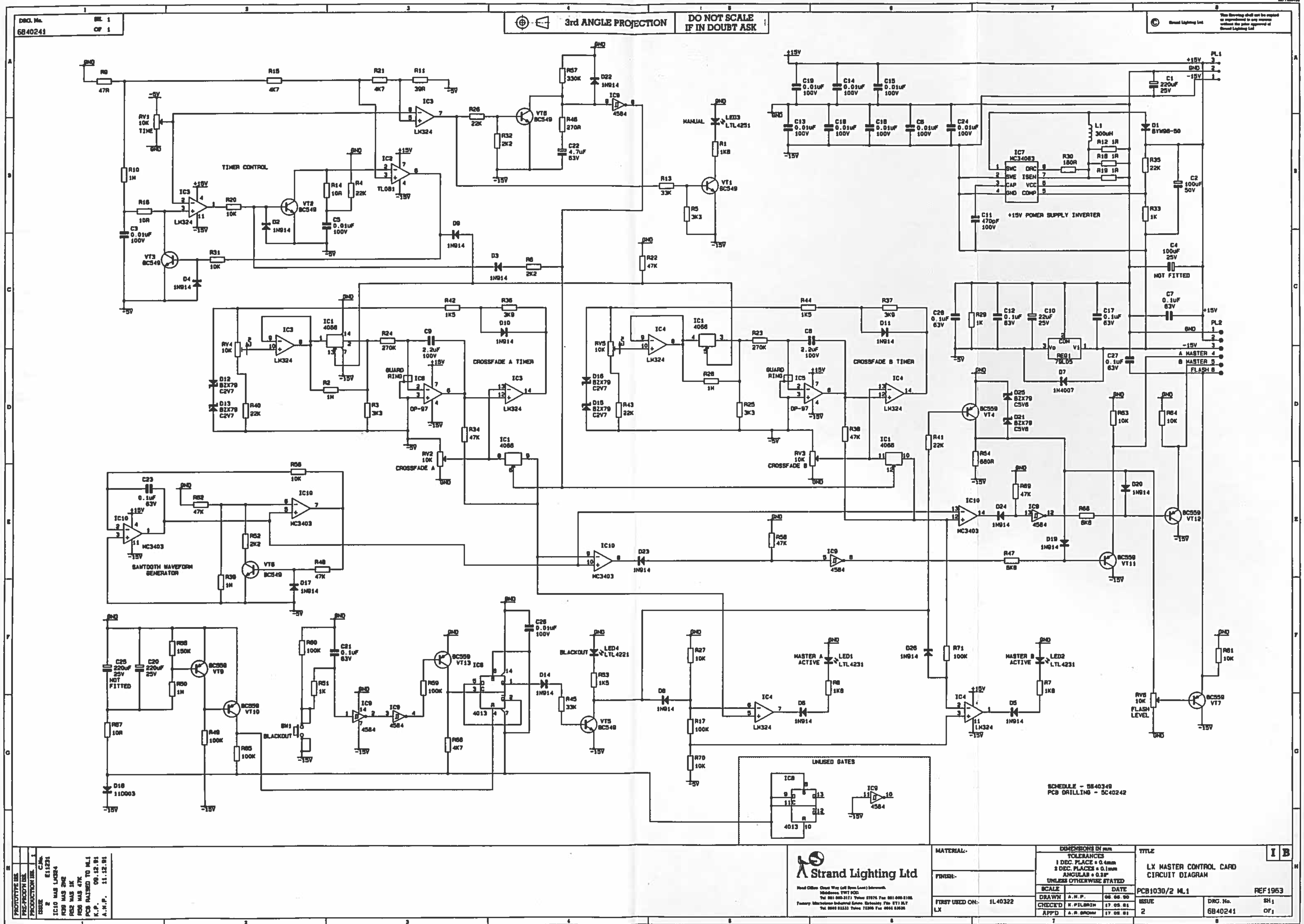
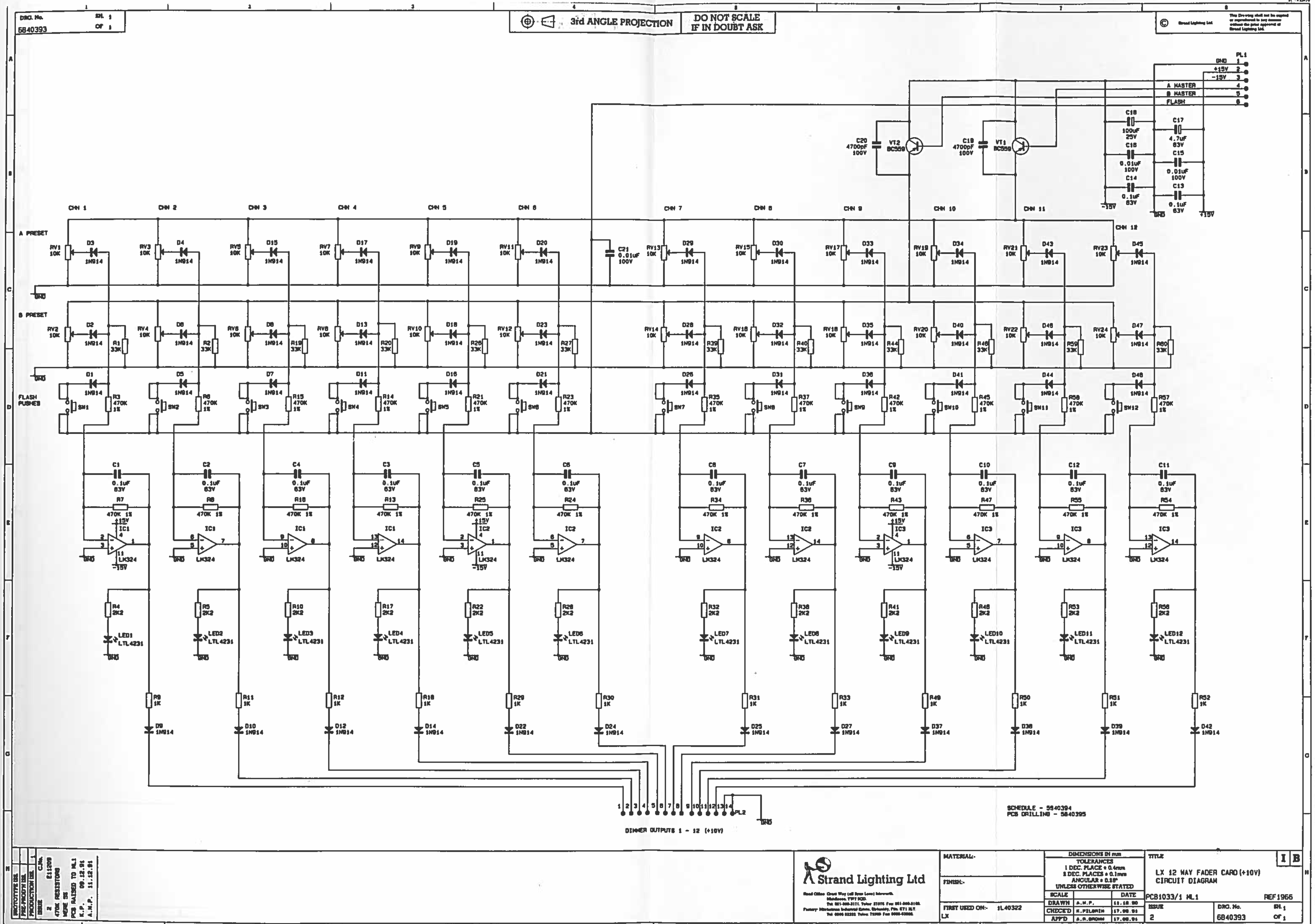
PROTOTYPE ISS. | PRE-PRODUCTION ISS. | PRODUCTION ISS. | ISSUE | C.No.

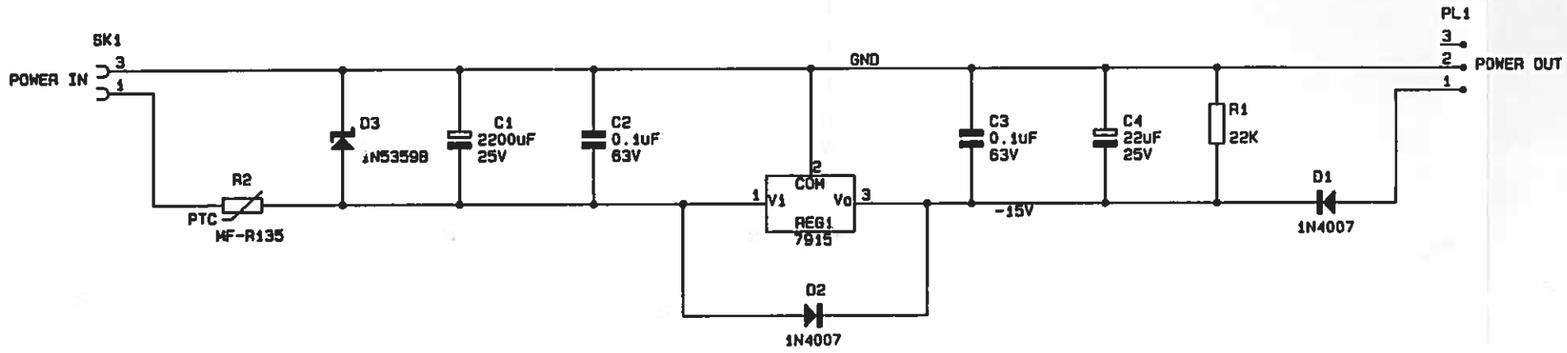

DRG. No. 6B40241 SH. 1 OF 1
3rd ANGLE PROJECTION
DO NOT SCALE
IF IN DOUBT ASK
TIMER CONTROL
CROSSFADE A TIMER
CROSSFADE B TIMER
+15V POWER SUPPLY INVERTER
SAWTOOTH WAVEFORM GENERATOR
UNUSED GATES
SCHEDULE - 5B40349
PCB DRILLING - 5C40242
Strand Lighting Ltd
MATERIAL:-
FINISH:-
FIRST USED ON:- 1L40322
TITLE
LX MASTER CONTROL CARD
CIRCUIT DIAGRAM
PCB1030/2 ML1
REF1963
ISSUE 2
DRG. No. 6B40241


DRG. No. 6840393
3rd ANGLE PROJECTION
DO NOT SCALE IF IN DOUBT ASK
A PRESET
B PRESET
FLASH PUSHES
GND
+15V
-15V
A MASTER
B MASTER
FLASH
PL1
PL2
DIMMER OUTPUTS 1 - 12 (+10V)
SCHEDULE - 5840394
PCB DRILLING - 5840395
Strand Lighting Ltd
MATERIAL:-
FINISH:-
FIRST USED ON:- 1L40322
LX
DIMENSIONS IN mm
TOLERANCES
1 DEC. PLACE ± 0.4mm
2 DEC. PLACES ± 0.1mm
ANGULAR ± 0.10°
UNLESS OTHERWISE STATED
SCALE
DATE
DRAWN A.M.P.
CHECK'D K.PILGRIM 17.08.91
APP'D A.R.BROWN 17.08.91
TITLE
LX 12 WAY FADER CARD (+10V)
CIRCUIT DIAGRAM
PCB1033/1 ML1
REF 1966
ISSUE 2
DRG. No. 6840393
SH. 1 OF 1

DRG. No.	SH. 1
6C40281	OF 1

3rd ANGLE PROJECTION

DO NOT SCALE
IF IN DOUBT ASK



SCHEDULE - 5S40282

PCB DRILLING - 5C40283

ISSUE	C.No.
PROTOTYPE ISS.	
PRE-PROD'N ISS.	
PRODUCTION ISS.	

Strand Lighting Ltd

Head Office: Great Way (off Syon Lane) Isleworth. Middlesex. TW7 5QD.
Tel: 081-560-3171. Telex: 27976. Fax: 081-568-2103.
Factory: Michaelston Industrial Estate, Kirkcaldy, Fife. KY1 3LY.
Tel: 0592-52333. Telex: 71300. Fax: 0592-53888.

MATERIAL:-

FINISH:-

FIRST USED ON:- 1L40322
LX

DIMENSIONS IN mm
TOLERANCES
1 DEC. PLACE ± 0.4mm
2 DEC. PLACES ± 0.1mm
ANGULAR ± 0.25°
UNLESS OTHERWISE STATED

SCALE		DATE
DRAWN	A.N.PIELOU	14.05.90
CHECK'D	K.PILGRIM	16.05.91
APP'D	A.R.BROWN	17.05.91

TITLE

LX POWER SUPPLY REGULATOR
CIRCUIT DIAGRAM

I C

PCB1034/2 REF1967

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