

Atlas 210X/215X

Si570 VFO

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I. OVERVIEW

Altas Radio HF transceivers were produced from the mid to late 70s. There were various models that 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. Installing a digital VFO inside the Altas radio 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. There was a main tuning capacitor for all bands and a capacitor and inductor combination that was changed for each band. This design removed the need for a hetrodyne 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 50 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 quite a bit of space inside the VFO compartment. Two bandswitch 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, and the Si570. 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

The ADxxxx chips produce excellent VFO 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. I have found only one chip that will work well with the Atlas radio – the Si570. The one negative in using the Si570 is the large number of generated 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 a more stable VFO for their radio. A moderate amount of technical skills is needed to perform the needed changes. The author is in his late 60s, 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 board and the output power amplifier. 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 describes how to build an internal VFO that is very stable and provides a very accurate frequency display. The design goals were to:

Provide a 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. Supplementary Documentation

An engineering document has been produced that shows schematics, wiring diagrams, test measurement results, etc. This document is called “Si570 VFO Engineering Package”. This document will need to be referenced during various stages of the VFO build process.

D. Options

A bare bones implementation of the VFO would include the SDR-Kits VFO kit, the PAOKLT Atlas chip, and a Mini Circuits SCLF-23 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-23 low pass filter

QRP Labs Multi-filter Low Pass Filter board

QRP Lab 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 leakthrough around the filters. The QRP Labs filters will also work, but the response curves are degraded about 20 to 30 db 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. SDR-Kits VFO Output signal

The output signal of the VFO board comes directly off the Si570 chip and is about +10 dbm 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. This causes the signal level to deviate from the normal +10 dbm level and impacts the response curve of the attached low pass filter. That in turn increases the number of receiver spurs in the radio.

The fix is to provide a constant 50 ohms load on all bands by using a MMIC amplifier board. The recommended board is the W3IAC unit, using the MCL GALI-6 MMIC chip. A 10 db attenuator is installed on the input of the board. This results in a +10 dbm output signal. With this attached amplifier board, there is minimal degradation of the low pass filter response curves, there a consistent input signal to the mixer on all bands, and there are a minimal number of spurs in the receiver.

II. SPECIFICATIONS

The main building block for the Si570 VFO is the kit provided by SDR-Kits. This kit allows one to build out a fully functional VFO or signal generator with a 16x2 LCD display. Here is a resulting VFO with a 16X2 display.



The built-in controls of this VFO would not work very well for an Atlas radio implementation. Ton Blokker, PA0KLT has created a customized program chip (AVR) to replace the one provided in the kit. This chip changes a number of control lines on the VFO board so that they mesh very nicely with the existing control lines available on the Atlas radio.

If one is unsure about modifying their Atlas radio, then the standard VFO can be built out. It can be used as an external VFO for the Atlas radio, using the Accessory interface 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, replace the factory program chip with the Atlas program chip, and install the VFO module in the Atlas radio.

Here is a summary of the specs resulting from using the customized program chip installed in the SDR-Kits VFO kit:

Minimal cost to implement

Internal jumper to select Atlas radio model – 210X or 215X

Internal jumper to select Atlas IF frequency – 5520 KHz or 5645 KHz

About 100 ma current draw, including back-lighted LCD display

Selectable VFO A and VFO B

One frequency can be saved on each of the five bands

RIT Control (transmit and receive)

Frequency Lock

Built-in Calibration controls

Contrast adjustment for LCD display

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 8X2 and 12X2 LCD displays (KHz digits will be truncated with the 8X2 display)
+10 dbm output signal
10 hz frequency increment tuning – 1.28 KHz change per frequency control rotation
500 Hz frequency increment tuning – 64 KHz change per frequency control rotation
Frequency increment selected via push button on the frequency control (encoder)
High quality mechanical encoder included in SDR-Kit package
Works with standard Bournes optical encoder (extra cost option)
Uses freed up contacts on the Atlas bandswitch 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
50 hz drift after a 15 minute warmup – 10 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
- Prepare Atlas radio
- Fabricate VFO enclosure
- Build VFO board
- VFO board interfacing
- Low Pass Filter build
- Testing

B. **Parts Procurement**

In order to get needed parts for the project, you will need to place as least three orders.

Programmed Atlas AVR chip

Available from Ton Blokker (PA0KLT) for 20 Euros (including shipping)

Ton's email address is: a.blokker44@quicknet.nl

Payment should be made to Ton's PayPal account: pa0klt@quicknet.nl

The customer assumes normal shipping risks and any possible custom's duties

Si570 VFO Kit

The basic Si570 VFO Kit is available from SDR-Kits (<http://sdr-kits.net>)

The kit will not include the AVR chip or the 16X2 LCD display

The kit will include a quality mechanical encoder

The link to the kit is:

<http://www.sdr-kits.net/Webshop/products.php?30&cPath=6&osCsid=96rdb515ogqi7q10qu0m8vekg0>

When ordering, please state in REMARKS column "Heiman Atlas KLT Kit without LCD and AVR"

A price reduction of GBP 10.00 will be applicable to this kit.

Buyers will be asked to pay the full amount for the kit via PayPal, however, we will refund GBP 10.00 via PayPal once we receive the order.

It is recommended that one also purchase the following items when making the purchase:

- Bournes optical encoder

- Either SMD Transformer WBC4-1WLB or the Transformer Kit

LCD Display

12x2 and 8x2 backlighted 5 volt LCD displays are available on eBay. The wiring scheme is the same as the 16x2 display that is referenced in the Si570 VFO kit instructions.

Typical eBay sources would be:

<http://www.ebay.com/itm/5V-Blue-Character-8x2-LCD-Module-Display-w-Tutorial-HD44780-White-Backlight-/301011084596?hash=item4615a8a534:g:r2QAAOSwdzVXkEZ1>

<http://www.ebay.com/itm/5V-12x2-Blue-LCD-Module-Character-Display-w-Tutorial-HD44780-White-Backlight-/291014176633?hash=item43c1cbef79:g:M9UAAMXQWzNSgFY~>

Miscellaneous Parts

Low Pass Filters – Possible sources:

QRP Labs Relay Switched LPF Kit - <http://grp-labs.com/ultimatelpf.html>

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

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

Hammond 1590A die cast aluminum enclosure

Miniature chassis mount feed through capacitor

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

Short piece of RG-316 coax cable terminated with female bulkhead mount SMA connector

Male pin strips (Jameco)

Female headers (Jameco)

Pins for female headers (Jameco #100766)

26 gauge, stranded Teflon hook-up wire

22 gauge, stranded Teflon hook-up wire

12x2 LCD back lighted display – several China sources available on eBay

ON-OFF-ON toggle switch

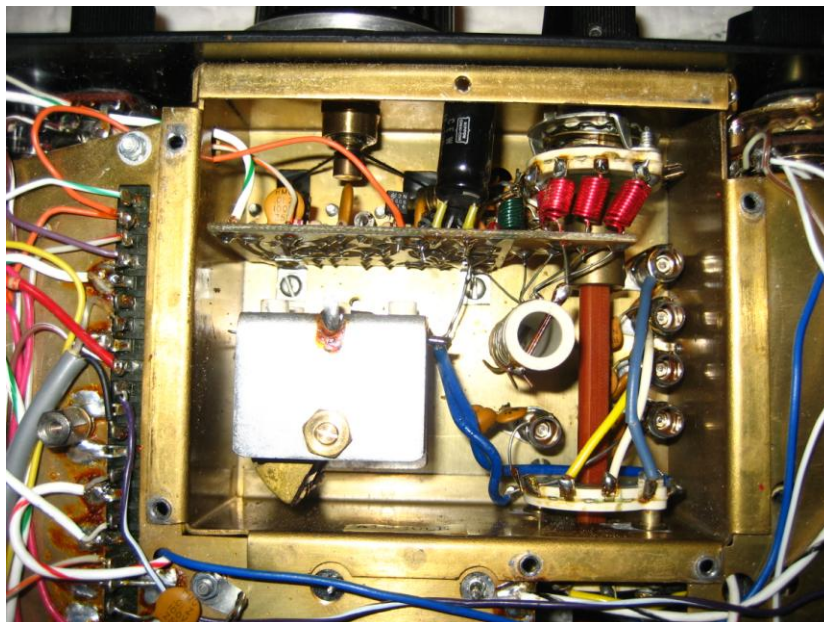
Miniature 2 pole, rotary switch

IV. Prepare Atlas Radio

These steps were written for an Atlas 210X/215X LE radio. Similar steps can be used for a non-LE radio but some hole drilling of a couple of front panel holes may be needed.

A. 210X LE Radio Preparation

The existing 210X LE VFO parts and RIT control will need to be removed from the radio. It will take about 60 minutes to remove the parts. Here is a picture of the stock VFO before the parts were removed:



Remove the following parts:

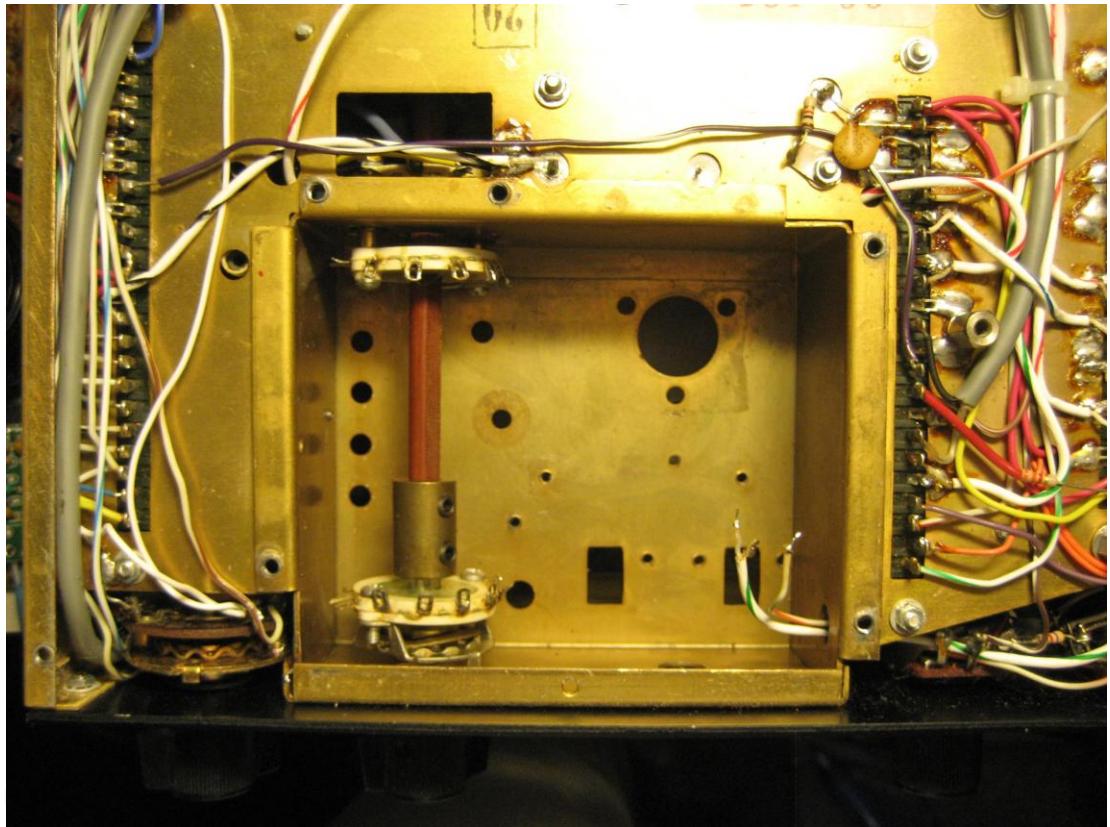
- plastic frequency drum (set screw must be loosened)
- dial cord
- dial cord pulley bracket and the two dial lamps (two screws)
- VFO tuning knob (set screws must be loosened)
- plastic frequency window (two front panel screws must be removed)
- metal pulley on the top of the VFO (it is secured to the shaft of the VFO tuning capacitor)
- bottom cover of the VFO
- VFO front panel vernier (lock nut)

Desolder all wires to the band switch wafers in the VFO compartment
Desolder the two wires to the VFO turning capacitor

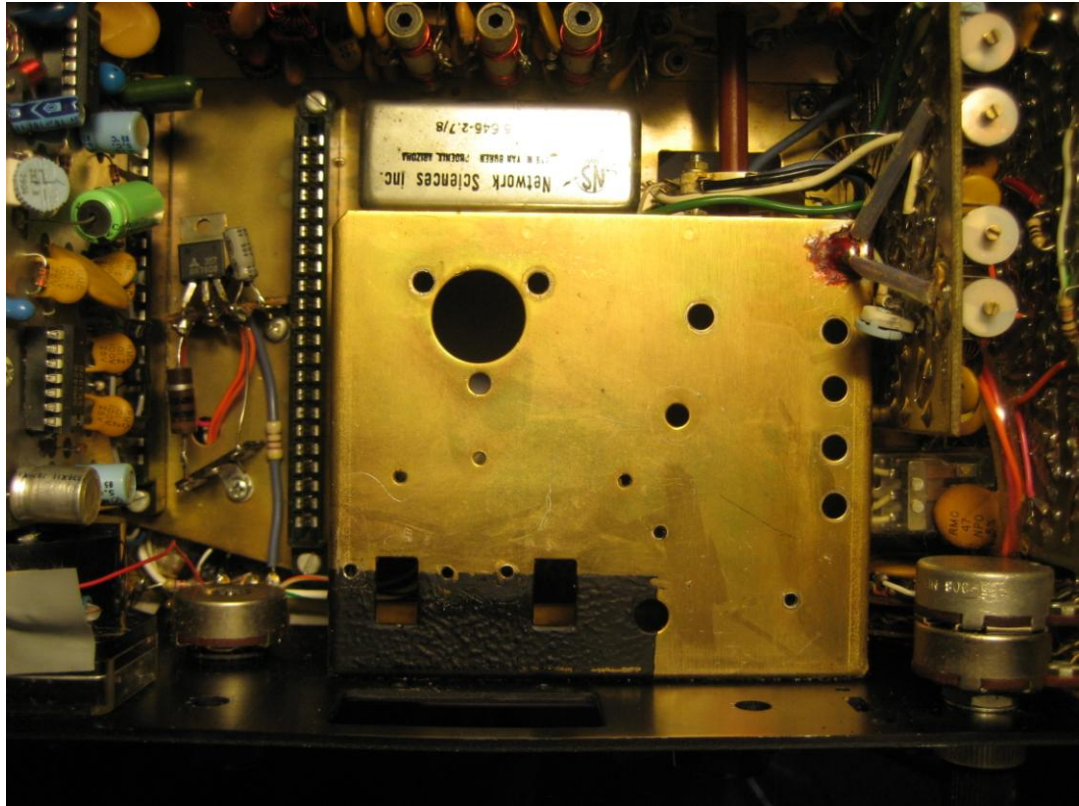
Remove the following parts:

- VFO tuning capacitor (two screws)
- two screws holding the VFO circuit board
- VFO circuit board
- 80M, 40M, 20M, 15M and 10M VFO piston capacitors (lock nuts)
- dial set pot (lock nut)
- terminal strip from the front panel (screw)
- RIT pot (lock nut)

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



Here is the top side of the VFO compartment:



V. **Build VFO Module**

Please refer to the Si570 Engineering Package doc for pictures of boards, enclosures, wire routing, etc.

The Si570 VFO board is installed in a Hammond 1590A die cast aluminum case. Here is a link to the technical specs for the case:

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

This case will be installed on the top-front of the existing 210X VFO enclosure.

Mark locations and drill the following holes in the case:

- 6 mm hole for chassis mount female SMA connector
- 2 mm hole for chassis mount DC power feed through capacitor
- Hole for machine screw that secures the voltage regulator heat sink to the case

Drill and tap the following holes in the case:

- 3 each 6-32 holes for mounting the Si570 circuit board
- 1 each 6-32 hole for attaching the voltage regulator heat sink to the enclosure

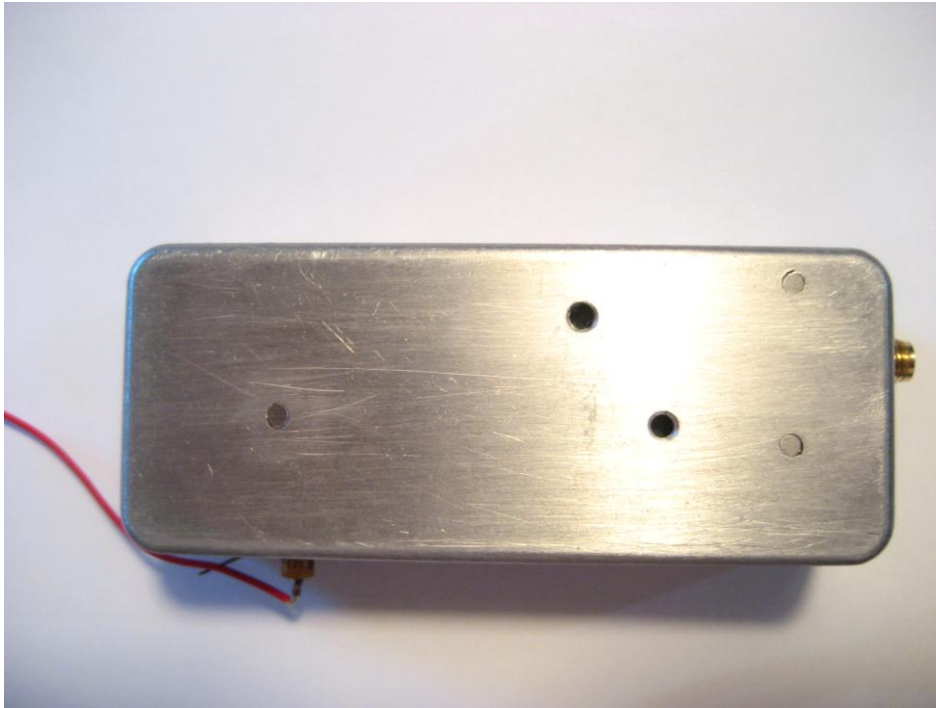
Here is a recommended process for accurately drilling the location of the holes. Fabricate the brass heat sink. The heat sink is optional. The two voltage regulators do not get hot. Attaching the two regulators to a heat sink provides better long term frequency stability.

- Drill holes for attaching the heat sink to the case
- Position circuit board in bottom of case and mark spots for drilling three holes

Drill and tap the three circuit board holes in the bottom of the case

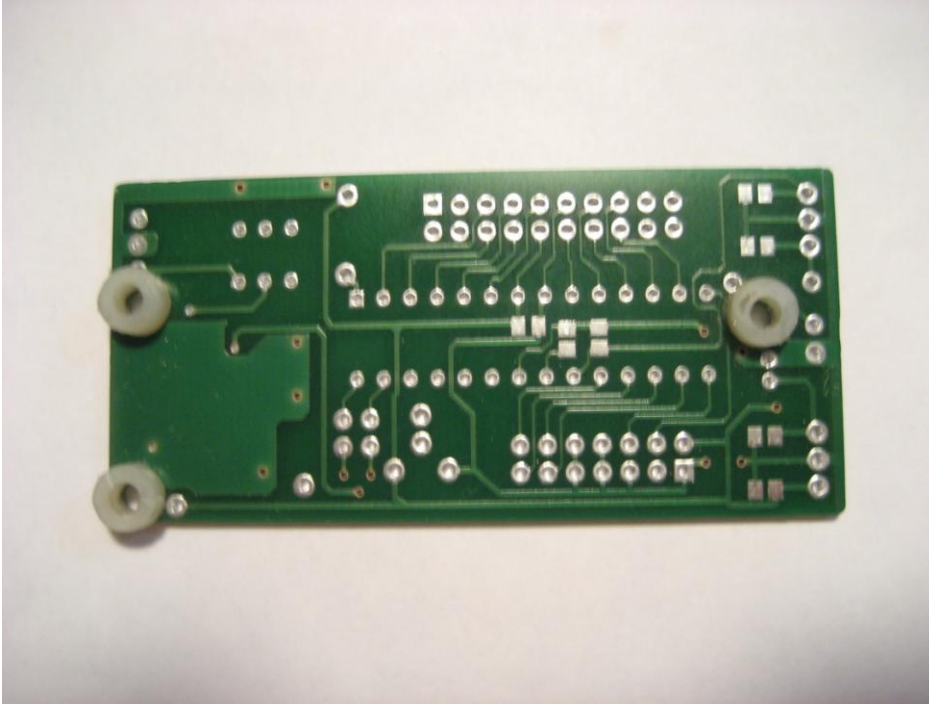
Drill the hole for the DC Power Feedthrough capacitor

Drill the hole for the chassis mount female SMA RF output connector. The hole will be located on the right hand side of the case, closest to the front panel, when viewing the radio from the top.



There are three mounting holes for the Si570 board. The stock holes will allow a 2-56 screw to pass through. The holes can be slightly enlarged so that a 6-32 machine screw can pass. Place the raw board inside the case and position it in one corner of the case, with the two locations for the voltage regulators next to the case wall. Mark the inside of the case with a positioning hole for the circuit board hole next to the two voltage regulators. Drill and tap this hole for a 2-56 machine screw. Mount the circuit board on the outside of the case and mark the locations of the other two mounting holes. Drill and tap these two holes for 2-56 machine screws.

Glue three each 3mm high nylon spacers to the bottom on the circuit board, at the location of each hole.



Assemble the Si570 circuit board. It takes about two hours for the assembly.

It is recommended that a 12" length of multi-colored ribbon cable be used for the interface cable (20 wires). This will make it easier to hook up the various controls and also makes it easier to trouble-shoot problems.

Install circuit board in case and mark positions on heat sink for the holes in the voltage regulator tabs

Drill and tap 2 each 6-32 holes for securing the tabs of the two voltage regulators to the heat sink

Apply thermal grease between heat sink and case

Attach heat sink to case with machine screw

Install circuit board in case and secure with three machine screws.

The ends of the three screws should be flush with the bottom of the case.

Apply thermal grease to tab on the LM7805 voltage regulator and attach to heat sink.

No tab insulator is needed

Install thermal insulator on the tab of the LF33ABV voltage regulator and attach to heat sink.

The tab needs to be insulated from the heat sink.

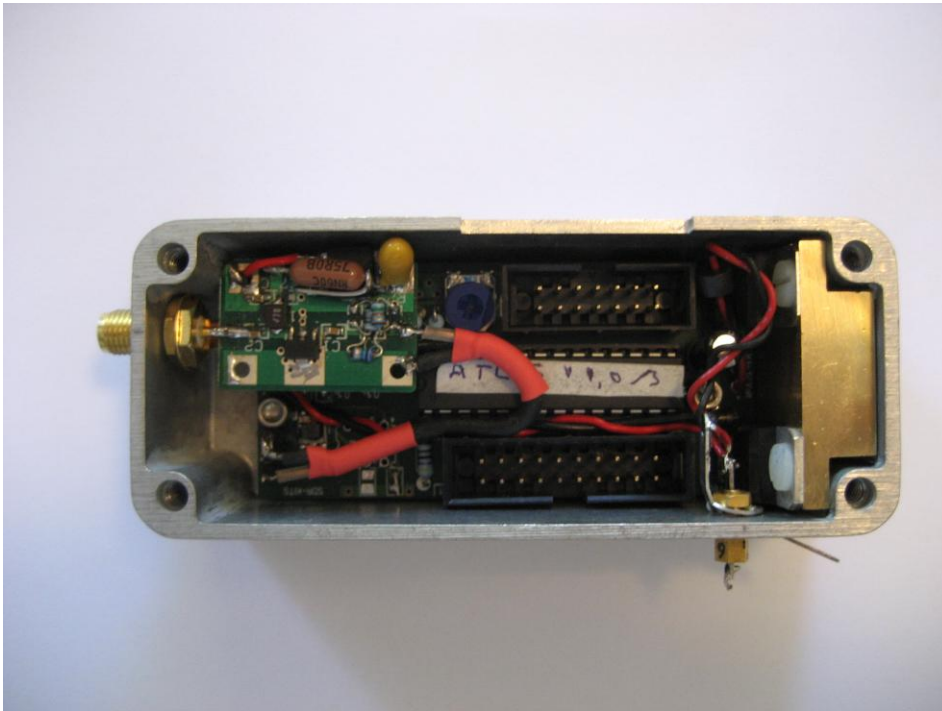
Install circuit board in case.

Install DC Power feedthrough capacitor

Install chassis mount SMA connector

The Si570 board will be mounted to the inside of the enclosure with three 3 mm nylon spacers and three 2-56 machine screws. The machine screws should not extend past the outside of the bottom of the case.

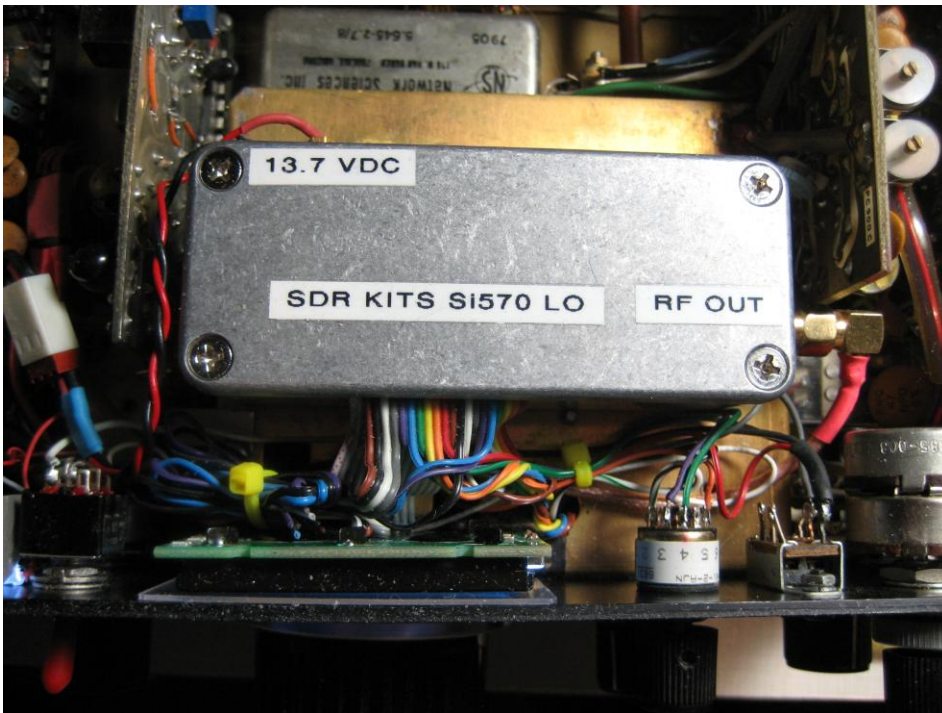
Completed VFO Module with 10 db MMIC amplifier



VI. Install VFO Module and Miscellaneous Parts

Please refer to the Si570 Engineering Package doc for pictures of boards, enclosures, wire routing, etc.

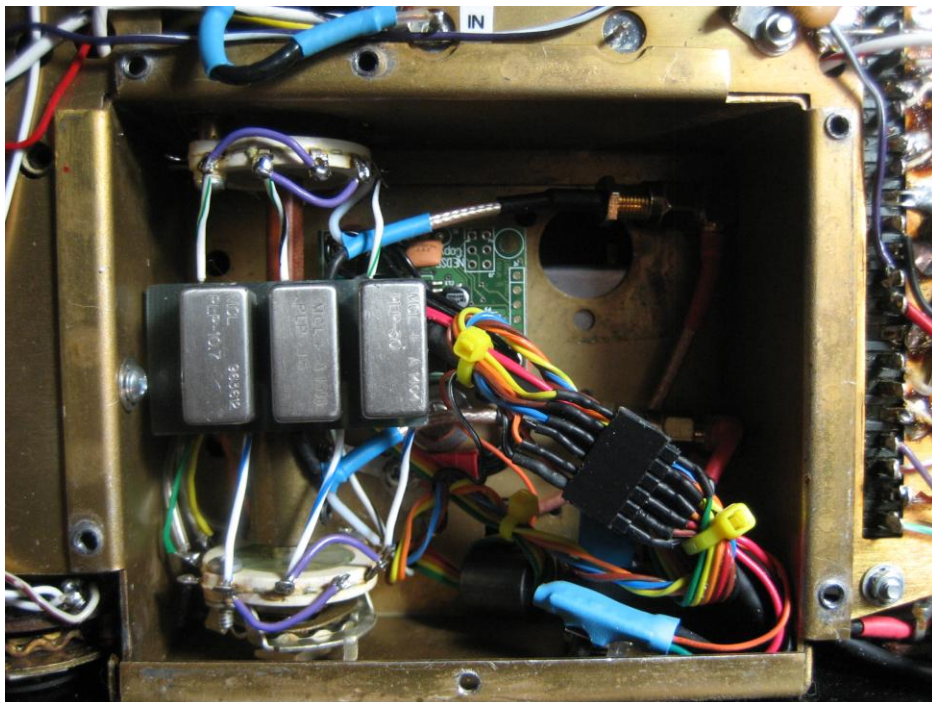
Install the Hammond VFO box on the top side of the VFO enclosure



Fabricate a brass mounting bar for the 12X2 or 8x2 LCD display
Mount the LCD display to the front panel of the radio.



Install the low pass filter board



Connect the 13.7 vDC power cable to the Hammond VFO box

Install the Mode select rotary switch and the Save/RIT toggle switch.

Connect the LCD ribbon cable to the Si570 circuit board

Connect the control ribbon cable to the Si570 circuit board

Connect the output of the VFO box to the input band-switch contacts

Connect the output of the bandswitch contacts to the existing Atlas VFO cable

Power up the radio

Verify proper display reading on the LCD display

Allow 4 hour warmup of the VFO. Calibrate the VFO

Confirm an ~ +10 dbm VFO output for each band

Confirm proper operation of the VFO B

Confirm proper operation of the Lock control

Confirm proper operation of the RIT control

Confirm proper operation of the Save function

VII. **Si570 VFO Front Panel Control Descriptions**

There are four controls on the front panel of the 210X/215X radio that are needed for the operation of the Si570 VFO. One control serves a dual purpose – control function for the Si570 VFO and control function for a BHI DSP module. The following descriptions references the controls on a 210X LE radio. A similar set of controls would be needed for a standard 210X/215X radio.

Dial Set: Factory Control

Potentiometer is changed to a three position ON-OFF-ON DPDT toggle switch with center as off, momentary up ON and down ON

Frequency Tuning: Factory Control

VFO dial vernier is replaced with either a mechanical or optical decoder with a SPST spring loaded switch that is turned on when the Frequency Control is pushed in.

RIT Frequency: Factory Control

The potentiometer is replaced with a multi-position, dual pole, rotary switch.

RIT Enable: Factory Control

Slide switch remains in place.

Initial One Time Setup

In the default mode, the output frequencies covers the bands of 80M to 10M. If pin 5 on the control cable is grounded, then the output frequencies will cover the bands of 160M to 15M.

In the default mode, the IF Shift is 5645 Khz. To get a 5520 Khz IF Shift, pin 6 on the control cable should be grounded.

IF Shift:

For the 80M and 40M bands, the IF Shift is positive,
For the 20M, 15M, and 10M bands, the IF Shift is negative.

VIII. Operation of VFO Front Panel Controls**Normal operation:**

Frequency tuning control changes the frequency of the VFO.
Frequency Tuning Momentary Push Button Switch
Short press button: Switchable between slow and fast tuning.
Longer push: The RIT is cleared.

Frequency Step Change:

In normal mode, the frequency increments are in 10 Hz steps. There will be a bar under the 10 Hz digit of the LCD display. To change to 500 Hz frequency step increments, briefly push and release the Frequency control knob. The bar will move under the Khz digit. To change back to a 10 Hz frequency increment, push in and release the Frequency control knob. The bar will move back under the 10 Hz digit on the display.

Frequency Lock

Move the Rotary Control from the Off to the Lock position
The frequency will be locked to the current display

Calibration Mode:

Attach a frequency counter to pin 4 of the PC-120 socket
Set band switch to 40 Meters. This puts the Si570 LO frequency in the 12 Mhz frequency range.
Set the tuning rate to the 10 Hz frequency increment
Slide the Calibration switch to the Calibrate position
Adjust the frequency tuning to the desired calibration factor, while monitoring the displayed frequency
Push in the Frequency Tuning Control knob and hold until you see the word "Stored"
Release the switch and return the Calibration switch to the OFF position

Enable DSP Noise Reduction

Set the rotary switch to the DSP position
Hold the DSP switch in the up position and listen for the beep tones.
Select the desired beep tone – 1 beep, 2 beeps, 2 beeps, etc. Release the switch
If you hold the switch up too long, you will go past the desired noise config and you will have to go all the way through all beep tones until you get back to the mode that you want.
Return the Rotary switch to the Off Position

Enable RIT

Enabling RIT affects the frequencies for transmit and receive.
Put the DSP/MEM/RIT toggle switch in the down position.
The Tuning knob now adjusts the RIT for the RX and TX modes. The display will show the amount of frequency offset down to 10 Hz. The main frequency display will change to reflect the amount off-set. The amount of available offset is 0 to +9.99 Khz and 0 to -9.99 Khz.

To disable RIT, place the DSP/MEM/RIT switch back to the Off position (center position)

Frequency Save

Set the frequency and tuning increment on each band to the desired values
The Rotary Control can be in any position other than DSP.

Hold the DSP/MEM/RIT switch in the up position for 4 seconds and then release switch.

All frequency and tuning rate info is saved and the values will be set after any power up

Restore to Default Configuration

Press in the Frequency Tuning control and apply DC power

Continue to hold in the Frequency Tuning Control until you see the word "Deleted" on the LCD display

All frequency calibration and memories are returned to their default values

Any configuration information previously applied will have been deleted and will need to be re-applied.

VFO B

Normally, the VFO operates in the A mode.

Moving the rotary switch to the VFO B position changes to a second VFO.

In the VFO B mode, all normal VFO functions are available with the exception of the Lock feature.

All VFO B frequencies on each band can be saved using the MEM Save function described earlier.

One use of VFO B is to program up specialized receive frequencies such as WWV. The receiver front end band pass filters are wide enough to receive WWV frequencies on the 80M, 40M, 20M and 15M band switch positions.

80M	5 MHz WWV
40M	10 MHz WWV
20M	15 MHz WWV
15M	20 MHz WWV