Atlas 210X/215X
Si5351 VFO

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I. OVERVIEW

Atlas Radio HF transceivers were produced from the mid to late 70s. Available models included the 180 and the 200 series of 210/215, 210X/215X, and 210X/215X LE. In a separate Atlas engineering document, a number of fixes, mods, and changes have been provided that improve the overall operation of these radios. One area of marginal performance is the factory analog VFO. Replacing this VFO with a digital unit represents a significant modification to the radio, but the change is not difficult to perform and the cost is minimal when one considers the tremendous improvement in the overall operation of the radio.

All of the Atlas radio models used the same basic VFO design, with the oscillator frequency range being changed for each band via different LC combinations. This design removed the need for a heterodyne mixing oscillator and reduced the overall cost of the radio. The downside was that the VFO was never very stable, even when new from the factory. It was also difficult to get better than 1 KHz frequency accuracy when trying a move to a specific frequency. During a 30 minute warm up, the drift was somewhere between 1 to 2 KHz. There is also a 100 to 300 Hz drift throughout the day after the radio has been warmed up. The VFO output signal also had very strong 2nd and 3rd harmonics, which degraded the performance of the receiver.

The Atlas radios have a different frequency range for each of the five ham bands. In theory, the band with the highest VFO frequency (10M) would have the most drift, but there have been some cases where a lower band had the most drift. The mechanical design of the VFO plays a major role in the resulting drift. This is due to the mechanical switching of frequency capacitors and coils in changing bands. On the Atlas assembly line, the assemblers would measure the drift on each band and install the appropriate temperature compensating ceramic disc capacitors to counter-act the drift. I am not sure of the amount of drift on a brand new radio, but as mentioned earlier, most of the 40+ year old units have quite a bit of drift.

Installation of a digital VFO greatly reduces the amount of drift. On my particular radio, with a digital VFO, I have a warm-up drift of about 10 Hz during the first 15 minutes. Over the course of 24 hours, the drift is no more than +/- 5 Hz.

Installing a digital VFO involves removing all existing parts associated with the analog VFO. This frees up a large amount of space inside the VFO compartment. Two band switch wafers are freed up inside the VFO compartment. There are two sets of switched contacts on each wafer. One set of switched contacts will be used to change the band of the digital VFO. Two sets of switched contacts are used for switching the appropriate low pass filter for the band being used.

There are a large number of different digital chips that can be used in a VFO. This includes the AD9834, AD9850, AD9951, Si570, and the Si5351. There are even a larger number of Web sites that sell various digital VFO kits. The following considerations were taken into account in arriving upon which particular digital chip to use:

Phase noise
Generated spurs
Generated harmonics
Available output signal drive level
Low cost

The ADxxxx chips produce excellent VFO sine wave signals, have very low phase noise, and are very stable. The one negative is that they result in a large number of receiver spurs on the 15M and 10M bands of the Atlas radios. The Si570 chip works well with the Atlas radio, but the chip is difficult to find at a reasonable cost. SDR Kits offered a Si570 VFO kit, but that kit has been discontinued. The Si5351 chip works almost as good as the Si570 and is low in cost. The chip has a large number of even/odd order harmonics. This problem is resolved by using good low pass filtering in the output of the VFO.

Be sure to read the Tech Tips section in the Appendix before starting the VFO build.

A. Audience

This document is written for Atlas radio owners that want an accurate frequency display, along with a very stable VFO. A moderate set of technical skills is needed to perform the needed changes. The author is in his late 70s, has not so good close-in vision, etc. but was able to make the changes without any problems. Some SMD part soldering is needed on the main VFO circuit board. The time required for this assembly is not more than 6 - 8 hours. If one approaches the project with a systematic construction plan, then one should be successful in ending up with a fully functioning radio.

B. Objectives

This document provides details on how to build an internal VFO that is very stable and provides a very accurate frequency display. The design goals were to:

Provide a detailed step-by-step process for building an internal digital VFO.
Provide detailed engineering drawings that will remove confusion on how the radio should be modified.
Provide testing results of the installation.

C. Options

A bare bones implementation of the VFO would include the Si5351 VFO and a 12 meter low pass filter. I have not completed any extensive testing with the bare bones setup and the Atlas receiver appears to work the same as a factory radio. One can build the bare-bones package and then update with the additional filters at a later date.

1. Low Pass Filter options:

Single QRP Labs 12M low pass filter
QRP Labs low pass filters on a custom mounting board (3 filters)
Mini-Circuits PLP-xx low pass filters on a custom mounting board (3 filters)

The MCL PLP-xx filters provided the best response curves with minimal leak through around the filters. The QRP Labs filters will also work, but the response curves are degraded about 10 to 20 dB in the upper frequency ranges as a result of signal leak through around the filters.

The following low pass filters were used:

80M/20M	QRP Labs 30M filter or MCL PLP-10.7
40M/15M	QRP Labs 20M filter or MCL PLP-15
10M	QRP Labs 12M filter or MCL PLP-30

2. Si5351 VFO Output Signal

The output signal of the VFO board, after passing through a low pass filter, is about +11 dB in level. That is the right signal level for feeding the Atlas receiver mixer. That is OK if the attached load is a pure 50 ohms. In the Atlas radio, the load varies in impedance, depending upon the band being used. On the 15M and 10M bands, the output signal can be as low as +5 dB with the factory VFO.

The fix is to provide a constant 50 ohms load on all bands by using a MMIC amplifier. The VFO circuit board includes a Mini Circuits GALI-6 MMIC chip amplifier. Using the resistor values shown on the schematic, the output signal is about +11.3 dB on all bands, as measured on the SMA jack of the VFO box.

II. SPECIFICATIONS

If one is unsure about modifying their Atlas radio, then an external VFO can be built and attached to the radio via the Accessory Socket on the rear of the radio. If one is comfortable with the operation of the VFO, then the VFO module can be installed inside the Atlas radio.

Here is a summary of the specs for the VFO:

Minimal cost
Code modification to select Atlas radio model – 180, 210X or 215X
Code modification to select Atlas IF frequency – 5520 KHz or 5645 KHz
About 240 ma current draw, including back-lighted TFT display

The following sections on the VFO board are connectorized:
DC power to circuit board
ESP-32 microprocessor
QRP Labs Si5351 module
5.0 volt regulator
TFT Display
Optical Rotary Encoder

Five memory channels on each band
Frequency Lock
Uses existing Atlas front panel frequency display window
Supports standard color TFT 170x320 display
+11.3 dbm output signal
With 1 KHz frequency step tuning – 50 KHz change per frequency control rotation
Frequency step increment selected via momentary push of toggle switch on front panel
Frequency steps of 10 Hz, 100 Hz, 500 Hz, 1 KHz, and 10 KHz
Works with standard Bourns or Oak Grigsby optical encoders
Uses freed up contacts on the Atlas band switch control to change VFO frequency band and low pass filter
LSB/USB toggle for changing display frequency when shifting sidebands of the Atlas carrier oscillator
Plus IF shift for 80/40M and – Minus IF shift for 20/15/10M
10 Hz drift after a 15 minute warmup – less than 5 Hz drift over the next 24 hours
Minimal number of spurs on all bands – especially on 15M and 10M

Power Supply Dissipation with 11.7 volts supply from Atlas power rail:

9 V regulator	0.5 watts	power to 3.3 V and 5 V voltage regulators and R5
5 V regulator	0.2 watts	power to Si5351 oscillator board
3.3 V regulator	0.6 watts	power to ESP-32, TFT display, & optical encoder
R5	0.3 watts	power to GALI-6 MMIC

III. Project Description

A. Mini-Project Tasks

The project can be divided into the following mini-projects:

Procure Parts
Machine die cast aluminum enclosure
Build QRP Labs Si5351 Oscillator
Fabricate Wiring Harness
Program ESP-32
Build Si5351 VFO Assembly
Initial testing
Remove factory VFO
S-Meter Lighting Upgrade
Build Low Pass Filters
Final Installation and Testing

B. Parts Procurement

In order to get needed parts for the project, you will need to place several different orders. Parts can be obtained from AliExpress, Amazon, eBay, Jameco, Mouser, etc. The total cost for parts is less than $185 if you can buy in single lot quantities. It you take advantage of the parts kit offered by the author, then the total cost is about $135.

Here is a picture of the major components used in the project:

Printed Circuit Boards
VFO board
Low Pass Filter Board
Atlas 210X/215X standard front panel labels (3 boards)
Atlas 210X/215X LE front panel labels (2 boards)
TFT Display Mounting Bracket

1/8" End Mill
A four flute end mill is needed for the milling machine or a drill press.
https://www.amazon.com/gp/product/B0D52ZY59S/ref=ppx_yo_dt_b_asin_title_o00_s00?ie=UTF8&psc=1

ESP-32 Microprocessor board
https://www.aliexpress.us/item/2251832791060787.html?spm=a2g0o.order_list.order_list_main.10.73d71802FGFiyW&gatewayAdapt=glo2usa

TFT Color 170x320 1.90" Display
https://www.aliexpress.us/item/3256805935800579.html?spm=a2g0o.order_list.order_list_main.35.20621802lIiJvW&gatewayAdapt=glo2usa

SMA Female Chassis Bulkhead Mount
10pcs SMA Female Jack Bulkhead Nut Surface Connector Solder Panel Mount RF Coaxial Brass 50ohm Wire Terminals Straight New - AliExpress 13

Hammond 1590A Clone die cast aluminum enclosure
Here are the specs for the Hammond case:
http://www.hammondmfg.com/pdf/1590A.pdf

https://www.aliexpress.us/item/3256802438032687.html?spm=a2g0o.order_list.order_list_main.55.3d571802V9lNu1&gatewayAdapt=glo2usa

AMS-1117 5 volt voltage regulator
1/5/10PCS AMS1117 3.3V 5V DC-DC Step-Down power supply module AMS1117-5.0V Power Buck module AMS1117-3.3V LDO 800MA - AliExpress 502

AMS-1117 3.3. volt voltage regulator
Amazon.com: AMS1117-3.3 DC 4.75V-12V to 3.3V Voltage Regulator Down Power Supply Buck 800mA Module 3Pin 20pcs : Electronics

Here is a link that gives the specs for the 3.3 volt and 5 volt regulator chips:
http://www.advanced-monolithic.com/pdf/ds1117.pdf

78M09 9 volt SMD voltage regulator
10pcs/lot L78M05CDT L78M05 TO-252 78M06 78M08 78M09 78M12 78M15 79M05 - AliExpress 502

Resistor – through hole 1/2 watt
56 ohm
https://www.aliexpress.us/item/3256805535539702.html?spm=a2g0o.order_list.order_list_main.55.5b671802yccQDs&gatewayAdapt=glo2usa

Resistors – through hole 1/4 watt
220 ohm
560 ohm band-switch resistor
820 ohm band-switch resistor
1K ohm band-switch resistor
1.1K ohm 2 each - band-switch resistor
2.2K ohm 5 each
3.6K ohm band-switch resistor
4.7K ohm
10K ohm
100pcs 1/4W 1R~22M 1% Metal film resistor 100R 220R 1K 1.5K 2.2K 4.7K 10K 22K 47K 100K 100 220 1K5 2K2 4K7 ohm resistance - AliExpress 502

Resistors – 1206 SMD
20 ohm
240 ohm 2 each
https://www.aliexpress.us/item/3256803911285437.html?spm=a2g0o.order_detail.order_detail_item.3.5c20f19cGsWJq4&gatewayAdapt=glo2usa

Ceramic disc capacitors – through hole
0.1 uf 50 volt 5 each
0.01 uf 50 volt 6 each
https://www.aliexpress.us/item/3256804674697278.html?spm=a2g0o.order_list.order_list_main.15.21ef18020epeZ5&gatewayAdapt=glo2usa

Ceramic disc capacitors – SMD
0.1 uf 50 volt 1 each
100PCS 1206 104 SMD Capacitor 4.7NF 10NF 22NF 47NF 100NF 220NF 50V 472 103 223 473 224 k/m/z 0.01/0.022/0.047/0.1/0.22/uf Kit - AliExpress 502

Tantalum capacitors – through hole
10 uf 16 volt 3 each
22 uf 16 volt 1 each
100 uf 25 volt 1 each
10PCS Tantalum Capacitor 16V 20V 25V 35V 50V 0.1UF 0.22UF 0.33UF 0.47UF 100UF 220UF 1UF 2.2UF 4.7UF 10UF 15UF 22UF 47UF DIP - AliExpress 502

RF Choke SMD
100 uh 1210
20PCS/LOT 1210 SMD Inductance 2.2/3.3/4.7/10/22/47/100/220/470UH NLV32 3225 Inductor - AliExpress 13

Resettable Fuse – 72 volt 500 ma (Trip point = 1000 ma)
https://www.aliexpress.us/item/3256801635578473.html?spm=a2g0o.order_list.order_list_main.103.46a81802yPc6Ic&gatewayAdapt=glo2usa

SMD Practice Soldering Board
SMD Practice Board SMD Component Soldering Board for Electrical and Electronic Soldering Techniques Soldering Kit - AliExpress 502
1N4001 Diode
100pcs 1N4001 IN4001 Rectifier Diode 1A 50V DO-41 New Original - AliExpress

SPDT Toggle Switch – ON/OFF/OFF – one side momentary ON
10Pcs SH T8014B Standard Lever 3Pin One Side Momentary ON-OFF-MOM SPDT Mini Toggle Switch - AliExpress 13

SPDT Toggle Switch – ON/OFF/OFF – both sides momentary ON
10Pcs T8014A Standard Lever 3Pin Momentary MOM-OFF-MOM Self-Return 3-Position SPDT Mini Toggle Switch - AliExpress 13

Brass Standoffs M2x5 - 4 each
2-50pcs M2 M2.5 m3 m4 m5 m6*L hex brass standoff female to female thread brass spacer length 3mm to 50mm - AliExpress

Bourns Optical Encoder
https://www.ebay.com/itm/295327320682

Oak-Grigsby Optical Encoder (optional)
https://www.ebay.com/itm/284621140106

Machine screw 6-32 x ¼"
Machine screw 6-32 x ½"
https://www.aliexpress.com/p/order/detail.html?spm=a2g0o.order_list.order_list_main.57.231e1802asfahR&orderId=8195846035542839

Machine screw M2x5 Phillip's head - 6 each
Machine screw M2x4 Phillip's head - 4 each
200/ 100/ 50pcs M1 M1.2 M1.4 M1.6 M1.7 M2 M2.5 M3 M3.5 M4 M5 304 Stainless Steel Phillips Cross Recessed Pan Head Screws DIN7985 - AliExpress

Machine screw M2x4 Counter-sunk Phillip's head - 4 each
50PCS M2*3 3.5 4 5 6 8 10 12 16 18 20 25 304 Stainless Steel Cross Phillips Flat Countersunk Head Screw Bolt M2x3 M2x12 M2x25 - AliExpress 13

Machine screw M2.5x4 Phillips Truss head – 2 each
https://www.aliexpress.us/item/3256801978454684.html?spm=a2g0o.order_list.order_list_main.19.600d1802yMXSMp&gatewayAdapt=glo2usa

QRP Labs Si5351 Oscillator with TCXO option
https://www.qrp-labs.com/synth.html

Right Angle Male SMA connector with 5" pigtail RG316
RG-316 15" – one piece
Rg179 Coax|rg316 Sma Male To Male Rf Coaxial Cable - Straight & Right Angle Connectors

Male and female pin headers
20 Pcs 10 Pairs 40 Pin 1x40 Single Row Male And Female 2.54 Breakable Pin Header PCB JST Connector Strip For Arduino DIY Kit - AliExpress 13

Mini Circuits Gali-6 MMIC
https://www.mouser.com/ProductDetail/Mini-Circuits/GALI-6%2B?qs=xZ%2FP%252Ba9zWqb5emXNudX23g%3D%3D

DPDT Slide Switch - 2 each
https://www.ebay.com/itm/333627411530

Ribbon cable multi-colored – 16 wire
30 inches
2Meter 6P/8P/10P/12P/16P/20P/40P 1.27mm PITCH Grey Flat Ribbon Cable 6/8/10/16/20/40 Pin 28AWG WIRE for IDC FC 2.54MM Connector - AliExpress 13

IDC ribbon female cable connector – 16 pin
Idc Connector 10 Female | Idc Female Connector 26 Pin | 34 Pin Female Connector - Connectors - Aliexpress

Internal DC Power Cable – JST XH 2 pin
10Sets 2/3/4/5/6/7/8/9/10 Pin Pitch Male Female Plug Socket JST XH2.54 XH 2.54mm 15cm Wire Length 24AWG Wire Cable Connector - AliExpress 13

External DC Power Cable – JST SM 2 pin
https://www.aliexpress.us/item/2255801107031792.html?spm=a2g0o.order_list.order_list_main.139.6c431802cYTdvP&gatewayAdapt=glo2usa

Terminal Solder Lug M3.2 – 2 each
https://www.aliexpress.us/item/3256804355897571.html?spm=a2g0o.order_list.order_list_main.263.4a681802gWAffK&gatewayAdapt=glo2usa

#24 solid conductor tinned buss wire
https://www.amazon.com/Jameco-Valuepro-3819-100-Hook-up-Tinned-Copper/dp/B00B8866TW?source=ps-sl-shoppingads-lpcontext&ref_=fplfs&psc=1&smid=ATVPDKIKX0DER

Heat Shrink Tubing
https://www.aliexpress.us/item/3256805376954605.html?spm=a2g0o.order_detail.order_detail_item.11.2f8bf19cKsC0HL&gatewayAdapt=glo2usa

1 mm x 2" yellow – RF out and Si5351 jumper
2 mm x 6" black – TFT pin header, encoder, LPF Male Pin Headers, band-switch control leads
2 mm x 2" blue – bottom slide switch
3 mm x 2" yellow – top slide switch
3 mm x 1" red – accessory jack pins
3 mm x 3" black, blue, or yellow – feedthrough cap internal & external ground lug, toggle switches
4 mm x 2" blue - RG316 cable ends
5 mm x 0.5" blue - Feedthrough Cap External
12mm x 0.5" black – encoder

Low pass filter mounting bracket – brass square stock
K&S Engineering 154 – 7/32" square x 1.5" (eBay)

#22 gauge Teflon insulated stranded wire
4" yellow for band-switch jumpers
3" blue, 2" green, and 2" gray – In/Out interface wires to low pass filter board
10" red for DC power wire

FB43-101 Ferrite Bead
https://toroids.info/FB-43-101.php

C. Low Pass Filters

There are a number of different options for procuring the three needed low pass filters. One can design/create their own, purchase kits, or purchase units that are fully assembled. Here are possible sources:

QRP Labs Low Pass Filters - 12M, 20M, & 30M (three kits)
http://qrp-labs.com/lpfkit.html

Mini Circuits Low Pass Filters – PLP-10.7, PLP-15, & PLP-30
http://www.minicircuits.com/products/filters_pic_low.shtml

IV. VFO Front Panel Control Descriptions

There can be up to four controls on the front panel of the 210X/215X Standard/LE radio that can be used to control the operation of the Si5351 VFO.

A. 210X/215X Standard

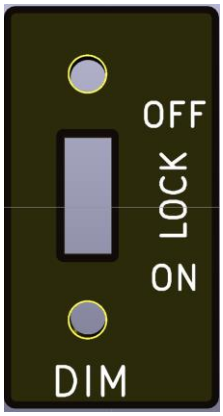
The existing DIM control is a SPST slide switch. This switch can be replaced with a DPST slide switch. One pole would still control the S Meter light brightness. The second pole can be used as a Frequency Lock function. In the up position of the slide switch, the S Meter light would be max brightness and the Frequency would not be locked. In the down position, the S Meter light would be dim and the Frequency would be locked.

A second alternative is to replace the Dim slide switch with a SPDT ON-OFF-ON toggle switch with a momentary ON in only one position. The center of the slide switch hole would need to be drilled out with a 7/32" drill bit so that a toggle switch can be installed. Cycling through the momentary ON position would cycle through the scan options. Scan Mode 1 scans between the three memory frequencies. A second momentary push of the switch goes to Scan Mode 2. In this mode, the frequency scans in 1 KHz increments. Another momentary push turns the scan function off. Placing the toggle switch in the down position would lock the Frequency.

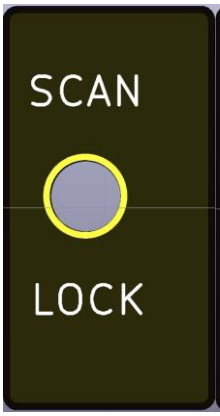
A SPDT toggle switch ON-OFF-ON, with momentary ON, would replace the Dial Set capacitor. Cycling through the up position will cycle through the Frequency Steps. On power up, the step is 1 KHz. Subsequent pushes select 10 KHz, 10 Hz, 100 Hz, 500 Hz, and 1 KHz. Cycling through the bottom position will cycle through the Memory channels.

Here are the available front panel labels:

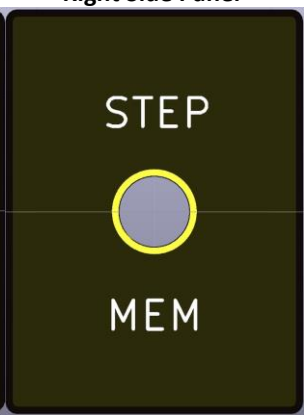
Alternative 1
18mm x 34mm
Left Side Panel



Alternative 2
18mm x 34mm
Left Side Panel



25mm x 34mm
Right Side Panel



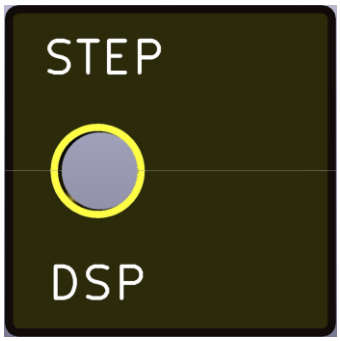
B. 210X/215X LE

The existing Dial Set pot is replaced with a SPDT toggle ON-OFF-ON switch, with momentary ON in both positions. Cycling through the up position of the switch will cycle through the Frequency Steps. On power up, the step is 1 KHz. Subsequent pushes select 10 KHz, 10 Hz, 100 Hz, 500 Hz, and 1 KHz. Cycling through the down position cycles through the DSP functions, if a DSP module has been installed.

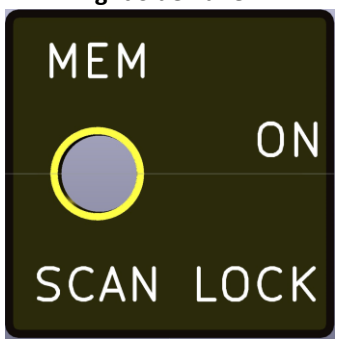
The existing RIT Pot is replaced with a SPDT toggle ON-OFF-ON switch, with a momentary ON in both positions. Cycling through the up position cycles through the Memory channels. There are five memory channels. Cycling through the down position cycles through the Scan functions. Scan Mode 1 scans between the three memory frequencies. A second momentary push of the switch goes to Scan Mode 2. In this mode, the frequency scans in 1 KHz increments. Another momentary push turns the scan function off.

Here are the available LE labels:

Atlas 210X/215X LE
25mm x 25mm
Left Side Panel



Atlas 210X/215X LE
25mm x 25mm
Right Side Panel



V. Enclosure Machine Work

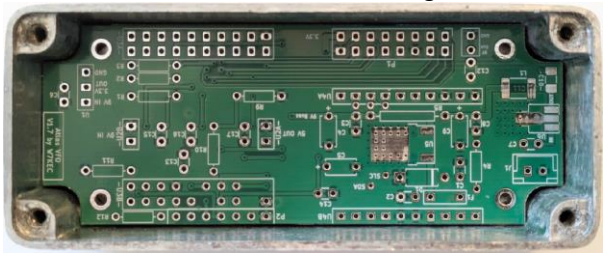
The SI5351 VFO enclosure machine work should be completed before the VFO circuit board is assembled.
The time required to complete this work is 30 - 60 minutes.
The project requires the following machine work:

Clean up any casting debris on the inside and outside of the enclosure. There may be aluminum fingers sticking up from the bottom inside of the enclosure near the four casting circles.

With the picture as a guide, use an extra fine point Sharpie to label the outside of the enclosure walls:

Feedthrough	Right side wall	this is the DC power feed terminal
Ribbon	Top center wall	the SMA jack is also on this wall
USB	Left side wall	optional access opening for USB plug
Clearance	Bottom side wall	no milling/drilling on this wall

Place the VFO circuit board inside the enclosure. Ensure that the circuit board is fully seated against the bottom of the enclosure – it will be a tight fit.

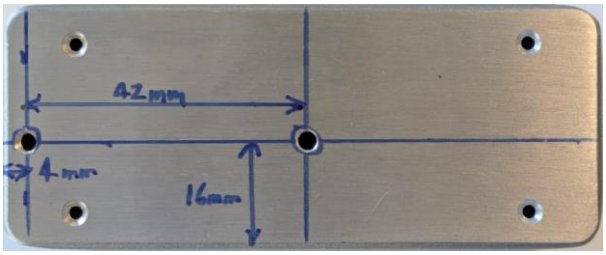


Using the four circuit board mounting holes as a guide, drill four each 5/64” holes in the bottom of the enclosure. Ensure that the drill bit is centered in each circuit board hole so that you do not remove any circuit board material while you are drilling. Also ensure that you have a sharp drill bit. Otherwise, the end of the bit will wander when you start to drill.

Remove the circuit board from the enclosure.
Counter sink the holes on the outside bottom of the enclosure.
Use a Phillip’s countersunk screw to determine needed depth of counter sunk holes.

Mark two new screw hole positions on the bottom of the VFO enclosure. Mark one hole 4 mm from the USB wall of the enclosure and 16 mm from the Ribbon wall. Mark a second hole 42 mm to the right of the first hole and 16 mm from the Ribbon wall. Center punch the positions and drill 3/32” holes.

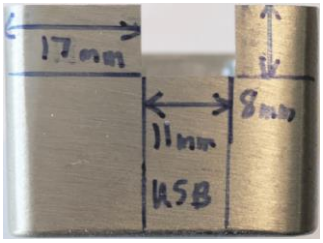
Tap the holes with a 6-32 tap. If you do not have a 6-32 tap, drill the holes with a 1/8" bit and let the screws cut the threads.



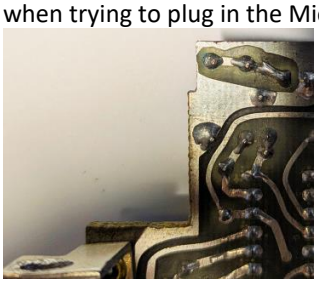
OPTIONAL:
The ESP-32 microprocessor can be programmed without cutting out the rectangle in the side of the enclosure. With no cutout, the ESP-32 would need to be removed from the VFO circuit board in order to connect the USB programming cable.

On the USB wall, cut a rectangle 11 mm wide by 8 mm high.
The left edge of the rectangle should be 17 mm from the Ribbon wall.
The size of the opening will depend up the size of the Micro USB connector that you use.

USB Wall

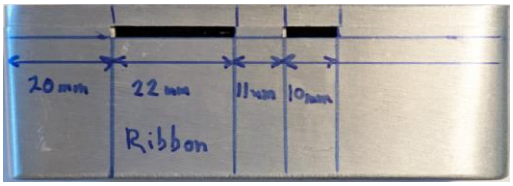


Write USB on the top cover next to the notch in the USB Wall.
Cut a 1 mm x 7 mm notch in the top corner of the PC200 board. The notch will remove the interference when trying to plug in the Micro USB connector.

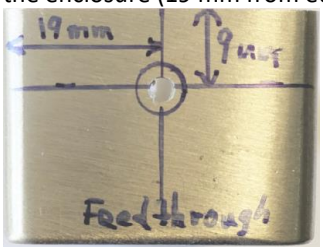


Here is a Micro USB cable plugged into the ESP-32 module:

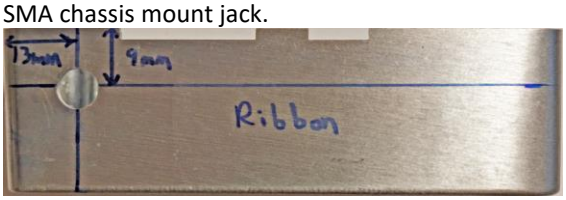
Cut two notches in the enclosure on Ribbon side. These notches are for the 16 wire and 6 wire ribbon cables. The 16 wire notch should be 20 mm from the Feedthrough end. It would be 22 mm wide and 1.5 mm deep. The 6 wire notch should be 10 mm wide and 1.5 mm deep. Cut matching notches in the enclosure cover. The wide notch should be 25 mm wide so that the IDC connector keeper bar edges will not hit the edge on the top cover.



Drill a 7/64” OD hole on the end of the enclosure labeled Feedthrough. Center the hole across the width of the enclosure (19 mm from edge) and 9 mm down from the top edge.



On the Ribbon wall, drill a ¼” OD hole 13 mm from Feedthrough wall and 9 mm from the top edge for the SMA chassis mount jack.



Remove all traces of the Sharpie pen markings from the enclosure.
All milling/drilling work is now complete on the enclosure.

Here are top, bottom, inside, and side views of the completed enclosure:

Top Cover

Bottom

Inside Enclosure

Bottom of Top Cover

Ribbon

Clearance

USB

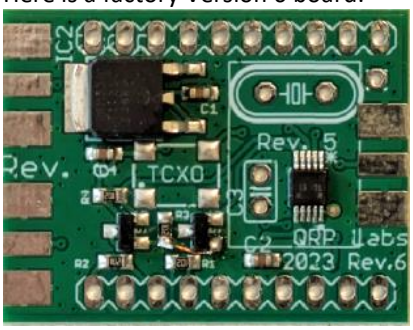
Feedthrough

VI. Build QRP Labs Si5351 Oscillator Board

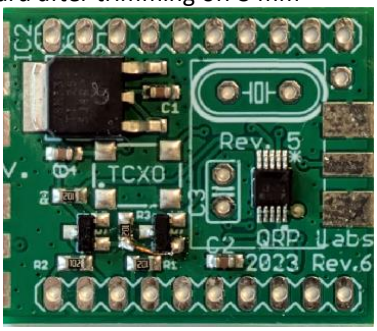
The QRP Labs Si5351 oscillator board plugs into the VFO circuit board.

On the QRP Labs Si5351 oscillator board, cut off a max of 4 mm and min of 3 mm of circuit board material from the end that has the Clock 1 and Clock 2 solder pads. The solder pads are 4 mm long. Clock 1 and Clock 2 are not used for the VFO. However, those two signals are still present on the board's IO header pins 19 and 20.

Here is a factory Version 6 board.



Board after trimming off 3 mm



Build the board per the info in this link:
https://qrp-labs.com/images/synth/synth_assembly6.pdf

Solder two single row male pin headers onto the oscillator board.
Cut off pins 19 and 20 on the male pin header (clock 1 and clock 2).
Do not install the crystal on the board.
Install the TCXO module on the Si5351 oscillator board per QRP Labs instructions.
On the top side of the circuit board, connect a jumper from pin 11 to pin 18.
Install a 10 uf tantalum capacitor between Pin 18 and Pin 16 (ground). Observe polarity.

Carefully inspect the solder connections on the bottom of the board. Set aside the oscillator board.
Here is some technical info about the Si5351 chip used on the board:
https://qrp-labs.com/synth/ms5351m.html

VII. VFO Enclosure Interfacing

Four cables are used to interface the VFO enclosure to the Atlas radio. These consist of a 16 wire ribbon cable, a 6 wire ribbon cable, a DC power cable, and a RG316 coax cable.

A. 16 Wire Ribbon Cable

The 16 wire ribbon cable performs three functions:
Interfaces to TFT display
Interfaces to front panel controls
Interfaces to optical encoder

Cut a 16 wire ribbon cable to 13".
Crimp an IDC connector on the end of the cable. Be sure to observe the cable color code. Ensure that the key on the 16 pin IDC connector will be on the inside of the enclosure – i.e. it should not be touching the wall of the enclosure.

Install the protector bar on the top of the IDC connector and fold the ribbon cable over the top of the protector bar.

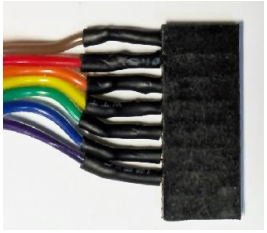
Separate 7 wires from the main body of the cable, starting with the outside brown color. Ensure that you do not pull a wire out of the insulation.

Cut the 7 wire cable to 7” when measured from the end of the IDC connector to the other end of the cable. The wire colors should be brown, red, orange, yellow, green, blue, and violet. These wires will interface with the TFT display.

Cut a 4 wire cable to 7” when measured from the end of the IDC connector to the other end of the cable. The wires colors will be gray, white, black, and brown. These wires will interface with the optical encoder.

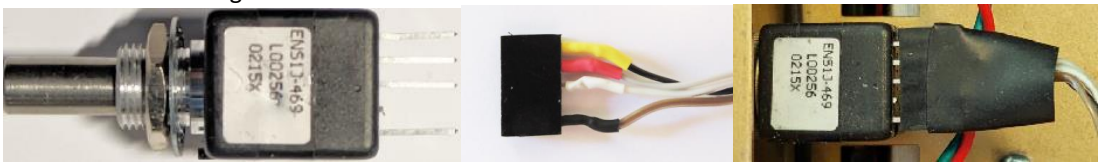
Ensure that a factory pin male header is soldered to the TFT display. Cut off pin 8.
Solder a jumper wire from pin 2 to pin 8 on the TFT display.
Solder an 8 pin female pin header to 7 ribbon cable wires.

Here is the completed pin header connector:



Solder a female 5 pin header to the brown, white, gray, and black wires on the 16 wire ribbon cable. Put a large piece of black heat shrink around the ribbon cable before soldering the wire connections. Put ¼” pieces of black heat shrink around each individual pin. This header is for the optical encoder. Cut off the NC pin 4 on the encoder.

Put heat shrink tubing around the wires of the ribbon cable.



Here is the completed harness for the 16 wire ribbon cable:

B. 6 Wire Ribbon Cable

The 6 wire ribbon cable performs these three function:
Band-switch resistor matrix
Ext VFO control
CW Terminal control

Cut a 6 wire ribbon cable to 12” length
Cut the wire colors blue, red, brown to 7” long.
These wires will be routed into the VFO compartment near the rear band-switch wafer.
Install a 7 pin female pin header on the 6 wire ribbon cable. Note color coding of wiring.
Pin 7 is not used.

Here is the completed harness:

C. Ground Buss Wiring Harness

Fabricate a ground buss wiring harness using black stranded insulated wire. One wire is 2" long and the other wire is 5" long. This harness will be connected to the front panel controls. The solder terminal will be placed under the cover screw of the enclosure.

D. DC Power Wiring

Route the red/black DC power cable through the Feedthrough hole (cable with white female connector on the end). Install heat shrink tube around the two wires where they go through the side of the enclosure. Put a drop of super glue on the heat shrink where is goes through the hole.

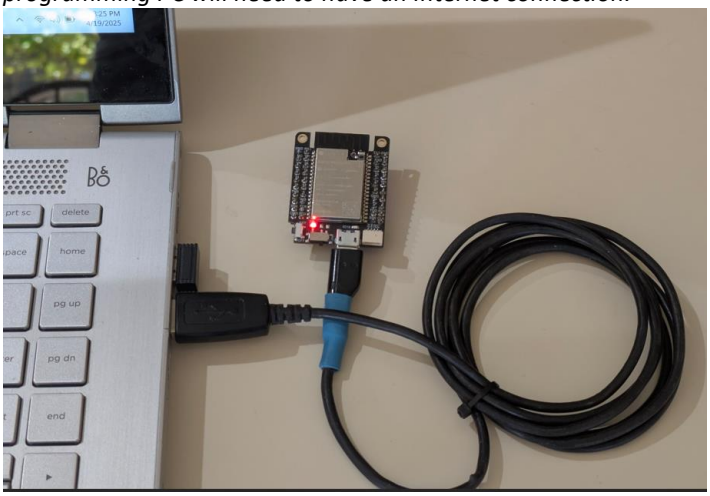
On the red wire outside the enclosure, slide on a FB43-101 ferrite bead. It will initially be a tight fit. Solder a single pin male header to the end of the red wire. Solder a terminal lug on the end of the black wire.

Take a piece of 10" red Teflon insulated stranded wire and solder a female pin header on one end of the wire. Install heat shrink around the male and female pin headers.

VIII. Program ESP-32 Microprocessor

Caveats:
This installation process has been tested on Windows 10 and Windows 11.

The following steps assume that the Arduino IDE app has never been installed on the PC. It is also assumed that the ESP-32 module is not installed in the VFO box and that it is connected to a USB port of a PC. The programming PC will need to have an Internet connection.

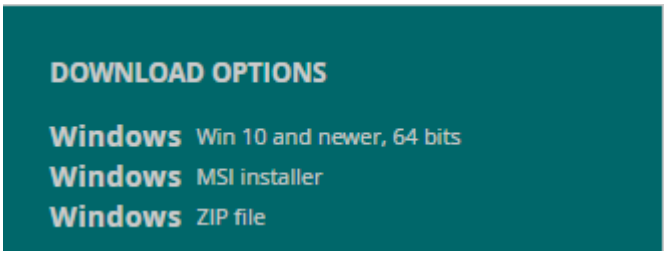


On your PC, create a subdirectory C:/VFO_4_1_1 and download the contents of the VFO4_1_1.zip file. Unzip the file. Ensure that the ino file is named VFO_4_1_1.ino.

Name	Date modified	Type	Size
config.h	4/11/2025 8:48 PM	H File	41 KB
dial.cpp	12/23/2024 9:45 AM	CPP File	13 KB
dial.hpp	12/23/2024 9:45 AM	HPP File	2 KB
encodersetup.h	12/23/2024 9:45 AM	H File	2 KB
PCF8574.cpp	12/23/2024 9:45 AM	CPP File	32 KB
PCF8574.h	12/23/2024 9:45 AM	H File	8 KB
pcf8574inputpins.h	12/23/2024 9:45 AM	H File	3 KB
si5351.cpp	12/23/2024 9:45 AM	CPP File	42 KB
si5351.h	12/23/2024 9:45 AM	H File	13 KB
si5351mcu.cpp	12/23/2024 9:45 AM	CPP File	16 KB
si5351mcu.h	12/23/2024 9:45 AM	H File	6 KB
ST7735S_128x160.hpp	12/23/2024 9:45 AM	HPP File	9 KB
ST7789_170x320.hpp	12/23/2024 9:45 AM	HPP File	11 KB
ST7789_240x320.hpp	12/23/2024 9:45 AM	HPP File	8 KB
VFO-4_1_1.ino	4/11/2025 11:51 AM	INO File	82 KB

On your PC, open a web browser to the Arduino Web site
https://www.arduino.cc/en/software

Select the 2.3.6 download file.
Under the Download options found on the right side of the first page, click on the “Windows Win10 and newer, 64 bits” option.



You will see a couple of screens asking for a donation. Feel free to donate if you want but if not, look for the download button and click to start your download. The file download will start. When complete, the downloaded file will be about 153 MB in size.

NOTE: During the install and setup procedures for the IDE app, you may see several pop-up windows asking if it is OK to install IDE driver xxx. Hit Accept/Yes for each pop up. These pop-ups could include the following but expect many more.

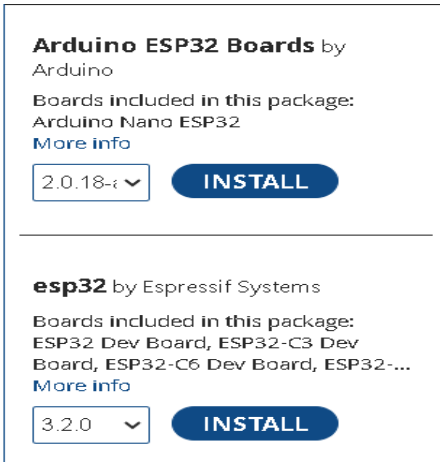
Arduino IDE	Allow
Dpinst-amd64.exe	Yes
Dpinst-amd64.exe	Yes (repeat of previous pop-up)
Arduino IDE	Allow

Double click on the downloaded file. The application installation will start.

License Agreement:	Hit I agree.
Choose Installation Options Select Anyone who uses this computer:	Hit Next
User Account Control	Hit Yes
License Agreement:	Hit I agree
Use the default installation folder	Hit Install

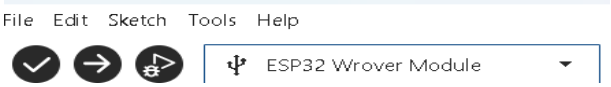
The remaining installation should take less than one minute.
Uncheck the box for “Run Arduino IDE”.
Hit Finish

Double click on the VFO_4_1_1.ino file under the VFO_4_1_1 directory. The Arduino IDE app will open.
You may see a message asking if you want to install ESP32 library 3.2.0. Hit Install later.
On the left hand side of the GUI, you should see this window:

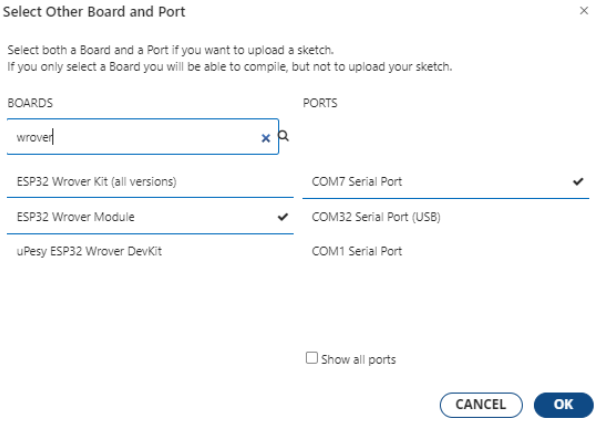


In the “esp32 by Espressif Systems” box, click on the down arrow by 3.2.0 and select 3.0.0.
Click on Install.
The library will be downloaded from the Internet and it will take about 13 minutes to install the library.

In the upper left hand side of the app GUI, you will see this box:



If you do not see “ESP32 Wrover Module”, you will need to select it.
Click on the down arrow in the box. Highlight “Select other board and port”.
In the search window, enter “Wrover”.

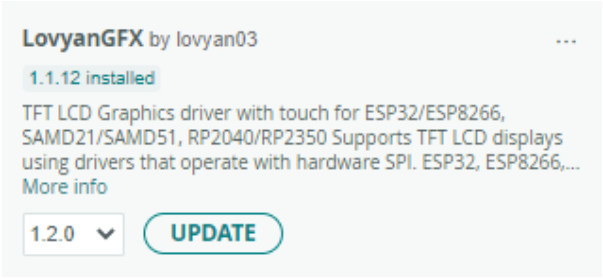


Highlight ESP32 Wrover module and kit OK.

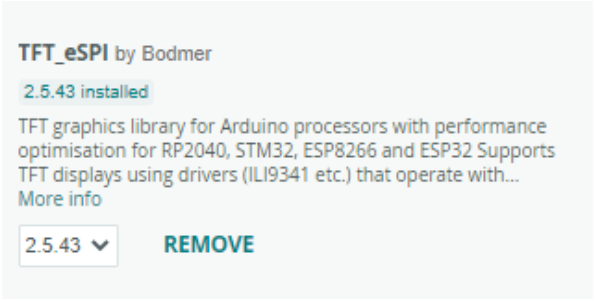
On the IDE menu, go to Files-Preferences
Under “Additional Boards Manager URLs, enter these URLs and hit OK:
The IDE app will go out to the Internet and will download the needed files.

https://raw.githubusercontent.com/espressif/arduino-esp32/gh-pages/package_esp32_dev_index.json
https://raw.githubusercontent.com/espressif/arduino-esp32/gh-pages/package_esp32_index.json

Under Tools/Manage Libraries, enter “LovyanGFX” under Filter your search.
Select version 1.2.0 and install it. Several files will be downloaded and installed.
It will take about one minute to download and install the library.



Under Tools/Manage Libraries, enter "TFT_eSPI" under Filter your search.
Select version 2.5.43 and install it. It will take less than one minute to download and install the file.

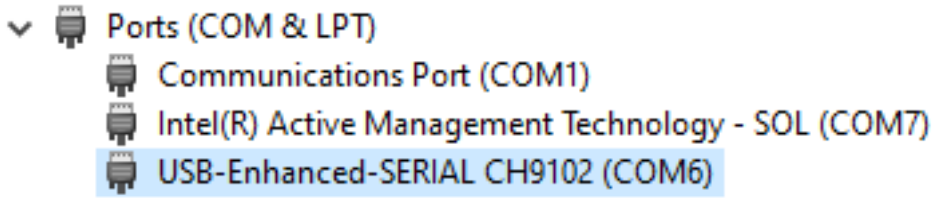


If you exit the VFO_4_1_1 sketch at this point or anytime going forward, when you reopen it, in the lower right corner of the app GUI, you will be prompted that updates are available for some of your boards. Do not update, instead click on "LATER".

Connect your PC to the Micro USB port on the ESP32 module with a USB cable.
The ESP32 module will be powered up by the computer once the USB cable is connected. A red LED will light up on the ESP32 module once the connection is made.

If you see several available USB ports, then these steps will help you to select the correct port.

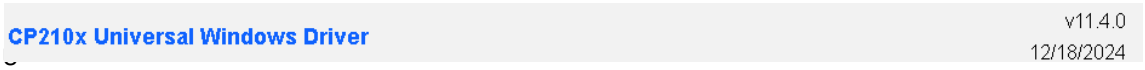
In Windows, open Device Manager
Open Ports (COM & LPT) and look at available ports
In the Arduino IDE app, select the port that shows up as "USB-Enhanced-SERIAL



If no USB Comm ports show up, it is likely that your computer does not have the driver installed for the Silicon Lab CP2104 USB to UART.

Go to this site:
https://www.silabs.com/developer-tools/usb-to-uart-bridge-vcp-drivers

Download this driver:

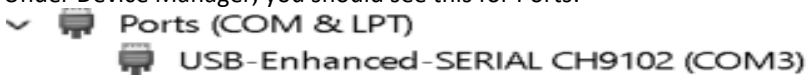


nzip the file and install the driver.
Once installed, unplug your ESP32 cable from your computer and reconnect it. The driver should then install, and the module will show up under one of the Comm ports in the device manager as seen above.

If the driver is installed, you should see this entry under Programs and Features:

Windows Driver Package - Silicon Laboratories Inc. (silabser) Ports (11/2... | Silicon Laboratories Inc. | 2/28/2021 | 11/26/2018 10.1.4.2...

Under Device Manager, you should see this for Ports:

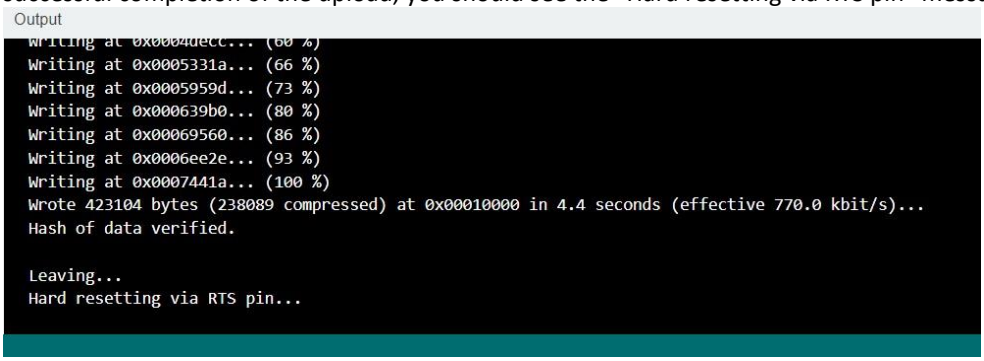


You may see a different value for the Com port. That is OK.

You are now ready to compile your code and see if you can program an ESP32 module.
Select Sketch-Upload (Ctrl+U). Do not use Configure and Upload or Upload Using Programmer..
Your will see a status window in the lower right-hand corner of your screen showing Compiling sketch.

If no errors are found, then the IDE will upload the code to your ESP32 module. The first phase will show Compiling sketch in the status window at the bottom right of the computer screen. This process takes some time. Just sit back and keep an eye on this window. When the sketch is fully compiled, the programming of the chip will automatically begin. If you get a comm port not found or comm port error, go back to the Select Board step above and make sure you selected the correct Comm Port.

The status of the upload functions will be shown in the black display window of the IDE app. At the successful completion of the upload, you should see the “Hard resetting via RTS pin” message.

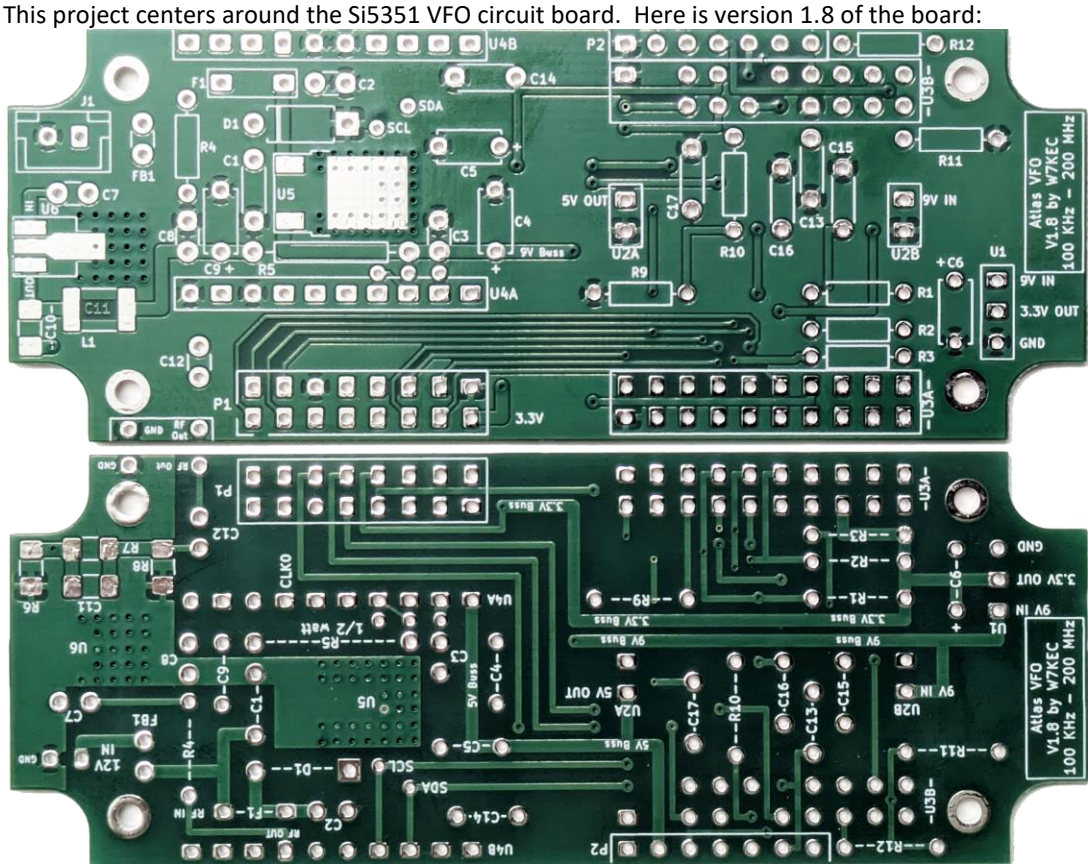


Your programmed ESP32 module can now be used on the VFO board. The green light on the ESP-32 module should be lighted. This indicates that the module has been programmed.

On subsequent Uploads, the process will be much quicker because the code has already been compiled.

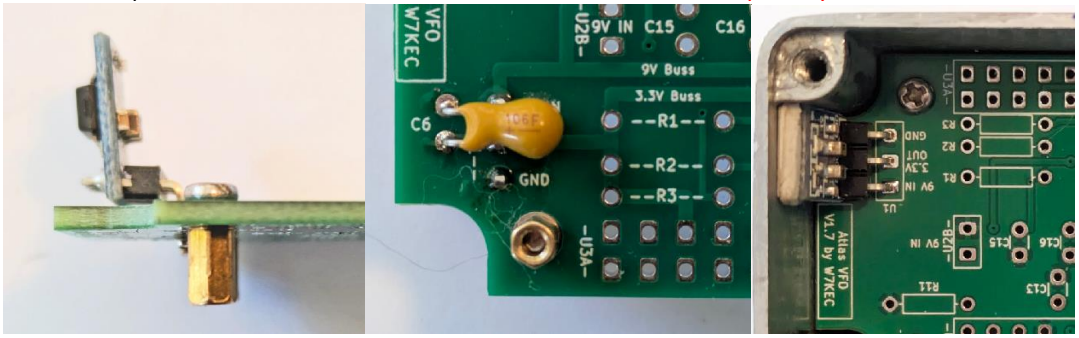
IX. Build Si5351 VFO Board

This project centers around the Si5351 VFO circuit board. Here is version 1.8 of the board:



Install four brass standoffs on the bottom of the VFO circuit board with four each M2-4mm Phillip's head screws.

Fully seat the 3.3 volt regulator on the top of the VFO circuit board. Ensure that the board has a slight tilt toward the enclosure wall. You want the body of the AMS1117-3 chip to touch the wall of the enclosure so that the wall will provide a heat sink. Solder the three pins on the regulator board. Solder C6 (22 uf) tantalum capacitor to the bottom of the VFO circuit board. Observe polarity.

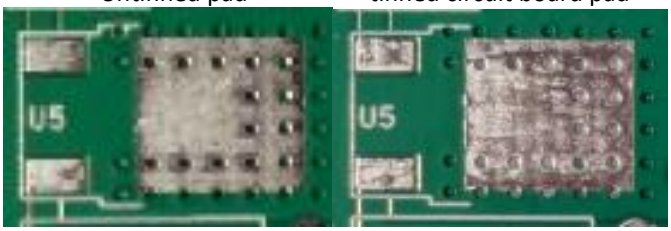


Sort out the resistors and capacitors by measuring their values.
Tape parts to sheet of white paper with value next to each part.
Insert the power jack at location J1 – matching the silk screen to the body of the plug.
Solder two pins on the jack. Connect the DC power cable to the jack and apply 11.7 VDC power.
There should be no current draw.

Tin the pads associated with the 78M09 voltage regulator chip.

Untinned chip tinned back side of chip

Untinned pad tinned circuit board pad



It is recommended that you confirm the operation of the 78M09 chip before soldering the chip to the VFO circuit board.

Solder the following TH and SMD parts to the VFO circuit board:
U5 – 78M09 9 volt voltage regulator – SMD
L1 – 100 uh 1210 SMD
R4 – 220 ohm TH
R6 & R8 – 240 ohms 1206 SMD and R7 20 ohms 1206 SMD – bottom of board
U6 – GALI-6 MMIC
C2, C3, C7, C8 and C12 - 0.1 uf ceramic monolithic disc capacitor - TH
C10 – 0.1 uf 1206 SMD

Solder the following parts to the VFO circuit board:
C1, C13, C14, C15, C16, and C17 – 0.01 uf ceramic monolithic disc capacitors - TH
C4 – 10 uf tantalum TH – observe polarity
C5 – 100 uf tantalum TH – observe polarity
C9 – 10 uf tantalum TH - observe polarity
D1- 1N4001 diode - TH
F1 resettable fuse – 500 ma - TH
R1, R2, R3, R9 & R11 – 2.2K ohms TH
R10 – 4.7K ohms TH
R12 – 10K ohms TH

Apply 11.7 VDC power to the board. The current draw should be about 7 ma. The red LED on the 3.3 volt regulator should turn on. Confirm that you have 9.0 volts out of the 9 volt regulator and 3.3 volts out of the 3.3 volt regulator.

Install R5 - 56 ohm 1/2 watt TH

All resistors, capacitors, and active devices have been installed on the circuit board.
There will be no capacitor installed at C11.

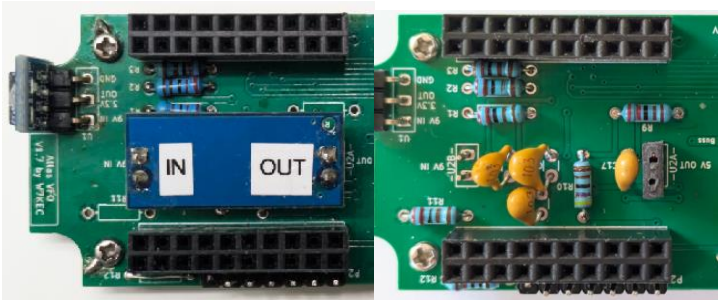
Apply 11.7 VDC power to the board. The current draw should be about 77 ma. This current draw comes from the GALI-6 amplifier. If you do not see 77 ma of current draw, then trace the voltages to the GALI-6. Confirm that you have good solder connections on the L1 inductor.

11.7 volts into 78M09
9 volts out of 78M09
9 volts into R5
5 volts out of R5
5 volts into L1
5 volts out of L1

On the circuit board, solder the following parts:
Insert four 10 pin male headers on the ESP-32 module.
Insert four 10 pin female headers onto the VFO board for the ESP-32 module.
Look at circuit board at J3A and J3B. Note pins that have no solder pads.
Remove those pins from the female pin headers.
There are five pins that will need to be removed from J3B female pin header.
Insert the female headers into the circuit board holes.
Insert the ESP-32 module into the female headers.
Solder the male header pins on the ESP-32 module.
Solder all of the pins on the female pin headers.
Remove the ESP-32 module from the circuit board
Insert two each single row 10 pin female headers into the circuit board at U4A and U4B
Insert the Si5351 oscillator board into the female pin headers
Solder all pins on the female pin headers at U4A and U4B
Remove the oscillator board from the VFO circuit board
Get two each single row 8 male pin headers
Install the pin headers at P1 on the circuit board.
The male pins may have a tight fit in the circuit board holes. Ensure that the pins do not move in the plastic body of the header.
Solder the P1 pins on the circuit board.
Get one each single row 7 male pin header.
Install the pin header at P2 on the circuit board
Solder the P2 pins on the circuit board.
Cut off the long part of pin 7. This will be a keying pin for the ribbon cable connector.

The following steps will create low profile female pin header sockets so that U2 can be mounted underneath the body of the ESP-32 module.

The body of a female pin header is 8 mm long.
Cut the top off of two mm on two each female pin headers so that the body is 6 mm long.
You should just barely see the top of the metal contact pins
Pull four pins from a male pin header.
Insert the pins into the female pins headers that you just modified.
Insert the long pins of one header into the component side of the AMS-1117 5 volt regulator on the Out pins
Insert the long pins of one header into the circuit board for U2 at the In pins
This will key the voltage regulator board so that it can only be attached one way to the VFO circuit board
Solder the four pins on the voltage regulator board
Solder the four pins on the VFO circuit board.
When the U2 board is installed on the VFO board, the component side of the board will be down.



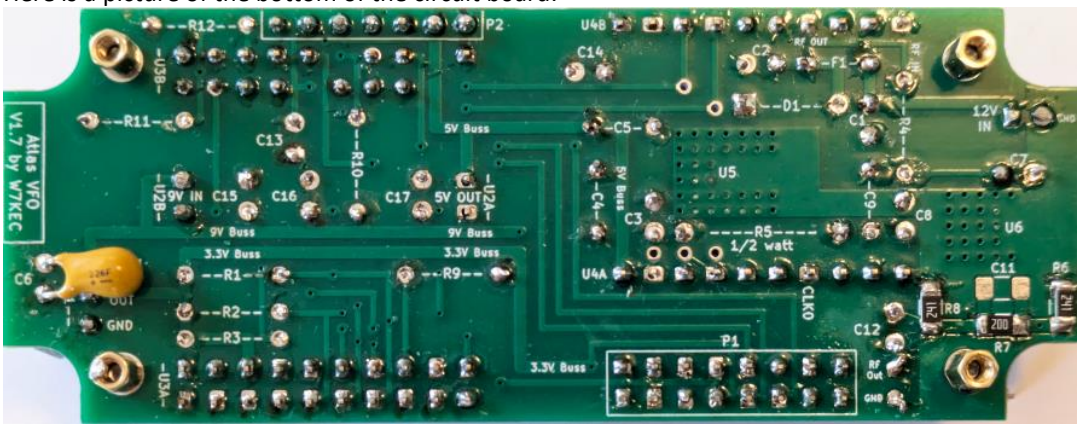
Cut off the excess lead length on the pins on the bottom of the VFO circuit board.
Cut off the excess lead length on the pins on the top of the voltage regulator board.
You may have to fold over the capacitors in order for the regulator board to fit.
Remove the 5 volt regulator board from the VFO circuit board

Install an insulated solid black wire (15 mm long) on the RF Out ground solder tab on the circuit board.
Install an insulated solid yellow wire (10 mm long) on the RF Out solder tab on the circuit board.

All pin headers, sockets, and plugs have now been installed on the VFO circuit board.
Carefully inspect all solder connections on the bottom of the board.
Check for solder splatters. Remove any flux from the bottom of the circuit board.

Here is a top view of the circuit board:

Here is a picture of the bottom of the circuit board:



X. Keyed Connectors

The IDC connectors/sockets are keyed to prevent the male IDC connector from being inserted the wrong way. Key the following IDC connectors/sockets:

On the ESP-32 module male IDC connector, cut off pin TXD (see Atlas Interconnect drawing for location). Fill the corresponding TXD hole on the female pin header with epoxy.

On the Si5351 board, cut off male pins 19 and 20. Fill the female socket hole 20 with epoxy.

On the low pass filter control six wire ribbon cable with the seven pin female IDC connector, pull pin 7. The male pin 7 pin was previously removed when the VFO circuit board was built. Fill the corresponding socket 7 with epoxy.

On the five pin female IDC connector on the sixteen wire ribbon cable, pull the unused pin 4. Fill the hole with epoxy. The corresponding pin 4 on the optical encoder was previously cut off when the wiring harness was built.

On the 8 pin male TFT IDC connector, cut off pin 8. On the corresponding pin 8 of the female IDC socket, fill hole 8 with epoxy.

NOTES:
The AMS1117-5 volt regulator board can only be installed one way.
The 11.7 VDC JST power connector has a built-in factory key.
The 16 pin IDC ribbon cable connector has a key that should be placed so that it is closest to the female IDC socket for the Si5351 board.

XI. Initial VFO Testing

Ensure that the ESP-32 module, the Si5351 oscillator board, and the 5 volt regulator module have been removed from the board.

Apply 11.7 VDC to the power plug. You should see about 77 ma of current draw. This current draw comes from the 9 volt regulator feeding the Mini Circuits GALI-6 MMIC amplifier.
Remove power from the board.

Install the 5 volt regulator board.
Apply 11.7 volts to the power socket. You should see about 85 ma of current.
The red LED on 3.3 and 5 volt regulator boards should light.
Confirm that the output voltage on the 5 volt regulator board is 5.0 volts.
Remove power from the board.

Install a programmed ESP-32 module. Apply power.
The total current draw should be around 148 ma.
Remove power from the board.

Install the QRP Labs Si5351 oscillator board. Apply power.
The total current draw should be around 183 ma.

Remove power from the board.

The VFO can be tested on the bench before being installed into the Atlas radio. It is recommended that the VFO be tested before removing the factory VFO parts from the radio.
Connect the 16 pin ribbon cable to the VFO circuit board
Connect the TFT Display to 16 pin ribbon cable
Apply 11.7 volts to the white DC power connector on the circuit board.
The system should boot up. Total current draw will be about 236 ma.
Remove power from the board.
Connect the optical encoder to the 4 pin ribbon cable
Apply power.
The system should boot up and you should be able to change the frequency using the encoder.
Total current draw will be about 250 ma.

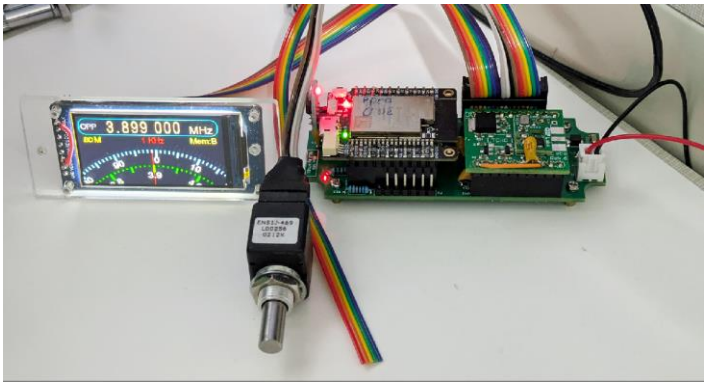
You should see the following lights:
Green LED – ESP-32 module

This LED will be flashing if the ESP-32 module has not been programmed. During a program upload, the light will go out. Once the ESP-32 module has been programmed, the light should be solid as opposed to flashing. Once the ESP-32 module is installed on the VFO board, the LED will not be lighted when the NOR mode is selected.

Red LED – ESP-32 module – this LED should be lighted any time power is applied to the module
Red LED – 3.3 volt regulator module
Red LED – 5 volt regulator module

With no ribbon cable wires connected to the front panel controls and the band-switch, you should see the following defaults on the display:
3.900 000 MHz
80M
OPP
1KHz
Mem:B

With an oscilloscope, confirm that you can see a 3.6 peak to peak voltage at the RF Output pin on the circuit board.



Install the board into the enclosure using four each M2-3 counter-sunk Phillip's head screws
Apply a thin layer of heat sink compound on the body of the AMS1117-3.3 chip.
Install a thermal pad between AMS1117-3.3 volt chip and the wall of the enclosure.
Install the feed through capacitor (with terminal lugs on both sides) on the end of the enclosure.
Solder a JST XH wiring harness (red and black wires) to the inside of the feed through capacitor.
Plug in the male connector on the wiring harness to the female connector on the circuit board.
Solder a JST SM wiring harness to the outside of the feed through capacitor.
Install a SMA female bulkhead connector to the Ribbon side of the enclosure.
Solder the circuit board RF Out ground wire to the ground lug on the connector.
Solder the circuit board RF Out wire to the center conductor of the connector.

Here is a picture of the circuit board installed in the enclosure with the interface cables connected:

Install Brother's labels on the top cover of the VFO enclosure:

Apply 11.7 vdc power to the JST power wires.
Total current draw should be about 220 – 240 ma.
Confirm that you see a normal display and that you can change the frequency with the encoder.

Note: The TFT display is susceptible to lockups when on the bench due to static electricity, inadequate grounding, etc. When the display is locked up, you will be able to change the frequency with the encoder, but the display frequency will not change. A power cycle of the board will resolve the problem.

Confirm that you see a 3.2 volt PP signal at the chassis mount SMA jack.

XII. Remove Factory Atlas VFO

Do not remove the VFO parts until you have built out the Si5351 VFO enclosure and confirmed for proper operation.

The VFO can be tested on the bench by:
Attaching TFT display and optical encoder to the 16 wire ribbon cable wiring harness.
Connecting 16 wire ribbon cable to the VFO circuit board.
Applying 11.7 VDC power to the enclosure.

After the factory VFO parts have been removed, the radio can still be used by attaching an external signal source to the Accessory jack on the rear of the radio.

A. Remove Parts 1

Top and bottom equipment covers to the radio
VFO bottom cover
Main VFO tuning knob (two 5/64" Allen wrench set screws)
LE radio
    Dial set knob
    RIT tuning knob
Standard radio
    Dim slide switch – if you are going to install a toggle switch Scan and Lock functions
    Dial Set knob and capacitor
Plastic frequency drum (5/64" Allen wrench set screw)
Dial cord
Dial cord pulley bracket (two screws)
VFO dial lamps (two) and power wires
Plastic frequency window (two front panel screws must be removed)
Metal pulley on the top of the VFO (it is secured to the shaft of the VFO tuning capacitor)

B. Remove Parts 2

PC-200 circuit board
Dial set pot (cut two resistor wires going to regulator terminal strip on top of chassis
There are two external wires to the RIT sub-assembly control
There are several wires that attach to the ON-XCV switch
RIT terminal strip – single screw holding ON-XCV switch
Varactor terminal strip – single screw holding strip to top of VFO enclosure
RIT wire going to VFO circuit board – cut wire at RIT terminal strip
RIT pot
Main tuning capacitor (3 screws and three wires)
Three terminal strips inside VFO compartment
Capacitor to band switch contact and white wire to RIT subassembly
Reattach the screw, lock washer and nut that holds the ON-XCV slide switch
Reinstall PC-200 circuit board
Remove the red and yellow wires going to the ON-XCV slide switch.

Unsolder all wires between main inductor and VFO circuit board
Remove main inductor by removing single screw
Desolder all wires to the band switch wafers in the VFO compartment
Desolder the two wires to the VFO turning capacitor

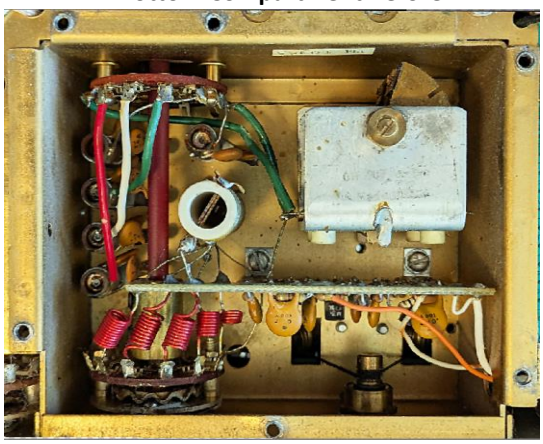
C. Remove Parts 3

VFO circuit board orange and orange white wires – unsolder both ends of each wire
RG174 coax cable center conductor and shield on VFO circuit board – do not remove the cable
Lock nuts on 5 ceramic piston capacitors
5 wires between ceramic piston capacitors and the VFO circuit board

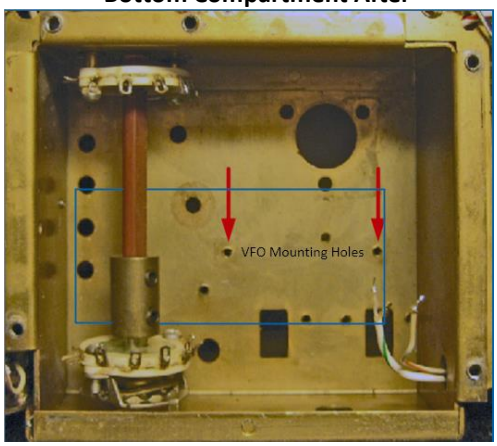
5 ceramic piston capacitors
All wires going to rear band-switch contacts
Inductors on front band-switch contacts that go to VFO circuit board
Two screws holding the VFO circuit board
VFO circuit board
VFO front frequency control vernier lock nut and vernier
Band labels on top of VFO compartment
Remove variable capacitor C327 on the bottom side of board PC-300

At this point, all factory VFO parts have been removed. Here is how the VFO compartment will look:

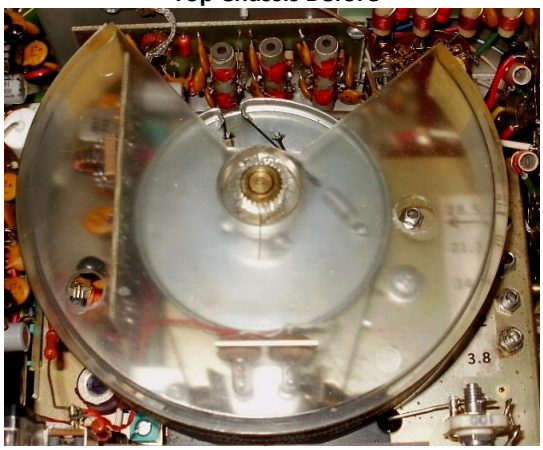
Bottom Compartment Before



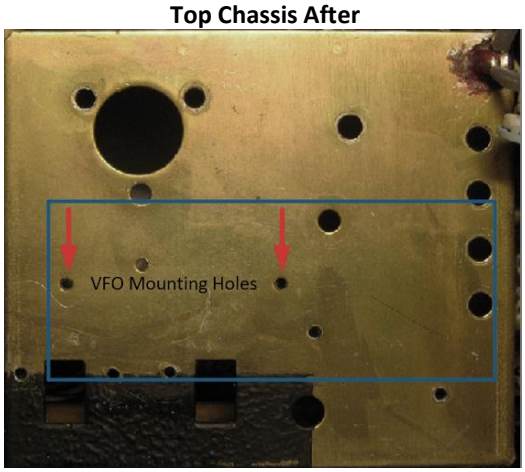
Bottom Compartment After



Top Chassis Before



Top Chassis After

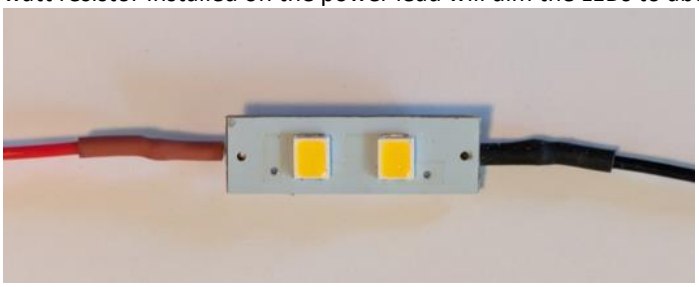


Enlarge the two VFO circuit board mounting holes with a 9/64” drill bit (see two red arrows in the above snapshots). These holes will be used to attach the Si5351 VFO box to the top of the VFO enclosure using 6x32 screws. The two screws will screw into tapped holes in the bottom of the VFO enclosure. The screw hole closest to the brass coupler will also secure the low pass filter board mounting bracket.

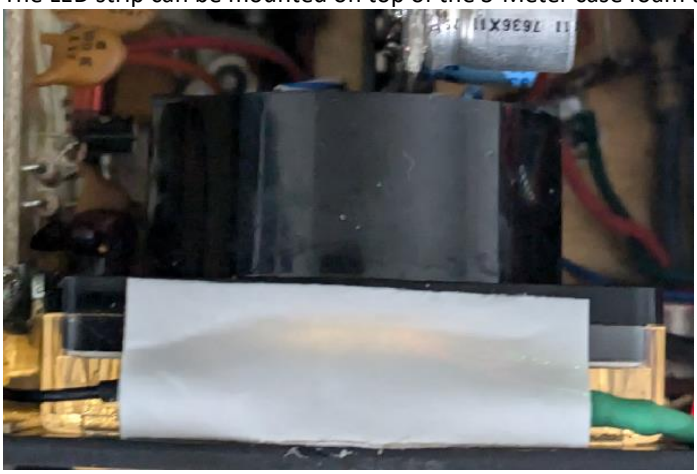
XIII. Upgrade S-Meter Lights

After the factory VFO parts have been removed, the S-Meter dial light will still be functioning. They will be drawing more current because of the decreased voltage drop across R9. The two VFO dial lamps were drawing about 120 ma of current. After the factory VFO and dial lamps were removed, the total receive current draw was about 200 ma. With the Si5351 VFO connected, the total receive current was about 420 ma.

A better replacement is to use high intensity 12 volt warm white axial strip LED. These LEDs attach directly to the Atlas 11.7 volt power bus and draw about 8 ma. This type of LED is not polarity sensitive. An 8.2K ¼ watt resistor installed on the power lead will dim the LEDs to about the right brightness.



The LED strip can be mounted on top of the S-Meter case foam tape.



Here is a front view of the S-Meter lighting.

XIV. TFT Display Mounting Bracket

The frequency display window in an Atlas radio is 22mm high by 46mm wide. There is 6 mm from the top of the frequency window to the top of the radio's front panel. The TFT display needs to be mounted in this window. This is accomplished by attaching the display to a mounting bracket. The mounting bracket is then secured to the front panel with two machine screws. The mounting bracket has eight holes. Four of the holes secure the TFT display to the bracket. The two Standard Atlas 210X holes secure the bracket to the front panel of the radio. The other two holes secure the bracket to the front panel of an Atlas 210X.215X LE radio.

A. Prefabricated Bracket

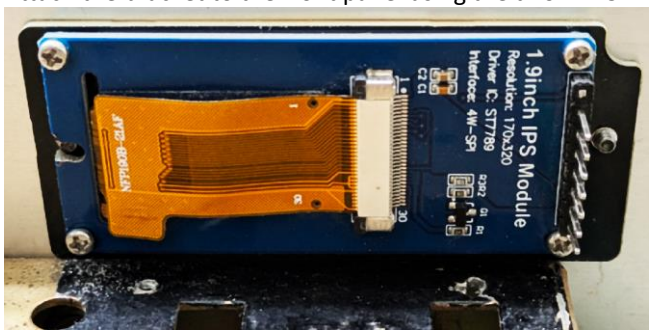
A prefabricated bracket already has drilled mounting holes for a standard 210X/215X, a LE 210X/215X, and an external VFO.

Smooth off the inside edges of the cutout with a flat file.

Using a black Fine Point Sharpie marker, mark the inside edges of the rectangle.

Attach the TFT display to the bracket with four each M2x5mm screws. Do not over-tighten the screws.

Attach the bracket to the front panel using the two M2.5x4mm black truss head screws.



B. Connect Display to VFO box

Attach the display to the 7 wire ribbon cable from the VFO box. The female pin header is keyed so that the connector can only be attached one way to the male pin header soldered to the TFT circuit board.

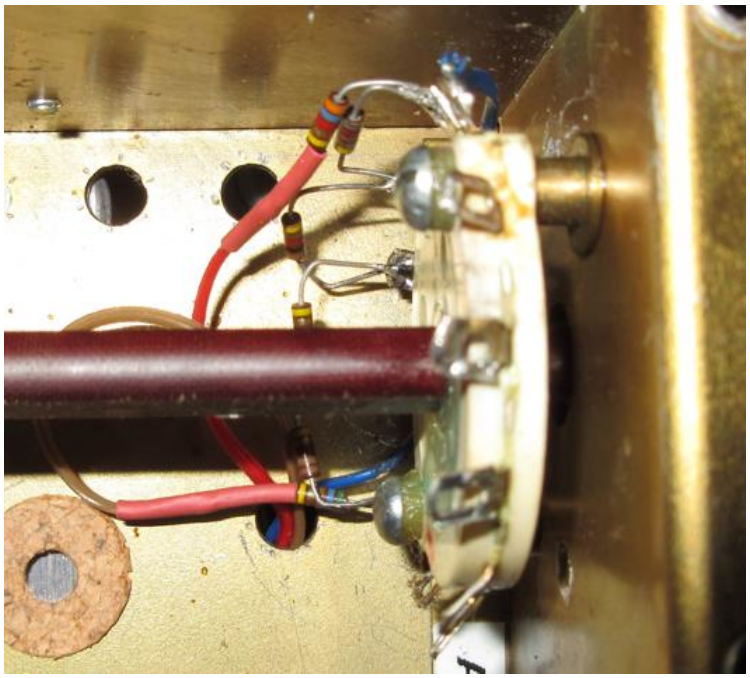
XV. Build VFO Low Pass Filters

Three Low pass filters are needed in the output of the Si5351 in order to reduce the signal amplitude of even and odd harmonics. The filters turn the square wave signal into a nice looking sine wave. Filters are needed for the 80M/20M bands, the 40M/15M bands and the 10M band. The low pass filters are mounted on a Low Pass Filter Board. The LPF Board has space for either 3 each Mini Circuits PLP filters or 3 each of the QRP Labs low pass filters.

A. Band-Switch Resistor Matrix

Install the band switching resistors (R13 to R18) on the rear section 2b of the band-switch wafer. Ensure that the switch solder tabs are not touching the chassis. There will be three ribbon cable wires that run from the VFO circuit board to the rear band-switch wafer (red, blue, and brown).

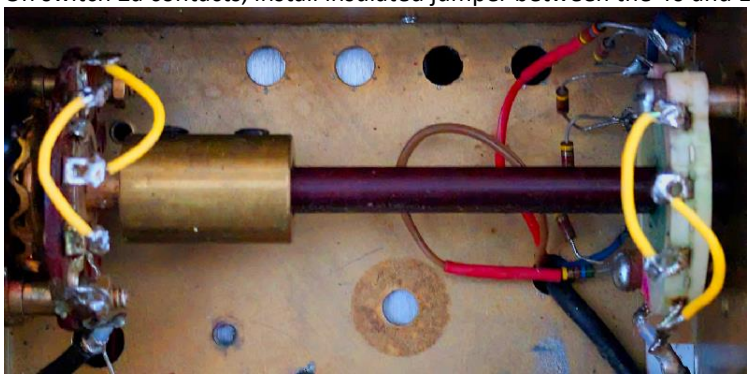
R13 is soldered to the end of the red wire. R18 is soldered to the end of the brown wire. The blue wire is soldered to the common tab on the band-switch.



B. Band-Switch Jumpers

Install 7/8" yellow Teflon wire jumpers on the band-switch front and back wafers.
There will be switch contacts jumpers for 80/20M and 40/15M.

On switch 1a contacts, install insulated jumper between the 80 and 20 meter contacts.
On switch 1a contacts, install insulated jumper between the 40 and 15 meter contacts.
On switch 2a contacts, install insulated jumper between the 80 and 20 meter contacts.
On switch 2a contacts, install insulated jumper between the 40 and 15 meter contacts.

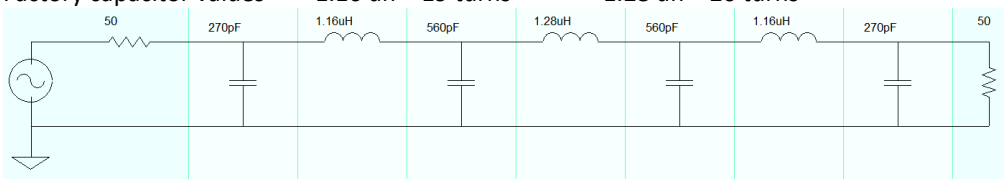


D. VFO Low Pass Filter Design

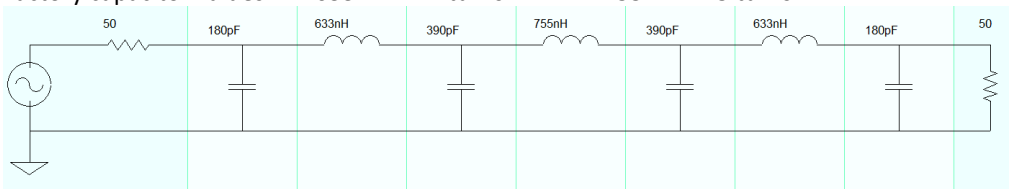
1. The video describes the process on how to build the low pass filters:
   https://www.youtube.com/watch?v=pdPrmiURB_U

2. QRP Labs Low Pass Filter Chart
   https://qrp-labs.com/images/lpfkit/assembly_LT.pdf

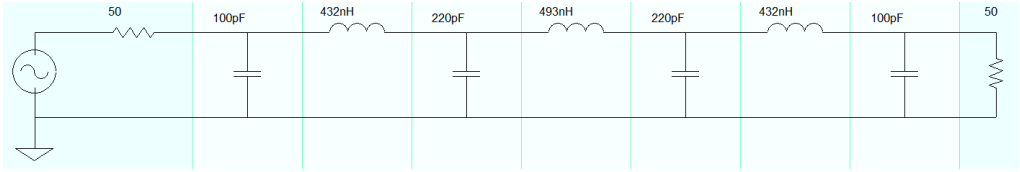
3. QRP Labs 30M Low Pass Filter for bands 160M, 80M & 20M
   3 db cutoff: 11400 KHz Desired cutoff: 9645 KHz
   Factory capacitor values 1.16 uh = 19 turns 1.28 uh = 20 turns



4. QRP Labs 20M Low Pass Filter for bands 40M & 15M
   3 db cutoff: 18200 KHz Desired cutoff: 15805 KHz
   Factory capacitor values 633 nh = 14 turns 755 nh = 15 turns



5. QRP Labs 12M Low Pass Filter for band 10M
   3 db cutoff: 29400 KHz Desired cutoff: 24055 KHz
   Factory capacitor values 432 nh = 11 turns 493 nh = 12 turns



C. Build Low Pass Filter Board Mount

Fabricate a low pass filter board mount from a piece of 1/4" brass square channel.
Drill a 9/64" hole 1/8" from the left hand end of the mount. Center the hole across the channel.
Drill one 1/16" hole 7/32" from the left hand end of the mount and center the hole on the channel.side.
Drill a second 1/16" hole 0.8" to the right of the first hole.
Cut the length of the mount to 1 1/8". Screw in M2-4 screws into the 1/16" holes. The screws will cut threads into the brass.

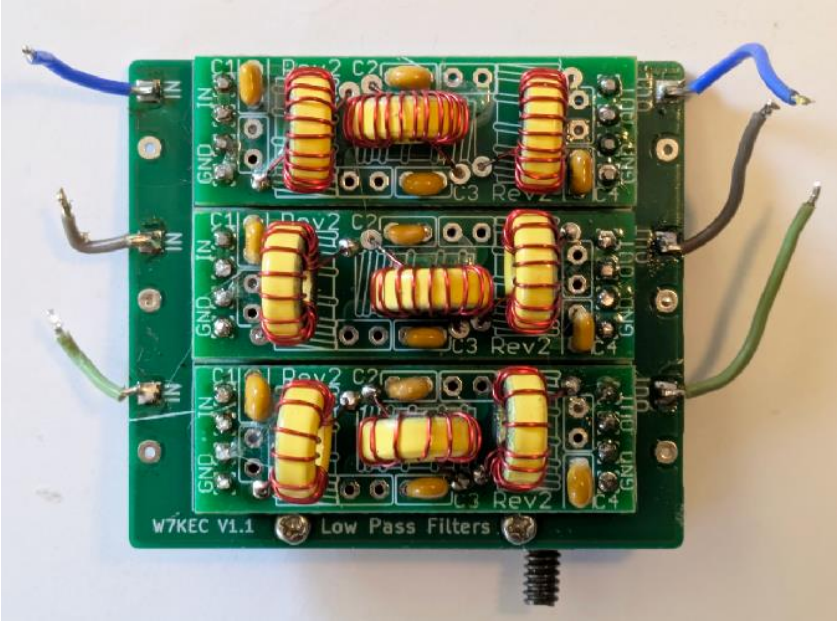
9/64" Hole 1/16" Holes Completed Mount

D. QRP Labs Low Pass Filter Board

Place the 4 pin male pin headers on the holes on each LPF board.
Place the QRP Labs low pass filter board on top of the male pin headers.
Solder the top side of the male pin headers on the QRP Lab filter boards.
Remove the QRP Labs filter boards from the main low pass filter board.
Solder the four ceramic capacitors to the QRP Labs filter board, per the QRP Labs diagram.

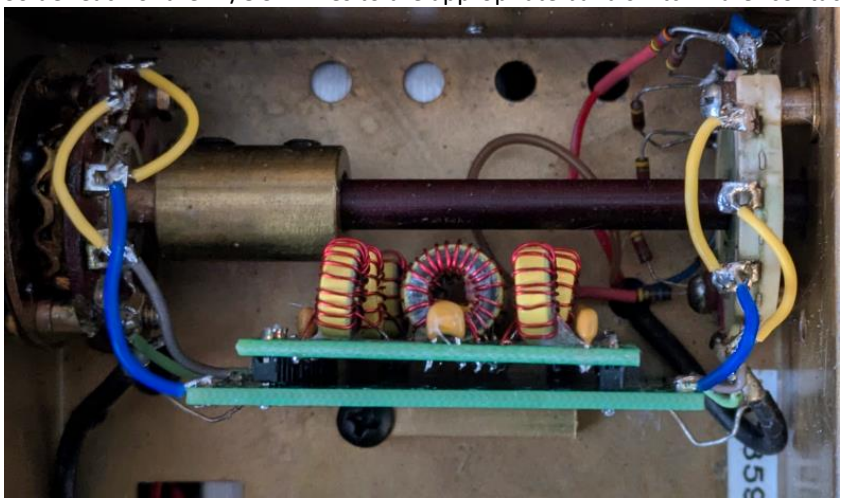
Wind the three T37-6 cores, using customized turns count, and solder them to the circuit board.
Observe proper band placement of each LPF board on the main filter board.
Solder all three LPFs to the main low pass filter board. Cut off excess pin lengths.
Ensure the IN/OUT pins on the LPF board match up with the IN/OUT pins on the main LPF board.
Solder IN/OUT wires to each of the three QRP Labs low pass filters.

In Filter 5: 6/8" (blue)	Out Filter 5: 1 1/4" (blue)
In Filter 3: 4/8" (gray or orange)	Out Filter 3: 7/8" (gray or orange)
In Filter 1: 4/8" (green)	Out Filter 1: 1" (green)



Confirm that there is an open between the input pin and ground on each filter.
Confirm that there is an open between the output pin and ground on each filter.
Confirm that you see a short between the input pin and output pin on each filter.

Secure the low pass filter board to the radio chassis with the 6x32 screws.
Solder each of the IN/OUT wires to the appropriate band switch wafer contact.



Power up the radio and turn mode switch to CAL postion. Confirm that you can hear a 100 KHz calibration signal on each band.

E. Inductance Measurements

There are three low pass filters in the system. Each filter has three T37-6 toroid cores.
Here are the measurement test results for the coil turns that were used:

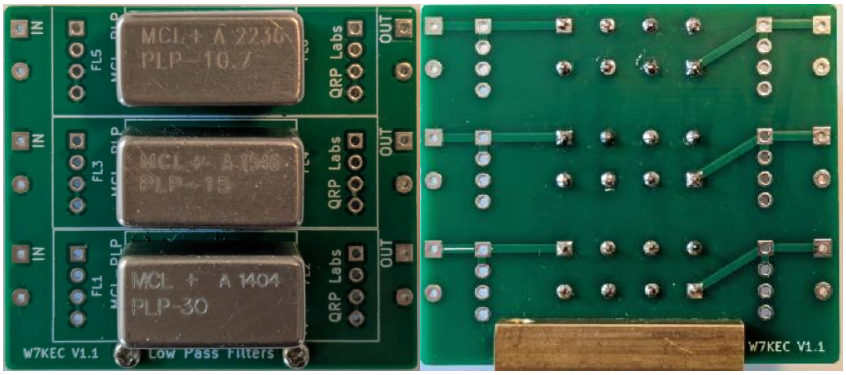
Turns	Calculated	LCR-ST1	FA-VA5
11	0.36 uh	0.4 uh	0.432 uh
12	0.43 uh	0.5 uh	0.493 uh
14	0.59 uh	0.6 uh	0.633 uh
15	0.68 uh	0.7 uh	0.755 uh
19	1.08 uh	1.0 uh	1.16 uh
20	1.20 uh	1.1 uh	1.28 uh

For these particular cores, the inductance can be increased by reducing the spacing between each turn.
The following values were obtained by varying the turns spacing:

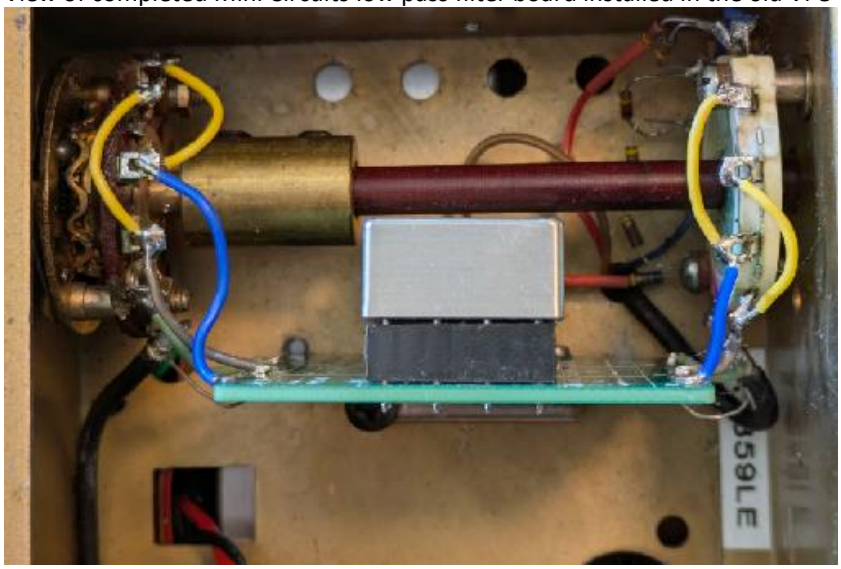
11 turns	432 nh to 650 nh
20 turns	1.28 uh to 1.73 uh

F. Mini Circuits PLP Low Pass Filter Board

Configure six each 7 pin female headers. Remove three of the pins on each header.
Shave off the top of each header so that the plastic header body is 6 mm high.
Solder the headers to the top of the circuit board.
Attach the circuit board to the brass mounting channel, using two M2-5 screws
Here is a front and back view of the filter board with the Mini Circuits LPF filters installed:



View of completed Mini Circuits low pass filter board installed in the old VFO cavity.



G. Coax Cable Interfacing

Install a RG316 coax cable, with a male right angle SMA connector, between the output of the Si5351 box and the RF input contact on switch 2a. Be sure to ground the shield on the end of the cable attached to the RF input contact.

Remove the factory RG174 coax cable that runs between the output of the factory VFO circuit board and Pin 3 of the Accessory jack J4 on the rear panel of the radio.

Install a RG316 coax cable between the RF output contact switch 1a and Pin 3 of the Accessory Jack J4 on the rear panel of the radio. Be sure to ground both ends of the coax cable.

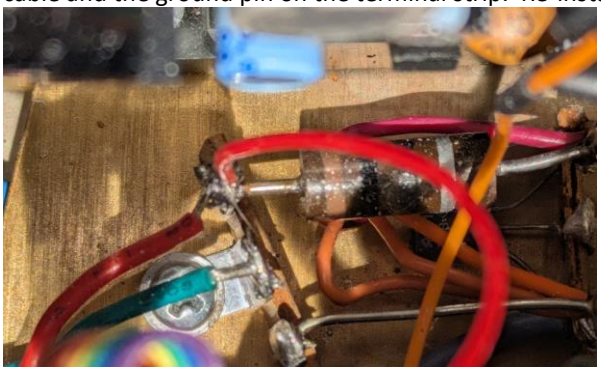
XVI. Install VFO Module and Miscellaneous Parts

Install the Si5351 VFO box on the top side of the Atlas VFO enclosure using the two screw holes that secured the factory VFO circuit board. Use a 6-32 x ½" screw for the hole that also has the low pass filter mount. Use a 6-32 x ¼" screw for the other hole. The screws inside the VFO enclosure should not protrude more than 3 mm from the bottom of the enclosure.

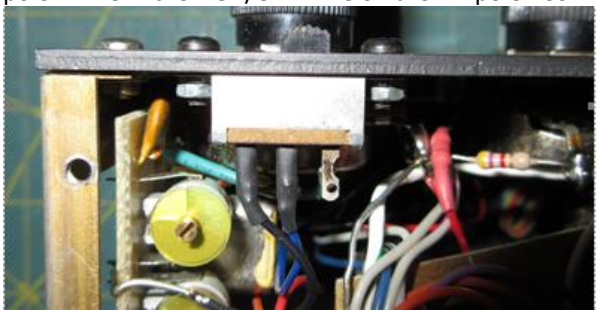
Install the rotary encoder in the front panel VFO tuning hole. Attach the VFO tuning knob to the shaft of the encoder. Use a spring-loaded washer between the back side of the VFO knob and the front bushing shaft of the encoder. This will allow one to apply tension to keep the tuning know from free spinning. Attach the Plug the 5 pin female header into the optical encoder.

Either replace the DIM slide switch with a DPDT unit or a toggle switch. Install the appropriate switch label. Install a SPDT toggle switch in the old Dial Set hole. Install the appropriate label.

Remove the PC-200 board from the radio. This will allow easy access to the voltage regulator terminal strips located on the top side of the chassis. Install a connectorized power cable between the 13V point downstream of R9 (10 ohm resistor that provided power to the original dial lamps) and the Si5351 DC power cable and the ground pin on the terminal strip. Re-install the PC-200 board.



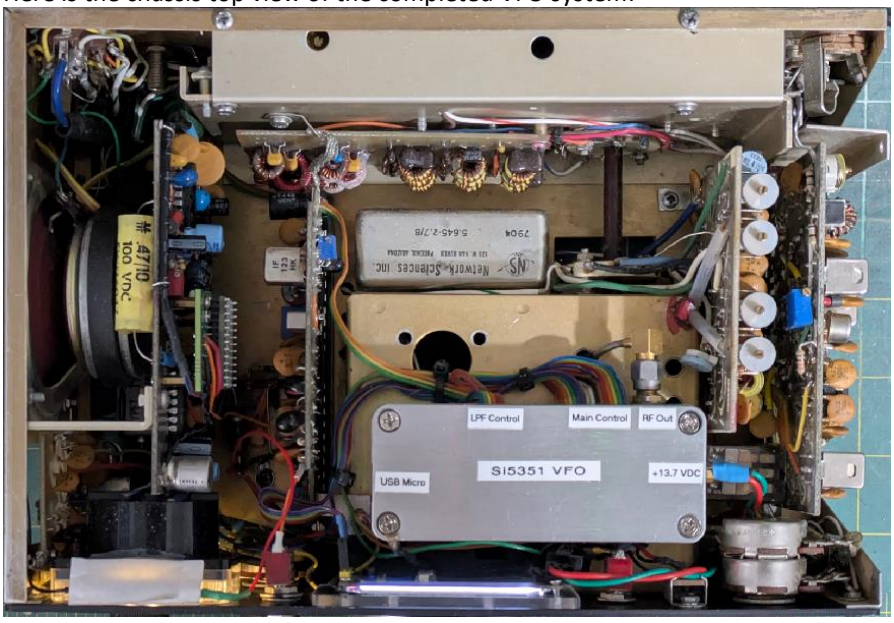
Install a ground bus wire between the Frequency Lock slide switch and the Mem/Step toggle switch. Replace the NOR/OPP slide switch with a DPDT unit. Reconnect the carrier oscillator switching wires on one pole. Wire in the NOR/OPP wire on the 2nd pole. Connect a ground wire to the tab on the NOR position.



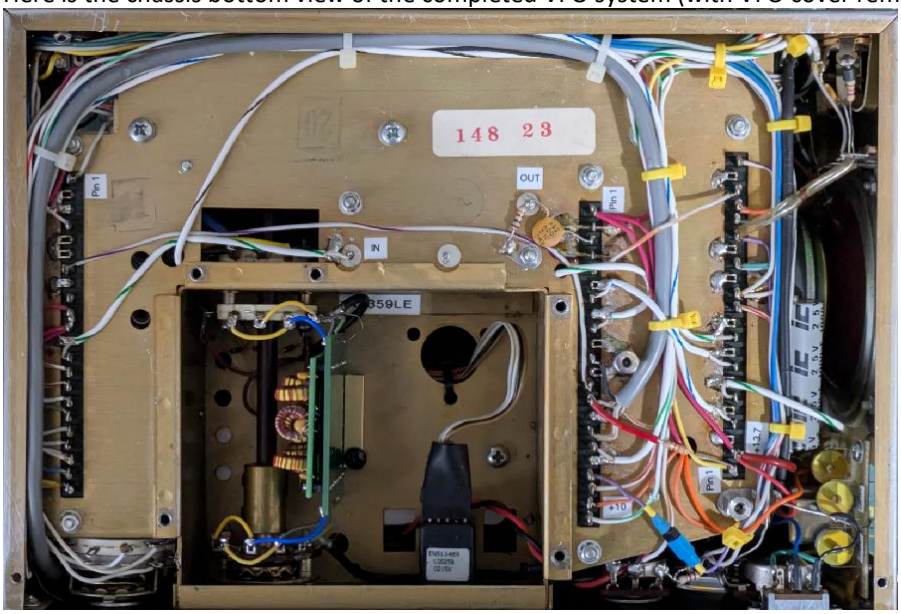
Connect the appropriate wires from the 16 wire ribbon cable to the front panel VFO controls. Connect the appropriate 6 wire ribbon cable wires to the Ext VFO terminal on the Accessory jack and the CW Terminal connection.

Testing

Power up the radio
Verify proper display reading on the TFT display
Allow 4 hour warmup of the VFO. Check calibration with a frequency counter.
Confirm a ~ +10 dbm VFO output for each band
Confirm proper operation of the following controls:
Frequency Lock
Mem (5 memories per band)
Step – 5 available steps
Scan – 2 scan modes
Here is the chassis top view of the completed VFO system:



Here is the chassis bottom view of the completed VFO system (with VFO cover removed):



XVII. Appendix

A. Tech Tips

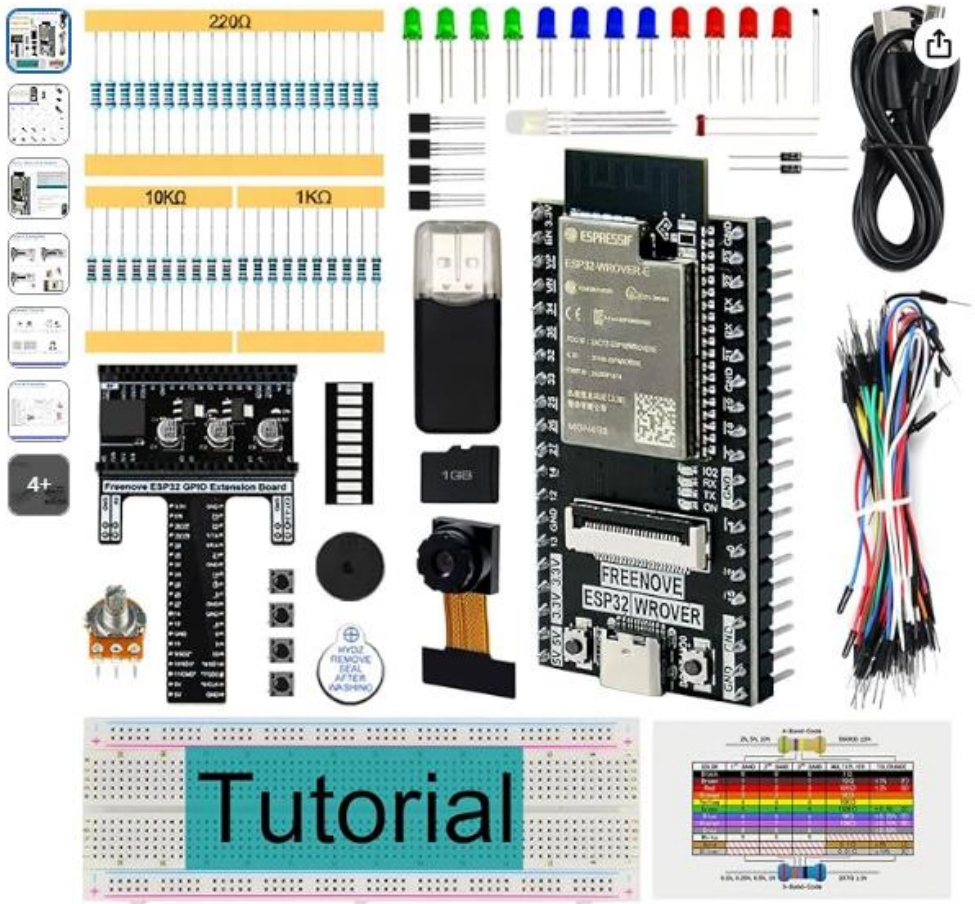
1. Parts Kit

The parts kit will come with a parts list. Be sure to confirm that you have received all of the parts that are listed on the Parts List.

2. ESP-32 Programming Kit (~ $30)

If you want to learn how to program an ESP-32 chip in C/C++, then you might want to consider this expensive training kit:

https://www.amazon.com/Freenove-ESP32-WROVER-Included-Compatible-Wireless/dp/B0CJJKSN4F/ref=sr_1_2_sspa?crid=1X8GIMO6XGK2D&dib=eyJ2IjoiMSJ9.Bb8F_GU1pt634Xoi2LYVtjEencD1RgZL6f2a6YiHxR-6RI3pf1kGfVMML9WYBEoYiI3czo5FhaCPvww4mZHYbw1-vTAMpb-dEfUjBtiLtU_rFK6LQHZcR8vDqzif1KvNh0MRHNUFFY5RQGXmOrCv2-calO1S7pYRlaXDBFWOqGKpWUi_m2PhnBqjyaciervwI2nE6-vI3BJykvwokJJ07GmDr9gk7o5YKyQcJBt_fmA.W7RUjML6A-lE1udn2J5CE_9fK3xeqF24B_VUmRhhwLc&dib_tag=se&keywords=freenove&qid=1744985767&sprefix=freenov%2Caps%2C601&sr=8-2-spons&sp_csd=d2lkZ2V0TmFtZT1zcF9hdGY&th=1



3. Programmed ESP-32 Microprocessor

The ESP-32 has been programmed so that no wiring connection is required on Atlas Accessory socket. This will allow testing without the connecting the wire. At some point, the one line of code can be changed so the Ext VFO checks can be made.

4. Hand Tools

The following equipment will be needed in order to complete the project:

Electric drill with bits	mandatory	1/16”, 5/64”, 3/32”, 1/8”, 7/64”, ¼”, 9/64”
Heat Gun	mandatory	
DC Power Supply	mandatory	
Soldering Station	mandatory	
Solder Sucker	mandatory	
Sharpie – extra fine point	mandatory	
Phillips screwdriver	mandatory	1/8”
Steel ruler in mm	mandatory	6” long
Diagonal wire cutters	mandatory	similar to Xcelite 170M
Center punch	nice to have	
Dremel tool	nice to have	with carbide cutting disk and router bit
Drill press	nice to have	with 1/8” end mill bit & 6-32 tap
Jeweler’s file	nice to have	
LCR Meter	nice to have	to check values of resistors and capacitors
PanaVise	nice to have	
Spectrum Analyzer	nice to have	
Oscilloscope	nice to have	

5. Tantalum Capacitors

There are several tantalum capacitors that will need to be installed. These capacitors have negative and positive terminals. If you install the capacitors backwards, then it will short out when DC power is applied. The long lead on the capacitor is the positive terminal.

6. Resistors

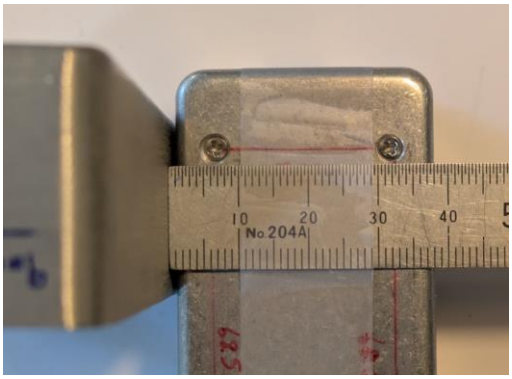
It is recommended that you measure the resistance of each resistor before soldering it into the system.

7. Heat Shrink Tubing

Most of the wiring connections require the use of heat shrink tubing. In the parts package, there are a number of different diameters and lengths of tubing. See the parts description at the beginning of this document. Be sure to slide the required tubing over the wiring before the wiring is soldered to the connection. Then use a heat gun to shrink the tubing to conform with the soldered connection.

8. Measuring distances for drilling holes

The enclosure has rounded corners on the outside of the box. When measuring hole distances, be sure to place a straight edge against the side of the enclosure to keep from using a rounded corner as a measuring reference point. Otherwise, your measurements are going to be 1 – 2 mm too short.



9. **Drilling Holes**
   Whenever you need a large hole, do not start out with a drill bit for the final hole size. Start out with a smaller bit and work your way up to the large hole. This will result in more accurate drilling and a round hole.

10. **Optical Encoder**
    There are two different optical encoders that can be used in the VFO. Both encoders are available on eBay for about the same price.

    Bourns unit
    https://www.ebay.com/itm/295327320682
    Oak Grigsby unit
    https://www.ebay.com/itm/284621140106

    The Bourns unit has a very light feel and has a short tuning shaft. With a weighted tuning knob, you may find the tuning knob turning on its own. The stop this, one needs to install a spring loaded flat washer between the back of the tuning knob and the encoder mounting shaft. Pressure is applied to the tuning knob prior to locking down the knob set screw. The amount of pressure determines the feel of the tuning knob.

11. **LCR Meter (~ $40)**
    A digital LCR meter will make it easier to determine the values of resistors, inductors, and capacitors. This unit has great performance and is low priced:

    https://www.amazon.com/dp/B0DBQ4SQGK?ref=ppx_yo2ov_dt_b_fed_asin_title

12. **Magnifier (~ $20)**
    There are a lot of small parts that will need to be installed for the project. Installation will be much easier if you use some type of lighted magnifier. I use this one:

    Amazon.com: Vision Aid 30x Hands-Free Magnifier with Ultra Bright 36 LED Lights and Case - 40x Loupe Magnifying Glass with Stand for Reading Jewelry Coins Watch Hobby Crafts Close Work : Health & Household

13. **Dremel Rotary Tool (~ $70)**
A Dremel rotary tool is very handy for cutting/shaping metal, circuit boards, etc. The author uses a Model 395.

14. **Micro-Mark Mini Drill Press with Proxxon X-Y Table (~ $300)**
The drilling of holes and the milling of the notches on the VFO enclosure is easily accomplished with a milling machine that has accurate vise control of the x and y axis. The milling can also be completed with a 1/8" end mill and a drill press with a fence. The quality of the milling will not be as good as that of a mill, but will be acceptable. Also keep in mind that the drill press spindle and bearings are not designed for high side forces.

These videos provides details on how to use the drill press and the x-y table.
https://www.youtube.com/watch?v=t80JeBpDMfE
https://www.youtube.com/watch?v=1CEUlFG9LFY
The x-y table can be adapted to fit most drill presses.

15. **Parts Vice (~ $70)**
A PanaVise with vacuum base and nylon jaws makes it very easy to solder parts to the circuit board, fabricate pin header wiring harnesses, etc.

16. **Taig Micro Lathe and Vertical Mill Attachment**

The spindle and bearings on a lathe are designed for high side forces. This is a picture of a Taig micro-lathe with a vertical mill attachment:

17. **Proxxon MF70 Micro Mill (~ $450)**

Here is a milling operation using the XY table on a Proxxon MF70 micro mill.

B. VFO Spurs

Spurs were measured on each of the five ham bands. The radio was terminated with a 50 ohm load and the frequency step was set to 100 Hz. The S-meter signal level of each spur was recorded.

Using even division in the Si5351 results in fewer spurs than using fractional division. The higher the frequency step rate, the higher the probability that even division will be used. Example: A 10 KHz step rate will have fewer spurs than a 1 KHz step rate.

Spurs have very narrow bandwidths. So, if the step rate is too high, you will tune past the spur – i.e. it is there but you will not be able to hear it. If you set the step rate to 100 Hz, you will hear a lot of spurs on the 15 meter and 10 meter bands.

The Si5351 Library code has been optimized for minimal clicking/popping when changing frequency. For a given set of libraries, the amount of clicking/popping will vary depending upon what part of the band is being used, as you change frequency.

The Pavel Milanes Library uses the si5351mcu.cpp and si5351mcu.h files.
The Jason Milldrum Library uses the si5351.cpp and si5351.h files.

Overall, the Jason Milldrum library had the most spurs, especially on 10 meters. To confirm my testing process, I ran a spur test using my IFR 2025 signal generator as an external VFO. There was a total of 5 spurs across all five bands. In normal operation, a step rate of 1 KHz will be used. There is a minimal number of spurs with that step rate.

C. Build Times

These are typical build times for various pieces of the project. special functions, it may be advantageous to convert the Atlas VFO to a full function signal generator. This can be accomplished by the following steps:

1. Prep ESP-32 Module
   5 minutes
   Solder four each 10 pin male headers to the module
   Program the ESP-32 module
   Test the ESP-32 module

2. Prep Si5351 Oscillator Board
   5 minutes
   Cut off end of board
   Solder two each 10 pin male headers to the module
   Solder TCXO module to the board

3. Enclosure Machine Work
   60 minutes

4. Build VFO Circuit Board
   2.5 hours

5. Build TFT Display plate mount
   5 minutes

6. Build low pass filters, install master board, and build LPF board mount
   60 minutes

7. Install band-switch resistor matrix
   60 minutes

8. Remove factory VFO
   60 minutes

9. Build 6 pin and 16 pin ribbon cable wiring harnesses
   20 minutes

10. Install front panel controls and labels
    20 Minutes

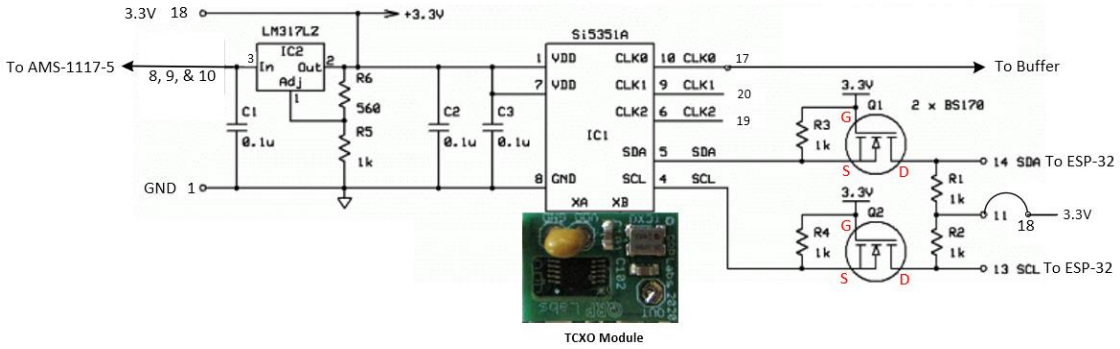
D. How To Remove VFO Enclosure From Radio

For some trouble-shooting operations, the VFO enclosure will need to be removed from the radio. This can easily be done without having to unsolder any wires.

Please follow these steps:
Remove the top and bottom covers to the radio
Remove the cover to the bottom VFO compartment
Unscrew the male SMA connector from the RF Output jack
Disconnect the DC power connector
Remove the top cover from the enclosure
Remove the 6 wire ribbon cable
Remove the 16 wire ribbon cable
Remove the two 6-32 screws that secure the VFO enclosure to the radio chassis
Remove the enclosure from the radio.

E. Si5351 Checks

This is the schematic for the Si5351 board. Problems in this area are usually related to bad solder joints.



Confirm that the current draw of the board is about 36 ma.

Confirm that you can see 5.0 VDC on pins 8, 9, and 10 of the Si5351 board.
Confirm that you can see 3.3 VDC on pins 11, 13, 14, and 18 of the Si5351 board.
Confirm that you can see 3.3 VDC on the VDD solder pad

Q1 is located next to R1 on the circuit board. Q2 is located next to R2. The input pin on IC2 is located next to the silkscreen text "TCXO" on the Si5351 board. The output pin on IC2 is located next to pin 7 on the Si5351 board. Confirm that you can see 5.0 VDC on the input pin and 3.3 VDC on the output pin. Look at the OUT pin on the TCXO module with an oscilloscope. You should see a 25 MHz signal with a peak to peak voltage of about 960 mv. Find the TCXO silkscreen on the Si5351 board. On the solder pad next to the "O", confirm that you can see a 25 MHz signal at 960 mv peak to peak.

Remove the Si5351 board from the VFO board.
Confirm continuity for the following paths on the TCXO board:
GND solder pad to pin 1 on the Si5351 board.
VDD solder pad to pin 11 n the Si5351 board.

Confirm continuity from the following paths on the Si5351 board:
pin 17 to pin 10 of the Si5351 chip.
pin 7 of the S5351 chip to the output pin of the voltage regulator.
pin 18 to the output pin of the voltage regulator
drain of Q1 to pin 14 of the Si5351 board
drain of Q2 to pin 13 of the Si5351 board
top of R1 to the drain of Q1.
bottom of R2 to the drain of Q2.

gate of Q1 to pin 18 of the Si5351 board
gate of Q2 to pin 18 of the Si5351 board.
gate of Q1 to the gate of Q2.

F. DC Voltage Checks

In the event that one finds the VFO is not working correctly, then perform the following checks:

Power down the VFO, including the Atlas radio.
Remove the top cover from the radio.
Remove the top cover to the VFO box.
Remove the ESP-32 module and Si5351 module from their sockets
Select the 40 meter band
The three GND pins on the ESP-32 socket should show 0 ohms to ground.
Pin 19 should show 0 ohms to ground.
Move the Nor/Opp switch to Opp. Pin 19 should not show open.
Move the slide switch to Lock. Pin 32 should show 0 ohms to ground.
Pin 26 should show 2200 ohms to ground.
Pin 2 should show 2200 ohms to ground.
All other pins should show infinite resistance

Power up the radio from a regulated 13.7 voltage source.
You should be able to measure the following voltages:

Power Supplies	Test Point
13.7	Atlas red bus (supply to R9)
11.7	Input to VFO board (downstream of R9)
9.0	Input pin of the 3.3 volt regulator
3.3	Output pin of the 3.3 volt regulator
9.0	Input pin to 5 volt regulator
5.0	Output pin of the 5 volt regulator
9.6	Pin 5 of Atlas accessory socket
9.6	Pin 6 of Atlas accessory socket

Si5351 Osc.	Test Point
5.0	Pin 8
5.0	Pin 9
5.0	Pin 10
3.3	Pin 11
3.3	Pin 13
3.3	Pin 14
3.3	Pin 18

ESP-32 Socket	Test Point	
3.10	RST	
3.10	26	
3.30	35	
3.30	34	
3.30	3.3V	
3.30	22	
3.30	25	
3.30	21	
0.35	27	80M
1.00	27	40M
1.65	27	20M
2.23	27	15M
2.74	27	10M

Return band switch to the 40 meter position
Power down the radio
Install the ESP-32 module and the Si5351 module
Remove 16 pin ribbon cable connector
Remove 6 pin ribbon cable connector
Insure the NOR/OPP switch is in NOR position
Power up the radio
You should see red LEDs on the 5 volt regulator, 3.3 volt regulator and the ESP-32 module
You should not see a green LED on the ESP-32 module when the NOR/OPP switch is in the NOR position.
Measure the voltages on the 16 pin ribbon cable connector on the VFO board.
Measure the voltages on the 6 pin ribbon cable connector on the VFO board.

Install the 16 pin and 6 pin ribbon cables and measure the voltage on the ESP-32 pins.
The first set of ESP-32 reading are on the same side of the ESP-32 as the Reset Switch.
The second set of ESP-32 readings are on the same side of the ESP-32 as the 12C connector.

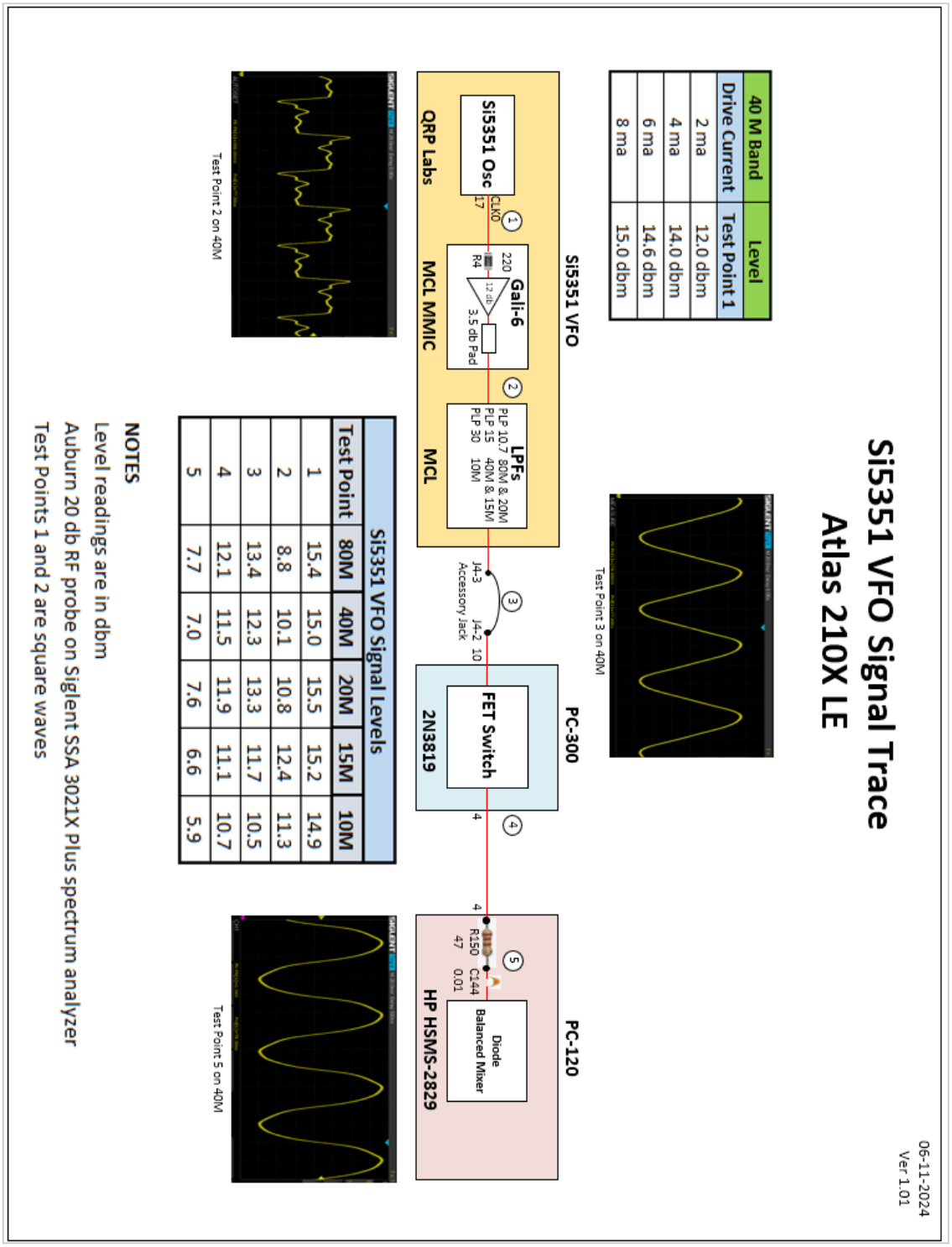
16 Pin Ribbon Cable	Test Point
0	1
3.3	2
3.3	3
0	4
3.3	5
3.3	6
3.3	7
3.3	8
3.3	9
3.3	10
0	11
3.3	12
3.3	13
3.3	14
3.3	15
2.2	16

6 Pin Ribbon Cable	Test Point
0	1
5	2
3.3	3
0.3	4
0.3	5
0.3	6
NA	7

ESP-32 Pins	Test Point
0.0	GND
3.2	RST
0.0	NC
0.5	VP
0.4	VN
3.0	26
3.2	35
0.0	18
3.2	33
2.2	19
3.3	34
0.0	23
3.3	TMS
3.3	5
0.0	NC
3.3	3V3
0.0	SD2
0.0	TCK
0.0	CMD
0.0	SD3

ESP-32 Pins	Test Point
3.3	TXD
0.0	GND
2.8	RXD
1.0	27
3.3	22
0.0	25
3.3	21
3.3	32
1.0	27
0.0	TDI
3.3	25
0.0	4
0.0	GND
3.3	0
3.3	5V
0.3	2
3.3	TDO
0.0	SD1
0.0	SD0
0.0	CLK

G. Si5351 VFO Signal Trace



H. System Diagrams

Figure 1 – Block Diagram

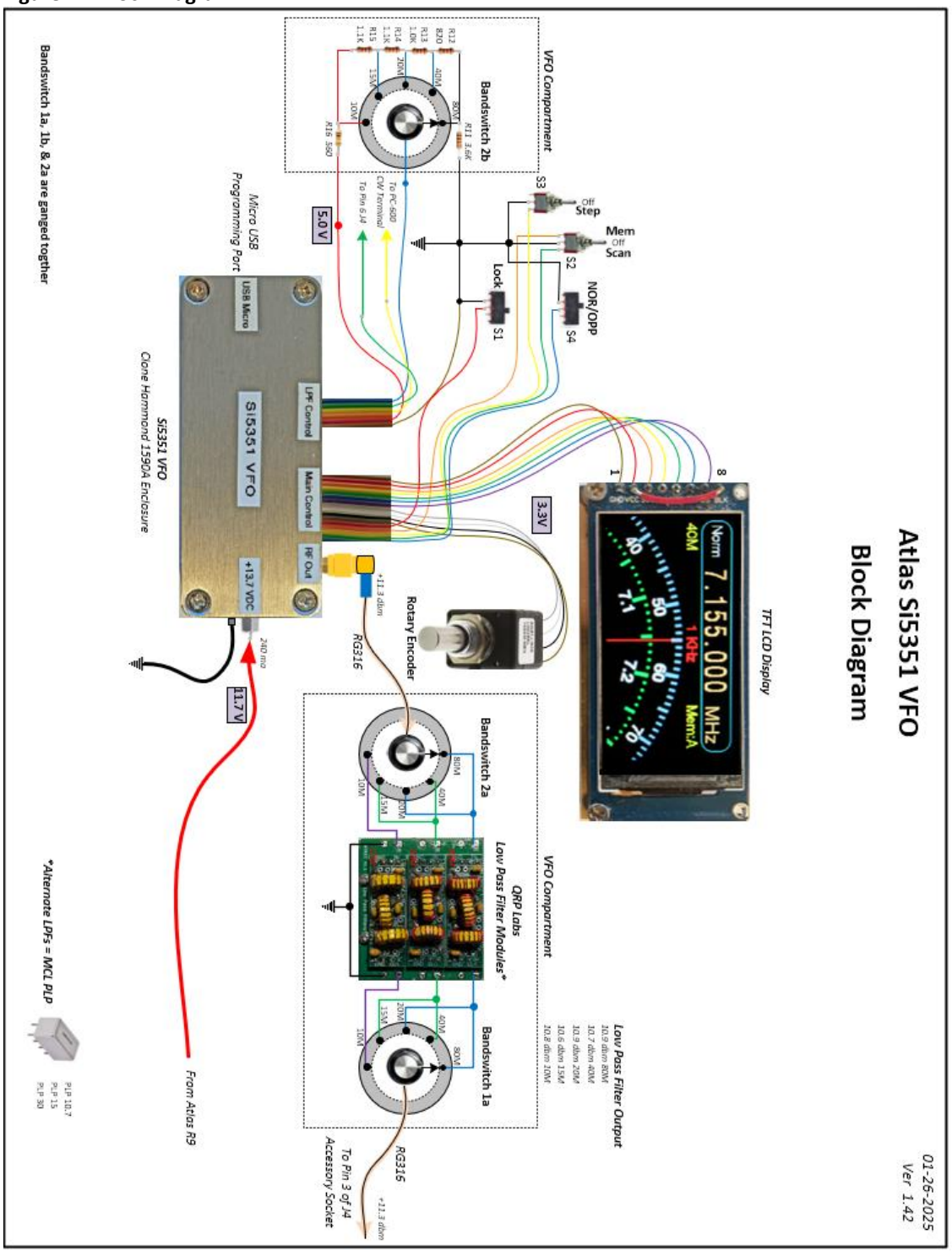


Figure 2 – Schematic

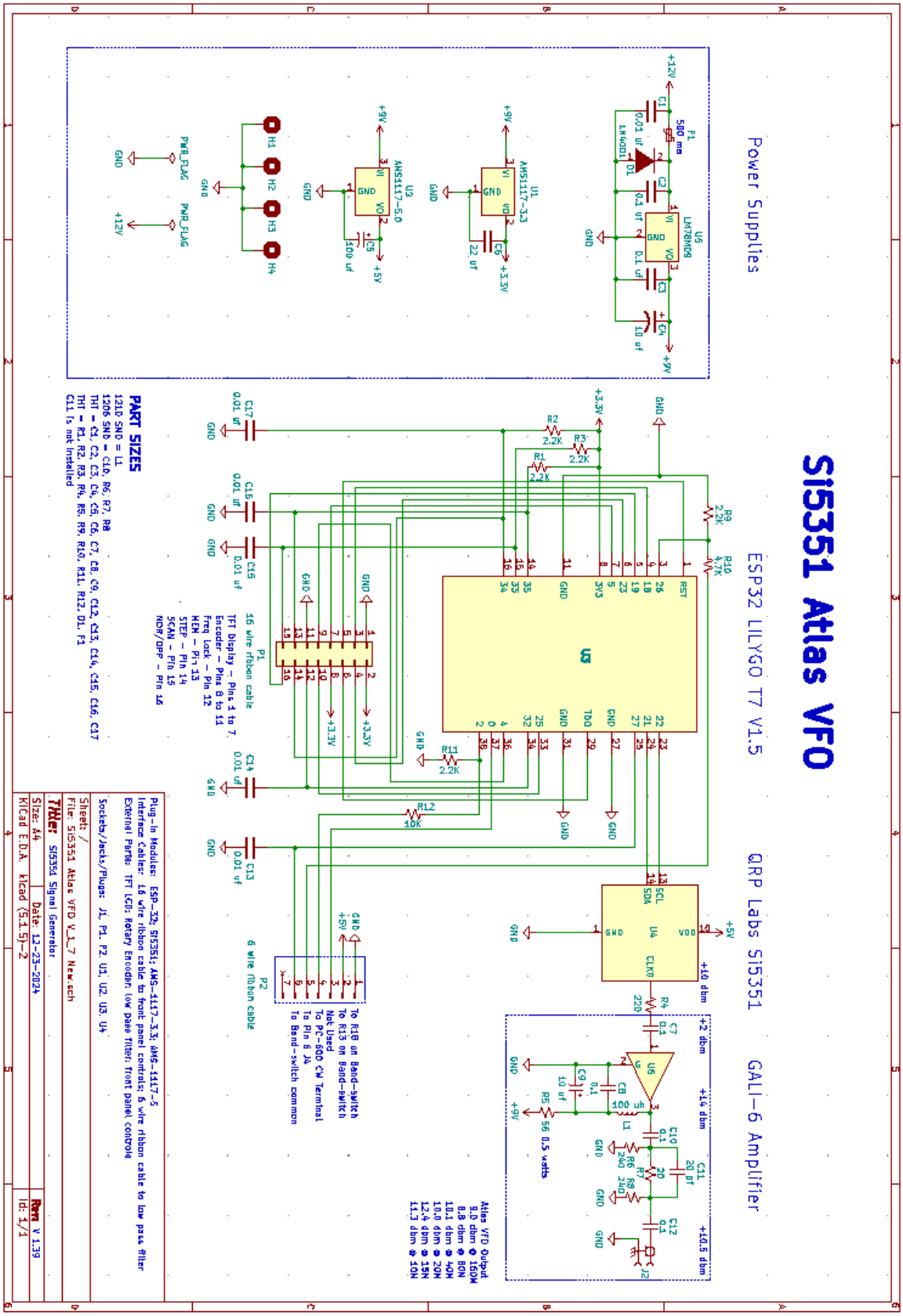


Figure 3 – Interconnection Diagram

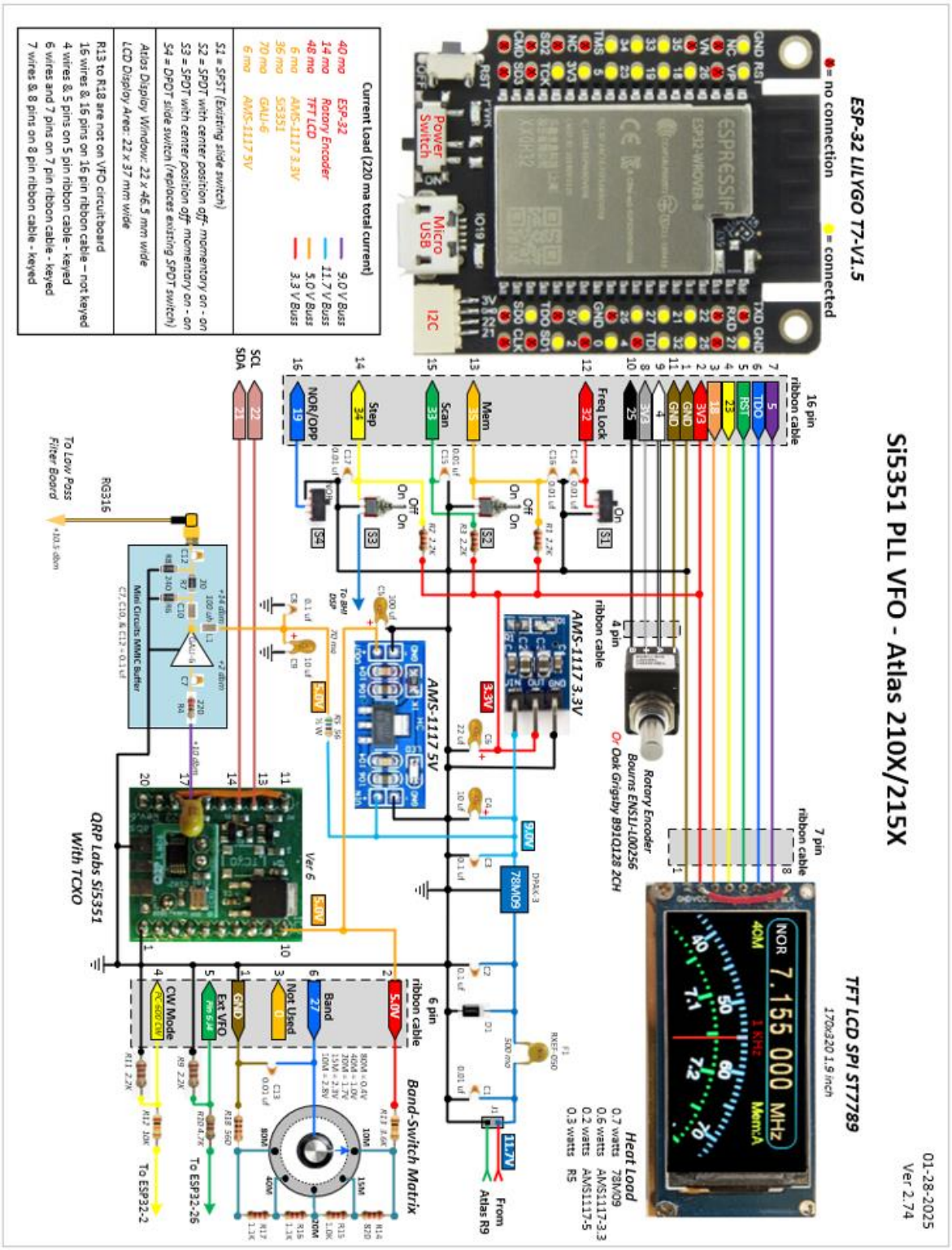
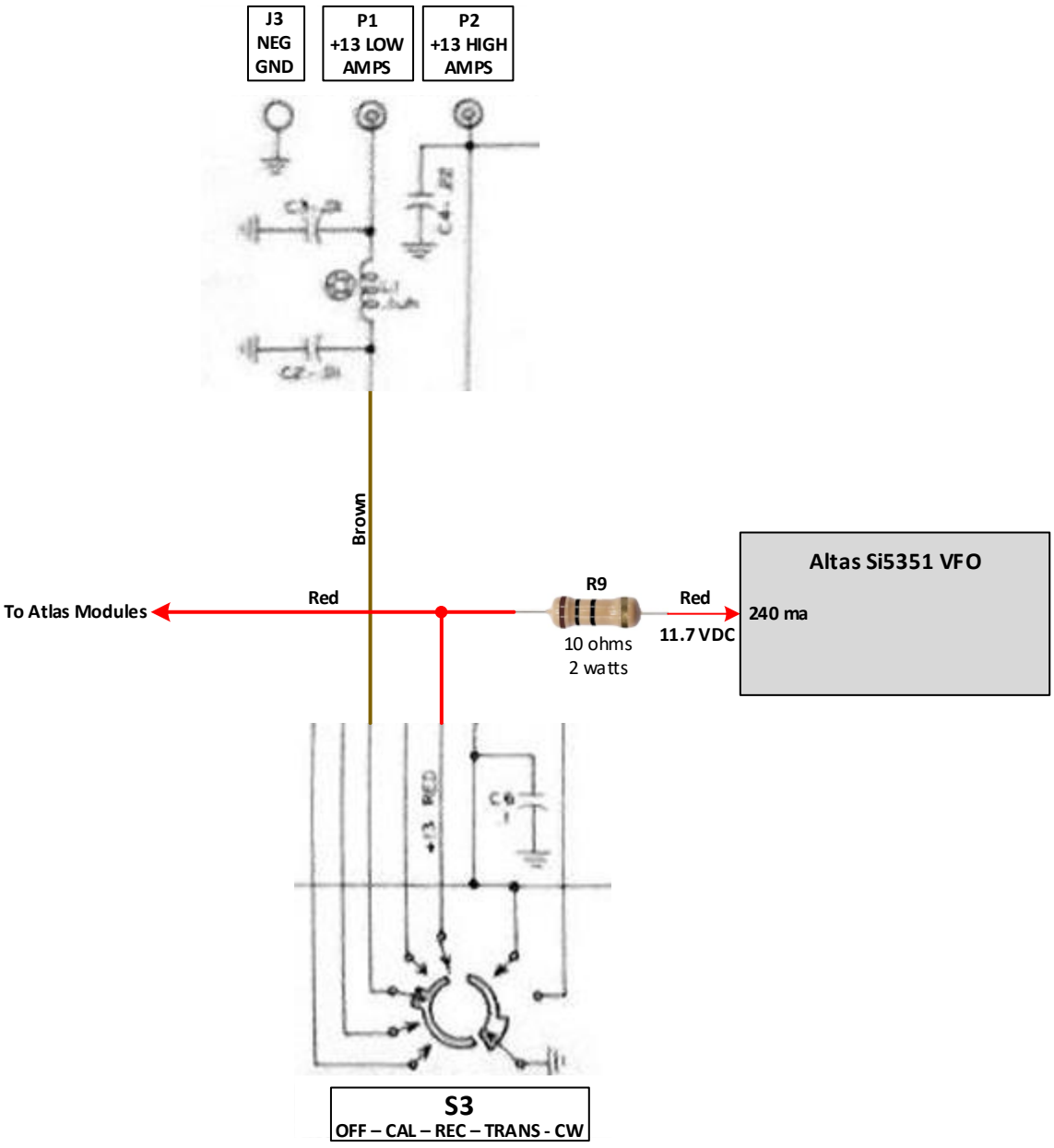


Figure 4 – Atlas Power Distribution



I. VFO Harmonics

Figure 5 – Factory VFO – 80M (20 dB pad)

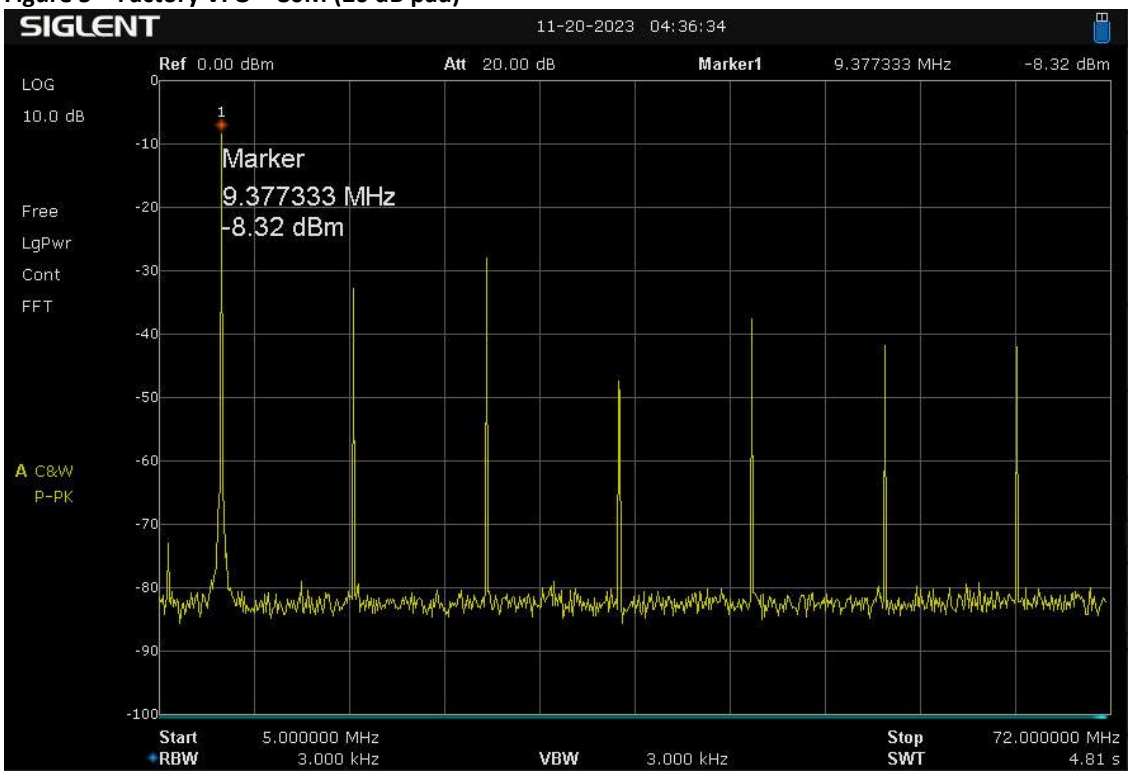


Figure 6 – Si5351 Atlas VFO with QRP Labs Low Pass Filter – 80M (20 dB pad)

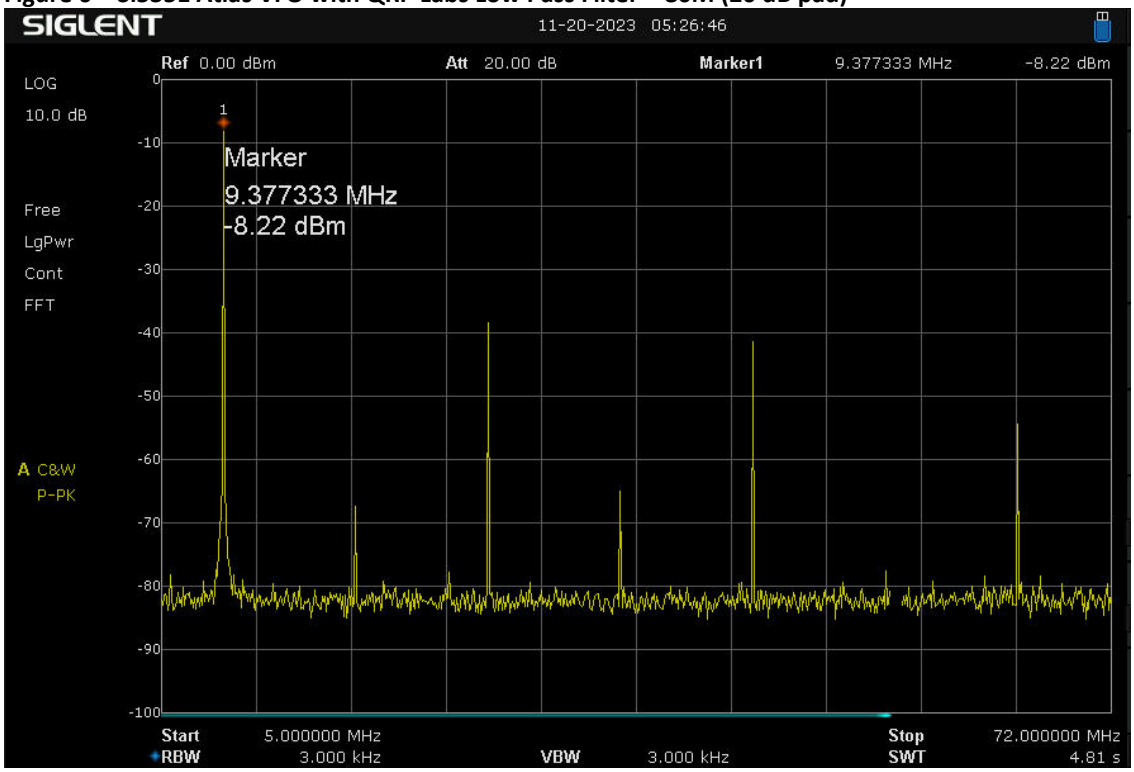


Figure 7 – Factory VFO – 40M (20 dB pad)

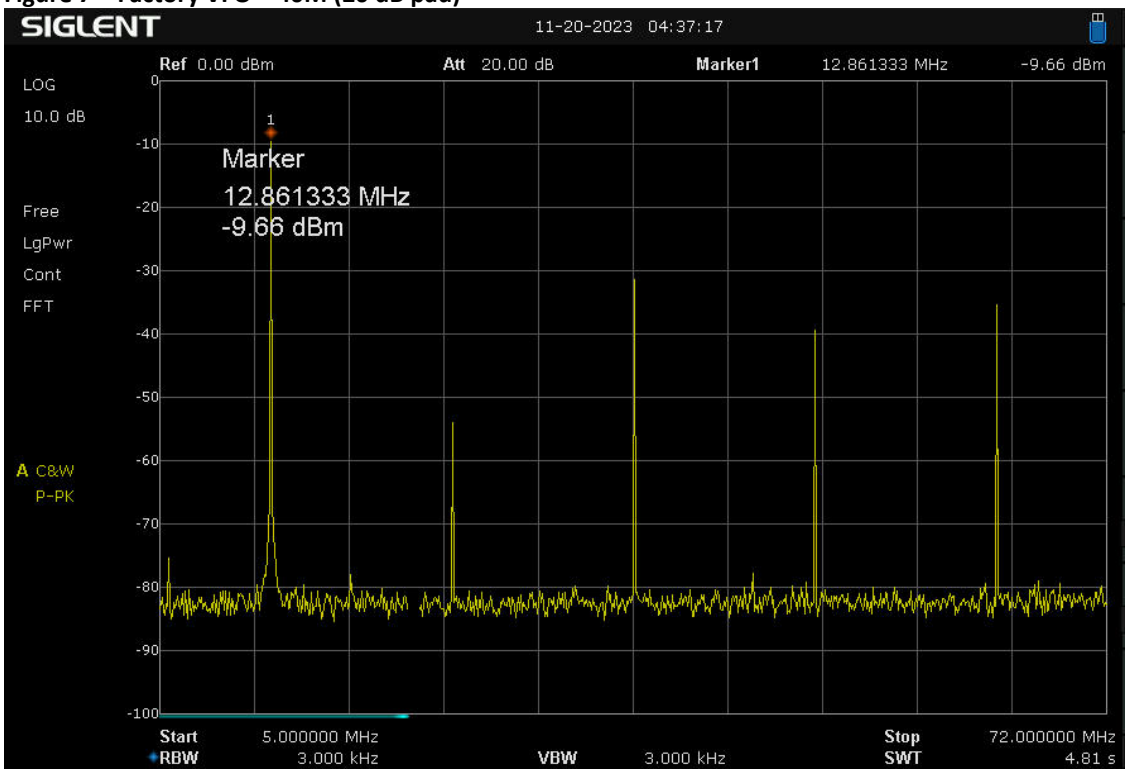


Figure 8 – Si5351 Atlas VFO with QRP Labs Low Pass Filter – 40M (20 dB pad)

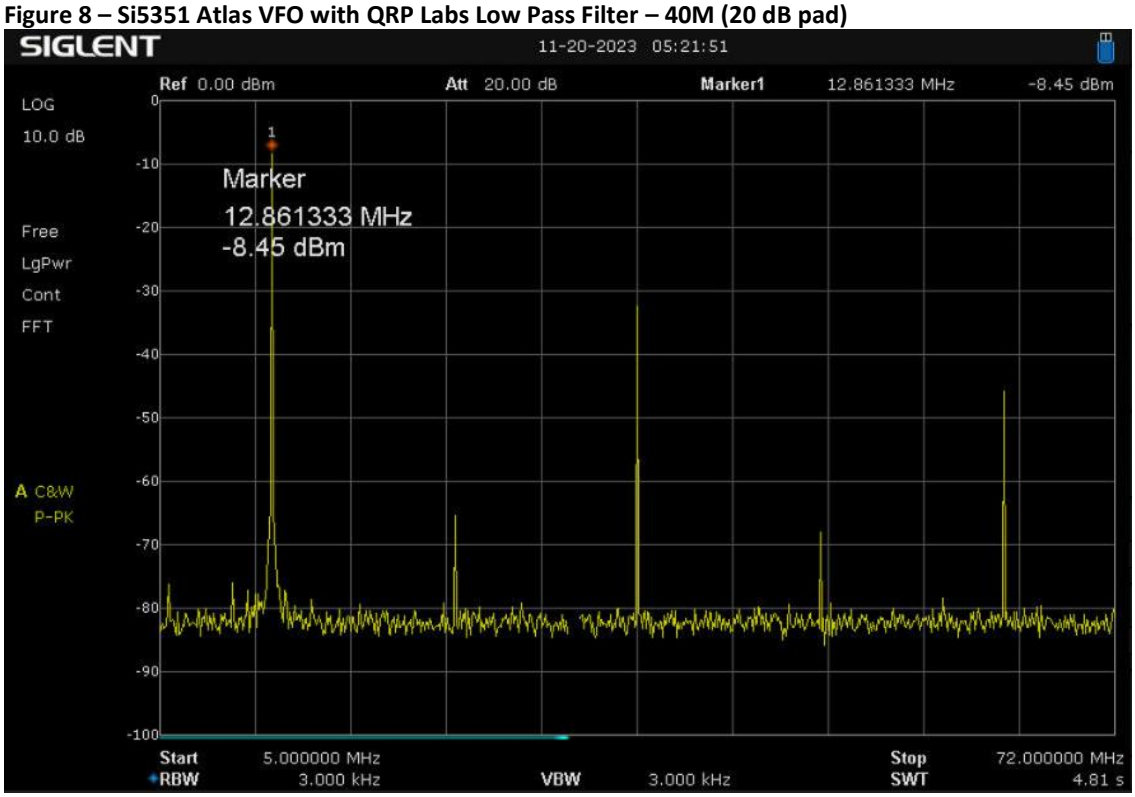


Figure 9 – Factory VFO – 20M (20 dB pad)

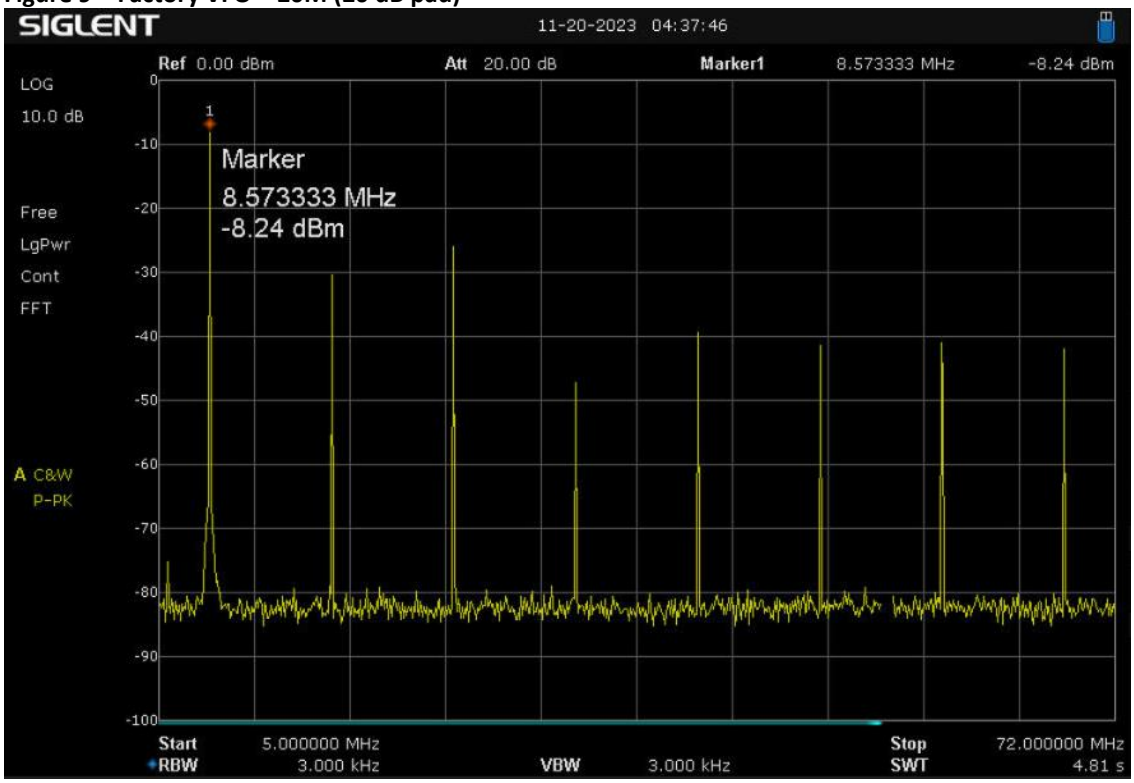


Figure 10 – Si5351 Atlas VFO with QRP Labs Low Pass Filter – 20M (20 dB pad)

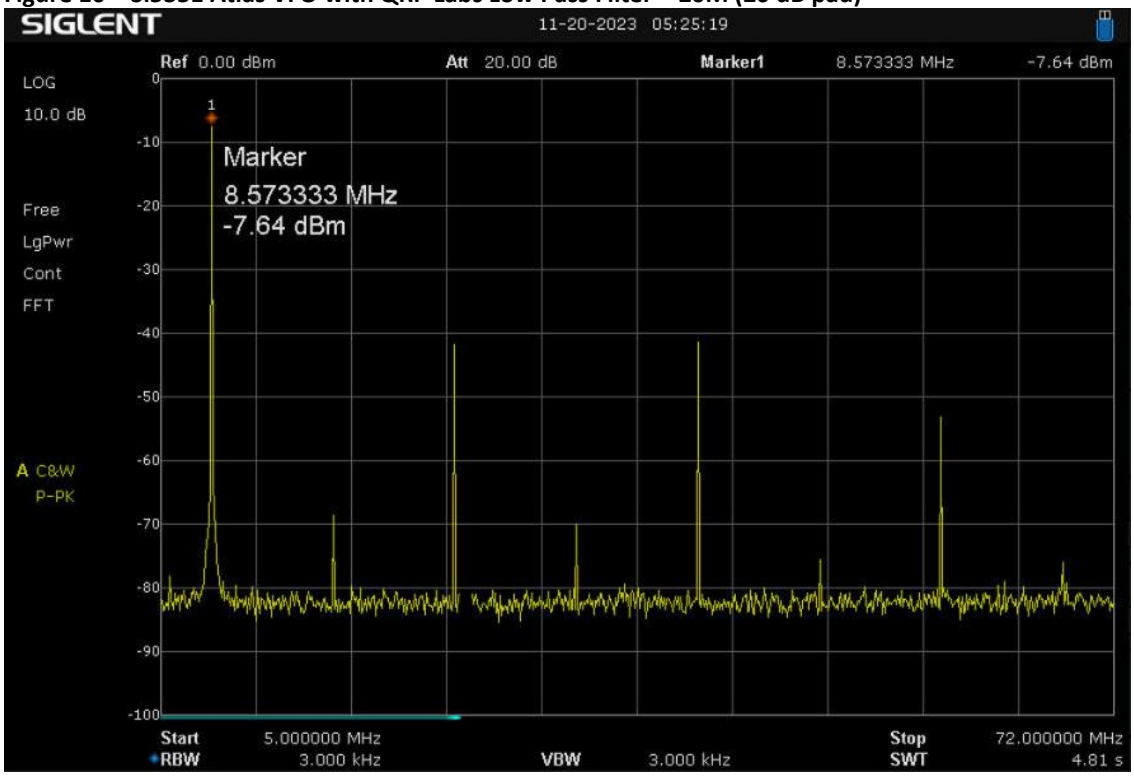


Figure 11 – Factory VFO – 15M (20 dB pad)

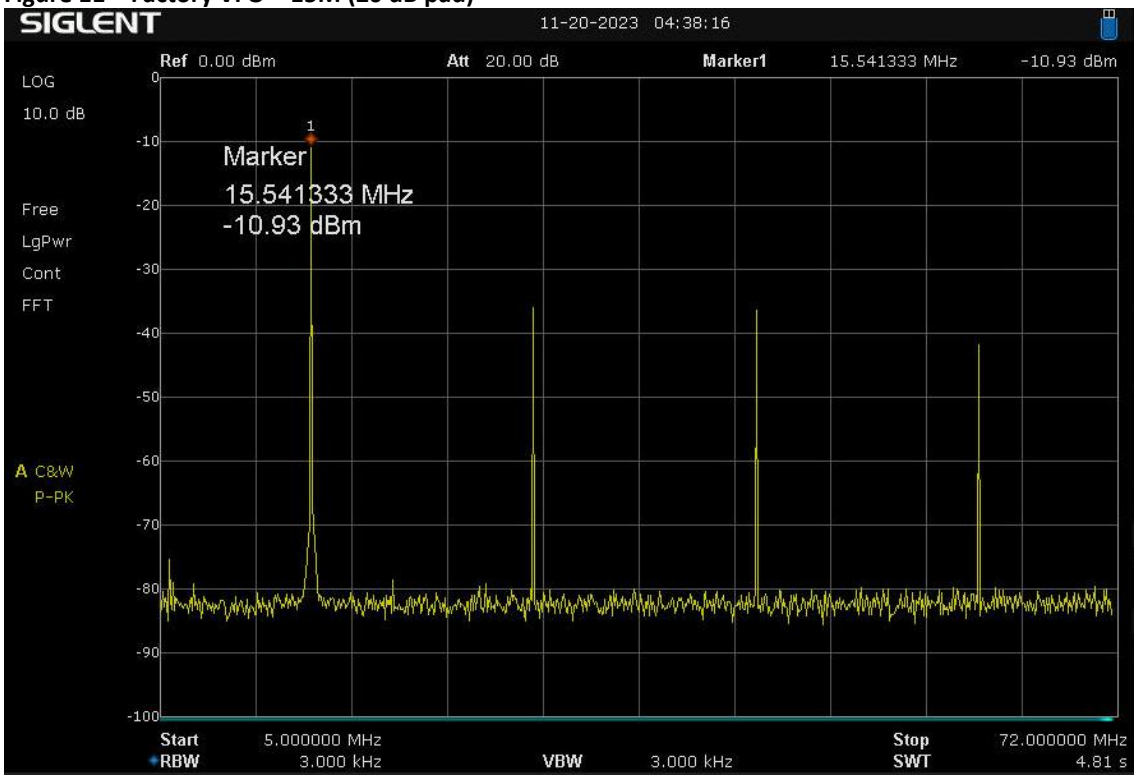


Figure 12 – Si5351 Atlas VFO with QRP Labs Low Pass Filter – 15M (20 dB pad)

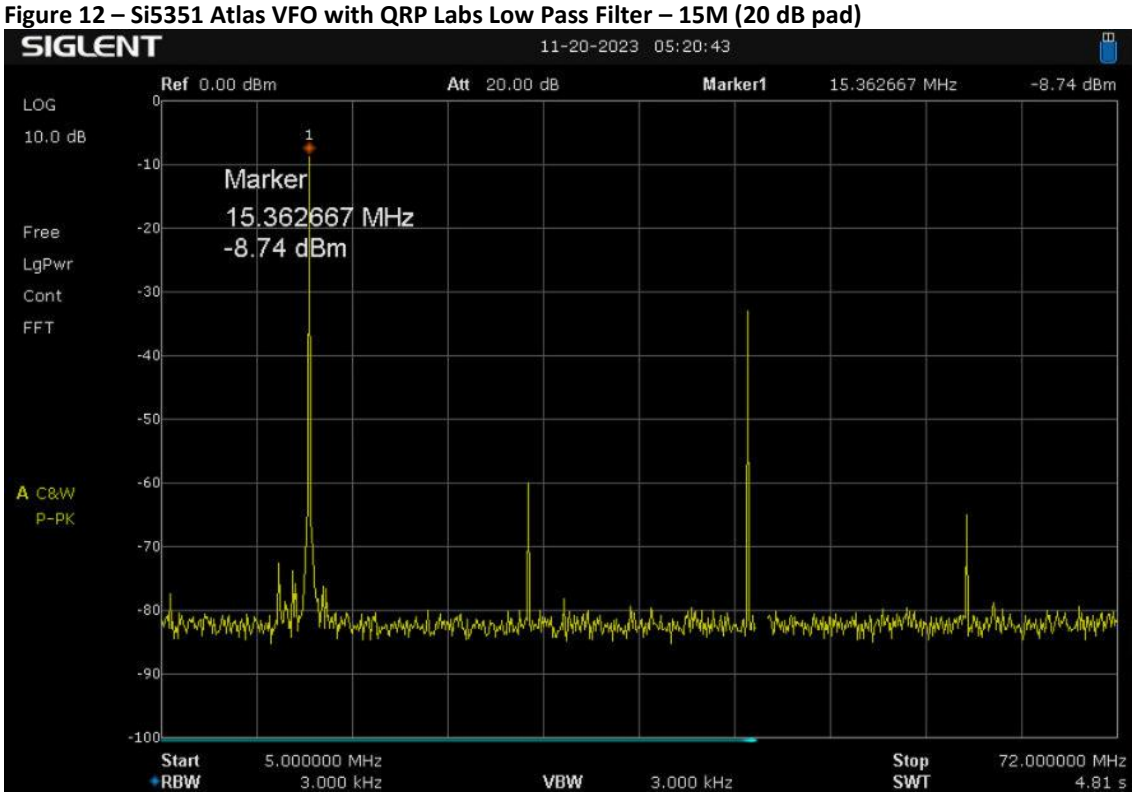


Figure 13 – Factory VFO – 10M (20 dB pad)

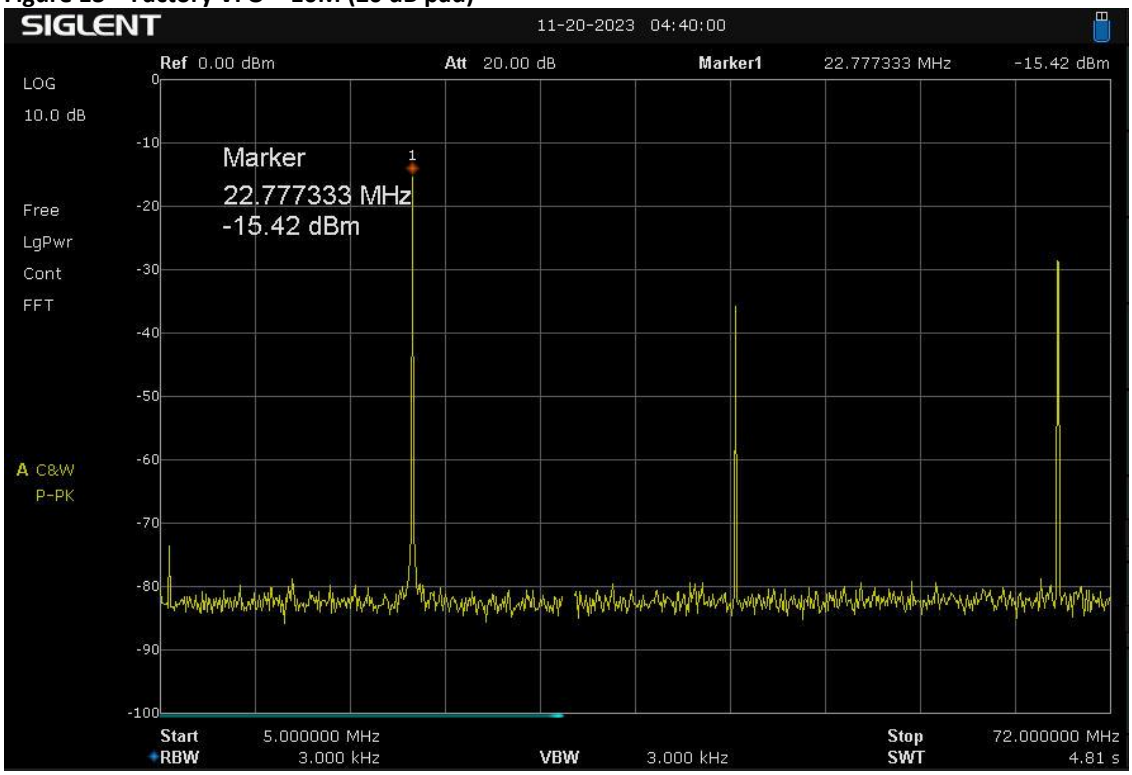
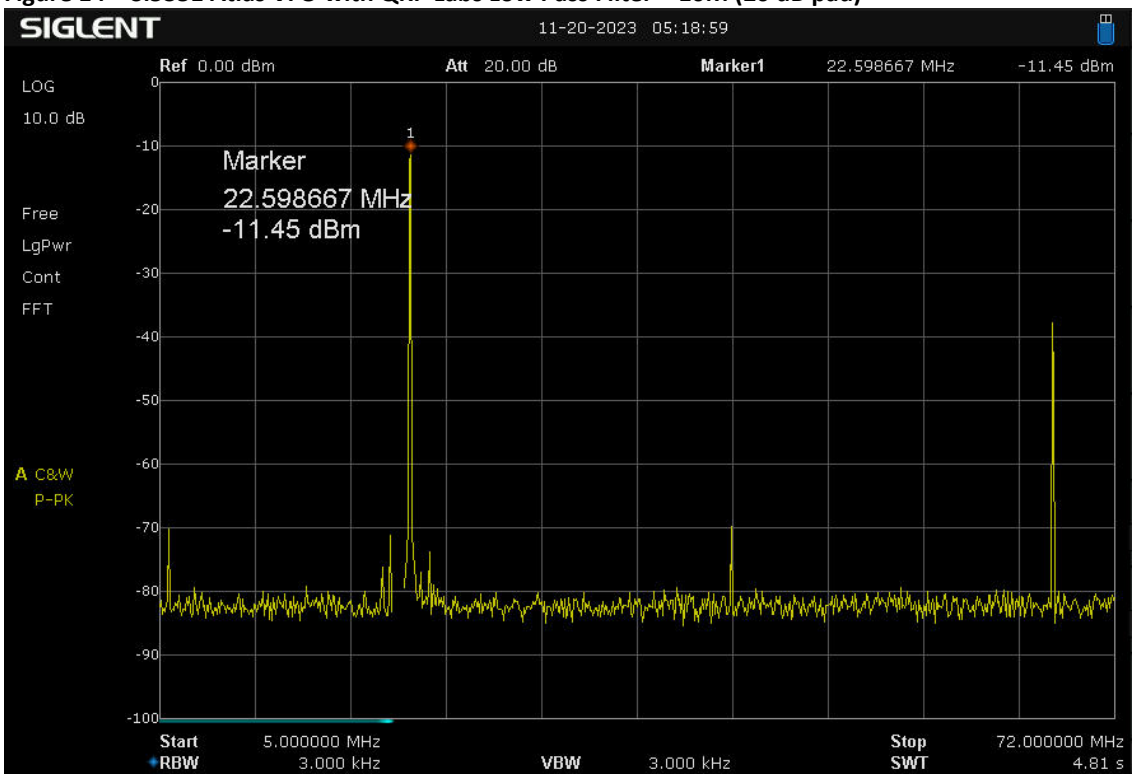


Figure 14 – Si5351 Atlas VFO with QRP Labs Low Pass Filter – 10M (20 dB pad)



J. Figure 15 - Sine Wave Quality

Si5351 Atlas VFO 80M Sine Wave with QRP Labs Low Pass Filter

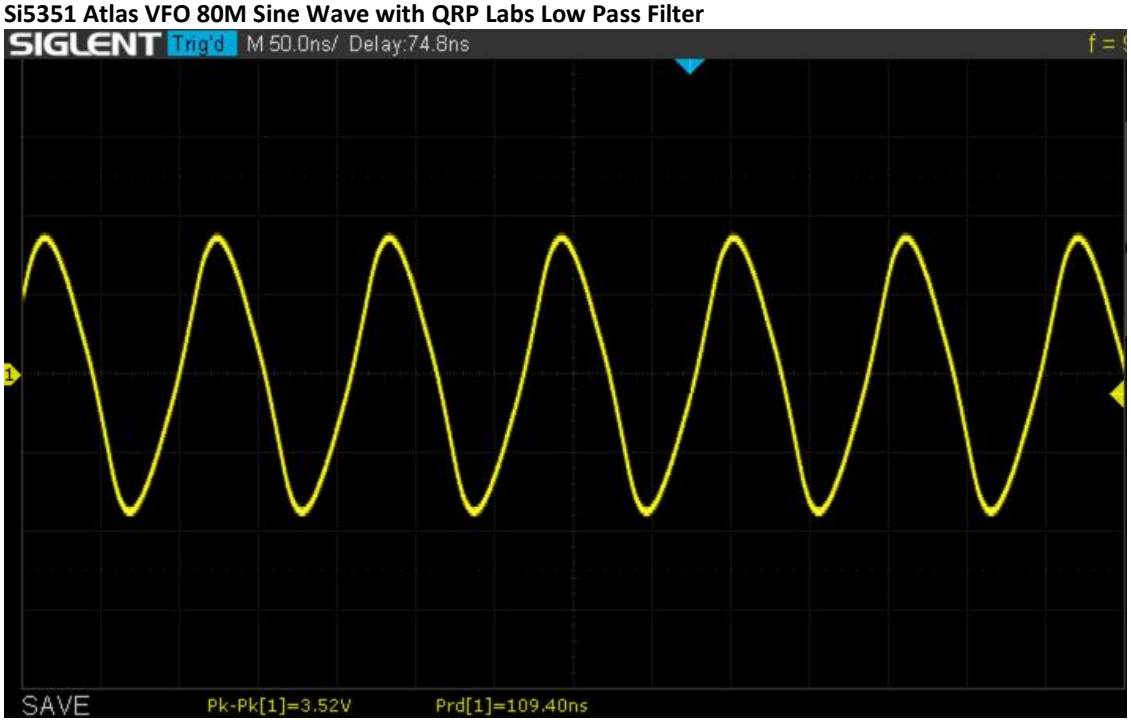


Figure 16 – Si5351 Atlas VFO 40M Sine Wave with QRP Labs Low Pass Filter

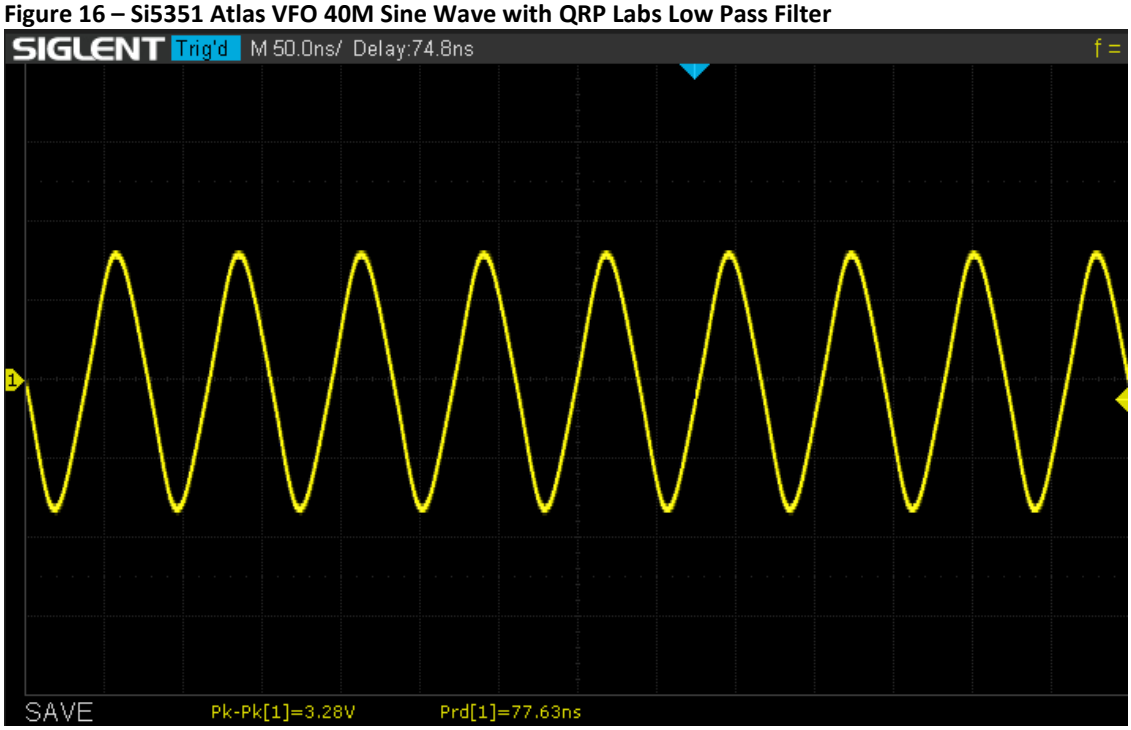


Figure 17 – Si5351 Atlas VFO 20M Sine Wave with QRP Labs Low Pass Filter

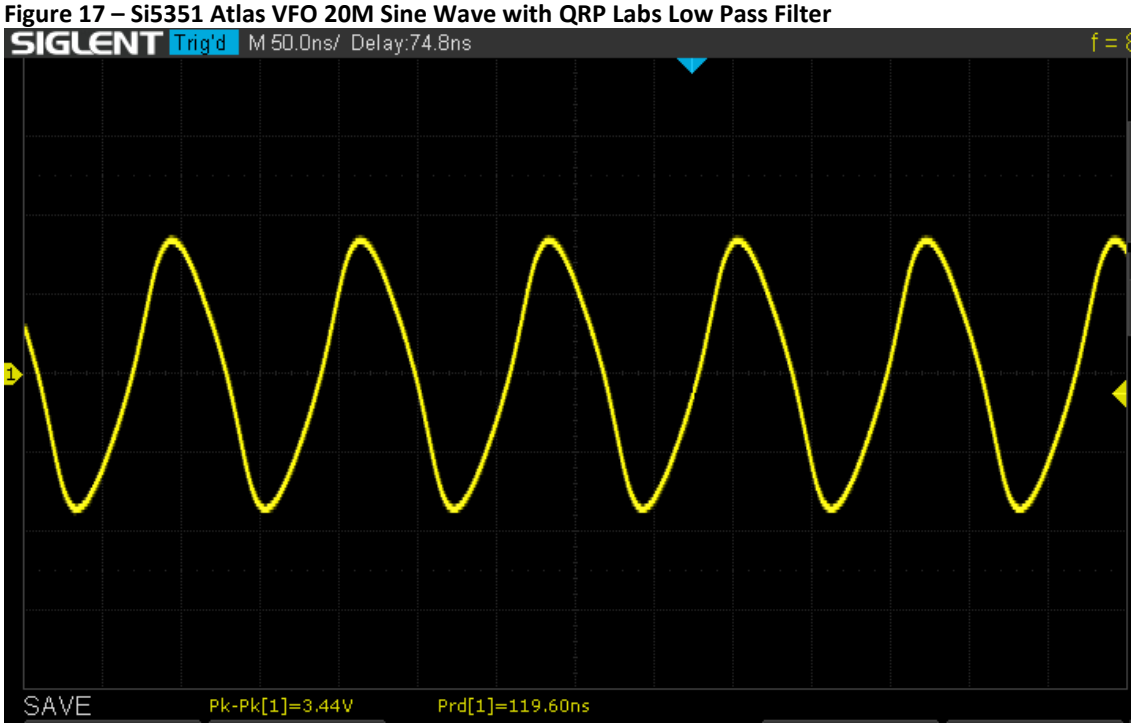


Figure 18 – Si5351 Atlas VFO 15M Sine Wave with QRP Labs Low Pass Filter

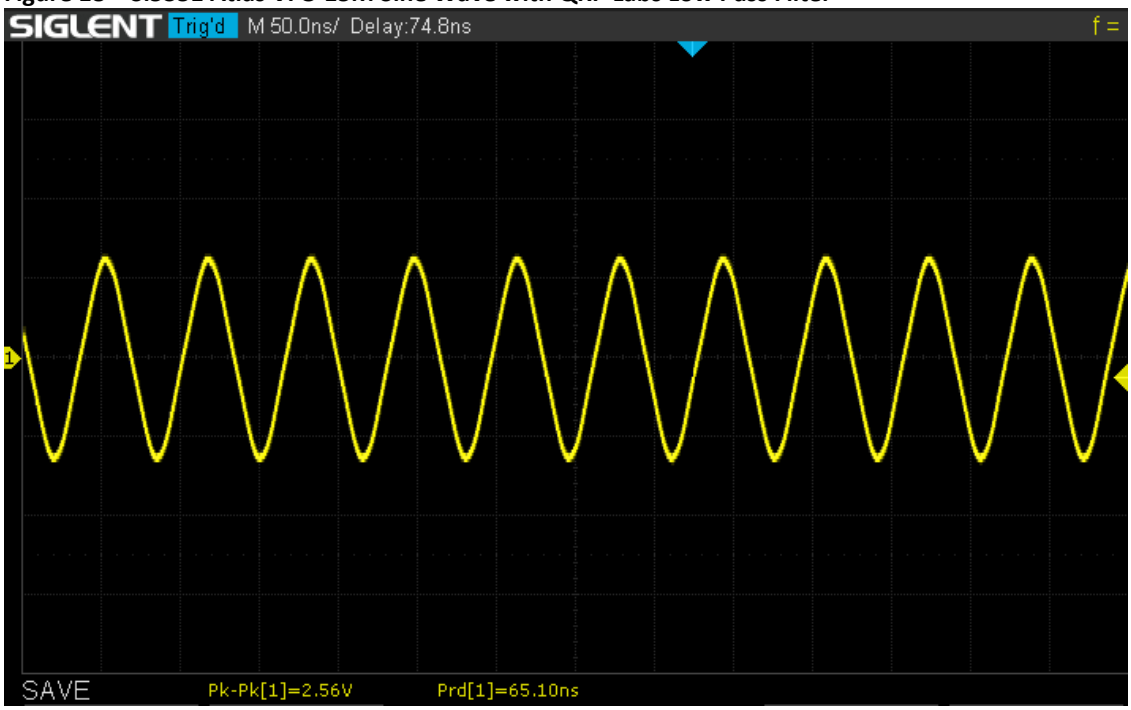
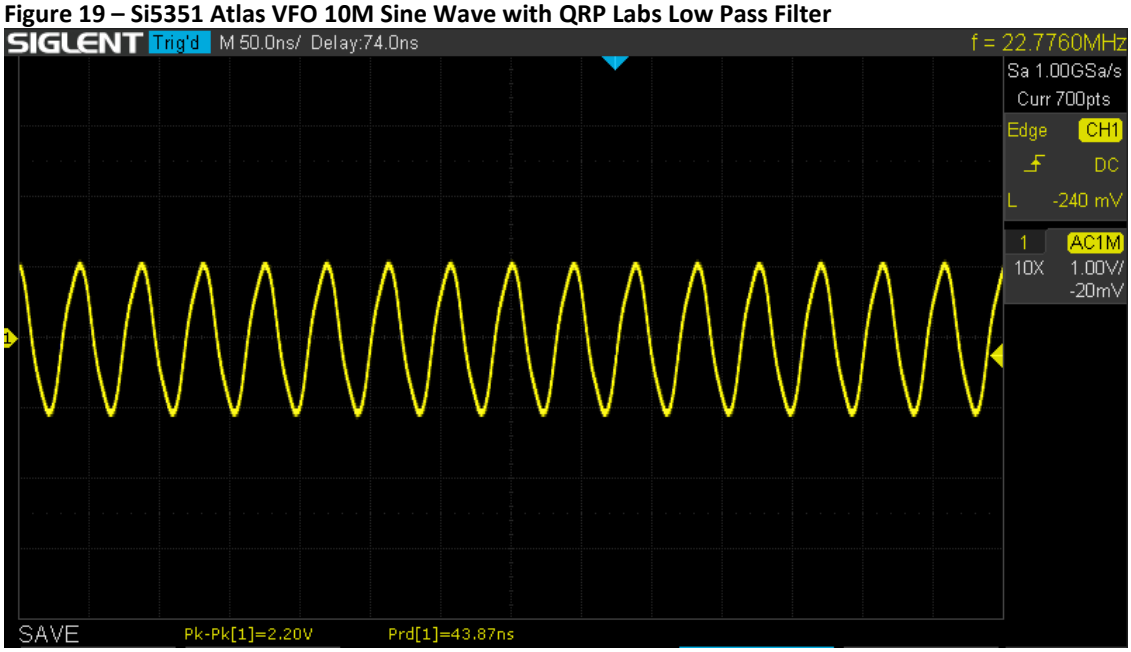
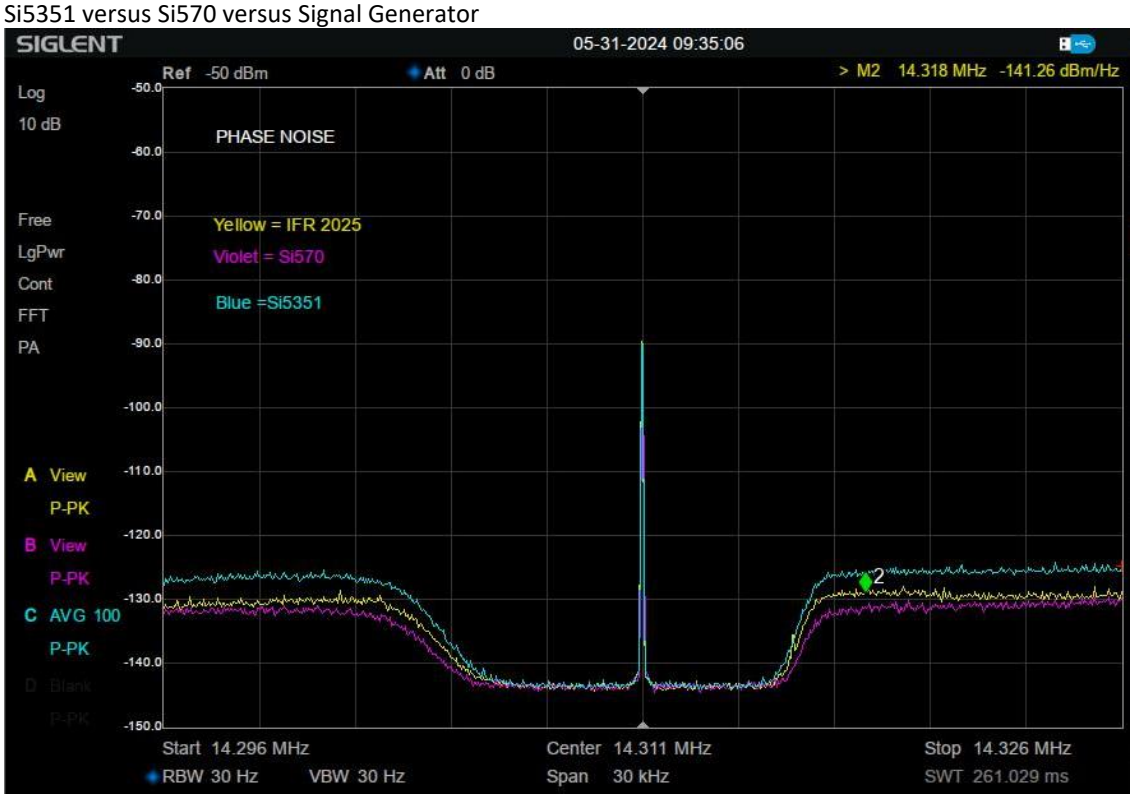


Figure 19 – Si5351 Atlas VFO 10M Sine Wave with QRP Labs Low Pass Filter



K. Figure 20 - Phase Noise

Si5351 versus Si570 versus Signal Generator



L. Figure 21 - Low Pass Filter Sweeps

Mini Circuits

PLP 10.7 MHz, 15 MHz, and 30 MHz filters

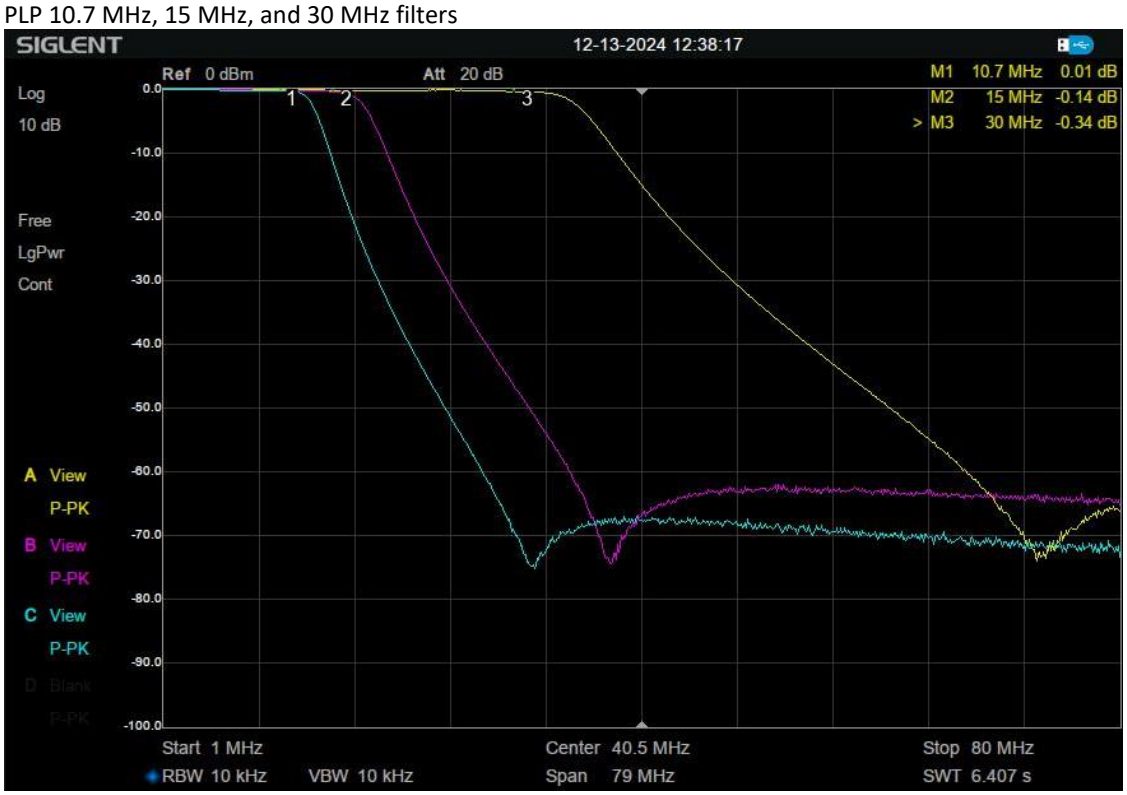
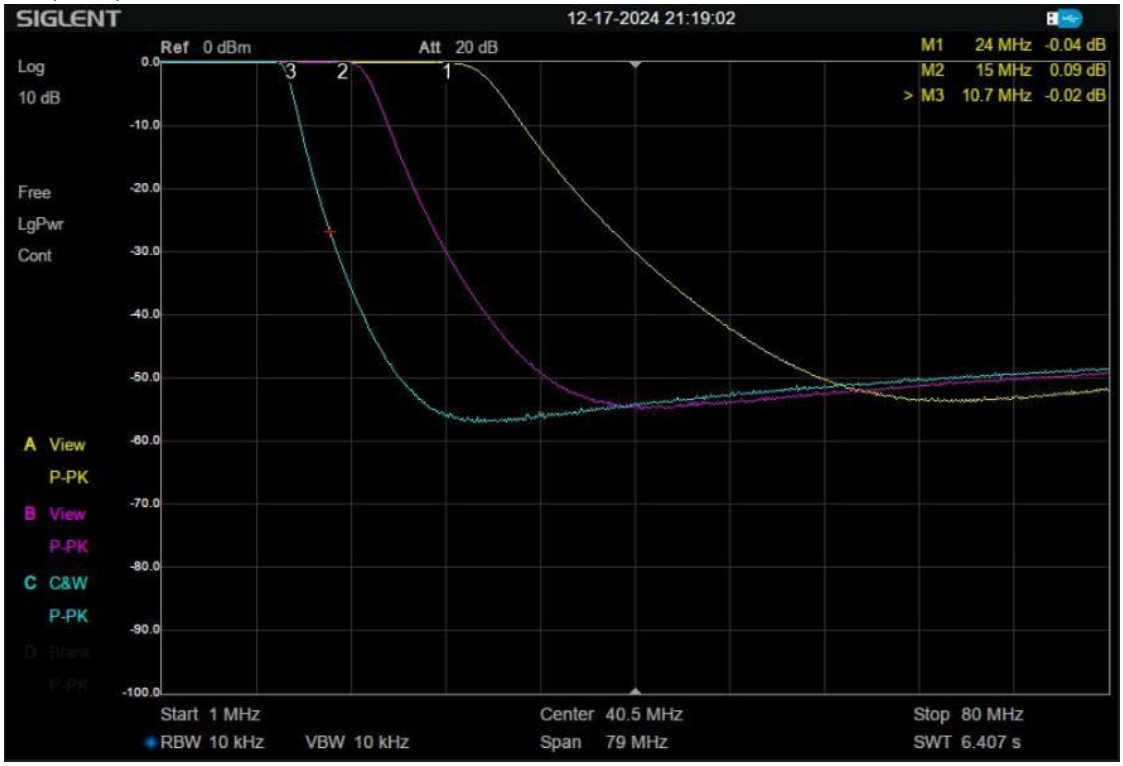


Figure 22 – QRP Labs

30M, 20M, and 12M filters



M. Signal Generator Conversion

For some types of testing and/or special functions, it may be advantageous to convert the Atlas VFO to a full function signal generator. The same circuit board is used for a Si5351 signal generator or a VFO. The following changes are needed to use the circuit board as a signal generator – please refer to schematic diagram in the Appendix.

1. **Parts change**

   Install capacitor C11
   Do not install C13
   Do not install resistors R9, R10, R11, and R12
   Install jumpers across R10 and R12
   Install the VFO enclosure and control parts in a larger enclosure

   Arduino IDE application Config

   Connect USB cable between the VFO USB port and the USB port on your PC
   The VFO board will power up and the TFT screen will be white
   Run the Arduino IDE application on our PC
   In the IDE application, go to Tools-Board-Board Manager
   Select "Select other board and port"
   Ensure that you are using the right Com port, per the earlier setup instructions
   In the search window, enter "wrover"
   Select ESP32 Wrover Module
   Hit OK
   Under Board Manager on the left side of the app, search on "ESP"
   You should see esp32 by Espressif Systems version 2.0.14
   Select Tools-Board-Board Manager. This will close the Board Manager GUI

   Here is how the Signal Generator will look:

2. **Program upload**

   Select File-Open
   Find your Si5351 Signal Generator directory for SigGen031
   Select the ino file in the directory and hit Open
   Load the Arduino IDE Signal Generator code
   The ino file and associated files will load into a new Arduino IDE GUI
   Ensure that you have the correct Com port selected by using the Windows Device Manager.
   Select Sketch-Upload

The ino file will compile and will then load
The TFT display should have the Signal Generator screen layout
Disconnect the USB cable to the VFO box
Power up your Atlas radio
The signal generator will power up at 10 MHz
You can now use the Signal Generator

N. Arduino IDE App Colors

Change color settings for code display
https://johndecember.com/html/spec/colorhex.html#google_vignette

O. End-user Customizable Code for large display

The following lines are code is located in the config.h file:

Selects model of radio

```
38   #define RADIO  A210            // A180, A215 or A210
```

MCU selects the Pavel Milanes library to minimize birdies.
ETHERKIT selects the Jason Milldrum library.

```
46   #define SI5351_DRV MCU   // SI5351 Driver can be ETHERKIT or MCU
```

Check for 10 volts on Ext VFO pin of Accessory socket

```
55   //#define VFO_OK              //comment out if not using VFO pin
```

Allows use of Lilygo T7 Ver 1.4 ESP32-S2 board – actual board is Ver 1.5

```
86   #define MC_TYPE WROVER
```

Determines band-switching hysteresis window for band changes

```
96   #define BANDDIV  750      //  DIV routine for analog resistor matrix normally set to 712
```

Sets IF of radio

```
131  #define CF NEWER              //OLDER for 5520 CO, NEWER for 5645 CO and DRAKE for Drake CF
```

Allows use of large 172 x 320 display

```
176  #define DISP_SIZE CUSTOM_DISP      // SMALL_DISP  CUSTOM_DISP  LARGE_DISP
```

Splash screen

```
193  /*-------------------------------------------------------
194      Splash Screen Startup intro - Version Number
195  -------------------------------------------------------*/
196  #define NAME "VFO System"     //Start-up Intro with version number
197  #define VERSIONID "VFO4.1.1-Ver.9.62" //version ID number
198  #define ID "by KI5IDZ"        //ID writer of program code
199
```

Change dial pointer

```
256    #define DP_WIDTH        1      // Width of Dial pointer 0,1 OR 2
257    #define DP_LEN        180      // Length of Dial pointer
258    #define DP_POS         10      // Length Dial pointer extends above dial
```

You can customize the text colors by going to this site:
https://www.computerhope.com/htmcolor.htm

The end-user can customize the following text, font size, and location on the TFT display. It is assumed that the 172 x320 display is being used. The “CLINT” preference is used in the ino file.

The details of the Clint preferences are found in the config.h file.

```
42   #define PREFERENCE CLINT      //PREFERENCE can be defined as CLINT MARK JOHN
350  #if PREFERENCE == CLINT
351  #define   CL_BG          CL_BLACK    // Display background (Black)
352  #define   CL_POINTER     CL_RED      // Dial pointer (Red)
353  #define   CL_TICK_MAIN   CL_GREEN    // Main Ticks (Lime green)
354  #define   CL_NUM_MAIN    CL_WHITE    // Main dial numbers (White)
355  #define   CL_TICK_SUB    CL_SKYBLUE  // Sub Ticks (Light blue)
356  #define   CL_NUM_SUB     CL_WHITE    // Sub Numbers (White)
357  #define   CL_DIAL_BG     CL_BLACK    // Dial background (Black)
358  #define   CL_SPLASH      CL_LT_BLUE  // Splash screen text
359  #define   CL_FREQ_BOX    CL_CYAN     // Numerical frequency box
360  #define   CL_F_NUM       CL_ORANGE   // Numerical frequency
361  #define   CL_NUM         CL_YELLOW   // Numerical small numbers
362  #define   CL_NUM_O       CL_RED      // Step color in CUSTOM_DISP
363  #define   CL_NUM_NORM    CL_WHITE    // Normal Text inside box
364  #define   DP_POS           0         // Length Dial pointer extends above dial
365  #define   DISP_TM         30         // Top Margin moves Dial up and down
366  #define   F1_POS          15         // Vertical Position of the frequency box 14 60    32,14
367  #define   T1_POS          60         // Align the secondary text information on this line
368  #define   DIAL_SPACE      40         // Number of pixels between the main and sub arcs
369  #define   TICK_SUB1        8         // Length of Sub Tick(1)
370  #define   TICK_SUB5       14         // Length of Sub Tick(5)
371  #define   TICK_SUB10      18         // Length of Sub Tick(10)
372  #define   TICK_MAIN1       4         // Length of Main Tick(1)
373  #define   TICK_MAIN5      14         // Length of Main Tick(5)
374  #define   TICK_MAIN10     18         // Length of Main Tick(10)
375  #define   TNCL_MAIN       18         // Space between Number and Tick (Main)
376  #define   TNCL_SUB        18         // Space between Number and Tick (Sub)
377  #define TICK_PITCH_MAIN 10.5         // Main Tick Pitch (note small changes make a big difference)
378  #define TICK_PITCH_SUB   9.8         // Sub Tick Pitch  (try not to go below 4.0)
379  #define CORRECTION       0ULL
380  #define CORRECTION_MCU   0
381  #define EncoderStep     12
382  #define CO ATLAS_CO
383  #define LOCK_OK
384  #undef  CLOCK_OK
385  #undef  SHORT16_OK
386  #endif
387
```

The following lines of code are located in the ino file:

Change memory frequencies

```
136  #if PREFERENCE == CLINT
137  long freqa[5] = { 3853000, 3900000, 3916000, 3950000, 5000000};  //80M band memory presets
138  long freqb[5] = { 7155000, 7162000, 7235000, 7255000, 5000000};  //40M band memory presets
139  long freqc[5] = {14235000,14250000,14300000,14325000,10000000};  //20M band memory presets
140  long freqd[5] = {21285000,21300000,21320000,21350000,15000000};  //15M band memory presets
141  long freqe[5] = {28385000,28425000,28450000,28500000,28900000};  //10M band memory presets
142  int recall[5] = {2,1,3,2,2};                                     //prefered memory recall at startup
143  const long begofBand[5] = {3803000,7178000,14225000,21275000,28300000}; //General Class
144  const long endofBand[5] = {4000000,7300000,14348000,21448000,28998000}; //All bands
145  #else
```

Change scanning times

```
199    int delaytime1 = 2000;            //Delay time in ms for frequency scanning
200    int delaytime2 = 5000;            //Delay time in ms for memory scanning
```

Change Si5351 Power Out

The output power level of the VFO can be changed by modifying the setpower settings.

The power is currently set for 8ma.

```
295     si5351.setPower(0,SIOUT_8mA);            // Set output power of CLI0 Si5351
```

Here are the readings with the output of the VFO disconnected from the FET switch and terminated on a spectrum analyzer (50 ohms) via a 10 db pad.

BAND	2 ma drive	4 ma drive	6 ma drive	8 ma drive
80M	8.9 dbm	10.6 dbm	11.2 dbm	11.5 dbm
40M	8.8 dbm	10.7 dbm	11.2 dbm	11.4 dbm
20M	8.6 dbm	10.7dbm	10.9 dbm	11.2 dbm
15M	8.8 dbm	10.6 dbm	11.3 dbm	11.5 dbm
10M	8.7 dbm	10.5 dbm	11.2 dbm	11.5 dbm

Change text, font, and colors for Splash screen

```
439   lcd.setCursor( 0.5f*(lcd.width()-lcd.textWidth(NAME) ), 0.1f*lcd.height() ); //where to write Name intro
440   lcd.printf( NAME );                 //send name intro to display
441   lcd.setCursor( 0.5f*(lcd.width()-lcd.textWidth(VERSIONID) ), 0.3f*lcd.height()); //where to write Version ID
442   lcd.printf(VERSIONID);              //send version ID to display
443   lcd.setCursor( 0.5f*(lcd.width()-lcd.textWidth(ID) ), 0.5f*lcd.height());  //where to write ID
444   lcd.printf(ID);                     //sendi ID to display
```

Set Band names

```
1056  #if RADIO == A210
1057    switch(count) {                          //determine which position the band switch is located
1058      case 1: sprintf(band_str, " 80 M"); break; //set to 80M position USB
1059      case 2: sprintf(band_str, " 40 M"); break; //set to 40M position USB
1060      case 3: sprintf(band_str, " 20 M"); break; //set to 20M position USB
1061      case 4: sprintf(band_str, " 15 M"); break; //set to 15M position USB
1062      case 5: sprintf(band_str, " 10 M"); break; //set to 10M position USB
```

Change Digital display Band font and text and color

```
1065    sprites[flip].setFont(&fonts::Font4); // Set font
1066    sprites[flip].setTextSize(0.75f);     // Scale font size
1067    sprites[flip].setTextColor(CL_NUM);   // Set font color
```

Set Frequency Steps

```
1089  void display_Step() {                    //code to handle large & custom display
1090    #if  DISP_SIZE == LARGE_DISP || DISP_SIZE == CUSTOM_DISP
1091    switch (fstep) {                                //determine step position
1092      case 10: sprintf(step_str,  "10  Hz");break;  //step frequency is 10Hz
1093      case 100: sprintf(step_str, "100  Hz");break;  //step frequency is 100Hz
1094      case 500: sprintf(step_str, "500  Hz");break;  //step frequency is 500Hz
1095      case 1000: sprintf(step_str,"1  KHz");break;  //step frequency is 1KHz
1096      case 10000: sprintf(step_str,"10  KHz");break;  //step frequency is 1KHz
```

Change Digital display Step font and text and color

```
1108    sprites[flip].setFont(&fonts::Font4); // Set font
1109    sprites[flip].setTextSize(0.75f);     // Scale font size
1110    sprites[flip].setTextColor(CL_NUM);   // Set font color
```

Set Memory names

```
1230  //----------------------------code to handle memory Display 2 -----------------
1231  void display_Mem() {                  //code to display the current memory A, B, or C
1232   #if  DISP_SIZE == LARGE_DISP || DISP_SIZE == CUSTOM_DISP
1233    switch (memory) {                          //determine memory position
1234      case 1: sprintf(mem_str, "Mem:A");break;  //memory A
1235      case 2: sprintf(mem_str, "Mem:B");break;  //memory B
1236      case 3: sprintf(mem_str, "Mem:C");break;  //memory C
1237      case 4: sprintf(mem_str, "Mem:D");break;  //memory D
1238      case 5: sprintf(mem_str, "Mem:E");break;  //memory E
```

Change Digital display Memory font and text and color

```
1250      sprites[flip].setFont(&fonts::Font4);// Set font size
1251      sprites[flip].setTextSize(0.75f);     // Set font scale
1252      sprites[flip].setTextColor(CL_NUM);  // Set font color
```

Define location of Frequency Display box

```
1295          sprites[flip].drawRoundRect(1,F1_POS+1,318,38,5,CL_FREQ_BOX); // draw box (x1,y1,x2,y2,thick,color) (15,40)
```

P. Si5351 Chinese Oscillator Board

The VFO circuit board is setup to use either a QRP Labs Si5351 module or a Chinese Si5351 module. The QRP Labs module requires that two 10 female pin headers be installed for U4. A Chinese module only has seven pins on the board and only uses the U4A socket.

To use the Chinese board, the following changes need to be made for the build of the VFO board.
Install a single 10 female pin header at U4A.
There is a solder pad connected to pin 9 of U4A.
Install an insulated ground wire from this solder pad to a ground point on the motherboard.
Near pin 14 of U4A, there is a solder pad labeled SCL.
There is a solder pad next to pin 8 of U4A and it is connected to pin 7 of U4A.
Install an insulated wire from this solder pad to the SCL solder pad next to the U4B socket.
Near pin 13 of U4A, there is a solder pad labeled SDA.
There is a solder pad next to pin 7 of U4A and it is connected to pin 8 of U4A.
Install an insulated wire from this solder pad to the SDA solder pad next to the U4B socket.
Install an insulated wire from pin 4 of U4A to pin 17 on the U4B socket.
The Chinese board is installed so that the following pins matchup:

U4A pin 4	Clk0 pin of Chinese board
U4A pin 5	Clk1 pin of Chinese board (not used)
U4A pin 6	Clk2 pin of Chinese board (not used)
U4A pin 7	SCL pin of Chinese board
U4A pin 8	SDA pin of Chinese board
U4A pin 9	GND pin of Chinese board
U4A pin 10	VIN pin of Chinese board