Kentech Instruments Ltd.

Regenerative Driver for an Acousto-Optic Mode Locked Laser

1st. November 1999

PLEASE READ THIS MANUAL CAREFULLY BEFORE USING THE UNIT

Unit 9, Hall Farm Workshops, South Moreton, Didcot, Oxon, OX11 9AG, U.K.

DISCLAIMER AND CAUTION

With an appropriate load, this unit is safe for use by an educated user in a laboratory environment. You are warned, however, that the radiation from the system with an antenna or inappropriate load connected can damage sensitive equipment. This equipment is be supplied on the understanding that the user will analyse these risks, accept responsibility for them and take appropriate precautions in the use of this instrument.

Kentech Instruments Ltd. accepts no responsibility for any damage or liabilities incurred in the operation of this equipment.

Please read the manual before applying power.

Do not remove the covers. In the event of a problem return it to Kentech Instruments Ltd. or its appointed agent for servicing.

The accessible terminals of this instrument are protected from hazardous voltages by basic insulation and protective grounding via the IEC power input connector. It is essential that the ground terminal of this connector is earthed via the power lead to maintain this protection.

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1 INTRODUCTION

This manual describes the operation and use of the Regenerative Mode Locker Driver. This device is used to drive an acousto-optic mode locker. The drive signal is derived from the laser pulse train and a phase locked loop fixes the output phase with respect to the input phase. The unit can operate over a wide frequency range, has adjustable "Q" and has enough output power to drive mode lockers either resonantly or non resonantly.

1.1 SPECIFICATIONS:-

1. Frequency coverage, 60MHz to 110MHz input, the main output is half of these values.
2. Output power ~1 watt (the amplifier delivers 2 watts but there is a reverse terminating network which reduces this to ~1 watt.
3. Input sensitivity, approximately 4μ Watts will lock the unit. (The unit needs about 2μ Watts in the fundamental frequency).
4. Maximum sweep width, typically 665kHz @ 60MHz, 530kHz @ 80MHz and 677kHz @ 110MHz. At least 500kHz over the operating band.
5. Maximum sweep speeds are typically:-
   580kHzs^{-1} at 60MHz
   400kHzs^{-1} at 80MHz
   300kHzs^{-1} at 110MHz
6. Minimum sweep width is nominally zero but the unit actually just sweeps very fast between the start and stop values. The width is then similar to the oscillator bandwidth.
7. Adjustable Q, 5,7,10,15,20,50, 70 &100.
8. Delay 10 steps of 2.5ns plus fine delay of 4ns.
9. Input gain adjustment >40dB diode voltage or >20dB refered to optical power. I.e. better than 100:1 on optical power.
10. The output can be adjusted and also an attenuator can be switched in to give both a lower output and a reverse termination. Output purity is better at higher output powers.
11. There is a frequency meter with 6 digit 1kHz resolution. The reading is updated at 8Hz.
12. There is an indicator of the locked and sweep conditions. When it is sweeping slowly the indicator tells you which way it is sweeping, green/up, red/down.
13. There are controls for the start frequency, stop frequency and rate of sweep when it is scanning the drive and looking for a signal on which to lock.
14. Ancillary output, approximately 2 volts into 50Ω at the frequency of the local oscillator. This output does not go through the delay circuitry and is intended as an additional metering point.
15. There is an output inhibit, both manual and external. The latter is intended for use with a thermistor. There is a potentiometer to set the threshold level. This can be used to stop the driver when the mode locker overheats.
16. Mains input is universal.
17. It has a fibre optic input and is supplied with a 2 meter length of 200μm fibre and a focussing lens.
18. Size 330mm wide, 140mm high, 250mm deep
19. Connectors, Input fibre optic SMA (cable provided with a focusing lens). Main output SMA, ancillary output BNC. Thermal trip input, Lemo "00". Power IEC (Lead supplied)

2 GETTING TO KNOW THE INSTRUMENT

2.1 FRONT PANEL CONTROLS, CONNECTIONS AND INDICATORS.

The front panel is shown in figure 1.

The input signal is a low power optical signal from the laser to be driven. Typically the optical signal is collected as the leakage through a cavity mirror.

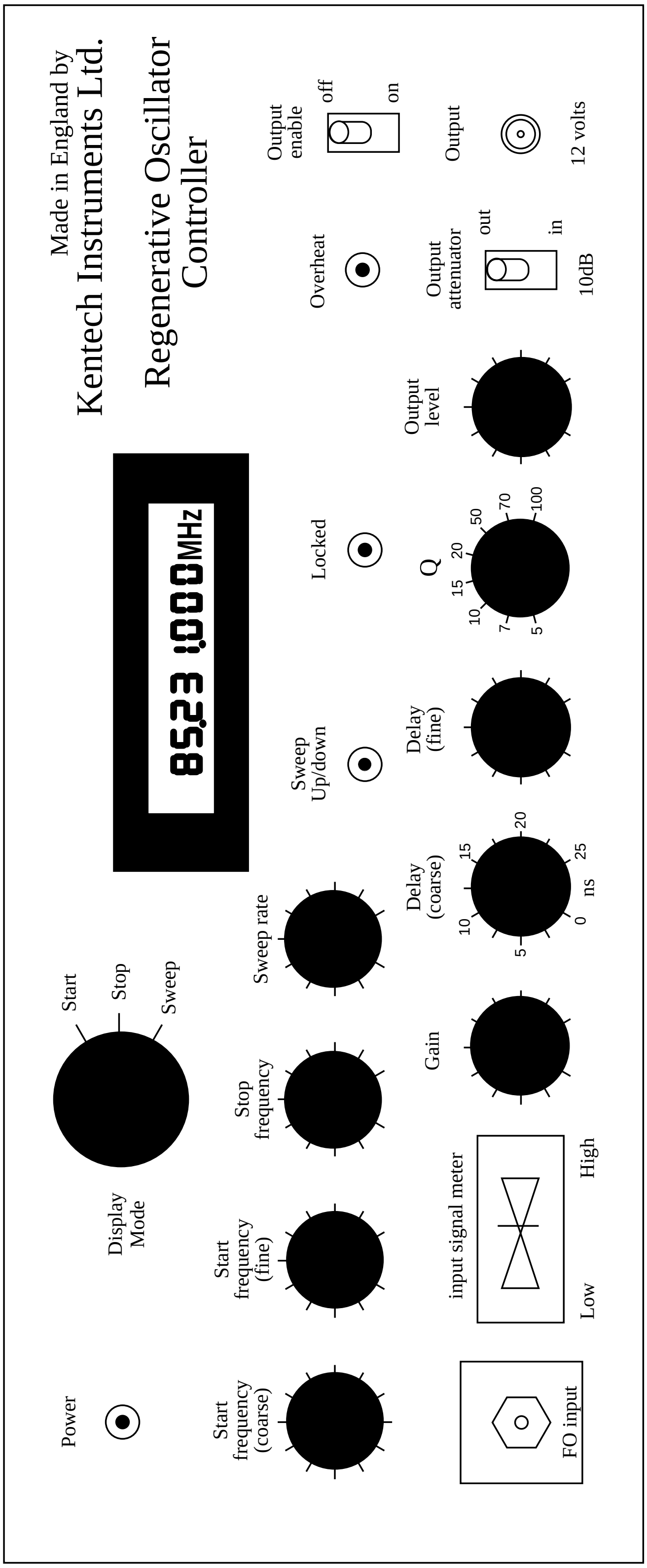

Figure 1 The front panel

The gain control next to the input allows the input level to be set to match the optimum of the unit. The input is an SMA fibre optic connector. The unit is supplied with a 2 meter by 200μm fibre optic cable with a focusing lens. The lens is set for collection of nominally parallel light.

Above the input are the scanning controls. These enable the frequency scan range to be set. The start frequency and the end frequency are set using the mode switch and the meter along with the adjustment control. In addition the sweep rate can be controlled. In the absence of an input signal the unit will scan the output frequency over the range. Actually the output frequency is half the input frequency as is required to drive an acousto-optic mode locker.

The direction of the sweep is given by the colour of the sweep light; green for up and red for down.

There is a delay control that allows the overall loop delay to be adjusted by more than one cycle of the input signal. This allows the unit to operate at the best possible part of the phase of the input signal. The “Q” control sets the number of cycles of the input frequency that are averaged to obtain the phase error signal that corrects the output phase.

The output level is controlled by both a switched attenuator and a gain control. The output can be disabled from the front panel and this is useful when setting the start and stop frequencies to stop a lock occurring.

There is a indicator of the overheat condition. If the mode locker overheats this will disable the RF output. This should be used in conjunction with a negative temperature coefficient thermistor (10k @25°C) placed in the mode locker housing. The thermistor is connected to the rear panel and the thermal trip level set with the rear panel control. The rear panel also has an RF output that is phase locked to the input and at the same frequency, i.e. twice that of the main output. This can be used to drive ancillary electronics synchronously with the laser.

2.2 REAR PANEL CONNECTIONS

The rear panel has connections for power, including the on/off switch, a thermistor for overheat protection and a RF output at the laser frequency.

The rear panel is shown in figure 2.

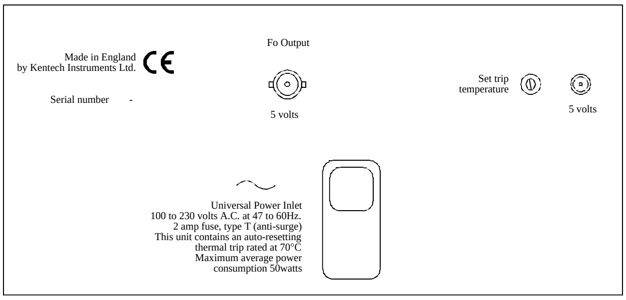

Figure 2 The rear panel

3 USE

3.1 CONNECTIONS AND APPLICATIONS

The unit is for use with an acousto-optically mode locked visible or near visible laser having a mode locked train running at 60 to 110MHz. The mode locker works by deflecting the laser beam in a reciprocating manner from a sinusoidal varying density caused by the sound wave in the mode locker. The beam is undeflected twice per cycle and at these times the pulse can continue in the cavity and losses are small. Consequently the mode locker is run at half the frequency of the laser output. This halving of the frequency is performed in the driver after the phase locking.

The unit is designed so that the laser cavity determines the laser frequency. Ideally the cavity length should be tuned so that the mode locked train frequency is near to an acoustic resonance of the mode locking crystal. Both of these should be measured and set to be nearly equal.

A small light signal from the laser is required to be fed into the unit; a few μwatts will suffice and should be available as leakage through a cavity mirror.

The light must be fed into the optical input of the unit. A fibre optic cable with a focusing lens is provided. The focus may need adjusting if the beam is not parallel or possibly due to dispersion in the lens making the focal length significantly different from 670nm (the wavelength it was set up at).

The main output from the front panel should be fed to the mode locker. It is important that the mode locker not be fed so hard that it heats up as this will change its properties significantly. To this end the unit is fitted with a thermal overload protection which is connected to a thermistor that should be integrated into the modulator. Most modulators are available with such a device. It should be negative temperature coefficient device with an impedance of about 10kΩ at 20°C. This is a very standard device. The thermistor is connected to the Lemo™ connector on the rear panel. If the users wishes to limit the temperature to a specific value then the threshold needs to be set up carefully, see section??

If the mode locker has no suitable resonances it may be driven non resonantly but this will require more power and the risk of heating is increased.

There is also an RF output from the rear panel that is at the laser output frequency. This may be used for more accurate frequency measurement, output bandwidth measurement or synchronising ancillary equipment.

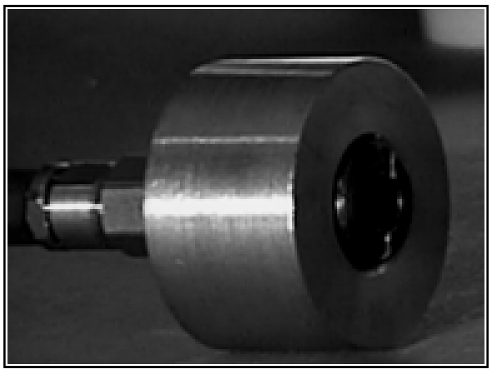

Figure 3 The input lens showing front lens position adjuster slot.

3.2 SETTING UP THE SYSTEM

The laser should be set up with the mode locker in place such that it lases continuously with no drive to the mode locker. The connections should be arranged as indicated in section 3.1.

The start and stop frequencies should be set. This is done by switching the "Display Mode" switch to "Start" and adjusting the start coarse and fine controls until the correct start frequency is displayed. This should be a frequency around 250kHz less than the expected resonance of the laser cavity and the mode locker. The stop frequency can be set to maximum which is around 500kHz above the start frequency. The scan rate should be set fairly slow. The unit should then be allowed to scan. The up/down indicator will indicate the scanning direction.

During this set up procedure it is possible that the laser will mode lock and cause the unit to lock. This will cause the internal oscillator to lock onto the input and ignore the start and stop frequency settings. Although this is the aim of the set up procedure it may be preferable to turn off the output during the set up so that the set up can be completed. Once the controls are set the output can be switched on. If a lock does occur during set up, the frequency meter will indicate the locked frequency not the start or stop value. This value should be noted as it may be somewhat different from that expected and it will make it easier to find.

Once the start and stop frequencies are set the "Display Mode" should be set to sweep and the sweep rate may be adjusted. A fast sweep rate will work if the laser mode locks well. If the mode locking is not very strong it will be better to sweep more slowly. If the laser does not lock after several sweeps then it may be necessary to adjust the range of the sweep until a lock is achieved.

Once lock is achieved the system can drift outside the range of the start and stop frequencies; drifting is normally due to the laser cavity length changing, possibly due to a movement of the laser axis or a component heating up. The problem with this is that if the lock is lost the unit cannot recover. Consequently it is a good idea to make sure that the sweep range is always spread around the actual locked frequency. Also it may be better to reset the start and stop frequencies once the unit is warm. Temperature stabilisation of the mode locker may well improve the long term stability of the system. This unit has not been designed with such a facility as heaters deliver large currents which are not compatible with the sensitive electronics of this unit.

Note that if the start and stop frequencies are changed whilst the unit is sweeping, the sweep will continue to the new value(s) at the set scan rate; this may take a long time.

3.3 DELAY AND "Q" SETTINGS

Once lock is achieved the delay and the "Q" value should be set for optimum performance. The delay controls the timing of the output signal with respect to the input signal. i.e. the point at which the phase is measured. It is possible to have a delay setting that causes the unit to switch between adjacent cycles of the output RF. This will cause poor lasing and the delay should be changed until the lasing is stable. The "Q" value sets the number of cycles of the laser output that are averaged to give the signal to change the phase of the output. With a high "Q" the driver will try to keep driving the mode locker at the same frequency if the output timing changes and will only allow very slow changes in the overall frequency of the system. A lower "Q" will allow this change to happen more quickly and for the output to track the input faster. This may be more suitable for changing the cavity length whilst maintaining a mode locked lasing condition.

3.4 AMPLITUDE SETTING

The output amplitude should be set so as to obtain good depth of modulation of the laser cavity without undue heating of the mode locker. Heating will change its characteristics and change the mode locking conditions or possibly stop mode locking altogether. The user should consult the specification of the mode locker to determine the optimum output level and then use an oscilloscope or power meter to determine the best setting.

3.5 GAIN SETTING

The gain setting control sets the input signal to the unit to the optimum for the phase locker. If the meter indicates that the signal is too high or low the gain should be adjusted suitably.

The meter only indicates the amplitude of the incoming signal within the overall bandwidth of the unit, 60 to 110MHz. The meter will not indicate the incident power from a CW source. Prior to mode locking this amplitude is very small and a high gain is required. It may be that the unit will then lock but loose the lock because the input is too high. However, in this case the user will have a good idea of the operating frequency and be able to attempt a lock again with a lower gain setting.

If the signal is too high with the gain at minimum then the input coupling to the fibre optic should be reduced suitably.

3.6 THERMISTOR SET UP

The thermistor input is set up to trip when the temperature of a 10K @ 25°C NTC themistor reaches around 25°C. For setting up to a different temperature one of the follow procedures should be used. The available range is 2.8kΩ to 13kΩ which represents 20 to 55 °C for the recommended thermistor.

1 Set the temperature of the thermistor to the required trip temperature by suitable heating or cooling it. Then adjust the trip level on the rear panel (with a small screwdriver) until the unit just trips out and the "Overheat" light illuminates.

2 Find out what resistance the thermistor will have at the required trip temperature. Connect a resistor of this value across the thermistor input. Adjust the trip level until the unit just trips.

3.7 FIXED FREQUENCY OPERATION

The unit is designed to allow the drive frequency to track changes in the cavity and consequently the drive frequency may fluctuate in a locked condition.

For fixed frequency operation the unit can be used unlocked and the stop frequency control set to minimum. This results in an output frequency that is sweeping an amount comparable to the oscillator bandwidth and is nominally stable. The unit does not use a crystal controlled oscillator and so is subject to thermal drift.

For improved fixed frequency operation the cavity length needs to be adjustable and the user should arrange to monitor the oscillator output from the rear panel and adjust the cavity length so as to maintain this at a fixed value. This unit has not been designed for this mode of operation.

4 CIRCUIT DESCRIPTION

The unit is based on a phase locked loop. The phase of the incoming signal is compared to that of a local voltage controlled oscillator and the difference in phase is used to adjust the local oscillator frequency so that the output phase matches the input phase. The output frequency is then divided by two, fed through a passive coarse delay adjustment network, an active fine delay adjustment and then amplified to the output.

The number of cycles of input that are used to compare the two phases is set by the Q switch that adjusts time constants in the bandwidth of the voltage control to the local oscillator.

A separate section delivers ramp voltages to the local oscillator to control the sweeping of the output frequency prior to lock.

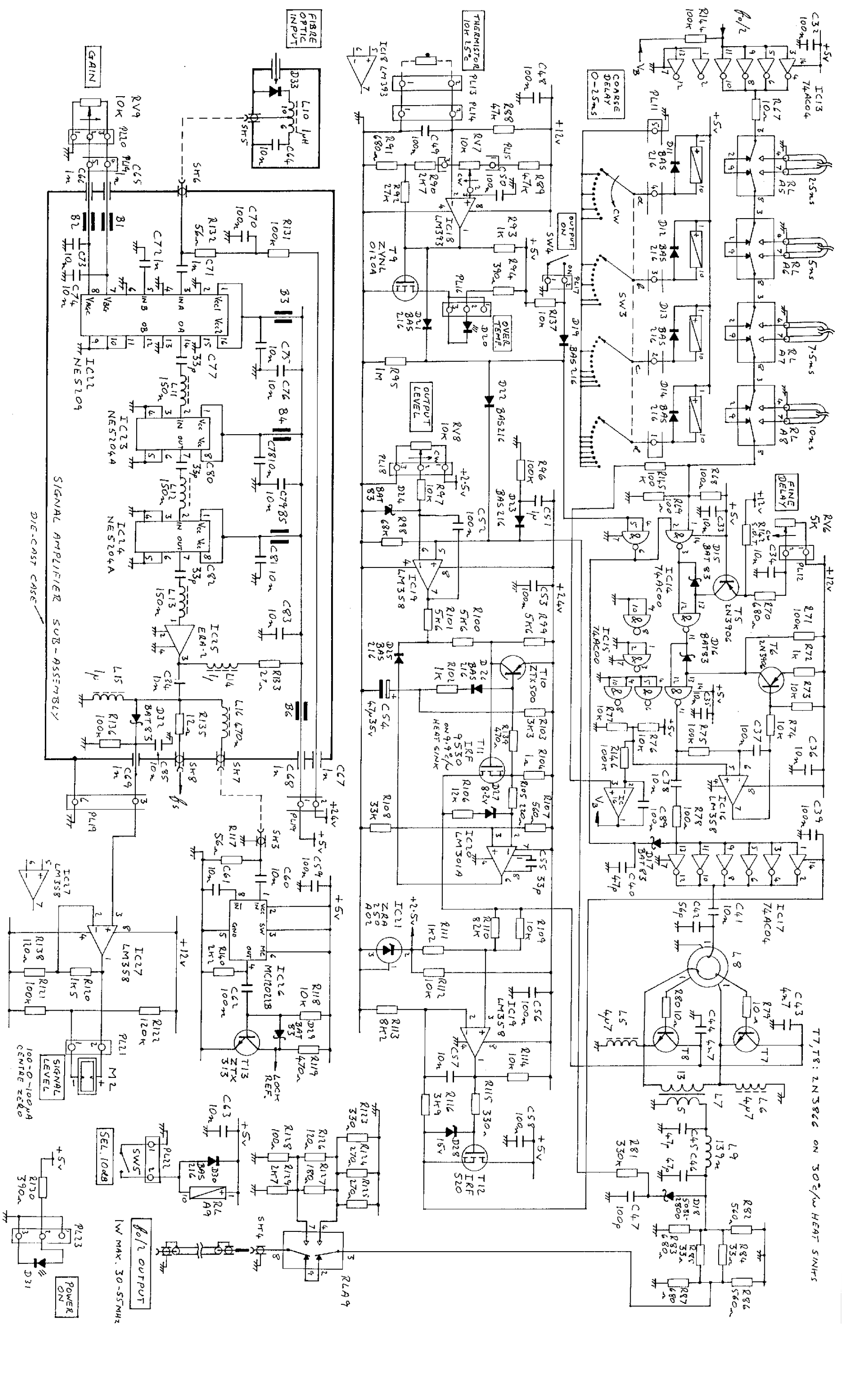

Figure 4 Circuit 1 of 2

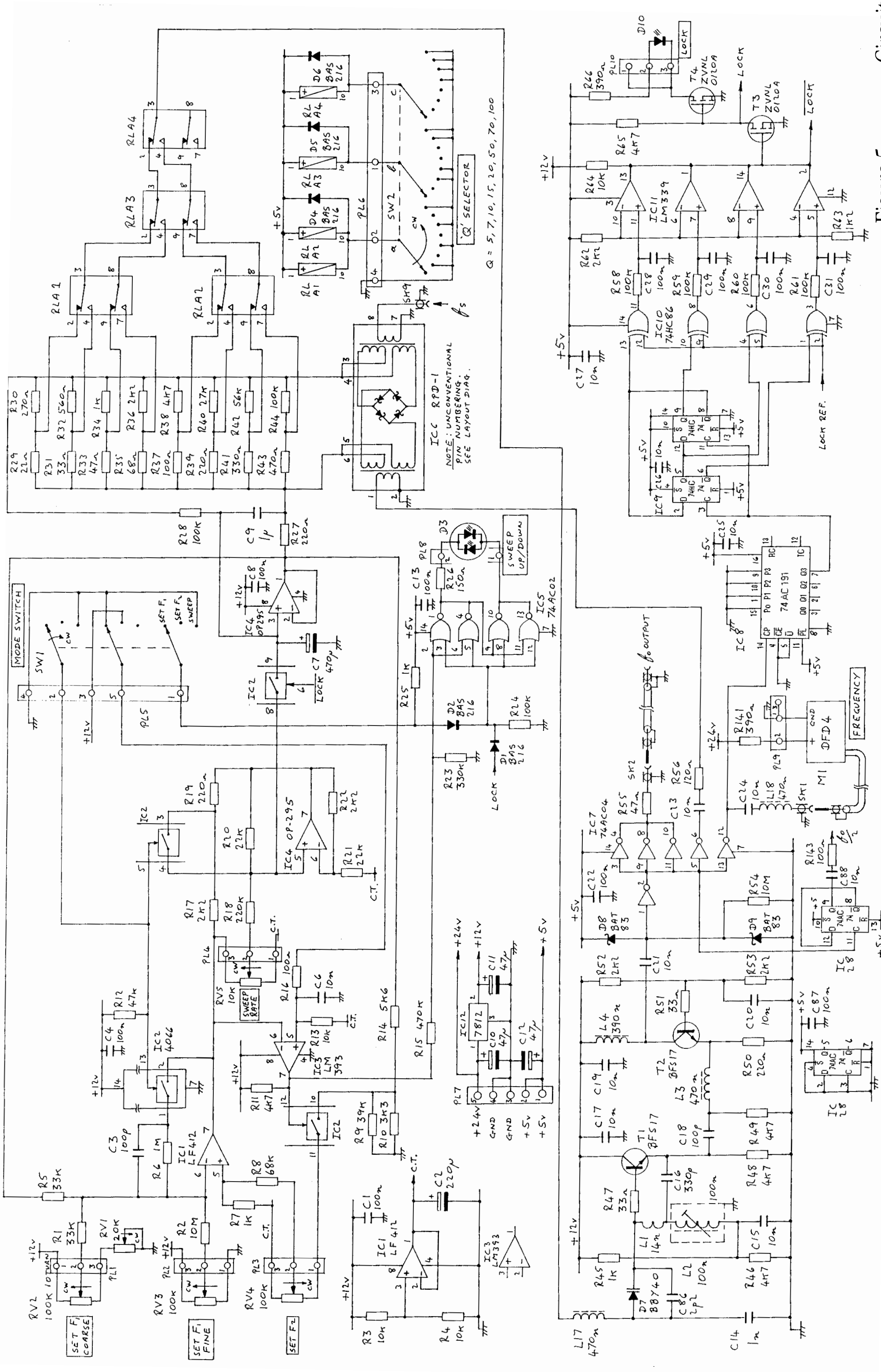

Figure 5

Circuit 2 of 2

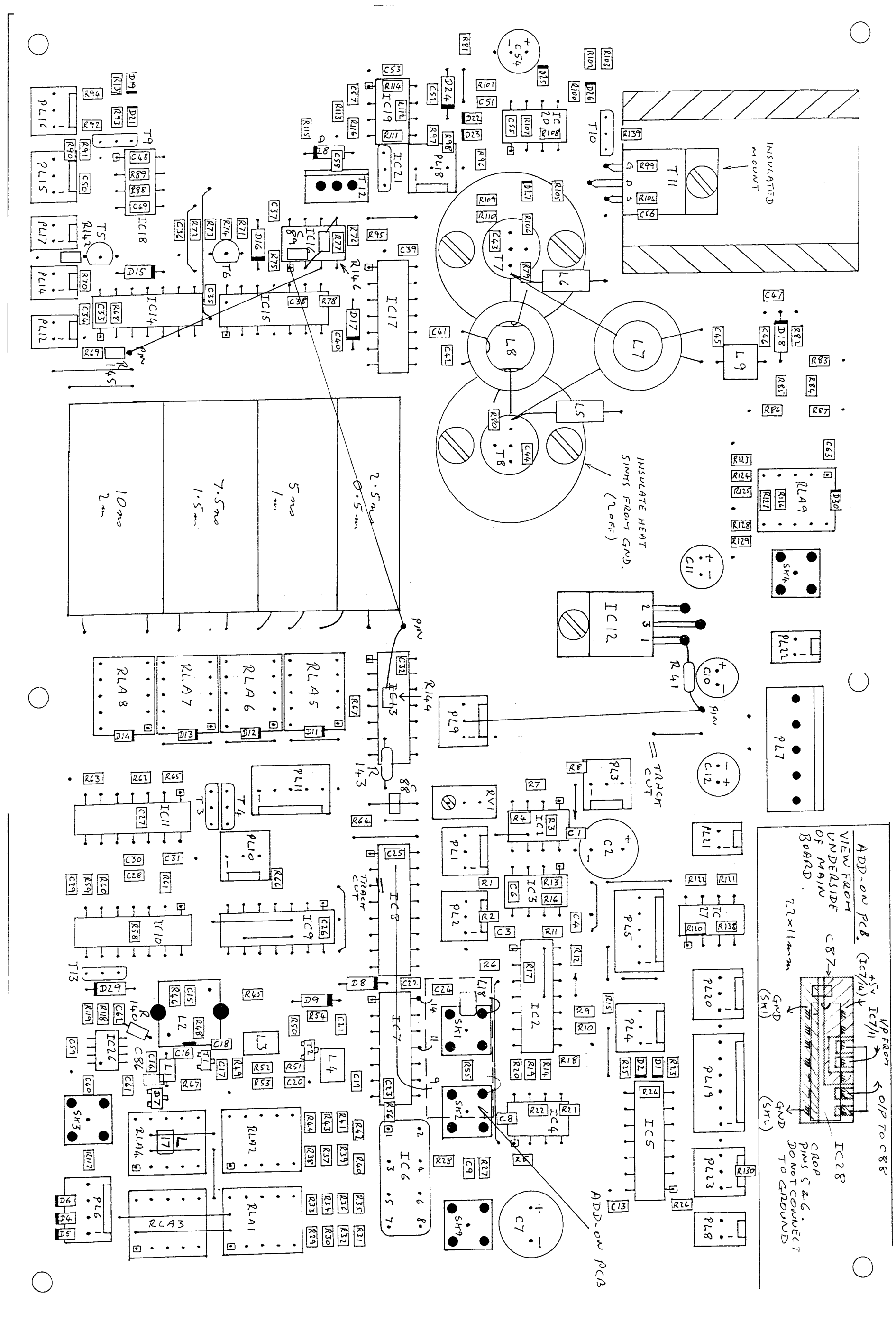

Figure 6 Layout

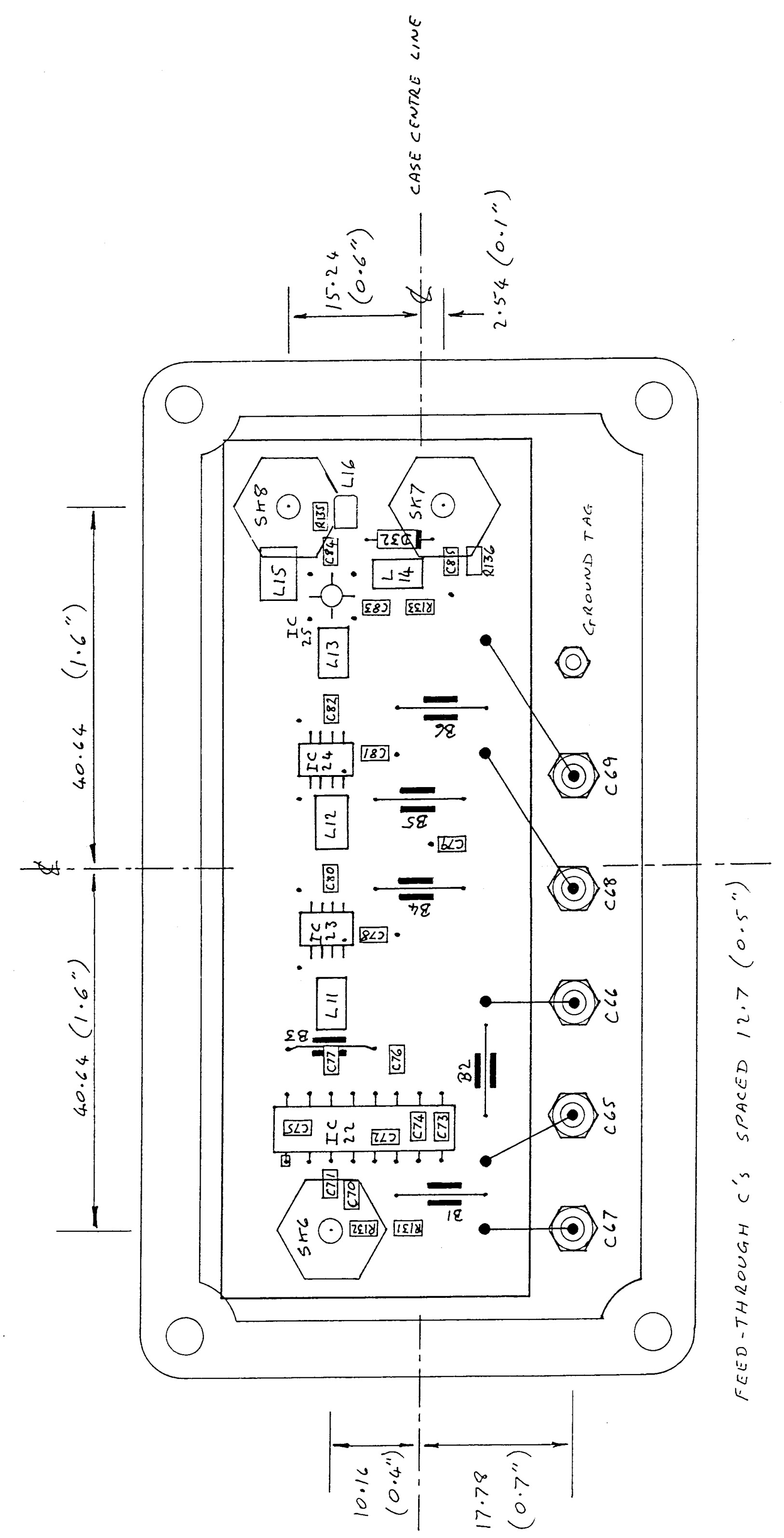

Figure 7 Signal amplifier layout