



bw broadcast

# TX5 FM Broadcast Transmitter



## Technical manual

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# WARNING

This transmitter should never be operated without a suitable antenna or test dummy load! Failure to observe this requirement may result in damage to the transmitter that is not covered by the warranty.

# IMPORTANT

This transmitter has been shipped with the internal stereo generator enabled. The internal jumper J1 (MPX loop-through) is set to ON.

If you intend to connect a MPX signal to the MPX input BNC connector you will need to move J1 (MPX loop-through) to the OFF position.

Routing the internal MPX signal through an external RDS encoder.

Connecting an external audio processor or stereo generator to the transmitter.

Connecting a re-broadcast or STL receiver to the transmitter.

Consult the manual for further information on the transmitter's jumpers and connections.

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## 1.1 TX5 FM TRANSMITTER

The BW Broadcast TX5 is a high specification FM broadcast transmitter. Its broadband "no-tune" design allows 87.5-108 MHz operation from internal direct reading rotary switches or the front panel LCD frequency control system if enabled. Digital PWM techniques provide an easily adjustable and accurate automatic level controlled R.F. output of the MOS-FET power amplifier stage.

RF, audio and other parameters are shown on the LCD graphics display. This display offers a very easy method of transmitter parameter monitoring and a new level of ease for setup and installation, with metering accuracy normally only found on expensive test equipment. Local and remote personal computer control and metering are achievable via RS232 interface and there's an alarm I/O as well.

The FM modulator section employs a dual speed "virtual VFO" system for extremely low audio distortion and excellent stereo performance.

A built in high specification stereo encoder provides crystal clear stereo sound and combined with the internal limiter a fully compliant "plug and play" all in one low power broadcast transmitter.

For future compatibility all settings are switchable with on board jumpers. The stereo and/or limiter settings can be switched in and out to suit the requirements of any external broadcast equipment you may have now and in the future.

The lightweight universal mains input design ensures a high reliability efficient design compatible with any mains system in the world.

## 1.2 SAFETY

### MAINS VOLTAGE

This equipment operates from an AC power source of between 90 and 265 volts. There are hazardous voltages present internally. PLEASE OBSERVE CAUTION WITH THE COVER REMOVED.

### SWITCHED MODE POWER SUPPLY HAZARD

Please note that the power supply units in this equipment is of the switched mode variety and have lethal voltages present internally. The switched mode supplies are universal input fully approved type. They are non serviceable modules and should be fully replaced should they fail.

### FUSES

Only use fuses with the specified voltage and current ratings as stated on the back panel. Failure to do so may increase the risk of equipment failure, shock and fire hazard.

### R.F.

The N type R.F. power output socket contains R.F. voltages which may burn or present a shock. Please make sure that the equipment is connected to an adequately rated load or antenna system while in operation.

### TOXIC HAZARD

This equipment includes R.F. components that may contain Beryllium oxide which is a highly toxic substance that could be hazardous to health if inhaled or ingested. Care should be taken when replacing or discarding such devices. Seek expert advice from the manufacturer should you physically damage a device that contains Beryllium Oxide. The main R.F. output power transistor contains Beryllium oxide.

### OTHER SAFETY CONSIDERATIONS

Do not operate this equipment in the presence of flammable gases, fumes or liquids

Do not expose this equipment to rain or water.

### CE CONFORMANCE

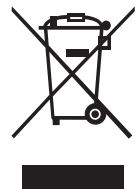
This device complies with the requirements of the 1995/5/EC Radio and Telecommunications Terminal Equipment (R&TTE). The equipment will meet or exceed the following requirements: EN 301 489-11 (ERM/EMC for Radio Equipment, Part 11 Specific Conditions for FM Transmitters), EN 302 018-2 ERM (Transmitting Equipment for FM Radio Broadcasting service)



The operating frequencies of this transmitter may not be harmonised in the intended countries of use. The user must obtain a license before using the product in the intended country of use. Ensure respective country licensing requirements are complied with. Limitations of use can apply in respect of operating frequency, transmitter power and/or channel spacing.

### WEEE COMPLIANCE

BW Broadcast Ltd is registered with Northern Compliance PCS number WEE/P3438PR/SCH and has been issued with WEE/FA0268RX as its unique producer ID by the appropriate environment agency. BW Broadcast Ltd full comply with its explicit responsibilities, subject to WEEE Collections Policy outlined in their General Terms and conditions of Sale, when it sells Electrical and Electronic Equipment (EEE) to B2B customers in the UK and EU.



This appliance has been designed and manufactured with high quality materials and components that can be recycled and reused. Electronic appliances are liable to contain parts that are necessary in order for the system to work properly but which can become a health and environmental hazard if they are not handled and disposed of in the proper way. Consequently, please do not throw your inoperative appliance with the household waste. Having purchased this appliance it is your responsibility to dispose of this equipment appropriately.

# 1.3 Quick set-up guide

## Using a transmitter stand-alone (without RDS encoder)

This set-up uses the built-in audio limiter and stereo generator. The transmitter as shipped from factory is already configured for this set-up, so there are no internal changes to be made.

1. Place a transmitter in a well ventilated space. If it's rack-mounted, leave at least 1U free above and below it for adequate cooling.
2. Connect the antenna to the RF output N-connector on the back of the transmitter.
3. Connect the left and right program audio signals to the XLR input connectors on the back of the transmitter.
4. Plug in the power cord to the transmitter.
5. Once the transmitter is operating, set the correct carrier frequency from the front panel (this can also be locked and set internally).
6. Adjust the desired power output level using front panel. Check reflected power is OK.
7. Check the gain reduction of the built-in limiter - it should be doing a couple of dB with normal program level. If necessary adjust the audio input level trimmers on the back of the transmitter.

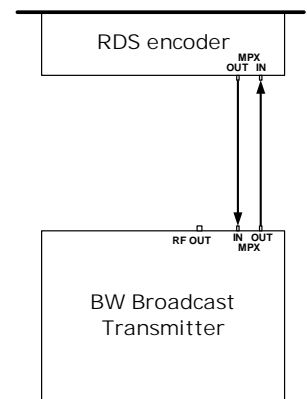
That finishes the set-up. A much more detailed explanation is available in the appropriate sections of this manual as well as additional options. You should read through it!

# 1.3 Quick set-up guide

## Using a transmitter stand-alone with RDS encoder

This set-up uses the built-in audio limiter and stereo generator.

1. Remove the screws that hold the lid of the transmitter and remove the lid.
2. Locate the main board on the right side of the transmitter. Locate jumper J1 right behind the BNC connectors. Move it to down position (Loop-through off).
3. Reassemble the lid back on.
4. Place a transmitter in a well ventilated space. If it's rack-mounted, leave at least 1U free above and below it for adequate cooling.
5. Connect the antenna to the RF output N-connector on the back of the transmitter.
6. Connect the left and right program audio signals to the XLR input connectors on the back of the transmitter.
7. Connect the Baseband/MPX output on the back of the transmitter to the MPX input of the RDS encoder.
8. Connect the MPX output of the RDS encoder to the MPX input on the back of the transmitter.
9. Plug in the power cord to the transmitter.
10. Once the transmitter is operating, set the correct carrier frequency from the front panel (this can also be locked and set internally).
11. Adjust the desired power output level using front panel. Check reflected power is OK.
12. Check the gain reduction of the built-in limiter - it should be doing a couple of dB with normal program level. If necessary adjust the audio input level trimmers on the back of the transmitter.
13. Check the documentation that came with your RDS encoder on how to set/check the proper RDS injection level.



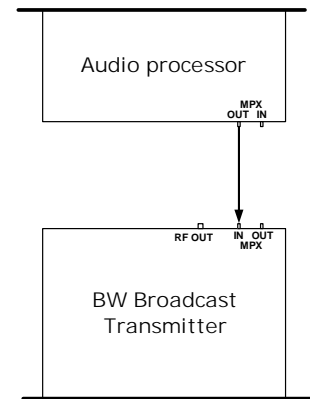
**MPX connections**

That finishes the set-up. A much more detailed explanation is available in the appropriate sections of this manual as well as additional options. You should read through it!

## 1.3 Quick set-up guide

### Using a transmitter with external audio processor/stereo generator but without RDS encoder

1. Remove the screws that hold the lid of the transmitter and remove the lid.
2. Locate the main board on the right side of the transmitter. Locate jumper J1 right behind the BNC connectors. Move it to down position (Loop-through off).
3. Reassemble the lid back on.
4. Place a transmitter in a well ventilated space. If it's rack-mounted, leave at least 1U free above and below it for adequate cooling.
5. Connect the antenna to the RF output N-connector on the back of the transmitter.
6. Connect the MPX output of your audio processor (or stereo generator) to the MPX input on the back of the transmitter.
7. Plug in the power cord to the transmitter.
8. Once the transmitter is operating, set the correct carrier frequency from the front panel (this can also be locked and set internally).
9. Adjust the desired power output level using front panel. Check reflected power is OK.
10. Check the modulation level - if the modulation level is low, adjust the MPX output level on your audio processor (or stereo generator) and/or the MPX input level on the back of the transmitter. The maximum modulation should not exceed 75kHz.
11. Check the documentation that came with your audio processor on how to set/check the proper pilot injection level.



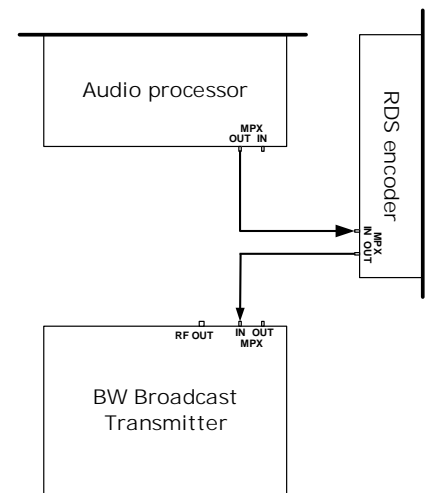
**MPX connections**

That finishes the set-up. A much more detailed explanation is available in the appropriate sections of this manual as well as additional options. You should read through it!

## 1.3 Quick set-up guide

### Using a transmitter with external audio processor/stereo generator and with RDS encoder (in-line connection)

1. Remove the screws that hold the lid of the transmitter and remove the lid.
2. Locate the main board on the right side of the transmitter. Locate jumper J1 right behind the BNC connectors. Move it to down position (Loop-through off).
3. Reassemble the lid back on.
4. Place a transmitter in a well ventilated space. If it's rack-mounted, leave at least 1U free above and below it for adequate cooling.
5. Connect the antenna to the RF output N-connector on the back of the transmitter.
6. Connect the MPX output of your audio processor (or stereo generator) to the MPX input of your RDS encoder.
7. Connect the MPX output of your RDS encoder to the MPX input on the back of the transmitter.
8. Plug in the power cord to the transmitter.
9. Once the transmitter is operating, set the correct carrier frequency from the front panel (this can also be locked and set internally).
10. Adjust the desired power output level using front panel. Check reflected power is OK.
11. Check the modulation level - if the modulation level is low, adjust the MPX output level on your audio processor (or stereo generator), RDS encoder and/or the MPX input level on the back of the transmitter. The maximum modulation should not exceed 75kHz.
12. Check the documentation that came with your audio processor on how to set/check the proper pilot injection level.
13. Check the documentation that came with your RDS encoder on how to set/check the proper RDS injection level.



**MPX connections**

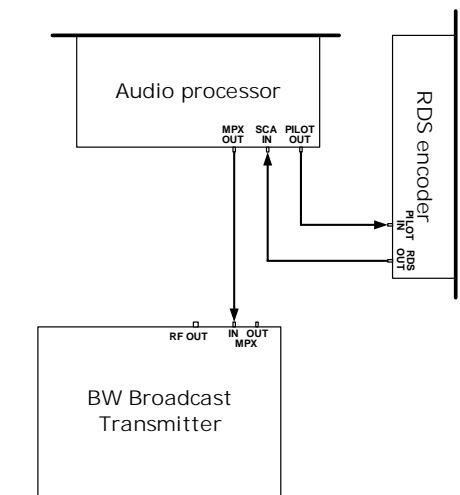
That finishes the set-up. A much more detailed explanation is available in the appropriate sections of this manual as well as additional options. You should read through it!

## 1.3 Quick set-up guide

### Using a transmitter with external audio processor/stereo generator and with RDS encoder (sidechain connection)

This is the best connection in terms of pilot and RDS subcarrier phase synchronization and MPX spectrum cleanliness.

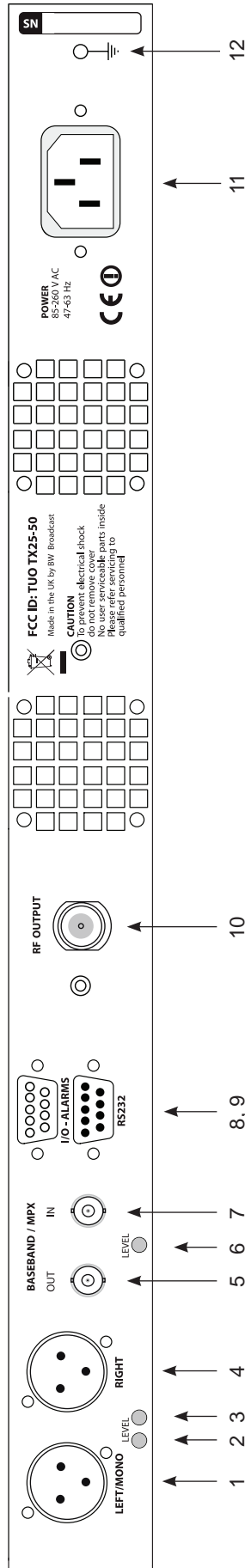
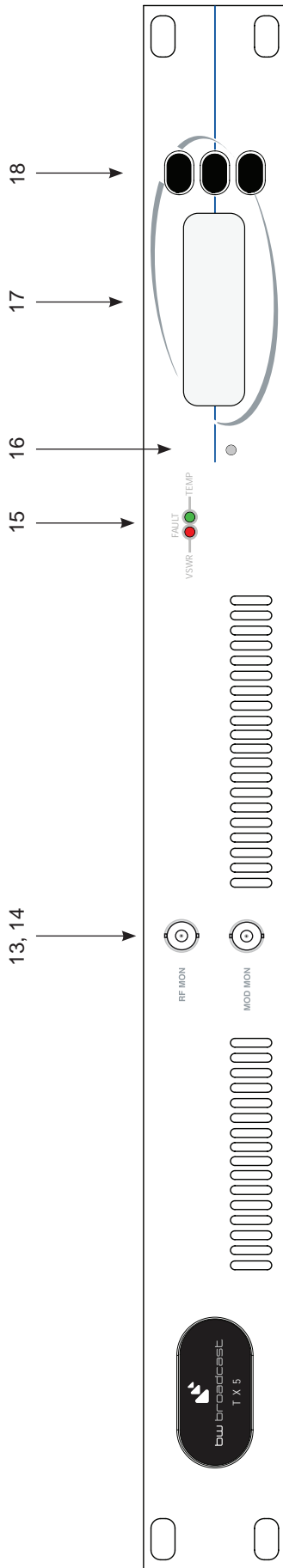
1. Remove the screws that hold the lid of the transmitter and remove the lid.
2. Locate the main board on the right side of the transmitter. Locate jumper J1 right behind the BNC connectors. Move it to down position (Loop-through off).
3. Reassemble the lid back on.
4. Place a transmitter in a well ventilated space. If it's rack-mounted, leave at least 1U free above and below it for adequate cooling.
5. Connect the antenna to the RF output N-connector on the back of the transmitter.
6. Connect the MPX output of your audio processor (or stereo generator) to the MPX input on the back of the transmitter.
7. Connect the Pilot output of your audio processor (or stereo generator) to the Reference input on your RDS encoder.
8. Connect the MPX output of your RDS encoder to the SCA input on your audio processor.
9. Plug in the power cord to the transmitter.
10. Once the transmitter is operating, set the correct carrier frequency from the front panel (this can also be locked and set internally).
11. Adjust the desired power output level using front panel. Check reflected power is OK.
12. Check the modulation level - if the modulation level is low, adjust the MPX output level on your audio processor (or stereo generator) and/or the MPX input level on the back of the transmitter. The maximum modulation should not exceed 75kHz.
13. Check the documentation that came with your audio processor on how to set/check the proper pilot injection level.
14. Check the documentation that came with your RDS encoder on how to set/check the proper RDS injection level.



**MPX connections**

That finishes the set-up. A much more detailed explanation is available in the appropriate sections of this manual as well as additional options. You should read through it!

# 1.4 FRONT AND REAR PANELS

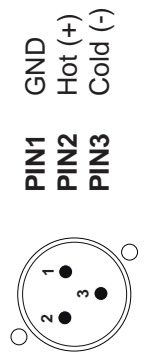


- 1. Left audio input
- 2. Left Input gain
- 3. Right input gain
- 4. Right audio input
- 5. MPX output
- 6. MPX level control
- 7. MPX Input
- 8. I/O + Alarms
- 9. RS232
- 10. R.F. output
- 11. Power socket
- 12. Chassis ground post
- 13. RF monitor output -50dBc (not suitable for harmonic measurements)

- 14. Modulation monitor output (buffered multiplex, nominally 3V peak-to-peak for 75kHz)
- 15. VSWR and temperature fault LEDs
- 16. Maximum forward power adjust
- 17. LCD display
- 18. Up / Down frequency buttons

**I/O - Alarms D-type connector pinout:**

Pin 1	MOD failure alarm (TTL)
Pin 2	PLL failure alarm (TTL)
Pin 3	RF failure alarm (TTL)
Pin 4	RF Mute
Pin 5	+18V DC 200mA
Pin 6	MOD failure alarm (OC)
Pin 7	PLL failure alarm (OC)
Pin 8	RF failure alarm (OC)
Pin 9	GND

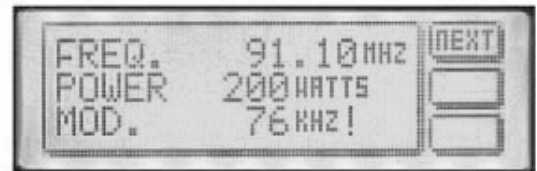


## 1.5 CONTROL AND MONITOR LCD

The front panel LCD graphics display has seven screens (shown below). These allow monitoring of the transmitter's R.F, audio and other parameters and the adjustment (if internally allowed) of the transmitter's frequency. You can move through the screens by pressing the NEXT button, which will display them in the following order.

### Main parameter screen.

This shows together the three most important transmitter parameters. Frequency, R.F. output power and the peak deviation.



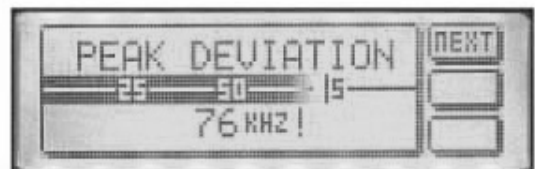
### Frequency display and control

This screen will display the frequency and PLL locked condition. The up and down buttons will allow 100 kHz frequency steps from 87.5 to 108Mhz if the internal switches are set to 4440. If the frequency is set internally with the rotary switches then the up / down buttons will give a 'not allowed' message



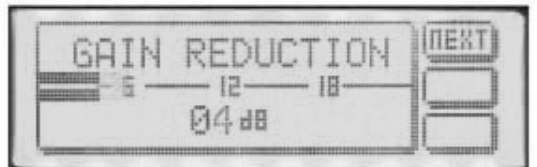
### Peak deviation

This display indicates the peak and average deviation. Peak deviation is shown both numerically and as a moving single pixel wide bar. Average deviation is shown with the solid black bar. Over-deviation will display an exclamation ( ! )



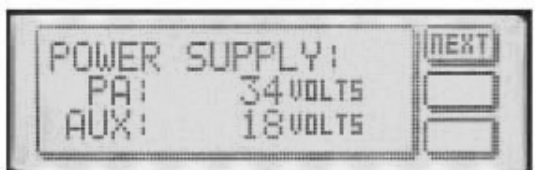
### Gain reduction

This display indicates the amount of gain reduction of the internal audio limiter. The range is 0 to 24 decibels of gain reduction.



### Power supply

Power amplifier voltage is shown together with the transmitter's secondary supply that feeds the exciter section. The power amplifier voltage will vary depending on set output power and the presence of any fault conditions which also cut the voltage back and with it the R.F. output.



## 2.1 FREQUENCY SETUP

The Frequency can be set on the transmitter in one of two ways:

1. From internal direct reading decimal switches on the main board
2. From the front panel LCD display and front panel buttons.

Many radio regulatory bodies stipulate that the transmitters parameters including the frequency must not be easily changed from the front panel. To meet this requirement you will need to set the frequency internally with the dial switches.

The switches have a silkscreen diagram next to them on the board (see diagram below) clearly indicating what each switch represents.

The top dial switch represents the value selected x 10 Mhz with the exception of '0' which represents 10 so when selected would equal 100 Mhz.

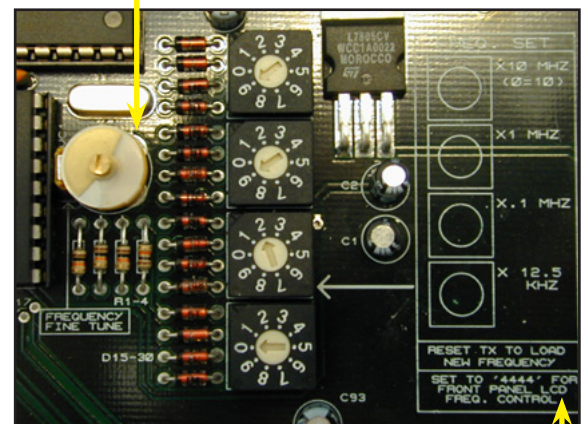
The second dial switch represents the value selected x 1 Mhz.

The third dial switch represent the value selected x .1 Mhz (100 kHz)

The bottom switch represents the value selected x .0125 Mhz (12.5 kHz)

Fine frequency control. Do not adjust unless you know what you are doing. Consult advanced setup section of manual for more information.

Frequency selection switches on main board



For example:

FREQ	SWITCHES (MHz)			
	X10	X1	X.1	X.0125
87.90	'8'	'7'	'9'	'0'
98.75	'9'	'8'	'7'	'4'
100.00	'0'	'0'	'0'	'0'
104.225	'0'	'4'	'2'	'2'
108.00	'0'	'8'	'0'	'0'

As you can see, the switches directly read the frequency with the exception of frequencies above 100 Mhz, where the top switch being set at '0' represents '10'. The X0.125 'offset' switch is only used when you want to provide a shift to the carrier of between 12.5 kHz and 112.5 kHz. Note that setting the switch on 8 or 9 will have the same effect as setting the previous switch (100 kHz) 1 position higher, as 8 represents 100 kHz on the 12.5 kHz switch.  $8 \times 0.125\text{MHz} = 0.1\text{MHz} = 100\text{kHz}$

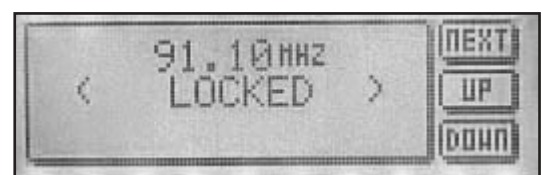
Note that some pcb's have "set to 4444 for front panel LCD control". This is an error that will cause a +50kHz offset to the frequency set on the LCD screen. Please set to 4440 unless you specifically want the offset.

The LCD display on the front panel will display the frequency that you have set on the internal switches. If you try to adjust the frequency with the front panel up / down buttons you will get a ' NOT ALLOWED ' message appearing on the LCD display. This protects against unauthorized front panel frequency changes when the frequency has been set internally with the dial switches.

*The TX will load the switch values at power up. You will need to remove the mains power to the transmitter and then reapply it if you want to change the frequency by using the direct reading switches*

### LCD front panel frequency selection.

If you want to control the frequency from the front panel LCD control system you will need to set the internal switches to 4440. The transmitter will pass frequency control to the LCD control system and the frequency can be moved up and down by pressing the NEXT button until the frequency menu is displayed. The other two buttons control the UP and DOWN frequency selection. PLL lock status is also displayed on this screen.



*The LCD readout will only display frequencies in 100Khz steps. Any frequency offsets derived from the internal 12.5kHz offset switch will not show on the LCD. Consult a frequency counter if using offsets.*

## 2.2 R.F. POWER SETUP

The R.F. power output from the transmitter can be controlled by an analogue potentiometer (POT) or from the front panel LCD screen or a combination of both.

### ANALOGUE POWER CONTROL

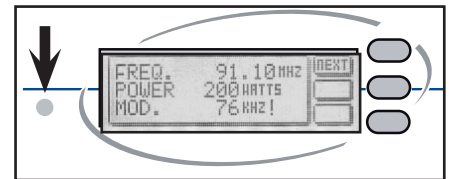
If the frequency is set internally with the dial switches you will not be able to adjust the power from the LCD screen. This is to comply with regulatory body's that stipulate that the transmitter is not to have it's parameters adjustable from the front panel. In this case you must use the maximum power set control to set the transmitters power. This control will give the full power range adjustment.

If the transmitter has been internally set to 4440 with the dial switches then you can also control the power from the LCD screen's R.F. power menu's up and down buttons. A "not allowed" message will be displayed to the user if the dial switches are not set to 4440

*RS232 power control will over-ride the power control restrictions caused by having the frequency set internally (not set to 4440).*

### DIGITAL POWER CONTROL

When the power is to be controlled from the front panel the max power set POT takes on a new role of setting the maximum power of the transmitter. If you want the LCD screen to have full power range control of the transmitter you will need to ensure that the max power set control is at maximum power. Otherwise your control range may be limited. This feature enables you to limit the transmitters maximum power to a fixed level but to still allow the LCD screen to provide adjustment of the R.F. power down from that maximum power set point. This can be desirable in transmitter hire situations where you wish to govern the maximum output to a fixed level but to allow the customer (hirer of the transmitter) to run the power of the transmitter at a lower level if they so decide.

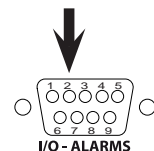


The maximum power set is positioned to the lower left of the LCD screen on some models, other models may not have the hole in the front panel and you will need to remove the lid of the transmitter to access the adjustment which will be in the same position but on the other side of the PCB. You will need a small 'tweaker style' flat-head screwdriver to adjust the pot. This control is quite delicate so try to not be too heavy handed in it's adjustment.

*Please note that the VSWR and temperature protection circuitry will turn back the R.F. power if a fault condition exists. Make sure that you have a good VSWR (low reverse power reading) before setting the R.F. power as the removal of a fault condition may cause the R.F. power to increase.*

### RF POWER MUTE (analogue)

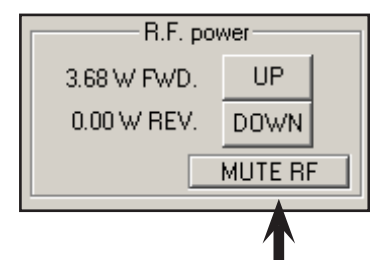
There is a pin (2) on the back panel I/O D-type that can be pulled low to mute the transmitters RF power.



### RF POWER MUTE (digital/RS232)

The transmitters RF power output can be muted via the RS232 control system. Terminal software can mute/unmute the RF power with the 'o' and 'f' commands respectively.

The windows application has a button that can toggle the RF output of the transmitter.



*Please consult the RS232 section of this manual for more information on controlling the transmitter remotely.*

## 2.3 ALARMS

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### R.F. POWER, PLL LOCK, MODULATION

The alarms when set are available on the back panel 9-pin D-type. Each alarm has an open collector (OC) and a TTL level contact on the D-type. The alarm induced active open collectors can pull down any external signals and the TTL outputs will provide a 5 Volt indication. The alarm is also visible if any RS232 monitoring (through Windows Remote Control application or terminal software) is employed.

For the alarms to function correctly the transmitter must be left on the default menu screen. This is the screen that displays frequency, R.F. power and peak deviation. To ensure that the alarm system functions correctly the transmitter will return to the default menu screen if the LCD is left on another menu screen for more than 5 minutes.

#### R.F. POWER.

The R.F. power alarm will be set if the R.F. power falls below a threshold level during normal operation. This threshold is set below the normal operating lowest wattage available from the transmitter. If you require a different setting for the alarm, contact our tech dept. The alarm will only be set if the fault condition exists for sixty seconds or more. You will need to reset the transmitter to clear the alarm/s or you can do it via RS232 connection.

#### PLL LOCK.

The PLL lock alarm will be set if the transmitters falls out of frequency lock during normal operation. The alarm will only be set if the fault condition exists for sixty seconds or more. You will need to reset the transmitter to clear the alarm/s or you can do it via RS232 connection.

#### MODULATION FAILURE.

The Modulation failure alarm will be set if during normal operation the peak deviation of the transmitter drops and remains below 16 kHz. The 16 kHz alarm level allows the alarm to be set if the audio feed to the transmitter fails even if the stereo pilot internal to the transmitter is still modulating the transmitter. The alarm will only be set if the fault condition exists for sixty seconds or more. You will need to reset the transmitter to clear the alarm/s or you can do it via RS232 connection.

#### MORE INFO ON ALARMS

The three alarms are available on the back panel D-type connector. The pin-outs are shown on the rear panel diagram. The three alarms are available as TTL level and as open collector outputs. The TTL level outputs are active high in the event of an alarm. The open collector outputs are ON in the event of an alarm and will pull down any external levels. The open collectors can sink 100 mA MAX with an absolute maximum switched voltage of 25 volts.

The D-type connector can also supply 18 volts at 200 mA that can be used for pull-ups on the open collector alarm outputs and for your own external switching circuitry.

The RS232 interface provides the ability to reset the alarms either through Windows Remote Control application or terminal software. More info is found in the following pages of the manual.

BW Broadcast can also customise the alarm / fault software to meet the requirements of major broadcasters and networks or supply N+1 solutions. More information on this and other custom features can be obtained from our technical department.

## 2.4 RS232 CONTROL AND MONITORING

The TX range of transmitters can be monitored or controlled from a personal computer either locally or remotely. The Transmitters can “chat” either by a windows application or via a standard serial terminal program. The windows application is the more versatile option and is to be preferred but the ability to use a terminal program can prove useful in the absence of the windows application or a computer that runs windows.

### 2.41 Windows remote control application

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<http://www.bwbroadcast.com>

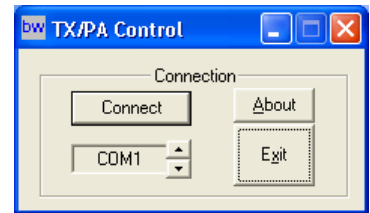
#### Installation

After downloading just click on the .msi file to run the set up program. The set up will place icons in both the Windows start menu and on your desktop. Simply run the program by clicking on icon from either location.

#### Running the application

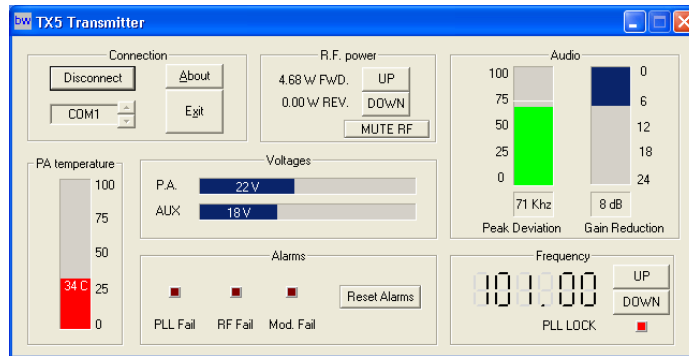
When started the application will resemble the picture to the right.

The application can connect to any COM port currently available on your computer that is running the application. Connect a serial cable between the RS232 connector on the rear of the transmitter and one of your computers COM ports. If you are using a codec or other STL device then you may be able to connect that device in line to act as part of the serial link.



Remote Control Application startup screen

Selected the COM port you want to use and then click the Connect button.



Remote Control Application

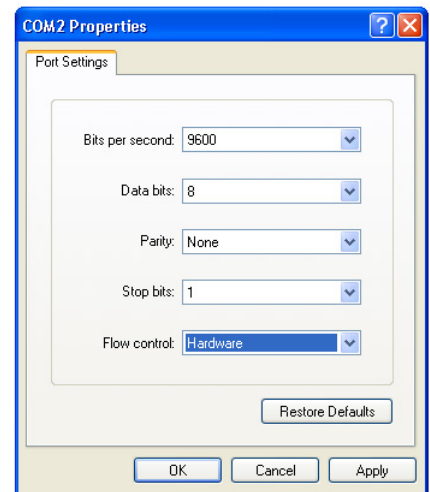
If the application is able to connect to the transmitter then you will be presented with a screen similar to the one above. Once connected you should be able to monitor all the parameters of the transmitter as well as being able to mute the R.F., change the frequency, change the R.F. power and reset any alarm flags that have been set.

### 2.42 Terminal control of the transmitter

#### Installation

Please see the instructions for your terminal software package to find out how to connect to a remote serial device. The transmitter is internally set to communicate at 9600 bps, no parity with 1 stop bit and hardware flow control. This is commonly known as 9600 8N1. If your using Windows then you can use the pre-bundled terminal program “Hyper-terminal”. This is located in the Programs -> Accessories -> Communications folder accessible

from the Start menu. Select direct to COM port x where x is the com port that the transmitter is connected to. You will be presented with a dialog box like the one shown to the right. Select 9600, 8, none, 1 with hardware flow control and then click OK.



Hyper Terminal connection

If you are using another terminal program then you may need to consult the documentation for that software, but it should be pretty much straight forward.

**Operation**

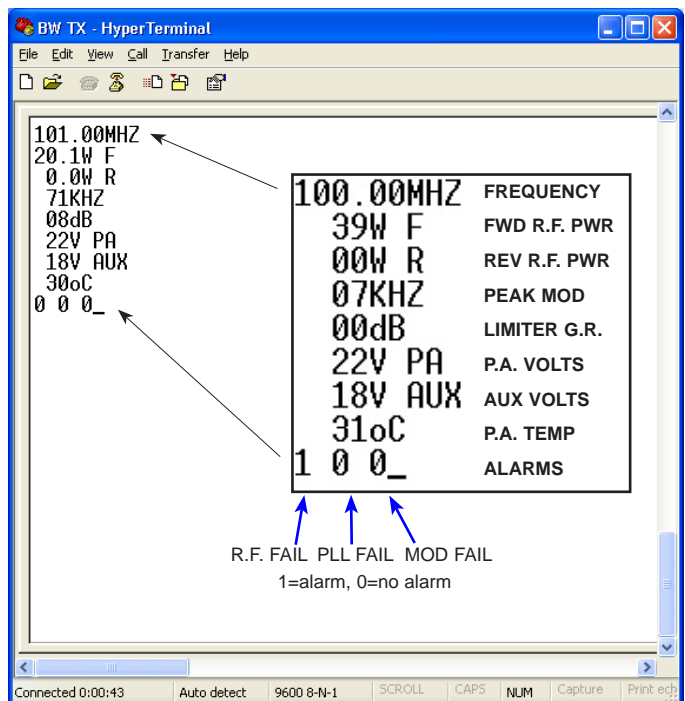
The transmitter will respond to certain key presses and each one has a certain function. See the list below for details of what key to press for each function.

The most important key press is the 'Enter' key. This will need to be pushed as soon as you connect to the transmitter so you can get the transmitter to refresh your terminal window with the transmitters status and parameters.

The transmitter won't respond to any of the other key presses until it detects the 'Enter' key is pressed. Once the Enter key is pressed the transmitter will listen out for other key presses for 60 seconds. This Initial 'Enter' key validation and time window is a safety feature to prevent the transmitter from detecting an erroneous key press such as R.F. mute and causing a service affecting problem.

After performing a function you may need to press the 'Enter' key to see a response to your function. For example, If you pressed 'o' for R.F. Mute you would not see the effect of the R.F. power change until you refreshed the screen again because the terminal window would still be showing the transmitters R.F. power from the previous 'Enter' (screen refresh) command, prior to you performing the R.F. mute command.

The frequency change key's will perform an automatic screen refresh on there execution but the other keys will require a refresh command to be sent to the transmitter for you to visibly be able to see the effect of your command. In some circumstances you may need to press the refresh screen key several times in order to see what's happening. Take the R.F. mute function again as an example. You press the R.F. mute key ('o') and then press refresh screen key ('ENTER') to get a status update. The transmitters power control circuitry may not have had time to turn the R.F. power down into full R.F. mute by the time it has sent back to you the status requested by the refresh screen command. It does no harm to wait a second or two before asking for a refresh screen or by asking for several refresh screens by pressing the 'Enter' key a few times in succession.



Hyper Terminal window

KEY	COMMAND
1	Frequency up
2	Frequency down
3	R.F. power up
4	R.F. power down
5	reserved
6	Reset alarms (all to 0 / off)
o	Mute R.F.
f	Unmute R.F.
ENTER	Refresh screen

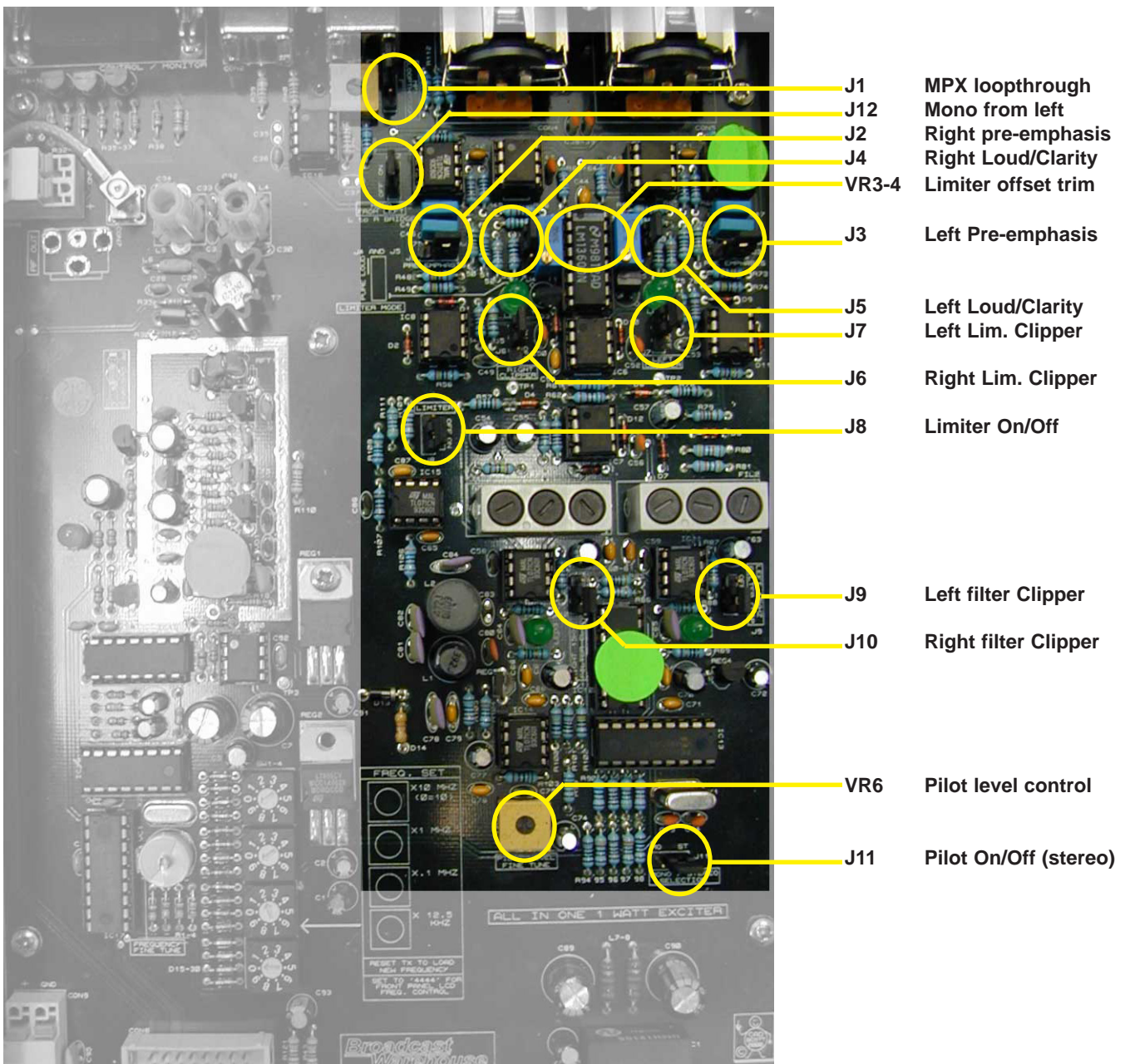
## 2.5 MODES OF OPERATION

The transmitter is fully configurable and can be set up to support various modes of operation. The mode of operation is set by the configuration of the internal jumpers.

This chapter provides a guide to the various jumpers, followed by a brief description of the main modes of operation. The advanced setup procedure pages that follow provide a little more information on each mode as well as providing some information on setting the equipment up accurately if you have access to some test equipment.

### 2.51 A guide to the jumpers

Main combo board



There are altogether twelve jumpers on the board which can be set - at the time of installation - to establish the way the board operates.

The board leaves the factory with default settings which should be suitable for most locations and requirements. Nevertheless, it is worth familiarizing yourself with all the options available, and checking that the settings are appropriate, as part of the installation process.

### Jumper 1: MPX loopthrough

The default position is ON.

This is where you want the audio left and right XLR sockets on the back of the board to be the signal source, duly limited and stereo coded internally. Only when you want to use the rear BNC socket for a complete multiplex (MPX) input for the broadcast should you change the position of this link.

If the link is in the OFF position, only signals from an external encoder or processor will be accepted, unless the internal coder has been 'loop-throughed' (see later).

### Jumpers 2 and 3: Pre-emphasis 0 / 50 / 75 $\mu$ s

The default position is 50  $\mu$ s (75  $\mu$ s/Japan).

#### *What is pre-emphasis?*

Pre-emphasis is the treble boost that must be applied to all FM broadcasts to compensate for the treble cut (de-emphasis) present in every receiver. The aim of this process is to reduce noise in the broadcast path without degrading the audio.

The precise nature of the treble boost is defined by a time-constant in microseconds, which describes the resistor/capacitor network that will produce the appropriate 6dB per octave treble boost curve.

There are two different standards in use worldwide.

In Europe and Africa, the standard is normally 50  $\mu$ s. This represents a lift of about 3dB at 3 kHz, and 10dB at 10 kHz. In the Americas, and in Japan, more boost is in use with a network of 75  $\mu$ s, about 3dB up at 2 kHz.

Jumpers 2 & 3 may either link the 50  $\mu$ s pins, the 75  $\mu$ s pins, or not link any pins, but be fixed to just one of them for safekeeping, producing no pre-emphasis - '0'.

#### *The effects of pre-emphasis*

The absence of any pre-emphasis will result in a broadcast sounding noticeably lacking in treble. Applying pre-emphasis when 50 is called for, the received sound will have some 3dB shelved treble boost above 3kHz. This is undesirable. Conversely, if you only apply 50 where 75 is required, there will be 3dB treble loss, which is also undesirable. You should not have to change the pre-emphasis setting from 50 to 75 or back unless you are relocating the installation abroad where the standard is different.

However, whenever pre-emphasis is deliberately applied to your audio at some point before it enters the XLR sockets on the back of the board, by an external processor for example, then you must set the pre-emphasis to '0', because pre-emphasis must only be applied once. *Double pre-emphasis must be avoided* because it will make a signal sound far too bright and topky.

Both Jumper 2 and Jumper 3 should be in the same position at all times because both left and right audio channels should have the same treatment. These jumpers do not affect the operation of the board when external MPX is used with Jumper 1 off.

### Jumpers 4 and 5: Limiter loud/pure

The default position is 'Loud' (hard limiting).

This option affects the character of the sound passing through the limiters inside the board. The sound can be either (a) processed to be competitively loud, with some sacrifice in fidelity (hard limiting, the Loud position) or (b) treated more gently, with high fidelity, but some loss in volume (soft limiting, the Pure position).

It's instructive to listen to and compare the options while passing a representative selection of typical programme material through the board. This will help you establish which sound you prefer.

As before, both jumpers 4 and 5 should always be in the same position. These jumpers, like all the following ones, do not affect the operation of the board when external MPX is used with Jumper 1 off.

### **Jumpers 6 and 7: Limiter clippers on/off**

The default position for these jumpers is ON.

If they are to be switched off when external audio processing is used, careful monitoring of deviation is recommended. The 15 kHz post-filter clippers must be switched off at the same time (J9/10).

These jumpers control the clippers applied to the signal after the limiter but before the 15kHz low-pass filters on the way into the stereo coder. Again, these jumpers work as a pair and do not affect external MPX inputs.

### **Jumper 8: Limiter on/off**

The default position for this jumper is ON, i.e. limiter active.

If you are using a pre-processed and limited signal and do not want the additional protection of the internal limiters, their action can be disabled by putting Jumper 8 in the OFF position. This one jumper controls both channels, because the gain-reduction control voltage (which this jumper disables) is common to left and right.

Even with the limiter disabled you may still wish to use the pre-filter clippers (J6/7) and post-filter clippers (see below, J9/10) for protection. Always observe the deviation produced very carefully for excesses above 75 kHz if you ever remove the action of the limiter or clippers.

### **Jumpers 9 and 10: 15kHz filter clippers on/off**

The default position for these clippers, placed after the 15kHz filters on the input to the coder, is ON.

These clippers protect against over-deviation caused by signals which 'ring' in the 15kHz filter, even after having been caught by the clipper before the filter. With certain pre-processed and filtered inputs, however, they may be switched out of circuit. But keep a close eye on the deviation.

Don't have these clippers switched on unless you also have the limiter clippers active. Otherwise, your signal could go out of specification.

These jumpers work as a pair and don't affect external MPX drives.

### **Jumper 11: Mono / Stereo**

The default position is STEREO, pilot tone on.

This option allows you to remove or restore the stereo pilot tone, at a frequency of 19 kHz, normally sitting at a level between 8 and 10% of total deviation.

It is this tone which alerts stereo FM receivers to the need to switch on their stereo decoders. The presence of a pilot tone is all that is required for the 'stereo' beacon to light on a receiver. If no 19kHz tone is received, the receiver will operate in mono. It will not decode any L-R information modulated on the 38 kHz subcarrier, *even when it is still present.*

To make sure that no 38 kHz energy is generated during mono operation even from stereo inputs, operate jumper 12, the 'bridge' link (see below). This jumper does not affect the mono/stereo status of externally-coded MPX inputs (J1 off).

### **Jumper 12: Mono bridge**

The default position is OFF.

When the board is operating in mono, the bridge should be set to ON. This ensures that when the board is operating in mono, no stereo information is broadcast, and that a mono drive to either left or right inputs, or a stereo input applied simultaneously to L and R inputs, will produce proper summed mono operation and no spurious 38kHz signals.

## **Modes of operation**

### **Multiplex / broadband input.**

The Internal stereo encoder and audio limiter are not used. Wideband modulation is fed into the rear panel BNC multiplex input socket. Allows external processors, encoders and rebroadcast receivers to be plugged straight into the transmitter.

JUMPERS. J1 (OFF), J2-12 (N/A)

### **Stereo with internal limiter. ( factory setting )**

Left and Right audio are fed to the back panel balanced inputs and are pre-emphasized, peak limited, filtered and then fed to the internal stereo encoder for multiplex generation. The multiplex signal is then fed through to the exciter module and to the back panel multiplex output BNC socket. See loophrough mode below \*

JUMPERS. J1 (ON), J2-3 (50 or 75), J4-5 (LOUD or CLARITY), J6-7 (ON), J8 (ON), J9-10 (ON), J11 (ST), J12 (OFF)

### **Stereo with internal limiter disabled.**

As the above stereo with limiter mode except the limiter section is disabled. This mode can be used when you want an external limiter / processor to provide all the peak limiting and protection. Clippers at the output of the limiter module can be left in or out subject to your requirements. See loophrough below \*

JUMPERS. J1 (ON), J2-3 (0 or 50 or 75), J4-5 (LOUD or CLARITY), J6-7 (ON or OFF), J8 (OFF), J9-10 (ON or OFF), J11 (ST), J12 (OFF)

### **Mono from two independent channels.**

Essentially the same as the stereo with limiter mode except the stereo pilot is disabled which will enable receivers to receive you in mono. See loophrough mode below \*

JUMPERS. J1 (ON), J2-3 (50 or 75), J4-5 (LOUD or CLARITY), J6-7 (ON), J8 (ON), J9-10 (ON), J11 (MO), J12 (OFF)

### **Mono from one channel input.**

You can provide one audio feed to the transmitter via the left balanced input. Setting the internal bridge jumper J12 to ON will join the left and right audio signals internally to maintain the same volume from the transmitter and forces the stereo encoder section to replicate true mono. See loophrough mode below \*

JUMPERS. J1 (ON), J2-3 (50 or 75), J4-5 (LOUD or CLARITY), J6-7 (ON), J8 (ON), J9-10 (ON), J11 (MO), J12 (ON)

## Other configurations

We have illustrated what we feel to be the most popular options.

JUMPERS. To suit application

### \* Loophrough mode

The transmitter has been provided with a multiplex output socket to present the output of the internal audio stages to the outside world. This allows you to connect the signal from the internal limiter and stereo encoder to an external piece of equipment before being reinjected back into the transmitter via the multiplex input socket.

The most common application is for RDS encoders which nearly always have a loophole connection for this purpose. Other applications include SCA generators and composite clippers. You will need to set the internal jumper to off for external loophole. This is to stop the internal stereo encoder's multiplex output signal from being fed to the exciter section internally.

More information on loophole setup is provided at the end of the advanced setup procedure section

## ADVANCED SETUP PROCEDURE

The front panel LCD metering is accurate enough to set up the transmitter in the absence of external test equipment. If you have access to a modulation meter and RF power meter then substitute those for references to the relevant LCD display menu.

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 Audio signal generator capable of -10dbu to +10dbu  
 Voltmeter

### 2.52 Multiplex input only.

Open the lid of the transmitter and make sure that jumper J1 on the main board is configured so that MPX Loopthrough is OFF. This makes sure that the internal stereo encoder is not connected through to the modulator. Connect your wideband audio source (processor, coder or rebroadcast receiver) to the multiplex input on the back panel. Setup your external equipment for its correct output level making sure that it falls into the range of -6 to +10 dbu. Adjust the multiplex input level control on the back panel for a peak deviation of +/- 75kHz. The peak deviation can be shown on the LCD system.

The factory setting for the multiplex input level is +6dBu. This corresponds to the output level of our internal stereo encoder module. We recommend feeding this level input to the multiplex input socket if it is available from the external equipment.

### 2.53 Stereo with internal limiters.

The transmitter will come set to this mode from factory with the following settings. Input Gain at maximum, limiter active and in loud mode, limiter clippers on and 15 kHz filter clippers on. This provides the loudest, most competitive settings available with the transmitter without using an external multiband processor to significantly boost loudness.

The gain controls on the back panel control the input drive to the limiter module and can be set so that limiting occurs for a given input level. Factory setting is at maximum to enable maximum compression / limiting so that a loud commercial sound is obtained. You can reduce your input level to suit the amount of compression required. The Limiter ON jumper is set so that the limiter is enabled. The limiter clippers are on to define the maximum output from the limiter under any conditions. The Limiter has two modes of limiting, Loud and Clarity. Loud will give a more processed brighter sound and Clarity will retain a sound more true to the original audio input. If you want a more punchy commercial sound leave the limiter in Loud mode. The 15 kHz filters have overshoot clippers after them. These if activated remove any overshoots caused by ringing in the filters. These are best left active if you want the loudest sound for a peak deviation of +/- 75 kHz. (See note on 15 kHz filters at the end of the section)

#### Advanced setup procedure.

1. Firstly make sure that the exciter is set to your chosen operating frequency. If you have not already done so then remove the top cover from the transmitter.
2. Connect the transmitter to a dummy load.
3. Turn on the transmitter and within 15 seconds it should lock to frequency.
4. Set the internal limiter to OFF with jumper J8. Set the limiter clippers to ON with jumpers J6 and J7. Set the 15 kHz filter clipper jumpers J9 and J10 to ON. Remove the pre-emphasis jumpers from J2 and J3 completely for now. Make sure the loopthrough jumper J1 is switched to LOOPTHROUGH and the MONO FROM LEFT jumper J12 is set to the OFF position. Disable the stereo pilot by setting jumper J11 to MONO. Set the limiter mode jumper J4 and J5 to LOUD. These settings will allow any audio straight through the limiter and into the limiter clippers that set our final peak level.
5. We should check that any offsets internal to the limiter are nulled out to keep distortion to a minimum. Connect

a multimeter set to millivolts to testpoint TP1 which is located next to the right clipper jumper. You will also need an earth point for the meter. The bolt on REG2 is a good earth. The case of the transmitter is not a good earth due to the allo-chrome finish on the case. Adjust the blue multiturn pot VR3 in the center of the limiter section for the minimum voltage reading on the meter. Aim for below 10 millivolts. Repeat for the left channel with VR4 and by taking the reading from test point TP2.

**6.** Connect an audio source to both channels and apply a 400hz tone with a level of +6 dbu. Make sure the gain controls are set to maximum (Fully clockwise). These are multiturn so make sure you hear / feel the pots click indicating end of travel.

**7.** Work out the the pilot level you intend to use. It is usually between 8 and 10 percent of the modulation with 9 percent being standard in most countries. 9 percent corresponds to 6.75 kHz deviation so for a total peak deviation of 75 kHz (the industry standard for 100 percent modulation) we need to adjust the multiplex level for a peak deviation of 68.25 kHz (91 percent modulation). This corresponds to the total minus the intended pilot level that we will re-introduce in a moment. We recommend further backing off the deviation by 4 % which equates to 3 kHz deviation. This 4 % acts as a guard-band for any small overshoots that may occur in the limiter and the stereo encoder filters. You should at this point with your tones applied have a peak deviation of 75 kHz - 6.75kHz (or intended pilot level) - 3 kHz = 65.25kHz. If you have not already done so, adjust the multiplex input level on the back panel to this level. If you are using the LCD display metering then 65 kHz would be an acceptable setting.

**8.** Reinstate the pilot by setting jumper J11 to stereo. Now adjust the pilot level control VR6 for a peak deviation of The previous setting plus the intended pilot level. In our example this would mean setting the deviation at 72kHz. This equates to our modulation and pilot leaving 3 kHz for our guard-band.

**9.** Set the limiter to ON with jumper J8. Decide on Clarity or Loud mode for the limiter and set jumpers J4 and J5 accordingly.

The transmitter should now have the multiplex and pilot setup at the correct level. All that is left to do is to set the input gain controls to your desired settings. For most applications where you require a compressed loud competitive sound we recommend setting the gain controls at maximum. But if you are supplying a very high level feed you may have to turn the gain controls down to stop internal clipping occurring prior to the limiter. (Please see note on pre-emphasis at the end of the section). You may also wish the limiter to start to limit for a given level of input. To set the limiters input controls up for a given input level consult step 10. Otherwise leave the input gain controls at maximum and skip to step 12.

**10.** Apply your audio feed to the left channel input socket on the rear panel at the desired level you want limiting to commence. This will need to be a minimum of 0dbu. The limiter inputs will need at least a 0dbu input to achieve limiting even with the rear panel gain controls set at maximum. Read the pre-emphasis note at the end of the section for more info on input level restrictions.

Set the LCD display to limiter gain reduction and with audio applied to the left channel reduce the left channel input gain control until the display flickers from 0dB to 2dB gain reduction. This is the onset of limiting.

**11.** Remove the left channel audio and repeat the procedure for the right channel. This procedure also ensures that both inputs to the internal limiter are driven equally.

**12.** Set the pre-emphasis jumpers J2 and J3 to the correct setting for your region, 75µs for the Americas and Japan and 50µs for the rest of the world. If your audio feed has gone through an external processor prior to this transmitter then check to see if that unit has pre-emphasis capability and if it is switched on. If it has pre-emphasis and it is enabled then you should remove the pre-emphasis jumpers J2 and J3 to ensure that only one set of pre-emphasis has been applied throughout the broadcast chain.

**13.** Connect your studio feed to the transmitter. Turn the power off to the transmitter, connect your external antenna, reconnect the power and you're on the air!

**14.** Monitor your total peak deviation with your real world audio material and check with the deviation display that your peak deviation does not exceed 75 kHz. If you have set up the transmitter as per the instructions in this section then you should be within 1 kHz or so of this figure. If your deviation does exceed 75 kHz then adjust the back panel multiplex control to keep your maximum deviation at 75 kHz.

## 2.54 Stereo with internal limiters disabled.

The limiter can be disabled internally if you do not require it. This effectively allows any audio input signals straight through to the stereo encoder unaltered. You may wish to disable the limiter when you have an external processor or limiter that may be of a higher performance than the internal limiter in this transmitter. You can still have the limiter active even with external limiters in operation, as the limiter will not discolor the sound when fed with pre-processed audio. We leave that up to you. For safety purposes you may wish to leave the clippers on the limiter and the 15 kHz filters in to provide extra protection when you are unsure of the peak output characteristics of the external piece of equipment. When you know that the piece of audio processing equipment is band-limited to 15 kHz and peak limited you can leave out the clippers safe in the assumption that the external processor will be able to handle the level control completely.

### Advanced setup procedure.

1. Firstly make sure that the exciter is set to your chosen operating frequency. If you have not already done so then remove the top cover from the transmitter.
2. Connect the transmitter to a dummy load.
3. Turn on the transmitter and within 15 seconds it should lock to frequency.
4. Set the internal limiter to OFF with jumper J8. Set the limiter clippers to ON with jumpers J6 and J7. Set the 15 kHz filter clipper jumpers J9 and J10 to ON. Remove the pre-emphasis jumpers from J2 and J3 completely for now. Make sure the loophrough jumper J1 is switched to loophrough and the mono from left jumper J12 is set to the OFF position. Disable the stereo pilot by setting jumper J11 to mono. Set the limiter mode jumper J4 and J5 to CLARITY  
These settings will allow any audio straight through the limiter and into the stereo encoder without any form of level control apart from the peak level clippers, so we can set the system internal levels correctly.
5. We should check that any offsets internal to the limiter are nulled out to keep distortion to a minimum. Connect a multimeter set to millivolts to testpoint TP1 which is located next to the right clipper jumper. You will also need an earth point for the meter. The bolt on REG2 is a good earth. The case of the transmitter is not a good earth due to the allo-chrome finish on the case. Adjust the blue multiturn pot VR3 in the center of the limiter section for the minimum voltage reading on the meter. Aim for below 10 millivolts. Repeat for the left channel with VR4 and by taking the reading from test point TP2.
6. Connect an audio source to both channels and apply a 400Hz tone with a level of +6dBu. Make sure the gain controls are set to maximum (Fully clockwise). These are multi-turn so make sure you hear / feel the pots click indicating end of travel.
7. Work out the the pilot level you intend to use. It is usually between 8 and 10 percent of the modulation with 9 percent being standard in most countries. 9 percent corresponds to 6.75 kHz deviation so for a total peak deviation of 75 kHz (the industry standard for 100 percent modulation) we need to adjust the multiplex level for a peak deviation of 68.25 kHz (91 percent modulation). This corresponds to the total minus the intended pilot level that we will re-introduce in a moment. We recommend further backing off the deviation by 4 % which equates to 3 kHz deviation. This 4 % acts as a guard-band for any small overshoots that may occur in the limiter and the stereo encoder filters. You should at this point with your tones applied have a peak deviation of 75 kHz - 6.75kHz (or intended pilot level) - 3 kHz = 65.25kHz. If you have not already done so, adjust the multiplex input level on the back panel to this level. If you are using the LCD display metering then 65 kHz would be an acceptable setting.
8. Re-instate the pilot by setting jumper J11 to STEREO. Now adjust the pilot level control VR6 for a peak deviation of 75kHz peak deviation (100 percent modulation)

The transmitter should now have the total multiplex and the pilot setup at the correct level. All that is left to do is to set the input gain controls to suit your external equipment.

9. Set the limiter clippers J6 and J7 to OFF and set the filter clippers J10 and J11 to OFF.
10. Connect a 400 Hz tone at your desired level to the left channel and adjust the left channel gain control on the

rear panel for a peak deviation of 75 kHz. Remove the left channel audio lead.

**11.** Connect a 400 Hz tone at your desired level to the right channel and adjust the right channel gain control on the rear panel for a peak deviation of 75 kHz.

It is a good idea to check that both of the audio input gain controls are set to provide equal gain to both channels. To do this connect an oscilloscope to the multiplex output socket. Connect an identical 400Hz tone to both audio inputs and set the pilot to off by setting J11 to MONO. Adjust one of the audio input gain controls slightly to minimize any distortion of the 400Hz tone observed on the scope. The distortion is 38 kHz switching information superimposed onto the sine wave. When you have adjusted the input gain control to provide the same gain as the other channel you will observe a pure sine wave with no switching information present. This is because if  $R=L$  then  $L-R=0$  and the subcarrier is L-R, so no gain difference between R and L equates to no 38 kHz subcarrier. Reinststate the Pilot by setting jumper J11 to STEREO.

You can set the limiter clippers and the 15 kHz filter clippers back to ON if you require. These will prevent over-modulation no matter what input level you apply.

**12.** If you wish to employ pre-emphasis within the transmitter then you will need to setup the transmitter for a peak deviation of 75kHz with 15 kHz tones instead of 400Hz. This is to prevent overmodulation of the transmitter from high frequencies, which would be the case if we set the transmitter up for 75kHz peak deviation at 400Hz. The pre-emphasis filter can put the 15 kHz audio 17db higher than 400Hz. We strongly advise you to ensure pre-emphasis is built into any external equipment if you decide not to use the internal limiter. If you do need to use the 75µs for the Americas and Japan and 50µs for the rest of the world.

**13.** Connect your studio feed to the transmitter. Turn the power off to the transmitter, connect your external antenna, reconnect the power and your on the air!

**14.** Monitor your total peak deviation with your real world audio material and check with the deviation display that your peak deviation does not exceed 75 kHz. If you have set up the transmitter as per the instructions in this section then you should be within 1 kHz or so of this figure. If your deviation does exceed 75 kHz then adjust the back panel multiplex control to keep your maximum deviation at 75 kHz.

## 2.55 Mono from two independent channels.

This is essentially the same as the stereo with limiter mode except the stereo pilot is disabled which will enable receivers to receive you in mono. A stereo feed can be supplied to the transmitter's left and right inputs. These will be mixed in the stereo encoder as normal to produce a multiplex signal. The absence of the pilot will force tuners to decode the broadcast in mono. If both the right and left channels have the same content then no stereo subcarrier will be created and the multiplex signal will resemble true mono. However we recommend mono from one channel input mode if both channels are identical to ensure that the subcarrier content is kept to a minimum. This mode is for when you want to broadcast in mono but have a stereo sound source that can't be supplied as a single mono feed, such as a stereo mixer with no mono button.

### Advanced setup procedure.

1. Firstly make sure that the exciter is set to your chosen operating frequency. If you have not already done so then remove the top cover from the transmitter.
2. Connect the transmitter to a dummy load.
3. Turn on the transmitter and within 10 seconds it should lock to frequency.
4. Set the internal limiter to OFF with jumper J8. Set the limiter clippers to ON with jumpers J6 and J7. Set the 15 kHz filter clipper jumpers J10 and J11 to ON. Remove the pre-emphasis jumpers from J2 and J3 completely for now. Make sure the loophrough jumper J1 is switched to LOOPTHROUGH and the MONO FROM LEFT jumper J12 is set to the OFF position. Disable the stereo pilot by setting jumper J11 to MONO. Set the limiter mode jumper J4 and J5 to LOUD.

These settings will allow any audio straight through the limiter and into the limiter clippers that set our final peak level.

5. We should check that any offsets internal to the limiter are nulled out to keep distortion to a minimum. Connect a multimeter set to millivolts to testpoint TP1 which is located next to the right clipper jumper. You will also need an earth point for the meter. The bolt on REG2 is a good earth. The case of the transmitter is not a good earth due to the allo-chrome finish on the case. Adjust the blue multiturn pot VR3 in the center of the limiter section for the minimum voltage reading on the meter. Aim for below 10 millivolts. Repeat for the left channel with VR4 and by taking the reading from test point TP2.
6. Connect an audio source to both channels and apply a 400Hz tone with a level of +6 dbu. Make sure the gain controls are set to maximum (Fully clockwise). These are multiturn so make sure you hear / feel the pots click indicating end of travel.
7. Adjust the multiplex gain control on the back panel for a peak deviation of 72 kHz. This allows a 3 kHz guard-band for slight overshoots that may occur in limiter and filters inside the system.
8. Set the limiter to ON with jumper J8. Decide on Clarity or loud mode for the limiter and set Jumpers Jx and Jy accordingly.  
All that is left to do is to set the input gain controls to your desired settings. For most applications where you require a loud competitive sound we recommend setting the gain controls at maximum, however if you are supplying a very high level feed you may have to turn the gain controls down to stop internal clipping occurring prior to the limiter. (Please see note on pre-emphasis at the end of the section). You may also wish the limiter to start to limit for a given level of input. To set the limiters input controls up for a given input level consult step 9. Otherwise leave the input gain controls at maximum and skip to step 11.
9. Apply your audio feed to the left channel input socket on the rear panel at the desired level you want limiting to commence. This will need to be a minimum of 0dbu. The limiters inputs will need at least a 0dbu input to achieve limiting even with the rear panel gain controls set at maximum. Read the pre-emphasis note at the end of the section for more info on input level restrictions.  
Set the LCD display to limiter gain reduction and with audio applied to the left channel reduce the left channel input gain control until the display flickers from 0dB to 2dB gain reduction. This is the onset of limiting.
10. Remove the left channel audio and repeat the procedure for the right channel. This procedure also ensures that both inputs to the internal limiter are driven equally.
11. Set the pre-emphasis jumpers J2 and J3 to the correct setting for your region, 75 $\mu$ s for the Americas and Japan and 50 $\mu$ s for the rest of the world. If your audio feed has gone through an external processor prior to this transmitter then check to see if that unit has pre-emphasis capability and if it is switched on. If it has pre-emphasis and it is enabled then you should remove the pre-emphasis jumpers J2 and J3 to ensure that only one set of pre-emphasis has been applied throughout the broadcast chain.
12. Connect as before. Turn the power off to the transmitter, connect your external antenna, reconnect your power and you're on the air!
13. Monitor your total peak deviation with your real world audio material and check with the deviation display that your peak deviation does not exceed 75 kHz. If you have set up the transmitter as per the instructions in this section then you should be within 1 kHz or so of this figure. If your deviation does exceed 75 kHz then adjust the back panel multiplex control to keep your maximum deviation at 75 kHz.

## 2.56 Mono from one channel input.

You can provide one audio feed to the transmitter via the left balanced input. This has the advantage of supplying two exact audio signals to the stereo encoder section that will in turn cancel the stereo subcarrier leaving only a pure mono signal with content falling to zero above 15 kHz.

### Advanced setup procedure.

1. Follow the advanced setup procedure for the '*mono from two independent channels*' mode completely as if you would be using that mode. Set all the jumpers and levels correctly as if you would be using that mode. Both

input gain controls must be set equally and correctly for the this mode to work correctly and create a true mono signal. Any gain difference would create L-R subcarrier information which is not necessary and wastes bandwidth. Following the *'mono from two independent channels'* advanced setup procedure should have you set up the two channels input gain controls at the same level.

2. Set the MONO FROM LEFT bridge jumper J12 to ON. this disconnects the right channel socket internally and feeds the left information to the internal right channel circuitry.
3. Apply your audio feed to the left channel input.
4. Connect your studio feed to the transmitter. Turn the power off to the transmitter, connect your external antenna, reconnect your power and your on the air!
5. Monitor your total peak deviation with your real world audio material and check with the deviation display that your peak deviation does not exceed 75 kHz. If you have set up the transmitter as per the instructions in this section then you should be within 1 kHz or so of this figure. If your deviation does exceed 75 kHz then adjust the back panel multiplex control to keep your maximum deviation at 75 kHz.

## 2.6 OTHER SETUP CONSIDERATIONS

### PRE EMPHASIS

due to the characteristics of the pre-emphasis curve. There is 17dB more gain into the limiter with a 15 kHz input signal compared to a frequency which is below the start point of the pre-emphasis curve. The pre-emphasis curve provides a 6db per octave boost from the 50 or 75  $\mu$ s breakpoint. For this reason we have used 400Hz for our tests because it is below the pre-emphasis filter curve. With pre-emphasis active the maximum usable input level to the limiter is 10dBu when the gain controls are at maximum. Anything above this may cause high frequency content to hit the internal supply rails, clipping the audio and introducing distortion. To ensure you can reduce your input level or reduce the rear panel gain controls.

### 15 kHz FILTER CLIPPERS

Our tests have concluded that when the limiter and limiter clippers are active any overshoots caused by ringing in the filters when clipped will not contribute any significant harmonics to make the transmitter non compliant. The 15 kHz clippers are set to clip at the same amplitude as the limiter clippers. In effect the 15 kHz filter clippers are out of circuit except for instances where the 15 kHz filters overshoot caused by ringing in the filters. The overshoots from the filters will increase the amplitude of the audio material past that of the limiter clippers clip point and the 15 kHz clippers will clip them back down to almost the same amplitude. This setup only allows a small amount of clipping to be applied to post 15 kHz filtered audio keeping the spectral output to an acceptable level.

You can safely use the clippers and still conform to the FM broadcast specifications set out by the FCC and CCIT. This is not an issue if you are using an external processor that has band-limited (15 kHz) processed audio as the filters will not overshoot.

We don't advise ever to use the 15 kHz clippers without the limiter clippers.

### LOOPTHROUGH

The rear panel BNC sockets provide an easy interface to the multiplex path. You can insert an external piece of equipment between the multiplex output of the internal stereo encoder and the modulator section.

To connect an external piece of equipment consult the external equipments documentation. It should be as easy as configuring the transmitter as per normal and then simply setting the internal Loophrough jumper to OFF and taking the multiplex output to the input of the external equipment and the output of the external equipment back into the multiplex input socket. If the external equipment is not unity gain you may have to readjust the multiplex input gain slightly to take account for any gain differences. Most loophrough designed equipment is unity gain to make setup and use as simple as possible.

**FREQUENCY FINE TUNE ( WARNING, ADVANCED TECHNICIANS ONLY)**

While the frequency is controlled by the phase locked loop system, the stability is governed by the stability of the reference. A quartz crystal is used for the reference for its high stability however component ageing can affect the frequency slightly over time. The frequency can be finely adjusted via VC2. This provides a small adjustment of the VCO frequency when locked. This will have been adjusted at factory to the correct setting and the transmitter should remain within 1kHz of the channel required. If however the frequency does move off slightly due to component ageing then you can adjust VC2 to trim the unmodulated carrier back onto channel. You will need a frequency counter to monitor the output frequency of the un modulated transmitter when adjusting VC2.

**LCD SYSTEM METERING ACCURACY**

DISPLAY	Measurement	Accuracy
POWER SUPPLY	Volts	+/-1 Volt
TEMPERATURE	Degrees Centigrade	+/-1 Degree
PEAK DEVIATION	kHz	+/-1 kHz
LIMITER GAIN REDUCTION	Decibels	+/-1 dB
RF POWER	Watts	5 %

## 3.1 SPECIFICATIONS

### RF

Power	30mW - 5W
Connector	N-type 50 Ohm
Harmonics	better than 72 dBc
Spurious	< -90 dBc
Frequency range	87.5 - 108 MHz
Frequency steps	100 kHz from LCD or 12.5 kHz from internal switches
Frequency selection	Internal switches or LCD system
Frequency control type	Dual speed phase locked loop
Frequency stability	< +/- 500 Hz (fine adjustment available)
MPX input	BNC
MPX input level	MPX input level -10 dB to +10 dB (adjustable)
MPX input response	MPX input response +/- 0.3 dB, 5 Hz to 100 kHz
Modulation	Direct frequency modulation
Synchronous AM Noise	0.31% (at normal deviation)
Asynchronous AM Noise	0.18% (at centre frequency of 97.7MHz)

### STEREO

Subcarrier generation	Microprocessor generated 8x over-sampled 19 kHz +/- 1 Hz (adjustable)
Pilot	Microprocessor generated 16x over-sampled
Pilot generation	(BNC) 0dB
Output level (BNC)	> 40dB at 19 kHz
15 kHz filtering	On or off
15 kHz overshoot filter clipping	
Spurious	> -60dBr
> 80 kHz	> -80dBr
>160 kHz	> 55dB (20Hz-15kHz)
Stereo separation	

### LIMITER

Audio input levels	-10dB - +18dB for limiting
Audio input connectors	XLR balanced (RF shielded)
Input cmrr	> 60dB
Audio distortion	<0.1% at limiting 1 KHz (clarity mode)
Tone	Program dependent
Program material	20 Hz to 20 kHz +/- 0.5dB (pre-emphasis off)
Frequency response	Limiter control range >24dB (pre-emphasis off)
Limiter control range	10 kOhm
Input impedance	50 µs,75 µs and 0 µs (off)
Pre-emphasis	Clarity and loud
Process modes	On or off
Clipping	

### OTHER

Control system	3 buttons, 122x32 graphics display
External control/monitor	I/O Alarms D9-type Male; RS232 D9-Type Female
Size	489mm x 44mm x 322mm
Weight	3 kg
Voltage input	85 - 260 VAC
Current input	110V - 4A / 220V - 2A
Power connector	IEC, FUSED and switchable
Switched mode approvals	UL / TUV / CE

## 3.2 CIRCUIT DESCRIPTION

The transmitter consists of three main circuit boards, two power supply modules and the associated wiring and connectors. The power supplies are fully approved modules and won't be discussed electrically except for the connections to the other boards where appropriate.

The three PCB's previously mentioned are the combo board, the power amplifier board and the control / LCD board. The wiring and connection between the boards can be seen in the internal case diagram.

### The combo board contains

1. Audio limiter with pre-emphasis capability
2. High spec over-sampled digital stereo encoder
3. High spec low distortion PLL exciter
4. Power supply circuitry to supply various voltages to the different sections
5. A logic / control section to interface to external equipment
6. Control connections to the LCD control board

### The Power amplifier board contains

1. A 2 stage 150/300 Watt FM amplifier
2. Low pass harmonic filter
3. VSWR bridge / coupler and power sniff circuitry
4. Temperature sensing circuitry

### The Control / LCD board contains

1. A 122x32 LCD graphics display
2. Three front panel buttons for LCD control
3. Power control adjustment and transmitter fault / protection circuitry
4. An 8 bit microcontroller to control all the LCD functions, metering and alarm monitoring

We will describe the electrical workings of the transmitter from the audio input through to the RF output and will attempt to explain how the three boards tie together and form the complete unit.

We will start at the audio input sockets on the back panel which are part of the combo board.

## 3.21 COMBO BOARD

The description of the circuitry describes the right channel path where stereo sections are mentioned. The component for the left channel is bracketed next to the right channel component.

### Audio limiter description

Left and right audio signals are applied to balanced input XLR sockets on the back panel. The balanced audio signals are fed to IC1(IC4) which are configured as differential amplifiers to convert the balanced inputs to unbalanced for the rest of the limiters circuitry. The output from the differential op-amps feed a pre-emphasis filter which can be switched in or out of circuit via the on board jumpers J2(J3). The audio is then fed from the pre-emphasis filters to one half of dual op-amps IC2(IC3) where input gain can be adjusted through the rear panel input gain control VR1(VR2) which forms the feedback path for the op-amp. The audio is then fed into the other half of IC2(IC3). These dual op-amps are also the limiter gain control and output for the limiter.

The output of the input gain op-amps also feed the full wave rectifier circuitry which provides a DC representation of the audio signal. This DC voltage is applied to a time constant circuit which provides the attack and release parameters for the limiter. The time constant capacitors C54 and C55 together with R58 and R59 provide a programme dependent interactive time constant for clear punchy sound at all levels of limiting. After passing through the time constant filter the DC signal is buffered by IC7 and then fed to IC6 which drives PNP transistors T1(T2) which controls the current passing through the gain control element, transconductance amplifier IC5.

Transconductance amplifier IC5 is configured as a variable resistor which is placed in the feedback path of the gain control op-amps. IC5 varies its resistance in accordance with the level of audio drive so that the output of the gain control op-amps is fixed at 0dB. LED1(LED2) provide clipping of any overshoots that get through the limiter. This clipper can be switched in and out of circuit by jumper J6(J7). This provides significantly more loudness than can be obtained by making the attack time quicker to catch the overshoots. The amount of clipping can be controlled by J4(J5). These provide more drive to the gain control op-amps by putting resistor R53(R69) in parallel

with R47(R68) . This has the effect of a more “commercial loud sound” when in loud mode compared to a more true to the original sound when in clarity mode due to less clipping taking place. VR3(VR4) is connected across the inputs of the transconductance amplifier and provide offset adjustment to null any distortions introduced by offsets inherent in the op-amps

### Stereo encoder description

The stereo encoder section is based around a high speed switch which is used to generate the multiplex at 38 kHz. The switch is controlled by microcontroller IC13 which supplies the timing signals to the switch at 304 kHz. The high speed enables an over-sampled 38kHz subcarrier to be generated that is rock steady and spectrally clean. As the signal is generated digitally no adjustments or setups are required for the encoder. The only adjustments on the encoder section are the stereo/mono control and the level of the stereo subcarrier. The 19kHz pilot tone is also generated by the microcontroller and because of this the stereo separation is excellent due to the perfect timing between the pilot and the subcarrier. The 19 kHz pilot is also generated by over-sampling techniques to produce a very low distortion pilot tone.

The audio path through the encoder starts at 15 kHz brickwall filter FIL1(FIL2). These provide over 40 dB of protection by 17 kHz, 50 dB by 20 kHz as well as a notch at 19 kHz to protect the pilot signal even further. The output from the filters are buffered by op-amp IC10(IC11). These buffer op-amps can also be used as clippers, which can be used to remove any overshoots introduced by ringing in the 15 kHz filters. The buffer op-amps drive into the analogue switches. The switches are controlled by the microcontroller IC17 and the output from the switches feed into three resistors R100,101,102 to provide a D/A type function producing the multiplex signal. The resistors are carefully chosen to provide sine weighting for the reconstruction, which keeps the lower order harmonic content down to almost zero. These three resistors are combined in virtual earth mixer op-amp IC14. The stereo pilot tone emerges from the microcontroller as a 4 bit word which has sine weighting applied to it by resistors R93 to R98. At this point, apart from 19 kHz, the pilot has no significant energy below 304 kHz. The pilot is fed through VR6 for adjustment of the pilot level before being combined with the subcarrier at the virtual earth mixer op-amp IC14. The complete stereo multiplex signal emerges from IC14 and is fed into a low-pass filter formed by L1,L2 and C78 to C84. This filter removes any high frequency products due to the sample rate. The filter is buffered by output op-amp IC15 which also provides a fixed output level of +6dBu, which is fed to the multiplex output BNC socket on the back panel, as well as to one side of the loophrough jumper J1.

### Exciter description

The frequency determining elements are inductor L3 and varicap diode VD1 together with capacitors C20 - C23. These components, together with transistors T4 and T5, form a cascade oscillator whose output is then buffered by RF transistor T6. The RF output from T6 is impedance matched to the base of P.A. transistor T7 by RFT1, a 4 to 1 matching transformer. The one watt power output from P.A. transistor T7 is impedance matched by coils L4 and L5 and associated capacitors C30-34 to the 50 ohm output socket CON7. These components also provide harmonic filtering. A coaxial cable carries the RF output from this socket to the RF input connector on the main power amplifier PCB.

The PLL circuit is primarily IC18 which is a serially programmable PLL chip. The microcontroller IC17 reads the dial switches at power up and outputs a serial code to the PLL chip in a format that determines the output frequency that the PLL will lock the transmitter to. If the microcontroller IC17 detects that the switches are set to 4440 then the microcontroller IC17 will talk to the microcontroller on the control / LCD board to request the LCD display control system stored frequency. The PLL chip delivers raw control pulses to the loop filter built around op-amp IC20. The loop filter is a low-pass filter that takes the raw rectangular differential outputs from the PLL chip and creates a DC voltage to apply to the frequency determining component, varicap diode VD1. The main time constant in the loop filter is formed by resistor R6 driving C8 and R5 driving C9. The high resistance of R5 and R6 allows slow charging of C9 and C6 from the PLL chip. The DC voltage derived from the output of the op-amp will be slow to change in response to the raw PLL pulses due to the slow charging of those capacitors. This slow DC voltage change is converted to slow frequency change by the varicap diode. IC19 is an analogue switch that shorts out the two high resistance resistors in the loop filter to allow faster charging of C9 and C6, and so, a faster change of the output DC voltage from the filter. This faster changing voltage can allow the transmitter to get on frequency faster. When the transmitter is on frequency the analogue switch stops shorting out the high resistance resistors and the slow loop takes control, which greatly improves the audio response of the transmitter. The microcontroller IC17 determines when to switch the analog switch in and out by reading the lock detect signals from the PLL chip. The microcontroller can also use this information to switch off transistor T6 with open collector configured T11 which mutes the RF output when the transmitter is out of lock. LED5 provides visual indi-

cation of the PLL locked condition. The front panel control system will also display the locked condition when in the frequency display screen.

Audio is fed into the modulation input of the exciter from external multiplex input connector CON2 which is a BNC type or from the internal stereo encoder section by having jumper J1 set to loopthrough. The modulation level can be adjusted from the back panel by the adjustment of variable resistor VR5 which is in the feedback loop of op-amp IC18. The output of the op-amp feeds the modulation element, varicap diode VD1, via potential divider R31 and R18.

CON8 provides an interface to the control / LCD board. This ribbon cable interface provides connections for the alarm signals to the back panel D-type from the microcontroller on the LCD board together with connections for the modulation, the limiter gain reduction level and a serial interface which provides frequency and status information between the PLL microcontroller on the combo board and the main system microcontroller on the LCD board.

## 3.22 LCD CONTROL BOARD

The LCD control board is the heart of the transmitter. The board contains an eight bit microcontroller, LCD display, a voltage regulator and a dual op-amp together with a few passive components.

CON1 provides a 10 way interface to the power amplifier board and its sensors. Some of the connections of CON1 are routed around to the power supply modules. CON2 provides a 16 way interface to the combo board providing power to the combo board as well as routing signals to the back panel D-type sockets for alarms/RS232 and returning modulation and limiter gain reduction signals to the main microcontroller.

The voltage regulator REG1 and decoupling capacitors C1 and C2 takes the 18 volt auxillary supply from CON1 and regulate it down to 5 volts for the microcontroller and LCD circuitry. The microcontroller is a 40 pin 8 bit type running at 8 MHz. The microcontroller has several ports that have various functions and connect to external components.

PORTA (6 bits) is primarily used for the analogue voltage inputs. Bit 0 is the limiter gain reduction, Bit 1 the modulation, Bit 2 the AUX volts and Bit 3 the Fwd RF power. Bit 4 is not used and bit 5 of PORTA has a control connection to the LCD display.

PORTB (8 bits) has a few different functions. Bits 7,6 and 3 of the port are the alarm signal outputs and are routed off via CON2 to the D-type on the back of the combo board. Bit's 5,4 and 2 are connected to the front panel buttons to allow navigation of the LCD functions. Bits 1 and 0 provide a 2 wire interface to the PLL microcontroller on the combo board.

PORTC (8 bits) bits 0 and 1 are used to write information to the LCD display. Bit 2 is the pulse width modulator output (PWM) and connects into unity gain DC amplifier op-amp IC2A. The voltage generated by the PWM is set by the software in the microcontroller. This PWM level is then fed through potentiometer VR2 and smoothed by C13 before being buffered by the aforementioned op-amp. PORTC bits 3-5 are not used. Bit's 6 and 7 of PORTC are used by the UART inside the microcontroller. These pins are RXD and TXD for the RS232 interface. They are routed via CON2 to the back panel D-type.

PORTD's 8 bit's are interfaced to the 8 bit data bus of the LCD display. The data byte on PORTD can be latched into the LCD display by the LCD control bits on PORTC.

PORTE (3 bits) has the remaining A/D inputs. Bit 0 is the PA volts, Bit 1 is the Rev RF power and bit 2 is for the PA temperature.

The microcontrollers software reads all the analogue voltages, converts and displays them where necessary and outputs alarm signals in the event of a transmitter error. There are various passive components associated with IC1. Each A/D port has input current limiting resistors R1-11 and decoupling capacitors C5-11. X1, C3 and C4 provide the 8 MHz signal for the clock of the microcontroller. R12 and R13 provide pull downs for correct operation of the internal processor communications channel. C12 provides supply decoupling for the microcontroller and VR1 sets the contrast of the LCD display.

IC2 is a dual op-amp whose purpose is to control the output power of the transmitter. Side A of the op-amp is configured as a unity gain buffer for the PWM and was described previously. VR2 provides an adjustable DC level to side B of the op-amp. Side B is configured as a DC amplifier with the gain set by R17, R18, R19, R20 and R25. The larger the DC signal provided by side A and the larger the DC signal at the output of Side B. This DC signal is used to turn down the output of the Power amplifiers power supply and with it the RF power output level.

LED3 and R20 provide a connection from the reverse RF power sensor into the input the non inverting input of side B of the op-amp. LED3 only allows DC through above a certain level. Any DC above this level will increase the output voltage from the op-amp and the RF power level will decrease. This forms the VSWR protection for the transmitter. LED1 and LED2 also provide the same function but with the DC level this time being supplied by the temperature sensor on the PA board. Too high a temperature will cause the DC level to exceed the turn on point of the two diodes and voltage will once again turn up the op-amps voltage and turn down the RF power level which should lower the temperature of the transmitter. The output from side B is fed to the switched mode power supply of the power amplifier via R21 and CON1. R22 and C15 provide supply decoupling for the op-amp. C14,15,16,17,18 provide further decoupling and feedback for the power control feedback loop formed around side B of the op-amp.

## 3.23 POWER AMPLIFIER BOARD

The RF signal from the exciter section of the combo board arrives at the MCX RF input connector CON5 via a coaxial cable. From here the 50 ohm input impedance is matched to the gate of the FET transistor T1 by the impedance matching network formed by C8, C9, C30, L1 and L7. R26, R22, VR2 and C10 provide bias control to the gate of T1.

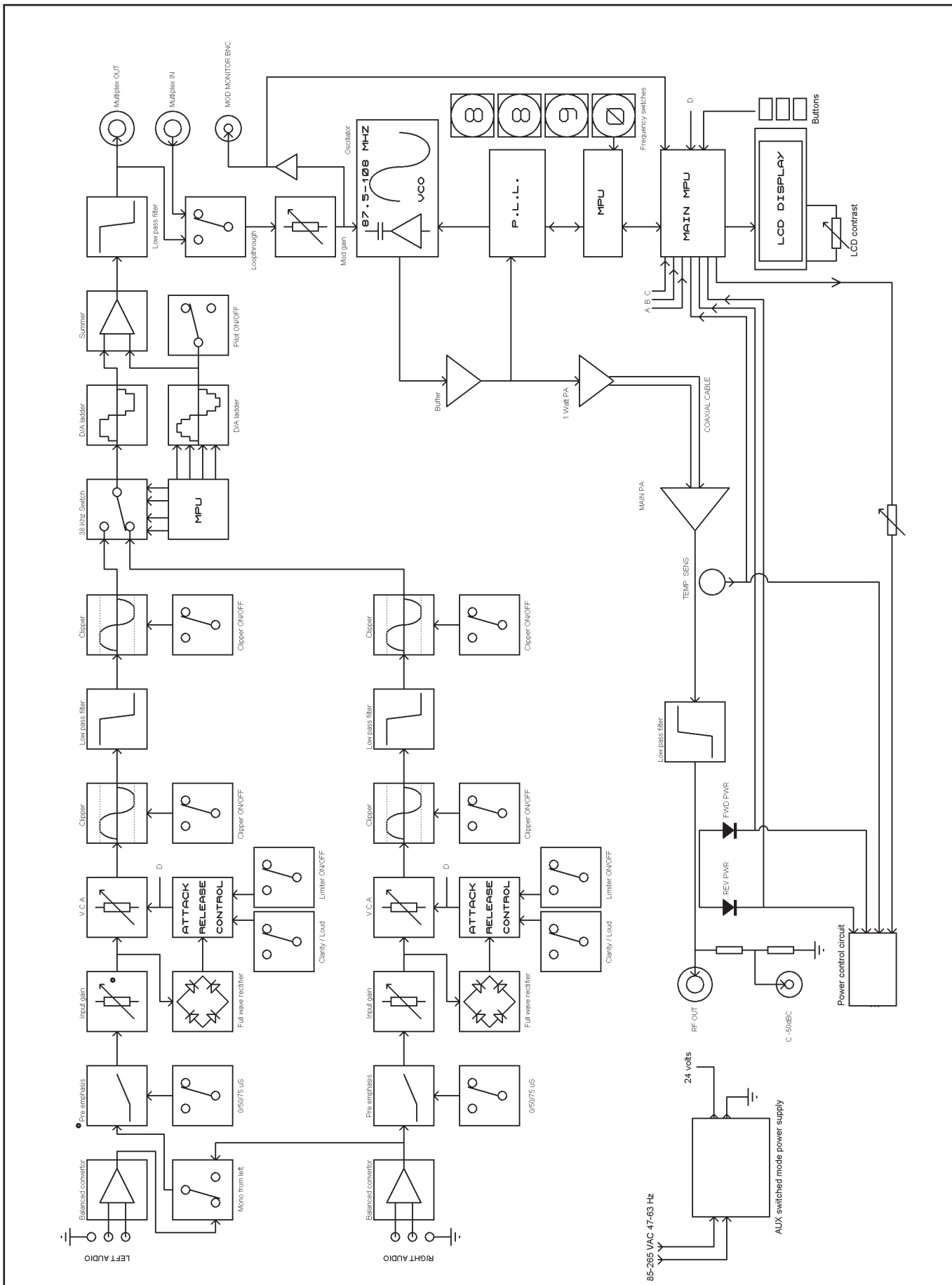
FB, L2 and L2 provide 24 volts to T1's drain from the 24 volt line as well as providing some impedance matching to the output of T1. The RF output is further fed into a low pass filter composed of C17 to C24 and inductors L3 to L5. These components reduce the level of any harmonic products generated by the power amplifier. The output of the low pass filter feeds into the VSWR sensor which generates our forward and reverse RF power measurements for metering and for VSWR fault protection and alarms. The RF line passes through ferrite ring RFT1. IC1 and associated resistors R2-R12 buffer the sensors outputs and provide a level suitable for the control/LCD boards microcontroller and protection circuitry.

The RF output sniff for the front panel is formed by a potential divider from the RF output line. This potential divider is formed by resistors R1 and R2. A coaxial cable connects the potentially divided RF output to the front panel.

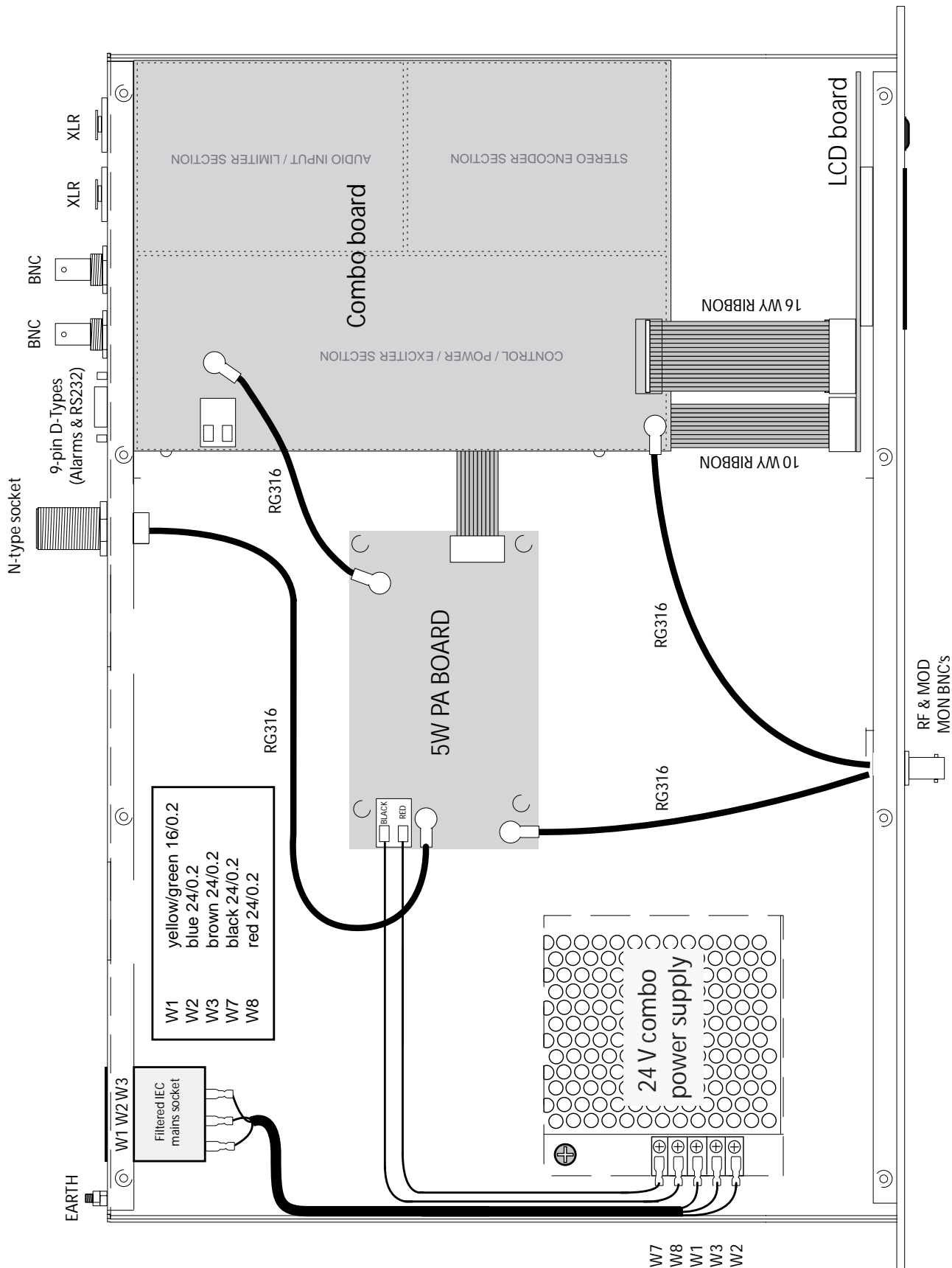
A temperature sensor circuit is located close to the main RF transistor T1. This temperature sensor is mounted into the heatsink and consists of the sensor itself TS1 which is located under the board and an op-amp circuit for level adjustment. The op-amp IC2 and associated components convert the output signal from the sensor itself to a level more suitable for the microcontroller and protection circuitry on the Control / LCD board.

CON2 connection block provides an interface to the board for the power connections from the two power supply modules and an interface to the LCD control board. This connector carries readings for the forward and reverse power, temperature, PA voltage, 18 volts from the regulator off the AUX power line to power the LCD control board and the combo board, and last but not least the PA power modules control line which controls its output voltage.

### 3.3 BLOCK DIAGRAM

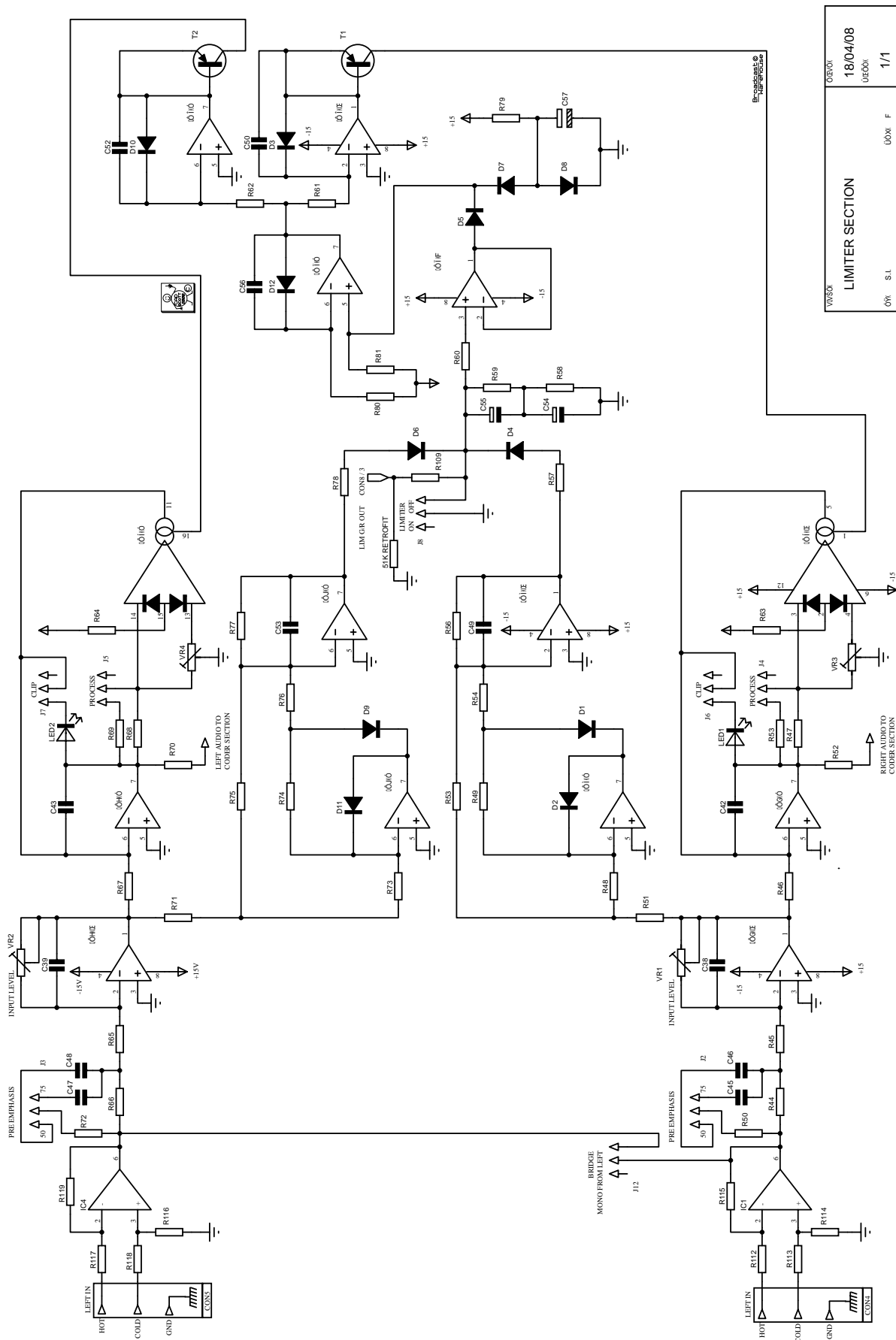


### 3.4 WIRING AND INTERNAL OVERVIEW



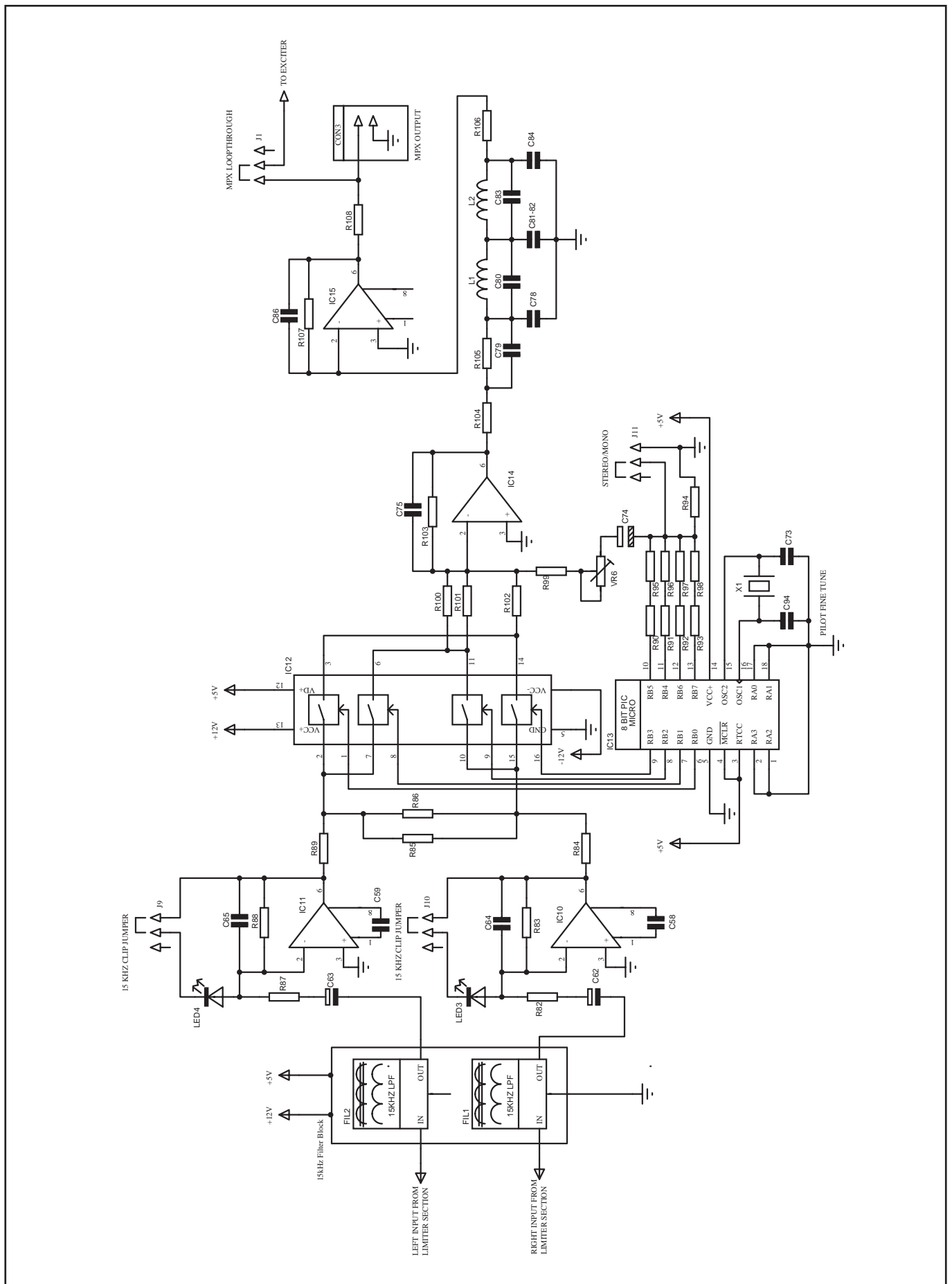
# 3.51 COMBO BOARD SCHEMATICS

## 3.511 Limiter section

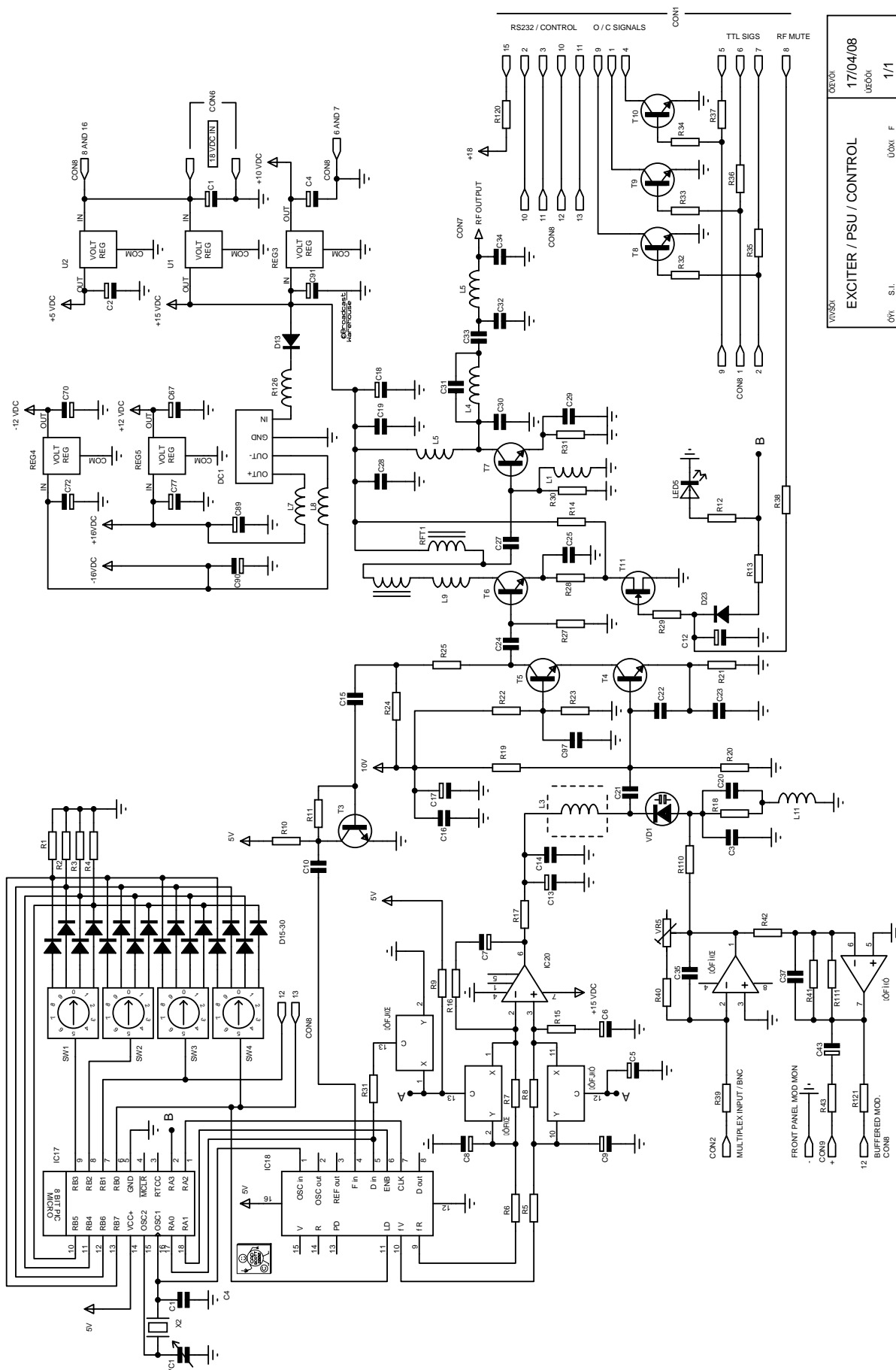


VR2001	18/04/08	U00X F	1/1
U00X F	U00X F	U00X F	U00X F
<b>LIMITER SECTION</b>			
0Y	S.I.		

### 3.512 Stereo encoder section



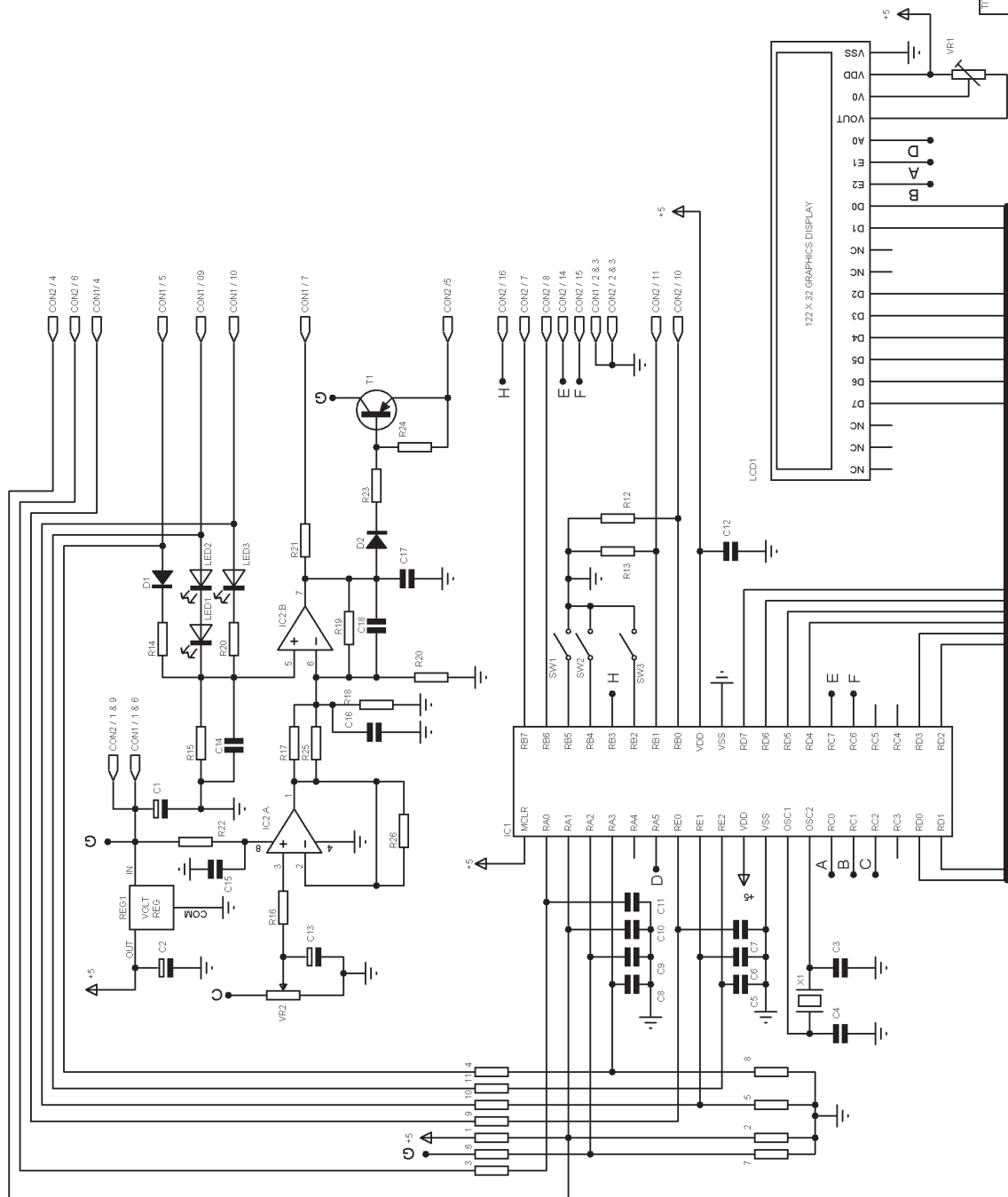
### 3.513 PLL exciter section



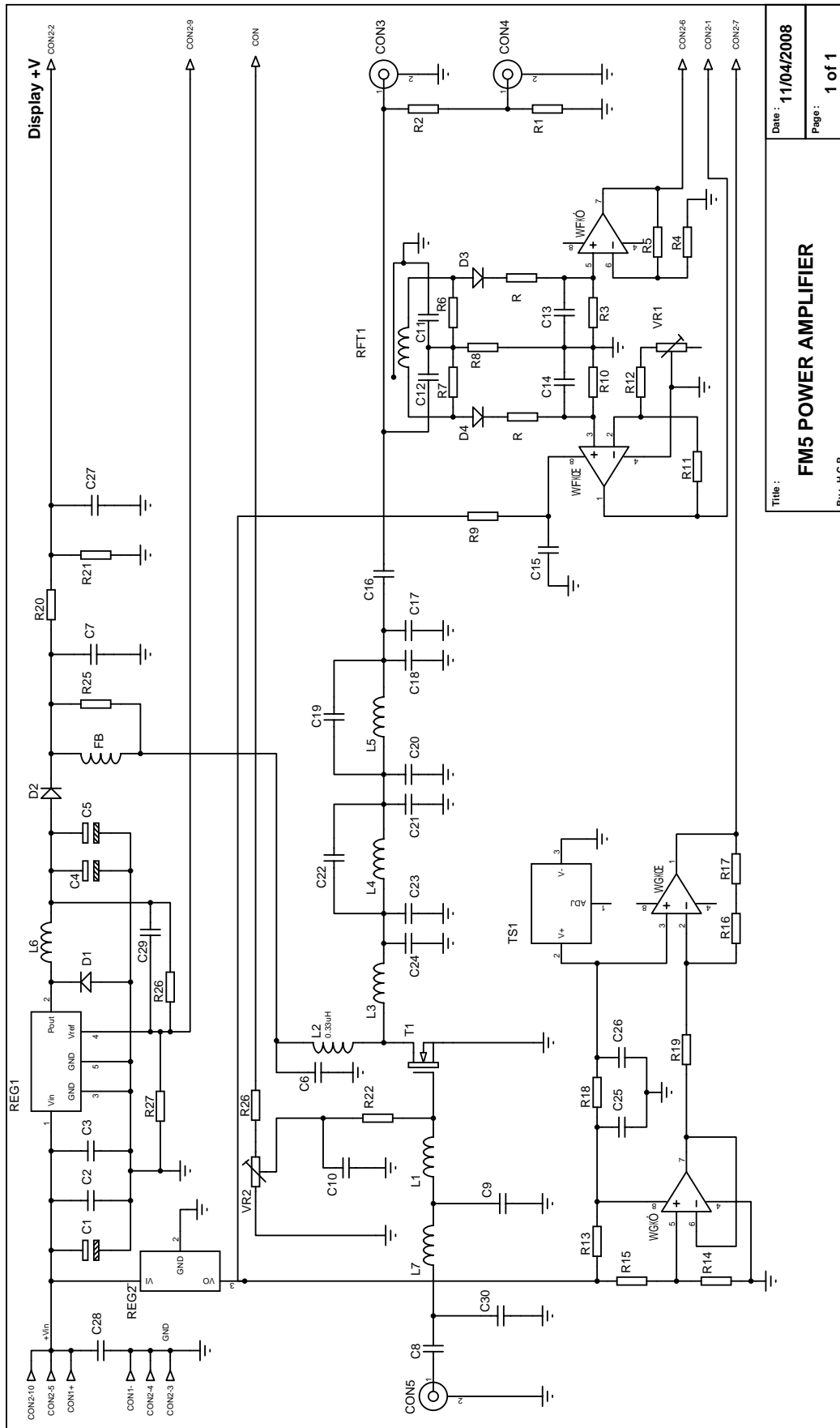
03700	17/04/08	1/1
EXCITER / PSU / CONTROL		
000	S.I.	U00X F

### 3.52 LCD CONTROL BOARD

TITLE:	LCD CONTROL BOARD
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BY: S.I.	REV. 1



### 3.53 Power amplifier board



## 3.6 PARTS LIST

### 3.61 Combo board

Qty	Reference	Value	Description
10	C1, C2, C5, C8, C9, C13, C72, C74, C77, C91	2.2uF 50V	Miniature Radial Electrolytic - 4-5mm Dia, 2mm Pitch, Tolerance +- 20%
1	C7	470uF 16V	Non-Polarized Electrolytic Capacitor
1	C27	82pF	Ceramic Plate 2.5mm pitch (680 Series)
3	C17, C18, C96	100uF 16V	Miniature Radial Electrolytic - 6mm Dia, 2.5mm Pitch, Tolerance +- 20%
3	C25, C29, C33	1n	General Purpose Ceramic Disc 2.5mm pitch
2	C97, C14	2n2	Ceramic Plate 2.5mm pitch (629 Series)
1	C15	220pF	Low K Ceramic capacitor
1	C95	220pF	General Purpose Ceramic Disc 2.5mm pitch
1	C21	3p9	General Purpose Ceramic plate 2.5mm pitch
6	C22, C30, C49, C53, C58, C59	27pF	Ceramic Plate 2.5mm pitch (680 Series)
1	C32	68pF	Ceramic Plate 2.5mm pitch (680 Series)
1	C23	39pF	Ceramic Plate 2.5mm pitch (680 Series)
2	C10, C24	2n2	Ceramic Plate 2.5mm pitch (680 Series)
21	C3, C11, C16, C19, C26, C28, C36, C40, C41, C44, C51, C60, C61, C66, C68, C69, C71, C76, C85, C87, C92	100n Y5V	Radial Multilayer Ceramic 2.5mm pitch - Y5V Dielectric
5	C99, C100, C101, C102, C103	1uF Y5V	Radial Multilayer Ceramic 2.5mm pitch - Y5V Dielectric
2	C79, C98	100nF	Miniature Polyester Capacitor 5mm pitch (Dubilier DMP5 Series)
1	C31	15pF	Ceramic Plate 2.5mm pitch (680 Series)
2	C75, C86	12pF	Ceramic Plate 2.5mm pitch (680 Series)
8	C4, C38, C39, C42, C43, C50, C52, C56	47pF	General Purpose Ceramic Disc 2.5mm pitch
2	C73, C94	33pF	General Purpose Ceramic Disc 2.5mm pitch
2	C34, C20	47pF	Ceramic Plate 2.5mm pitch (680 Series)
2	C46, C47	6n8	Polyester 5mm pitch 250V DC
2	C45, C48	4n7	Polyester 5mm pitch 250V DC
7	C54, C57, C62, C63, C67, C70, C88	47uF 16V	Miniature Radial Electrolytic - 5mm Dia, 2mm Pitch, Tolerance +- 20%
3	C55, C93, C12	10uF 16V	Miniature Radial Electrolytic - 4-5mm Dia, 2mm Pitch, Tolerance +- 20%
3	C6, C89, C90	470uF 16V	Radial Electrolytic - 8mm Dia, 3.5mm Pitch, Tolerance +- 20% (Forever RB Series)
6	C64, C65, C78, C81, C82, C84	330pF	Ceramic Plate 2.5mm pitch Capacitor
1	C80	100pF	General Purpose Ceramic Disc 2.5mm pitch
1	C104	120pF	Ceramic Plate 2.5mm pitch
1	VC1	5-65pF	Variable Capacitor - 100V DC, Dia 10.5mm, Pitch 7.62x5.08mm-(BC 808 Series)
N.F	C35, C37, C83	n/a	Not fitted
1	D13	1N4001	Axial 1 Amp Silicon Rectifier Diode - DO41 Packate 0.8mm leads
29	D1-D12,D15-D30, D31	1N4148	Glass Axial General Purpose Diode - DO-35 Package
4	LED1-4	GREEN	Bi Directional 5mm Green LED - Vf 2.2V - (Kingbright L-57D Series)
1	LED5	RED	5mm Pitch Standard Red LED (eg Kingbright L-53 Series)
1	VD1	BB809 **	VHF Varicap Diode
1	L1	3.9mH	Radial Inductor (Toko 8RBS) #181LY-392J
1	L2	4.7mH	Radial Inductor (Toko 10RB) #181LY-472J
1	L3	MC100 075	Screened Variable Inductor (MC120) #E526HNA-100075
1	L4	MC100 112	Screened Variable Inductor (MC120) - #E526HNA-100112
1	L5	MC120 073	Screened Variable Inductor - (MC120) #E526HNA-100073
1	L6	0.33uH	Axial Inductor Body 7mm, Dia 2.8mm

2	L9, L10	0.15uH	Axial Inductor Body 7mm, Dia 2.8mm - Sigma Inductors (C30 Series 0.25W)
2	L7,L8	220uH	Axial Inductor Body 9.2mm, Dia 4.0mm - Epcos Inductors (B78108S Series RF Inductors)
1	L11	MC141- 100 110	Screened Variable Inductor - (MC141) #NE547SNAS-100110
1	CON1	15 Way D	Right Angled Female Dual Double Height D-Type PCB-Mount Connector
2	CON2, CON3	R/A BNC	Right Angled BNC PCB-Mount Connectors
2	CON4, CON5	R/A XLR	Right Angled XLR PCB-Mount Connectors (F3FRAF)
0	CON6	2 Term	2 Way Screwless Terminal (Mask off, & do not fit)
3	CON7, CON9, CON13	MCX	MCX PCB Mount Socket
1	CON8	16 way	Straight IDC Header
3	CON10, CON11, CON12	4-way	4 Pin Jumper Header
1	DC1	B31215S	Bothand 2W Dual Output DC Converter
1	FB	n/a	Radial Axial Ferrite Bead
1	FIL1-2	5085	15kHz Block Filter- Separate board
1	Heatsink	TO5	TO5 Heatsink - Height 12.7mm (Aavid Thermalloy 5F)
1	IC Holders (14 pin) IC19,	14 pin	IC Holder - Dual wipe contacts - eg Eurocon TS1001-xx
4	IC Holders (16 pin) IC18, IC12, IC5, IC21	16 pin	IC Holder - Dual wipe contacts - eg Eurocon TS1001-xx
2	IC Holders (18 pin) IC13, IC17	18 pin	IC Holder - Dual wipe contacts - eg Eurocon TS1001-xx
14	IC Holders (8 pin) IC1, IC2, IC3, IC4, IC6, IC7, IC8, IC9, IC10, IC11, IC14, IC15, IC16, IC20	8 pin	IC Holder - Dual wipe contacts - eg Eurocon TS1001-xx
12	J1-12	3 pin	3 Pin Jumper Header - (2.54mm 3-Way Row)
12	J1-12 LINKS	n/a	Jumper Link 2.54mm - Protech 'Easy Pull' Style
1	RFT1	1 Turn	1 Complete Turn Ferrite Core
4	SW1-4	Dec Rota	Decimal Rotary PCB Switches
1	X1	4.864Mhz	HC49 Micro Crystal
1	X2	8.000MHZ	HC49 Micro Crystal
1	RFT1 Wire	28Gauge Twist	Approx 3cm lengh per coil- 28 Guage Self fluxing wire
1	R126	330uH	Axial Inductor
7	R1, R2, R3, R4, R5, R6, R9	10K	1/8 Watt Carbon Film - Tolerance +- 5%
1	R10	470R	1/8 Watt Carbon Film - Tolerance +- 5%
1	R100	1M	1/4 Watt Metal Oxide - Tolerance +- 1%
10	R101, R110, R112, R113, R114, R115, R116, R117, R118, R119	10K	1/4 Watt Metal Oxide - Tolerance +- 1%
3	R103, R47, R68	5K1	1/4 Watt Metal Oxide - Tolerance +- 1%
1	R106	3K6	1/4 Watt Metal Oxide - Tolerance +- 1%
1	R107	12K	1/4 Watt Metal Oxide - Tolerance +- 1%
1	R11	33K	1/8 Watt Carbon Film - Tolerance +- 5%
9	R12, R13, R17, R32, R33, R34, R35, R36, R37	1K2	1/8 Watt Carbon Film - Tolerance +- 5%
2	R22, R23	1K2	1/4 Watt Metal Oxide - Tolerance +- 1%
2	R15, R16	680R	1/8 Watt Carbon Film - Tolerance +- 5%
1	R18	100R	0.4 Watt Carbon Film - Tolerance Low Noise
1	R105	100R	1/4 Watt Metal Oxide - Tolerance +- 1%
1	R19	12K	1/4 Watt Metal Oxide - Tolerance +- 1%
3	R20, R26, R29	4K7	1/4 Watt Metal Oxide - Tolerance +- 1%
3	R21, R57, R78	220R	1/4 Watt Metal Oxide - Tolerance +- 1%
1	R30	220R	1/8 Watt Carbon Film - Tolerance +- 5%
1	R24	68R	1/4 Watt Metal Oxide - Tolerance +- 1%
1	R25	300R	1/4 Watt Metal Oxide - Tolerance +- 1%
2	R28, R132	22R	1/4 Watt Metal Oxide - Tolerance +- 1%
1	R31	4R7	1/4 Watt Metal Oxide - Tolerance +- 1%
1	R39	2k2	1/4 Watt Metal Oxide - Tolerance +- 1%

8	R40, R45, R51, R65, R71, R94, R98, R125	1k	1/4 Watt Metal Oxide - Tolerance +- 1%
1	R41	560R	1/4 Watt Metal Oxide - Tolerance +- 1%
1	R42	820R	1/4 Watt Metal Oxide - Tolerance +- 1%
3	R43, R108, R121	75R	1/4 Watt Metal Oxide - Tolerance +- 1%
9	R44, R54, R60, R66, R76, R79, R86, R91, R96	12K	1/4 Watt Metal Oxide - Tolerance +- 1%
2	R61, R62	7K5	1/4 Watt Metal Oxide - Tolerance +- 1%
10	R48, R49, R55, R56, R58, R73, R74, R75, R77, R102	24K	1/4 Watt Metal Oxide - Tolerance +- 1%
4	R27, R50, R85, R72	470R	1/4 Watt Metal Oxide - Tolerance +- 1%
3	R59, R97, R104	3K3	1/4 Watt Metal Oxide - Tolerance +- 1%
2	R52, R70	WLNK - 0/Ohms	WLNK - Wire Link across pads (use other resistor legs)
2	R53, R69	100K	1/4 Watt Metal Oxide - Tolerance +- 1%
2	R63, R64	16K	1/4 Watt Metal Oxide - Tolerance +- 1%
3	R7, R8, R14	330K	1/8 Watt Carbon Film - Tolerance +- 5%
2	R80, R81	470K	1/4 Watt Metal Oxide - Tolerance +- 1%
3	R83, R88, R99	6K8	1/4 Watt Metal Oxide - Tolerance +- 1%
5	R38, R84, R89, R120, R131	10R	1/4 Watt Metal Oxide - Tolerance +- 1%
2	R82, R87	13K	1/4 Watt Metal Oxide - Tolerance +- 1%
1	R90	5K6	1/4 Watt Metal Oxide - Tolerance +- 1%
4	R92, R111, R46, R67	47K	1/4 Watt Metal Oxide - Tolerance +- 1%
2	R93, R109	120K	1/4 Watt Metal Oxide - Tolerance +- 1%
1	R95	4K3	1/4 Watt Metal Oxide - Tolerance +- 1%
1	R128	51R	1/4 Watt Metal Oxide - Tolerance +- 1%
2	R129, R130	4k7	1/4 Watt Metal Oxide - Tolerance +- 1%
3	R133, R134	470R	0.6 Watt Metal Oxide - Tolerance +- 1%
3	VR1,VR2,VR5	10K	Horizontal Multiturn (Bourns 3006P Series)
2	VR3,VR4	1K	Vertical Multiturn (Bourns 3296W Series - Top screw adjustment)
1	VR6	10K	Vertical 5mm Pitch (Spectrol 63M Series - Top screw adjustment)
1	VR7	200R	Vertical 5mm Pitch 63M - Top screw adjustment)
2	R122, R123	1k	1/8 Watt Carbon Film - Tolerance +- 5%
1	R127	180R	1/8 Watt Carbon Film - Tolerance +- 5%
1	R124	1K3	1/4 Watt Metal Oxide - Tolerance +- 1%
6	IC1, IC4, IC10, IC11, IC14, IC15	TL071	Low Noise Op Amp
1	IC12	DG201-HS (HI3) HI3-0201HS-5Z	Analog Switch
1	IC13	PIC16C620A-04P	8 Bit Microcontroller
1	IC17	PIC16CE624-20P	8 Bit Microcontroller
1	IC18	MC145170-P **	PLL Synthesiser
1	IC19	4066	Analog Switch
7	IC2, IC3, IC6, IC7, IC8, IC9, IC16	TL072	Low Noise Dual Op Amp
1	IC20	LF351	Bi-FET Op Amp
1	IC5	LM13700N	Transconductance Amplifier
1	IC21	ST232CN	ST232CN RS232 TRANSCIEVER
1	REG1	7815	1A TO220 15V Linear Regulator
1	REG2	7805	1A TO220 5V Linear Regulator
2	T1,T2	BC327 (C3271)	BC327-16 TO92 50V PNP GP TRANSIST
4	T3,T4,T5,T6	MPSH10	High Speed Switching Transistor
1	T11	ZVN4306A	Zetec Transistor
1	T7	2N4427	High Speed Switching Transistor APT
3	T8,T9,T10	BC337 (C3371)	C337-16 TO92 50V NPN GP TRANS

### 3.62 LCD control board

Qty	Reference	Value	Description
4	C1, C2, C13, C18	2.2uF	63V Electrolytic Cap
2	C12, C15	100n	2.5mm Pitch Radial Multilayer Ceramic ( Y5V )
2	C3, C4	33pF	33pF Ceramic 2.5mm Pitch
10	C5, C6, C7, C8, C9, C10, C11, C14, C16, C17	560pF	560pF Ceramic
1	D1	1N4148	1N4148
1	LED1	3mm	Mini 3mm Green LED - L-7104GD
1	LED2	3mm	Mini 3mm Red LED - L-7104GD
3	R1, R2, R16	33k	1/8 W Metal Film 1% - CR12
3	R12, R13, R14	1k8	1/8 W Metal Film 1% - CR12
4	R15, R18, R20, R22	100R	1/8 W Metal Film 1% - CR12
1	R17	560R	1/8 W Metal Film 1% - CR12
1	R19	100k	1/8 W Metal Film 1% - CR12
6	R3, R7, R8, R9, R10, R11	820R	1/8 W Metal Film 1% - CR12
2	R4, R5	390R	1/8 W Metal Film 1% - CR12
1	R6	10k	1/8 W Metal Film 1% - CR12
1	R21	4k7	1/8 W Metal Film 1% - CR12
1	R23, R24	4R7	1/8 W Metal Film 1% - CR12
1	R25	1K	1/8 W Metal Film 1% - CR12
1	VR3	200R	Bourns 3296 W 3/8in
1	VR1	500R	Bourns Minipot
1	VR2	100k	Minipot Spectrol 63M
1	Reg1	7805	7805CV 1A VOLTAGE REGULATOR
1	IC1	40 Pin	40 Pin PIC16F877-20P (NOT FITTED)
1	IC2	CA3240EZ	CA3240 Op Amp
0	IC3	TBA	NOT FITTED
3	SW1-3	9.5mm	9mm Tactile Switch
1	X1	8MHz	8MHz Crystal
1	Connector	20-Way	Header Strip (20-Way)
1	LCD Screen	LCD	Blue LCD Display
1	IC1	40-Pin	40 Pin IC Socket
2	IC2,IC3	8-Pin	8-Pin IC Socket
3	Panel Buttons	n/a	Molded Cap for Switch (NOT FITTED)
1	Con1	10-Way	10 Way Boxed Header
1	Con2	16-Way	16 Way Boxed Header

### 3.63 Power amplifier board

Qty	Reference	Value	Description
1	C1	100uF	63V Electrolytic - Radial Electrolytic - 10mm Dia, 12mmH, 5mm Pitch
1	C2	100nF	General Purpose Ceramic Disc - 5mm pitch
12	C3, C8, C10, C13, C14, C15, C16, C25, C26, C27, C28, C29	10nF	General Purpose Ceramic Disc - 2.5mm pitch
2	C4, C5	470uF	35v Electrolytic - Radial Electrolytic 10mm Dia, 17mm H, 5mm pitch
1	C6	330pF	General Purpose Ceramic Disc - 2.5mm pitch
3	C7, C30, C31	1uF	63V Polyester Cap
2	C9, C24	33pF	General Purpose Ceramic Disc - 2.5mm pitch
1	C12	1p8	(680) Ceramic Disc - 5mm pitch
2	C17, C18	12pF	General Purpose Ceramic Disc - 2.5mm pitch
1	C19	10pF	General Purpose Ceramic Disc - 2.5mm pitch
1	C20	22pF	General Purpose Ceramic Disc - 2.5mm pitch
1	C21	18pF	(680) Ceramic Disc - 2.5mm pitch
1	C11	18pf	(680) Ceramic Disc - 5mm pitch
2	C22, C23	15pF	General Purpose Ceramic Disc - 2.5mm pitch
0	C32	47pF	(680) Ceramic Disc - 2.5mm pitch NOT FITTED
1	D2	1N4001	1N4001 1A 50V SILICON RECTIFIER DIODE
1	D1	UF5401	3A Ultra Fast Recovery Diode
2	D3, D4	BAT 42	Signal Diode
4	L1, L3, L4, L5	2.5t S18	2.5t Toko Clone S18
1	L2	0.33uH	Axial Inductor
1	L6	220uH	220uH 0.7A Choke
1	FB	Radial	Radial Ferrite Bead
1	R1	51R	1/4W Metal Film Resistor
1	R2	1k8	1/4W Metal Film Resistor
4	R3, R5, R10, R11	100k	1/4W Metal Film Resistor
1	R4	16k	1/4W Metal Film Resistor
2	R6, R7	22R	1/4W Metal Film Resistor
5	R8, R12, R16, R19, R27	10k	1/4W Metal Film Resistor
1	R9	200R	1/4W Metal Film Resistor
1	R13	10R	1/4W Metal Film Resistor
1	R14	5k6	1/4W Metal Film Resistor
1	R15	22k	1/4W Metal Film Resistor
1	R17	18k	1/4W Metal Film Resistor
1	R18	24k	1/4W Metal Film Resistor
1	R20	6k8	1/4W Metal Film Resistor
1	R21	560R	1/4W Metal Film Resistor
1	R22	22k	1/4W Metal Film Resistor (30k best for 10K pot) NOT FITTED
1	R23	200R	1/4W Metal Film Resistor
1	R24	4R7	2W Resistor
1	R25	12R	1/4W Metal Film Resistor
1	R26	160k	1/4W Metal Film Resistor
1	VR1	10k	3/8in single turn cermet potentiometers 63M
1	VR2	10k	4mm SMT Trimmer Resistor
0	R26	2K	1/4W Metal Film Resistor- Runs on underside of board
2	IC1, IC2	CA3240EZ	Op-Amp
1	T1	VN66AFD	FET
1	TS1	LM335Z	Temp Sensor
1	REG1	LM2575T-ADJ	Adjustable switcher voltage reg
1	REG2	L7818CV	L7818CV Voltage Regulator
1	Heatsink	Aavid Thermalloy	Heatsink for TO220 Package

2	ICH1, ICH2	8 Pin IC Holder	8 Pin IC Holder
1	Con1	2-Way	2-way screwless terminal 45deg conn
1	Con2	10-Way	10-Way IDC Header
3	Con3, Con4, Con5	MCX	MCX PCB Mount Connector
1	RFT1	Ferrite Core TFR	Yellow/Red Ferrite Core S37-8/90
1	RFT1	Scientific Wire	Self Fluxing Enamelled Copper Wire
1	RFT1	Semi Rigid Coax	50Ohm Semi-Rigid Coax EZ50-.090 - 28mm
1	INS	Ceramic Insulator	Ceramic insulator
1	MOD	2n2	R23 to ground

