

A Guide to Operating, Troubleshooting and Repair of the SW-3B QRP Radio



Donald E. Koehler / KL7KN

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Foreword from the author:

Amateur radio, as a hobby, is growing worldwide. One thing I've noticed is that a significant number of these new hams have little to no background in radio/electronics. Many new hams have a license but no real *understanding* of how the technology works.

That is to say, a large number of folks entering this hobby have no clue on how to perform basic troubleshooting of or repair of the radios they use in enjoying the hobby. With wide spread use of SMT devices, most lack the equipment, let alone the skills to repair an ailing rig.

There are, however a great many things the average 'HAM' operator/hobbyist *can* do at home with minimal tools and equipment to effect repairs on a rig that is out of service. Repair of their rig can become problematic for a new or inexperienced operator. Even experienced hams will need at least some technical data and a parts list prior to attempting a repair.

Happily, Dale Yu, BA4TB published a schematic on the Internet to go with the SW-3B radio from the beginning, at release. The work you are reading now adds detailed circuit descriptions, troubleshooting steps and possible fixes, in addition to a Parts Breakdown for sourcing repair parts in North America.

I wrote this manual with the view of the new ham trying to fix what are the *most likely* problems with a dead radio, quite literally, on the kitchen table with very minimal equipment. The Manual covers the most common items that might need repair in the lifetime of the rig. I have included an expanded Operations manual at the beginning so all required technical information resides in a single document.

Don//KL7KN

Anchorage, Alaska.

About the Author:

Mr. Koehler first tested for and received his FCC Commercial Radiotelephone license with a RADAR endorsement in 1977. He received his Amateur Radio Service license on the next test cycle. This was back when FCC employees had to give the test in person.

After spending 22+ years as a Master Technician working on radio/electronics, maintaining a wide variety of communications equipment to the component level, Mr. Koehler went on to spend another 10 years working with telecommunication equipment as a technician, technical writer, quality manager and finally, a supervising manager.

He now works part-time as a technical writer for a local Corporation in the IT field. His published works include many articles in "73" Magazine, Site (later, Above Ground Level) Magazine and multiple other industry periodicals. He was also a Contributing Editor for Mobile Radio Technology magazine for a number of years.

He has a Bachelor of Science degree from the University of the State of New York, with multiple Associate degrees, to include an Associate of Science in Communications Technology.

In addition to HAM radio, he enjoys shortwave listening, sailing, hiking, camping and just being outdoors in Alaska. A prolific fiction writer, he has many full-length novels currently on the market under a pseudonym.

Table of Contents

A NOTE to the reader. This manual covers *two versions* of the SW3B. The current version of the radio set, CW-3B3/2020 and the earlier SW3/SW3B1.

The earlier model (3B1) has 4 large variable capacitors on the board [as seen here](#).

Operations Manual (expanded)

1. **How to Use this Guide**
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How do I???

How to use test equipment and run certain tests.

Basic Maintenance and Repair of the radio

- T1) Tune VC series for best signal (3B1)
- T2) Remove main circuit board from case to access both sides of system board
- T3) Install main circuit board back into case
- T4) Minimum checks before power up after maintenance
- T5) Replacement of DC feed protection diode
- T6) Replacement of Q3 (transmitter final)
- T7) Replacement of DDS rotary encoder
- T8) Replacement of Volume / RF Gain potentiometer

Illustrations

Data for system components

Hints, Tips, Kinks

Recommended items not supplied with radio set

Building a portable DC power system

A pair of schematics for the SW-3B is attached as an Annex to this document to allow the reader to use the 'zoom' function of most PDF readers.

This Guide focuses on the new amateur population providing simplified:

- Diagrams of important systems and sub-systems.
- Troubleshooting and maintenance steps that may be taken with minimal test equipment. I explain how to use the listed test equipment and how to build some of your own.
- A *How Do I* section of links to videos on line showing how to use test equipment and make tests.
- A *limited* parts listing for those items *most likely* to need replacement at some point in the life of the radio set. I'll explain *how* to replace those parts and hopefully allow you to get your rig up and running.
- I also provide at least one source (available at the time of this writing) and common part numbers to source the parts for yourself in the future.

Please note the list of parts; part numbers and parts source were current at the time this was written.

SW-3B Operating Instructions – modified.

This is an *expanded comments* version of the excellent manual provided by Dale.

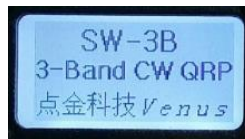


Warning: Before attempting to operate your SW-3B radio on air, *read through the entire manual*. Failing to adhere to prescribed setup and operating recommendations could result in permanent damage to your radio!

Initial power up

After connecting a known good antenna or dummy load, key or paddles, headphones and then finally connecting the power supply, turn the radio on via the on/off switch.

The initial splash screen displays:



Then, after system initialization, the screen displays the current settings:



(M) Memory number or **(V) VFO** (8 memory locations per band)

Operating Mode (CW/CWR/USB/LSB) (**CW Reverse** covered in detail later)

Supply Voltage (xx.x VDC). (Range 8 to 15 VDC)

Frequency (RX - 5-8MHz (40M), 8-11MHz (30M), 11-16MHz (20M)
TX 7.0-7.2MHz (40M), 10.1-10.15MHz (30M), 14.0 -14.35MHz (20M)

S meter display (relative)

Band in use (40M, 30M, 20M)

Setting frequency with VFO control:

- Turning the large VFO (**Tune**) knob *clockwise*, raises the displayed frequency.
- Turning the large VFO (**Tune**) knob *counter-clockwise*, lowers the displayed frequency.



VFO Tuning Steps: The VFO tuning steps are set / changed by pressing down *momentarily* on the **Tune** control. Press briefly to change tuning steps. (Observe location of triangle (**carat**) above digit) The tuning steps for the VFO are (R to L) 10Hz, 100Hz, 1KHz and 100KHz.

- **RIT Steps:** 10-Hz default (+ to – 9 KHz) (**R**eceiver **I**ncremental **T**uning)
- **XIT steps:** 100 Hz default (+ to – 30 KHz) (**X**(trans)mitter **I**ncremental **T**uning)

VFO Memories: 8 *per band*

VFO Display: LCD, switched backlight

VFO Display Frequency Resolution: 100-Hz, 10-Hz.

RT/MOD button:

Press button *momentarily* to activate RIT/XIT (offset) function.

Press/Hold button for 2 seconds to change operating Mode (CW/CWR/LSB/USB)

- **Operating Modes:** Transmit - A1 (CW) **only**, Receive - A1, (CW/CWR) A3J (LSB or USB)
AM reception is possible with careful tuning in USB/LSB mode.

T/R Switching: Fully QSK capable

Sidetone - ~600 Hz (fixed offset)

Band Switch:

Used to set for (1) 40 M / (2) 30M / (3) 20 Meter operation.

The switch is ganged, that is to say, the two switches are connected.

External Power Supply

Any 8 to 15 V DC power supply or battery may be connected to the radios coaxial power jack with the supplied co-axial cord. The sleeve (outside) of the power connector should be negative (-). Reverse-polarity protection at the main DC input is provided. *No* internal battery is offered or accommodated.

Antenna

Any resonant / well-matched (50 Ohm) antenna may be connected to the ANT jack BNC connector. An external antenna tuner is required for antennas that are not resonant at the selected frequency. The radio does **not** provide for any adjustments other than audio /RF gain and VFO. High SWR *will* damage the radio. Use care when tuning any antenna. I strongly suggest using a series of 'dits' to reduce the chance of damage to the final amplifier while tuning. See the manual for your antenna tuner for instructions on how to match an antenna to the SW-3B radio set.

Headphones

A stereo headset can be connected to the PHONE jack. Impedance should be 8-32 Ohms. A *stereo* connector **must** be used. A MONO headphone plug will **SHORT** the output! Alternatively, you may use a mini stereo amplified speaker. While 8-32 ohms is recommended, a 4 ohm stereo speaker will work – just barely.

I also recommend a set if earphones with a 90° connector to reduce strain to the jack.

Key/Paddle

If using a stereo plug for a **straight key**, both ring and sleeve must be connected together for use. A monaural plug may also be used with a straight key. The radio is set to detect the type of key used. With paddles and a stereo plug, the internal keyer is automatically enabled on power up and annunciated with the Morse letter "A".



3.5mm stereo plug

TIP. Connects to DOT paddle or one side of straight key contact

RING. Connects to DASH paddle or straight key ground

SLEEVE. Connects to paddle or straight key ground

Key Operation

When power is applied with a paddle connected or **no** key is present, the letter "A" will be heard in the headphones upon power up. The letter "M" is heard if a straight key is connected on power up. Connect the key *prior to power up* to ensure the radio senses the type of key in use.

AF GAIN

Used to set volume of received signal. Turn control clockwise to increase volume. Exercise caution if using "earbuds".

RF GAIN

Provides variable attenuation of incoming (RF) signal to the first mixer. Useful in noisy band conditions.

M/V/SAV Button

Pressing this button alternates the display between Memory mode (**M**) and VFO (**V**) mode. The display will show M-# or V-#. # represents the numbers 1 thru 8.

In **Memory** mode, the Tune knob is used to change memory locations.

In **VFO** Mode, the Tune knob is used to change the displayed frequency.

Pressing and then *holding* the **M/V/SAV** key for more than two seconds will display **SAVE** and the current frequency and mode will be stored in the memory # location displayed.

- **Transmit Error:** If the transmitter is keyed while the VFO is tuned outside the amateur band, the display shows [**ERROR**] and transmission is blocked.



- **TIP** - Setting the radio to an out of band frequency will allow the operator to practice sending with a new key or set of paddles. This is also a good time to set keyer speed and input your callsign.

Power Switch

Used to turn radio set on and off. Located after the reverse-protection diode.

RT/MOD button

RIT / XIT use:

Press the **RT/MOD** button *briefly* to enter the RIT/XIT (offset) function.

- To switch *between* RIT and XIT, *momentarily* press down on the **Tune** (VFO) knob.
- Moving the VFO knob changes the *amount* of offset in both RIT and XIT.
 - Turning the VFO knob *clockwise*, increases the offset,
turning the VFO knob *anticlockwise* decreases the offset.

The function, when active, shows on the screen on the right side of the top display line.

This also shows the *direction* of offset (+ or -) from the displayed VFO frequency and the *amount* of offset. The carrot (triangle) indicates *steps* selected for offset tuning. RIT changes will be in 10 Hz/step and XIT changes will be in 100 Hz/step.



In this example,

- The receiver is 50 Hz above the displayed frequency. (RIT is active)
- The transmitter is 530 Hz above the displayed frequency. (XIT is active)



Press the **RT/MOD** button *momentarily* to **exit** the RIT/XIT function

- If the RIT/XIT function is **not** active, the top line displays the mode and voltage.

CW Keyer

- **Changing Speed:**

Press and hold **Call** button for approximately two seconds, until the letter "S" is heard, then release.

Within FIVE seconds, press the DOT paddle to increase the keyer speed, or the DASH to decrease.

When done, press Call briefly to exit.

- The letter "E" is heard.
- After 8 seconds and **no** Call button press, the default is to **Exit**.

Entering Your Callsign:

Press and hold **Call** button until the letter "S" is heard, *continue to hold* **Call** button until you hear the letter "I", then release the button.

Send your callsign with the paddles as usual. When complete, press **Call** briefly to exit. (The letter "E" will be heard.) Otherwise, automatic exit will occur after 8 seconds.

Automatic CQ

Press **Call** button momentarily to send "CQ CQ DE (your callsign 2x) K" To *cancel* the CQ, press and *hold* **Call** button for 1 second. To test your entry, set the VFO *outside* of the ham bands, then press **Call**. The callsign and CQ will be heard, but the transmitter is inhibited.

LED

The red LED located between the BAND switches will flash when transmitting to provide positive indication of transmission.

BACKLIGHT setting:

Momentary press **both** the **RT/MOD** and **S/V/SAV** buttons at the same time to set Backlight operation. The **Tune** (VFO) knob is used to select Backlight mode. You may choose ON, OFF or AUTO. Auto will light the display for a few seconds when any control is moved. Leaving the backlight off or in AUTO mode *reduces* current consumption by ~6 mA (15% or so) and extends battery life.



About CWR or CW Reverse.

Switching between CW and CWR provides the experienced operator a tool to deal with QRN/QRM or a strong station on almost the same frequency as in use. Normally found on more expensive radios, this function allows the operator to 'flip' the BFO and possibly push an offending signal outside of the filter passband.

See the circuit description section for more detail.

NOTE – The radio set SW3B will transmit on the same frequency in CW or CWR. The unit will also transmit in USB mode, about 700Hz above the displayed frequency. The unit will transmit in LSB mode, about 600 below displayed frequency. This was tested on 30M setting.

End Operation Instructions

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1.0 How to Use this Guide for Maintenance and Troubleshooting:

As you examine the Table of Contents, you will see the radio set broken down into several basic sub-systems. Each of these sub-systems must work properly for the whole to perform. The order of the sub-systems is specific by design. Each section builds on the one before.

Please, READ the radio overview and the *entire* Concept of Operations sections before you attempt *any* of the troubleshooting steps. A basic understanding of each of the sub-systems is essential to be able to perform the troubleshooting steps that follow. Most sub-system sections will have either a portion of the schematic or block diagram as part of the description.

Any test points used in troubleshooting are identified in a linked illustration. A photo really is worth a thousand words, or nearly so... These photos **are linked** in the text for testing/repair to save space and reduce confusion. The images included may be *zoomed* (CTRL and +) to 400% or more and still be readable. To return to the test step, use the Back button on your reader.

The troubleshooting steps are separate from the sub-system description. Again, this is to avoid any possible confusion. Each of the troubleshooting steps builds on the prior step. In other words, you must ensure the DC power system is operating properly before you can tackle an issue, say, with the transmitter.

The information in this guide was obtained by direct observation and measurements on a working, current production SW-3B (CW-3B3/2020) board).

My sincere thanks to Dale Yu, BA4TB, for his generous support that was key in getting this manual written.

Finally, if you cannot resolve a problem with your radio, you can always ask for help on any of the amateur forums.

Good luck!

73s

Don // KL7KN

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Recommended tools & test equipment:

You will need some *minimum test equipment* to perform any troubleshooting on the SW-3B multi-band HF radio set. These are:

Multimeter. Sometimes called a V-O-M for a Volt, Ohm, Milliammeter. This is an 'analog' instrument – it has a meter. You may also see meters called a DMM, for Digital MultiMeter. This unit is used to measure voltage at several points within the radio set. I've made measurements listed with both a VOM and DDM. Any differences because of the meter type are identified.

The meter used must be a *quality* unit, with a listed input impedance of *at least* 20K ohms/volt, with 1M ohm/volt preferred. A quality DDM may be found new at a cost of under \$50 USD and can be used for other tasks, such as checking fuses or confirming power is present at a connector.

- Test leads for your meter should have a **sharp point** to allow measurement at a specific pin on a small SMD device without shorting across to any other pin.
- The test leads should have a way to clip at least one lead to the chassis ground.
- The test leads should be color-coded, usually red and black, to indicate polarity.

Resistive Dummy Load. Used to terminate the transmitter chain, this will both prevent damage from transmitting into an unterminated connector and allow a way to determine output power. If you don't have one, look at the end of the maintenance section. I show later you there how to build a suitable dummy load for a few dollars.

Wattmeter and Dummy load. A nice kit is available from Pacific Antennas and Kits for under \$20. This dummy load also allows use of your DMM to read power out. (See www.qrpkits.com). At some point, as an active Amateur operator, you will want to have some kind of working watt meter.

Signal tracer or Oscilloscope. I've been building or repairing radios since 1970 and I still don't have one of these at home for shack use. What to do? I use a small (portable) *general coverage receiver* equipped **with a BFO**, specifically an ATS-909. Most tests with the radio are just to see if a signal is present or not. In newer digital radios, generally something either works or it doesn't. If I can hear something on the tracer radio, I can keep going. If you have a main station rig, it is perfect for this use as well.

Signal Generator. While nice to have, there are alternatives for a new ham: A low-cost antenna analyzer, such as the MFJ 207, can serve as a signal source. There are multiple "DDS kits" to be found on line that may be used as a basic signal generator. One such kit is the N3ZI kit – <http://www.pongrance.com/super-dds.html> - about \$89 USD.

If you have another HF rig, feed it into a dummy load at low power, and then use it as a signal source.

Used commercial equipment may be found from time to time, but maintenance, manuals and ongoing calibration can be problematic for the amateur radio operator. Finally, a wire antenna can provide a small, broadband signal for use in very basic troubleshooting.

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Hand tools:

Screwdrivers (small and very small). Since the radio set SW-3B is tiny, your screwdrivers are going to be typically called a "Jeweler's screwdriver set" or the like. The internal adjustments available are very small.

Small needle nosed pliers. The kind with a wire cutter are nice to have.

Adjustable wrench (spanner). It is used to remove the BNC connector from the end-chassis plate, an unlikely occurrence.

Non-metallic tuning tools, both 1/8 Hex head and small screwdriver type.

An ESD- safe soldering iron and ESD-safe work surface.

-An ESD-safe soldering iron will be marked as such and on low-cost units is usually distinguished by a 3 prong AC connector. If you plan on attempting your own repairs as a matter of course, investing in a better grade unit, often called a soldering "station", is a worthwhile investment.

-I use a roll-up ESD safe pad to work on. This pad has a snap connection for my wrist-strap so I and the work surface, stay at the same potential. You may be tempted to skip this expense, please don't. Cost is only about \$30 USD for a nice unit.

Solder pump and soldering wick. You will need these to be able to remove any installed active devices. I have a spring powered solder pump that is nice for fast work. Wicking works as well, it's just not as fast.

Solder pump – an under \$4 USD example is from New Egg. They call it a "Solder Sucker Desoldering Pump Vacuum Soldering Iron 19cm Repairing Tool". Wow.

Solder wicking may be found on-line at Mouser Electronics or DigiKey. Get the Static Dissipative (SD) rated wicking. It's sold by the roll. *Get a couple...*

Magnifying lenses – you *will* need them. A headband unit with dual lenses allows working hands-free. Pick whatever will work for you, but you will need to be able to clearly see the pins on an installed SMD device to check the supply voltage, if nothing else.

Safety glasses for soldering! No joke, get 'em, wear 'em! *Save your eyesight...*

For testing, a 50 ohm dummy load may be made with a pair of 100 ohm, 2 watt composite resistors soldered in parallel and a BNC panel mount. BNC male to male adapter allows use on this radio.



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2.0 Warnings page

This radio contains Electro-Static Sensitive Devices (**ESD**). Use an appropriate conductive/grounded work surface when performing repairs.

If you will be soldering anything on this radio, use of an ESD – safe rated soldering iron with proper grounding is *a must have*.

- These kinds of iron may be found on-line, offered by multiple Vendors.

Use a personal ESD grounding device for yourself before beginning work on the radio.

Perform soldering only in a well-ventilated area!

ALWAYS wear eye protection when soldering! The eyes you save will be your own.

DO NOT key the radio without connection to an antenna, dummy load or into a high SWR load – *you will damage transmitter components*.

If using an external tuner, avoid extended key down times when making adjustments.

While the DC input is diode protected, use a fuse – 2 amp – inline on the DC input cable is strongly recommended..

Before any power on tests are made, ensure you have a set of phones and a dummy load attached to the radio or main board **before** applying power.

I STRONGLY suggest that operators remove the DC supply and antenna connections when the radio is not in active use.

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3.0 Basic radio overview / Concept of Operations

3.1 Radio Overview

The radio set SW-3B is a lightweight, rugged, miniature, single-conversion transceiver that operates (transmits) on three Internationally allocated high frequency bands within the Amateur Radio Service. It may be powered with any stable DC source between 8 and 15 VDC.

Power consumption is minimal. With the backlight on (display illuminated), the radio draws ~43 mA. With backlight off, it draws only ~37 mA (@13.8 VDC). Actual current used will vary slightly based on input voltage.

The radio set SW-3B also offers broadband reception from 5 to 16 MHz in the so-called shortwave bands. This broadband feature also allows reception of WWV on 5, 10 and 15 MHz for frequency check, time and weather reports. Reception of International Shortwave Broadcasts using USB mode is possible with careful tuning.

The unit is all digital. The VFO control provides for tuning in 10 Hz, 100 Hz, 1 kHz, 100 kHz increments. The RIT/XIT function permits receiver offset tuning in 10 Hz increments and transmitter offset tuning in 100 Hz increments.

In addition to manual tuning via the rotary encoder, eight memories *per band* are provided to store frequency/mode. Changing between stored Memory and the VFO is by a pushbutton. Changing between Memory locations is via the Tune (VFO) knob. A slide switch is used to change between bands.

Placement of the operator controls and connectors only on the *sides* of the chassis clearly puts this radio in the class generally known as *Trail Friendly*. With both the top and bottom of the chassis free of control ports, you may place the radio set upright, on a stand or tilt the radio set for the best viewing angle and not impact any connections. While seemingly a minor detail, this flexibility is a nice touch for operating in the field.

The high-contrast digital display is large enough to easily read in bright sunlight and it has a backlight for viewing at night. The backlight may be turned off during daylight operations for a ~15+% saving in current draw on receive. The backlight may be set to *on*, *off* or *AUTO*. In *AUTO* mode, the unit will light the display for 10 seconds on any command input, such as adjusting the VFO. After 10 seconds with no operator input, the display backlight will extinguish.

The receiver is single conversion, with a crystal ladder filter to reduce noise and adjacent signal interference. The Beat Frequency Oscillator (BFO) operates at 4.914 MHz. The BFO injection signal to the second mixer signal is provided directly by the Si5351 DDS source. Very clever and ensures the BFO signal tracks the VFO exactly..

The filter may be set for *narrow* (CW/CWR) and *wide* (USB/LSB). This bandwidth change is controlled by a simple pushbutton and is automatic, depending on the mode selected. Receiver performance is impressive, with Minimum Discernable Signal (MDS) levels of 0.1 to 0.2 microvolts (-127 dBm @ 50 ohms) typical.

The transmitter is a classic Master Oscillator/Power Amplifier (MOPA) type fed directly by the DDS system. The transmitted signal passes through several filters to reduce harmonic content in the output.

The transmitter final amplifier (PA), is a robust IFR510 MOSFET (or in earlier radios, an 2SC2078) transistor (Q3). The PA is protected from high VSWR by a Zener diode, type 1N4756A in the earlier models. The antenna is attached via a BNC connector mounted on side of the unit.

The internal keyer supports iambic keying via a set of operator-supplied paddles. Use of a straight key is supported as well. (See operation manual for more on keys). A keyer memory allows automated calling of CQ w/Operator callsign at the push of a button.

Operating on a DC input between 8 and 15 Volts DC, the radio transmits with a nominal power of five watts output with 12.8 DCV applied. The power input is protected against reverse polarity. External power supplies should be able to provide up to 2 amperes of current with no AC ripple. A simple battery pack made up of eight "AA" (or 10 NiMH) batteries provides ample power.

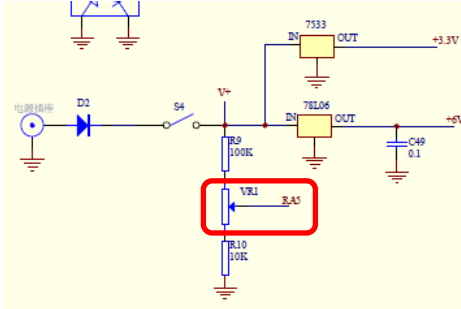
Please note that the unit transmitted power output drops off with lower input (supply) voltage.

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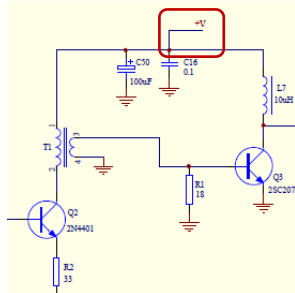
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3.2 DC power busses and protection:

The SW-3B uses three voltages to operate. These are: DC input voltage; +6 VDC regulated via an a 78L06, a 3 lead device and +3.3 VDC regulated via a 7533, also a 3 lead device.



One power buss is unregulated, the DC input. The applied DC voltage is measured in the PIC controller off of this buss at PIN RA5. The displayed voltage reading may be adjusted via VR1. This buss feeds the transmitter PA section (Q2/Q3).

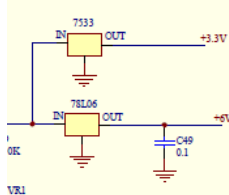


So, a higher input voltage means *more power out* and lower input voltage *reduces* the power out. The rated RF output power is easily obtained at 12.8VDC. While the radio will operate below 8 VDC input, this is **not** a recommended practice.

DO NOT exceed the 15 VDC limit on DC input power.
Operation above this voltage *will* damage the unit.

3.3 DC Voltage regulation:

The two additional power busses present are regulated. One buss is regulated for +3.3 Volts DC and the other is regulated for +6 Volts DC.

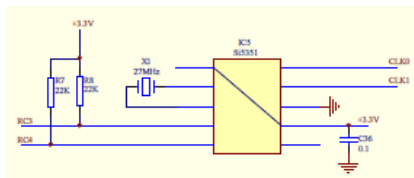


Regulation for each of the DC busses is provided by a small (SMD) solid state regulator device. These three lead devices are robust and provide excellent regulation as power varies in situations with marginal batteries, such as on extended transmit.

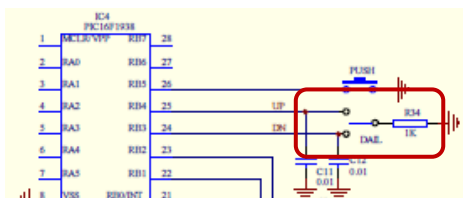
A potentiometer, labeled as "VR1" may be used to make an adjustment, as described later, for displayed voltage and is found on the main board. ([See Illustration](#))

3.4 DDS VFO sub-system

The **D**irect **D**igital **S**ynthesis (DDS) sub-system of the SW-3B is based the popular Silicon Labs Si5351 chip. The Si5351 is a low power, DDS device capable of producing two outputs, CLK0/CLK1 using the installed 27MHz crystal (X1) as the reference oscillator.



The DDS output is determined by the MCU per the rotary encoder inputs.



With the clock source provided, the DDS chip has an output resolution *better than 10 Hz*. The DDS system is controlled by the PIC (IC4) chip using a I2C (two wire) interface. The system provides a stable, accurate signal.

There is a calibration procedure available/provided for the DDS system. This procedure is covered in detail later, in the Maintenance section.

Output of the DDS system ranges from a low of 9.914 MHz to a high end of 20.0914 MHz. (5 Mhz – 16 Mhz RX) The output of this subsystem is buffered to eliminate loading.

On **transmit**; the DDS system output frequency is identical to the displayed VFO value (+ or – any XIT setting) . The DDS system output is fed to Q1 as CLK0 from the Si55351 chip.

On **receive**; the DDS output frequency is VFO value **plus** 4.914 MHz (Mode/Band independent but **+** or **-** any RIT setting) from the displayed VFO value. This BFO injection signal, 4.915 MHz, feeds the second mixer (NE602) as CLK1. This offset matches the first conversion scheme to allow the crystal filter to function.

The Si5351 is controlled via a 2 line serial interface from the PIC 16F1938 Master Control Unit (MCU). I don't have a way to read the embedded MCU code, and if I did, I still wouldn't put the code in this manual.

Currently, the manufacturer does not offer a replacement MCU chip. Specialized tools are required for any SMT device replacement, so this isn't a topic covered in this manual.

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Frequency chart for DDS system for selected frequencies

Band & test freq CLK0	Transmit VFO setting	DDS output
40 Meters 7.100 MHz	7.100 MHz	7.100 MHz
30 Meters 10.100 MHz	10.100	10.100 MHz
20 Meters 14.100 MHz	14.100	14.100 MHz
Band & test freq CLk0	Receive VFO setting	DDS output
40 Meters 7.100 MHz	7.100 MHz	12.015 MHz
30 Meters 10.100 MHz	10.100	15.015 MHz
20 Meters 14.100 MHz	14.100	19.015 MHz

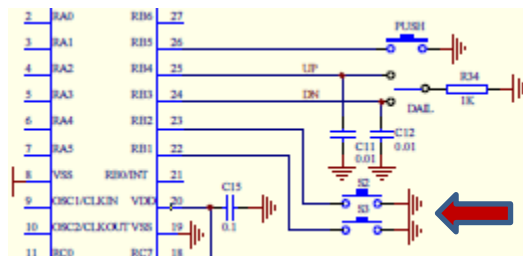
NOTE – BFO signal is provided by the Si5351 (CLK1) at 4.915 MHz. NOT Band or Mode dependent.

NOTE – Center frequency of crystal filter is nominally 4.915 MHz.

3.5 PIC control of the Si5351 DDS system

The DDS chip is controlled by two lines from the PIC controller, PIN 14 and 15. These lines feed in the Si5153 chip on PIN 4 and 5 (RC3/RC4) respectfully.

The PIC controller senses VFO changes via rotary switch (Dial). The selection(s) tie back to the PIC controller, inputs RB3/RB4. PUSH is the button on the rotary switch. Switches **S2/S3** are used for RT/MOD and M/V/SAV. Pressed together they control the backlight function, if pressed together at power up, they will cause the radio to boot into calibration mode.



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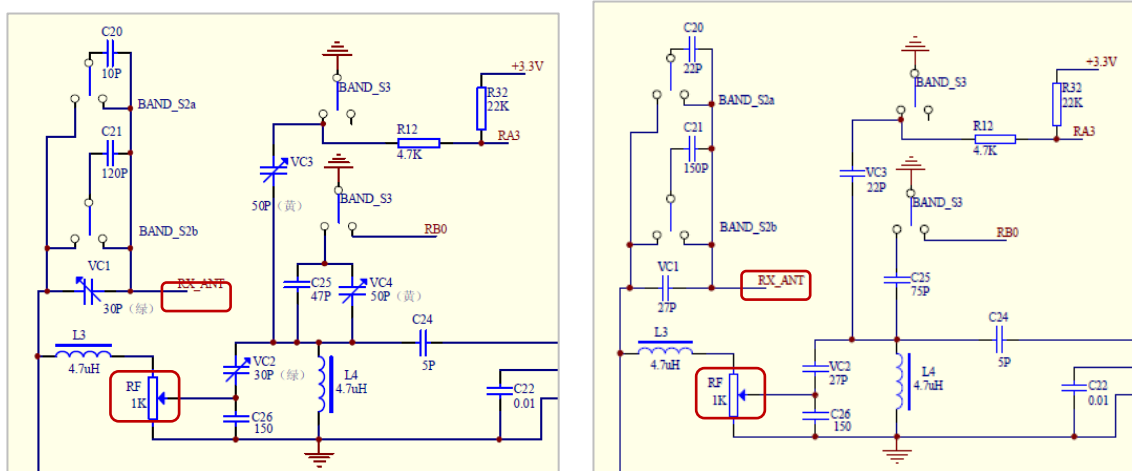
continue

3.6 Receiver

- Signal path.

The desired signal enters the antenna and enters the receiver via the BNC connector. The signal then enters the LC network (L1, L2, C4 thru C9) where it is tapped off to go into one side of VC1 and S2 (a and b).

(NOTE 1 – in current production board (CW-3B3/2020) VC 1 through VC4 are now fixed capacitors. Earlier board versions have variable capacitors.)



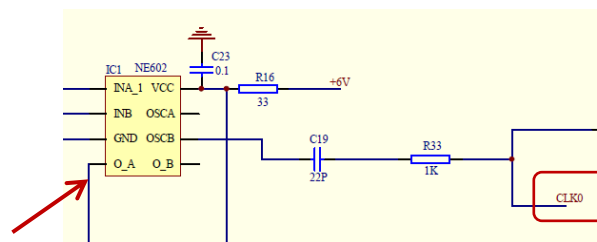
Band switch (Band_S2 and -S3) not only switches input filter components, it provides desired band information (selection) to the MCU via RA3 and RB0 by providing a HI/LOW to the identified lines.

This input point at VC1 is another bandpass filter network that consists of VC1, C20/C21 and L3. From the one side of L3, the signal is attenuated by a 1K potentiometer **RF** (RF Gain). From there, it enters another band pass filter (L4, C26 and VC2, 3 and 4). VC1, 2, 3 and 4 in older units permit peaking of the signal at the desired point of the band selected. **(NOTE2** – Adjustment not required on CW-3B3/2020 Version boards)

Note that Q5 (BAV99) is part of the T/R switching arrangement.

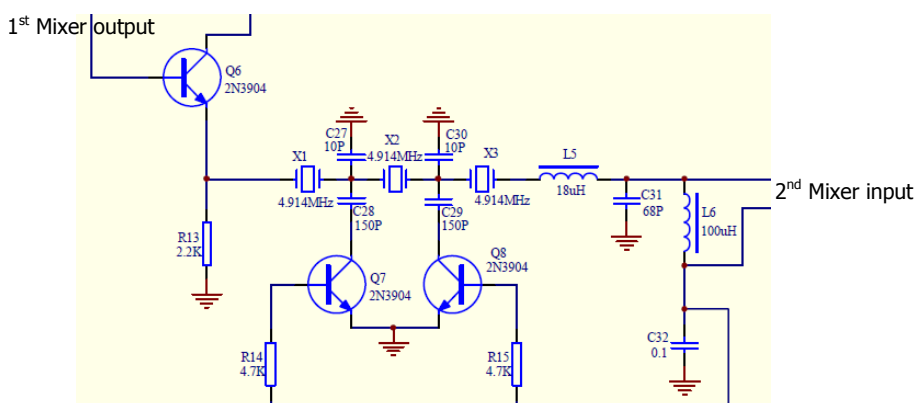
Leaving the Bandpass filters, the signal enters IC 1, the first of two NE602A mixers via C24 (5pf) . There, the incoming RF is mixed with a signal from the DDS sub-system, **CLK0**, input at OSCB. This is set by and the VFO control (+ or – RIT settings). (see [Chart](#) for DDS injection frequency)

The output of the NE602, O_A, now contains the two original signals (RF and DDS) **plus** the sum and difference of the two signals.



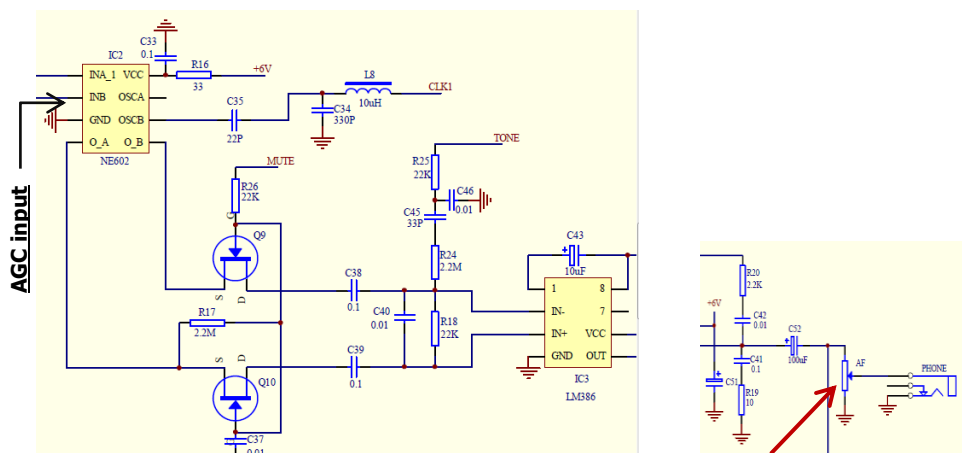
This is the *Intermediate Frequency* or IF. This complex output feeds through a buffer amplifier Q6 into the ladder filter, a matched set of three crystals. The crystals in the filter are marked as 4.9152 MHz.

The ladder filter, acting as a high-Q, series resonant circuit, then feeds the signal into L5/C31 and then on into IC2, the second NE602 mixer. This filtered signal (IF) is mixed with the BFO signal from the DDS sub-system. This BFO injection frequency is set by the MCU and is always 4.915 MHz.

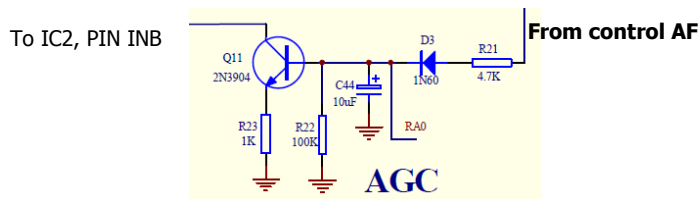


I'll note here this schema provides a very stable BFO injection frequency as it "tracks" *exactly* the VFO frequency. The VFO and BFO signals are both derived from the same source. In other rigs, the BFO is often an independent crystal oscillator that cannot exactly track with minor variations in the VFO output due to temp etc. The schema used here ensures the desired RX signal stays centered in the crystal ladder filter passband. A happy side benefit, CWR as a mode and a reduced parts count.

Again, the output of the second mixer has both original signals *plus* the sum and difference of the mixer input. One of those output products is the recovered audio (AF) or CW note from the signal that entered at the beginning. This goes to the LM386. This is a fixed gain audio amplifier, fed via Q9/Q10, a set of Unijunction transistors that serve as a fast audio switch for muting.



The amplified audio output then enters the Volume Control potentiometer **AF** and on to the Phone output jack.



The takeoff from one side of the volume potentiometer feeds into Q11 via diode D3 (1N60). This 'DC' voltage is fed into IC2, PIN INB – the second mixer, as part of the audio-derived AGC system.

The transmit side-tone is fed into the LM386 while the RX signal is muted by Q9/Q10. The sidetone comes from IC6 (12F629) the keyer sub-system. There is no adjustment for sidetone volume, other than the AF control.

This double mixer scheme, with crystal filter, is also seen in many other QRP radios and is vastly superior to the simple Direct Conversion (DC) receivers of an earlier age.

This circuit architecture allows filtering of unwanted noise and out-of-band signals, such as shortwave broadcasters. It is also inherently a low-noise system.

By changing the BFO injection frequency slightly via the CW/CWR choice, it is possible to move an interfering signal outside of the filter passband for removal. This function is possible due to the DDS subsystem providing the BFO injection signal.

Changing the MODE (USB/LSB) switches Q7/Q8, which alters the filter passband as noted earlier.

Finally, the experienced operator will quickly see the XIT offset function, up to 30 Khz, can be used for so-called split operation where warranted or required.

Discussion on receiver and filtering scheme:

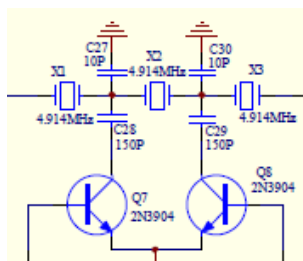
The DDS system, **in receive**, feeds the first mixer a signal that is offset from the desired (displayed) frequency.

This offset is nominally $\sim 600\text{Hz} + 4.914\text{ MHz}$ for CW/CWR by default. The DDS signal and the received signal are mixed in the NE602. The BFO offset is not changed for LSB/USB, the filter bandwidth is changed.

Since the crystals in the ladder filter act as a narrow passband filter, the desired signal is present at the output of the filter, L5.

The crystals act as a series resonant circuit and are much smaller the equivalent capacitor, coil and resistor of such a complex circuit.

The Q or bandwidth of the ladder filter is changed by use of a set of 'shunt' or swamping capacitors – C27/C28/C29/C30 controlled by Q7/Q8. The bandwidth is changed by these capacitors as the transistors are switched by the MCU when selecting CW/CWR or USB/LSB. This B/W change is triggered by the MCU via the state (HI/LOW) of the RA1 line .



Why does this matter? In the test equipment section, I stated I use a portable general coverage radio, an ATS 909 to be exact, as a signal tracer. With the BFO active in the ATS909, the DDS, BFO and mixer products can be heard as a tone on the radio. Since the portable radio used is fairly accurate, I can quickly see if the DDS system is working and on frequency, the filter has an output and the BFO system is working and on frequency by setting the radio to listen for the expected signal.

The DDS sub-system has a [Chart of frequencies](#) for the DDS chip in both transmit and receive states. This data is also used in the troubleshooting section.

For the receiver to work correctly, the BFO must be offset correctly to maximize the receiver performance. Since the BFO injection signal is produced by the Si5351 *as a programmed offset*, no BFO adjustment is possible – or ever required. The BFO signal will track exactly the VFO signal. The value set for RIT doesn't matter, the BFO injection frequency offset is a fixed value 4.915 MHz.

3.6.3 Audio switching, muting and side-tone:

Unlike many of the contemporary QRP radios on the market, the radio set SW-3B does **not** use relays for band-switching, muting or side-tone. It is also one of the few that offers a real, audio derived AGC function. Automatic Gain Control or AGC is what moderates the signals of nearby strong stations as you are working a station.

For the savvy operator this is an important distinction. Electromechanical devices, such as relays, are a prime failure point on many radios.

When the radio is keyed, the keyer chip, IC6, performs several functions.

IC6, Pin 7 changes state. Pin 7 is connected to the MCU, RB1 line. This state change indicates to the MCU that the radio has been keyed. The same line connects to Q12, which switches and provides the MUTE trigger to Q9/Q10.

This, in turn, causes the second mixer output to the LM386 audio amp to drop off. IC6, Pin 6 produces the sidetone, which feeds into the fixed gain LM386 via C45.

The keyer chip also changes state on Pin 5. The line, tied to Q1, a 2N3904, a switching transistor, which enables the transmitter chain. This allows the VFO signal (CLK0) to reach Q2, a 2N 4401, the driver amplifier for the transmitter power amplifier Q3.

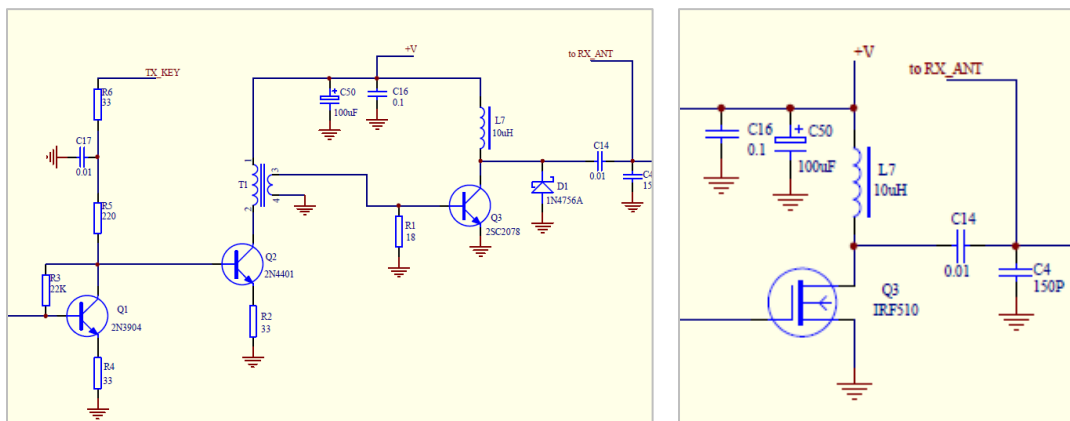
S1, a momentary pushbutton, is the CALL switch.

Finally, Q9/Q10 switch quickly enough to avoid the annoying 'thump' often heard on other QRP radios when switching from receive to transmit and back. This pair also switches fast enough to allow full QSk operation, a nice touch.

3.7 Transmitter

Signal path and SWR protection for final amplifier.

As mentioned earlier, the transmitter is a simple MOPA type. The signal from the DDS sub-system, CLK0, is fed into Q1, a switching transistor. This signal then goes to Q2, an emitter-follower amplifier, which drives Q3, the power amplifier.



NOTE – the newer CW-3B3/2020 layout is in the right iside.

T1 is the large toroidal transformer and is used to match the impedance of the base of Q3. The PA is powered by the DC input voltage, via L7/C50. Transmitter output power is directly related to the DC input voltage. To reduce power, you will need to reduce the input voltage; there are no other means to control power output.

The transmitter signal then enters a passband filter, L1 and L2 with the related capacitors. These capacitors are switched to enable the desired band via Bandswitch S1 (a-d). All capacitors and inductors in the transmitter are fixed. There are **no** adjustments possible by the operator nor are any needed.

If you don't have a resonant antenna, then some kind of matching unit is *required*. A mismatched antenna produces high Voltage, Standing Wave Ratio (VSWR).

These 'mismatch voltages' can cause failure of Q3 by exceeding the Base/Collector or Emitter/Collector breakdown voltage rating. In an effort to protect the final transistor, D1 - a Zener diode, rated at 47 Volts, is installed in the earlier units. Once the voltage present at the emitter exceeds the 47 volt level, the Zener diode will start to conduct, *hopefully* saving Q3. Q3 has a rating for Collector to Emitter of 75V and Collector to Base of 80V.

The current radio set (CW-3B3/2020) uses a IRF510 MOSFET power transistor and is both robust and stable enough to not require the 'SWR' diode. The earlier unit (3B/3B1) uses a quality and popular 2SC2087.

Just the same, if using an external antenna tuner, use a series of dots to the tune the antenna. The transmitter uses an LED as a positive indicator of transmission.

Any time you are testing, always have a 50 ohm dummy load connected to the BNC connector or between the ANT pad and ground.

continue

Troubleshooting Basic Radio Problems:

4.1. Radio does not function (seems to be dead)

Reminder – Click link (blue text) to view relevant illustration for test point.

Test condition: Attach headphones, dummy load, antenna/dummy load and then power lead. Activate on/off switch to ON.

Confirm trouble:– No sound in headphones. Display remains blank, backlight on display does not function.

Test Steps/Results/Action:

CAUTION!

If in-line fuse on DC supply cable blows repeatedly, **STOP**. An internal short will cause the in-line fuse will blow repeatedly.

If the SWR protection diode D1, C-50, or Q3 are shorted, the DC supply is shorted as well. If either of the regulators' have failed, this is generally not a shorted condition.

Quick Check 1: Disconnect power cable from DC supply. Attach an ohm meter in place of the power supply/battery. That is to say, connect the meter to the power cable, then the power cable to the radio.

When the power switch is activated, the ohm meter should read *around* 36K ohms.

NOTE - If the reading is at or above 36K then *drops*, it is an indication that C-50, an electrolytic capacitor, is charging.

- If meter indicates **an open** (zero on a VOM or 1. on most DMM), *reverse* the ohm meter leads as the reverse polarity protection diode is blocking your reading .
- ~36K ohms is indicated, go to (**TS1** below).
- Short (zero) indicated, go to Quick Check 2.

Quick Check 2 - Check [reverse protection diode D2](#) using VOM. Then [check Q3](#), then C-50 for shorts.

(**TS1**) Check DC supply:

- Remove DC feed connector and measure voltage and polarity present at power cable connector:
 - DC supply may be below 8 volts.
 - DC supply may be not be present (cable/connector broken).
 - DC supply at connector may have wrong polarity (must be + center/- on exterior).

Action: Correct issue with DC supply, if found.

If DC feed voltage is correct - Remove rear cover.

(**TS2**) Find J1. Check for supply voltage at [rear of jack](#). Is the supply voltage present? Yes? Continue.

Continue or [return to ToC](#).

No? Fault. See Action item 1.

NOTE – The power cable connector and installed jack may not fully match due to wear. Wiggle the connector to see if voltage appears. If supply voltage does appear, replace supply cable or connector.

3) Find power switch. Check for supply voltage [at 'top' pin](#). Is input voltage present?
Yes? Continue.
No? Fault. See Action item 2.

4) Find TEST POINT +6VDC. [Check +6 VDC](#). Is 6 VDC +/- 5% found?
Yes? Continue.
No? Fault. See Action item 3.

5) Find TEST POINT +3.3VDC. [Check +3.3 VDC](#). Is 3.3 VDC found?
Yes? End of test. All DC supplies test as operational.
No? Fault. See Action item 4.

Action items:

- (1) Supply voltage not present at J1. Possible fix, replace J1, or power cable.
- (2) Supply voltage not present. Possible fix, test/replace diode D2.
- (3) +6VDC not present at Test Point. Possible fix, replace 78L06.
- (4) +3.3VDC not present at Test Point. Possible fix, replace 7533.

DC power is required for radio to function. If you are unsure how to replace these board mounted devices, seek help.

4.2. No received signal is heard /check audio path:

Confirm by: Attach known good: Power, headphones and dummy load or known good antenna. Attach adjustable signal source to dummy load. There may be no sound in headphones. Volume control moves easily. Display operates normally, backlight on display functions.

Test Steps/Results/Action:

- 1) Remove back cover.
- 2) Find LM386 (IC3). Carefully touch the test lead [to PIN 2](#). (The circuit board trace from this pin leads to top of C40/R18). Is noise like a 60 Hz hum heard?
Yes? Continue.
No? Additional testing required. See item 3.
- 3) Find pins feeding the Phones Jack.
On Ohmmeter, select lowest value for Ohms, [measure between the Tip and Sleeve/Ring and Sleeve](#). Is a popping noise heard in headphones?
No? See Action item 4.
Yes? All audio subsystems appear functional. Continue

continue

Action items:

(2) Path from first mixer to audio output assumed functional.

See [Test DDS](#).

(3) Path to audio output appears functional.

See [Test First mixer](#). See [Test Second mixer](#). See [Confirm BFO](#).

(4) Phone Jack may be inoperative. Possible fix –Replace the Phone jack.

Action: If these steps fail to correct problem, start repair actions.

If Phones jack was replaced, restart checks at top of this tree.

4.3. No RF output

Confirm by: Attach known good: Power, headphones and dummy load. There may be sound in headphones. Display operates normally, backlight on display functions. Signals are heard with antenna attached.

Set VFO to listed test frequency (example – 10.100MHz). When keyed into the dummy load, no apparent signal is transmitted or watt meter indicates no output or very low output. Sidetone maybe audible in headphones when keyed with either a straight key or a set of paddles.

Alternatively, set tracer/radio to test frequency as above. A very loud tone should be heard when the SW-3B radio set is keyed. A very weak or no tone indicates a possible fault.

Test Steps/Results/Action:

1) Confirm DC power is correct at supply. Must measure between 8VDC and 15VDC. Is supply voltage between 8 and 15VDC ?

Yes? – Continue.

No? – Fault. Correct supply voltage before any more testing.

2) Confirm DC supply voltage is present [at C14](#). Is supply voltage is present?

Yes? – Continue.

No? – Fault. L7 appears to be open. Replace L7.

3) [Test DDS](#) to confirm output frequency is correct. Is DDS on correct frequency?

Yes? – Continue.

No? – Fault. .

5) Test SWR protection diode to see if it is defective. If receiver is working, this is very unlikely, but it is possible that the diode conducts when unit transmits.

Alternatively, if using dummy load, remove SWR protection diode. If it is faulted, transmit power should be seen on wattmeter.

Note - This diode normally has supply voltage present at anode at all times radio is on.

6) Check that Q3 has power. (3B/3B1)

- Attach power, headphones and dummy load..

- Using voltmeter, confirm supply voltage is present on [Pin 2 of Q3](#) (center pin) as seen on main circuit board. Is supply voltage present?

Yes? – Continue.

No? – Additional testing required. See [Test Q3](#).

NOTE - For 3B3/2020 units -- check voltage at Drain lead, which is the either the mounting tab or center Pin of device.

7) Check that C50 (100 uF electrolytic capacitor) is not shorted. This is only possible from front of main circuit board. If shorted, replace.

(**NOTE** – this check requires removing front cover and lifting Q3 for access. These are the two pins next to the brass standoff between Q3 and the BNC connector))

After all checks are performed and results are normal, additional troubleshooting will require advanced test equipment.

4.4. No or low audio output

Confirm by: Attach known good: Power, headphones and dummy load. There may be some sound in headphones. Display operates normally, backlight on display functions. Signals *may* be heard with antenna attached.

Test Steps/Results/Action:

1) No audio. Check audio path using steps from [Chapter 4.2](#)

2) If some audio is heard, but at a low volume, no matter where the volume control is set. Use one test lead to bypass the volume control.

- Find the sleeve pin of the Phones jack. Find C52, the pin connecting to the potentiometer. [See Illustration.](#)

- Short between these two leads, this will bypass the potentiometer.

- Volume should be 'loud'. Did audio output increase?

Yes? – Fault. Replace potentiometer.

No? – see replace LM-386.

4.5. Radio doesn't key or keys erratically

Confirm by: Attach known good: Power, headphones, key and dummy load. There may be sound in headphones. Display operates normally indicating a Band/frequency, backlight on display functions. Press key or paddle. Radio doesn't transmit or transmits erratically.

continue

Test Steps/Results/Action:

1) No transmit. Using VOM, confirm that a short develops on Tip to Sleeve on key plug when key is pressed. If using paddles, check both Tip and Ring to Sleeve for a short when paddle contact closes. [See Illustration](#) for Tip, Ring Sleeve location of KEY jack.

-Did VOM indicate a short when key/paddle contact closed?

Yes – Continue testing.

No – Fault. Assuming key or paddle contacts are clean, check, then replace or repair cable.

2) Erratic transmit (drops out with key pressed)

Remove DC power, headphones. Remove back cover. Find J3, key jack. Locate R29 and R30. The trace leads back to IC 6, pins 2 and 3. See [Illustration](#).

IC-6 is the keyer chip. Connect **dummy load**, headphones and power. Grounding either pin 2 **or** pin 3 at IC6 should cause the radio to transmit. Using test lead, short between Tip or Ring and ground at J3 or at IC6. Radio should transmit.

-Did radio transmit when pin 2 or 3 is grounded at key jack?

Yes – Fault. J3 may be loose or have bad contacts internally. Replace J3.

No – Fault. Possible bad IC6

4.6. Display is dead, displays "funny characters" or has no backlight

Confirm when radio is powered up that boot screen displays, then current frequency displays. If display does not show correct information (numbers), it may have faulted.

Or - Backlight doesn't light switched.

1) Check DC supply. If OK, continue.

2) Check voltages on display.

-Pin 1 to ground should have +3.3 VDC.

-Confirm ground is present. (PIN 2,3, 4 are tied together and are Ground)

Is +3.3VDC found on correct pin?

No? If +3.3VDC tests good and no voltage found on pin 1. Fault. See Action item 1.

Yes? If +3.3VDC tests good and voltage is found on pin 1. Fault. See Action item 1.

Action:

1) Replace display.

CAUTION – several pins on the display lead *directly* to MCU. **Use of ESD safe soldering iron required.**

continue

4.7. Radio is off frequency (display doesn't match measured output signal)

Confirm by: Attach known good: Power, headphones and dummy load. There may be sound in headphones. Display operates normally indicating a Band, backlight on display functions. Signals may be heard with antenna attached.

Set VFO to listed test frequency (example – 10.100MHz). When keyed into the dummy load, no apparent signal is transmitted, tracer/radio hears no signal. Tuning tracer/radio to a different frequency may yield a tone, indicating Transmitter is off frequency. Sidetone audible in headphones when keyed with either a straight key or a set of paddles.

Alternatively, set tracer/radio to test frequency as above. A very loud tone should be heard when SW-3B is keyed. A very weak or no tone indicates a possible fault.

Check receive by setting signal source to listed test frequency using tracer/radio as confirmation. Ensure RIT is not active. A loud tone should be heard.

1) Check DDS subsystem. If DDS shows as good in testing for receive, but off frequency for transmit, the MCU is faulted. The same is true for the opposite symptom, good frequency on transmit, off frequency on receive.

Does receiver or transmitter appear to be off frequency?

Receiver – Check that the RIT is not active. RIT not active? See Action item 1.

Transmitter – Transmitter off frequency? Yes – See Action item 1.

Action:

1) Check MCU calibration.

Use a **calibrated** frequency counter to measure the frequency at the **TEST point** on the PCB board (near the power socket). Turn the large knob to adjust the frequency until the frequency counter display 10.000.00MHz. Press the M/V/SAV button to exit.

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[Return to ToC](#)

Testing specific radio sub-systems:

Test DDS

Test Steps/Results/Action:

- 1) Remove back cover. Attach power, headphones and dummy load. Using Chart below, set VFO as shown. Set signal tracer/radio to frequency listed in chart below.

(NOTE – unless you have a precision/calibrated test receiver, tune up/down from the listed frequency a couple of KHz to find tone.)

- Place the tracer/radio input lead near T1, the large toroid coil. Is a tone heard at listed setting?

No. See Action item 1.

Yes? End of test, DDS system appears to be functional.

- If possible, set tracer/radio to 27 MHz. Is a tone heard?

No. See Action item 1.

Yes? End of test, DDS system and reference crystal appear functional.

(1) This test indicates the DDS system is inoperative.

Action: Repair of the DDS system/Master reference Oscillator requires additional (and expensive) tools and techniques, putting any repair beyond the scope of this manual.

Band	Receive VFO setting	Set test RX to:
40 Meters	7.100 MHz	12.015 MHz
30 Meters	10.100 MHz	15.015 MHz
20 Meters	14.100 MHz	19.015 MHz

Test First mixer

Test Steps/Results/Action:

- 1) Remove back cover. Attach power, headphones, dummy load and antenna/signal source. Set signal source to 10.100 MHz. Set signal tracer/radio to 4.915 MHz.

(Use listed test settings for other bands from Chart above.)

- Place the tracer/radio input lead near T1, large toroid coil. Is a tone heard at listed setting?

NOTE – A loud 1 KHz tone will be heard due to the 4.914 MHz BFO injection signal. As you adjust the signal source, a second, much weaker, tone will be heard. This second tone is the output of the first mixer after passing through the filter. This second tone will vary in frequency as you adjust the signal source. The louder (BFO) tone will not change regardless of signal source setting.

-No second tone is heard. See item A.

-Yes, second tone heard. End Test: First mixer appears to be functional.

(A) This test indicates the first mixer is inoperative. If mixing is not occurring, no mixing product will be present. Possible fix: Replace NE602 chip.

Action: replace NE602

Test Second mixer // Test Audio path:

Test Steps/Results/Action

1) Ensure First mixer has passed test above.

2) Find LM386 (IC3).

-Carefully touch unconnected test lead to PIN 2. (The circuit board trace from this pin leads to top of R18). (See [Illustration](#)) Is noise like a 60 Hz hum heard?

-A noticeable 60HZ hum is heard in phones. Yes. See item A. End of test.

(A) If the First mixer is good and the audio path is good, this indicates a fault in the second mixer. If mixing is not occurring, no mixing product (audio) will be present. Possible fix: Replace NE602 chip.

Action: replace NE602

Test SWR protection diode: (3B/3B1 units)

If the SWR diode is shorted, the DC supply is grounded. The in-line fuse will blow repeatedly. *You do have an in-line fuse for your power cable, yes?*

1) With power supplied, check anode of diode (D1) to see if supply voltage is present. See illustration.

Results: If shorted, replace the diode. Since this is a Zener diode, you can only check for the supply voltage with the test equipment called out. If the diode is open, it will have no effect on the transmitter, but damage from high VSWR is now possible.

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Testing Q3 (2SC2087) with Ohm meter

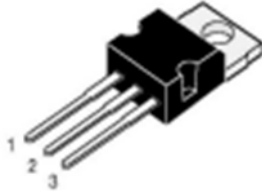
Transistors act like diodes when checked with an VOM set to lowest range (1 X). By swapping the leads, you should see a major change in the ohms measured. Once the transistor has been removed from the main circuit board, confirm Q10 status with this test.

1 is **B**ase, 2 is **C**ollector and 3 is the **E**mitter.

So, for the first column - Positive lead on meter (Red) is the first letter - **B**

Negative lead of meter (Black) goes on the second letter - **E**. (Red on lead 1, black on lead 3).

Then swap the meter leads – Red is now on lead 3...Black lead on 1 See chart below.

 Ohms Test for Q3					
B to E	E to B	B to C	C to B	C to E	E to C
Low	High	Low	High	High	High

Low = 1 to 10 ohms..

High = Many ohms to infinite.

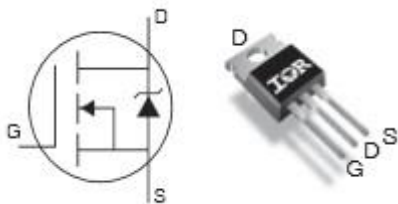
If you fail to obtain these reading, Q3 is likely faulted. Replace Q3.

Testing Q3 (IFR510) with Ohm meter

I've provided a link showing how to test a MOSFET device. You still use the ohmmeter, but only with the diode test function. (CW-3B3/2020)

If a photo is worth a thousand words, a video is even better.

<https://www.youtube.com/watch?v=gloikp9t2dA>



IF510 pinout.

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Basic Maintenance and Repair of the radio:

Common steps for every Task.

- 1) Remove main circuit board from case
- 2) Install main circuit board back in case.
- 3) Minimum checks before power up after maintenance.
- 5) Replacement of DC feed protection diode
- 6) Replacement of Q3 (transmitter final)
- 7) Replacement of DDS encoder.
- 8) Replacement of display module. (Display screen)
- 9) Replacement of AF/RF potentiometer.

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Basic Maintenance and Repair of the radio Tasks

Task preparation – a common set of steps for every Task:

- *Read the entire Task* in advance to ensure you understand what is required, that you have the correct items (parts and tools) and space on hand to perform the Task.
- Clear work area and set up ESD-safe work surface.
- Place small container near work surface to hold removed screws etc.
- Set out required tools (and solder, pump, etc)
- If required by the Task, plug in ESD-safe soldering iron to begin heating to operating temperature.
- Don safety glasses.

How do I:

Use an ohmmeter/DVM?

<https://www.youtube.com/watch?v=3bsdbnyf1Ss>

Test an electrolytic capacitor?

<https://www.youtube.com/watch?v=wrJXdJbX5zq>

Test a diode?

<https://www.youtube.com/watch?v=mMXDa5hVzXA>

Test a NPN power transistor?

<https://www.youtube.com/watch?v=IB7oUD1UVEw>

Test a N-channel MOSFET power device

<https://www.youtube.com/watch?v=RkWy1EirEu8>

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TASK 1 – Tuning each Band for best performance. (3B/3B1 units only)

Required by:

Task performed to ensure radio sensitivity is at maximum possible at selected frequency.

Tools required:

- Non-metallic miniature screwdriver or non-metallic hex head tuning tool, as appropriate.
- Voltmeter, AC. 0 to 1 or 0 to 3 VAC range, 0 to 1 VAC preferred.
Alternatively, use the S-meter display as an indicator

Begin Task:

Step 1: Determine *preferred* operating frequency for the operating Band.

NOTE – For the 30 Meter band adjustment, the common QRP calling frequency is 10.106 MHz, for 20 Meters it is 14.060 MHz, for 40 meters it is 7.030 Mhz.. These frequencies are by convention, not Regulation.

Peaking the Band for a preferred frequency ensures best possible sensitivity for operation. If you will use the SW-3B radio set primarily on an established net, then use that net frequency for this Task. The turning is fairly broadband

Step 2: Remove back cover. Attach 8 ohm speaker, power and dummy load. Feed signal source to radio via the dummy load.

Step 3: With the speaker attached, connect AC voltmeter leads *across* the speaker terminals.

CAUTION – **DO NOT** use the voltmeter as the only audio load, damage to audio sub-system may result.

Step 4: Turn on radio, set VFO to desired frequency. Apply test signal to ANT jack.. Turn up volume until the voltmeter indicates something.
Alternatively, observe the S meter graph.

Step 5: [Adjust VC1, 2, 3, 4](#)

NOTE - The adjustments affect one another, take your time. After adjustment produces no increase in measured voltage, turn off radio.

Step 6: Repeat as necessary for each Band.

Step 7: Replace back cover.

END OF TASK

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TASK 2 – Remove circuit board from case

Required by:

Task performed to gain access to front (display side) or rear of main circuit board for testing, replacement of devices or parts.

Tools required:

- Screwdriver, Phillips head. One small, one medium.
- Safety glasses.

Begin Task:

Step 1: Using fingers, gently remove the AF & RF Gain and TUNE control knob by pulling straight up. Place knobs in container.

Step 2: Front and rear covers are held by four each Phillips head screws. Remove appropriate screw set and pull gently on 'clamshell' rear cover of the radio set. Set cover and screws aside, out of the way.

Step 3: To remove front cover, pull the end piece Phillips head screws, then remove the three screws found on the front (display) side of the radio set.

- If you remove the front cover screw in the upper right side (closest to the BNC connector) use **Caution**. This screw holds Q3 power transistor to circuit board. . ([see Illustration](#)).
- There is an isolating pad that must be placed on top Q3 for reassembly. Also note this screw is longer than the others.

NOTE – *Carefully* remove insulator pad (white or gray) and place in container. There is an insulating washer *under* Q3. Do **not** lose either one of these insulators. ***They are required for operation.***

Step 4: If both covers are removed, leave the end piece on the BNC connector. No other work is required to fully expose the main radio board.

Step 5: The main circuit board is now fully exposed. Use ESD safety procedures when handling the board to ensure you do not damage any of the integrated circuits.

NOTE – the 3 silver colored screws visible on rear of board hold the standoffs.
DO NOT remove.

END OF TASK

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Task 3 – Install main circuit board back into case

Installing main circuit board is nearly the opposite of removing the board.

Step 1: Using medium Phillips head screwdriver mount screw holding Q3 power transistor to chassis. *Ensure the heat conducting insulator is evenly COVERING Q3. Ensure the insulating washer is installed under Q3.* Inset screw in chassis. Carefully tighten the screw, but to not over-tighten.

CAUTION –the Q3 insulator/heat conducting sheet and insulating washer is *required*, otherwise, the power supply is shorted to ground.

Step 2: Note the edge of the covers. One side has a slot, the other a tab. The front cover is obvious, ensure the rear cover is aligned correctly. Carefully tighten down remaining screws holding the front cover in place.

Step 3: Replace back cover, install all end screws.

Step 4 – [Perform post-maintenance checks](#).

END OF TASK

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Task 4 – Minimum checks before power up after maintenance

- 1) Ensure no solder bridges exist. Remove any small bits of wire or solder that might be loose on either side of the main circuit board. A small brush may be used to clean with. Use a bright light and magnifying glass to examine area where you performed any soldering task.
- 2) The Q3 screw should be tight, with the white insulator in place. The white insulating heat transfer sheet **MUST** be in place and appear symmetrical on all sides of the heat sink for Q3. Without this item (sheet) Q3 will ground out the DC supply.
- 4) Attached dummy load, headphones and power cable.

Task 5 – Replacement of DC feed protection diode (3B/3B1 units only)

- 1) Using solder wicking and soldering iron, remove the installed diode, if open. If shorted, this diode has no practical effect on the operation of the radio. Only the loss of reverse polarity protection is the issue.
- 2) Solder in replacement. Inspect area for solder bridges or splatter.
- 3) Recommend cleaning the area after soldering with 91% iso-alcohol to remove any residual flux. .
- 4) Re-install main circuit board back into chassis per [Task 3](#) above.

NOTE - Use of the listed diode is important. Any Schottky Rectifier rated at for least 20 V and 1.0 Amp will work. The reason for a Schottky diode is the low voltage drop found on these type of devices. Any quality rectifier, even one with axial leads may be pressed into service. Common power diode will work but at the cost of the voltage lost across the device.

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Task 6 – Replacement of Q3 (transmitter final)

- 1) Ensure you purchased the correct transistor. Most are plainly marked.
- 2) Remove main board from chassis as defined in [Task 2](#) above.
- 3) Carefully note the bend in the leads of Q3. This is essential when replacing the main circuit board – the hole in Q3's heat sink must line up with the hole in the chassis.
- 4) Using solder pump or wicking - heat, then clear solder on all three tabs of the transistor. Once cleared, the transistor should be easy to remove. You may have to reheat the area – use caution not to damage the board.
- 5) With Q3 off of the main circuit board, [test transistor](#) / test device as shown.
- 6) Trim leads on replacement transistor to match the length of the leads on transistor removed from main circuit board. You may need to trim the sides of the replacement – [see photo](#).
- 7) Carefully solder replacement Q3 onto main circuit board. Examine are to ensure there are no solder bridges between circuit pads.

HINT - If you worry about overheating the replacement Q3, clip a piece of *damp* paper toweling around the transistor while heat is applied to act as an additional heat sink.

Initial Test –

- Attach dummy load!
 - Tune tracer/radio to a listed test frequency (example – 10.100 MHz)
 - Briefly* key transmitter. A very loud tone should be heard. This confirms Q3 operational. If a wattmeter is available, confirm ~5 watts output @ 12.8VDC
- 8) Re-install main circuit board back in chassis per [Task 3](#) above.

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TASK 7 - Replacement of DDS encoder

- 1) Ensure you purchased the correct encoder..
- 2) Remove main board from chassis as defined in [Task 2](#) above.

NOTE – the Si5351 chip is an ESD sensitive device. Use caution.

- 3) Using soldering wick and ESD-safe soldering iron, unsolder encoder. Remove the encoder from the board. Using this, confirm lead spacing of replacement matches item removed.

NOTE - A solder pump is recommended for removing solder from mounting tabs.

- 4) Solder in new encoder. Examine your work to ensure no solder bridges are present between pins.
- 5) Connect power, phones and dummy load. Confirm encoder changes the VFO per Operations manual. Remove cables.
- 6) Re-install main circuit board back into chassis per [Task 3](#) above.

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TASK 8 - Replacement of RF/AF potentiometer

- 1) Ensure you purchased the correct potentiometer (1K ohm).
- 2) Remove main board from chassis as defined in [Task 2](#) above.
- 3) Using soldering wick and ESD-safe soldering iron, [unsolder all potentiometer pins](#). Remove the potentiometer from the board. Using this, confirm lead spacing of replacement matches item removed.

NOTE - A solder pump is recommended for removing solder from mounting tabs.

- 4) Solder in new potentiometer. Examine your work to ensure no solder bridges are present between pins.
- 5) Connect power, phones and dummy load. Confirm potentiometer changes the volume/RF levels. Remove cables.
- 6) Re-install main circuit board back into chassis per [Task 3](#) above.

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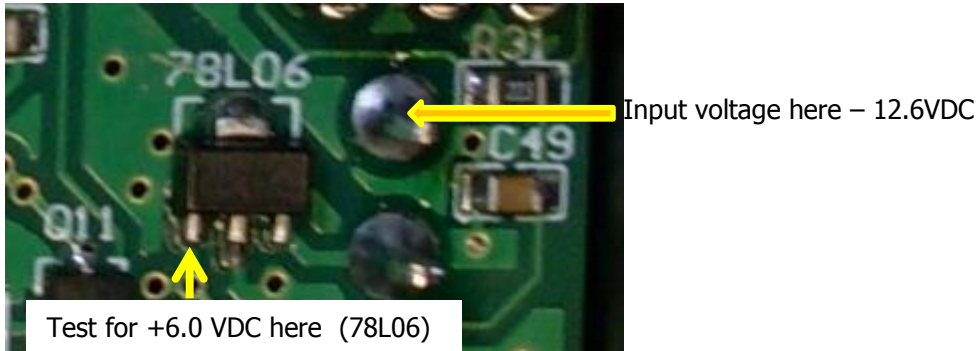
Data for system components

Item / Label	Nomenclature	Description
DDS encoder w/switch	Encoder, rotary, mechanical (confirm shaft length)	(Bourns) Mouser P/N 652-PEC11R-4215F-S24
AF/RF gain control	rotary potentiometer 1K liner taper	Mouser P/N 688-RK09D1130C2P
6 volt buss regulator 78L06	Voltage regulator +6 VDC SOT-89 pkg	78L06 Newark P/N 37X9027
3.3 volt buss regulator	7533 regulator	Newark MCP1700T-3302E/MB
IC 1, IC 2 Mixer	double balanced mixer & oscillator, SMT type NE602 or equal	SA612 Newark P/N SA612AD/01,118 sub for NE602.
IC 3 Audio amplifier	amplifier, audio, 8 pin, SMT type, DIP LM386	LM386 Newark P/N 41K5099
IC 7 Keyer (must be programmed)	CMOS Flash-based 8-bit microcontroller 12F629	12F629 (Microchip brand) Newark P/N 61K3433
D1	Surface Mount Schottky Barrier Rectifier	SS12, diode Multicomp brand Newark P.N 90R9168
Q 3 Transmitter PA (3B#/2020)	N-Channel power MOSFET TO-220AB pkg	JAMECO P/N 209243 / IRF510
Q# Transmitter PA (3B1)	NPN power transistor TO220 pkg 2SC2078	Futurlec 2SC2078
Crystal, filter, ladder	4.9152 MHZ (matched) 4 each	Digikey P/N X084-ND ECS P/N ECS-49-20-1

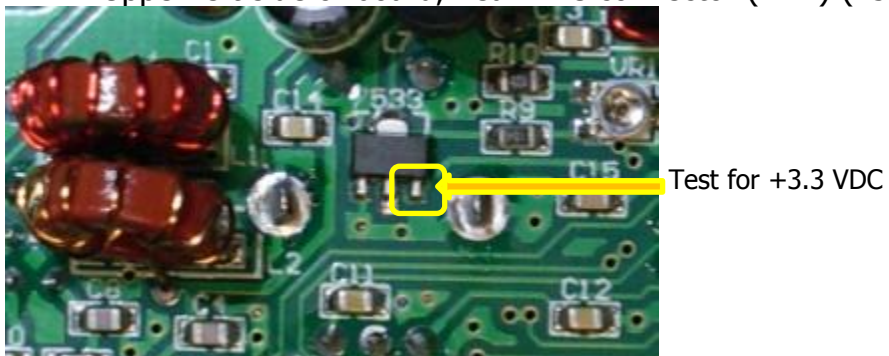
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Illustrations

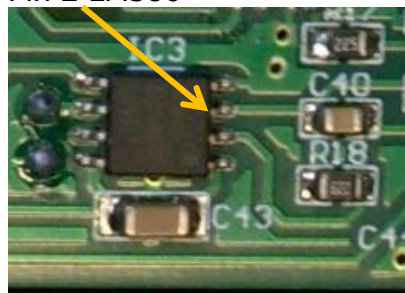
DC Power Test Points, adjustment and protection
(Lower right hand side, below the KEY jack.



Upper left side of board, near BNC connector (ANT) (7533 device)



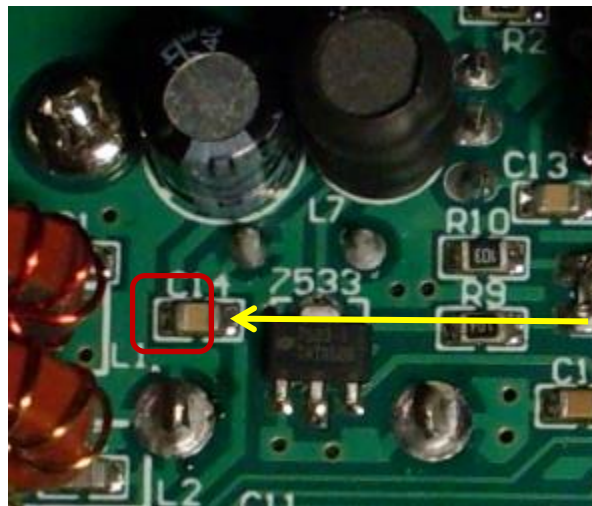
Pin 2 LM386



Test points, earphone/key jack

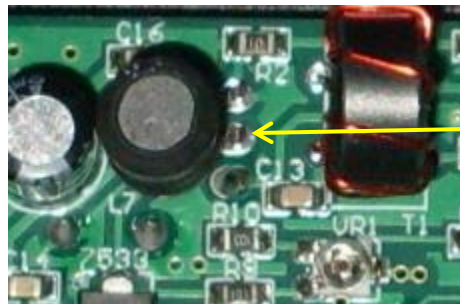


Check for supply voltage on C14.



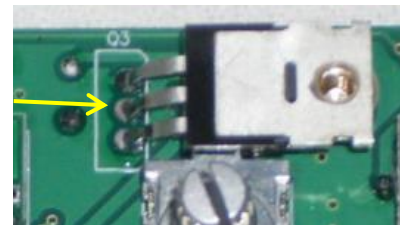
Measure C14 voltage here

Q3 test point – center pin



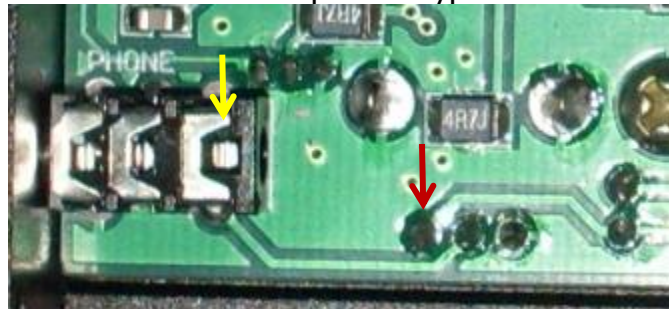
Back of board

or

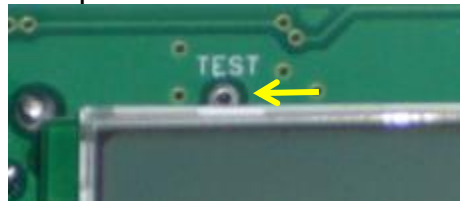


Front of board

Short between these pins to bypass AF Gain control.



Test point for MCU Calibration.



RX_ADJ



20 meter adjustment outlined

40M

30M

Image above courtesy AE5X, John

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Illustrations

VR1 adjust for DC voltage displayed



Power protection diode D2

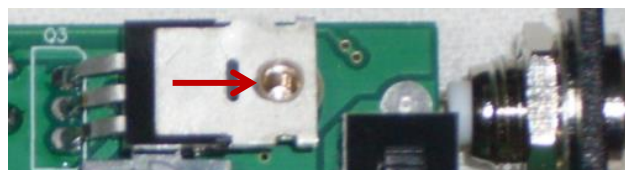
TEST for input voltage here

TEST for input voltage here



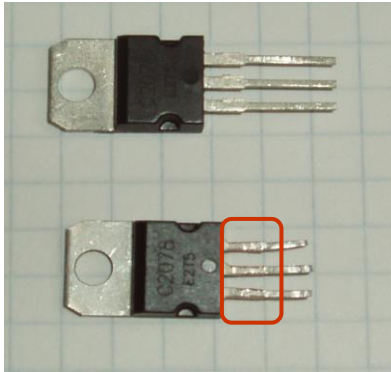
Power input jack

Q3 screw location



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Steve, M0SHM, sent these photos showing how he had to mod (slightly) the pins on a new 2SC2078 to fit it to his rig. He was kind enough to share these photos and allow use here.



Trim leads of Q3 as needed, use a fine file and take your time.

Hints, Tips, Kinks

Recommended items not supplied with radio set.

These are items I've added to my 'kit' to carry with the radio all the time. When operating outside of the shack, I make notes in my log about items I wished I brought along or needed. Here are some of those noted items:

- Adapter BNC male to BNC male. I use this with my home-made dummy load.
- Adapter BNC Female to SO239. Supplied.
- Cable, jumper, BNC to BNC. To connect to an external antenna tuner. You may need an adapter BNC Female to PL-259, depending on the tuner.
- Jameco P/N GSE 231015: Cable ASM RG58/U 15 Foot BNC to BNC 50 Ohm M-M.
- Adaptor, BNC To Dual binding posts MFJ-7704 (P/N 610-2106). Allows you put up a makeshift antenna.

KK6FVP uses these cleverly modified adapters for an antenna feed. Hook up your wire to the post for a dipole and hoist into a tree. The split rings carry the weight of the wire, saving wear on the binding post. Use a BNC to BNC cable and the adapter isn't required.



Image Copyright 2015 KK6FVP, All Rights Reserved, Used with permission

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Thoughts on building a portable DC power system

An easy place to start is with the supplied power cable allows you enough cable to park your battery pack someplace convenient. Like, inside your parka to keep the batteries warm in inclement weather.

ALWAYS put in-line fuses on any power cable. Use at least a 1.5 ampere fuse for this cable.

Add a "Holder, battery, "AA", for either 8 or 10 cells. I use a 10 cell unit and carry a pair of dummy cells. This allows use of NiMH or regular alkaline cells. The SW-3B is happy with anything over 8 volts, so a 9VDC battery is also an option.

The cell holders are just a couple of dollars. A rubber band on the outside to keep the cells in place and you're ready to travel.

For extreme cold weather, *Lithium-Iron* 1.5 volt "AA" cells are now available at reasonable prices. There are also Lithium primary cells at 3.6 VDC @ 2.4 aH that will work in a 3 or 4 cell holder – price is a major consideration here as the cells cost up to 3+ dollars - *per cell*. If *weight* is your primary consideration, these are worth a look. These are also TSA safe for travel where LiON cells are banned on many carriers.

I bought my cell holders on line because the output of the pack is a polarized connector – one that looks just like the top of a 9 volt battery. That was by design. *I cannot stress enough to USE A POLARIZED battery connector.*

A single 9 volt battery will power the SW-3B long enough for a few contacts or some extended listening to shortwave stations. I see this as maximum flexibility.

A connector for the power cable is easily had. Take a dead 9V battery and peel off the foil on the outside. You discover a set of very small 1.5 volt batteries and a ready-made for your cell holder connector. Solder this connector to your power cable, put some insulating tape over the soldered connections and you're in business.

With this setup I can run primary cells, rechargeable cells or to save weight on a hike, just carry a couple of 9 volt batteries for a few quick QSO's. All with the same, polarized, power cable.

Finally, a thought about LiPO batteries. The AA sized 14500 series are 3.7 VDC at almost 2.4 aH capacity – that's no typo. 2.4 amp hours. So, a 3 cell (11.1 VDC) or a 4 cell (14.8VDC) battery pack with that amount of power density has some appeal. Keep in mind LiPO cells require *exquisite care* in charging and use. These cells should *always* be monitored while under charge. Read more about these cells and related hazards elsewhere or on line.

I've been asked why I seem to be such a fan of AA batteries for powering this rig. Simple, AA batteries are just about universally available *world-wide*.

For example, I was working an oil spill clean-up project in the Komi Republic, part of the old Soviet Union. This was in 1995, just after the old Soviet fell apart. Despite being in an isolated town, quite literally at the end of the railroad line on the Arctic Circle, I never had any issues finding fresh AA batteries for my shortwave set. I've been a fan ever since.

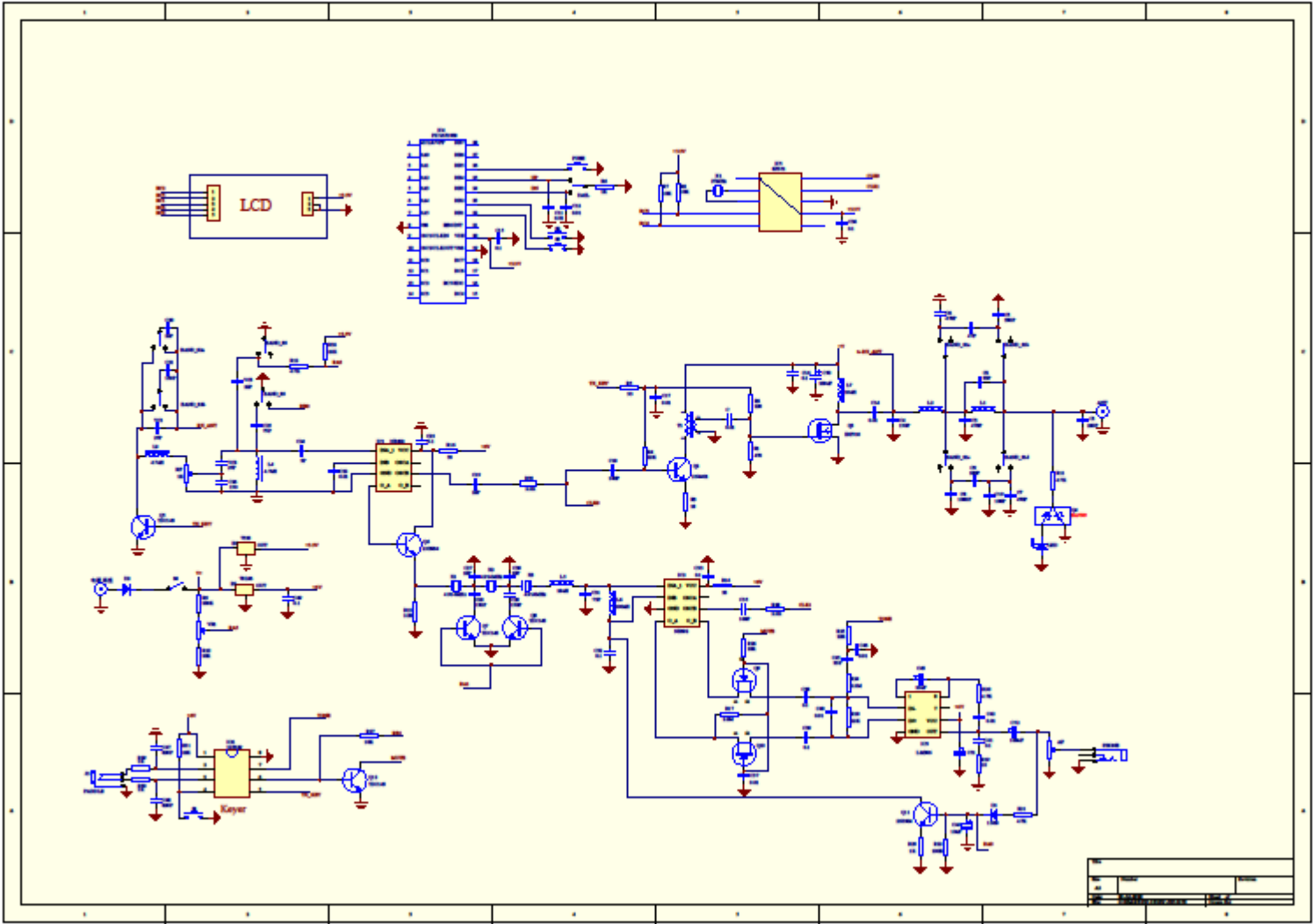
The antenna used must be resonant – so unless you plan to sting up a dipole on each outing, a tuner is indicated. I use the QRPGUYS end fed tuner. I have built and use the Pacific Antenna tuner kit, which comes with a nice metal case. The QRPGUYS is less expensive, and weighs less, which is why I use it. Both are based on identical components.

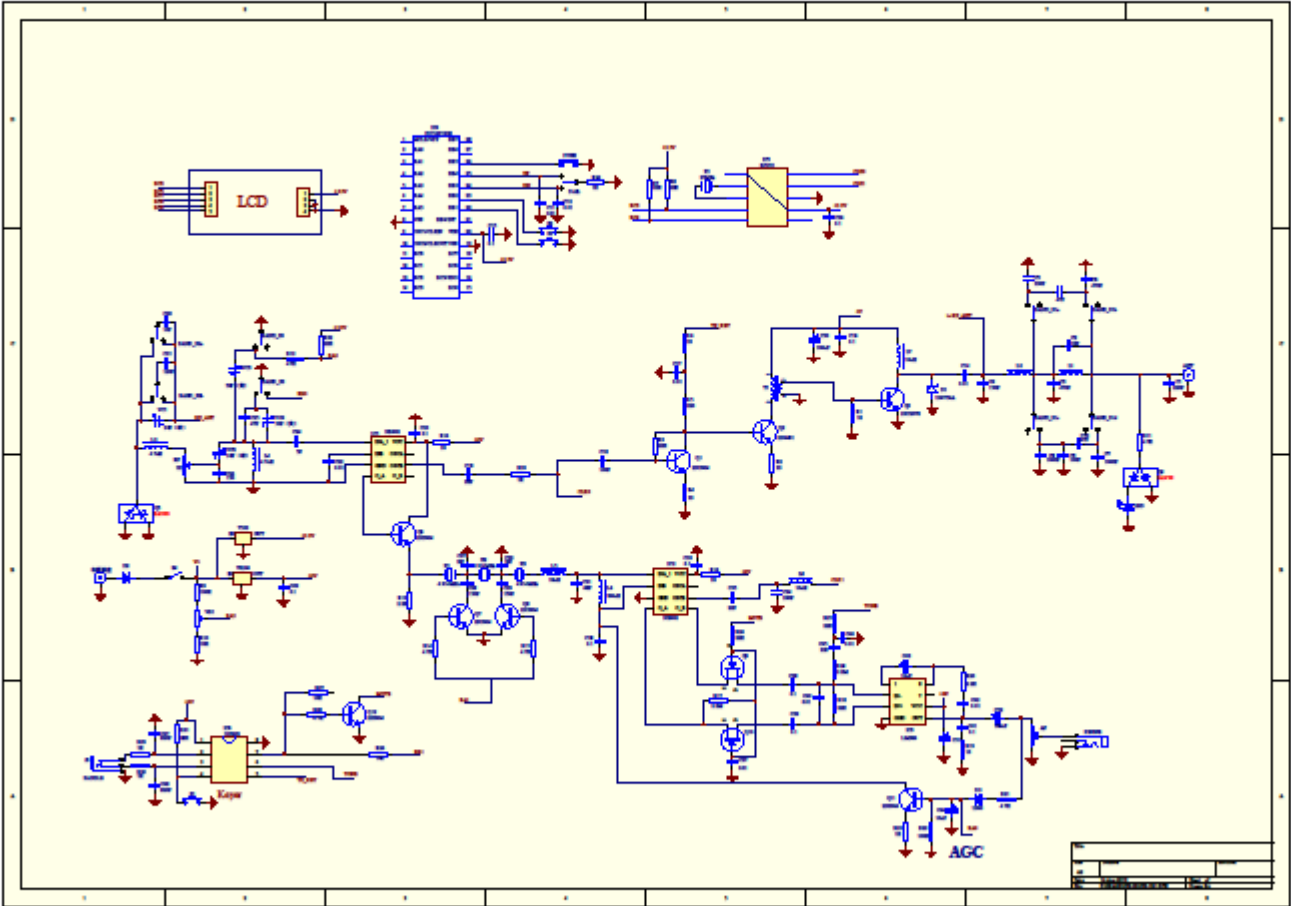
I carry 50 feet of 550 cord/shroud line/paracord (same thing, different name) for stringing up my End Fed Half Wave antenna. I also use the Coleman camping 'clothesline reel' to hold my wire. Makes for easy setup and a clean carry.

Best of luck with your new rig!

73

Don//KL7KN





Wuxi Venus Information Technology Co., Ltd