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FMX10+ Manual

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Safety note

This equipment uses high voltages internally. Any servicing should be performed by competent individuals.

Prolonged exposure to high level RF radiation has been shown to pose a health risk. Whilst the equipment is intrinsically safe, its use in conjunction with an antenna system may generate large RF fields. Appropriate precautions should be taken by individuals that habitually work close to the transmitting antenna.

The RF power devices of this equipment employ Beryllium Oxide. This substance is extremely toxic if pulverised. On no account should any RF power devices be smashed. Please refer to attached Material Safety Data Sheet for further information.

WARNING

THIS EQUIPMENT IS SUPPLIED WITH A MAINS LEAD INCORPORATING AN EARTH WIRE. IT IS IMPERATIVE THAT THIS EQUIPMENT IS CONNECTED TO A MAINS OUTLET THAT HAS AN EARTH. IN COUNTRIES WHERE EARTHED OUTLETS ARE NOT MANDATORY, IT IS THE CUSTOMER'S RESPONSIBILITY TO ENSURE THAT THIS EQUIPMENT IS APPROPRIATELY EARTHED.

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1 GENERAL DESCRIPTION

The FMX10+ is a high quality 10W-exciter intended for audio broadcast service in the FM band.

Its features include:

- Frequency agile.
- Extensive self test and auto diagnostics.
- Rugged design.
- Conservatively rated.
- Excellent audio quality
- Comprehensive telemetry.

Applications include low power broadcast, narrowcast, community broadcast, rebroadcast for tunnels, student radio stations and as a driver for high power transmitters.

The FMX10+ is designed and built in Australia.

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2 UNPACKING

This section details the way in which the FMX10+ should be unpacked upon receipt by the customer.

The FMX10+ should be removed from its packing, and the packing stored and used should it be necessary to return the FMX10+ to the manufacturer.

Along with the exciter, the following items should also be present:

- This manual
- Audio lead
- Telemetry cable (if ordered)

The customer should ensure that all items are present and then store them in a safe place.

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3 INSTALLATION

3.1 General

This section describes the installation and infrastructure requirements for the FMX10+. Departure from the instructions contained herein may void any warranty provided by SRK.

The FMX10+ is designed to be used with the fins of the rear heatsink vertical.

3.2 Environmental

The exciter is intended for indoor use. The exciter should be protected from rainfall and direct sunlight, extremes of temperature and humidity and from conditions of high dust levels. The exciter shall not be operated at altitudes in excess of 3500m above sea level. The exciter must be installed on a flat, stable surface. The exciter must be installed in the upright position. The exciter must be installed in a location free from vermin and the ingress of other animals. The exciter shall not be installed in locations prone to flooding.

3.3 Electrical supply

The electrical supply to the exciter must be of the voltage, form and frequency described in the specifications. All electrical wiring must be carried out in accordance with local laws, standards and regulations. If power supply voltages regularly fall outside specifications then a voltage regulator must be installed between the supply inlet and the exciter.

3.4 Antenna

The antenna load connected to the exciter must be tuned to minimise reflections. Whilst the exciter is designed to withstand high levels of reflection for short periods, continually high levels of reflected power will degrade the long term reliability of the exciter. Operating SWR should be kept to below 1.9:1.

3.5 Audio feed

In situations where the audio feed to the exciter is over any form of land line, suitable protection must be included external to the exciter to ensure voltage transients do not enter the exciter. These may be in the form of high power zener diodes and/or gas discharge tubes.

Where the exciter is co-sited with an AM installation, suitable filtering must be included in the audio feed to ensure that excessive RF voltages do not enter the exciter.

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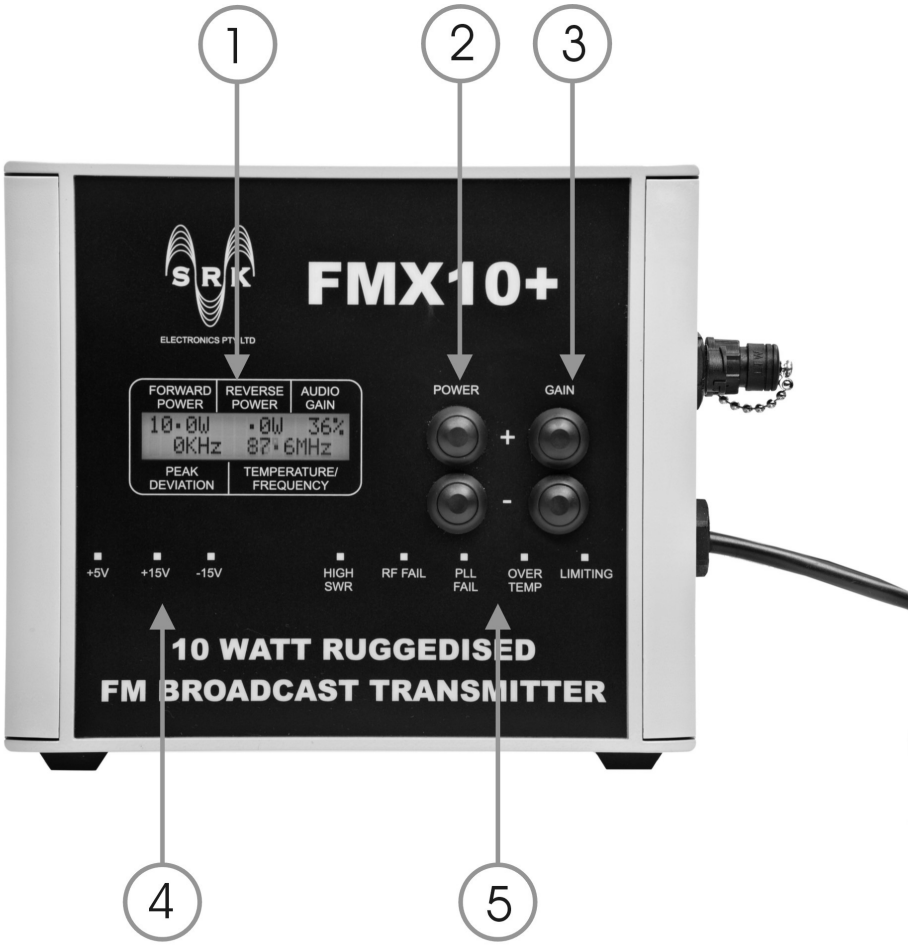

FIG 4.1 Front Panel

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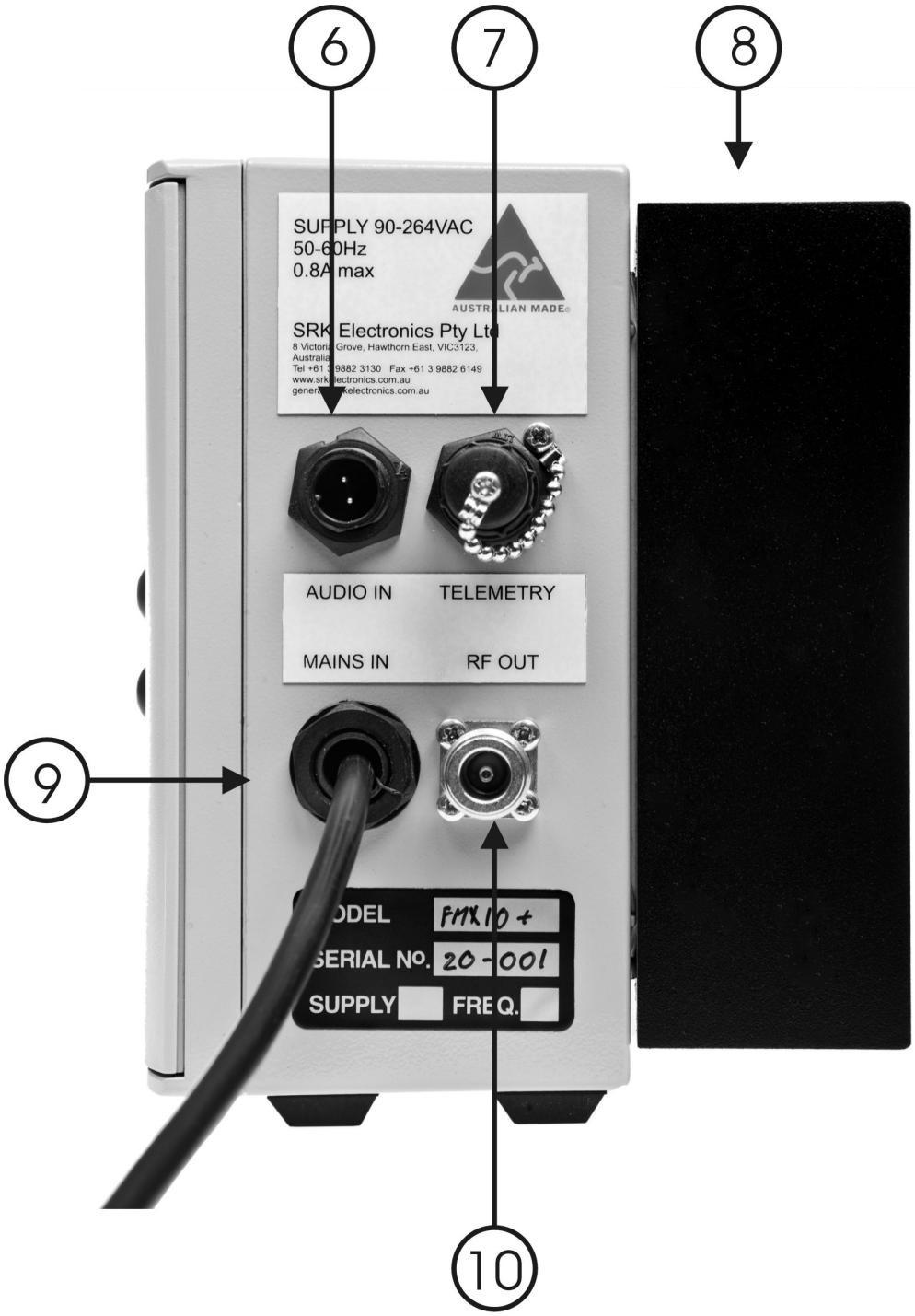

Fig 4.2 Side Panel

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4 OPERATION

4.1 Front Panel

Please refer to figure 4.1. The numbers of the following paragraphs refer to the controls shown in figure 4.1.

1 LCD.
Displays the forward and reflected power, peak deviation, audio gain, channel frequency and internal temperature.

2. Power increase/decrease buttons
Pressing these buttons increases or decreases to output power.

3. Gain increase/decrease buttons.
Pressing these buttons increases or decreases the audio gain and hence peak deviation.

4. Power Supply status lamps
These lamps light to show that the internal voltages are correct.

5. Alarm indicators.
These light red if the transmitters protection functions are tripped.

4.2 Side panel.

Please refer to figure 4.2. The numbers of the following paragraphs refer to the controls shown in figure 4.2.

6. Audio in connector.
This mates with the cable supplied. The other end of the cable is an RCA socket (or BNC plug). Input impedance >10K.

7. Telemetry connector.
This mates with the telemetry cable (if supplied). Otherwise keep dust cover in place. When used allows the transmitter to be controlled and monitored remotely. See the section on remote control for more details.

8. Heatsink.
This is the main means by which the transmitter keeps itself cool. The transmitter should always be operated with the fins vertically and at least 300mm from any other object, other than the surface on which it is placed.

9. Mains input.
This is the mains input and must be connected to an earthed outlet. The mains voltage can be any value in the range 90 to 264V.

10. RF out.
This connects to the antenna or amplifier via a male N type plug.

4.3 Switching on and off

The FMX10+ will turn on whenever mains voltage is present at the mains connector. The voltage indicator lights should come on, as well as the LCD backlight.

The “PLL FAILURE” lamp may light for a few seconds. This is normal and indicates that the PLL has yet to attain lock. After a few seconds the LCD should show something like the following:

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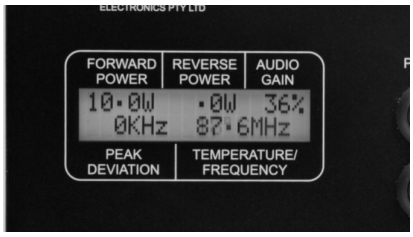


The FMX10+ is now in operative mode. The user may set the unit's parameters by either the front panel or remote control.

The FMX10+ may be switched off at any time by switching off the mains power.

4.4 Setting output power

The RF output power of the FMX10+ may be read by reading the first value on the top line of the LCD.

Pressing the power + and – buttons will increase or decrease the power respectively.

The power setting is recorded in non-volatile RAM, so it is not necessary to set the power level each time the FMX10+ is switched on.

The reverse output power is indicated by the second figure.

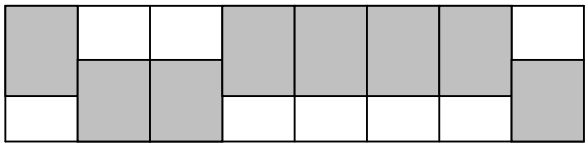
4.5 Setting Channel Frequency

The FMX10+ is frequency agile and may be set to any 100KHz channel in the range 87.5MHz to 108.0MHz. This can be done by setting the eight internal jumpers on the main PCB, marked JP2, or using the "CF=" command via the telemetry link.

The lid of the FMX10+ must be removed to allow access to these jumpers.

To set the frequency using telemetry, all 8 of the jumpers that make up JP2 must be in the "ON" position. The "CF=" command can then be sent to set the frequency. See section 4.8 for more specific information regarding the use of telemetry.

Alternatively, the jumpers may be used to set the frequency, which also disables the "CF=" command. Each of the eight jumpers may be in one of two positions, designated binary "0" or "OFF" and "1" or "ON", as indicated below. Furthermore each jumper represents a single bit of an eight bit number, using conventional binary weighting (ie, 1, 2, 4, 8 etc). Thus the settings of these jumpers can define any number between 0 and 255 decimal.



ON, binary "1"

OFF Binary "0"

128	64	32	16	8	4	2	1

weighting (in 100s of KHz)

In the example above, the number represented by the jumpers is 158 (2+4+8+16+128).

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This number determines the operating frequency of the FMX10+, where 0 equates to 87.5MHz and 205 equates to 108.0MHz. Thus in the example above the operating frequency is set to 103.3MHz (158 x 100KHz + 87.5MHz).

To work out the number for any given frequency (in increments of 100KHz), take the desired frequency in MHz, subtract 87.5 and multiply by ten. This number, when converted to eight bit binary, will define each of the eight jumper positions.

Note that the FMX10+ must be powered down then up again after each new set of jumper positions is arranged, otherwise all changes are ignored by the FMX10+.

Note also that any attempt to set a channel frequency higher than 108.0MHz will result in the FMX10+ displaying the error message “Invalid Channel”. Under this condition, no RF is generated and the jumpers must be set correctly before the unit will function. The exception to this is the value 255, which enables frequency setting by telemetry.

4.6 Setting audio gain

The audio gain of the FMX10+ may be set between 0 and 100%. Gain increments are 1%.

The actual deviation is a function of the audio input level and the audio gain and can be measured by reading the peak deviation shown on the LCD above “Peak Deviation”.

Pressing the gain + and – buttons will increase or decrease the gain respectively.

Upon installation, the exciter should be driven with program audio at the normal level, and the audio gain adjusted to give an approximate peak deviation reading of 75KHz.

The audio gain is stored in non-volatile RAM, so it is not necessary to set the gain each time the FMX10+ is switched on.

4.7 Protection

The FMX10+ incorporates a number of protective features that make it extremely rugged.

If the reflected power from the antenna exceeds 1W then the output RF power will be automatically reduced to bring the reflected power back to 1W. Under this condition the FMX10+ will continue to function, albeit at a reduced output power, indefinitely until the reflected power reduces. The “HIGH SWR” lamp will light.

If the temperature of the RF amplifier becomes excessive, then the RF output power will be reduced to zero until the amplifier temperature falls to an acceptable level. During this time the OVER TEMP light will come on.

If the RF output power cannot be made to equal the value demanded by the microprocessor then the “RF FAIL” light will come on.

If the PLL fails to lock or falls out of lock the PLL FAIL light will come on and the RF power will be reduced to zero.

All these protective features are self resetting once the cause of the fault has been removed.

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4.8 Remote operation.

The FMX10+ may be monitored and controlled remotely via the "TELEMETRY" connector on the side of the unit. This is an RS232 standard connection with the following characteristics:

Baud rate: 9600
Data bits: 8
Parity: NONE
Stop bits: 1
Flow control: NONE

The pinout for the DB9 connector is as follows: pin 2, transmit data, pin 3, receive data, pin 5, common (0V). All other pins are not connected.

The FMX10+ responds to the following commands. <CR> indicates the ASCII character 0D hex. All letters are upper case, spaces (20 hex) are indicated by "_". All commands must be terminated by <CR>. Note that a line feed (0A hex) must not be sent before or after <CR>. After a response is sent, a carriage return, line feed and ">" are sent.

FP?<CR>
Returns forward power in the form XX.XW<LF><CR>>. For example:

FP?<CR> (command)
10.0W<LF><CR> (response from exciter)
>

Note that the leading zeros are replaced with a space (or spaces).

RP?<CR>
Returns reflected power in the form XX.XW<LF><CR>>. For example:

RP?<CR> (command)
__.0W<LF><CR> (response from exciter)
>

Note that the leading zeros are replaced with a space (or spaces).

CF?<CR>
Returns channel frequency in the form XXX.XMHz<LF><CR>>. For example:

CF?<CR> (command)
_98.7MHz<LF><CR> (response from exciter)
>

Note that for frequencies of 99.9MHz and below, the leading zero is replaced with a space.

PD?<CR>
Returns the measured peak deviation in the form XXXKHz<LF><CR>>. For example:

PD?<CR> (command)
_45KHz<LF><CR> (response from exciter)
>

Note that any leading zeros are set to spaces, except for the special case of `0KHz`.

AG?<CR>
Returns the current audio gain in the form XXX%<LF><CR>>. For example:

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AG?<CR> (command)
_92%<LF><CR> (response from exciter)
>

Note that the leading zero is set to spaces, except for the special case of 09%.and below.

AT?<CR>
Returns the current amplifier temperature in the form XXC<LF><CR>>. For example:

AG?<CR> (command)
32C<LF><CR> (response from exciter)
>

ST?<CR>
Returns the current self test status in the form XXXX<LF><CR>>, where X can be either 0 or 1. A 1 indicates a failure, a 0 indicates a pass. The first byte indicates the locked/unlocked status of the PLL, the second indicates an RF failure, the third indicates a high SWR condition and the fourth indicates an over temperature condition. For further information consult the section on self test. For example:

ST?<CR> (command)
0010<LF><CR> (response from exciter indicating an RF failure condition)
>
or
0000<LF><CR> (response from exciter indicating no failures)
>

FP=XX.X<CR>
Allows the forward power to be set to the value XX.X, up to 10.0W. Valid range for XX.X is 00.0 to 10.0. For example:

FP=07.6<CR> (command, sets forward power to 7.6W))
Ok<LF><CR> (response from exciter indicating that command has been executed)
>

CF=XXX.X<CR>
Allows the channel frequency to be set to the value XXX.X. Valid range for XXX.X is 087.5 to 108.0. For example:

CF=097.4<CR> (command, sets channel frequency to 97.4MHz)
Ok<LF><CR> (response from exciter indicating that command has been executed)
>

AG=XX<CR>
Allows the audio gain to be set to the value XX. Valid range for XX is 00 to 99. For example:

AG=67<CR> (command, sets audio gain to 67%)
Ok<LF><CR> (response from exciter indicating that command has been executed)
>

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FE<CR>
Unlocks the front panel to allow parameters to be altered locally. For example:

FE<CR> (command to enable the front panel)
Ok<LF><CR> (response from exciter indicating that command has been executed)
>

FD<CR>
Locks front panel. Parameters can be measured but not changed locally. For example:

FD<CR> (command to disable front panel)
Ok<LF><CR> (response from exciter indicating that command has been executed)
>

HP?<CR>
Returns a summery of the above commands.

Any data received by the exciter, other than the commands listed above will generate the following error string:

Invalid_command.__Send_HP?(CR)_for_command_syntax.<LF><CR>
>

Any data outside the valid range for the parameter concerned will generate the following error string:

Incorrect_value_or_syntax.__Send HP?(CR)_for_help.<LF><CR>
>

Should it be necessary to make connection to the telemetry port using cables running external to the building housing the FMX10+, it is recommended that external filtering and transient protection be installed on these lines.

4.9 Audio limiter

The audio processor incorporates hard peak limiters. These are factory preset to limit the audio channel to a peak deviation of 75KHz. Whilst operational, the LIMITING lamp will light. Depending upon the quality of the compression applied to the audio, this lamp may be lit most of the time without any noticeable distortion.

In practice the user should increase the audio drive level until distortion just becomes noticeable, then reduce the gain slightly. The operation of the peak limiters will ensure that no adjacent channel interference is generated.

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5 MAINTENANCE

5.1 Recommended maintenance schedule

The FMX10+ will give many years of trouble free service with little or no attention

The heatsink fins should be kept free of any dust or other foreign objects that could impair its operation.

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6 CIRCUIT DESCRIPTION

6.1 Equipment Overview

The FMX10+ consists of the following sub-assemblies:

- Main Board
- Amplifier board
- Power Supply board
- +28V SMPSU

These assemblies are interconnected as per “FMX10+ wiring diagram”.

The Power Supply Board takes a nominal 28V from the SMPSU and generates +/-15V and 5V for the main board.

The main board takes in audio and generates a low power RF signal to drive the amplifier. All control, protection and communication functions are handled by the main board.

The RF power amplifier takes the low level RF output of the PLL and amplifies it up to a nominal 10W, with gain controlled by the front panel.

The SMPSU generates a nominal 28V from the incoming mains.

6.2 Power Supply board.

This board generates the auxiliary power supply voltages for the transmitter Please refer to the appropriate schematic.

+28V is generated off-board by the switched mode power supply unit (SMPSU) and supplies the linear regulators (U1 and U2). These generate +15V and +5V.

-15V is generated by the DC-DC converter (U2).

All these power supply voltages are passed to the main board by connector J1.

6.3 Main Board

The main board has most of the functionality of the transmitter.

Audio enters the board on J1. This is filtered by Z1 to ensure no RF enters the board.

Transient protection is provided by D5, D6 and R45.

A digitally controlled variable gain amplifier is formed by U13 and U9B. U13 is a four-quadrant multiplying DAC. The control bits are set by the microprocessor in accordance with the audio gain setting. U14, Q3 and R44 provide level shifting.

U15 allows the microprocessor to output serial data, which is then converted to eight bit parallel. This cuts down on the number of digital lines that must be routed around the board.

U9A has a feedback network formed by R58, R56 and C40 which provides pre-emphasis at a time constant of 50uS.

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U3, U4 and associated circuitry form a hard peak clipper. This circuit has VR1 to set the peak deviation to 75KHz. U6 monitors the clipper and triggers U8 when a limit occurs. U8 lengthens this pulse to about 100mS and then drives the “LIMIT” LED to give a clear indication that limiting is occurring.

The output of the limiter is passed through a 15KHz low pass filter formed by U1. This is configured as a Bessel response to give minimal distortion due to overshoot.

The output of the filter is then passed onto the voltage controlled oscillator (U16), which part of the PLL circuit..

The PLL is the heart of the FMX10+ and is responsible for generating and modulating the RF carrier. The careful design and construction of this circuit ensures excellent audio performance.

The majority of the PLL function is performed by U17. This contains phase detectors, programmable feedback and reference dividers, and serial interface. This device is programmed by the microprocessor via the three digital lines. These lines are filtered to ensure fast edges from the microprocessor do not enter the PLL.

The reference oscillator is generated from the microprocessor and runs at 100KHz which is internally divided down to 20KHz by U17. The reference frequency is compared to the output RF frequency via the programmable divider in U17, by the phase comparator in U17. The output error signal is filtered by C57-60 and R27, 72 and 68 and buffered by U10A. U10A is configured with a DC gain of +2.5. This allows the VCO to achieve its full tuning range. The error voltage is then passed into the tuning voltage terminal of U16, an extremely stable, low noise, VCO.

The power supply for the VCO is smoothed and filtered by Q4 to ensure the lowest possible phase noise.

The RF output of the VCO is fed to the output via a small resistive pad to mitigate frequency pulling, and a small amount is sampled by U17 for its feedback loop.

The audio modulation is also applied to the VCO input via R73, C63 and R67. The loop cutoff frequency is below the lowest frequency of modulation, in this way FM is achieved.

U17 generates a status signal to indicate the locked condition. This is monitored by the microprocessor. Thus the microprocessor can detect the most likely form of PLL failure. If the PLL fails to lock due to a fault, the microprocessor sets the RF output power to zero to ensure that no damage occurs to the RF amplifier when driving tuned loads (such as an antenna).

The audio modulation signal is amplified by U10B and peak detected by U18. This thus gives a DC voltage proportional to peak carrier signal. This is fed to the microprocessor for the deviation display.

Presence of +5V, +15V and -15V is indicated by LEDs D20-22, mounted on the board. This is intended as a diagnostics aid.

The LCD on the front panel is fitted with a back lighting LED. This is supplied with a constant 200mA nominal current by R66/65.

The directional coupler connected in the main RF output path generates two DC voltages proportional to the square of the forward and reflected output RF power. These voltages enter the board on J6. Both voltages are amplified by U2C and D. The gain of these amplifiers is adjusted to ensure that 10W on the RF output generates 5V on outputs of the amplifiers. Both the forward and reverse voltages are passed to the microprocessor.

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The reverse voltage is also passed to the inverting input of U2B. This continually monitors the level of reverse power and compares it with a reference generated by VR4. Should the level of reverse power exceed about 1W, then U2B proportionally reduces the forward power to bring the reverse power back within limits. In this way, seamless and smooth over SWR protection is achieved. U7B monitors the status of U2B and generates a digital low signal for the microprocessor should the over SWR condition eventuate.

Forward power is controlled by the loop formed by U2A. The control input is driven by a DC voltage generated by the microprocessor. This is compared to the DC voltage representing the forward power. The output of U2A is used to control the gate voltage of the driver MOSFET in the RF power amplifier.

This control voltage is passed to U7A. This constantly compares the control loop status and generates a digital low signal for the microprocessor should the output RF level fall below the reference. In this way, RF output failure may be detected by the microprocessor.

The digital section of the main board contains the microprocessor. This has a number of control and metering functions.

The LCD is controlled via J5. This is an 8 bit parallel interface.

The desired channel is read in at power up on the same interface when the signal READ_CHANNEL goes low. This signal is only asserted at power up, so and changes to the frequency settings will only take affect after a power off-on cycle.

LCD contrast is set by VR3.

The push buttons are read when the signal READ_PB goes low. This is performed by the microprocessor every few milliseconds.

The desired forward power is determined by the duty cycle of the PWM signal on pin 18 of the microprocessor. This is filtered by U11. The output of U11 is a voltage proportional to the square root of the demanded RF power, where 5V represents 10W. This voltage is passed to the forward power control loop as previously described.

Telemetry is provided by a UART in the microprocessor. U20 is a TTL to RS232 transceiver.

6.4 RF Power Amplifier

The RF power amplifier takes the low level RF output from the PLL and amplifies it up to in excess of 10W. Please refer to the appropriate diagram.

RF enters the amplifier on J2. C16 provides DC isolation. L6 in conjunction with the input capacitance of Q2 forms an impedance match into the gate of Q2. Bias for Q2 is provided by VR2, and filtered by R7,8 and 14 and C10/C14.

Power control is implemented by sinking current from the bias circuit via D3.

Impedance matching between the drain of Q2 and the gate of Q1 is performed by the transformer T2

Q1 generates in excess of 10W. Bias is provided by VR1. The output from Q1 is passed to the output filter to remove harmonics.

The output filter removes the harmonics from the RF coming from the amplifier. There is also a directional coupler which allows the forward and reflected output power to be monitored.

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The filter is formed by a 14 pole Chebishev filter that provides at least 50dB of attenuation at 175MHz (87.5MHz second harmonic).

The directional coupler consists of two 50Ω micro-strip lines. Both incident and reflected voltage is rectified and filtered, then passed to the main board.

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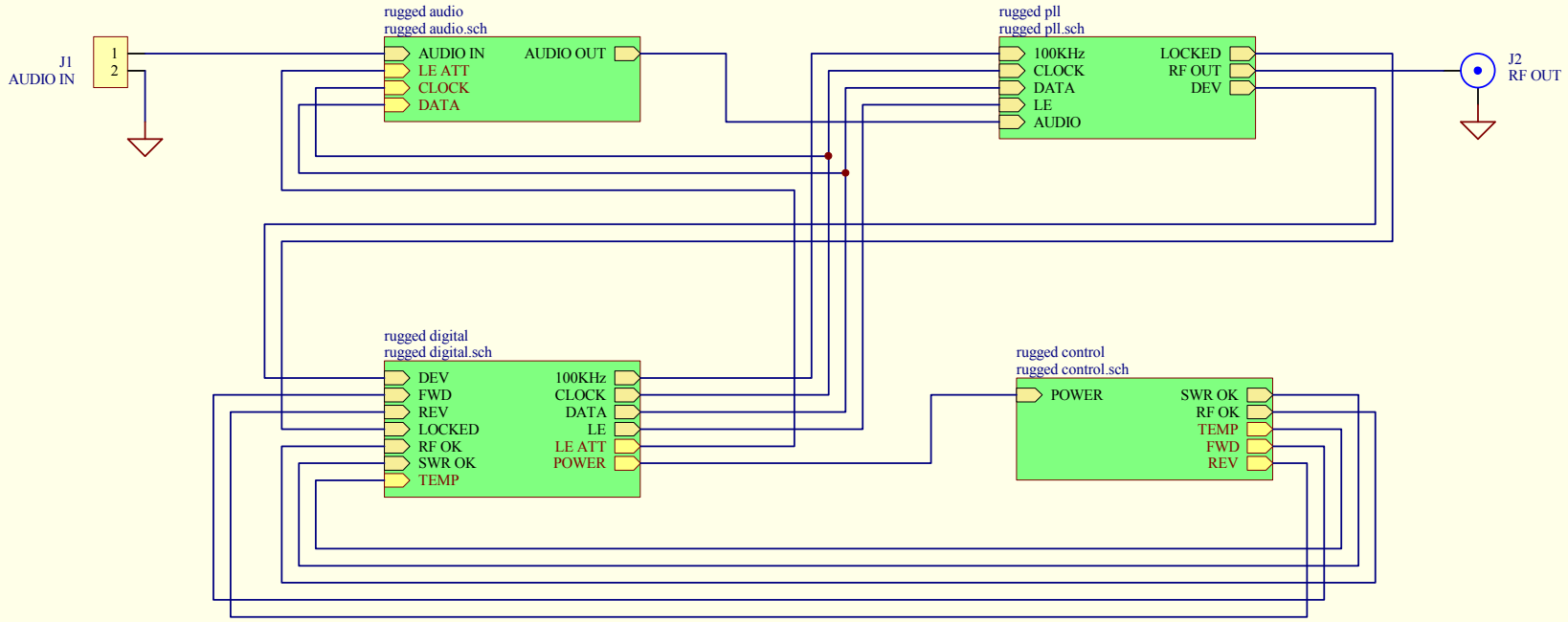

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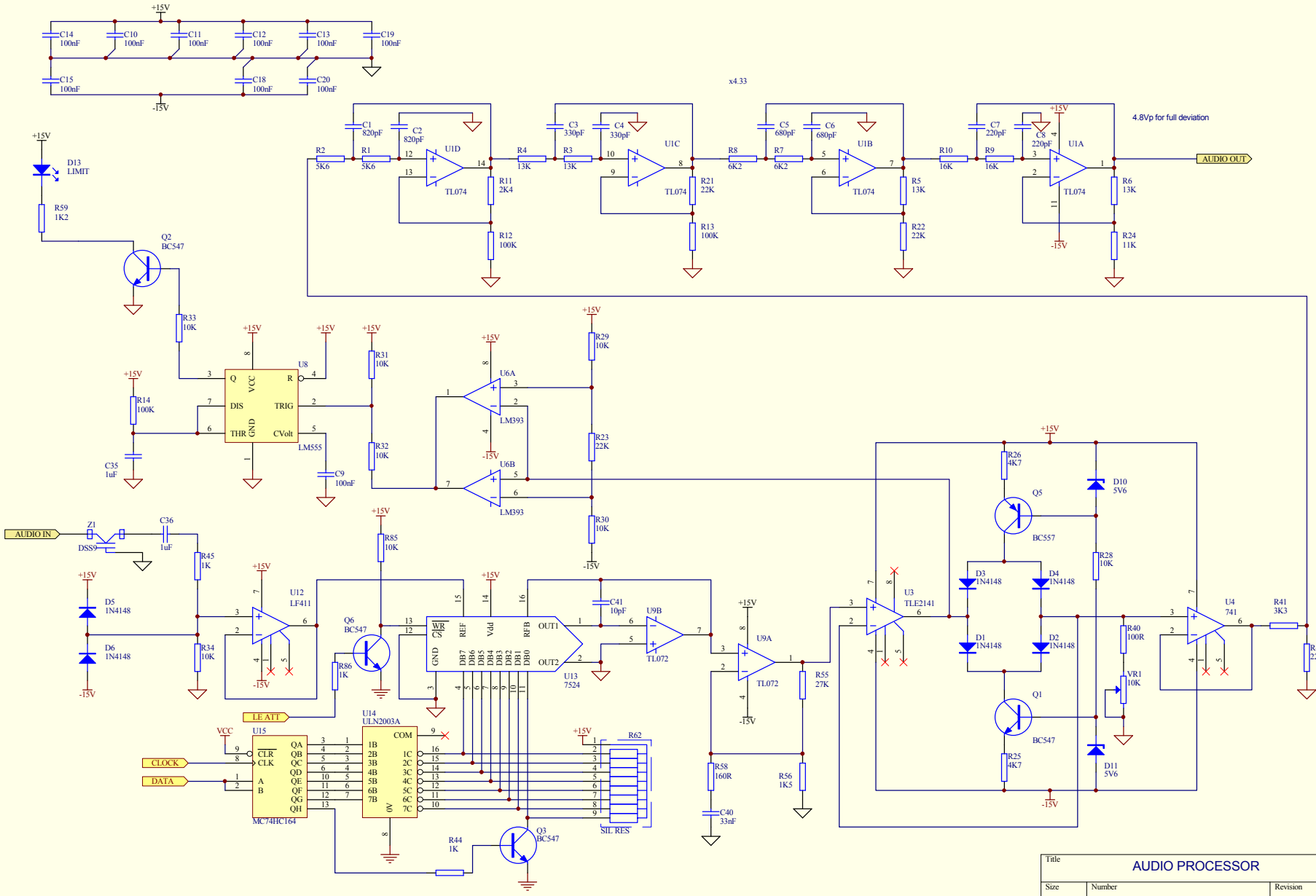

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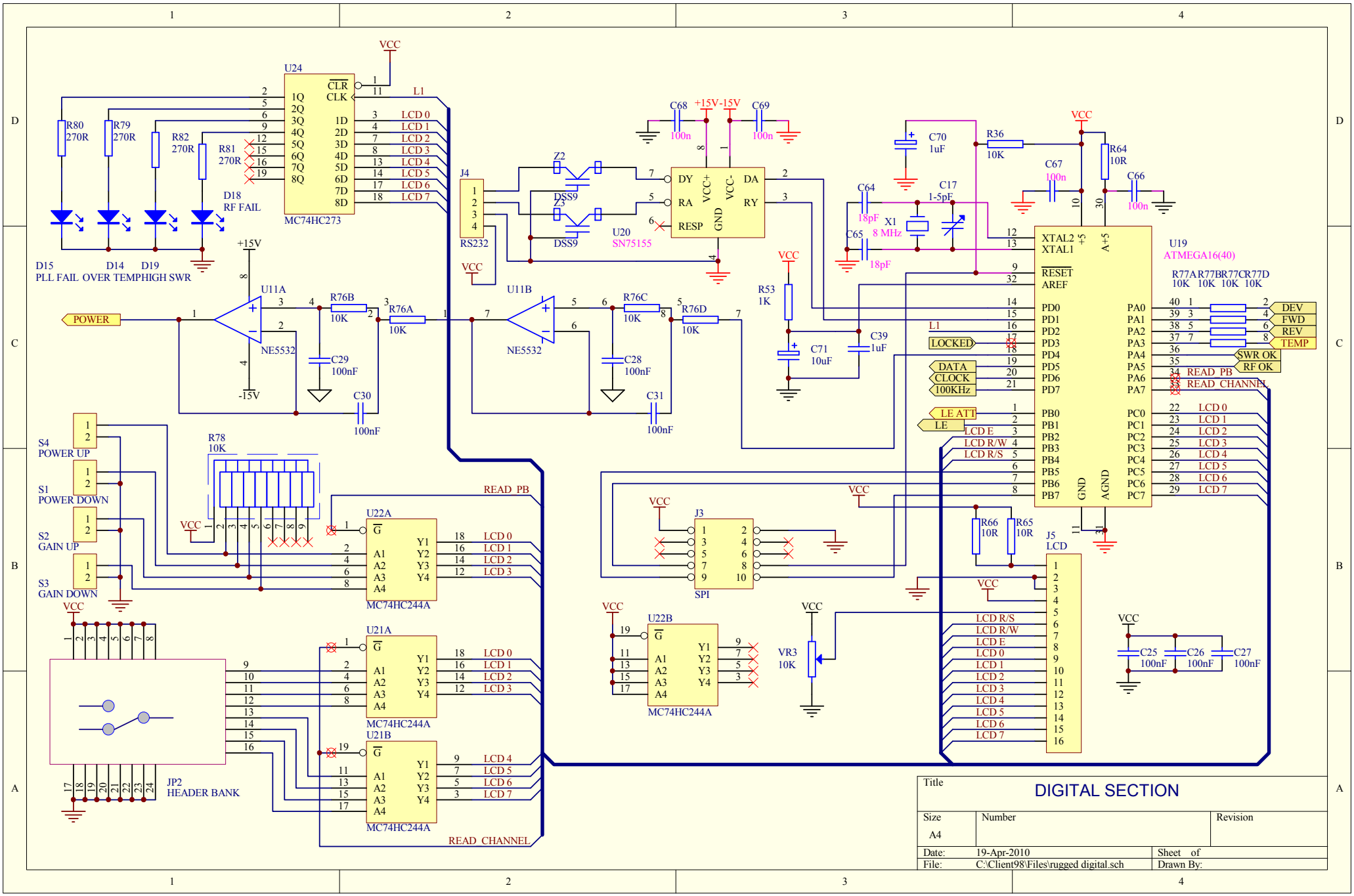
U24
MC74HC273
L1
LCD 0
LCD 1
LCD 2
LCD 3
LCD 4
LCD 5
LCD 6
LCD 7
R80 270R
R79 270R
R82 270R
R81 270R
D18 RF FAIL
D15 PLL FAIL
D14 OVER TEMP
D19 HIGH SWR
J4
RS232
U20
SN75155
Z2
Z3
DSS9
C68 100n
C69 100n
+15V
-15V
VCC
U11A
U11B
NE5532
POWER
R76A 10K
R76B 10K
R76C 10K
R76D 10K
C29 100nF
C30 100nF
C28 100nF
C31 100nF
R53 1K
C71 10uF
C39 1uF
C70 1uF
C17 1-5pF
C64 18pF
C65 18pF
X1 8 MHz
R36 10K
C67 100n
R64 10R
C66 100n
U19
ATMEGA16(40)
R77A R77B R77C R77D
10K 10K 10K 10K
XTAL2
XTAL1
RESET
AREF
PD0
PD1
PD2
PD3
PD4
PD5
PD6
PD7
PA0
PA1
PA2
PA3
PA4
PA5
PA6
PA7
PB0
PB1
PB2
PB3
PB4
PB5
PB6
PB7
PC0
PC1
PC2
PC3
PC4
PC5
PC6
PC7
DEV
FWD
REV
TEMP
SWR OK
RF OK
READ_PB
READ_CHANNEL
L1
LOCKED
DATA
CLOCK
100KHz
LE ATT
LE
LCD E
LCD R/W
LCD R/S
S4 POWER UP
S1 POWER DOWN
S2 GAIN UP
S3 GAIN DOWN
R78 10K
U22A
U21A
U21B
U22B
MC74HC244A
JP2 HEADER BANK
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SPI
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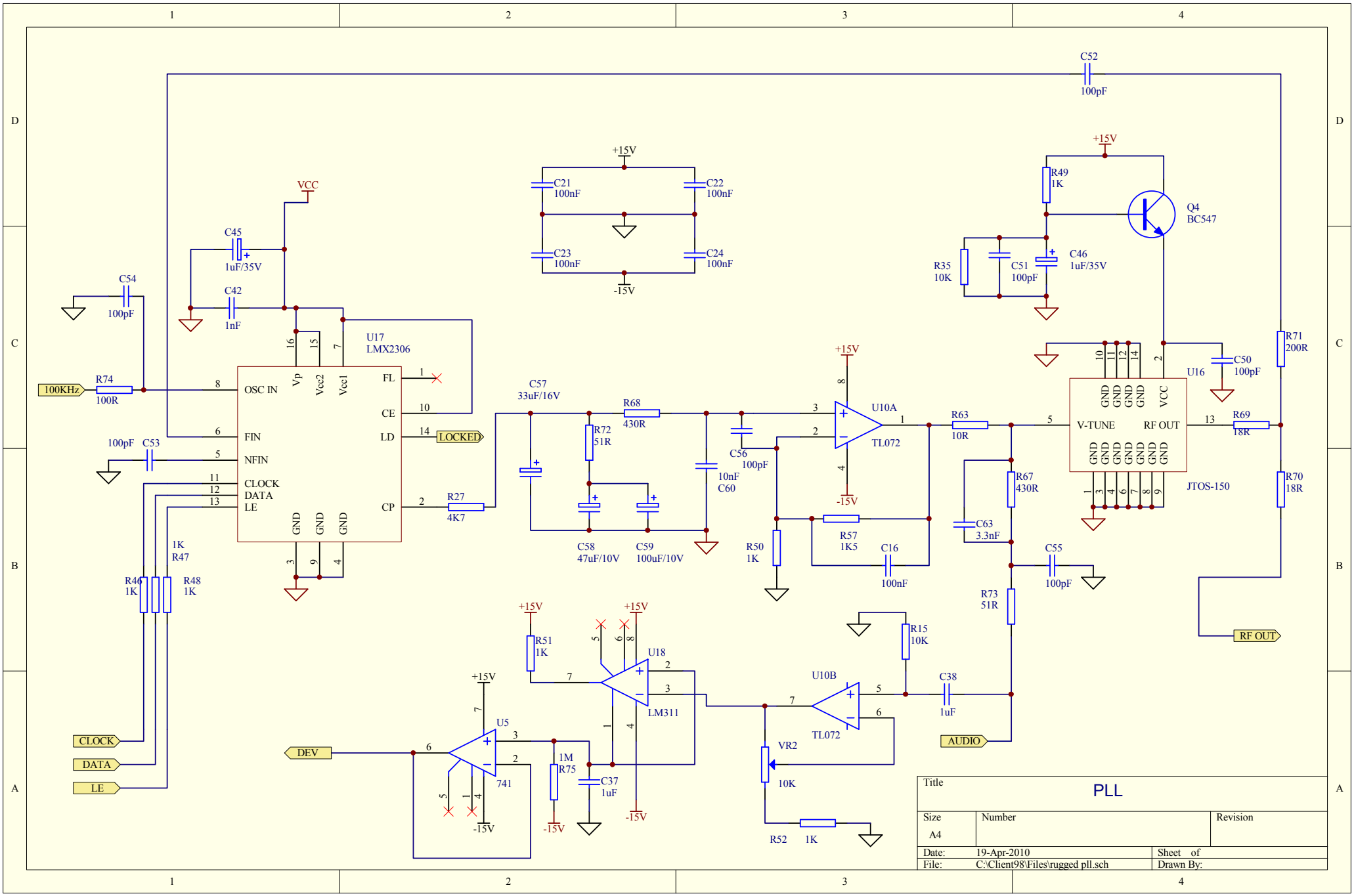
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10R
R49
1K
Q4
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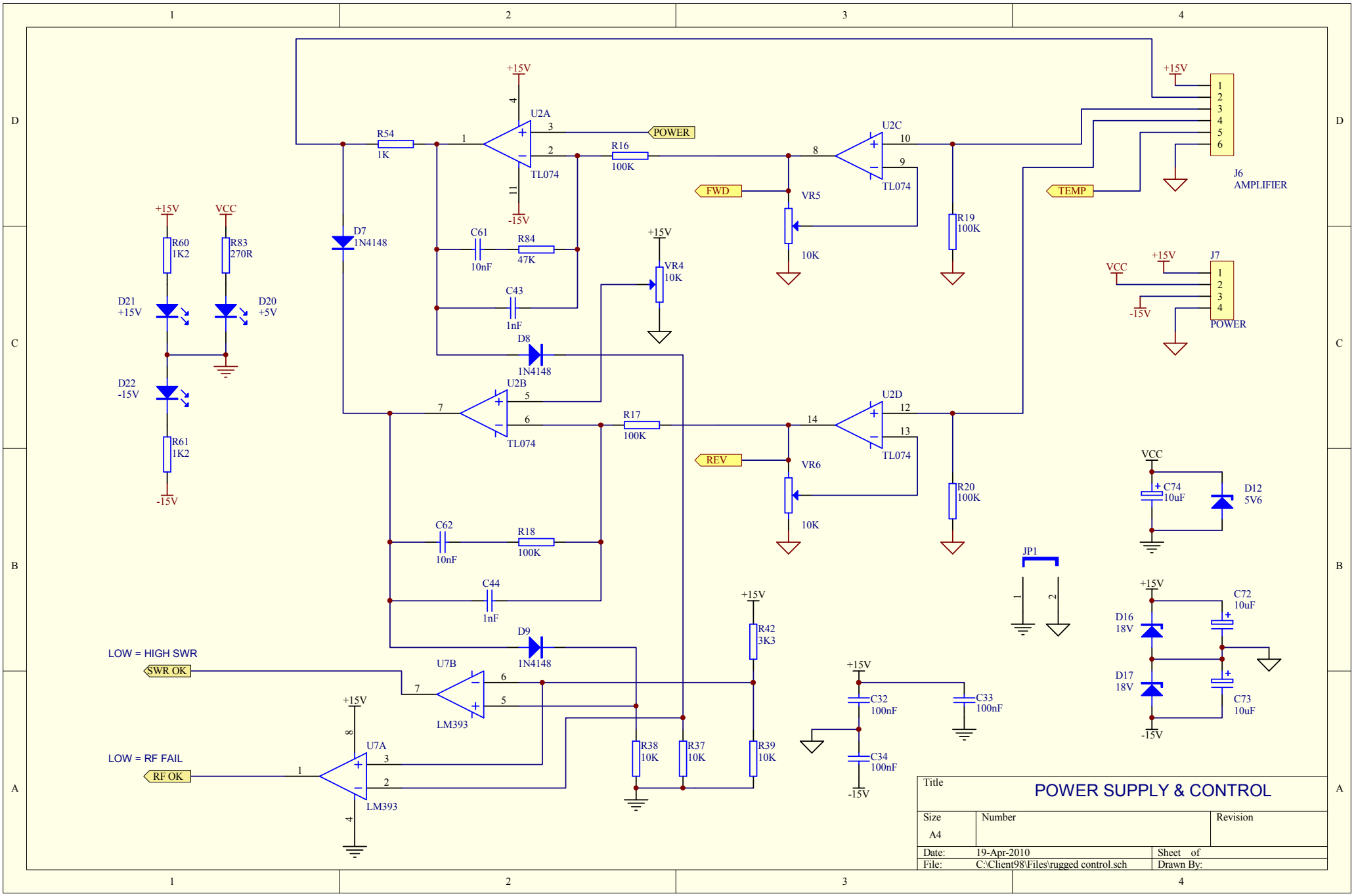
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R42
3K3
R38
10K
R37
10K
R39
10K
C32
100nF
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SWR OK
U7B
LM393
LOW = RF FAIL
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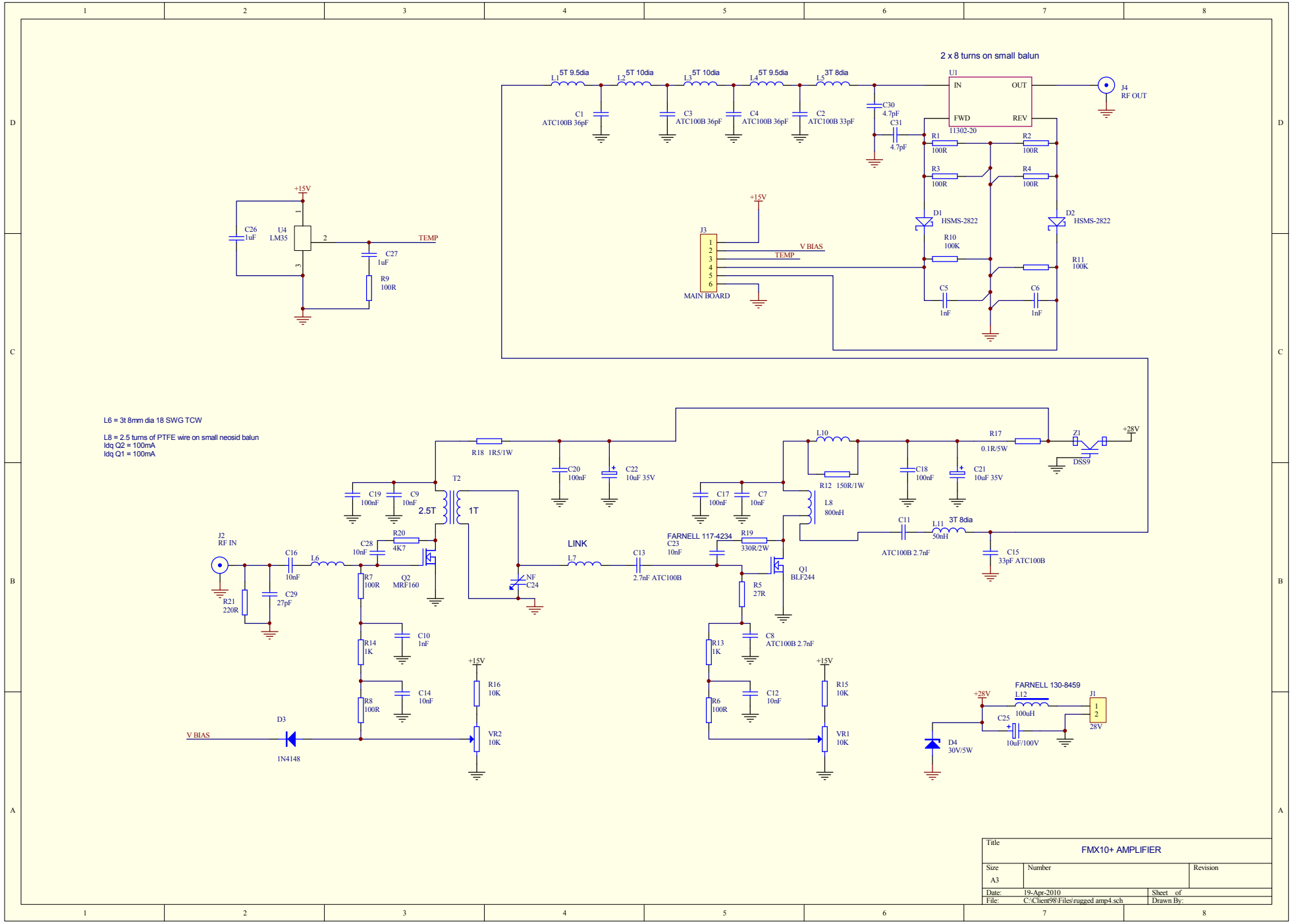

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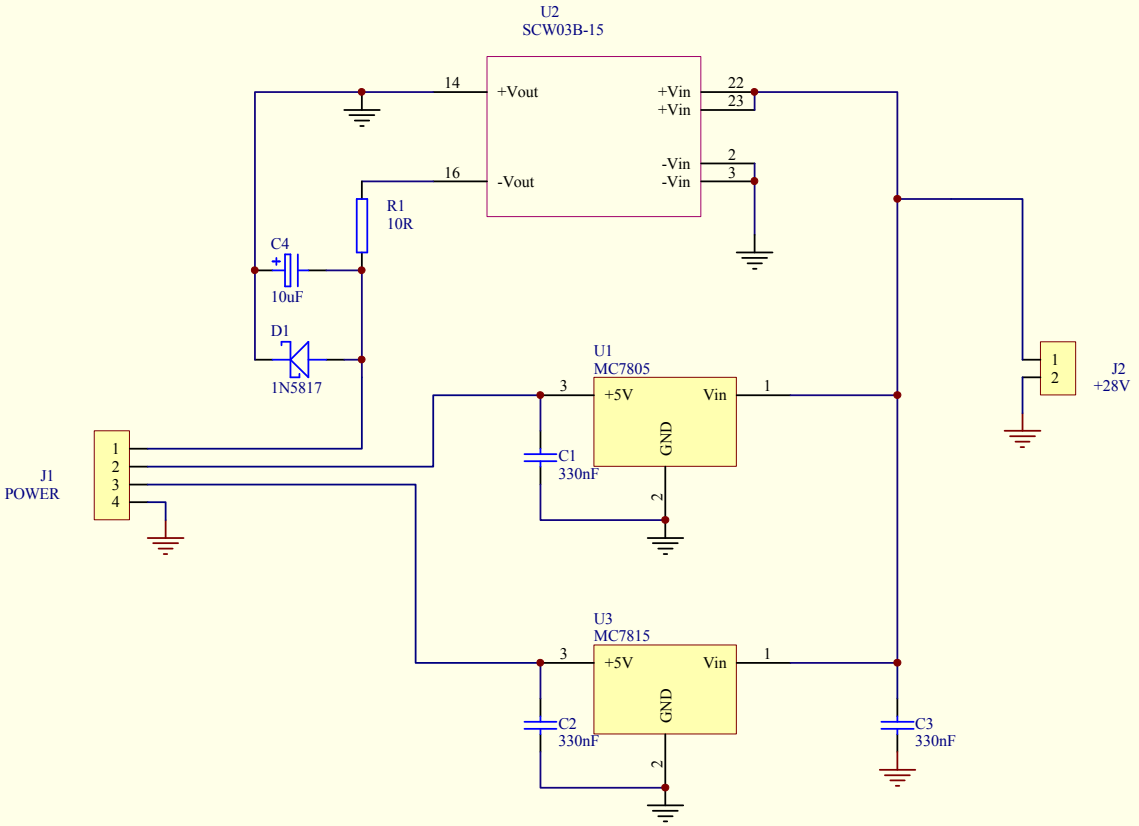

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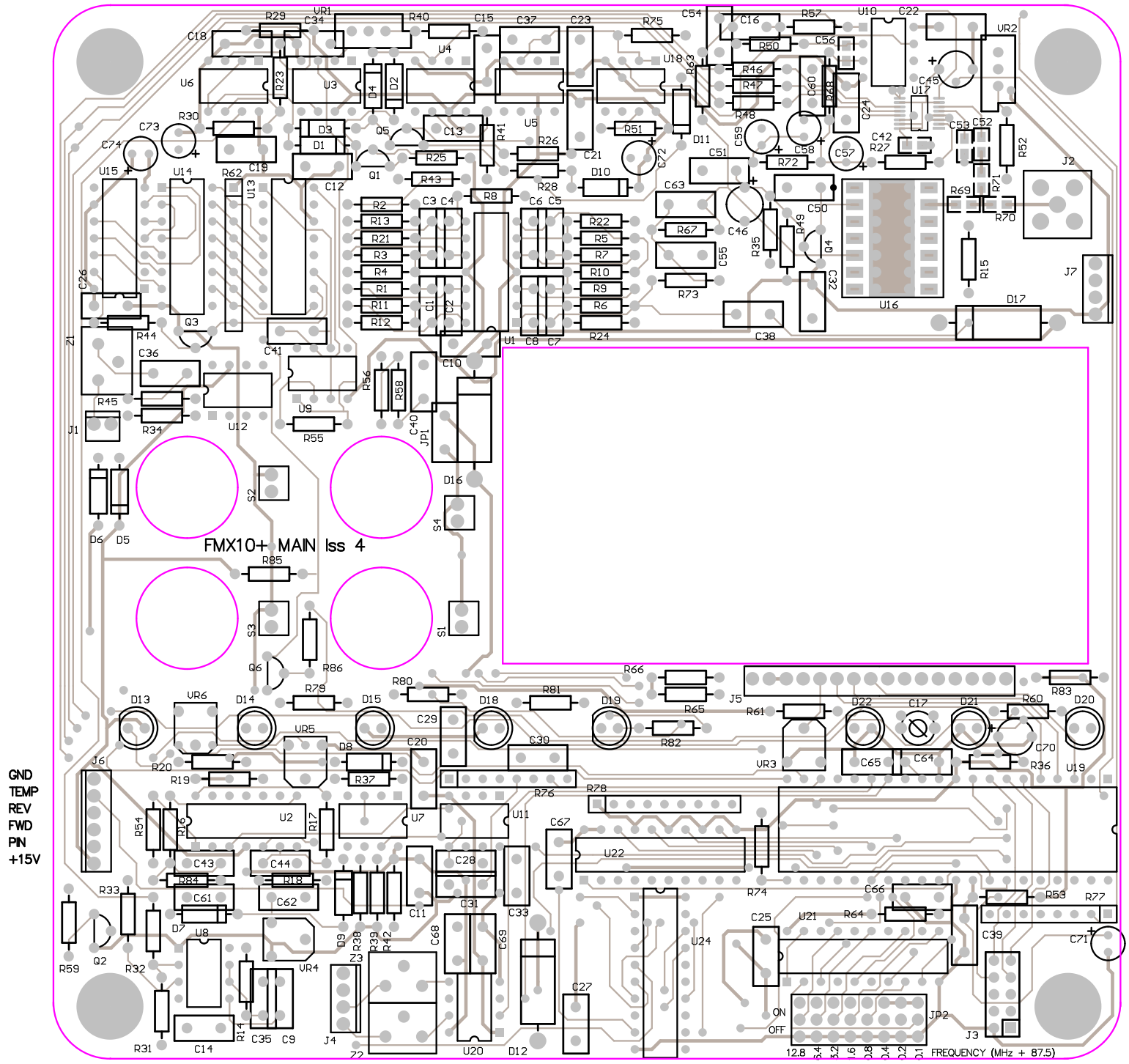
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FWD
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ON
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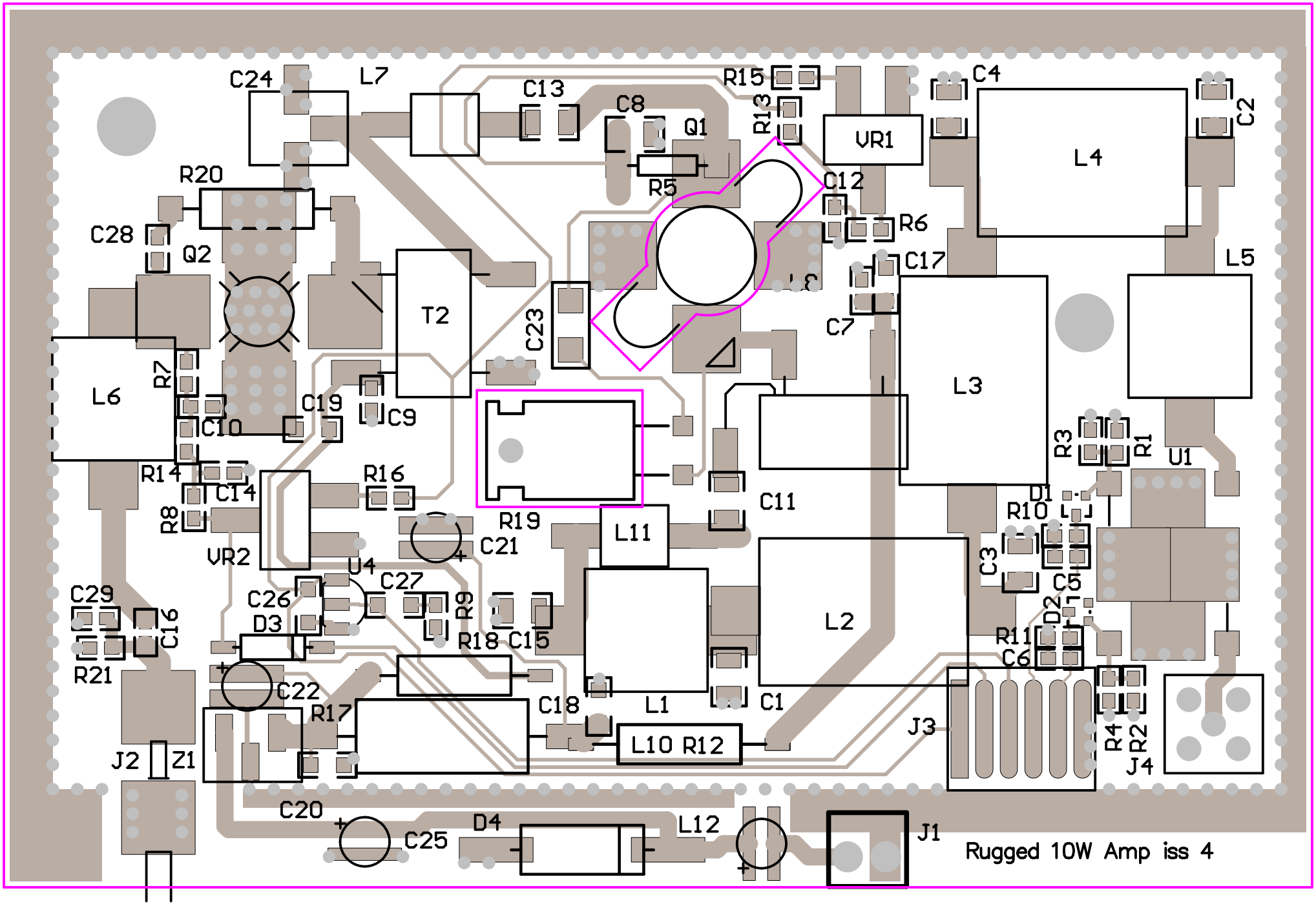
FREQUENCY (MHz + 87.5)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U1
R14
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R8
R19
C11
D1
R10
L11
VR2
C21
U4
C27
C3
C5
C29
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R9
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C16
R11
C6
R21
C22
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C18
L1
C1
J3
R4
R2
J4
J2
Z1
L10 R12
C20
C25
D4
L12
J1
Rugged 10W Amp iss 4

MATERIAL SAFETY DATA SHEET

I PRODUCT IDENTIFICATION

Trade Name: Beryllia Ceramic
Synonym: Beryllium Oxide, Beryllia, Thermalox, Super Beryllia
Chemical Family: Beryllium Compound

II HAZARDOUS INGREDIENTS

Constituents	OSHA(1995)*	ACGIH(1994-95)*	CAS #	NIOSH/ RTECS #
Beryllium	PEL: 0.002	TLV: 0.002	7440-41-7 (Be)	DS1750000
	Ceiling: 0.005	TLV-STEL: NA	1304-56-8 (BeO)	DS4025000
	Peak: 0.025			

*All concentrations are in mg/m^3 (at the concentrations noted above, this constituent may not be visible to the human eye).

ESPI recommends the following good industrial hygiene practice which includes reducing airborne exposures to the lowest feasible level for all constituents in this product. A leading scientific body recommending occupational standards is the American Conference of Governmental Industrial Hygienists (ACGIH). The ACGIH recommends standards for all listed substances. The ACGIH defines a threshold limit value (standards) as follows: "Threshold Limit Values refer to airborne concentrations of substances and represent conditions under which it is believed that nearly all workers may be repeatedly exposed day after day without adverse health effects."

Because of wide variation in individual susceptibility, however, a small percentage of workers may experience discomfort from some substances at concentrations at or below the threshold limit; a smaller percentage may be affected more seriously by aggravation of a pre-existing condition or by development of an occupational illness. "Individuals may also be hyper-susceptible or otherwise unusually responsive to some industrial chemicals because of genetic factors, age, personal habits (smoking, alcohol, or other drugs), medication, or previous exposures. Such workers may not be adequately protected from adverse health effects from certain chemicals at concentrations at or below the threshold limits."

III PHYSICAL DATA

Boiling Point:	N/A	**Sublimes At**:	N/A
Evaporation Rate:	N/A	**Vapor Density (Air=1)**:	N/A
Freezing Point:	N/A	**Vapor Pressure (mm Hg)**:	N/A
Odor:	None	**% Volatile By Volume**:	None
pH:	N/A	**Color**:	White
Physical State:	Solid	**Melting Point (°F)**:	2547 (BeO)
Radioactivity:	N/A	**Molecular Weight**:	25.01 (BeO)
Solubility:	None	**Density (g/cc)**:	2.86 (BeO)

IV FIRE AND EXPLOSION HAZARDS DATA

Flash Point: N/A
Explosive Limits: N/A
Extinguishing Media: N/A

Unusual Fire and Explosion Hazards: N/A
Special Fire Fighting Procedures: If this material becomes airborne as a respirable particulate during a fire situation, pressure-demand self-contained breathing apparatus must be worn by firefighters or any other persons potentially exposed.

V HEALTH HAZARD INFORMATION

Emergency Overview: If this material is involved in a fire, pressure-demand self-contained breathing apparatus and protective clothing must be worn by persons potentially exposed to the metal fumes or airborne particulate.

Primary Routes of Exposure:
Inhalation: An exposure to airborne beryllium in excess of the occupational standard can occur when sintering, machining, grinding, sanding, abrasive cutting, polishing, laser scribing and trimming, chemical etching, crushing, or otherwise abrading the surface of this material in a manner which generates finely divided particles.

Volatile beryllium hydroxide can be formed when firing solid BeO parts at temperature greater than 900 ^{o}C in a moist atmosphere such as in a hydrogen atmosphere sintering furnace.

Machining operations conducted under a flood of liquid coolant usually require complete hooded containment and local exhaust ventilation. Openings into the hood must be baffled to prevent release of fast moving particles. The cycling through a machine of liquid lubricant/coolant containing finely divided beryllium in suspension can result in the concentration building to a point where the particulate may become airborne during use. The coolant reservoir should be enclosed and ventilated. A coolant filtering system is recommended.

The Potential for Exposure Also May Occur During Repair or Maintenance Activities on Contaminated Equipment Such as: furnace rebuilding, maintenance or repair of air cleaning equipment, structural renovation, etc.

Ingestion: There are no known cases of illness resulting from ingestion of this material. Ingestion can occur from hand, clothing, food, and drink contact with metal dust, fume or powder during hand to mouth activities such as eating, drinking, smoking, nail biting, etc. This product is not intended for internal consumption. As a standard hygiene practice, hands should be washed before eating or smoking.

Skin: Skin abrasion may cause irritation. Imbedded material may lead to localized granuloma. The beryllium in this material is in an insoluble form and does not pose a potential for an allergic dermal response.

Eyes: Injury can result form particulate irritation or mechanical injury to the eyes by dust or particulate. Exposure may result from direct contact with airborne particulate (chips, dust, or powder) or contact to the eye if contaminated hands or clothing.

Effects of Overexposure:

Acute: (immediate or near-term health effects): The beryllium fraction of this product is insoluble and does not cause acute beryllium disease. The beryllium in this product does not pose a potential for allergic dermal response.

Chronic: (long-term health effects): Inhaling dust fumes containing beryllium may cause serious, chronic lung disease called Chronic Beryllium Disease (CBD) in some individuals. Over time lung disease can be fatal. Symptoms may include cough, chest pain, shortness of breath, weight loss, weakness, and fatigue. Long-term effects may include loss of lung function, fibrosis, or subsequent secondary effects on the heart with eventual permanent impairment. Chronic beryllium disease is a hypersensitivity of allergic condition in which tissues of the lungs become inflamed with a cellular nodular reaction. This inflammation, sometimes with accompanying fibrosis, may restrict the exchange of oxygen between the lungs and the bloodstream. This allergic response to beryllium is limited to susceptible studies and animal experimentation, the International Agency for Research on Cancer and the National Toxicology Program lists beryllium as a carcinogen.

Medical Conditions Generally Aggravated by Exposure: Persons with impaired pulmonary function, airway diseases, or conditions such as asthma, emphysema, chronic bronchitis, etc. may incur further impairment if dust of fume are inhaled. If prior damage or disease to the neurological (nervous), circulatory, hematologic (blood), or urinary (kidney) systems has occurred, proper screening or examinations should be conducted on individuals who may be exposed to further risk where handling and use of this material may cause exposure.

EMERGENCY AND FIRST AID PRODCEDURES:

INHALATION: Breathing difficulty cause by inhalation of dust or fume requires immediate removal to fresh air. There are no known cases in which a person stopped breathing as a result of exposure. If breathing has stopped, perform artificial respiration and obtain medical help.

INGESTION: Swallowing beryllium oxide dust can be treated by having the affected person drink large quantities of water and attempting to induce vomiting, if conscious. Obtain medical help.
SKIN: Skin cuts and abrasions should be treated by standard first aid. Skin contamination can be removed by washing with soap and water. Obtain medical help if irritation persists. Accidental implementation of this material beneath the skin requires it be removed to prevent infection or development of a corn-like lesion.
EYES: Dust should be flushed from the eyes with a lot of clean water. Obtain medical help if irritation persists. Contact lenses should not be worn when working with metal dusts and powders because the contact lens must be removed to provide adequate treatment.

Treatment of Chronic Beryllium Disease: There is not known treatment which will cure chronic beryllium disease. Prednisone or the corticosteroids are the most specific treatment available. They are directed at suppressing the immunological reaction and have been effective in diminishing many signs and symptoms of chronic beryllium disease. In cases where steroid therapy has had only a partial or minimal effectiveness, other immuno-suppressive agents, such as cyclophospharnide, cyclosporine, or methotrexate, have been used. These latter agents remain investigational. Further, in view of the potential side effects of all the immuno-suppressive medications, including steroids such as prednisone, they should be used only under the direct care of a physician. In general, these medications should be reserved for cases with significant symptoms and/or significant loss of lung function. Other symptomatic treatment, such as oxygen, inhaled steroids or bronchodilatores, may be used by some physicians and are effective in selected cases.

The decision about when and with what medication to treat is judgement situation for individual physicians. For the most part, treatment is reserved for those persons with symptoms and measurable loss of lung function. The value of starting oral steroid treatment, before signs or symptoms are evident, remains a medically unresolved issue currently under study. Some physicians are concerned that their patients may develop a resistance to medication if it is started too soon.

The effects of continued low exposure to beryllium are unknown for individuals who are sensitized to beryllium or who have diagnosis of chronic beryllium disease. This uncertainty leads some physicians to advise a reduction or elimination of further exposure to beryllium. However, some individuals have developed CBD or have gradually become worse after removal from further exposure. Others have continued to work in the beryllium industry without any additional, or accelerated, loss of lung function.

VI REACTIVITY DATA

General Reactivity: This material is stable
Incompatibility (Materials to avoid): NA

Hazardous Decomposition Products: None under normal conditions of use
Hazardous Polymerization: Will not occur
Ecological Information: This material is insoluble in water. This material can be recycled.

VII SPILL OR LEAK PROCEDURES

Steps to be Taken in Case Material is Released or Spilled: In solid form this material poses no health or environmental risk. If this material is in powder or dust form, establish a restricted entry zone based on the severity of the spill. Persons entering the restricted zone must wear adequate respiratory protection and protective clothing appropriate for the severity of the spill. Cleanup should be conducted with a vacuum system utilizing a high efficiency particulate air filtration system followed by wet cleaning methods. Special care must be taken when changing filters on HEPA vacuum cleaners when used to clean up potentially toxic materials. Caution should be taken to minimize airborne generation of powder or dust and avoid contamination of air and water. Depending upon the quantity of material released, fine powder or dust spills to the environment may require reporting the National Response Center at (800) 424-8802 as well as the State Emergency Response Commission and Local Emergency Planning Committee.

Handling and Storage: Wear gloves when handling to prevent cuts and skin abrasions. Store in a dry area.

Ventilation and Engineering Controls: Whenever possible, the use of local exhaust ventilation or other engineering controls is the preferred method of controlling exposure to airborne dust and fume. Where utilized, pickups on flexible ventilation lines should be positioned as close to the source of airborne contamination as possible. Disruption of the airflow in the area of a local exhaust inlet, such as by a man cooling fan, should be avoided. Ventilation equipment should be checked regularly to ensure it is functioning properly. Ventilation training is recommended for all users. Ventilation systems designed and installed by qualified professionals.

Respiratory Protection: When potential exposures are above the occupational limits shown in this MSDS, approved respirators must be used as specified by an Industrial Hygienist of other qualified professional. Respirator users must be medically evaluated to determine if they are physically capable of wearing a respirator. Quantitative an/or qualitative fit testing and respirator training must be satisfactorily completed by all personnel prior to respirator use. Users of any style respirator training must be clean shaven on those areas of the face where the respirator seal contacts the face. Exposure to unknown concentrations of fumes or dusts requires the wearing of a pressure-demand airline respirator or pressure-demand self-contained breathing apparatus. Pressure-demand airline respirators are recommended when performing jobs with high potential exposures such as changing filters in a bag house air cleaning device.

Housekeeping: Vacuum and wet cleaning methods are recommended for dust removal. Be certain to de-energize electrical systems, as necessary, before beginning wet cleaning. Vacuum cleaners with high efficiency particulate air (HEPA) filters are the recommended type. The use of compressed air or brooms to remove dusts should be avoided as such an activity can result in unnecessary short-term elevated exposures to airborne dusts.

Maintenance: During repair or maintenance activities the potential exists for exposures in excess of the occupational standard. Under these circumstances, protecting workers can require the use of specific work practices or procedures involving the combined use of ventilation, wet methods, respiratory protection, decontamination, special protection clothing, and when necessary, restricted work zones.

Other Protective Equipment: No special protective equipment or clothing is requires when handling solid forms. Protective over garments or work clothing must be worn by persons who may become contaminated with dusts, fumes, or powders during activities such as machining, furnace rebuilding, air cleaning equipment filter changes, maintenance, etc. Contaminated work clothing and over garments must be managed in such a manner so as to prevent secondary exposure to persons such as laundry operators and to prevent contamination to personal clothing. Never use compressed air to clean work clothing.

Protective Gloves: Wear gloves to prevent cuts and skin abrasions during handling.
Eye Protection: Wear safety glasses, goggles, or face shield when risk of eye injury is present, particularly during machining, grinding, etc.

Recommended Monitoring Procedures:

Environmental Surveillance: Exposure to airborne materials should be determined by having air samples taken in the employee breathing zone, work area, and department. The frequency and type of air sampling should be as specified by an Industrial Hygienist or other qualified professional. Air sample results should be make available to employees.

Medical Surveillance: Persons exposed to airborne concentrations of this material should be included in a periodic medical surveillance program. The program should include examination of the skin and respiratory systems. Non-specific findings of skin rash, skin granulomata, or respiratory signs or symptoms may indicate a reaction to this material. A minimum medical surveillance program should include (1) skin examination, (2) respiratory history, (3) auscultation of the lungs, (4) spirometry (FVC and FEV), and (5) periodic chest x-ray. In addition, a specialized, specific, immunological blood test, the beryllium blood lymphocyte proliferation test (BLPT), is available (on a limited basis to assist in the diagnosis) to screen beryllium-exposed persons for beryllium reactions. Note: It should be recognized that BLPT has limited sensitivity for chronic beryllium disease. Individuals who have an abnormal BLPT are normally referred to a lung specialist for additional specific tests to determine if chronic beryllium disease is present.

VIII SPECIAL PROTECTION INFORMATION

Transport Information: There are nor U.S. Department of Transportation hazardous material regulations which apply to the packaging and labeling of this product as shipped by ESPI. Hazard Communication regulations of the U.S. Occupational Safety and Health Administration require that this material be labeled.

Regulatory Information: OSHA Hazard Communications Standard, 29 CFR 1910.1200: Beryllium is considered a hazardous ingredient.

Ambient Air Emissions: Beryllium-containing materials are subject to the National Emission Standard for Beryllium as promulgated by EPA (40 CFR 61, Subpart (C). The National Emission Standard for beryllium is 0.01 micrograms per cubic meter (30 day average) in ambient air for those production facilities which have been qualified to be regulated through ambient air monitoring. Other facilities must meet a 10 gram per 24-hour total site emission limit. Most process air emission sources will require an air permit from a local and/or state air pollution control agency. The use of air cleaning equipment may be necessary to achieve a permissible emission. Tempered makeup air should be provided to prevent excessive negative pressure in a building. Direct recycling of cleaned process exhaust air is not recommended. Plant exhausts should be located so as not to re-enter the plant through makeup air or other inlets. Regular maintenance and inspection of air cleaning equipment and monitoring of operating parameters is recommended to ensure adequate efficiency is maintained.

Wastewater: Wastewater regulations can vary considerably. Contact your local and state governments to determine their requirements.

Toxic Substances Control Act: Beryllium is listed on the TSCA Chemical Substance Inventory of Existing Chemical Substances.

Sara Title III Reporting Requirements: On February 16, 1988 the U.S. Environmental Protection Agency (EPA) issued a final rule that implements the requirements of the Superfund Amendments and Re-authorization Act (SARA) Title III, Section 313 (53) Federal Register 4525. Title III is the portion of SARA concerning reporting on specific chemicals which are manufactured, processed or used at certain U.S. Industrial facilities.

Beryllium is reportable under Section 313. The Chemical Abstracts Services number is provided in this MSDS. SARA Title Hotline 1-800-535-0202 or 202-555-1411

This MSDS has been revised following the guidelines outlined in the American National Standard for Hazardous Chemicals Z400.1-1993 “Material Safety Data Sheets-Preparation.”

IX SPECIAL PRECAUTIONS

Disposal Considerations:

Byproduct Recycling: When recycled (used in a process to recover metals), this material is not classified as hazardous waste under federal law. Dusty or dust-like materials should be sealed inside two plastic bags, placed in a DOT approved container, and appropriately labeled.

Solid Waste Management: When spent products are declared solid wastes (no longer recyclable), they must be labeled, managed and disposed of, in accordance with federal, state and local requirements. This material is not classified a hazardous waste under federal law.

Prepared by: S. Dierks
Dated: January 1996