

DDS VFO



CONSTRUCTION MANUAL

 www.ozQRP.com

Important

Please read before starting assembly

STATIC PRECAUTION

The DDS VFO kit contains the following components which can be damaged by static discharge:

- **The DDS chip which is pre-soldered to the PCB and shipped in an anti-static bag.**
- **The microcontroller which is pre-programmed and shipped in an anti-static bag.**

Do not remove the devices from their protective anti-static bags until you have taken precautions against static discharge.

- **If possible use an anti-static wrist strap and conductive mat. These can be purchased readily from electronic retailers.**
- **If these are not available then at least ensure you have discharged yourself by touching an earthed metal surface.**
- **Try not to directly touch the pins of the devices.**
- **Ensure your soldering iron has an earthed tip.**

Contents

1	Introduction.....	4
2	Circuit Description	5
3	Parts List.....	7
4	Construction.....	8
4.1	General.....	8
4.2	Construction Steps.....	8
5	Testing.....	11
6	Configuration.....	11
6.1	Understanding options	11
6.2	Procedure	12
7	Operation.....	13
8	Options	14

List of Figures

Figure 1	Circuit diagram.....	6
Figure 2	Component overlay	10
Figure 3	Typical LCD operating display	13

1 INTRODUCTION

The DDS VFO is designed as a companion for the MST transceiver board although it could be used with most other Superhet or Direct Conversion radios. It is simple to use having only one control yet offers many advanced features. A short form kit is available containing a PCB with the DDS chip already loaded as well as the hard to get parts. You only need to add a few inexpensive components and an hour or so of time and your new DDS VFO is ready to go.

DDS VFO Features:

1. Stable frequency – no more drift!
2. Simple to operate using a single rotary encoder control with press button switch.
3. Bright 16 character by 2 line LCD display. Can also be used with a non-backlight display to reduce current consumption if needed.
4. Output frequency range of 1MHz to 10MHz.
5. Selectable 1KHz, 100Hz or 10Hz frequency steps.
6. Tuning lock control.
7. Displays power supply voltage.
8. Programmable IF frequency. Ensures the displayed frequency is the same as the transmitted frequency.
9. Programmable IF offsets:
 - Minus – DDS output frequency is the IF frequency minus the displayed frequency.
 - Plus - DDS output frequency is the IF frequency plus the displayed frequency.
 - Rev - DDS output frequency is the displayed frequency minus the IF frequency.
 - None – DDS output frequency is the same as the displayed frequency. Used for frequency generator applications or with Direct Conversion receivers.
10. Programmable option to save the current frequency and step into memory. These are re-loaded at power up.
11. Draws only around 80mA at 13.8V DC (with LCD backlight).
12. Spurious outputs at least -45dB.
13. Typically 300mV pk-pk sine wave output (200 ohms).
14. High quality double sided PCB with ground plane, plated through holes, solder mask and silk screen.
15. Simple and easy to build using through hole components apart from one SMD chip. To assist constructors the PCB comes shipped with the SMD chip already installed.

PCBs and a range of kits containing hard to get parts for the DDS VFO and the MST SSB transceiver are available from www.ozQRP.com.

2 CIRCUIT DESCRIPTION

Integrated circuit U2 is an Analog Devices AD9834 Direct Digital Synthesis (DDS) chip and forms the heart of the DDS VFO. A 50MHz crystal oscillator module supplies the master clock and gives usable output frequencies up to a quarter of that value or 12.5MHz.

The DDS is controlled by a 3 wire serial data bus from microcontroller U1. The microcontroller is an Atmel ATmega8 and runs an internal 8MHz clock which avoids the use and expense of an external crystal.

A rotary encoder produces quadrature signals when rotated and one line is fed into the microcontroller interrupt input and becomes the reference input. Once an interrupt is detected the state of the other input is read and the direction determined. The rotary encoder also incorporates a press button switch and is used for a number of functions as described later. U1 incorporates pull-up resistors for the encoder inputs so they are normally held high and capacitors C7 and C8 filter out switch bounce.

The microcontroller has an internal analog to digital converter (ADC) which uses the 5 volt rail as a reference. The ADC measures the incoming power supply rail via a resistive attenuator formed with R5 and R6. The calculated value is displayed on the LCD during use. Two other inputs, one analog (A) and the second digital (D), have been included in the PCB layout but are not implemented in the current software release. The PCB also includes an ISP connector to allow future software upgrades without having to remove the chip from its socket.

Most of the remaining pins of U1 are dedicated to driving the LCD in 4 bit mode. R9 sets the backlight current and may be left out if a non-backlight LCD is used. VR1 adjusts the LCD contrast and normally only needs to be set once at the testing stage.

The outputs from the DDS chip are current sources and the output is converted to a voltage by the 200 ohm resistors R12 and R13. The full scale value of the current and hence the pk-pk output voltage is set by the 5.6K ohm resistor R11. The output is passed through a simple 10MHz Butterworth low pass filter to attenuate unwanted high frequency components.

The incoming power supply is regulated to 5V by a 7805 1A regulator which mounts flat on the PCB to act as a heatsink.

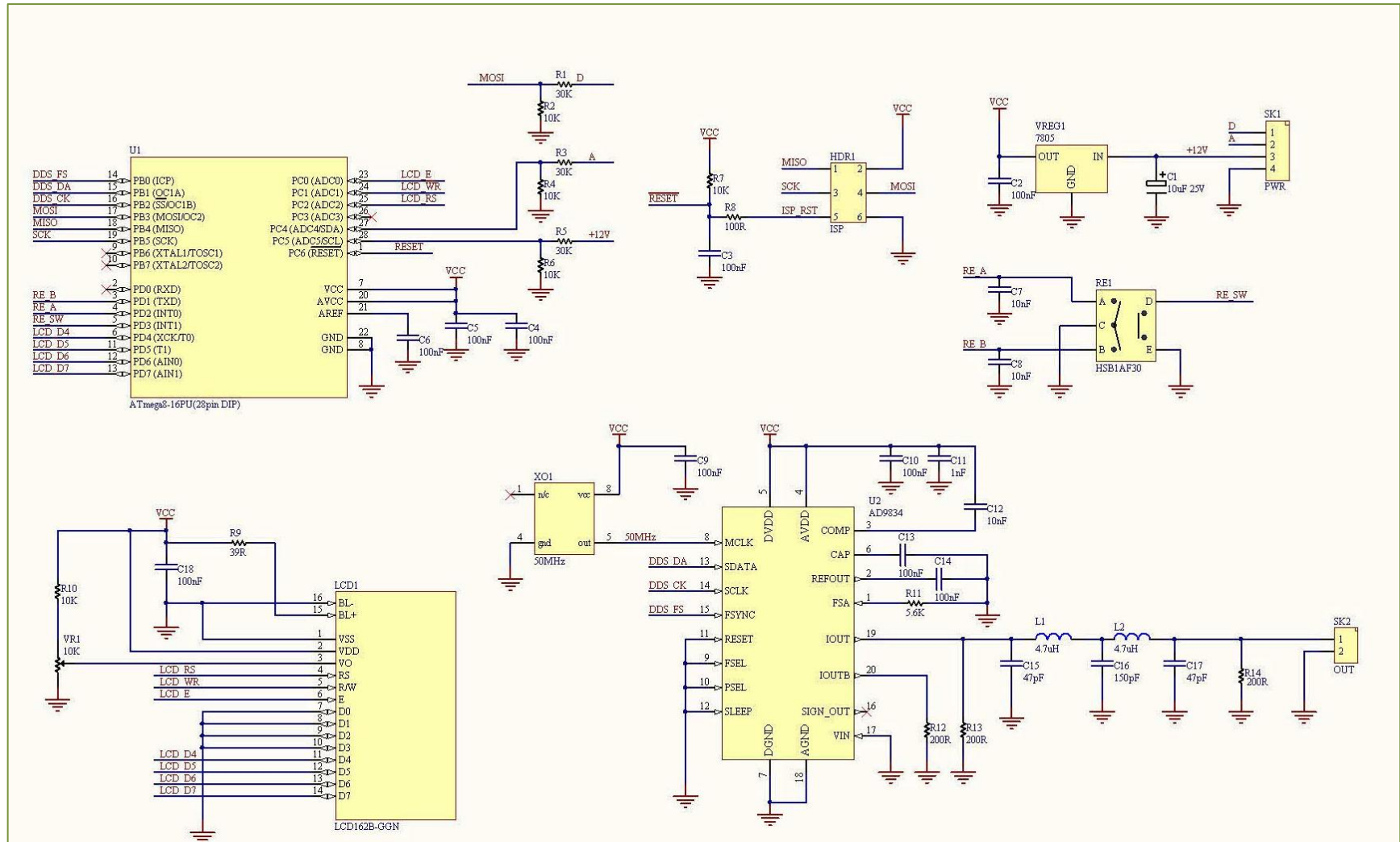


Figure 1 Circuit diagram

3 PARTS LIST

Quantity	Comment	Designator
2	47pF 50V disc ceramic	C15, C17
1	150pF 50V disc ceramic	C16
1	1nF 50V disc ceramic	C11
3	10nF 50V monolithic ceramic	C7, C8, C12
10	100nF 50V monolithic ceramic	C2, C3, C4, C5, C6, C9, C10, C13, C14, C18
1	10uF 25V RB electrolytic	C1
1	39R 1/4W 1% resistor	R9
1	100R 1/4W 1% resistor	R8
3	200R 1/4W 1% resistor	R12, R13, R14
1	5.6K 1/4W 1% resistor	R11
5	10K 1/4W 1% resistor	R2, R4, R6, R7, R10
3	30K 1/4W 1% resistor	R1, R3, R5
1	10K horizontal trimpot	VR1
1	ATmega8-16PU 28pin DIP	U1
1	AD9834BRUZ DDS 20 pin TSSOP	U2
1	7805 5V regulator TO220	VREG1
1	50MHz crystal oscillator module - half size	XO1
1	16 x 2 LCD with backlight. 80mm x 36mm. Winstar WH1602B or equivalent.	LCD1
2	4.7uH moulded RF choke	L1, L2
1	3 pin x 2 row 2.54mm pitch header	HDR1 (ISP)
1	11mm Rotary Encoder. BI Technologies EN11-HSB1AF30 or equivalent	RE1
1	4 pin 2.54mm pitch header RA	SK1 (PWR)
1	2 pin 2.54mm pitch header RA	SK2 (OUT)
4	12mm long 3mm nylon spacer	
4	2.5mm x 20mm screws	
4	2.5mm nuts	
1	16 way SIL male pin header	
1	16 way SIL female pin header	

4 CONSTRUCTION

4.1 GENERAL

The DDS VFO is built on a high quality fiberglass PCB. The PCB is doubled sided with tracks on both sides along with a ground plane. The holes are plated through and so it is not necessary to solder both sides to make connections. To assist construction the component overlay is screen printed on both sides and a solder mask is included to guard against solder bridges.

The ground plane is substantial and can sink quite a bit of heat from low wattage soldering irons so ensure you use a good quality iron that can sustain the power required. You may find that sometimes solder doesn't appear to flow through to the top side. This is not necessarily a problem because the plated through holes make a connection to the top side automatically.

Another point to consider is that plated through holes consume more solder than non-plated holes and makes it more difficult to remove components.

The lesson is to double check the values and orientation of components before installation.

There isn't a 'best' scheme for loading the components, however, the suggested procedure is to load the smaller components first and then work upwards.

4.2 CONSTRUCTION STEPS

Refer to the parts list and Figure 2 when installing the components.

Step 1: Resistors

If in doubt check the values with a multimeter before soldering. Pass the pigtails through from the top and bend out slightly underneath to hold them in place. Turn the PCB over and press down slightly to make them rest against the surface and then solder. Cut off the excess pigtail with side cutters. The trimpot can also be installed at this stage. R14 is not used.

Step 2: RF chokes

These are not polarized and can go in either way. Make sure they sit flat against the board before soldering.

Step 3: Capacitors

Install the capacitors with minimal lead length. The electrolytic is the only polarized capacitor and the positive lead points towards the edge of the PCB.

Step 4: IC socket

The IC socket is installed next with the notch facing the right side of the PCB.

Step 5: Crystal oscillator module

Ensure pin 1 of the oscillator module faces the bottom left of the PCB.

Step 6: 5 volt regulator

The regulator lays flat against the PCB so needs the leads bent at right angle to fit through the holes in the PCB. Insert into the PCB holes and secure with a 3mm screw and nut before soldering the leads.

Step 7: Connectors

The Output connector is a 2 pin right angle header while the Power connector is a 4 pin right angle header. Push them into the PCB so they lay flat against the board and then solder.

The ISP header is an un-shrouded 3 pin x 2 row header and the shorter pins are inserted into the PCB and soldered.

The LCD connector is a 16 way male pin header and is mounted on the reverse side with the short ends of the pins located in the PCB. Ensure it is pushed in completely and solder the end pins first and check it is at right angle to the PCB before soldering the remaining pins.

Step 8: Rotary encoder

The rotary encoder is mounted on the reverse side. Insert into the holes and check that it is at right angle to the board before soldering. It is not necessary to completely fill the mechanical mounting holes in the PCB with solder.

Step 9: Microcontroller

Remove the microcontroller from the bag and insert into the IC socket ensuring pin 1 points to the top right of the PCB towards the contrast control. It may be necessary to squeeze the rows of pins slightly together to get it to fit into the socket.

Step 10: LCD

Solder a 16 way female pin header to the rear side of the LCD PCB.

The LCD can then be mounted onto the DDS VFO and mate with the 16 way male pin header.

Place four 12mm long nylon spacers between the LCD and DDS VFO PCB at each corner and secure the assembly with 2.5mm screws and nuts.

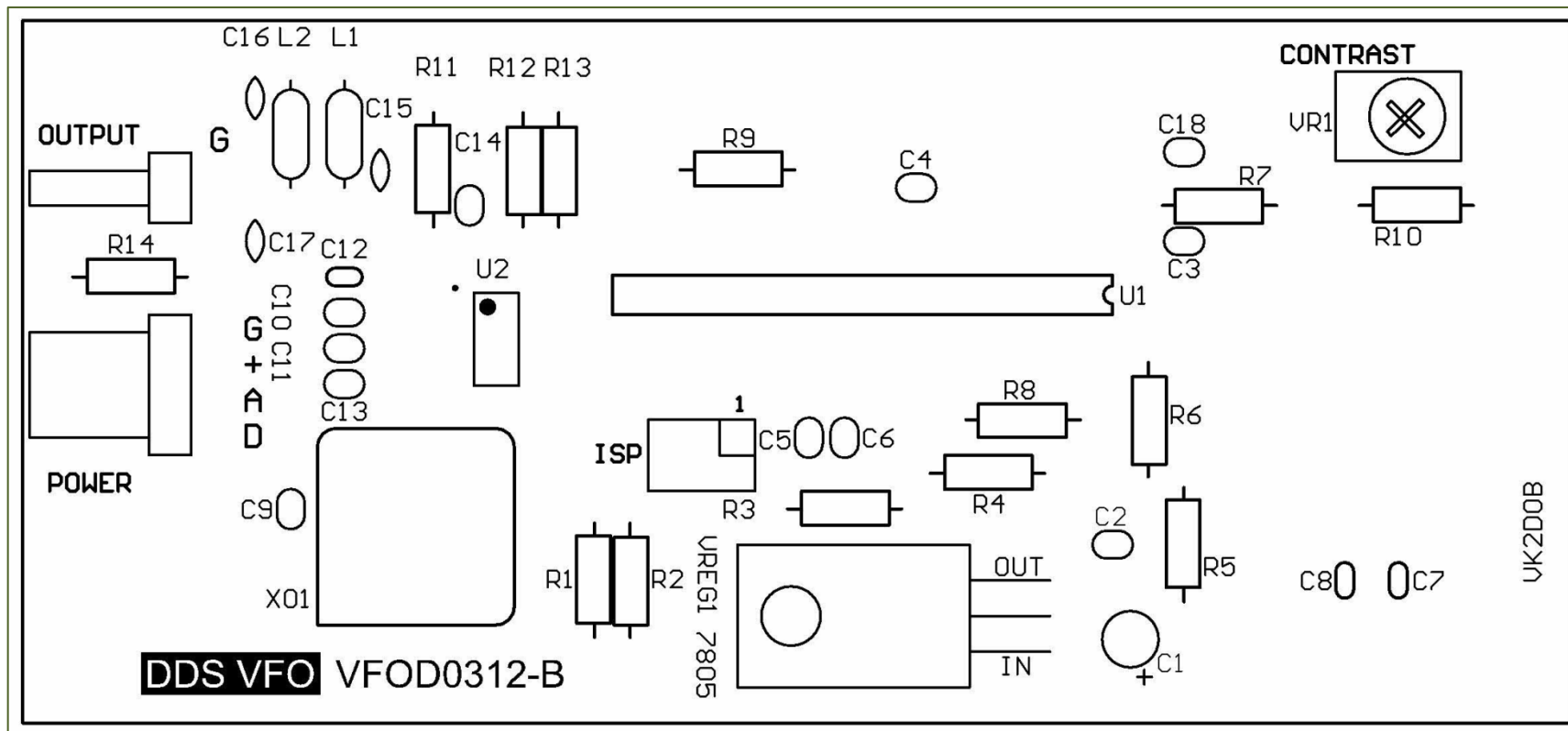


Figure 2 Component overlay

5 TESTING

Before applying power check the board over one more time. Look for solder bridges and components in the wrong way. A moment spent here may save a lot of frustrating time later on.

Once you are satisfied connect the DDS VFO to a power supply between 8 and 15V DC. If the power supply has current limiting set this to about 200mA.

Apply power and check that the LCD backlight turns on. Also check with a multimeter that the output of the regulator is between 4.75 and 5.25V DC. The power supply current should be around 80mA, but this will depend on the exact LCD you have installed and it's backlight characteristics.

If the readings are way outside this range turn off immediately and look for problems.

At this stage you may or may not see anything on the LCD. Adjust the contrast trimpot until the characters are clear and easy to read.

Turn the power off then on again and check that the first thing displayed is the firmware version number. This is then followed by the operating display.

As the DDS VFO has not been configured the LCD will display default settings. These are Transmit frequency of 7.1MHz and a 1KHz Step. The default IF frequency is 10MHz with a Minus offset so using an oscilloscope or a frequency counter verify that the DDS is outputting a 2.9MHz sine wave signal of around 300mV pk-pk.

6 CONFIGURATION

6.1 UNDERSTANDING OPTIONS

IF offset

Consider a transmitter using a Superhet mixing arrangement. The transmit frequency is a result of the IF frequency being mixed with a VFO frequency. If for example the IF carrier frequency is 10MHz and the desired transmit frequency is 7.1MHz then the VFO frequency can be either:

1. $10 - 7.1 = 2.9\text{MHz}$ using a Minus offset
2. $10 + 7.1 = 17.1\text{MHz}$ using a Plus offset

It is important to understand that when the DDS VFO is configured with an IF offset the frequency displayed on the LCD is not equal to the DDS output frequency.

If, however, the VFO DDS is to be used as a general purpose signal generator or with a Direct Conversion receiver, the IF offset can be disabled. In this case the displayed frequency will be the same as the DDS output frequency.

TX frequency

The TX (Transmit) frequency is the initial frequency displayed on the LCD at power up. The VFO DDS firmware uses this value and the IF carrier frequency as well as the IF offset to compute the actual DDS output frequency.

IF frequency

To generate an accurate output frequency using the equations above, the IF carrier frequency must be measured and the value entered at configuration. If not the displayed frequency may not match the transmit frequency.

30 second frequency save

This option enables the automatic saving of the current frequency and step in EEPROM so that it is recalled the next time the DDS VFO is powered on. This overrides the programmed TX frequency. The EEPROM has a maximum specification of 100,000 write/erase cycles, so to protect it from excessive writes, the save is performed only once per frequency change and only after a 30 second idle period has elapsed. If the encoder is operated so that there is less than 30 seconds between changes no saves will be performed.

6.2 PROCEDURE

To program the IF frequency, the Transmit frequency and the IF offset type use the following procedure:

1. Hold down the encoder button and apply power to the DDS VFO.
2. Wait until the LCD displays Configuration (about 3 seconds) and then release the button.
3. The IF offset screen will be displayed. Pressing the encoder button for less than 1 second will toggle through the options. Once completed press the encoder button for longer than 1 second and release.
4. The IF frequency screen will be displayed and the cursor will be positioned on the 10MHz digit. Rotating the encoder clockwise increments the digit while rotating the encoder anti-clockwise decrements the digit. Pressing the encoder button for less than 1 second will step the cursor onto the next digit. Once completed press the encoder button for longer than 1 second and release. **Note that if the IF offset has been disabled this screen will be bypassed as it becomes irrelevant.**
5. The Transmit frequency screen will be displayed and the cursor will be positioned on the 10MHz digit. Rotating the encoder clockwise increments the digit while rotating the encoder anti-clockwise decrements the digit. Pressing the encoder button for less than 1 second will step the cursor onto the next digit. Once completed press the encoder button for longer than 1 second and release.
6. The 30 second save frequency screen will be displayed. Pressing the encoder button for less than 1 second will toggle between the Yes and No options. Once completed press the encoder button for longer than 1 second and release.
7. The DDS VFO will then store the values in non-volatile memory and return to normal operation.

7 OPERATION

Power on

When the DDS VFO is powered on the version number is displayed briefly. This is followed by the operating display shown in Figure 3.

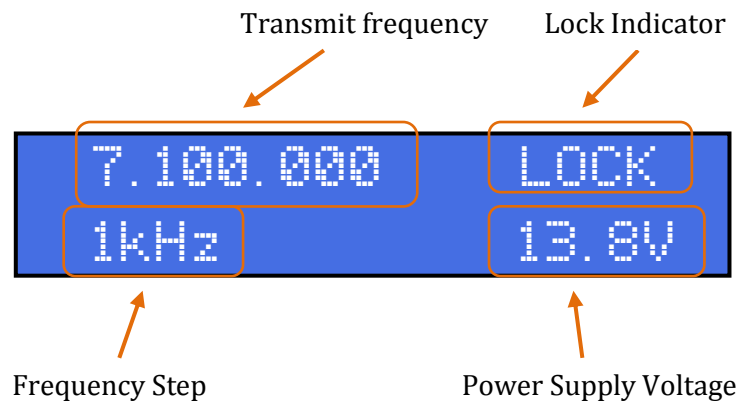


Figure 3 Typical LCD operating display

Tuning

To tune the DDS VFO rotate the encoder clockwise to raise the frequency and counter-clockwise to lower the frequency. The frequency will change by an amount equal to the Step value.

Frequency steps

To change the current frequency step press the encoder push button for less than 1 second and release. Each press cycles through the available steps which are 1KHz, 100HZ and 10Hz.

Tuning Lock

To lock the encoder from changing frequency press the encoder push button for more than 1 second. A lock message will be displayed on the upper right of the LCD.

To unlock press the encoder push button for less than 1 second.

Voltage Display

The power supply voltage is displayed in the lower right hand side of the LCD. This is updated every 500mS. If the voltage falls below 8V a low voltage warning message is displayed to indicate the power supply is too low for proper operation.

8 OPTIONS

LCD

The DDS VFO operates best with a backlit display. The characters are bright and clear and readable in dim environments. The backlight does consume extra current and if minimizing current consumption is a priority then a non-backlit LCD can be used instead. In this case resistor R9 can be left off the board, although leaving it in will not cause any issues.

If an LCD with backlight is used, but is not the same as listed in the parts list, the backlight may require a different value of current limiting resistor. Check the LCD data sheet before applying power to determine the correct resistor value and change R9 if needed.

A non-backlit display will also not be as deep and this needs to be taken into account when mounting to the front panel.

Additional inputs

The PCB includes two additional inputs. One is intended to measure an analog voltage and the other is configured as a digital input. Both are able to handle a voltage between 0 and 20V DC maximum. The current firmware release does not utilize these inputs and so when making the 4 pin power cable these pins can be left unterminated.

Firmware upgrades

The PCB contains a functioning 6 pin ISP header to allow future firmware upgrades.