Minisynth

10MHz – 200MHz VFO

User Manual

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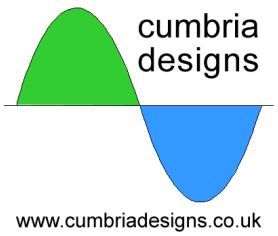

16 Chestnut Close
Culgaith
PENRITH
Cumbria
CA10 1QX
UK

1 Introduction

Thank you for purchasing the Cumbria Designs Minisynth. We hope that you enjoy constructing and using your new Minisynth VFO. This manual describes the assembly and operation of the Minisynth kit, even if you are a seasoned constructor, we respectfully ask that you read this manual and familiarise yourself with the instructions and kit contents before commencing construction. If assembled carefully, this unit will provide many years of reliable service.

The Cumbria Designs Team

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2 Preparation

2.1 Tools

We recommend that the following tools are used during assembly and testing;

25W fine tipped soldering iron

15W pointed tip soldering iron

60/40 Rosin cored solder

5” or smaller diagonal side cutters

Small pointed nosed pliers

Solder wick

Multimeter

2.2 Conventions

The following symbols are used within the assembly instructions to draw attention to critical steps such as component orientation and anti-static precautions. The associated narrative describes the action required.

Critical Step

Static Sensitive

2.3 Assembly

The production of a successful finished working kit is dependent upon careful component handling, careful placement and good soldering!

Don’t be tempted to rush the construction, even though this is a relatively simple kit, a wrongly placed component can be expensive! Also, as this kit uses a double sided Printed Circuit Board (PCB) with through plating, removal of a wrongly soldered part can be difficult. Follow the assembly instructions carefully to avoid mistakes.

2.4 Component Identification

This kit employs through hole and surface mount technology (SMT) components. All parts carry a coded identity to describe their values. It is important to be able to recognise these during assembly. For through hole parts, capacitors have their value printed numerically, e.g. 104 = 100nF, 103 = 10nF etc. Resistors have their values represented by coloured bands – this is a frequent source of confusion! Surface mount parts use a slightly different convention; 10nF SMT capacitors are unmarked. SMT resistors have their value printed on their upper side as a value follows by a multiplier. For example, 39R is shown as 390, i.e. 39 Ohms with no 10’s multiplier.

To simplify component identification, the assembly notes carry the identities of each component as it appears on the device. For through hole resistors the colour coding is given. For SMT parts the marked value is given. This should be referred to during assembly, for every part, to ensure the right parts are placed in their respective positions on the PCB.

2.5 Component Leads

Many of the through hole components will require their leads to be formed to align with the holes on the PCB. This mainly applies to the axial parts such as resistors and diodes. Forming component leads is easily done with a pair of pointed nose pliers and using the hole spacing on the PCB as a measure. Alternatively, small formers made from scrap off cuts of Vero board etc make ideal templates that produce consistent results. Some parts, such as variable resistors, have preformed pins designed for machine assembly. These will require straightening to align with the board layout. Again, a pair of pointed nose pliers should be used to carefully flatten the preformed pins.

2.6 Soldering

Before applying solder check **carefully that the component you have placed is in the right position!** This is a through plated double sided board. Whilst some of the pads are very small, the area presented by the through plating is more than adequate to allow good solder flow to form mechanically strong good electrical joints. However, these can be difficult to undo, so please double check placement!

The majority of problems are likely to be caused by soldering faults. These can sometimes be difficult to find. Here are some basic golden rules that will help you to avoid poor solder joints;

- **Clean Iron**

Make sure your soldering iron tip is in good condition and tinned. A small moistened pad for cleaning tips, regularly used to wipe off excess solder and flux, will ensure that your iron performs well. Remember to tin the iron immediately after each wipe.

- **Clean Leads and Pads**

All of the component leads and PCB pads in this kit are pre-tinned and should not need cleaning before soldering. Please ensure that parts are handled so as to avoid contamination with grease or fingerprints.

- **Soldering**

This is the bit that can trip up even experienced constructors. For the solder to fuse with the surfaces to be joined it is necessary for them to be hot – but not so hot as to damage the parts! It's as simple as ***1-2-3***;

1. *Place the tip of the iron against the joint, hold it there briefly to bring the metal surfaces up to temperature.*
2. *Apply the solder allowing it to flow smoothly onto the surfaces.*
3. *Remove the iron and inspect the new joint.*

The finished joint should have a smooth shiny coating of solder. If the joint is dull grey or has formed a spherical "blob", apply the iron to the joint, remove the old solder with a solder sucker and re-solder.

For SMT parts a simple clamp arrangement to hold a part in place during soldering is useful. This is easily made from a small square of MDF board with a small hole drilled in one corner. A piece of heavy gauge wire (e.g. from a coat hanger) is pushed into the hole and bent over to the centre of the MDF board in an arc such that it presses gently against the board. The PCB is positioned on the MDF base board such that the SMT part to be soldered is held in place under the end of the wire. Once the PCB and part are positioned, both hands are free to solder the component.

For those with a steady hand, SMT parts can be soldered without the use of a clamp. Lightly tin one pad, removing any excess with solder wick if necessary. Place to component onto the pads and hold in place with a suitable tool, (a 3mm or 4mm diameter wood dowel is perfect). Heat the

tinned pad with the tip of the iron to melt the solder and allow it to fuse with the component terminal. The part should now be held in place. Apply solder and the iron to the unsoldered pad and once cool re-soldered the first pad to ensure that the connection is electrically sound. Remove any excess solder with solder wick.

If you are new to using SMT parts we strongly recommend that you practice soldering and de-soldering on a scrap PCB. Old computer cards and motherboards make a perfect training ground!

3 Circuit Description

3.1 General

The Minisynth is a compact single board synthesiser designed to serve as a high performance VFO operating from HF to VHF. When used with an IF system of 8MHz or higher, the Minisynth is capable of providing continuous coverage from a few kHz to almost 200MHz. For quadrature direct conversion systems, a display option supports continuous operation from around 2MHz to 50MHz. Split and reverse split operation are provided and through the set up menus features such as frequency limits, IF offsets and step sizes can be programmed. The high level output is suitable for driving Level 7 Mixers.

3.2 Theory of Operation

The Minisynth employs an LVDS version of the Si570 programmable oscillator to generate a low phase noise, square wave output from at least 10MHz to 200MHz. Within the Si570 there is a crystal oscillator and dividers which are used to set the frequency of a 5GHz internal VCO. The output of the VCO is divided by programmable high speed logic to generate the output signal. The frequency of the output signal is set by a combination of the VCO frequency and the output divider value. The relationship between these settings and the output frequency is complex. A PIC18F1330 microcontroller performs the calculations required to translate a given frequency to the corresponding control data for the Si570. Communication between the Si570 and PIC is via an I2C bus.

In addition to managing the Si570, the PIC also controls the LCD and scans the switches, rotary encoder and external controls for change. Any detected change is interpreted and actioned.

A mechanical rotary encoder is used for the tuning control. This provides 48 tuning steps and incorporates a push switch which is used to change tuning rates. Three rates are offered, slow, fast and variable rate.

Three front panel push buttons provide standard VFO functions such as split, reverse split and lock. In set up mode these buttons are used to navigate through the set up menus and make selections.

A group of external controls are provided for interfacing into the host equipment. These are a T/R control input which is high for Rx and Low for Tx and an IF offset Sum (high), Diff (low) input. Both of these control inputs incorporate series blocking diodes to allow safe direct connection to equipment supplies at up to +20v DC.

The RF output from the Si570 is amplified by an ERA-4XSM amplifier to produce a +10dBm nominal output. A resistive attenuator is used to between the Si570 and MMIC to provide well defined load for the Si570 and improve inter stage matching and linearity.

4 Assembly

This kit is not intended for novice constructors or those not skilled in soldering surface mount parts. If you are unsure as to your ability to successfully complete this kit, seek assistance from a more experienced constructor.

The following assembly sequence is **strongly recommended**. This ensures that the SMT parts can be installed with minimal risk of damage to themselves and other components.

NOTE: <u>The switches and LCD are mounted on the underside of the board</u>.

4.1 Diodes

Fit the BAV21 control diodes D2..D6 observing the orientation marked on the PCB. The diode cathodes are marked by a black band The diodes are inserted with their cathodes towards the control connector pads. Once soldered, trim off the excess leads on the underside of the PCB.

4.2 SIL Resistor RN1

The orientation of the 10K SIL resistor is critical. Pin 1 is the common connection and is marked with a small “spot” on the text side of the resistor body. Install with Pin 1 towards C4 and the DC Power Connector position.

4.3 Regulator IC3

Install the T092 3v3 regulator that supplies the Si570 in position alongside the SIL resistor observing the orientation marked on the PCB. Mount the regulator low on the PCB, leaving about a 3mm gap between the regulator body and the PCB. Once soldered, trim off the excess leads on the underside of the PCB.

4.4 SMT Capacitors C11 and C12

Solder 10nF SMT capacitors in positions C11 and C12 taking care not to bridge pads and remove any excess solder with solder wick.

4.5 SMT Resistors R4, R5 and R6

These resistors form the Pi attenuator between the Si570 and the output amplifier.
Solder taking care not to bridge pads and remove any excess solder with solder wick.

R4	39R	390
R5	150R	1500
R6	150R	1500

4.6 Si570 IC4

This is the most critical step of the whole assembly process and involves the most expensive part. If you are not comfortable about soldering this device, seek assistance from someone with experience in SMT soldering.

Lightly tin the ground pad on the PCB (pin 3) Remove excess with solder wick to leave a slightly raised freshly tinned surface.

Pin 1 of the Si570 is marked by a small “spot”. On the PCB the Pin 1 position is the pad in the corner of the device footprint nearest to C6. Position the Si570 in place

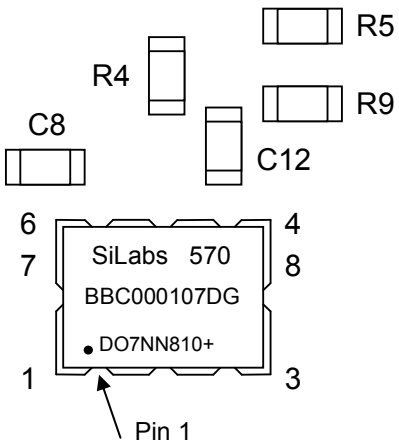


Fig.1 *Si570 orientation*

checking orientation. Ensure that the device is aligned directly over the pads, the small edge pads on the device must be aligned over the centre of each PCB pad. Holding the Si570 in place, apply heat from the tip of the iron to the tinned ground pad allowing the solder to melt. Remove iron and allow pad to cool. The Si570 should now be held in place by its ground pad, if it isn't, remove the Si570 and apply a little more solder to the ground pad. Re-align and re-solder.

Before soldering the remaining pads, re-check the alignment of the Si570 over the PCB pads, if necessary adjusting its position as described above.

To solder the Si570 in place, work round each pad applying heat to the pad from the tip and melting solder onto the pad allowing it to flow and fuse with the small edge pads on the device sides, removing any excess with solder wick. This will ensure a good connection on each of the device's 8 terminals.

4.7 SMT Capacitor C8

Solder the 10nF decoupling capacitor C8 into position alongside Pin 6 of the Si570, taking care not to bridge pads and removing any excess solder with solder wick.

4.8 Amplifier ERA-4XSM

Position the output amplifier as shown below and solder removing any excess with solder wick.

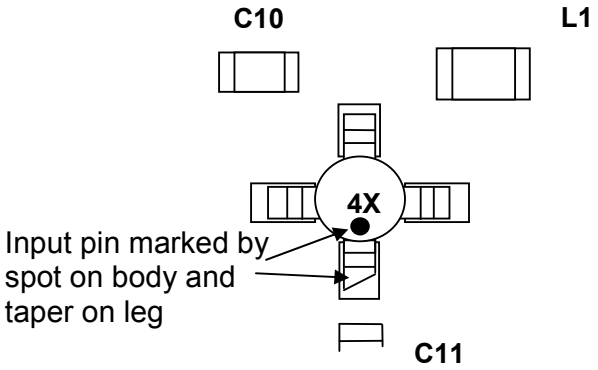


Fig.2 *ERA-4XSM Orientation*

4.9 Amplifier SMT Components

Complete the amplifier stage by installing the following components in the given order, taking care to prevent bridges and removing excess solder with solder wick.

C10	10nF		SMT Capacitor
L1	6u8	6.8uH	SMT inductor
R2	100R	1000	SMT Resistor
C7	10nF		SMT Capacitor
R1	10R	10	SMT Resistor

4.10 18 Pin IC Socket

Ensure correct orientation! Match index cut out on socket to board printing. Tip; solder one pin only then check positioning before continuing. Heat solder and reposition if necessary.

4.11 Ceramic Through Hole Capacitors

Install and solder the through hole capacitors close to the PCB and trim off excess leads on the underside of the board.

C3	10nF	103
C2,C9,C13	100nF	104

4.12 Regulator IC2

Install the T092 3v3 regulator that supplies the PIC18F1330S in position alongside C2 observing the orientation marked on the PCB. Mount the regulator low on the PCB, leaving about a 3mm gap between the regulator body and the PCB. Once soldered, trim off the excess leads on the underside of the PCB.

4.13 Electrolytic Through Hole Capacitors

Install the electrolytic capacitors ensuring that the polarity marked on the body aligns with that shown on the PCB.

C1, C4, C5, C6	10uF	10uF Electrolytic

4.14 Regulator IC1

Install the T0220 metal tab +5V regulator between C4 and C5 with the underside of the metal tab facing outwards are shown on the PCB. Trim off the excess leads on the underside of the PCB.

4.15 Diode D1

Install the DC protection diode D1 next to the +12V DC connector ensuring that the cathode, marked by a white band, matches the orientation shown on the PCB. Trim off excess leads on the underside of the PCB.

4.16 LCD Backlight Resistor

Install through hole resistor R3 and trim off excess lead on the underside of the PCB

R3	15R	Brown, Green, Black, (GOLD)

4.17 LCD Contrast Pot

Install the cermet pot, the pre-formed leads will require to be straightened to fit. Remove the corrugations by gently compressing each lead with a pair of small pliers.

VR1	10K	103

4.18 Connectors

Recommended Pin Header Connector orientation is with rear locking tab facing into the centre of the board. The three pin header position marked “EXP” is provided for future expansion and is unused at present.

Fit the three two pin headers;	+12V, AUX, BL
Fit the six pin header;	CONTROL

4.19 Switches – Underside Components

Mount the three push switches on the underside of the PCB. Orientation is set by the switch pin and PCB hole spacing. The switch top body retaining clips will face across the PCB.

4.20 Switch Buttons

Press the three black buttons onto the switch shafts.

4.21 LCD Module – Underside Component!

The LCD is connected to the board by the 16 way SIL connector. To ensure correct alignment the following procedure is recommended;

a) Place LCD face down on a flat surface, insert the broad pins of the **SIL pin strip** into the 16 Way LCD terminal. **Do not solder at this stage**.

b) Plug the 16 way SIL socket fully home onto the exposed narrow pins of the SIL pin strip.

c) Locate the Minisynth PCB onto the pins of the 16 way SIL socket.

d) Fit the four 8mm spacers between the two PCB's at each corner.

e) Place a 3mm spacer onto each M2.5 screw and pass through each mounting hole and 8mm spacer from the front of the LCD. Secure on the top side of the main PCB by first fitting an M2.5 steel washer and an M2.5 nut. (See final assembly picture for detail)

f) Once the LCD and main PCB are correctly adjusted for alignment, carefully solder the SIL connectors on the LCD and main PCB.

The countersunk head of the mounting screws are presented at the front of the LCD to support the mounting of the complete assembly to countersunk mounting holes within the chosen enclosure. The short nylon spacers provide clearance between the top side tracks of the LCD module and the rear of the mounting surface. The LCD header pins should be checked for clearance and if necessary trimmed to prevent contact with the underside of the enclosure surface.

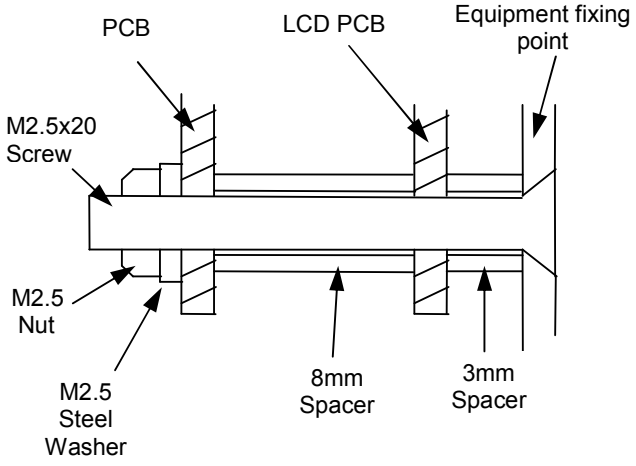


Fig.3 *Hardware Kit assembly detail*

4.22 PIC18F1330 Processor

Observe correct alignment of IC pins which will need to be gently formed for correct alignment before insertion into sockets. IC pins can be pushed inwards by placing the device on its' side on a firm surface, and gently pressing the body down against the pins. When inserting, take care to check pin alignment.

IC6 PIC18F1330 (18 pin DIL)

4.23 Connector Assemblies

Connector shells and pins are supplied to allow connection of power and signal lines to the Microcode. The use of good quality, colour coded, heat resistant, multi stranded wire is recommended. To avoid accidents, a colour code convention should be chosen to represent function, e.g. Red +ve supply, Black ground, striped colours controls etc. The connector assemblies comprise of two components; the shell and the pins. To terminate a conductor first strip back about 2mm of insulation and tin the exposed wire. Place the tinned end of the wire into a pin such that the tinned wire sits inside the inner pair of tabs and the insulation sits within the outer tabs. With small pointed nose pliers carefully compress the outer tabs onto the insulation to hold the wire. Repeat this with the inner tabs to grip the exposed conductor. Very carefully solder the exposed conductor in place taking care not to allow solder to flow onto the locking tab. Finally, insert the pin into the shell with the small locking tab orientated to the face of the shell with the small cut outs. Push home until the locking tab snaps into the cut out. Should you need to remove a pin, gently press the locking tab in with a small screwdriver or the end of a pair of pointed nose pliers. The pin will be released and can be pulled out of the shell.

Assembly complete, well done! Now carefully check your assembly and soldering work before moving on to testing.

5 SET UP AND OPERATION

5.1 DC Power

Carefully inspect your assembled Minisynth for solder bridges and correct component orientation before applying power. A +12v supply capable of delivering 200mA is required to power the Minisynth. The DC power connector connections are shown below.

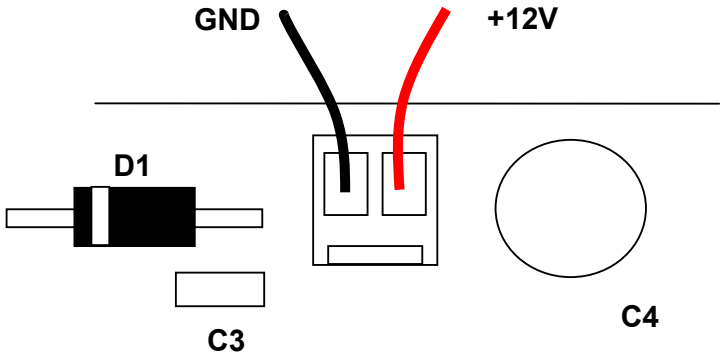


Fig.4 *DC power connection*

If the LCD is blank after power up, turn the contrast pot through its range. If the contrast is set too low, no text will be visible.

5.2 Control Connections

The encoder and external controls are connected to the CONTROL header as shown below. Where an optical or magnetic encoder is used, and auxiliary power connector is provided to supply the encoder's logic.

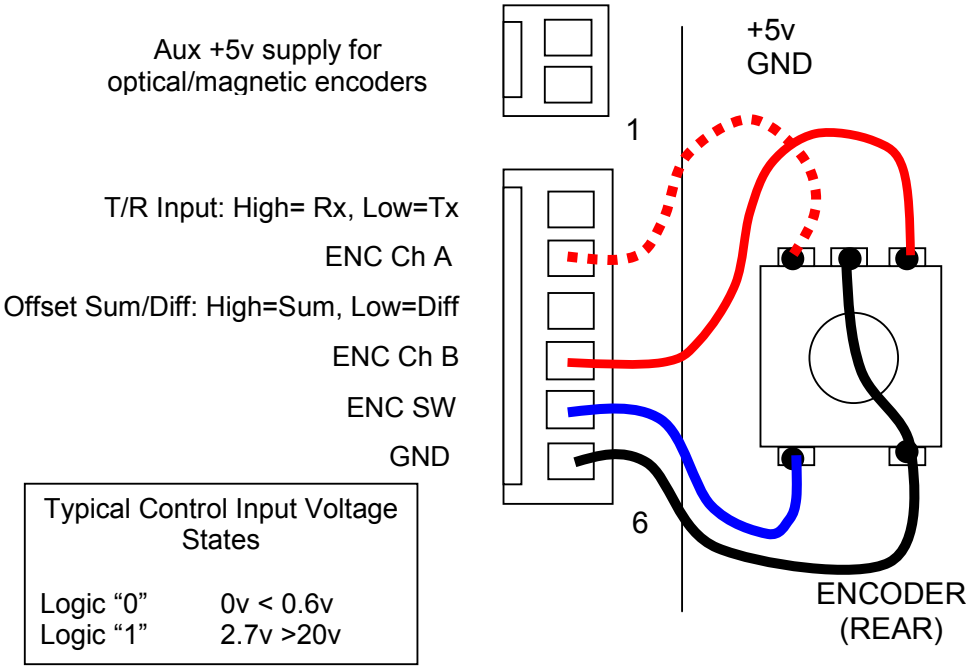


Fig.5 *Control connections*

5.3 Configuration

The Minisynth is easily configured to suit most applications through the front panel controls. This allows changes to be made to the configuration whilst the Minisynth is installed in a piece of equipment. The configuration menus are accessed and navigated through using the three front panel push buttons. The functions of these buttons in set Up mode is shown in **Fig.6**. To enter configuration mode, press the SEL button when the initial "Cumbria Designs" message is shown during power up. The display will clear and show the message "Set Up" for about two seconds before entering the top menu option. To navigate through the menus use the "Up/Down" buttons. To enter a menu, press the "Select" button. Depending upon the menu item, changes may be made with the Up/Down buttons and the encoder. To save a change and exit a menu item, press the "Select" button. The chart in Fig.7 shows the

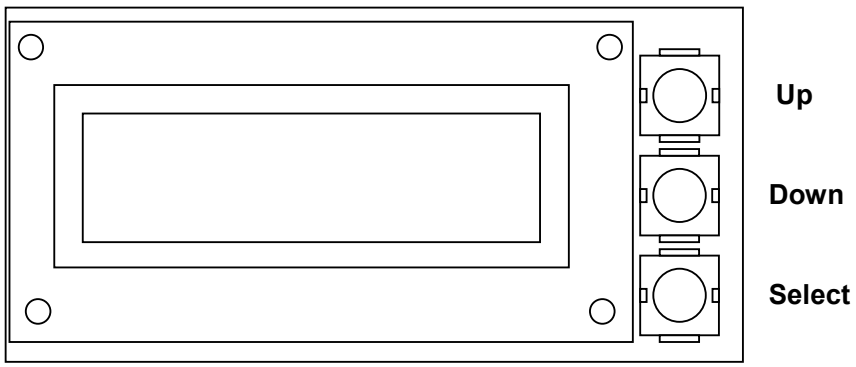


Fig.6 *Button functions in "Set Up" mode*

menu structure and actions needed to change the various options. The configuration process is quite intuitive and with a little practise becomes very familiar and easy to

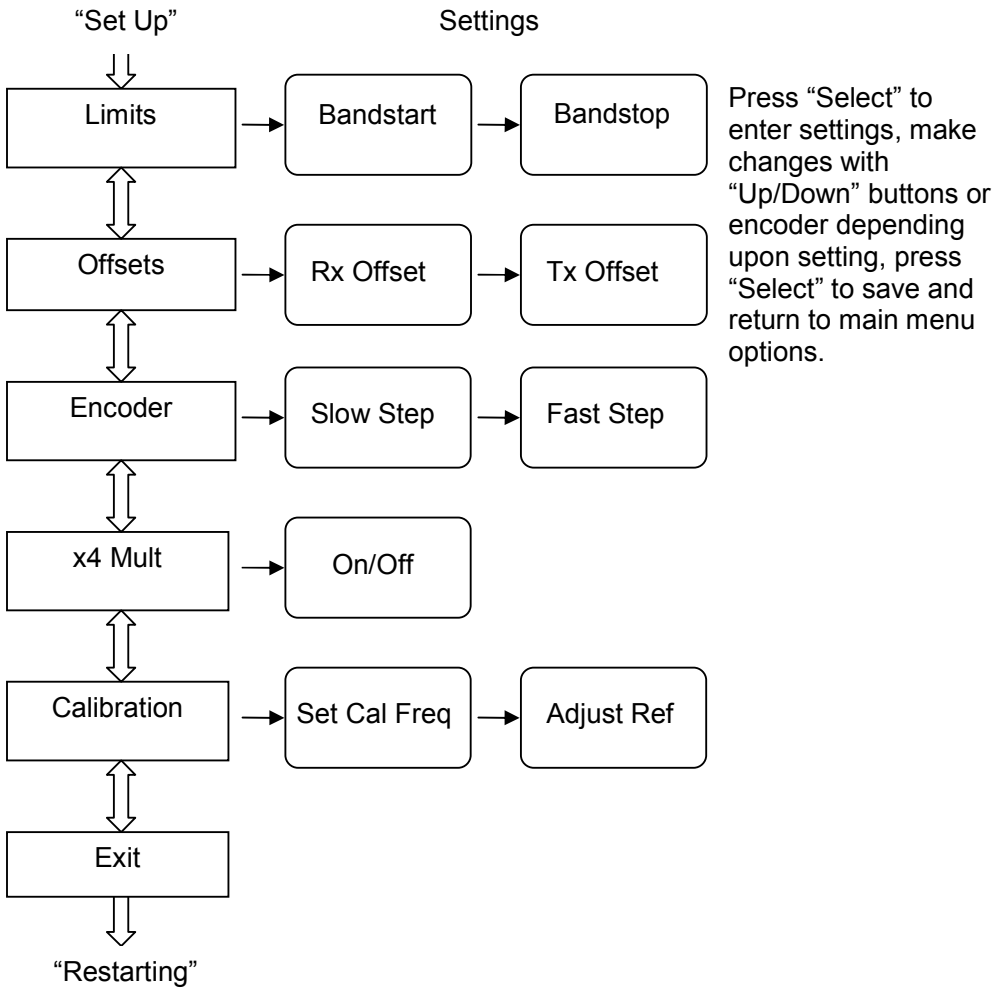


Fig.7 *Configuration Menu and Settings*

use. All settings are saved to EEPROM, upon exiting the Set Up menus, the processor will re-start and load the new settings. Thereafter the settings will be loaded upon power on of the Minisynth.

5.4 Configuration Settings

5.4.1 Limits

Purpose. Sets the Band Start and Band Stop frequencies to define the synthesiser operating range.

Operation. Press "Select" to enter "Band Start". Use the encoder to change the displayed frequency. For very fast tuning press and release the "Up" button. To return to normal tuning rates, briefly press the encoder switch. Press "Select" to save and exit Band Start and enter Band Stop. After adjustment, press "Select to save the settings and return to the main menu.

5.4.2 Offsets

Purpose. Sets the receive and transmit IF Offset values.

Operation. Press “Select” to enter “Rx Offset”. Use the encoder to change the displayed frequency. For very fast tuning, press and release the “Up” button. To return to normal tuning rates, briefly press the encoder switch. Press “Select” to save and exit Rx Offset and enter Tx Offset. After adjustment, press “Select to save the settings and return to the main menu.

5.4.3 Encoder

Purpose. Sets the rotary encoder fixed step sizes.

Operation. Press “Select” to enter “Slow Step”. Use the encoder to change the step size.

5.4.4 x4 Mult

Purpose. Toggle between x1 and x4 output frequency modes. The x4 mode is provided to drive quadrature mixers. In this mode the maximum usable displayed operating frequency will be around 50MHz (200MHz/4). This limit is set by the DSPLL architecture of the Si570 and will vary between devices.

Operation. Press “Select” to display the current operating mode, use the “Up” or “Down” buttons to toggle between x1 and x4. Press “Select” to save the settings and return to the main menu.

5.4.5 Calibration

Purpose. Allow fine adjustment of the Si570 frequency algorithm to set the output frequency against a defined standard. The calibration mode is designed to be used whilst the Minisynth is installed a transceiver and hence the respective IF offsets will be applied to the output frequency.

Operation. Press “Select” to enter calibration mode and display the calibration frequency. Use the encoder to change the calibration frequency to the desired standard. (Note. Remember that the respective IF offset will also be applied!). Press “Select” to save the calibration frequency and using a frequency counter or received frequency standard, use the encoder to change the software reference to bring the output onto frequency. Press “Select” to save the new reference value which wil be displayed on the LCD. Press “Select” to exit calibration and return to the main menu.

5.4.6 Exit

Purpose. Save all settings, exit the configuration mode and restart the Minisynth using the new settings.

Operation. Press “Select” to exit. The message “Restarting” will be displayed indicating that the Minisynth is reconfiguring itself with the saved settings.

5.5 Operation

5.5.1 Buttons

The operational controls are shown in **Fig. 8** The three front panel buttons provide Split, Reverse Split and Tuning Lock. All buttons have a toggle operation. Changes may only be made whilst the Minsynth is in the receive state (Tx/Rx input high). Pressing “SPL” saves the current frequency which will be used during Tx and allows the receive frequency to be changed. Pressing “REV” swaps the stored Rx and Tx frequencies.

The “LOCK” button prevents the set frequency from being changed by the encoder.

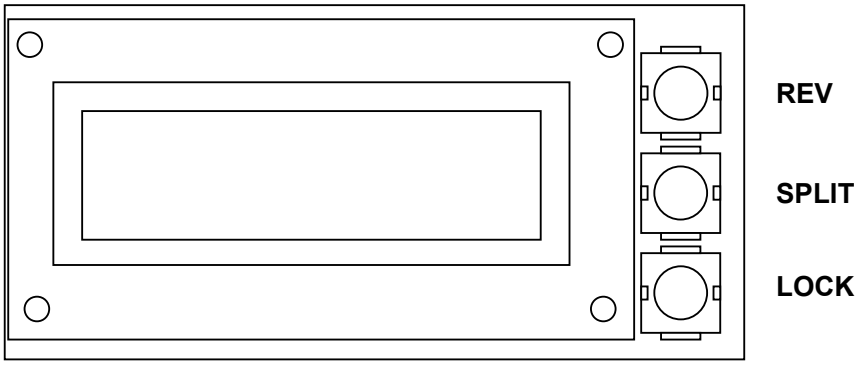


Fig.8 *Button functions in “Operating” mode*

5.5.2 Encoder

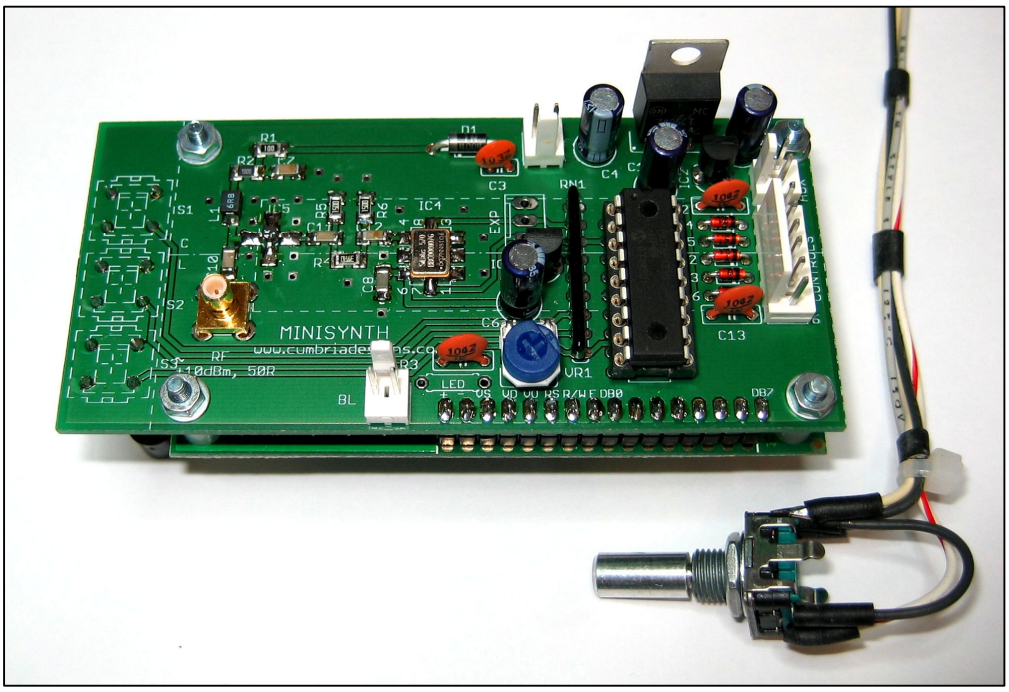
The rotary encoder is turned to change frequency. The size of the frequency change produced by each step of the encoder is set by the tuning mode and the step sizes defined during “Set Up”.

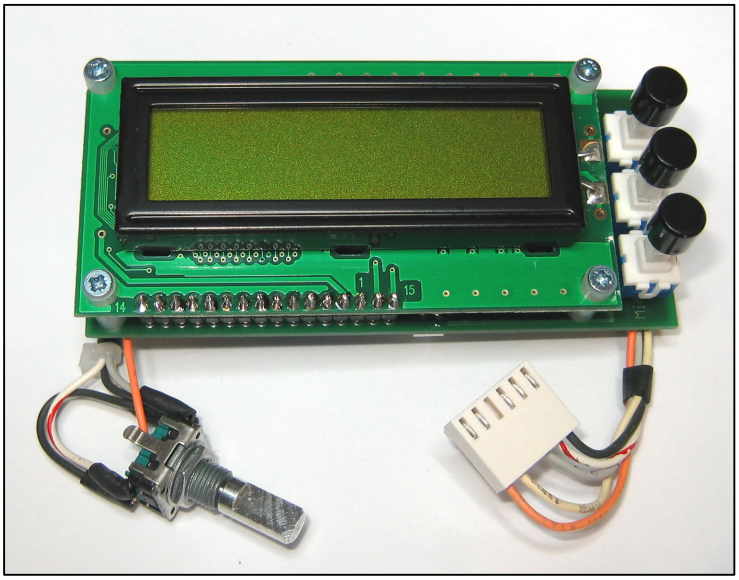
Linear Tuning “LIN” To toggle between the fast and slow step sizes, the encoder shaft is pressed briefly to operate the encoder push switch. The selected fixed tuning rate will be displayed on the LCD.

Variable Rate Tuning “VAR” In addition to fixed rate tuning the encoder provides the option to select variable rate tuning. In this tuning mode, the step size is variable and is set by the speed of rotation of the encoder. This feature is useful for quickly tuning across a band. To enter variable rate tuning, press and hold the encoder for about 1 second. The linear “LIN” mode indicator on the LCD will change to “VAR” indicating that variable rate tuning has been engaged. To return to LIN mode, press and hold the encoder again for about 1 second.

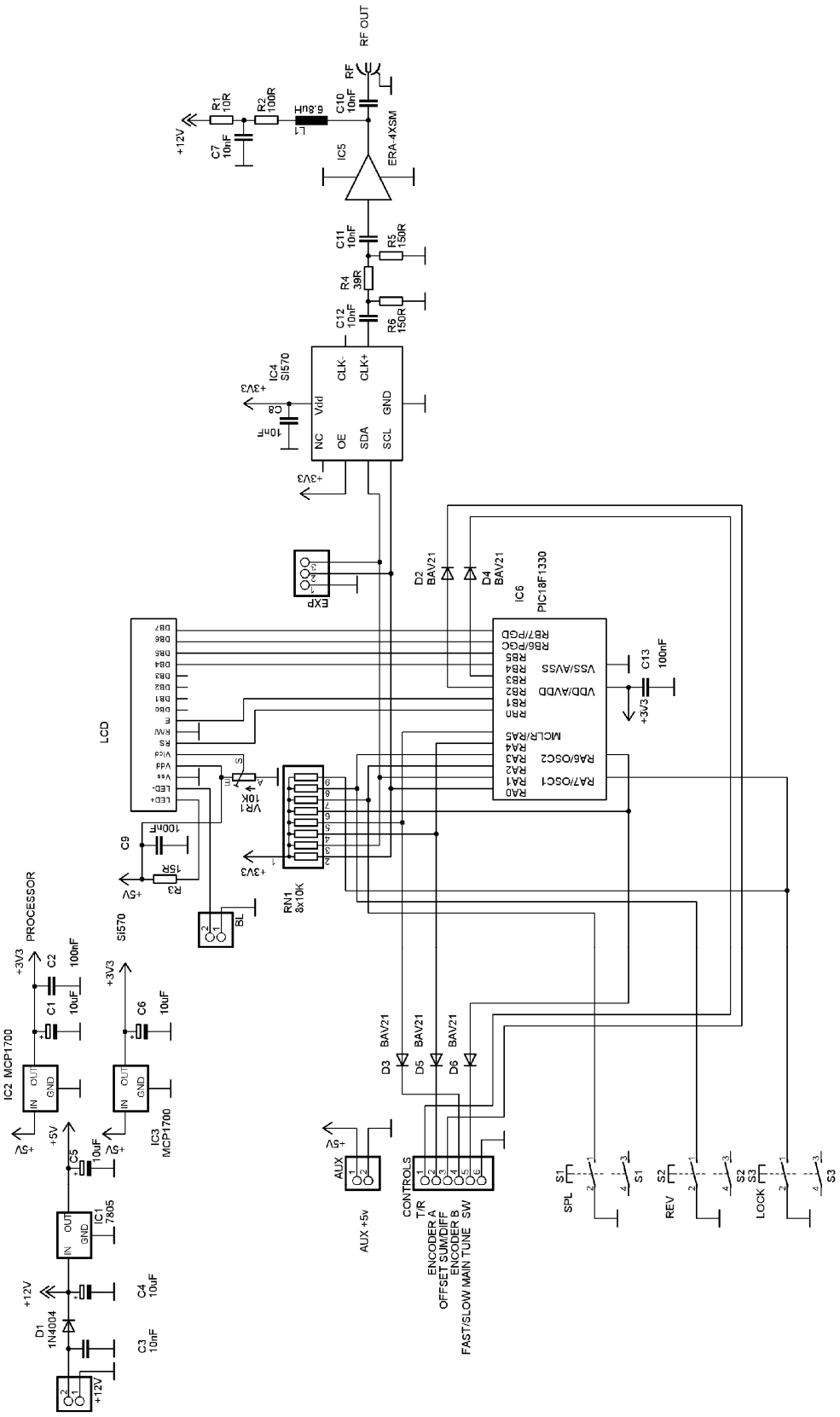
Band Spread Tuning A 250kHz tuning rate is provided to allow easy tuning across large frequency spans. A typical application for this would be during use as a general coverage VFO. To engage Band Spread tuning, press and release “LOCK” and briefly press the encoder shaft. The coarse tuning step will now be applied. To return to normal tuning, briefly press and release the encoder shaft.

The Assembled Kit

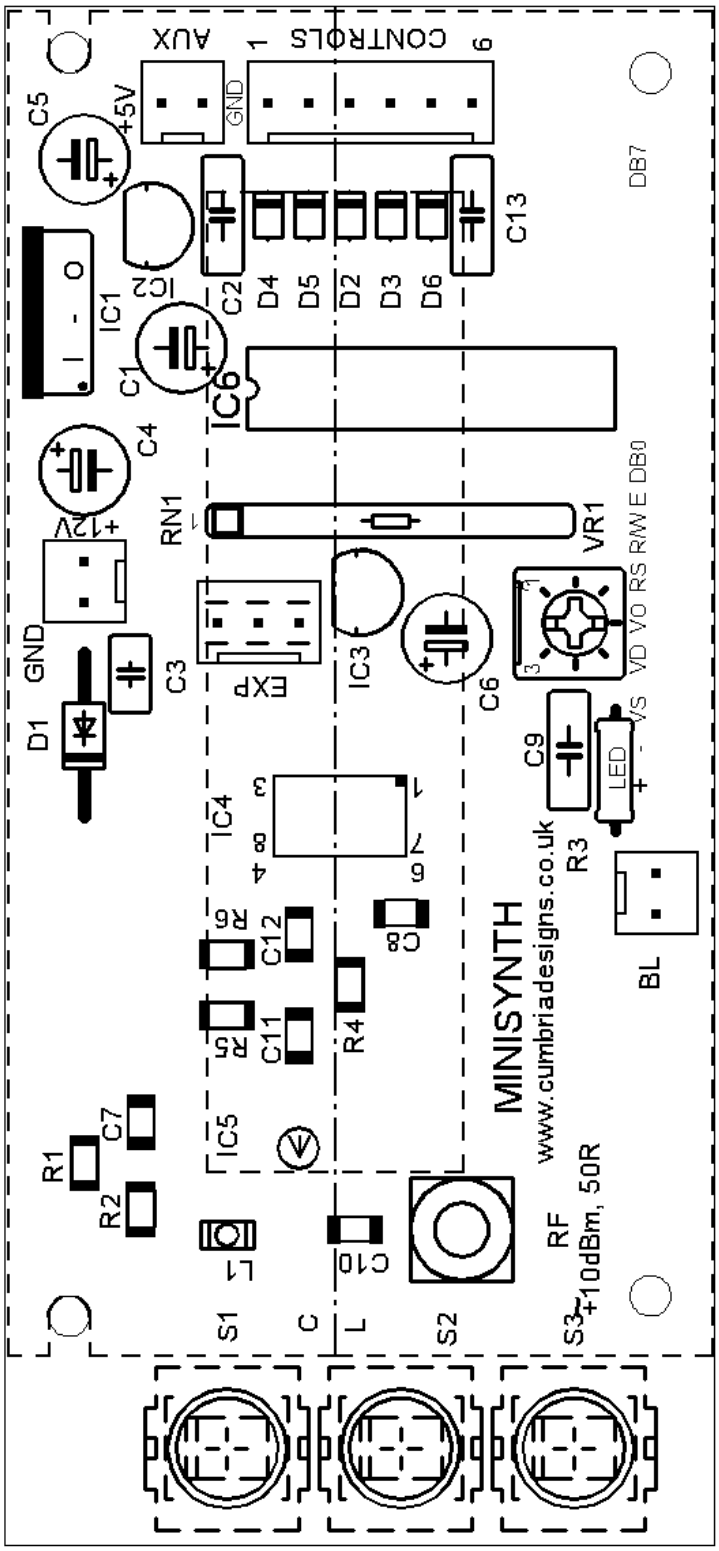




Appendix A Minisynth Schematic



Appendix B Minisynth Component Overlay



Appendix C Minisynth Version 1.0 Parts List

Resistors

1	10R	SMD	R1
1	15R	Through Hole	R3
1	39R	SMD	R4
1	100R	SMD	R2
2	150R	SMD	R5, R6
1	8x10K	SIL	RN1

Poteniometer

1	10K	Cermet Trimmer	VR1

Capacitors

1	10nF	Disk Ceramic	Through Hole	C3
5	10nF	1206 Ceramic	SMD	C7, C8, C10, C11, C12
4	10uF	Electrolytic	Through Hole	C1, C4, C5, C6
3	100nF	Disk Ceramic	Through Hole	C2, C9, C13

Inductor

1	6.8uH	Choke	SMD	L1

Semiconductors

1	1N4004	Silicon Diode	D1
5	BAV21	Silicon Diode	D2, D3, D4, D5, D6
1	ERA-4XSM	MMIC Amplifier, SMD	IC5
2	MCP1700	Voltage Regulator 3v3 TO92	IC2, IC3
1	7805	Voltage Regulator 5v TO220	IC1
1	SI570	Programmable Oscillator SMD	IC4
1	PIC18F1330	Microprocessor	IC6
1	LCD	16x2 BL LCD module	LCD

Connectors and Switches

1	SMA Socket	RF
1	SMA Clamp Plug	RF
3	Header 2 way	+12V, AUX, BL
3	Crimp Shells 2 way	
1	Header 6 way	CONTROLS
1	Crimp Shell 6 way	
12	Crimp Pins	
3	PVA1 Push Switch	S1, S2, S3
3	Switch Caps	
1	Rotary Encoder	

Miscellaneous

Minisynth PCB
Hardware Pack

END

NOTES