

Atlas 210X/215X Si5351 VFO

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TABLE OF CONTENTS

I.	OVERVIEW.....	3
A.	AUDIENCE	4
B.	OBJECTIVES	4
C.	OPTIONS.....	4
II.	SPECIFICATIONS.....	5
III.	PROJECT OVERVIEW	5
A.	MINI-PROJECT TASKS	5
B.	PARTS PROCUREMENT	5
IV.	BUILD QRP LABS SI5351 OSCILLATOR BOARD	8
V.	BUILD SI5351 VFO BOARD	10
VI.	VFO ENCLOSURE MODIFICATIONS.....	15
VII.	PROGRAM ESP-32 MODULE.....	20
VIII.	REMOVE FACTORY ATLAS VFO	22
IX.	FABRICATE LCD MOUNTING BRACKET	25
X.	INSTALL VFO MODULE AND MISCELLANEOUS PARTS	29
XI.	INSTALL VFO LOW PASS FILTERS	31
XII.	SI5351 VFO FRONT PANEL CONTROL DESCRIPTIONS.....	34
XIII.	APPENDIX	35

I. OVERVIEW

Atlas Radio HF transceivers were produced from the mid to late 70s. Available models included the 180, 210/215, 210X/215X and the 210X/215X LEs. 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 the factory analog VFO with a digital VFO 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 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
- Lost 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 cost is high \$40 - \$70. 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.

A. Audience

This document is written for Atlas radio owners that want an accurate frequency display, along with a very stable VFO. A moderate amount 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 SMT part soldering is needed on the main VFO circuit board. The time required for this assembly is not more than 2 – 3 hours. If one approaches the project with a systematic approach, then one should be successful in ending up with a fully functioning radio. Please note that there is no turning back after the existing VFO parts are removed. Once you start the project, the radio will be inoperative until the project is finished.

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 10 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 options at a later date.

1. Low Pass Filter options:

Single MCL SCLF-25 or SLP-25 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 20 to 30 dB in the upper frequency ranges as a result of signal leak through around the filters.

The following MCL filters were used:

80M/20M MCL PLP-10.7

40M/15M MCL PLP-15

10M 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 removed from the external VFO box and installed inside the Atlas radio.

Here is a summary of the specs for the VFO:

Minimal cost

Code change to select Atlas radio model – 210X or 215X

Code change to select Atlas IF frequency – 5520 KHz or 5645 KHz

About 240 ma current draw, including back-lighted LCD display

Three memory channels on each band

Frequency Lock

Uses existing Atlas front panel frequency display window

Uses existing Atlas 210X LE front panel control openings – no need to drill any new holes

Supports standard color TFT 170x320 display

+11.3 dbm output signal

10 Hz frequency increment tuning – 500 Hz change per frequency control rotation

500 Hz frequency increment tuning – 25 KHz change per frequency control rotation

1 KHz frequency increment tuning – 51 KHz change per frequency control rotation

Frequency step increment selected via push button on the front panel

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

+ IF shift for 80/40M and – 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

III. Project Overview

A. Mini-Project Tasks

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

Procure Parts

Build Si5351 VFO Assembly

Test Si5351 VFO on Atlas radio

Prepare Atlas radio

Mechanical install Si5351 VFO assembly in Atlas radio

Interface Si5351 VFO to Atlas radio

Install low pass filters

Test

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.

AliExpress has many of the needed parts at low prices.

<https://www.aliexpress.us/>

ESP-32 Microprocessor board

[LILYGO® TTGO T7 Mini32 V1.5 ESP32 WROVER B Dual Core PSRAM Wireless Wi Fi Bluetooth Module Development Circuit Board CH9102 | Circuits | - AliExpress](#)

AMS-1117 5 volt voltage regulator

https://www.aliexpress.us/item/3256803546112821.html?spm=a2g0o.detail.0.0.14e9X24SX24SVx&gps-id=pcDetailTopMoreOtherSeller&scm=1007.40050.362094.0&scm_id=1007.40050.362094.0&scm-url=1007.40050.362094.0&pvid=c012cffa-7831-4384-9982-db831c3b121a&t=gps-id:pcDetailTopMoreOtherSeller,scm-url:1007.40050.362094.0,pvid:c012cffa-7831-4384-9982-db831c3b121a,ttp_buckets:668%232846%238111%231996&pdp_npi=4%40dis%21USD%210.33%210.27%21%21%210.33%21%21%402103011516980660961726398ea56e%2112000026969548326%21rec%21US%21%21AB

AMS-1117 3.3. volt voltage regulator

https://www.aliexpress.us/item/3256804756651950.html?spm=a2g0o.productlist.main.1.402c3a8d3tv4yW&algo_pvid=2eb37010-cc48-491b-b847-504474ab3df4&algo_exp_id=2eb37010-cc48-491b-b847-504474ab3df4-0&pdp_npi=4%40dis%21USD%211.42%211.01%21%21%211.42%21%21%402101d4a716980658997023611e1d62%2112000031101603999%21sea%21US%210%21AB&curPageLogUid=9UV84keNh1lb

TFT Color 170x320 1.90" Display

https://www.aliexpress.us/item/3256805850210064.html?spm=a2g0o.order_list.order_list_main.15.6b701802u77yDw&gatewayAdapt=glo2usa

Hammond 1590A Clone die cast aluminum enclosure

https://www.aliexpress.us/item/3256802438032687.html?spm=a2g0o.order_list.order_list_main.25.21ef18020epeZ5&gatewayAdapt=glo2usa

Here are the specs for the Hammond case:

<http://www.hammondmfg.com/pdf/1590A.pdf>

Ceramic disc capacitors

https://www.aliexpress.us/item/3256804674697278.html?spm=a2g0o.order_list.order_list_main.15.21ef18020epeZ5&gatewayAdapt=glo2usa

Tantalum capacitors

https://www.aliexpress.us/item/3256802357267076.html?spm=a2g0o.order_list.order_list_main.20.21ef18020epeZ5&gatewayAdapt=glo2usa

Chassis Mount Feedthrough capacitor

https://www.aliexpress.us/item/3256802790468974.html?spm=a2g0o.order_list.order_list_main.30.21ef18020epeZ5&gatewayAdapt=glo2usa

Alternate source for feedthrough capacitor

(FRI) SA2A1503

<https://www.surplussales.com/Feedthrus/FTholeMnt4.html>

Resistors – through hole 1/8 watt

https://www.aliexpress.us/item/2251832660697020.html?spm=a2g0o.order_list.order_list_main.50.21ef18020epeZ5&gatewayAdapt=glo2usa

Brass standoff kit

https://www.aliexpress.us/item/2251832718469363.html?spm=a2g0o.order_list.order_list_main.10.21ef18020epeZ5&gatewayAdapt=glo2usa

Bourns Optical Encoder

<https://www.ebay.com/itm/295327320682>

Oak-Grigsby Optical Encoder

<https://www.ebay.com/itm/284621140106>

QRP Labs Si5351 Oscillator with TCXO option

<https://www.qrp-labs.com/synth.html>

M2 5mm stainless steel Phillips head screws. \$7

https://www.amazon.com/gp/product/B01DKI6VD8/ref=ppx_yo_dt_b_asin_title_o00_s00?ie=UTF8&psc=1

M2 brass standoff, stainless steel screw/nut kit. \$12

https://www.amazon.com/gp/product/B07ZSZW8T1/ref=ppx_yo_dt_b_asin_title_o01_s00?ie=UTF8&psc=1

40 pin male and female pin headers. \$6

https://www.amazon.com/gp/product/B074HVB7Z4/ref=ppx_yo_dt_b_asin_title_o00_s00?ie=UTF8&psc=1

Mini Circuits Gali-6 MMIC

78M09 voltage regulator

Multi-color 15 wire ribbon cable, 28 gauge tinned copper, with wire pitch of 1.27 mm

Miscellaneous IDC ribbon cable connectors

Toggle and push button switches

VFO circuit board

Front panel circuit board labels

Male pin strips (Jameco)

Female pin headers (Jameco)

ON-OFF-ON toggle switch

26 gauge, stranded Teflon hook-up wire

22 gauge, stranded Teflon hook-up wire

SMA Chassis mount jack

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:

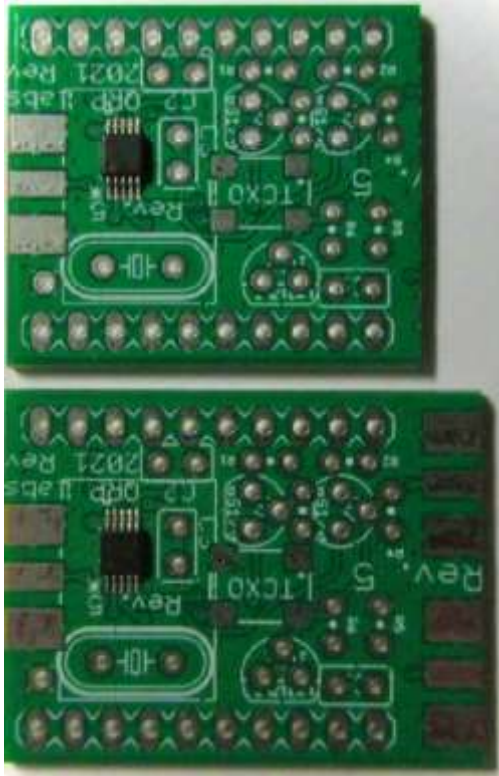
QRP Labs Low Pass Filters - <http://qrp-labs.com/lpokit.html> (three kits)

Mini Circuits Low Pass Filters – http://www.minicircuits.com/products/filters_pic_low.shtml

IV. Build QRP Labs Si5351 Oscillator Board

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

On the bare QRP Labs Si5351 oscillator board, cut off 4 mm of circuit board material from the end that had the Clock 1 and Clock 2 solder pads. 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.



Build the Si5351 oscillator board per QRP Labs instructions, with the following exceptions:

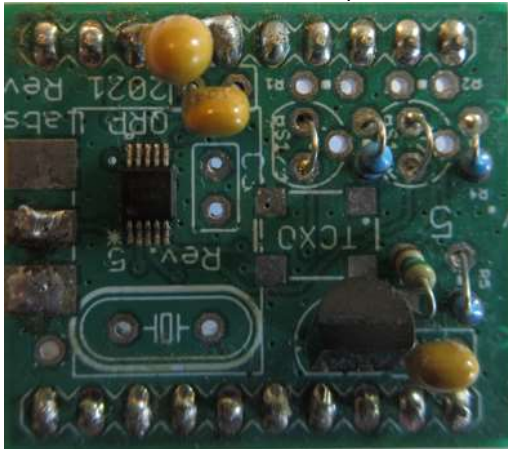
Do not install Q1, Q2, R1 and R2

Install a jumper wire from the source to the drain on Q1.

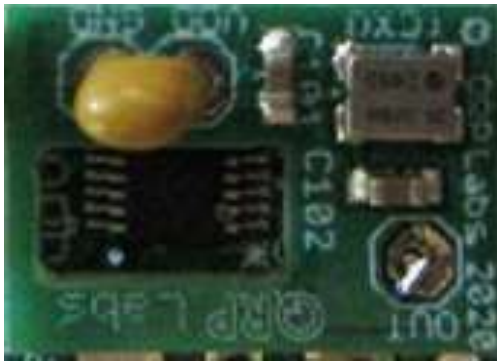
Install a jumper wire from the source to the drain on Q2.

Install a 10 uf tantalum capacitor between Pin 18 and Pin 16 (ground).

Here is how the board will look prior to the installation of the TCXO module:

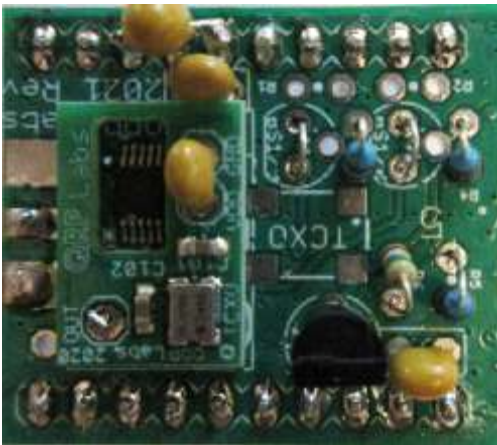


Build the TCXO board and install the TCXO board onto the Si5351 board.



Install 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).

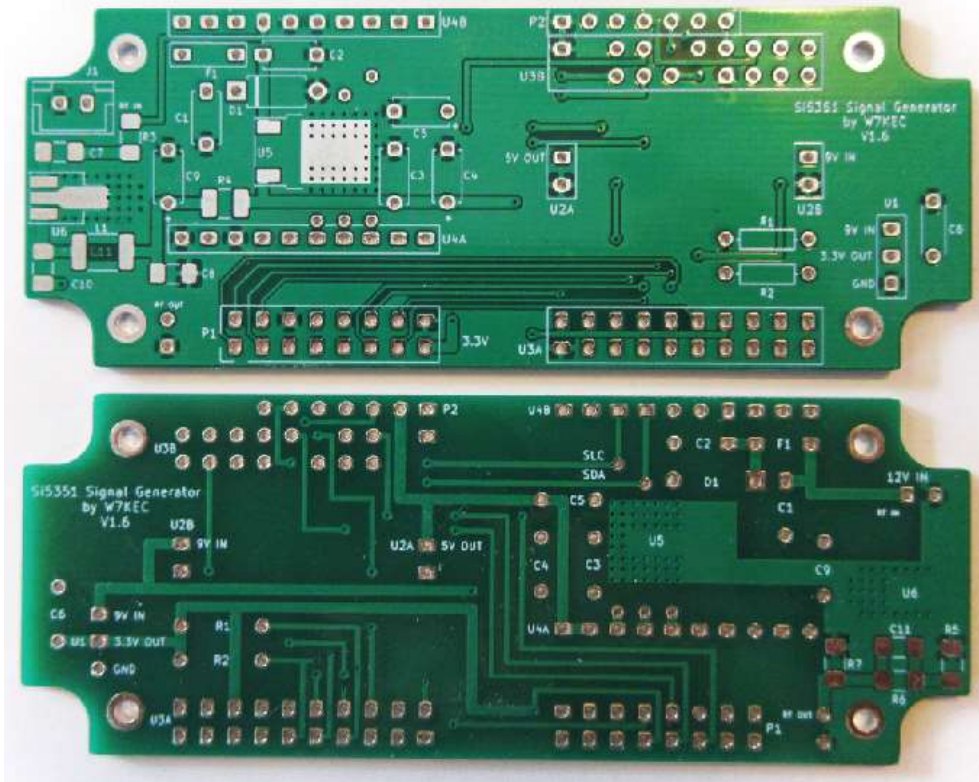
Here is the completed board with the TCXO module installed:



Set aside the oscillator board

V. Build Si5351 VFO Board

This project centers around the Si5351 VFO circuit board. Here is version 1.6 of the board:



The Si5351 VFO should be assembled in the Hammond 1590A enclosure (or clone) before any modifications are made to the Atlas radio.

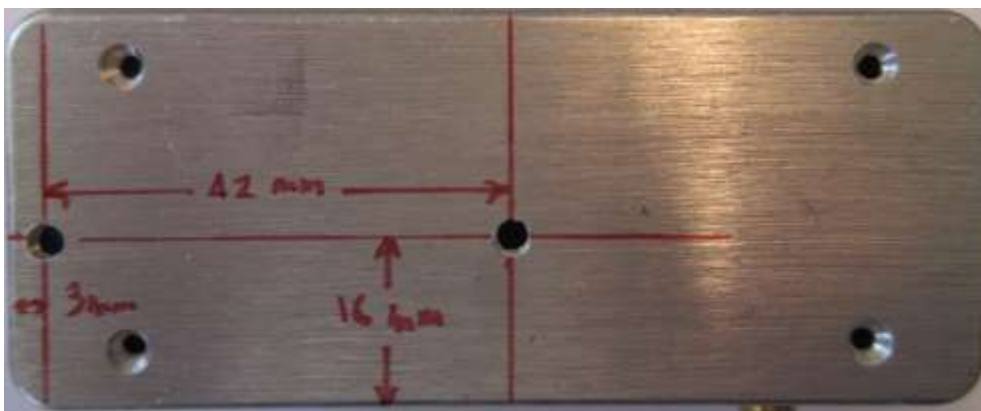
Place the circuit board inside the enclosure. It will be a snug fit.



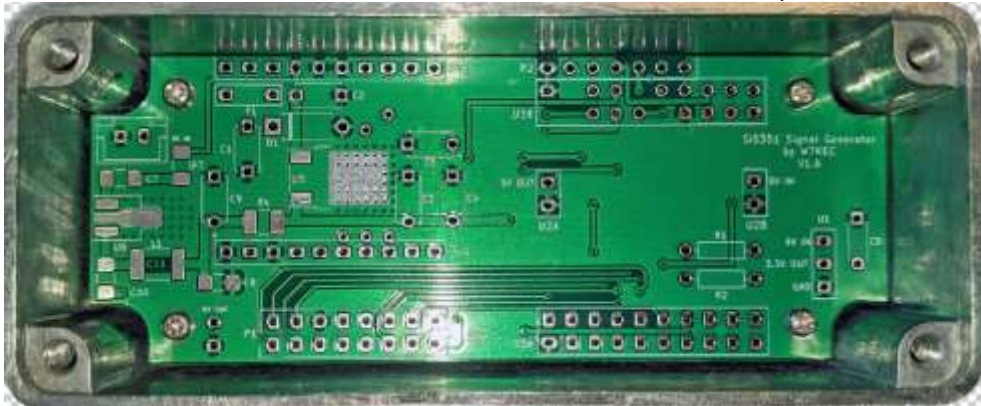
Center punch the inside bottom of the enclosure through the four mounting hole on the circuit board. Drill out each center punch with a 1/16" drill bit. Use a needle nose file to center up the holes in each circuit board. Drill out four holes in enclosure with a 5/64" drill bit. Counter sink the holes on the outside bottom of the enclosure. Install 4 each M2-5 brass standoffs on the bottom of the circuit board using M2-5 Phillips head screws.



Mark screw hole positions on the bottom of the VFO enclosure. Mark one hole 3 mm from the left edge of the enclosure and 16 mm from the top edge of the enclosure, when looking at the enclosure from the top view. Mark a second hole 42 mm to the right of the first hole and 16 mm from the top edge of the enclosure. Center tap the positions and drill 3/32" holes. Tap the holes with a 6-32 tap.



Secure the circuit board to the bottom of the enclosure with M2-3 Phillips flat head screws.



Remove the four bottom flat head screws and remove the circuit board from the enclosure.

The SMT capacitors and resistors should be soldered to the VFO circuit board before any pin headers, sockets, and plugs are installed. Remove the circuit board from the enclosure. Solder the following parts to the top of the circuit board:

U5 – 9 volt voltage regulator

F1 fuse

R1 & R2 – 2.2K ohm 1/8 watt resistors

C1, C2, C3 and C6 – 0.01 uf ceramic disc capacitors

C4 – 10 uf tantalum

C5 – 100 uf tantalum

D1- 1N4001 diode

R4 56.4 ohms SMT

C9 – 10 uf tantalum

U6 – GALI-6 MMIC

L1 – 100 uh SMT

C7, C8 & C10 – 0.1 uf SMT

C11 – 20 uf SMT – bottom of board

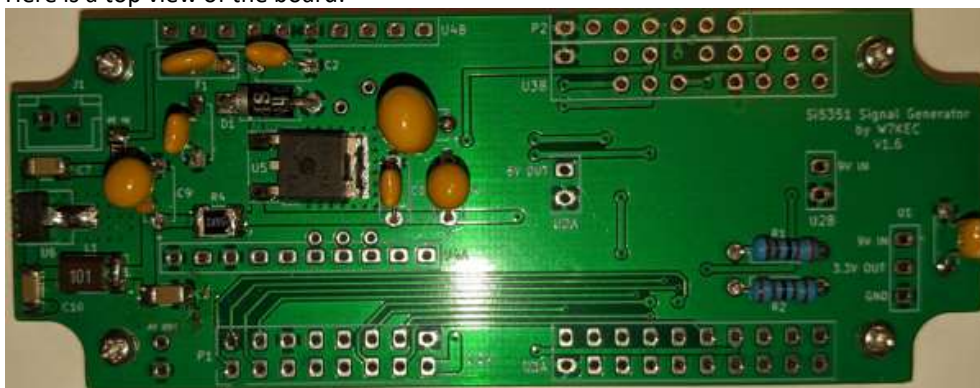
R3 – 121 ohms SMT

R6 – 48.7ohms SMT – bottom of board

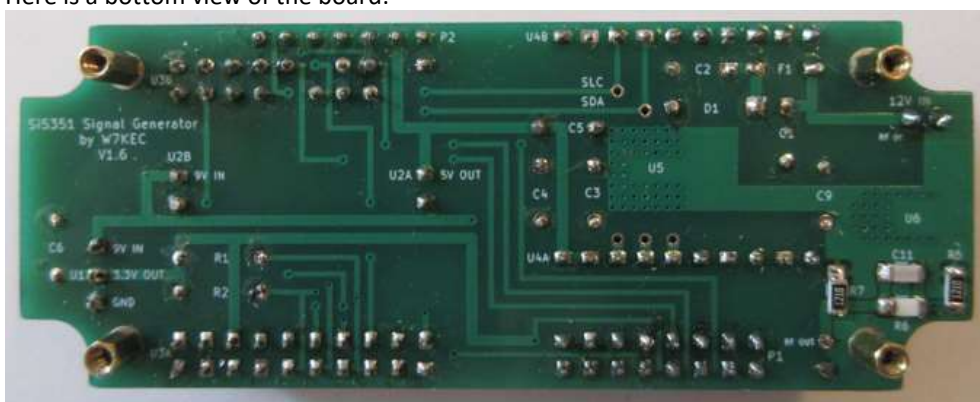
R5 & R7 – 121 ohms SMT – bottom of board

All resistors, capacitors, and active devices have been installed on the circuit board.

Here is a top view of the board:



Here is a bottom view of the board:



On the circuit board, solder the following parts:

Get two double row 10 pin male headers

Insert the male headers on the ESP-32 module

Solder the pins on both pin headers

Get two double row 10 pin female headers
Look at circuit board at J3A and J3B. Note pins that have no solder pads.
Remove those pins from the pin header
There are five pins that will need to be removed from J3B female pin header.
Insert the modified female pin headers into the circuit board at J3A and J3B
Insert the ESP-32 module into the female pin headers
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
Solder the P1 pins on the circuit board.

Get one each single row 7 male pin header. If possible, use a color other than black.
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.
Insert the power jack at location J1 – matching the silk screen to the body of the plug.
Solder two pins on the jack.

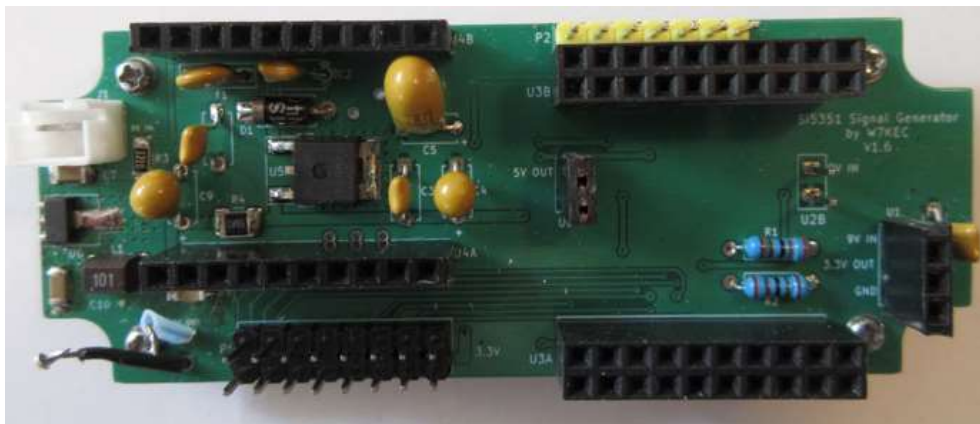
Solder a 3 pin female pin header at U1 on the circuit board.

The following steps will create a low profile socket so that U2 can be mounted underneath the body of the ESP-32 module.

The body of a female pin header is 9 mm long.
Cut the top off of two each two pin female pin headers so that the body is 6 mm long.
You should just barely see the top of the metal contact pin
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
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
Remove the voltage regulator board from the VFO circuit board

Install an insulated solid wire on the Ground solder tab on the circuit board.
Install a 0.01 uf mono ceramic capacitor on the RF Out solder tab on the circuit board.
Install the SMT parts on the bottom of the circuit board.

All pin headers, sockets, and plugs have now been installed on the VFO circuit board.
Here is a picture of the top of the completed board:



Ensure that the ESP-32 module, the Si5351 oscillator board, the 5 volt regulator module, and the 3.3 volt regulator module have been removed from the board.

Apply 13.7 VDC to the power plug. You should see about 75 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 13.7 volts to the power socket. You should see about 80 ma of current.

The red LED light on the 5 volt regulator board should light.

Confirm that the output voltage on the 5 volt regulator is about 5 volts.

Remove power from the board.

Remove the 5 volt regulator board.

Install the 3.3 volt regulator board

Apply power to the board.

You should see about 80 ma of current draw and the red LED light on the 3.3 volt regulator board.

Confirm that the output voltage on the 3.3 volt regulator board is 3.3 volts.

Remove power from the board.

Install the 5 volt regulator board.

Apply power to the VFO board.

The current draw should be about 83 ma.

The red LEDs on the 3.3 volt and 5 volt regulator boards should be lighted.

Run this config for 12 hours.

Install the QRP Labs Si5351 oscillator board.

The total current draw should be around 121 ma.

Install a programmed ESP-32 module.

The total current draw should be around 160 ma.

Install a SMA female chassis mount jack on the wall of the enclosure.

Install a 0.01 uf feedthrough capacitor on the wall of the enclosure, along with a ground lug on the inside of the enclosure. Solder red single pin header wire to feed through capacitor.

Solder two wire (black-red) wires to inside connection on the feed-through capacitor and ground lug.

VI. VFO Enclosure Modifications

The die cast aluminum enclosure will need the following modifications:

Cut rectangular 11 mm wide by 8 mm high opening on end of enclosure for USB jack.



On the cover, cut a matching notch on the edge 11 mm wide and 2 mm deep.



Cut notch in top cover inner edge for the U1 voltage regulator. The notch should be 10 mm wide and 2 mm deep. This notch will be next to the previous notch that was cut for the USB jack.



Drill a ¼" OD hole on the enclosure 15 mm from left edge and 9 mm from the top edge for the SMA chassis mount jack. Note: Please allow enough spacing between the fixed nut on the SMA jack and the 16 pin IDC pin header next to it. If there is not enough space, you will have a difficult time in plugging in the 16 pin ribbon cable.



Drill a 7/64" OD hole on the end of the enclosure that has the SMA chassis mount hole. Center the hole across the width of the enclosure (19 mm from edge) and 9 mm from the top edge. This hole is for the power feed-through capacitor.



Cut a notch in enclosure on the edge of top cover and main body of enclosure for the 16 wire ribbon cable. The notch should be 20 mm wide and 1 mm deep. It should match up with the ribbon cable when the cable is folded over the top of the enclosure. The notch should be on the same side as the SMA jack.



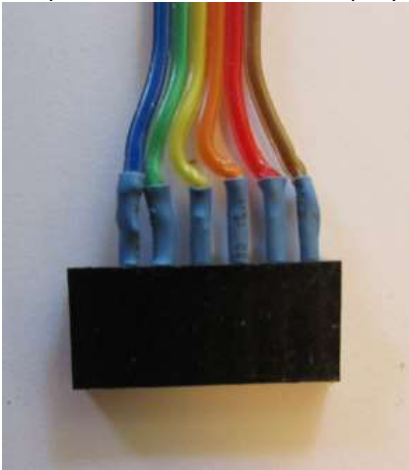
Cut notch in enclosure on the edge of top cover and main body of enclosure for the 6 wire ribbon cable. The notch should be on the same side as the SMA jack. The notch should be 8 mm wide and 1 mm deep for top cover and main body.



Fabricate a 16 wire ribbon cable is with a female IDC connector on the end.

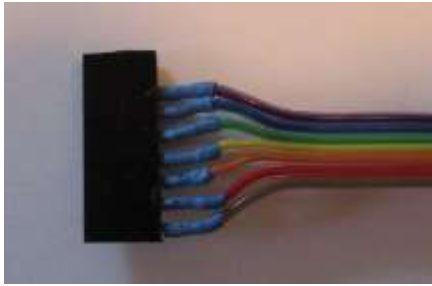


Fabricate a 6 wire ribbon cable with a female pin header socket on the end.
This end will attach to the male pin header on the Si5351 circuit board.
Pull pin 7 and fill the hole with epoxy.

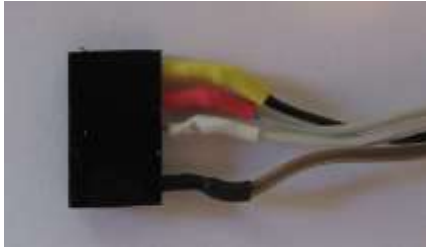


Install the feed-through capacitor on the enclosure.
Install the SMA chassis jack on the enclosure.
Connect the power cable from feed-through capacitor to J1 jack.
Connect the 6 pin ribbon cable
Connect the 16 pin ribbon cable
Install jumper wire from ground pad on circuit board to ground lug on SMA jack
Install VFO board into enclosure
Secure VFO board to bottom of enclosure with M2-3 counter sunk screws
Solder C12 to the SMA chassis jack

Solder an 8 pin male header to the LCD display. Cut off pin 8.
Solder a jumper wire from pin 2 to pin 8 on the LCD display.
Solder an 8 pin female pin header to appropriate wires on 16 wire ribbon cable. Fill the pin 8 hole in the header with epoxy. This will key the header so that it can only be installed one way.



Solder a female 5 pin header to the appropriate wires on the 16 wire ribbon cable. This header is for a Bourns encoder. Cut off the NC pin on the Bourns encoder. Pull the unused pin and fill the hole with epoxy. This will key the header so that it can only be installed one way.



Here is a picture of the circuit board installed in the enclosure:



Label the top cover on the enclosure and install it on the enclosure.



VFO box with power applied.



VII. Program ESP-32 Module

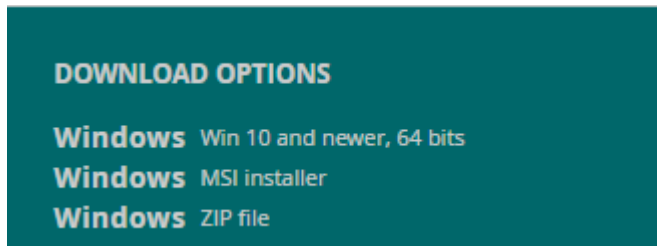
The app Arduino IDE 2.2.1 will be used to program the ESP-32

The following steps assume that no version of Arduino IDE has ever been installed on the PC.

On your PC, open a web browser to the Arduino Web site

<https://www.arduino.cc/en/software>

Under Download options, click on the Windows Win10 and newer, 64 bits



The download will start. When complete, the downloaded file will be about 140 MB in size.

Double click on the downloaded file.

Hit I agree.

Select Anyone who uses this computer.

Hit Next

Hit Yes

Hit I agree

Use the default installation folder and hit Install

The installation will start. The install will take less than five minutes

Hit Finish

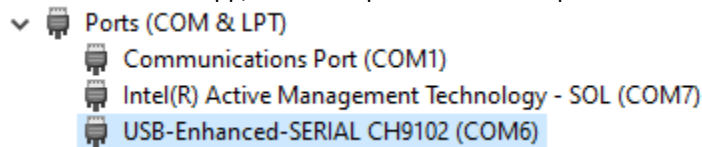
The Arduino IDE app will open

Connect your VFO box to your PC via a USB cable

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



Create a subdirectory /VFO and download the contents of the VFO.zip file

Copy the following files to the /VFO subdirectory:

User_Setup_Select.h

Setup72_ESP32_ST7789_172X320.h

Setup Instructions.txt

Find your Arduino/libraries subdirectory on your computer

Go to the /TFT_eSPI subdirectory and open it

Replace the User_Setup_Select.h file with the updated file

Replace the User_Setup.h with the updated file

Go to the /User_Setups subdirectory

Replace the Setup72_ESP32_ST7789_172x320.h file with the updated file

Open the VFO .ino file with Arduino IDE and to Tools and open Manage Libraries
Right click on "Filter your search" box and enter TFT_eSPI scroll down to TFT_eSPI
Select version 2.5.34 and install
On the IDE menu, go to Files-Preferences
Under "Additional Boards Manager URLs, enter this URL:
https://raw.githubusercontent.com/espressif/arduino-esp32/gh-pages/package_esp32_index.json

Go to Tools-Board Manager
Scroll down the libraries on the left hand side of the display.
Select esp32 by Espressif Systems version 2.0.11 and hit Install.
Go to Tools-Board Manager-esp32
Scroll down list and select ESP32 Wrover Module

Select the Verify/Compile option
If the file compiles without any errors, then do an upload.

Connect the two ribbon cables to the VFO board. Power up the board. You should see the screen:
The protective film cover has not been removed from the front of the display.



The total current draw will be somewhere between 220 and 240 ma. Confirm that you can change the frequency with the encoder. You should be able to connect the VFO to the Accessory jack on the Atlas radio and use the VFO to change the frequency of the radio. You will not be able to change bands until the band switching resistor matrix is installed.

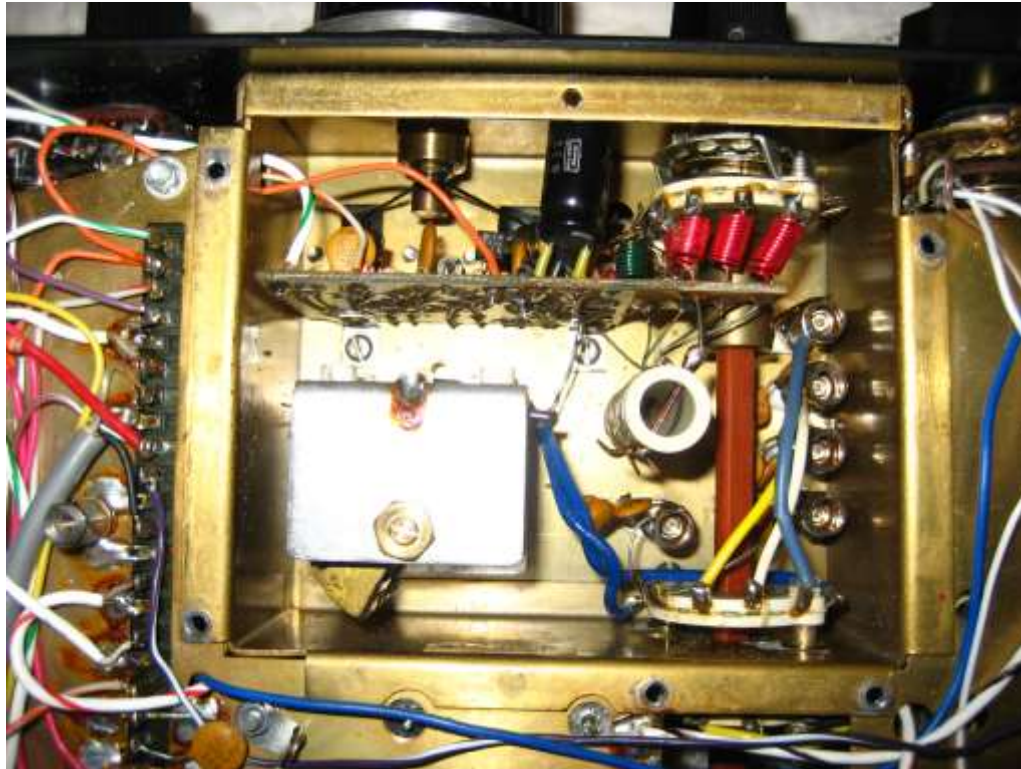
Connect a power meter to the output of the VFO. The signal level will be about +11.5 dbm from 1 MHz to 50 MHz.

VIII. Remove Factory Atlas VFO

These steps were written for an Atlas 210X/215X LE radio. Similar steps can be used for a non-LE radio.

A. **210X LE Radio Preparation**

The existing 210X LE VFO parts, the RIT control, and the Dial Set control will need to be removed from the radio. It will take about 30 - 40 minutes to remove the parts. Here is a bottom view of the stock VFO before the parts were removed:



Remove the following parts:

5 minutes time

- Top and bottom equipment covers to the radio
- VFO bottom cover
- Main VFO tuning knob (two 5/64" Allen wrench set screws)
- Dial set knob (3/64" Allen wrench set screw)
- RIT tuning knob (3/64" Allen wrench set screw)
- 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)

10 minutes time

- 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 strip inside VFO compartment
 capacitor to band switch contact and white wire to RIT subassembly
Reattach the screw, lock washer and nut that hold the ON-XCV switch
Reinstall PC-200 circuit board
Remove the red and yellow wires going to the ON-XCV slide switch.

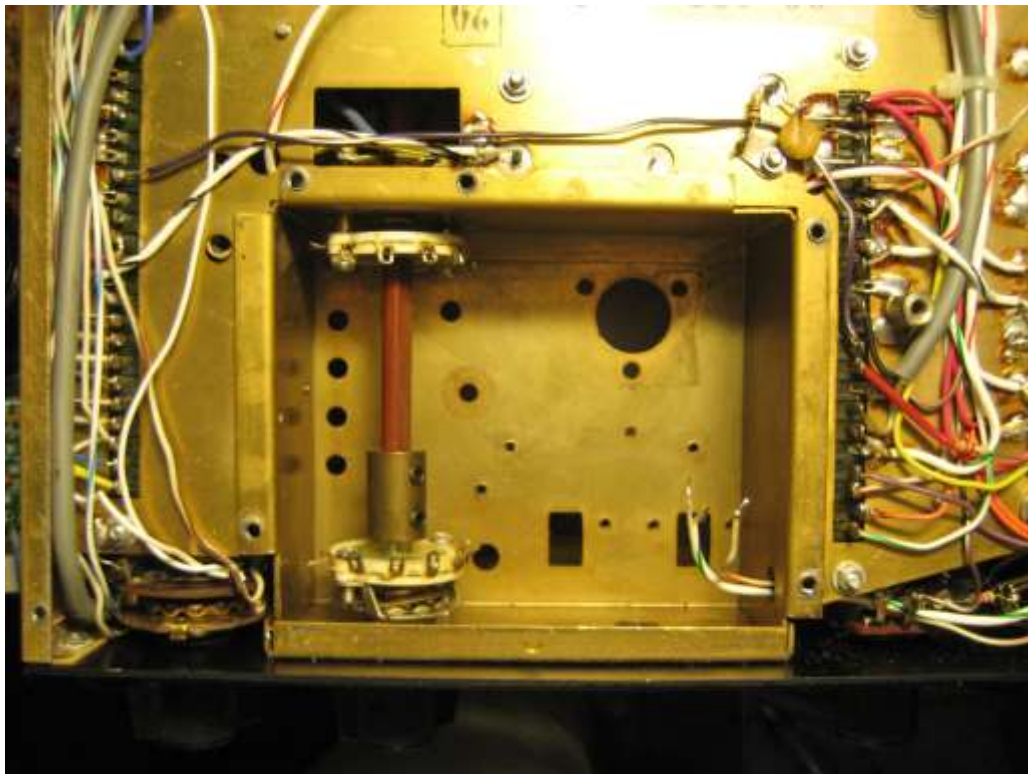
Unsolder all wires between main inductor and VFO circuit board
Remove main inductor by removing single screw
Desolder all wires to the band switch wafers in the VFO compartment
Desolder the two wires to the VFO turning capacitor

Remove the following parts:

17 time in minutes

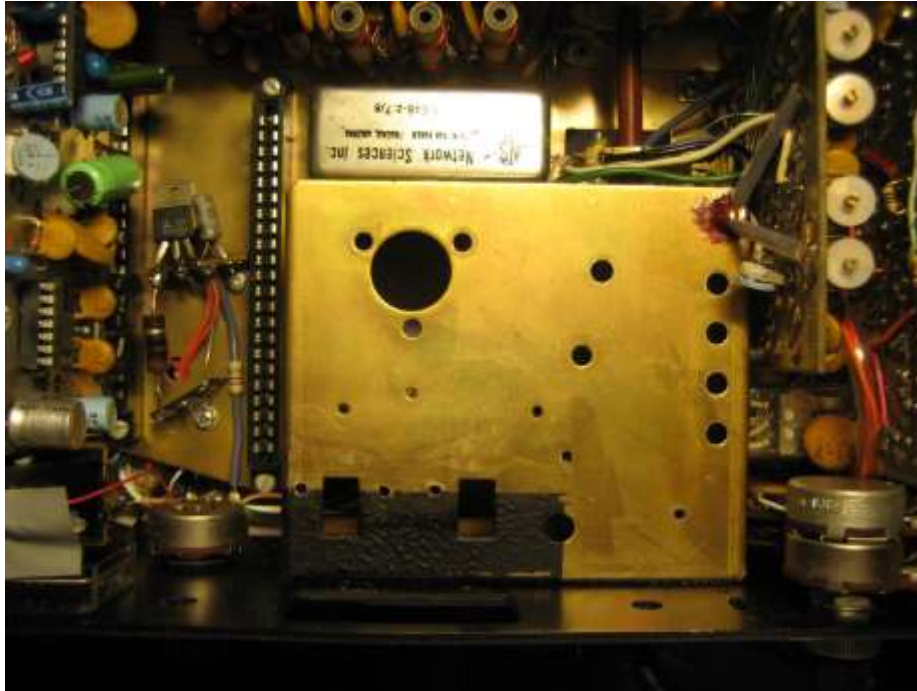
VFO circuit board orange and orange white wires – unsolder both ends of each
RG174 coax cable center conductor and shield on VFO circuit board – do not remove the cable
Lock nuts on 5 ceramic piston capacitors
5 wires between ceramic piston capacitors and the VFO circuit board
5 ceramic piston capacitors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

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



Drill out the two VFO circuit board mounting holes with a 9/64" bit. These holes will be used to attach the Si5351 VFO box to the top of the VFO enclosure.

Here is the top side of the VFO compartment from a 210X LE radio:



NOTES:

The S-Meter dial light will still be functioning, but will be drawing more current because of 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.

Remove the S Meter dial light. Install two white low current LEDs –one on either side of the meter.

Connect a series 2.2K ohm resistor to the positive leads of the LEDs and connect the other end of the resistor to R9. The total current draw of both LEDs is about 7 ma.

With the LEDs installed, the total current draw in the receive mode is about 360 ma.



IX. Fabricate LCD Mounting Bracket

There are two different available displays for the Atlas radio – a 128x160 (1.77”) unit and a 170x320 (1.9”) unit.

A. Procure Parts

Purchase brass bar stock

https://www.amazon.com/dp/B0C5H9RKCG?psc=1&ref=ppx_yo2ov_dt_b_product_details

Purchase 2-56 screws

https://www.amazon.com/binifiMux-Phillips-Countersunk-Assortment-Stainless/dp/B07X1CNVWD/ref=sr_1_6?crid=2FG7KATKBTP3J&keywords=2-56+screws+infinium&qid=1696891505&sprefix=2-56+screws+inifimu%2Caps%2C215&sr=8-6

B. 170x320 Installation

Cut brass bar stock (0.23”x0.23”) to a length of 62 mm.

Drill two 1/16” holes on one side of bar stock – centered on bar stock at 58 mm and 2.0 mm from top edge of bar stock. Tap the two holes with 2-56 tap.

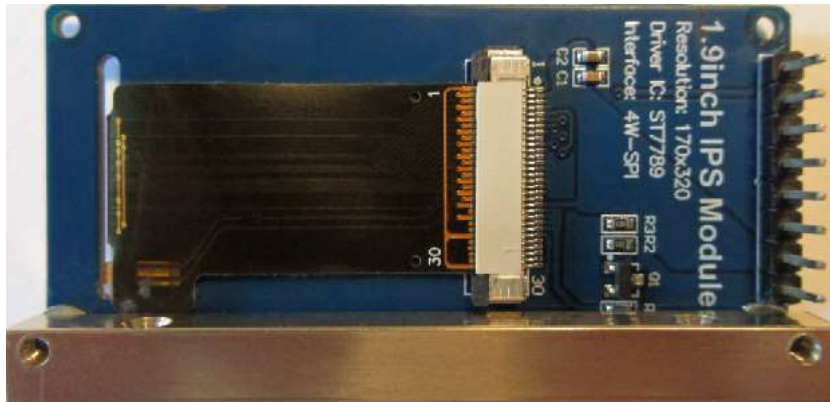


Drill two 3/32” holes on top side of bar stock – look at picture – centered on bar stock at 50 mm apart and in the middle of the bar stock. Countersink the two holes.



Secure LCD display to bar stock with two 2-56 5mm pan head screws. Place a 1 mm lock washer spacer between the display board and the brass mounting bar. Super glue two 4-40 nuts (2 mm thick) to the bottom of the brass bar. This will place the bottom edge of the VFO analog dial right at the bottom of the Atlas frequency window.





Solder an 8 pin male pin header to the back side of the display circuit board.
Solder a jumper wire between pin 8 and pin 2 on the LCD display board.

Attach the display to the ribbon cable from the VFO box. Power up the VFO box. Center the TFT display in the center of the Atlas display window. The actual physical display board will be slightly off center to the right.

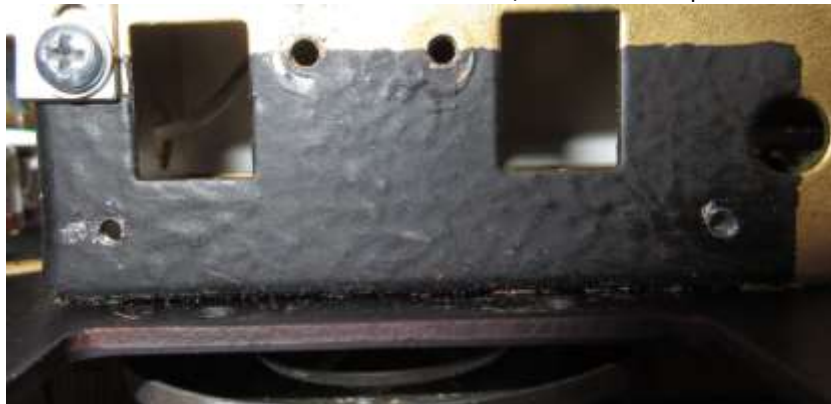
Remove the clear plastic protector from the front of the display.

Install black shiny electrical tape on each vertical side of the frequency box of the display. Trim off excess black tape with a sharp utility knife. Using a Sharpie black extra fine point pen, darken the narrow white trim on the bottom edge of the display. As needed, one can decrease the thickness of the 4-40 nuts in order to slightly lower the display in the display window.



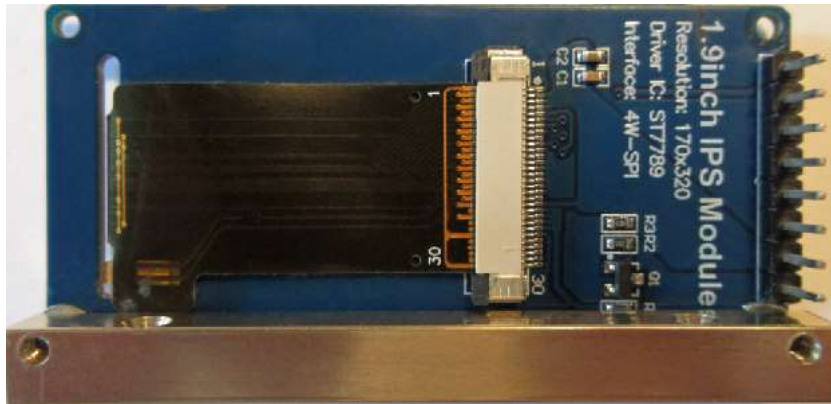


With the TFT display centered in the Atlas frequency window, mark drill holes on the top of the Atlas VFO enclosure. Drill out the two holes with a 1/16" drill bit. Tap 2-56 holes.



Attach the display assembly to the top of the VFO enclosure using two 2-56 10 mm counter sunk screws. As an alternative, one can drill out the holes slightly larger than 1/16" and secure the two screws with 2-56 nuts.





X. Install VFO Module and Miscellaneous Parts

Install the circuit board inside the VFO enclosure. Secure the circuit board to the bottom of the enclosure with M2-3 Phillips flat head screws. Solder the RF ground wire and the 0.1 uf coupling capacitor to the SMA jack.

Install the Si5351 VFO box on the top side of the Atlas VFO enclosure using the two screw holes that secured the VFO circuit board to the VFO Mount VFO box to top of VFO enclosure. Secure the VFO box to the top of the VFO enclosure with two 6-32 screws and lock washers. The screws inside the VFO enclosure should not protrude more than 2 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 knob from free spinning. Attach the four control wires to a female pin header. Plug the header onto the four pins of the encoder.

Mount the front panel Scan/Mem label and the ON-OFF-ON momentary Scan/Mem toggle switch. Mount the front panel Step label and the ON-OFF-ON momentary Step toggle switch.

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.

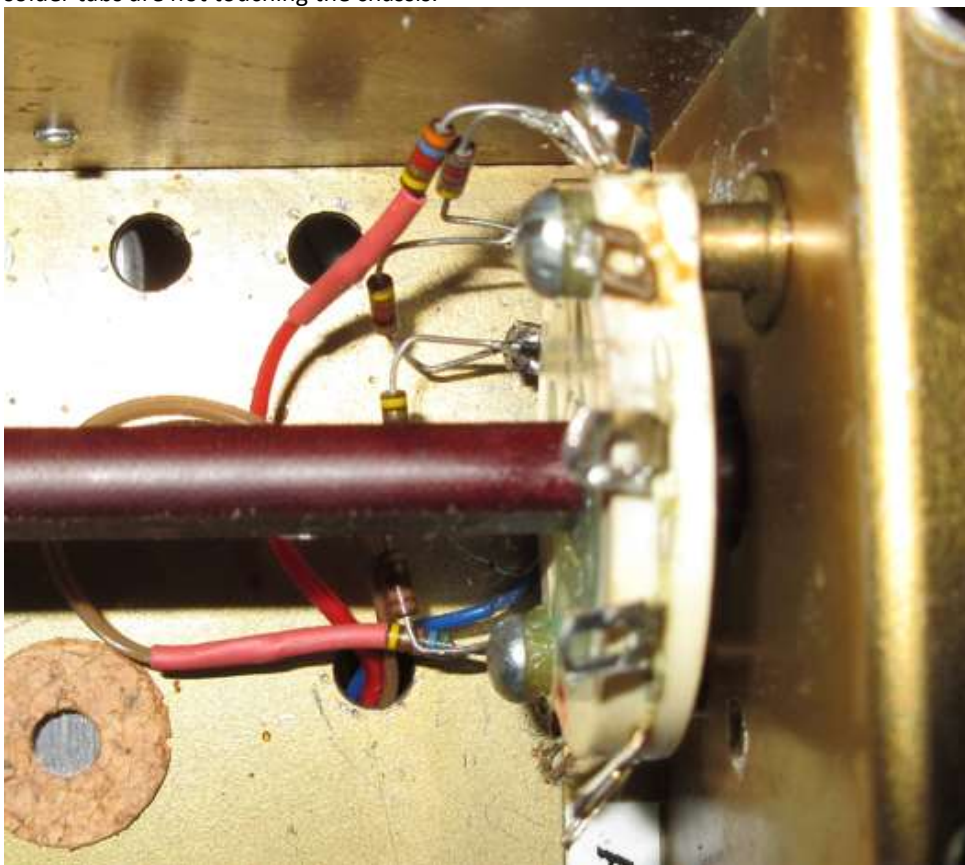
Install a ground bus wire between the Frequency Lock slide switch, the Mem/Scan toggle switch, the LCD display, and the Step toggle switch.

Swap positions of the original RIT slide switch and the NOR/OPP slide switch. A DPDT switch is needed at the NOR/OPP position. 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 ribbon cable interface wires to the Frequency Lock switch, the NOR/OPP switch, the Scan/Mem toggle switch, and the Step toggle switch.

Install the band switching resistors on the rear section 2b of the band switch wafer. Insure that the switch solder tabs are not touching the chassis.



XI. Install 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.

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 ran 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.

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.

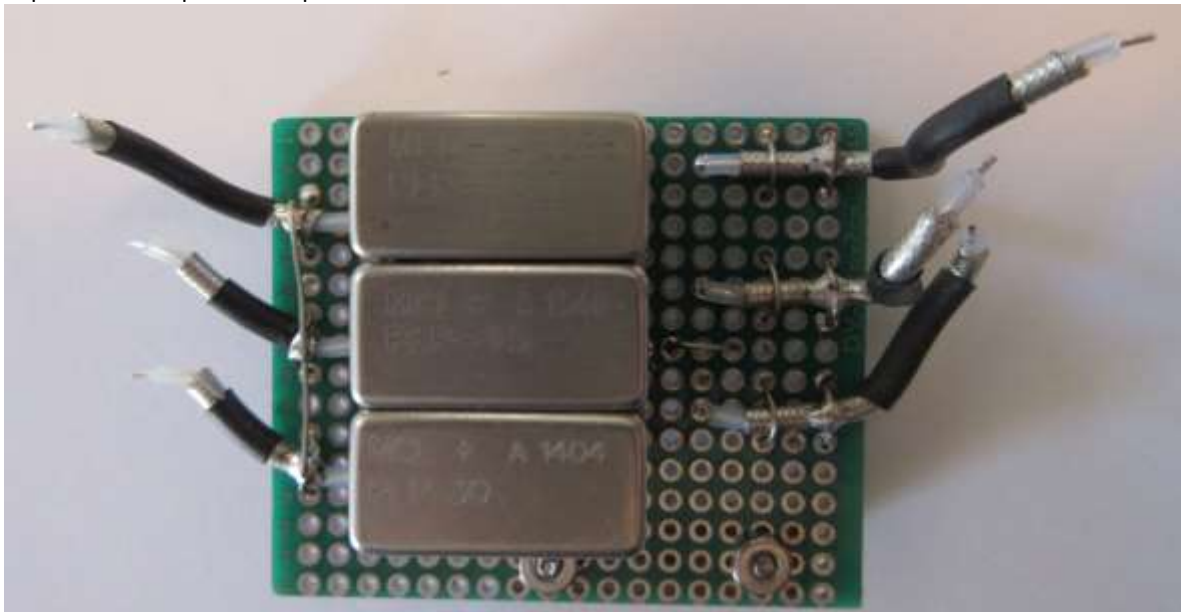
On switch 2a contacts, install insulated jumper between the 40 and 15 meter contacts.

Fabricate a low pass filter board using Perfboard. Trim the height of female pin headers to be used as sockets for the Mini Circuits PLP low pass filters. Solder the pin headers to the filter board. Solder a ground buss wire to each of the ground pins on each filter (6 pins per filter).

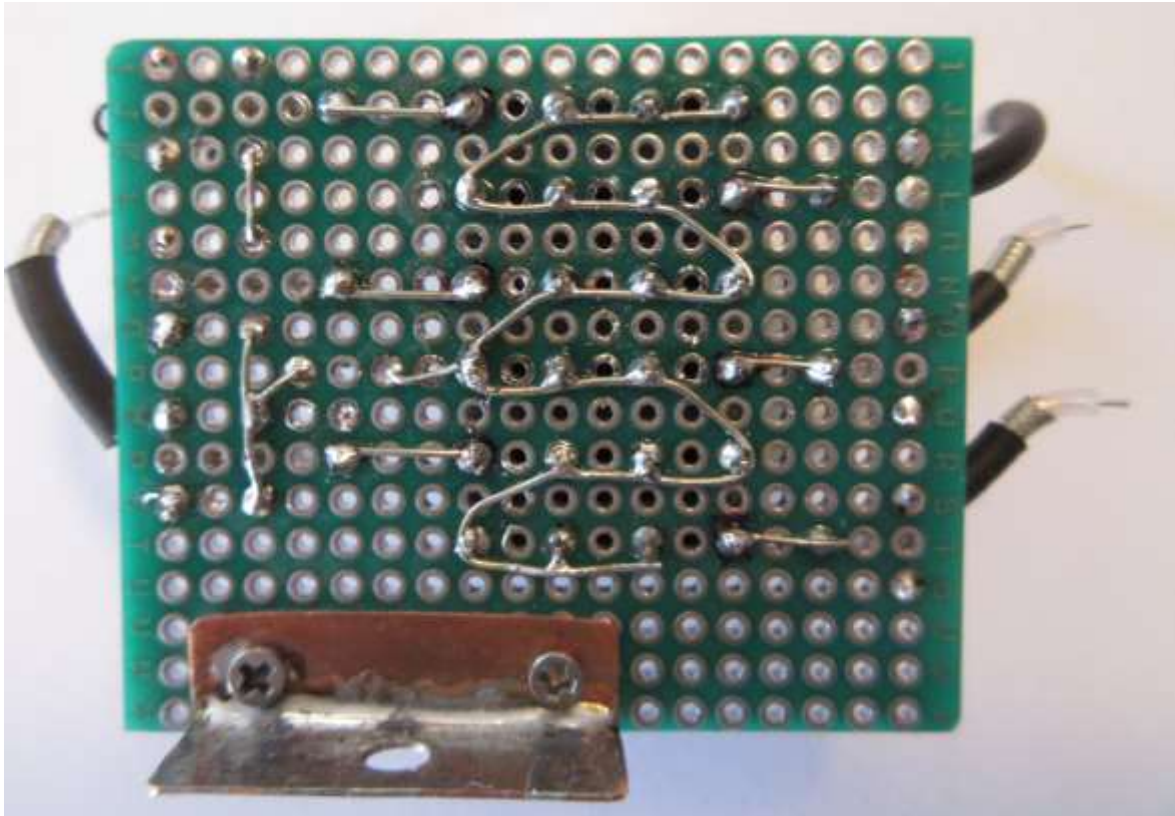
Install coax jumpers from the Band-switch contacts 2a and the inputs to the low pass filter board. There will be a jumper for 80/20M, 40/15M and 10M.

Install coax jumpers from the band-switch contacts 1a and the outputs of the low pass filter board. There will be a jumper for 80/20M, 40/15M, and 10M.

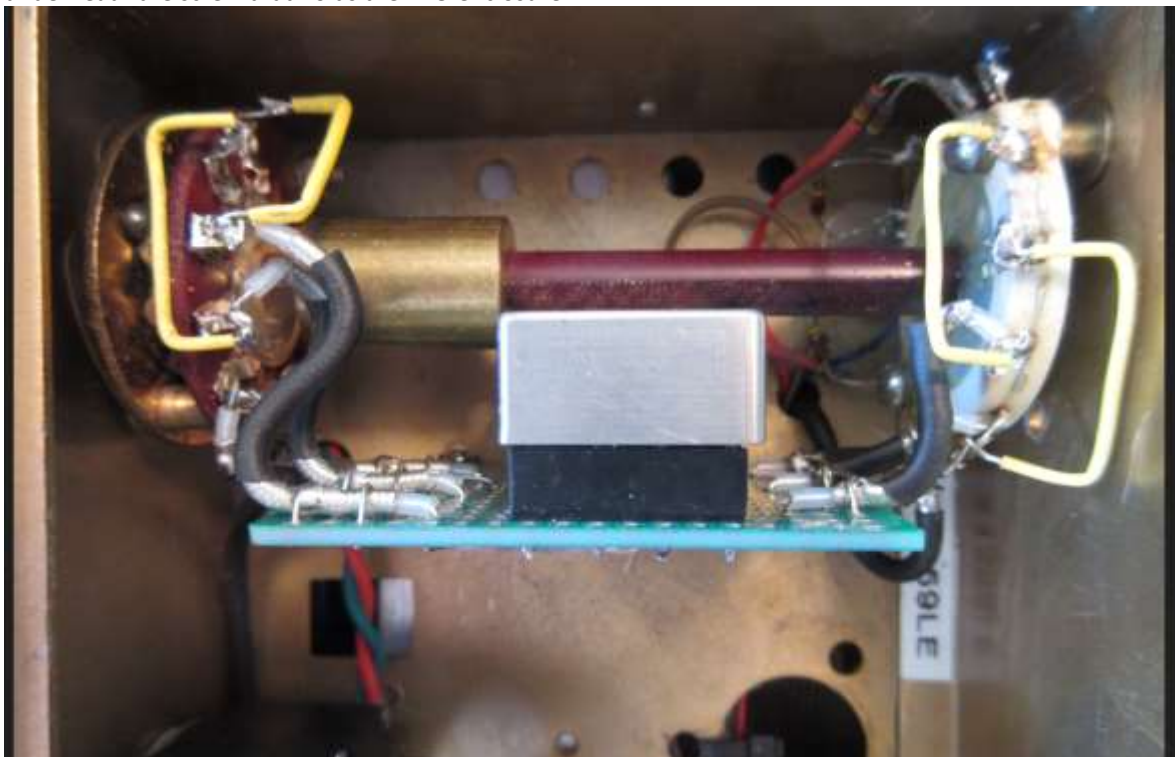
Top view of completed low pass filter board.



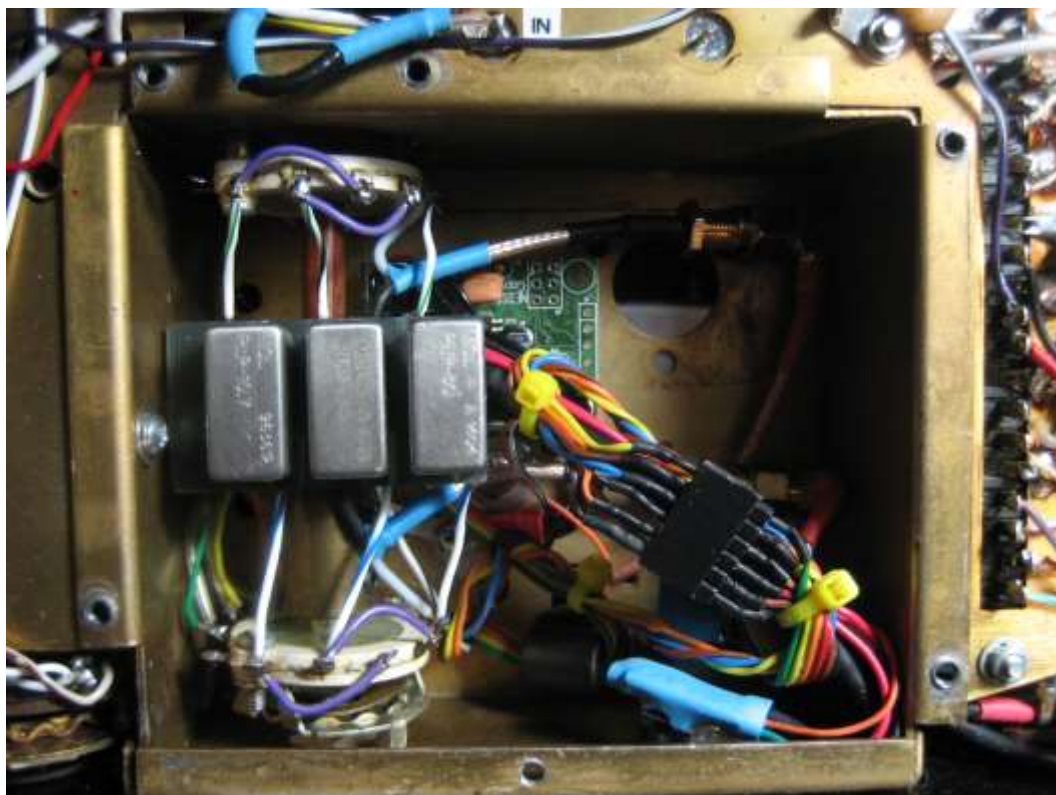
Bottom view of completed low pass filter board.



Attach the board to the bottom of the VFO enclosure with a right angle bracket. Secure the bracket underneath the screw that holds the VFO enclosure.



Here is alternative method for a MCL low pass filter board. This board is easier to implement.



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proper display reading on the LCD display
 Allow 4 hour warmup of the VFO. Calibrate the VFO
 Confirm a ~ +10 dbm VFO output for each band
 Confirm proper operation of the following controls:
 Lock (slide switch on LE model)
 Mem (3 memories per band)
 Scan – two modes

Here is a top view of the completed VFO:



XII. Si5351 VFO Front Panel Control Descriptions

There are three controls on the front panel of the 210X/215X LE radio that are needed for the operation of the Si5351 VFO.

Memory Mode

An up momentary push of the Mem/Scan switch cycles to the next memory position. A 2nd push cycles to the next memory position. A third push of the switch cycles back to the original memory position.

Scan Mode

A down momentary push of the Mem/Scan switch turns the Scan Mode 1 function on. In this mode, the frequency scans in 1 KHz increments. A second momentary push of the switch goes to Scan Mode 2. In this mode, the frequency scans between the three memory positions. Another momentary push turns the scan function off.

Lock Mode

Sliding the switch to the up position will lock the current frequency that is being displayed.

Step Mode

The toggle switch on the left side of the frequency display window controls the Frequency Step function. Each up momentary push of the switch selects the next frequency step. On power up, the step is 1 KHz. Subsequent pushes select 10 Hz, 100 Hz, and 500 Hz. Another push will bring you back to a 1 KHz step.

Option Mode

No function has been implemented for a momentary down push of the switch.

XIII. Appendix

Figure 1 – Block Diagram

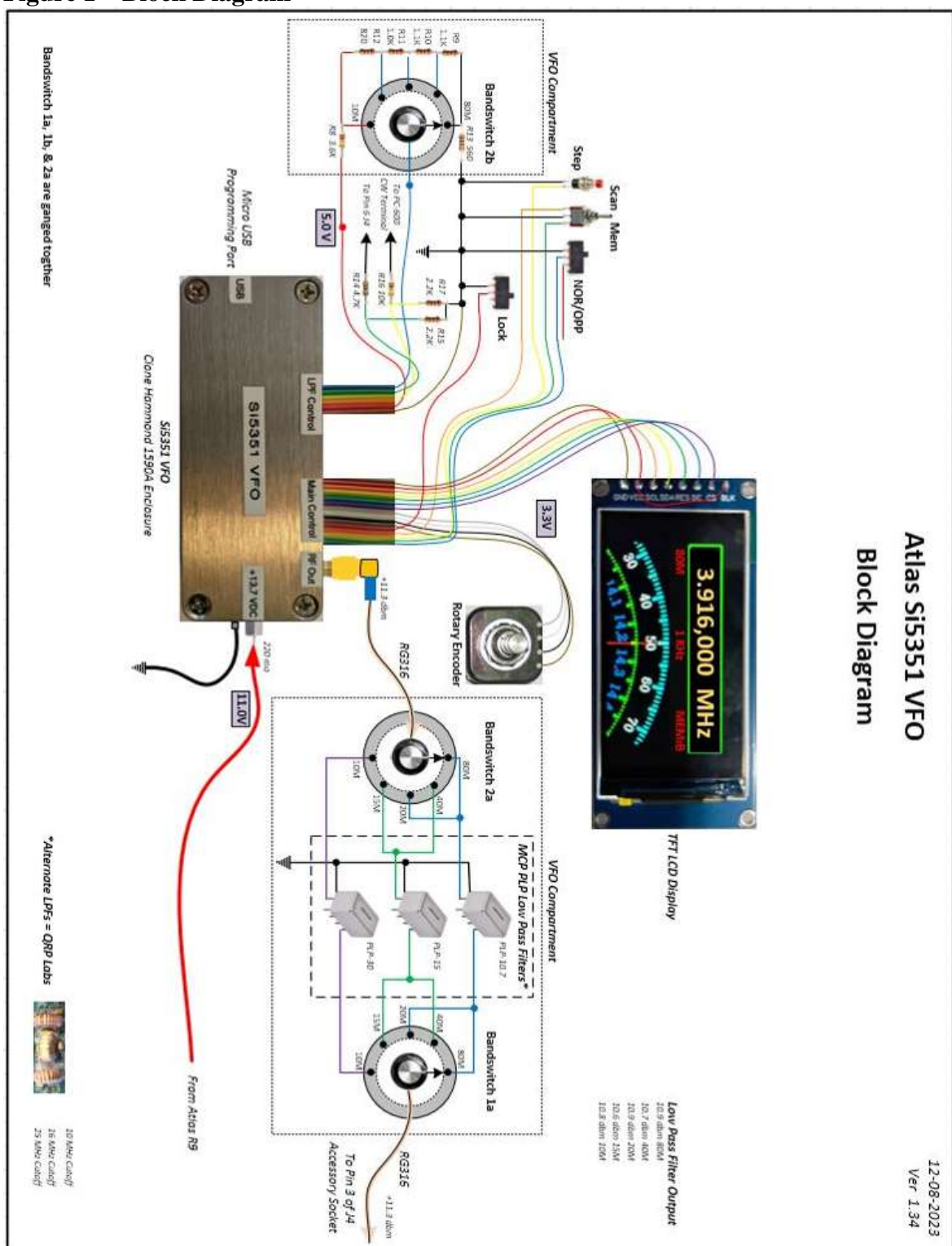
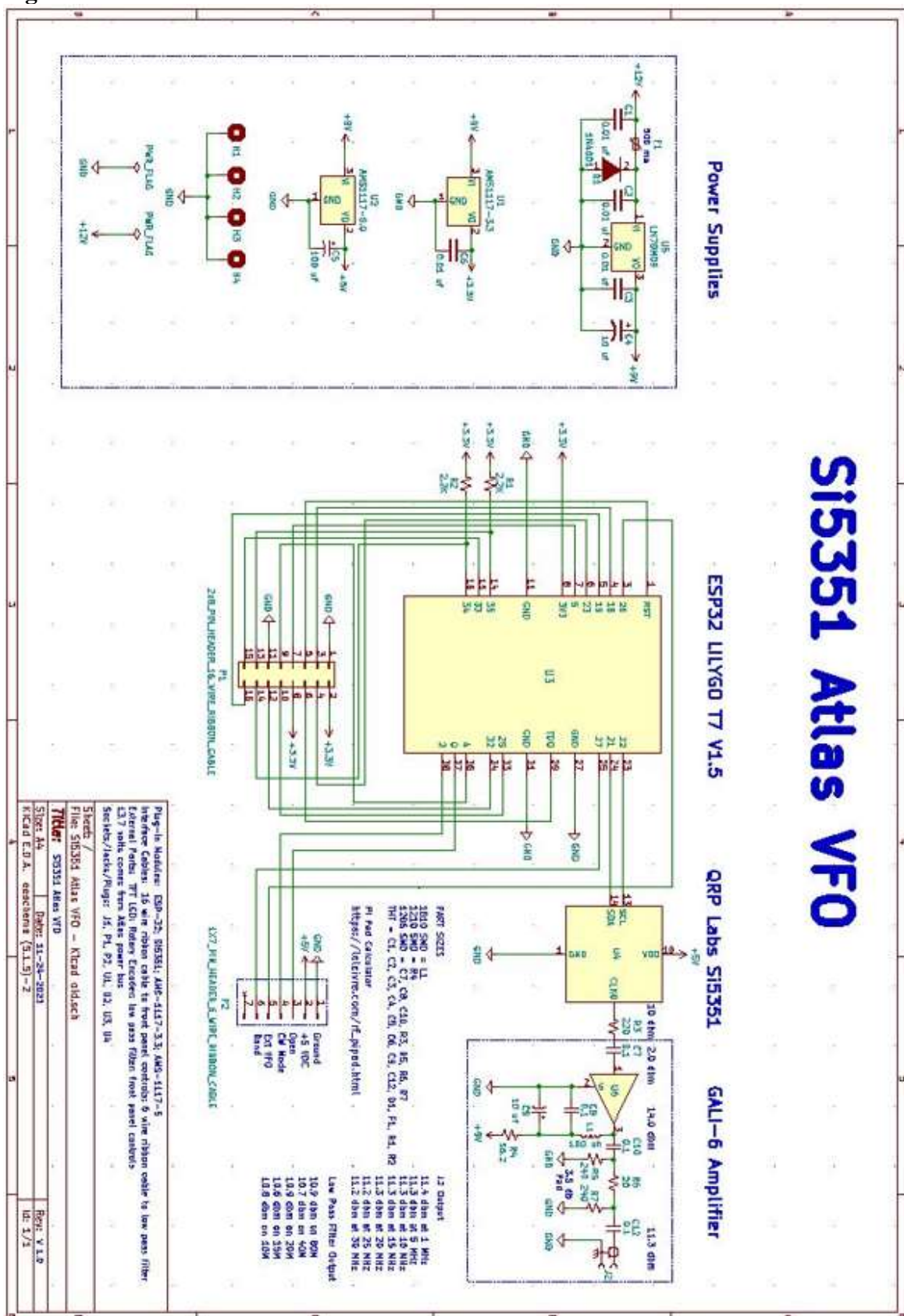


Figure 2 – Schematic



ESP-32 LILYGO T7-V1.5

● = no connection ● = connected

Si5351 PLL VFO - Atlas 210X/215X

TFT LCD SPI S7789
170x20 1.9 inch

Current Load (240 ma total current)

60 ma	ESP-32	13.7 V Bus
10 ma	Rotary Encoder	5.0 V Bus
40 ma	Si5351	5.0 V Bus
6 ma	AMS-1117 3.3V	3.3 V Bus
47 ma	TFT LCD	
70 ma	GALL-6	

Legend:

- S1 = SPST (Existing slide switch)
- S2 = SPDT with center position off - momentary on - on
- S3 = Momentary push button
- S4 = DPDT slide switch (replaces existing SPDT switch)
- Atlas Display Area: 22 x 46.5 mm wide
- Display Area: 22 x 42.7 mm wide

Figure 4 – Si5351 Atlas VFO with no Low Pass Filter – 80M (20 dB pad)

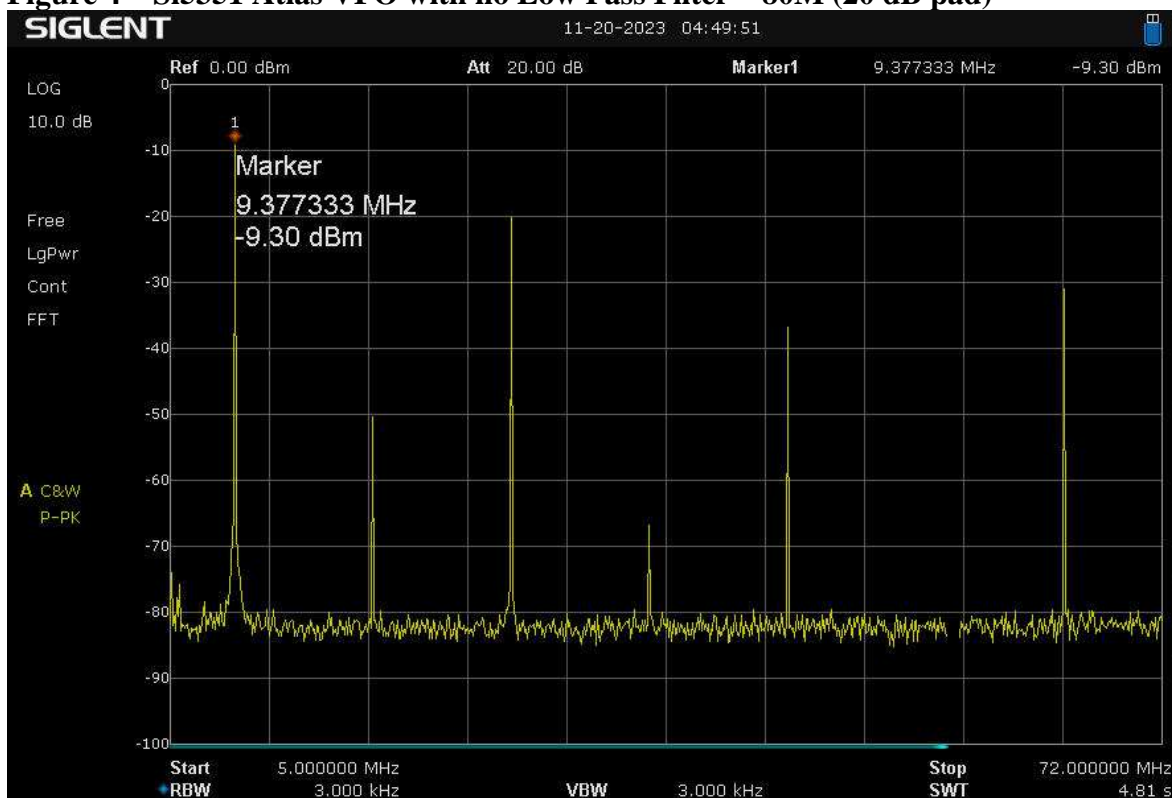


Figure 5 – Si5351 Atlas VFO with MCL PLP-10.7 Low Pass Filter – 80M (20 dB pad)

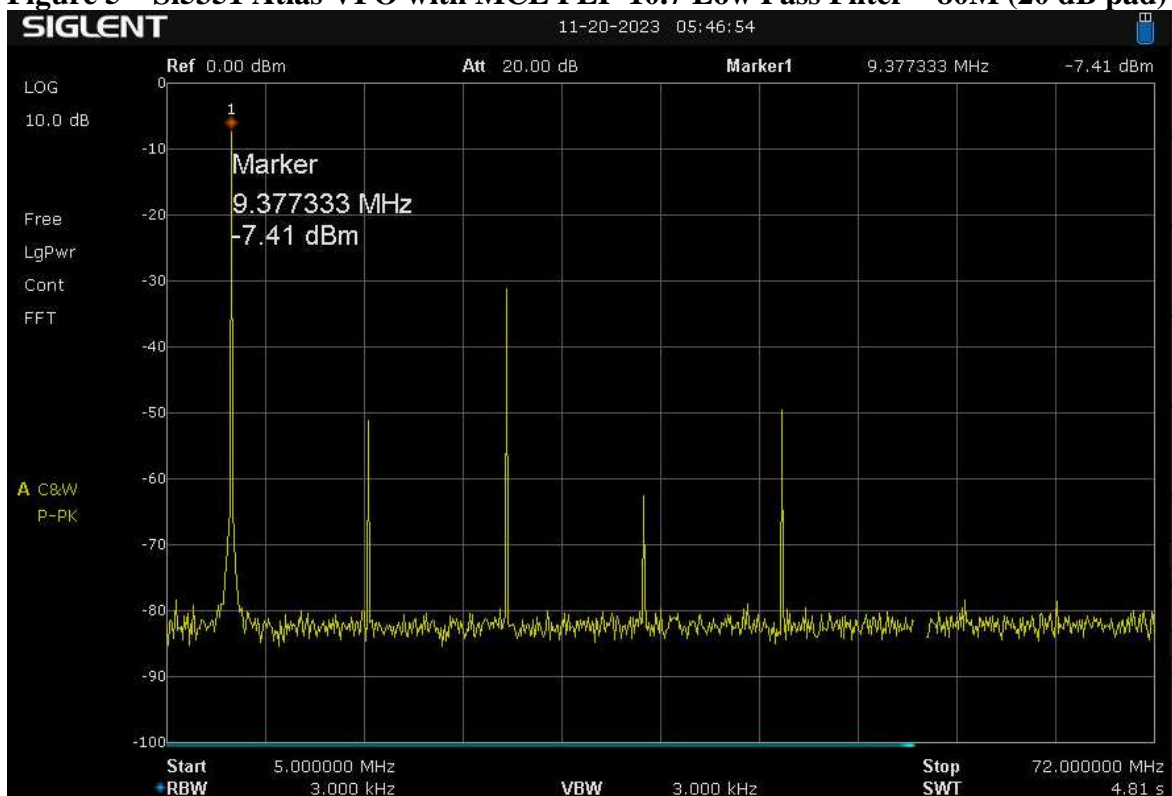


Figure 6 – Factory VFO – 80M (20 dB pad)

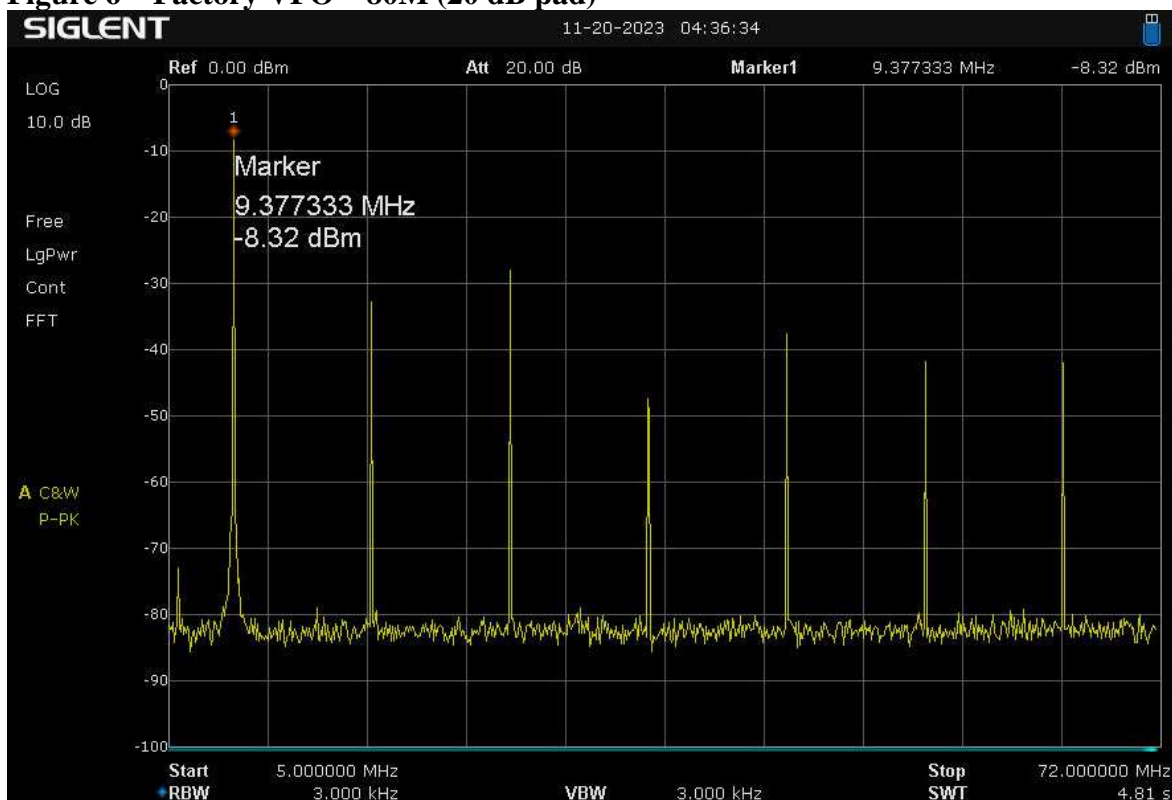


Figure 7 – Si5351 Atlas VFO with QRP Labs Low Pass Filter – 80M (20 dB pad)

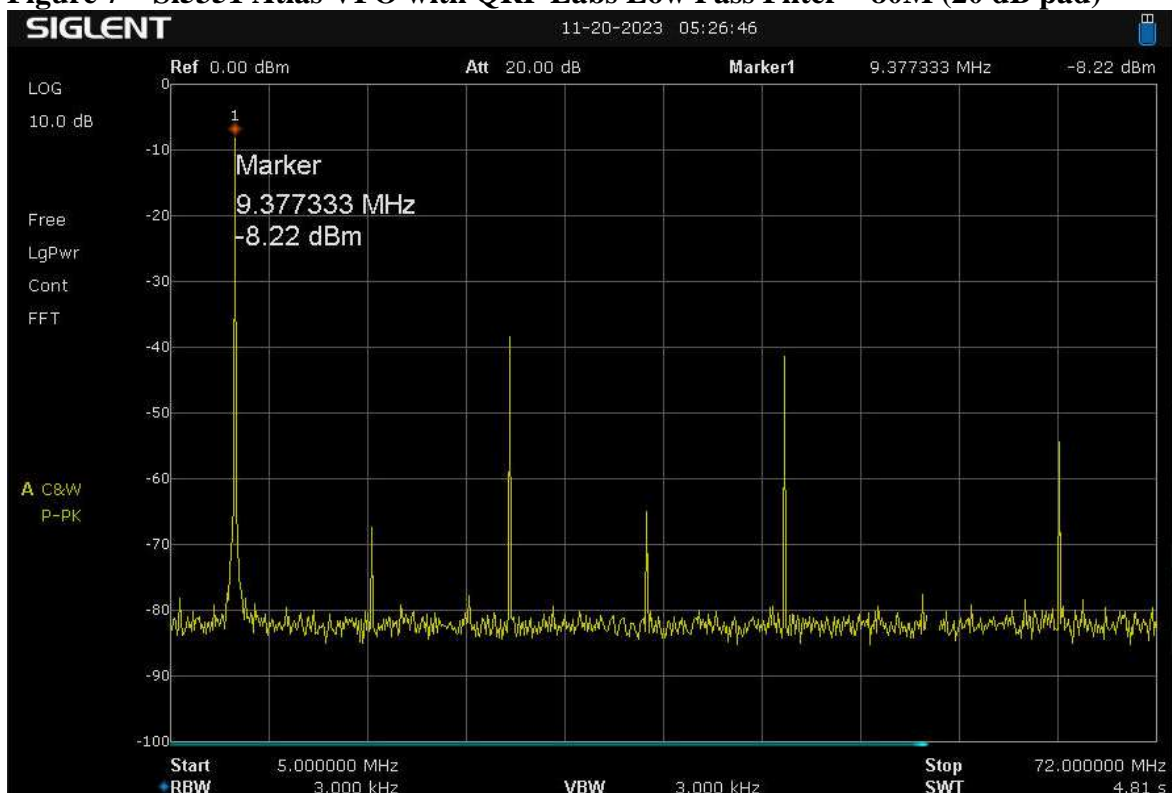


Figure 8 – Si5351 Atlas VFO with MCL Low Pass Filter – 80M (20 db pad)

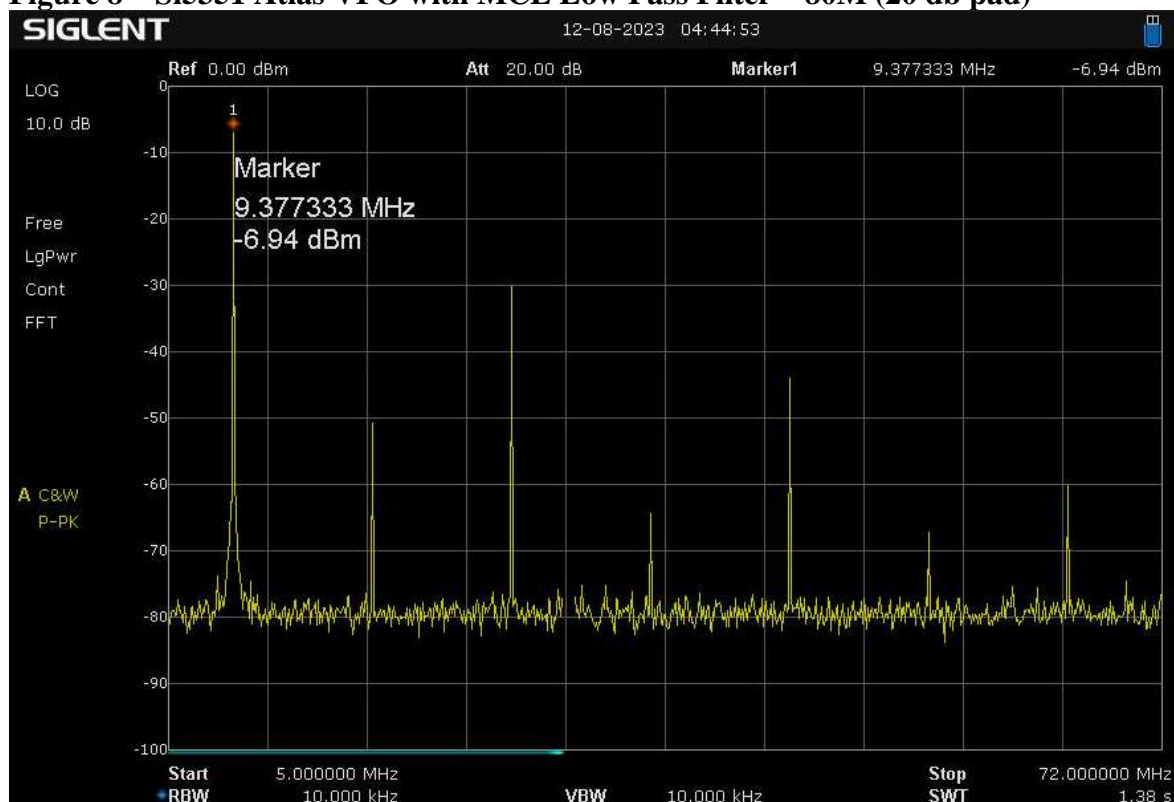


Figure 9 – Factory VFO – 40M (20 dB pad)

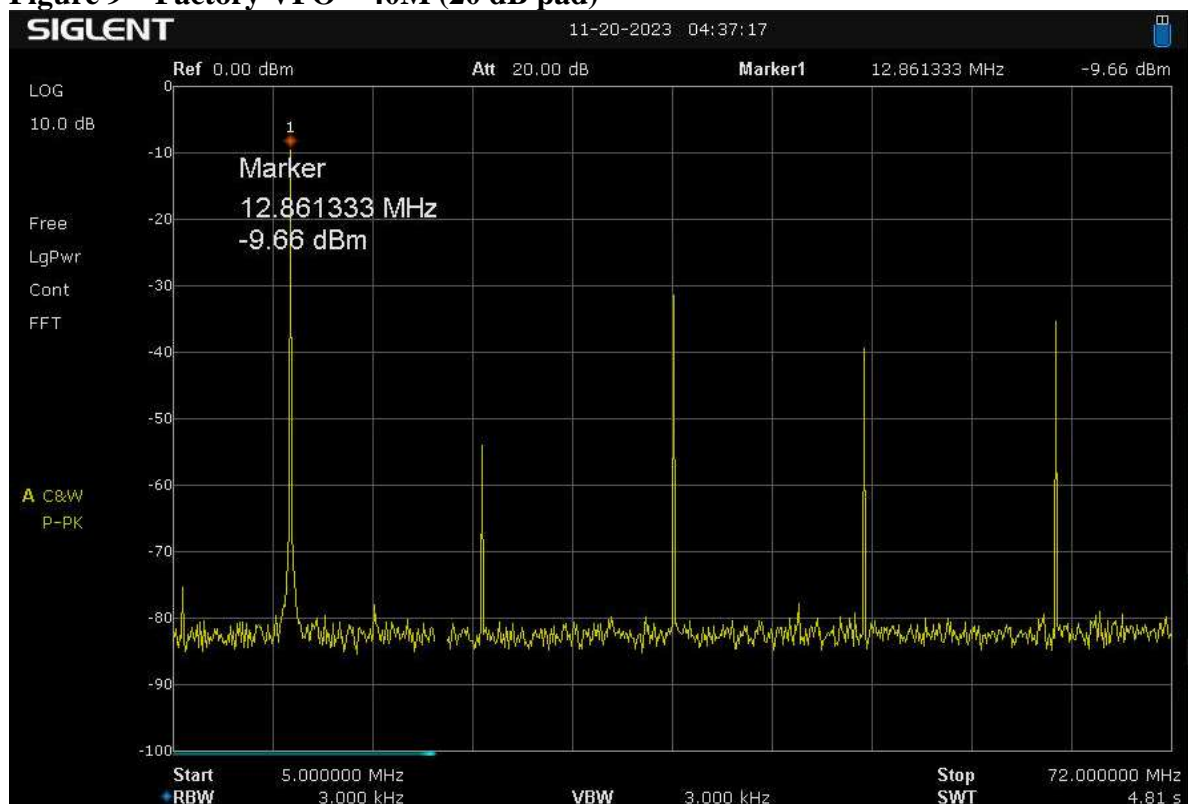


Figure 10 – Si5351 Atlas VFO with QRP Labs Low Pass Filter – 40M (20 dB pad)

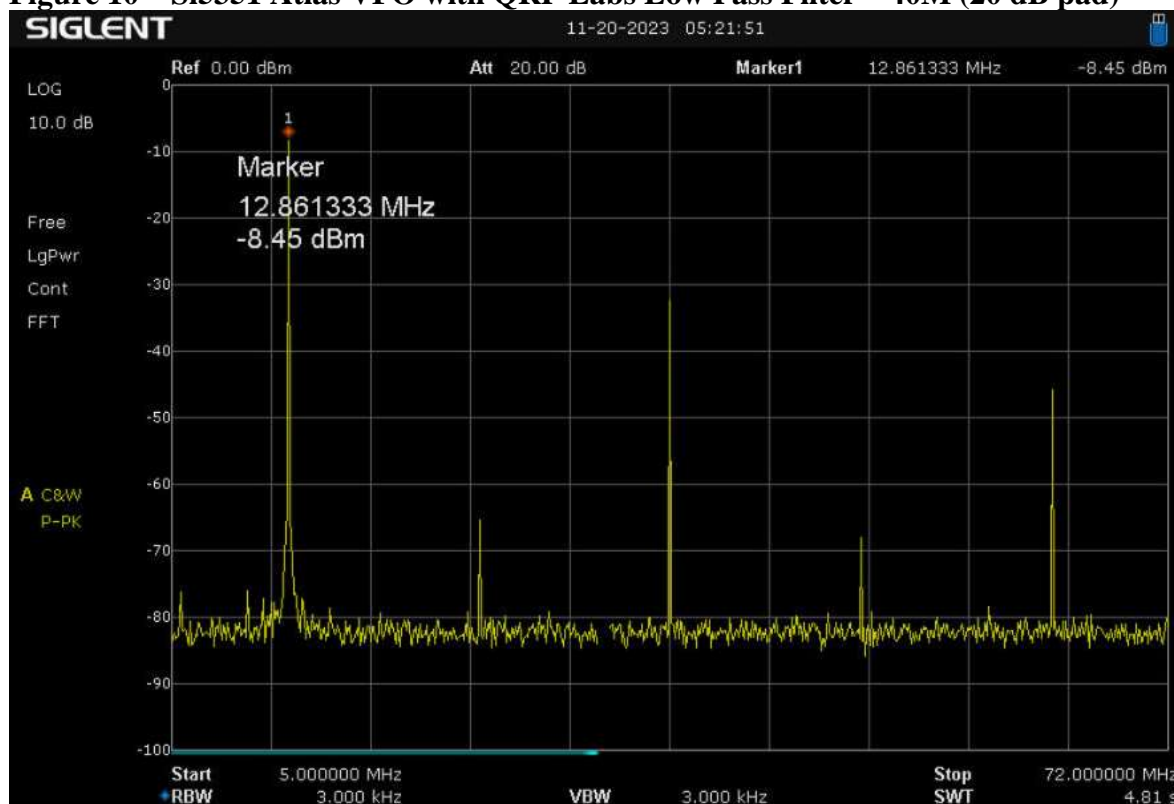


Figure 11– Si5351 Atlas VFO with MCL Low Pass Filter – 40M (20 db pad)

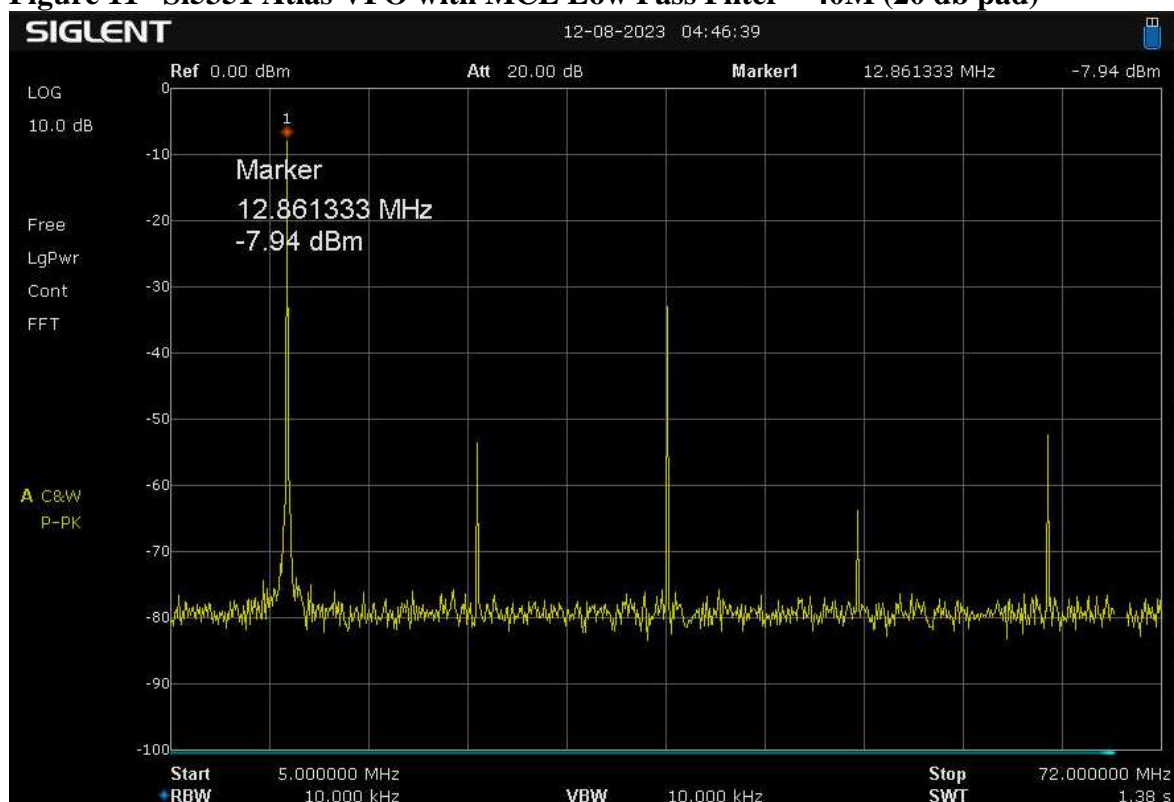


Figure 12 – Factory VFO – 20M (20 dB pad)

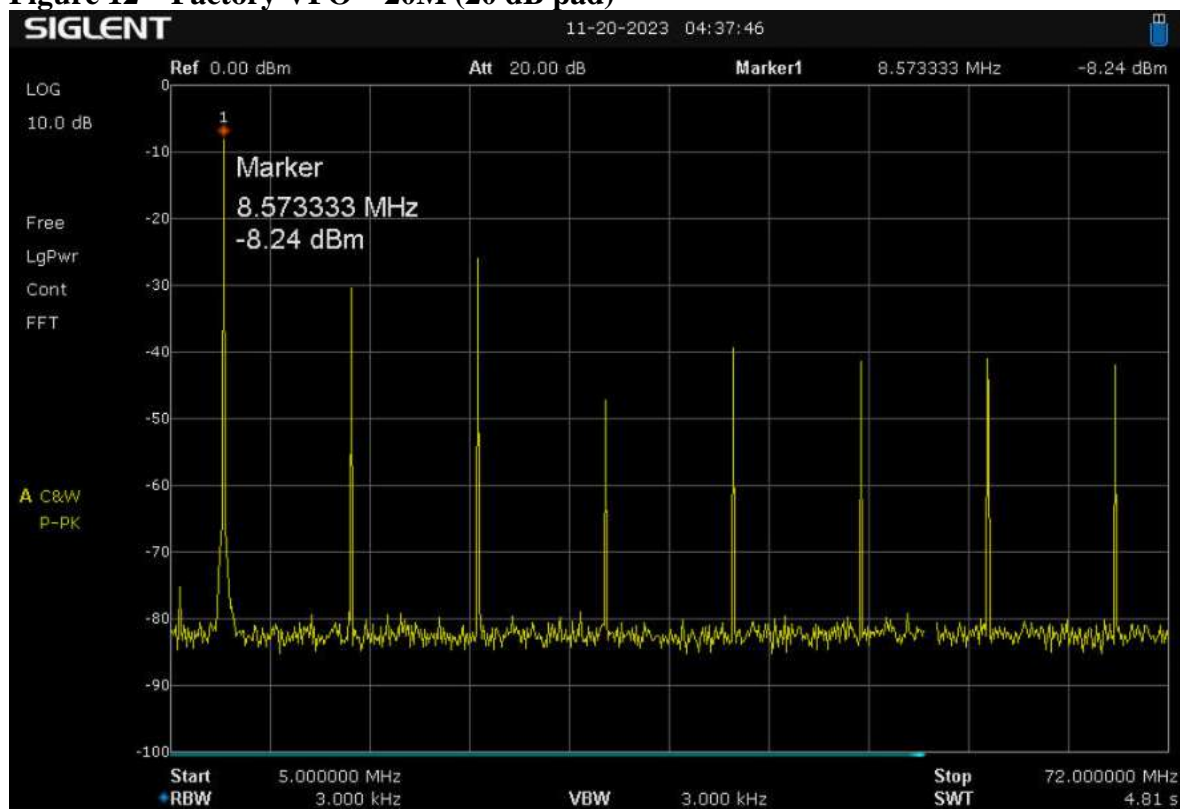


Figure 13 – Si5351 Atlas VFO with QRP Labs Low Pass Filter – 20M (20 dB pad)

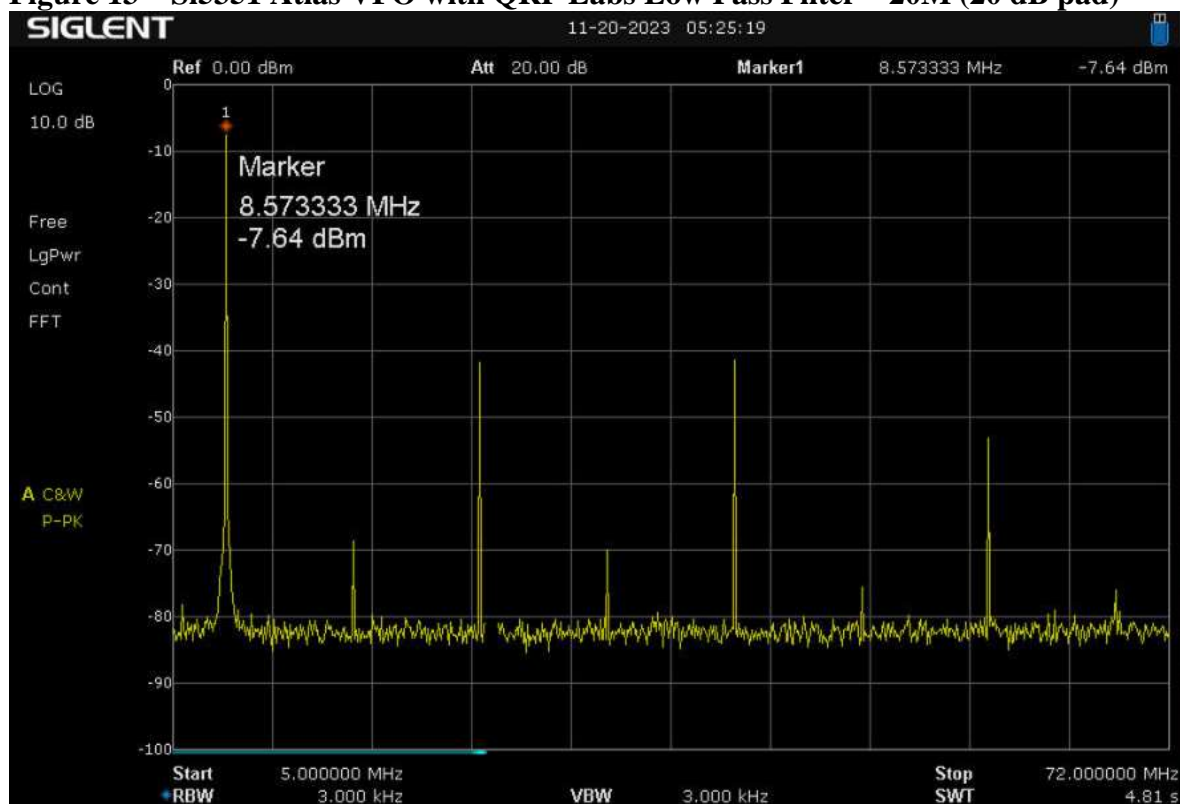


Figure 14– Si5351 Atlas VFO with MCL Low Pass Filter – 20M (20 db pad)

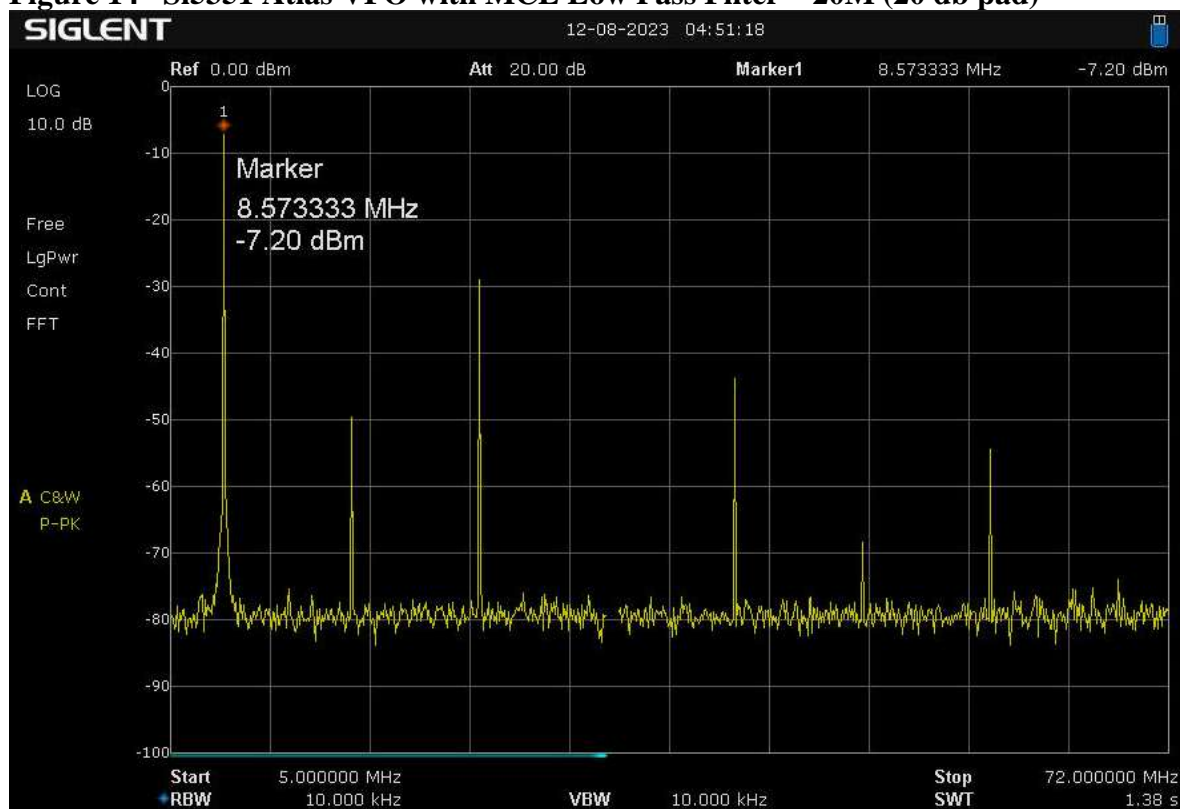


Figure 15 – Factory VFO – 15M (20 dB pad)

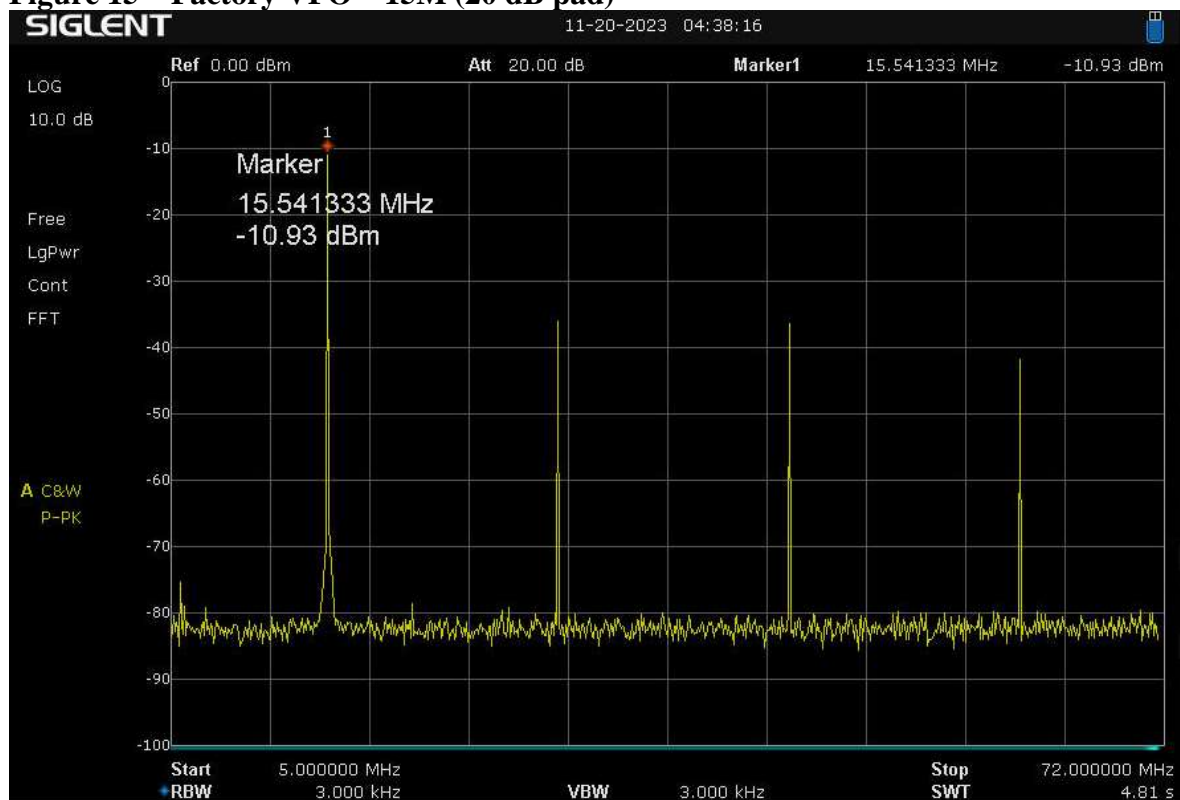


Figure 16 – Si5351 Atlas VFO with QRP Labs Low Pass Filter – 15M (20 dB pad)

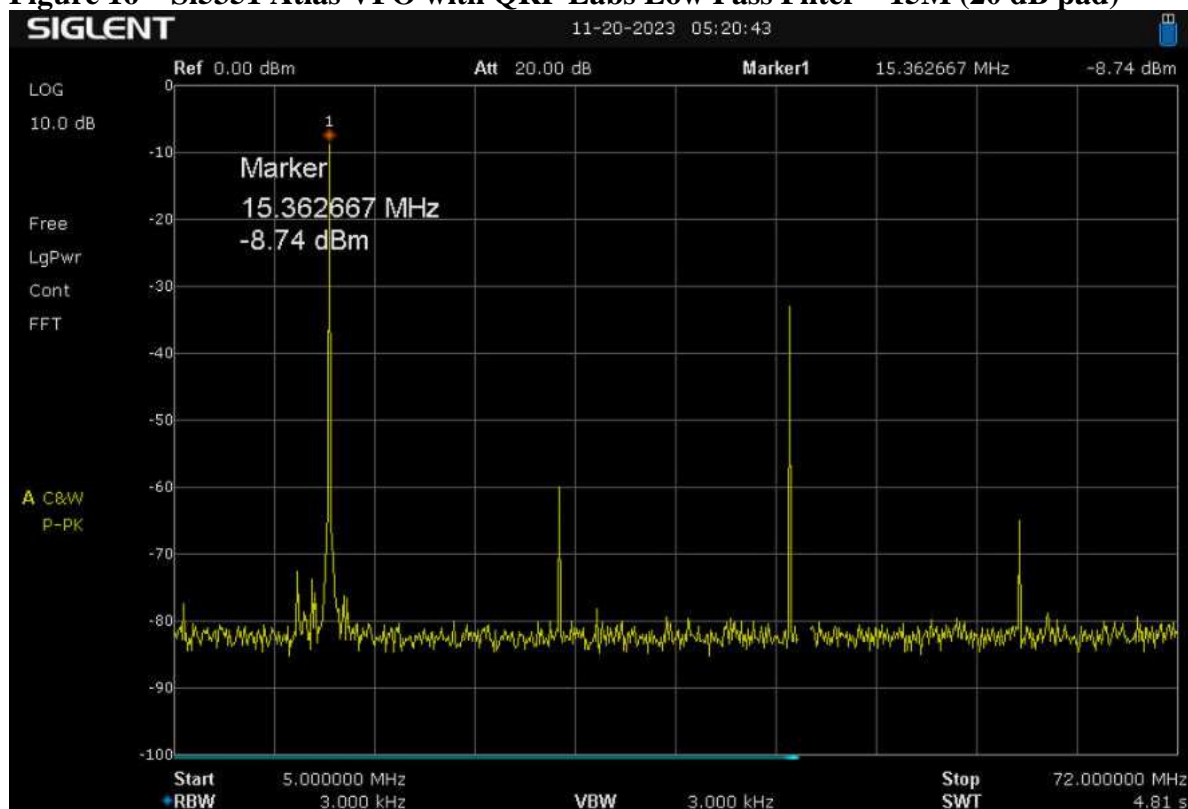


Figure 17– Si5351 Atlas VFO with MCL Low Pass Filter – 15M (20 db pad)

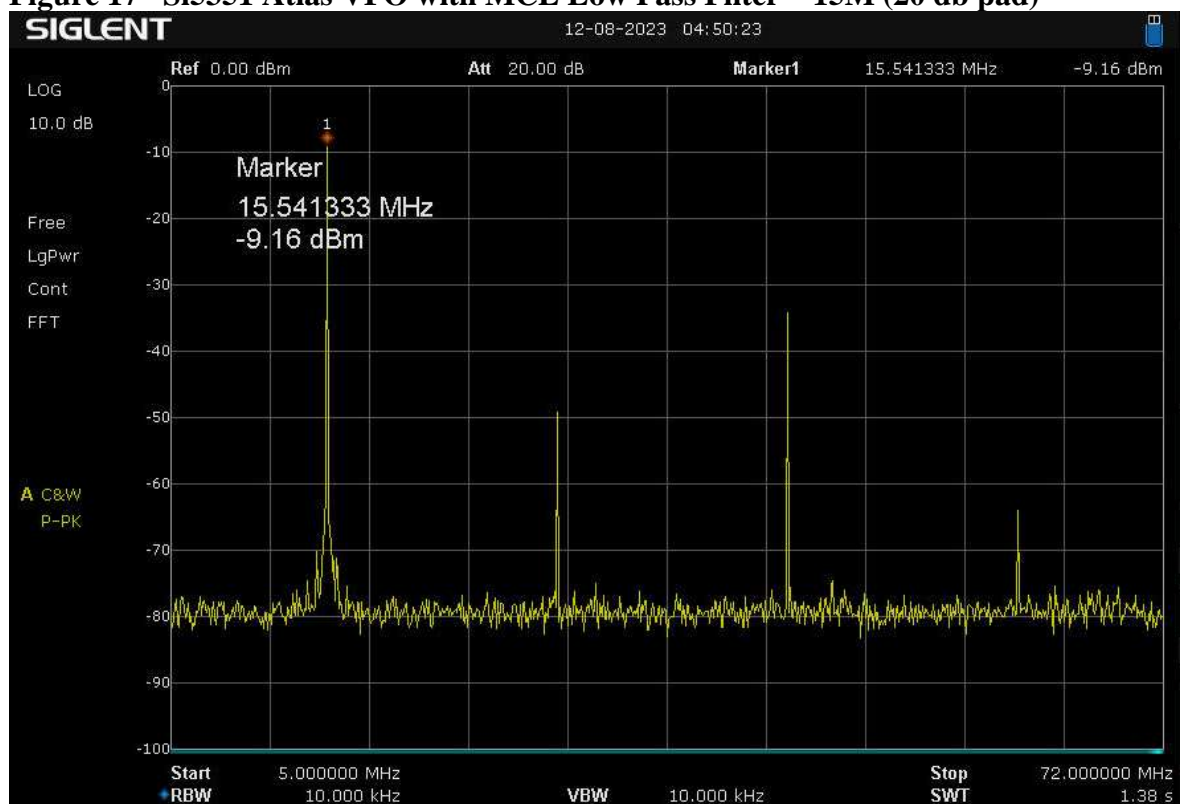


Figure 18 – Factory VFO – 10M (20 dB pad)

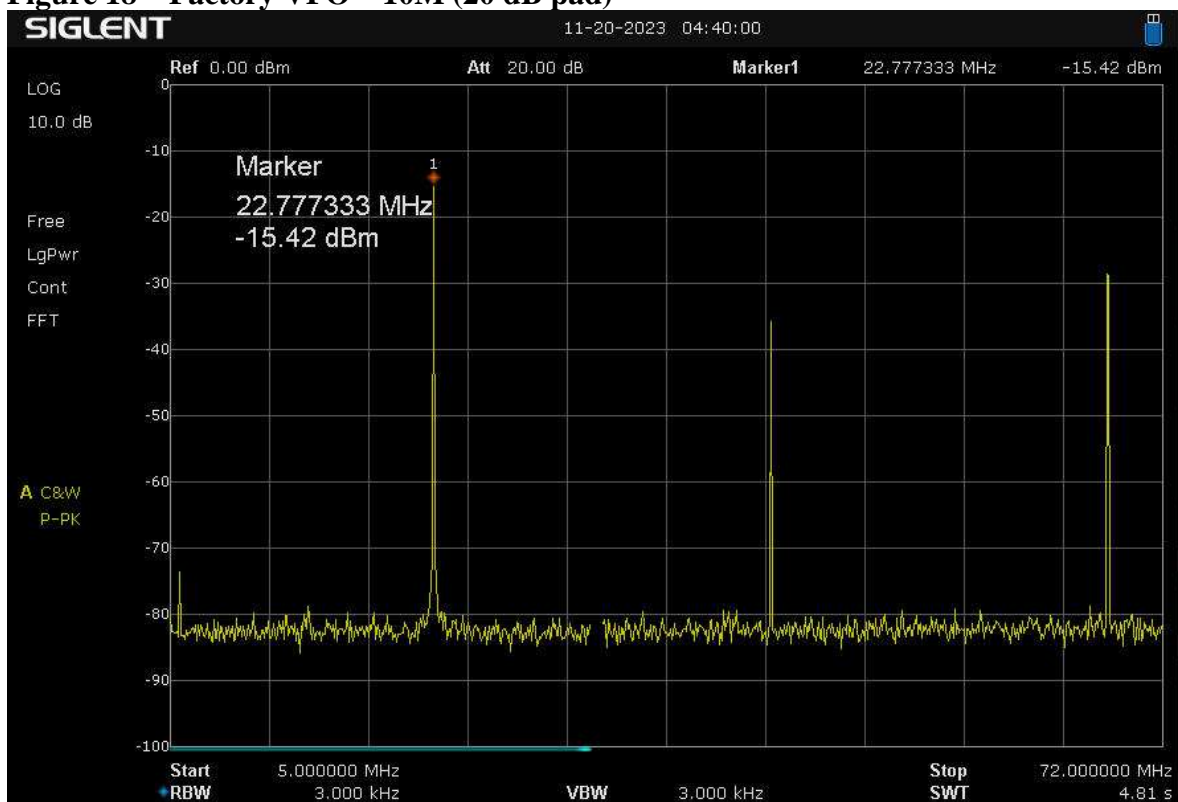


Figure 19 – Si5351 Atlas VFO with QRP Labs Low Pass Filter – 10M (20 dB pad)

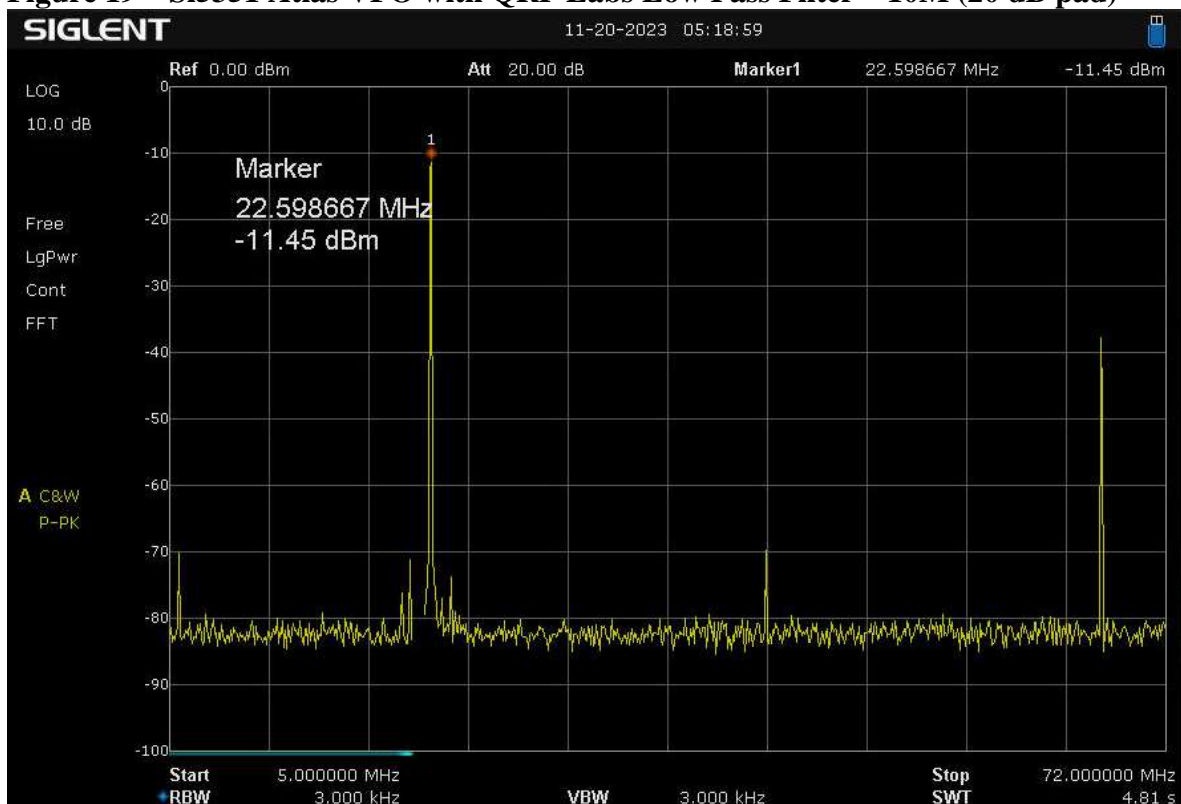


Figure 20– Si5351 Atlas VFO with MCL Low Pass Filter – 10M (20 db pad)

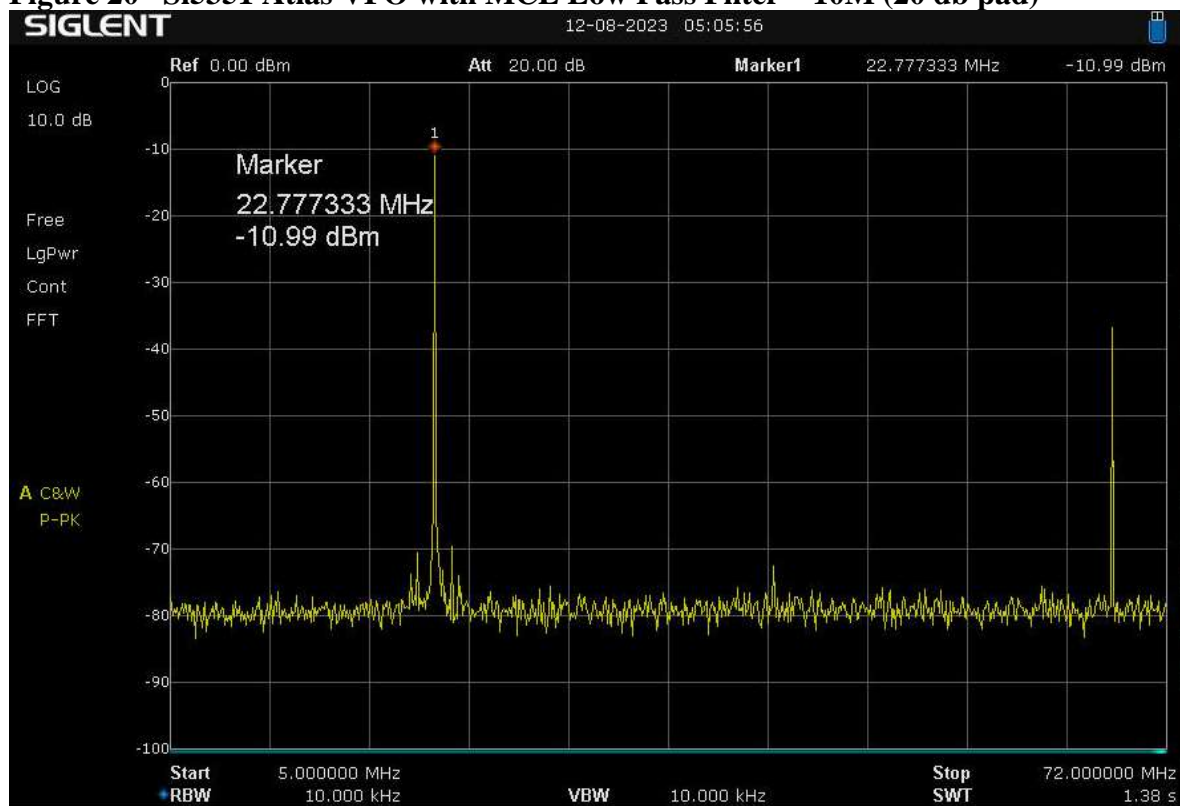


Figure 21 – Si5351 Atlas VFO 80M Sine Wave with MCL Low Pass Filter (14.9 dbm)

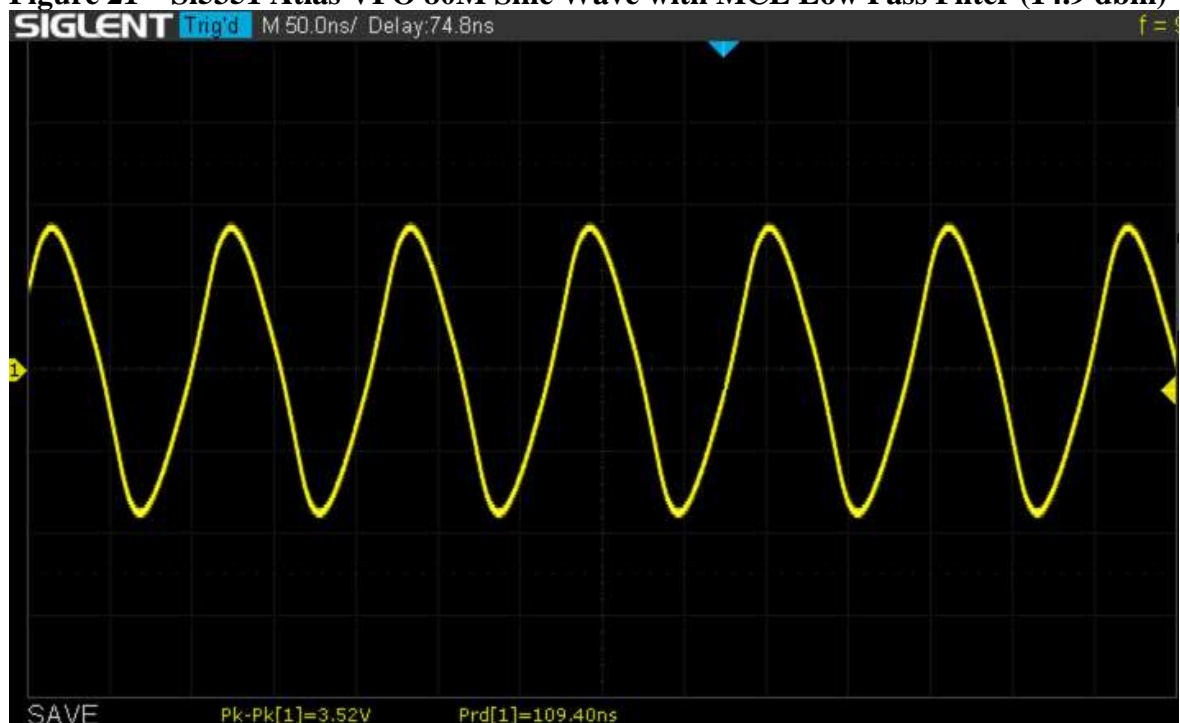


Figure 22 – Si5351 Atlas VFO 40M Sine Wave with MCL Low Pass Filter (14.3 dbm)

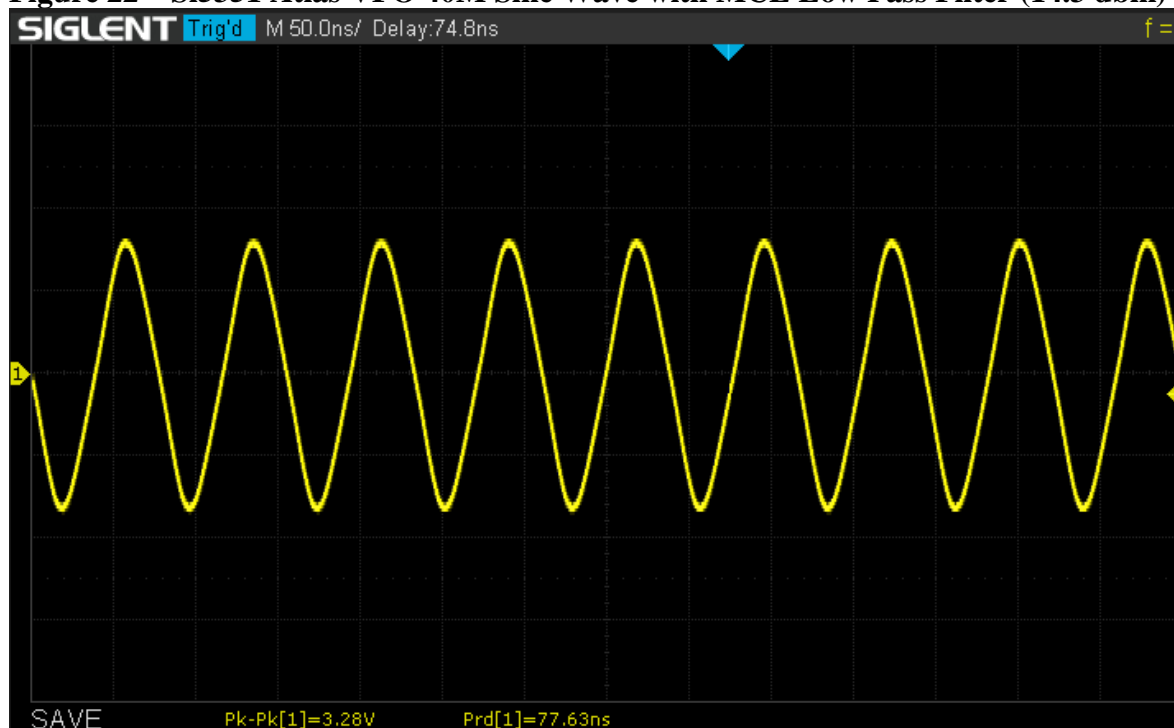


Figure 23 – Si5351 Atlas VFO 20M Sine Wave with MCL Low Pass Filter (14.8 dbm)

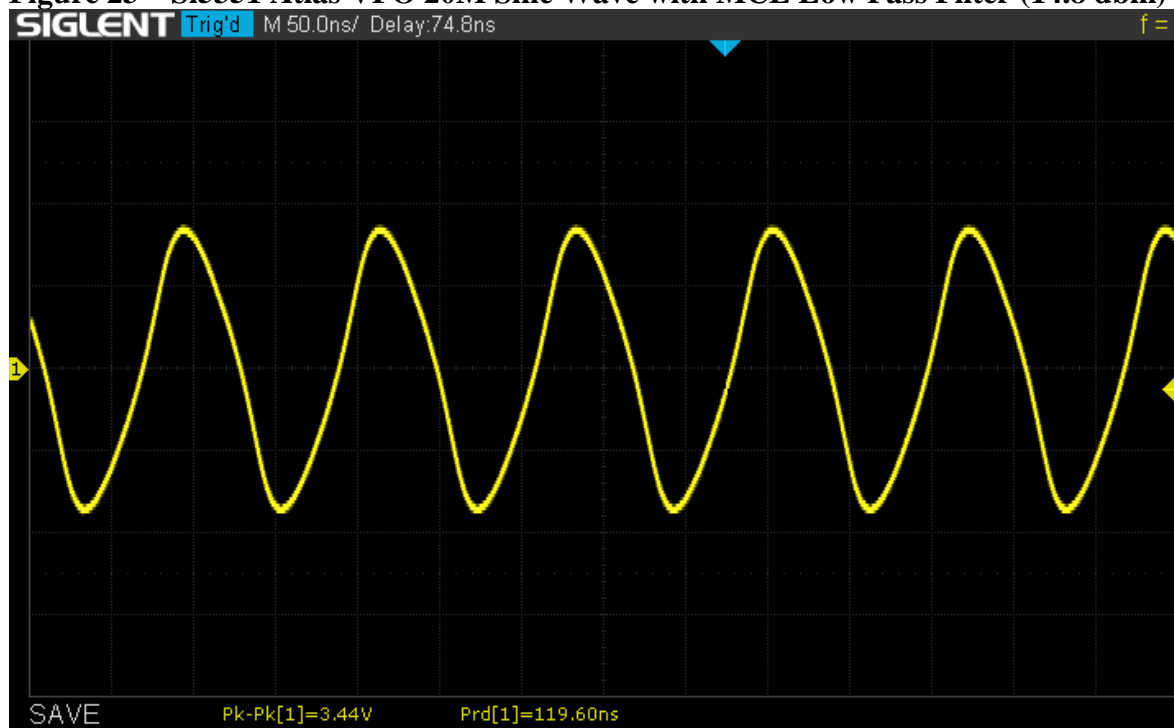


Figure 24 – Si5351 Atlas VFO 15M Sine Wave with MCL Low Pass Filter (12 dbm)

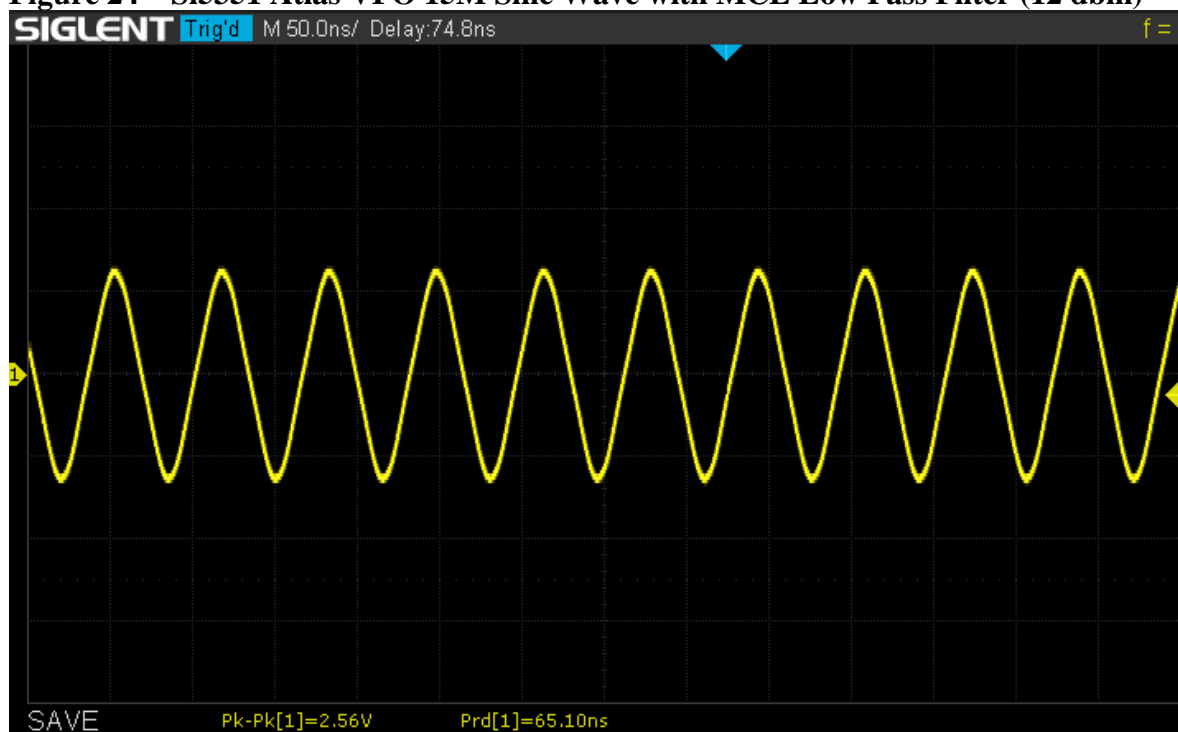


Figure 25 – Si5351 Atlas VFO 10M Sine Wave with MCL Low Pass Filter (10.8 dbm)

