

The AT Sprint 3B

A very small, very effective, 6 band HF CW rig

“DIGITAL READY”

Operation and Assembly Manual for version 3B.1



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Specifications:

Frequency coverage: 80/40/30/20/17/15 meter bands

Receiver MDS, 0.2 uV

Small signal bandwidth 500 Hz

Receive current, no signal 35 ma.

Transmit power output: 2.5 watts at 9V, 4.5 watts at 12 V

Transmit current: 460 ma at 9 V, 610 ma at 12 V

Supply voltage: 5.5 volts minimum, 12 volts maximum

Operation:

Basic operation:

Turning the rig on and off:

As there is no power switch, the rig is turned on and off by inserting or removing the power plug from the jack. Make sure the plug is firmly and fully inserted into the jack. Try not to put any sideways pressure on the plug, it the jack may become intermittent.

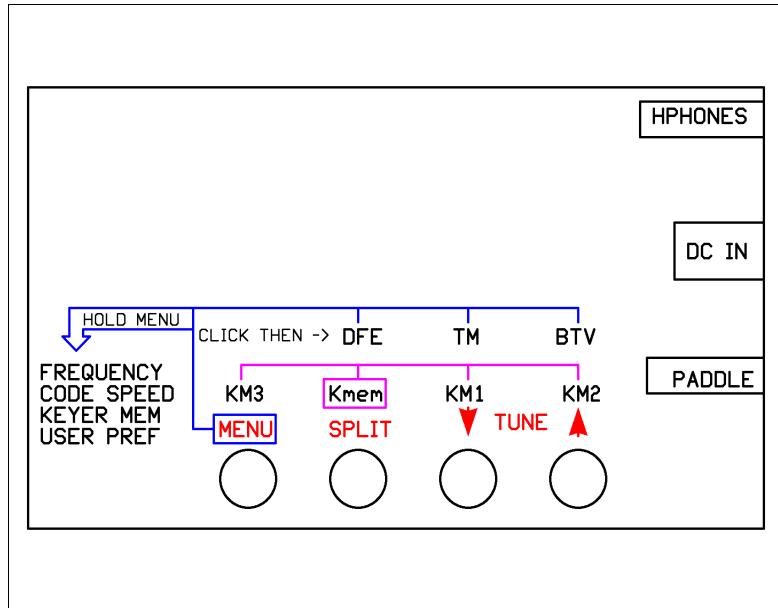
Band selection and power up:

The desired band of operation is selected by inserting the appropriate band module into the SIP header socket on the main board and then powering up the rig. On power up, a voltage determined by a voltage divider is read so the processor knows which band module is in use. A one digit number relating to the band module installed will be shown on the LED display and annunciated in Morse by the side tone. The standard QRP calling frequency for that band (if any) will be loaded into the DDS as the initial operating frequency. You can then tune from there or use the Direct Frequency Entry function to move directly to another frequency.

Band	Display/Morse	Initial frequency
80 M	8	3.560 MHz
40 M	4	7.030 MHz
30 M	3	10.110 MHz
20 M	2	14.060 MHz
17 M	7	18.070 MHz
15 M	5	21.060 MHz

Control switches:

Four push button switches control the operation of the ATS-3B. All switches have multiple functions. The primary function of each switch is labeled in red in the switch function flow diagram shown to the right. Secondary functions are enabled by a short click of either the MENU switch or the SPLIT switch, followed by clicking the switch for the desired function. This allows often used secondary functions to be quickly accessed. Print out this page and cut out the diagram to paste in the lid of your tin as a reminder of switch functions.



Frequency tuning:

The operating frequency of the rig is controlled by the **TUNE UP** and **TUNE DOWN** buttons. These are labeled on the front panel with an up arrow and down arrow, respectively. "Clicking" the appropriate switch will increment or decrement the current frequency by 50 Hz. Holding one of the tune switches closed for longer than one (1) second will start an auto-tune mode. The frequency will now change in 100 Hz steps at a rate of about 10 steps a second as long as the switch is held closed. Tuning will revert back to normal one step, 50 Hz tuning when the switch is released. The 100 Hz / 10 steps a second tuning rate is a compromise between being able to scan the band at a reasonable rate, while not being so fast its easy to miss weak signals.

Tuning limits:

The tuning range includes the entire band, though SSB reception is not possible since it will be received on the wrong sideband. A double beep will sound when the band edges are reached and tuning will stop there, preventing out of band transmission. A single beep will sound when you reach the edge of the USA CW band segment.

SPLIT MODES:

The ATS-3B has both RIT (Receive Incremental Tuning) and XIT (Transmit Incremental Tuning). Both modes are enabled by using the **SPLIT** switch and which mode is selected is determined by how long the switch is held closed. Once either RIT or XIT mode is enabled, the decimal point of the LED display will light to indicate split modes are active. There is no limit the the tuning range of RIT or XIT, other then the normal band limits.

RIT is enabled by clicking and holding closed the **SPLIT** switch closed until the letter "R" is annunciated in Morse by the side tone. There is a slight delay after closing the switch and the sending of the "R", as the split switch is also used to activate the transmission of keyer messages.

XIT is enabled by clicking and holding closed the **SPLIT** switch for one second after the "R" sounds and the letter "X" is annunciated. NOTE: If RIT is active, XIT can only be enabled by first exiting RIT mode.

Split modes are exited by clicking and holding closed the **SPLIT** switch until a "dot" is sounded by the side tone. The decimal point on the LED display will go out and the original (Rx =Tx) operating frequency which was in use when the split mode was activated will be restored.

Frequency annunciation while in Split modes:

Using the frequency annunciation while in split mode will indicate the delta (difference) between the receive and transmit frequencies. For example, if you have tuned above the initial frequency by 1 kHz, the frequency will display [01-0]. If you have tuned below the original frequency by 1 kHz, the frequency will display [99-0]. In addition, a "dot" (beep) will sound at each 1 kHz mark. If you tune back to the initial frequency, where receive and transmit frequencies are equal, a [0] will flash on the display.

MENU:

The Menu switch is used to access, activate or escape from, the various functions and options available in the rig. The Menu switch is sometimes used alone and sometimes in conjunction with the other switches to activate a function. In all cases, how long the menu switch is held closed will determine what function is to be activated.

Quick selections:

The DFE, Tune mode and battery voltage functions can be quickly accessed by using the Menu switch in conjunction with one of the three other switches. The MENU switch has to be clicked closed first, then one of the other three switches clicked within 1/2 second to activate the desired function.

DFE (direct frequency entry) = Menu, then SPLIT

Tune Mode = Menu, then Tune Down

Battery Voltage = Menu, then Tune Up

DFE Mode:

("D" is annunciated when mode is activated)

This mode allows you to enter a desired operating frequency using the paddle. This can be any frequency within the upper and lower band edges currently in use. Simply use the paddle to enter the frequency numbers in Morse, starting with the 100 kHz digit and ending with the 100 Hz digit (four numbers total). Zero's can be sent as a cut number "T" or full length. The LED display will flash the number which has been entered and the side tone will sound a beep. If a number is miss sent, a "?" will be annunciated and that digit must be re-entered.

When four digits have been entered, the rig will re-tune to that frequency. If the frequency entered is beyond the tuning limits, DFE mode will simply terminate and the frequency will remain where it was.

NOTE:

- DFE mode is not available if the rig is in Straight key mode.
- DFE mode is not available when split operation is active.
- DFE mode can be escaped by clicking the Menu switch at anytime before 4 digits have been entered.

Tune Mode:

(“T” is annunciated when mode is activated, “t” shown on display)

This mode allows you to toggle the transmitter on and off using the paddle. This makes it easier to adjust a small antenna tuner if two hands are required to operate it (One to hold it in place and one to turn knobs). This mode also allows you to make power output measurements, which require a steady carrier for a few seconds in order to make an accurate reading.

Toggle transmitter on: Tap the LEFT paddle.

Toggle transmitter off: Tap RIGHT paddle.

Exit Tune mode: Click Menu switch, “E” annunciated.

NOTE: Tune mode is not available if the rig is in Straight key mode.

Battery Voltage:

This mode reads the input voltage to the board and then displays it on the LED display and annunciated in Morse. The letter “B” is sent before the digits during Morse annunciate. The voltage is measured after the reverse polarity protection diode and has a 5% accuracy.

MENU switch only selected functions:

Frequency, Keyer code speed (S), keyer memory entry (M), Digital modes (D), user settable options (P) and Alternative paddle (A) functions are selected using only the Menu switch. With the exception of Frequency, click and hold closed the Menu switch until the letter on the 7 segment display appears and the Morse letter identifying the desired function has been annunciated by the side tone, then release the switch. The switch must be released before the next letter in the menu sequence is annunciated to select the desired function.

Frequency readout:

A quick click and release of the **MENU** switch will activate the frequency readout. The default mode of readout is both a numerical readout, sequenced one digit at a time on the LED display, and annunciated in Morse by the side tone. The 100 kHz, 10 kHz, 1 kHz and 100 Hz digits are indicated, in that order. MHz digits are implied by the band in which the rig is currently operating on. A dash [-] on the display and an “R” in Morse indicates the decimal point separating the 1 kHz digit from the 100 Hz digit. Zero's are sent as the cut number “T” in Morse. Therefore, a frequency such as 7.0400 will be sent as T4TRT in Morse and seen as 040-0 on the display. It is possible to set the rig to indicate the frequency only with the LED display or send it only in Morse.

S: Selecting Keyer code speed;

(“S” on the display)

Click and hold closed the **MENU** switch until the letter “S” is annunciated and appears on the 7 segment display, then release the switch. This mode will automatically exit after 1 second if no action has taken place in that time, or you may click the MENU switch to exit right away. The selected code speed will be retained in memory and is restored as the default code speed when the rig is powered up. Code speed can be changed by using either the paddle or tune up and tune down switches. Code speeds are selected in approximatively 1 wpm increment using the paddle and 5 wpm increments by using the tune up and tune down switches . A beep will sound at each new code speed increment. The 5 wpm code speed increments provided by the tune up and tune down switches

gives a quick means of changing the code speed to more or less match another stations code speed during contests.

Increase speed: Close RIGHT paddle or Tune Up switch.

Decrease speed: Close the LEFT paddle or the Tune Down switch.

NOTE: If the rig is in Straight key mode, the Tune up and Tune down switches are used to change code speed. While in Straight key mode, code speed increments in 1 wpm steps. This allows changing the code speed used to send previously stored messages.

M: Keyer Memory entry:

(“n” on the display – the closest we can get to “m” with 7 segments)

There are three keyer memories available, with a combined total of 124 character storage. Word spaces count as characters, as they take up one memory location. If more than one message is desired, they must be entered in sequence, all in one session. Once a message is started to be entered, all previously stored messages are deleted.

Upon releasing the Menu switch after the letter “M” has been annunciated, the receiver will mute and entry of the message via the paddle may begin. If keyer memory entry has been selected by mistake, clicking the Menu switch will exit this mode without disturbing the contents of the memory, provided the paddle has not yet been used.

Timing for determining letter and word spaces is automatic and is based on “ideal” timing. Since many of us have a hard time sending with ideal letter and word space timing, generally running letter groups and words together, segments on the LED will flash to let you know when a letter time out or word space time out has occurred. The upper left LED segment (f) will flash at the letter space interval and the upper right segment (b) will flash at the word space time out. Paying attention to the flashing lights will allow you to enter a message without timing mistakes.

Entering more than one message.

At the end of the first message, sending seven (7) (or more) dashes will signify the end of that message and the beginning of the next. If a third message is desired, again send seven dashes at the end of the second message. If the available memory space for messages is exceeded before you can complete an entry, the memory entry mode will be terminated and the check message playback mode will start.

Checking and storing the message:

When you have finished keying in the messages, click the Menu switch. The message(s) will then play back so you can check that they were entered correctly. If more than one message has been entered, you will hear the seven dashes indicating the break between them. If the playback is good and there are no mistakes, click the Menu button again to store the messages into Flash memory. If you need to redo the messages, click the Split switch and “EM” (Enter Message) will be sent by the side tone. Then re-enter in the messages.

Sending messages:

The SPLIT switch is clicked first, then within 1/2 second, click either the Tune Down, Tune Up or Menu switch to transmit the desired message. This new method eliminates the problem of accidentally sending message 1 when using the split switch for it's primary function, turning on or off split modes.

Message 1 is sent by clicking the Tune Down switch within 1/2 of a second after releasing the Split switch.
Message 2 is sent by clicking the Tune Up switch within 1/2 of a second after releasing the Split switch.

Message 3 is sent by clicking the **MENU** switch within 1/2 of a second after releasing the Split switch.

Message Pause, Stop and Beacon mode:

After a message has started being transmitted, it maybe paused or stopped using the paddle.

Pause: Closing the **RIGHT** paddle or Tune Up switch will pause the message for as long as the paddle is held closed. Pause will start when a character being sent has finished sending.

Stop: Closing the **LEFT** paddle or Tune down switch will terminate the transmission of the message when a character currently being sent has been completed.

Beacon mode:

Only message 1 can be used as a beacon. After message 1 has started transmitting, pause the message by closing the **RIGHT** paddle (pause), then tap the **LEFT** paddle. Tune up and Tune down switches can also be used. The letter "B" will be annunciated and a lower case "b" will be displayed on the LED to remind you your in beacon mode. There is a fixed length pause of a couple of seconds at the end of the message before it starts sending again. The message maybe paused or stopped as described above. In addition, tapping either dot or dash paddle during the pause will terminate beacon mode.

D: Digital modes:

(“d” on the display)

Thanks to the efforts of Vojteck Bubnic, OK1IAK, the ATS-3B can transmit a number of different types of digital modulation. However, since the rig was designed for CW use and hence uses a Class C PA and square wave drive, some of the digital modes are more effective than others. Digital modes can only be used in conjunction with the Pocketdigi program. No other digital mode program will work, as they do not have the required special communications protocols needed to tell the ATS3B what to do. Detailed operating instructions start on page 32 of the manual.

P: Program user preferences

(“P” on the display)

The following user preferences can be selected and stored in memory and are non-volatile. Only the functions you wish to change need to be selected.

- Iambic A or B mode, A mode initial default
- Reverse Paddle dot and dash sense. Default is right, dot / left, dash. This applies only to the sending of code.
- frequency annunciation code speed, 20 wpm initial default
- frequency readout -- Morse + Display (default), Morse only or Display only.

Iambic mode select: Click **TUNE UP** switch. Clicking the tune up switch will toggle between the A and B modes. The letter "A" or the letter "B" will be annunciated by side tone, indicating the selected mode.

Reverse paddle sense: click the **SPLIT** switch. This will toggle between normal (Morse N) and reverse (Morse R) modes

Annunciation code speed: Click **TUNE DOWN** switch. This will set the code speed at which the non-transmitted Morse annunciated characters are sent at to the code speed the rig is currently set to. The letter "S" is annunciated to let you know something happened when you clicked the switch.

Once the above selections have been made, click the **MENU switch again to advance to the next**

selections: (F will appear on the display)

Frequency readout method: The method used for frequency readout maybe selected using these switches:

SPLIT switch: Both Morse and display readout.

Tune Up switch: Morse only readout. "MO" annunciated.

Tune Down switch: LED Display only readout. "DO" annunciated.

To store the preferences you have selected, click the **MENU** switch.

A: Alternative paddle

(“A” on display and side tone)

This option allows using the Tune up and Tune down switches as a paddle. This option is a little clunky and difficult to use, but it is useful if you want to save weight or have a problem develop with your external paddle in the field. It will take some practice to get the hang of. The best method is to hold the tin with both hands and send with your thumbs.

When the alternative paddle mode is active, the keyer code speed is selected using the frequency tune up and tune down switches, as it would be in straight key mode. Code speed increments are at normal 1 wpm steps. DFE mode can be used as can entering in keyer memories. Reverse paddle option does not affect the dot and dash sense of these switches.

Selecting alternative or normal paddle modes:

Clicking the **SPLIT** switch toggles between these two modes. An “A” (alternative) or “N” (normal) is annunciated indicating the mode selected. Escape and store by clicking **MENU**.

Toggling between receive and transmit modes:

There has to be a method of toggling the function of the tune up and down switches between normal frequency tuning and transmitting. This is done by a short click of the **SPLIT** switch. A 't' will appear on the display when the switches are in transmit mode. There is a ½ second delay after clicking the split switch before the mode toggles between transmit or receive. This allows using the split switch to activate one of the keyer memories as would normally be followed by a short click of the split switch.

Straight key mode:

Straight key mode is automatically detected and enabled when the rig is powered up when a monaural plug is in the paddle jack. The sleeve of the mono plug grounds the dash input, which enables straight key mode. Straight key mode also allows use of an external keyer if one so desires.

Operating voltages:

The ATS-3B has been optimized for operation at 9 volts, with a minimum operating voltage of 6 volts and a maximum of 12.0 volts. Since power output is dependent on supply voltage, power output will vary from a low of about 900 mw at 6 V and up to about 5 watts at 12 volts.

NOTE: Since there is no fuse or current limiting in the rig, it is a good idea to use an in-line fuse in the power supply cord. A 1 amp fuse for supplies of 9 volts or less and 2 amp fuse for supplies above 9 volts.

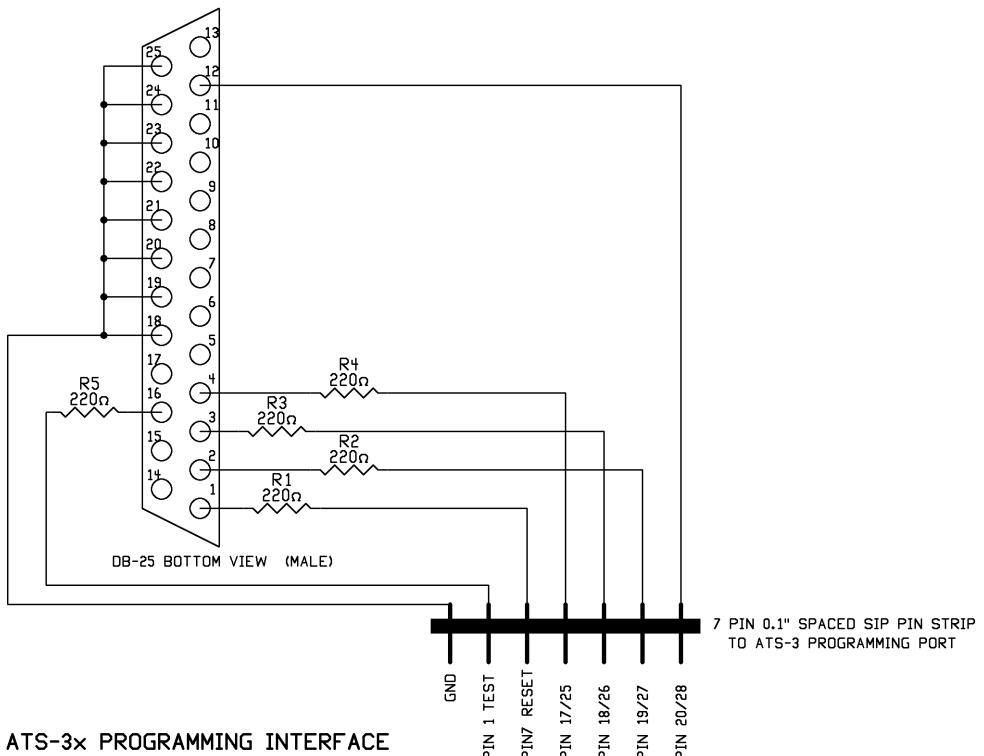
HIGH SWR CAUTION: If operating the ATS-3B with supply voltages greater than 9 volts, please ensure there is a low SWR load connected to the rig. High SWR conditions (especially those which are reactive) when operating above 3 watts output may cause the PA stage to become unstable or cause the PA FETS to be damaged. Be

very careful when using a fully charged gell cell to power the rig!

Spare DC power plug:
Mouser part number 171-3218-EX \$1.22

Reprogramming the MPU.

There is a row of pads above the MPU labeled "programmer". These bring out the programming pins for the MPU, so that the firmware can be upgraded or changed. Several people have modified the firmware to provide additional or different features to the rig. To reprogram the MPU, a simple level shifting interface must be constructed to go between a PC with a parallel port and the programming pads on the main board. As shown below:



In addition to the interface, you will need to install the MPS430 IAR development program to your PC. This program can be found in the MPS file folder with the name "FET_R451.exe" Double clicking on this will start the installation program.

The file folder labeled "MSP" on the CD should be copied to your hard drive, either in the C root directory or "My Documents" folder. Open the IAR program and select "open existing project" from the dialog box and direct it to look in the MPS folder. The project "ATS3B_digi" should show up and select that and click OK.

The source code file will now be displayed and can now be worked on if so desired. To reprogram the MPU with this file, connect the programming cable to the LPT1 parallel port of your PC, apply power to the ATS3B board and then plug the header pins from the interface cable into the board. The ground pin end goes into the pad hole to the left of the MPU, as seen with the MPU below the programming port pins. A SIP socket is not needed for the pins, the fit into the board is tight enough to the pins in the SIP plug to make reliable contact.

Now click on the C-Sky icon in the tool bar (looks like a magnifying glass) and the programming should start.

If you wish to program a different file into the MPU, add that file to the MPS folder and then add it to the list of files. Click on that file name to make it active and proceed as above.

Assembly:

- Your work area should be reasonably clean and uncluttered. Good lighting is a must.
- Empty the packets containing the parts into small paper bowls. This will ensure that they do not get lost. Some people like to do the assembly over a cookie sheet, as the lip around the edge helps to keep parts from going far. The metal sheet also provides some measure of static control, especially if you ground it. A white sheet under your work area could help in finding a part which might get away from you.
- A very thin (0.015") solder is supplied for soldering the surface mounted parts. Very little solder is need for each connection. Ideally, you want a little convex fillet at the end of chip resistors and capacitors. Try not to end up with a ball of solder at the end of the part.
- Do not use liquid solder flux. It simply makes a mess and is difficult to clean off the board and get out from under parts. If not completely removed from the board, it can cause problems.
- Before placing a part, lightly tin one pad for where it will go. You can speed assembly by tining one pad at all the locations for which a particular value of part will go. There is no need for a low wattage soldering iron. It is best to have a hot tip which will let you get the job done quickly. You will need a small tip on the iron, 1/32" to 1/16" chisel or round is best.
- Most of the surface mount parts come in part carriers. To remove the part(s), hold the carrier close to the work surface and carefully peel back the clear plastic covering the part. This can be done with the tip of a sharp hobby knife such as a #11 Xacto blade or pointy tipped tweezers. Once you remove the clear plastic strip, dump the part out of the carrier and onto your work surface.
- If you use tweezers to handle the parts, be very careful you don't grab onto them too tightly. These little parts have a way of flying out from between the tips of the tweezers, never to be seen again. Apparently, they go into the twilight zone, along with all the pens, small parts and hardware which falls off the bench. They must go someplace since its never anywhere I can ever find them again!
- An alternative to using tweezers to handle the parts is to use a tooth pick or chop stick with the end rubbed into a little bees wax. The bees wax makes the end sticky so the part will stick to it. For the smaller IC's I grab them length wise with the tweezers.
- Tack the end of a part in its place by applying heat to the end of the part over the tined circuit board pad, while applying a little pressure to make sure it lays flat to the board. Be sure to heat both the pad and the end of the part. Generally, you will not have to add any additional solder to this connection. Then solder the other end of the part. If you don't do this right away and go onto tacking down some more parts, there is a good chance you will forget to go back and solder all the parts which require it.
- It is nearly impossible not to make solder shorts between pins on the DDS chip, due to the close pin spacing. Remove any shorts with solder wick.

Using solder paste:

Using solder paste is the ideal way to build the board. Small amounts of solder paste in an application syringe can be bought for about \$5.00 from Cash Olson over the internet. Also needed is a warming plate to preheat the board to about 200 degrees and a low power heat gun. An "Embossing" heat gun is commonly used (found at craft stores), though a hair dryer on low setting might work. A soft air flow is required as to not to blow parts off the board.

A very small dab of solder paste is put on the pads and then the part placed over the pads. The parts will slide around very easily, so one must be careful not to nudge them. The phono jacks and LED display should be hand soldered, along with all the through hole parts. Start with the back side of the board with the most parts first.

Once all the parts have been placed, put the board on the warming plate and heat to about 200 degrees. Then slowly heat the top of the board with the hot air gun. When the solder paste reaches its melting point, you will see it liquefy and the parts snap into alignment to the pad. This is when the solder paste turns from a dull gray to shiny. Be on the look out for "tomb stoning" which is when a chip cap or resistor will stand up on one end. Once all the solder has reflowed, remove the power to the heating plate and let it cool down.

A video showing how to hand solder SMT parts and how to use solder paste can be found on the CD and is viewable with Windows media player. The file is in the folder labeled "Video"

Using the parts placement guides:

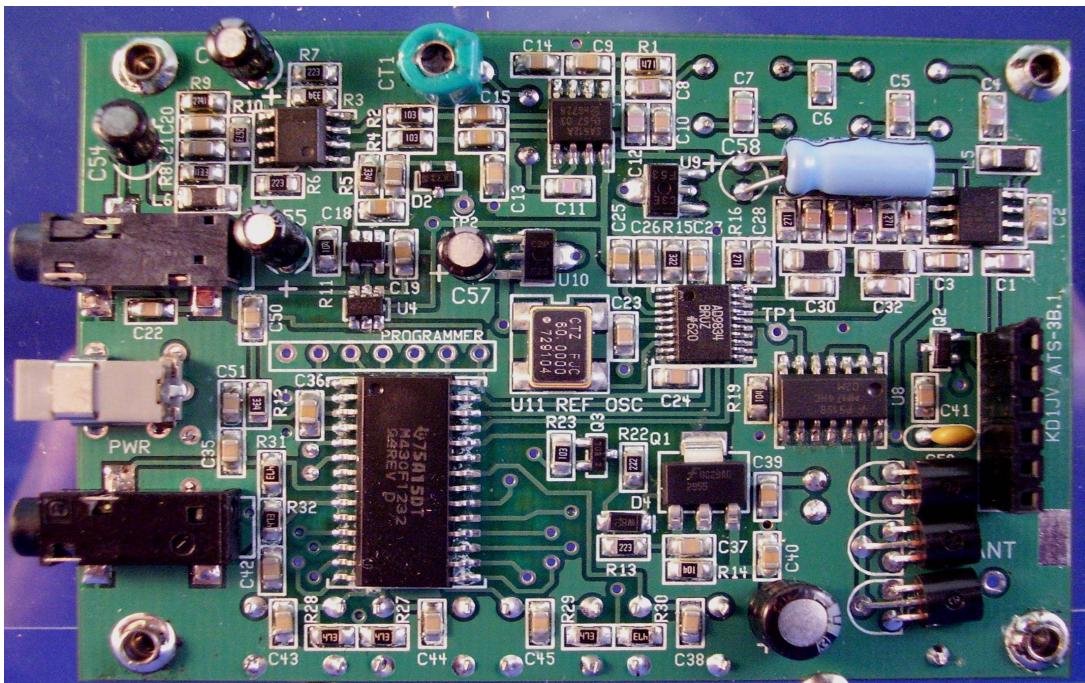
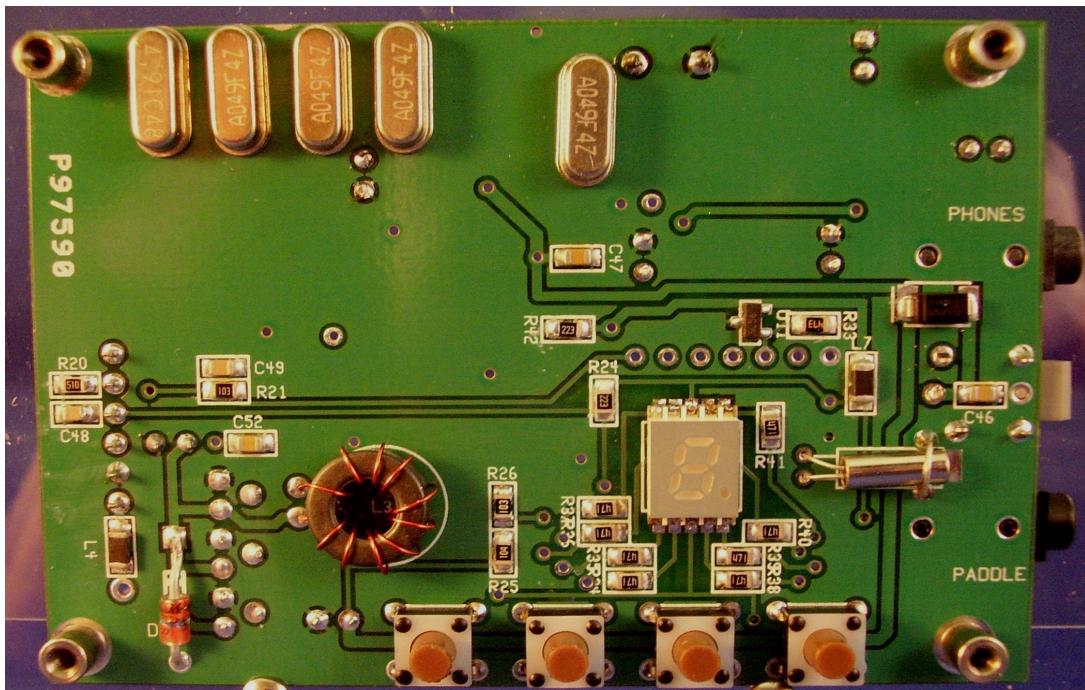
The parts placement guides on the following pages are color coded to show the location of the various parts. Parts which are not yet to be installed or already have been installed are colored the same as the background color. The guides are scaled so that the writing on them is easy to see on a computer monitor and come out crisper after the conversion to pdf. Unfortunately, if you print all these pages out, it will use up a bunch of your ink jet ink.

Some parts do not have values marked on them or are very hard to read. Capacitors are not marked so these have been color coded with a marker on the part carrier. This color matches the color shown on the location guides.

SOT-23 parts have numbers printed on them, but are very hard to read. Therefore, these parts are also color coded, but with a color sticker, as they come in plastic carriers. Again, the color on the carrier matches the color shown on the placement guide diagram.

Resistors have their value printed on them, though it might take a magnifying glass to read the numbers. Therefore, individual values are not color coded.

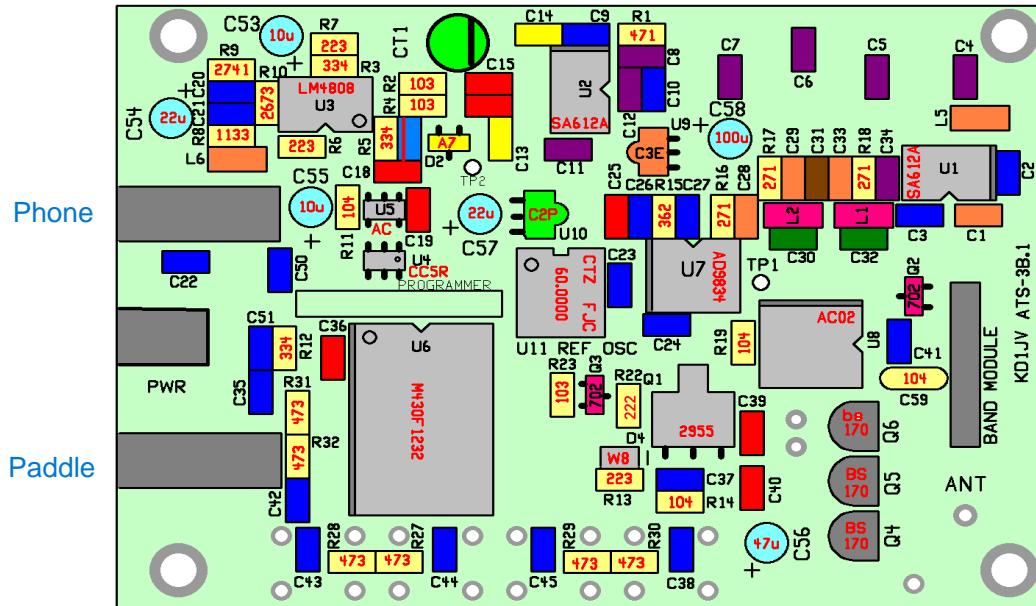
Reference pictures of the front and back sides of completed board:



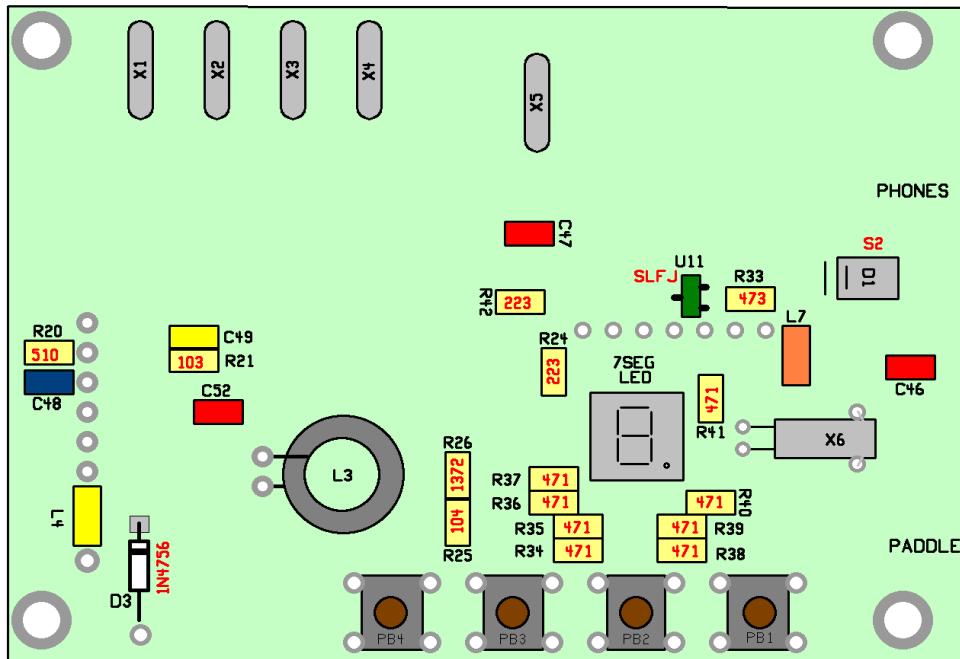
Overall placement diagrams.

The front and back parts placement guides below should be printed out for convenient reference while building. Color coded locations match the colors of the corresponding part carrier. Part outlines with numbers inside indicate resistors and the resistor value to be placed there. Also refer to the photos of the completed board.

Back side:



Front side:



Parts check list:

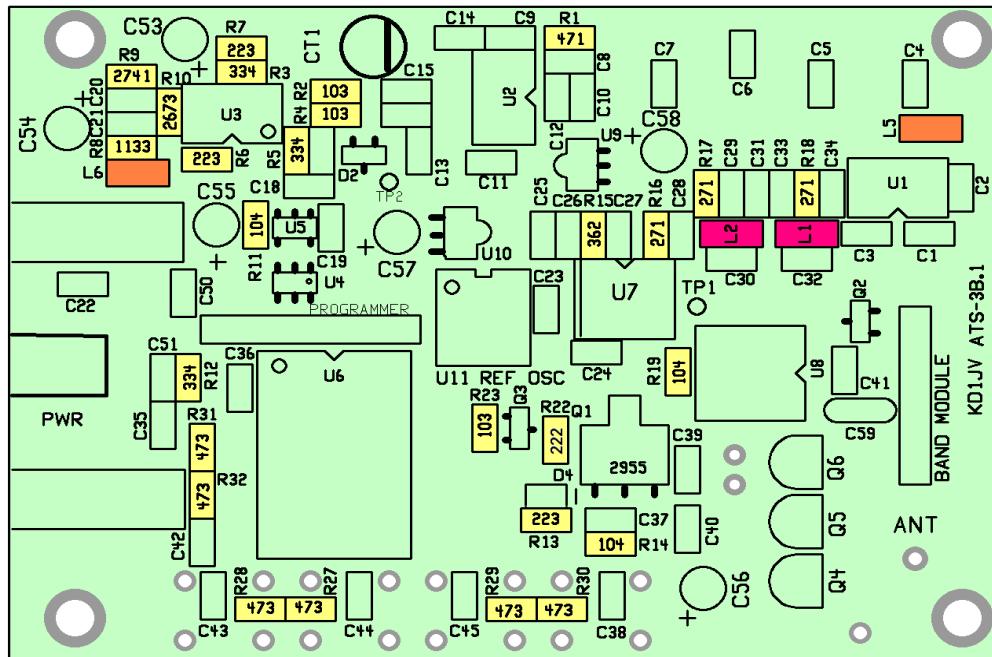
COLOR IS MARKER OR STICKER ON PART CARRIER PACKAGE

QTY	VALUE/ SIZE	MARKINGS OR COLOR	QTY	VALUE	MARKINGS OR COLOR
2	51 OHM	0805	510		
3	270 OHMS	0805	271	4	22 p
10	470 OHMS	0805	471	1	47p
2	2.2 K	0805	222	8	100 p
1	3.6 K	0805	362	1	470 p
5	10 K	0805	103	3	1000 p
6	22 K	0805	223	22	.01 u
7	47 K	0805	473	11	.1 u
5	100 K	0805	104	1	.1 u radial lead
3	330 K	0805	334	2	10 u /16V
1	2.74 K 1%	0805	2741	2	22 u /16V
1	13.7 K 1%	0805	1372	1	47 u /16V
1	113 K 1%	0805	1133	1	100 u /10V
1	267 K 1%	0805	2673		
			1	30p GREEN	TRIMMER
2	SA612A	SO-8			
1	LM4808	SO-8	1	0.15 uH	YELLOW
1	MPS430F1231	SO-28L	2	3.9 uH	PINK
1	AD9834	TSSOP-28	3	10 uH	ORANGE
1	74AC02	SO-14			
1	60.000 MHz OSC	SILVER RECTANGLE			
1	74LVC1G3157	CC5R SOT-6	5	4.9152 MHz	HC-49US
1	AN6123MS	AC SOT-5	1	32.572 kHz	SMALL CYLINDER
1	MCP120T-3151	Green, SLFJ, SOT-3	1	0.2" LED SMT	7 SEG DISPLAY
1	NDT2955	SOT-233	1	FT43-37	BLACK CORE
2	2N7002	Pink, 12W or 702 SOT-3	2	3.5mm STEREO	SMT JACK
1	BAV99IN dual diode	Yellow, A7, SOT-3	1	0.7mm DC PWR	JACK
1	812C50	C3E ORANGE, SOT-89	1	0.7mm DC PWR	PLUG
1	812C35	CP2 GREEN, SOT-89	4	6mm TACT	SWITCHES
3	BS170	TO-92	1	6 pin SIP	socket
1	SS12	S2	4	0.187" #2	Flanged stand off
1	5.1V 500 mw	W8	4	#2 1/4" screws	
1	1N4756A	47V ZENER			

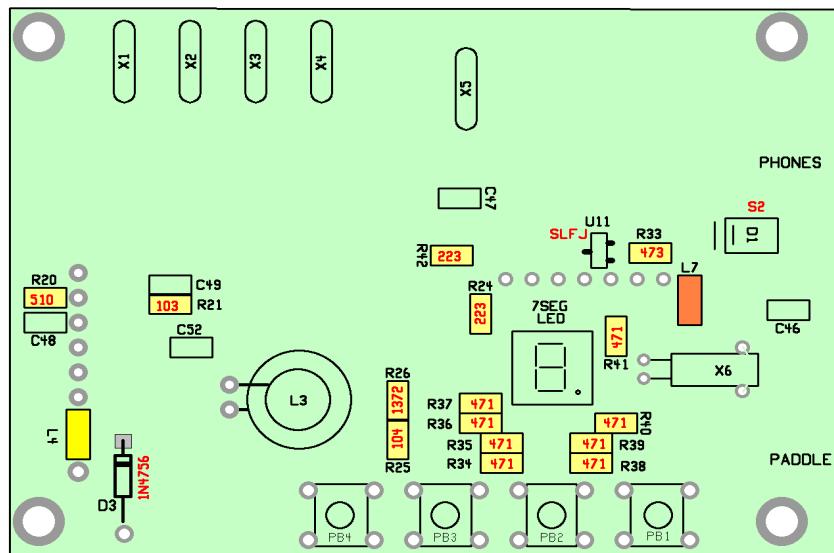
Resistors:

Resistor locations are highlighted in yellow. Number shown in outline is the same as marked on body of part. When all the resistors have been installed (front and back), you will find there are five extras. These will be used on the filter module boards. Put them aside someplace where they will not get lost! Four inductors are also installed at this time. These are larger than the resistors and usually come in a clear or black plastic part carrier.

BACK SIDE:



Resistors Front side:



R20	51 ohms	510	0805	R21	10 K	103	0805
R34	470	471	0805	R26	13.7K 1%	1372	0805
R35	470	471	0805	R24	22K	223	
R36	470	471	0805	R42	22K	223	0805
R37	470	471	0805	R33	47 K	473	0805
R38	470	471	0805	R25	100 K	104	0805
R39	470	471	0805	L7	Orange	10 uH	1206
R40	470	471	0805	L4	Yellow	0.15uH	1206
R41	470	471	0805				

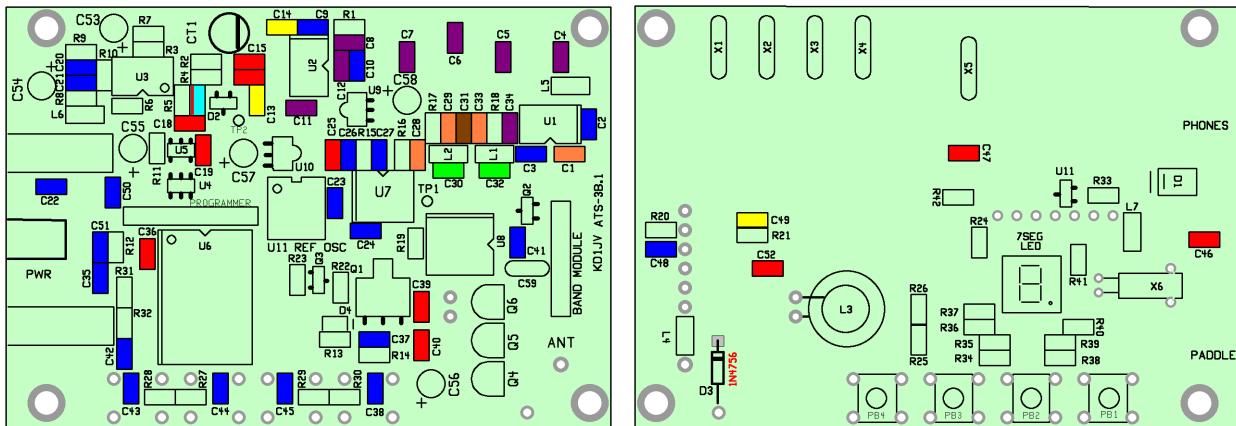
L7: Orange sticker L4: Yellow sticker

Capacitors:

Capacitors part carriers are color coded as the part its self has no markings to identify its value directly. Install all the capacitors of a given value (if required, both sides of the board) before starting to install another value. This will prevent mixing up values. All but one of the capacitors are coded with a solid color. The one exception is light blue with a red stripe along the top edge of the carrier. This is the one which goes to the right of R5

BACK SIDE

This side is a little “busy” so pay attention to where each value goes. Putting a cap in a wrong location can cause some parts of the circuits not to work properly and finding a miss-placed cap can be difficult.

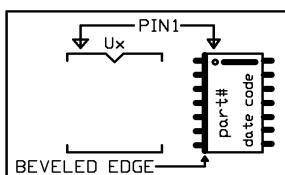


Color	Value	QTY	location
Green	0.0 pfd	2	C30, C32 (Not Used)
Orange	22 pfd	4	C1, C28, C29, C33
Brown	47 pfd	1	C31
Purple	100 pfd	8	C4, C5, C6, C7, C8, C11, C12, C34
Light Blue Red stripe	470 pfd	1	Not labeled on board, to right of R5.
Yellow	1000 pfd	2	C13, C14
Blue	0.01 ufd	21	C2, C3, C9, C10, C20, C21, C22, C23, C24, C26, C27, C35, C37, C38, C41, C42, C43, C44, C45, C50, C51
Red	0.1 ufd	8	C15, C16 (not labeled on board) C18, C19, C25, C36, C39, C40
Top Side			
Yellow	1000 pfd	1	C49
Blue	0.01 ufd	1	C48
Red	0.1 ufd	3	C46, C47, C52

Semiconductors:

Little details you will need to know:

Finding Pin 1.



Some of the ICs used in this kit have a dot or indentation at the Pin 1 corner of the chip. For others, the Pin 1 location isn't as obvious. The manufacturer's logo is sometimes used (as is the case for U1 and U2) or sometimes there is a line along the Pin 1 end of the chip. In all cases, there is a beveled or rounded edge along the side of the IC package. When the chip is viewed so the package is orientated vertically, Pin 1 is always in the upper left corner.

Before placing an IC or transistor, tin one of the corner pads and then tack that lead of the part down first. Before soldering any other pins, make sure all the leads are lined up on the pads. This is especially important for U7, where there isn't much room for error. Then solder the lead on the opposite corner from the tacked lead to make sure the body doesn't move when you solder the rest of the leads.

U4 and U5 are very similar. The way to tell them apart is the fact U4 has 5 leads and U5 has 6. U4 has a faint dot which marks the pin 1 end, also the lettering "CC5R" will be upside down when installed correctly.

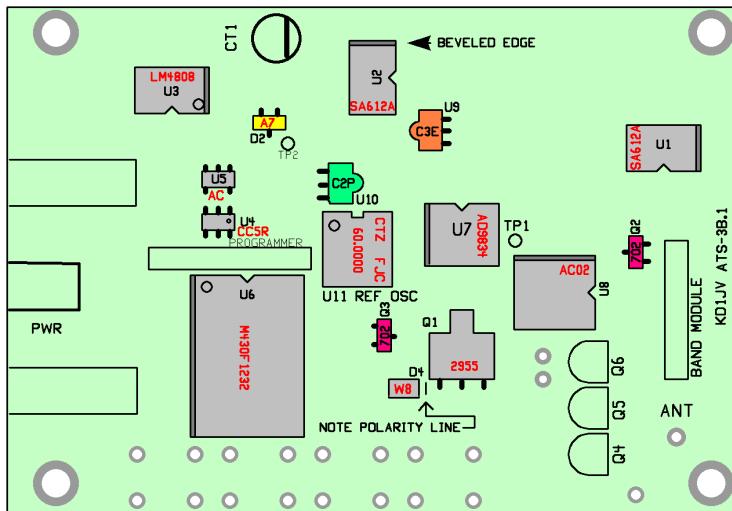
U11 is the rectangular box with the silver top. Be sure to get solder to flow into the little "U" shaped cups near each corner of the part. A number of builders have had trouble with this and not made solder connection to the pads under the part. A fine tipped iron is required here. Also, be careful of using too much solder and making a short to the metal top of the package.

D1 and D4 have very faint lines printed on them to indicate the cathode end. Look carefully for these lines and face them towards the line printed on the board.

The two regulators and the TO-23 sized transistors and IC carriers have been color coded with a sticker and corresponds to the color on the layout diagram. Simply match colors like with the caps.

There may be more numbers or letters on the semiconductor packages than indicated on the layout diagram. These are date or lot codes and can vary depending on when the parts are purchased. Therefore these are not used for part identification on the layout diagrams.

FRONT SIDE

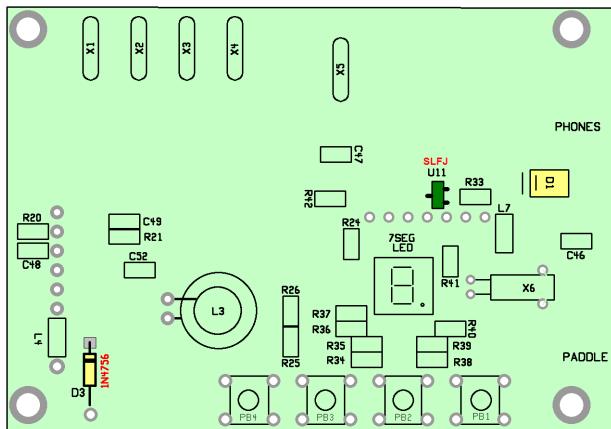


- U1, U2: SA612A
- U3: LM4808
- U4: CC5R Note dot showing orientation.
- U5: AC
- U6: M430F1232
- U7: AD9834
- U8: AC02
- U9: Orange sticker, C3E
- U10: Green sticker, C2P
- Q2, Q3: Pink sticker, 12W or 702
- Q4, Q5, Q6
- ANT
- D4: W8, small black rectangle Note polarity!

U11: 60 MHz clock oscillator. This is the silver can. Getting solder to flow under the pad can be tricky, be sure to put the iron up to the little cup on the side of the pad. Be careful not to short to the metal top of the package.

(Note the U11 designation is duplicated on the front of the board for the uP rest chip)

BACK SIDE



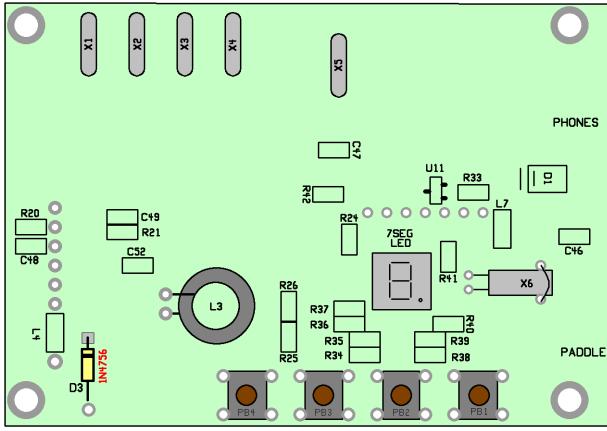
U11: Green sticker, SLFJ (last two characters maybe different on actual part)

D1: S2, larger black rectangle Note polarity! Faint line on one end of part faces line on board.

D3 not installed at this time.

Through hole parts

The SMT LED display should be soldered down first.



Carefully note the end of the display which has the decimal point. Make sure that it is in the lower right corner, towards the switches, before soldering! Use a small tipped iron and try to make the solder wick up into the little solder cups on the display.

Note: the display pads are not spaced quite right and are a little too close together. Therefore it is important to get the center pins of the display centered very well to prevent shorts between the outer pins and the pads.



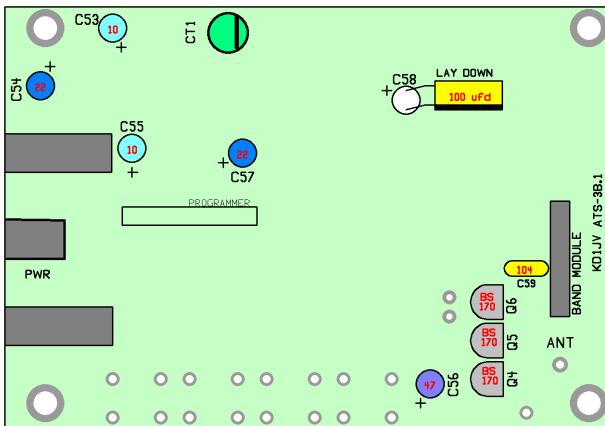
D3: The anode end of D3 goes into the hole in the board, while the cathode end gets soldered to the SMT pad. Put a little "L-kink" in the lead which goes to the SMT pad, so the body of the diode sits flush with the board.

X6: A small silver cylinder with two leads. Use a piece of electrolytic capacitor lead clipping to hold the end of the crystal down to the board, using the two holes on either side of the crystal, near its end.

X1-5, 4.9152 MHz crystals. Mount these snug to the board, don't worry, the pads under the can won't short to the can.

L3: 13 turns #30 wire (9") on black, FT37-43 core. You can wind this now and put it aside, as it should be mounted after initial board tests are done.

PB1-4: These can only fit one way. Snip the leads after you solder them in, as their sharp, pointy and stick out from the board a bit.



CT1: Green trimmer. The flat side of the trimmer goes towards the line in the outline.

C59: 0.1 ufd mono cap (104)

C58: 100 ufd aluminum electrolytic. Mount the cap on its side, angling the leads slightly so the body of the cap is above the row of chip parts below it. Long lead is +

Q7-9 BS170. These are mounted with the flat side of the package flush to the board. (See picture on page 12) Mounted this way, the board adds some measure of heat sinking. The easiest way to do this is to insert the leads into holes as you normally would, then bend the body over. You may have to push up on the leads a little from the other side of the board to create a sharper bend in the lead, so the body sits flat and square to the board.

C53 and C57, 10 ufd aluminum electrolytic. Long lead +

C54 and C57, 22 ufd aluminum electrolytic. Long lead +

C56, 47 ufd long lead +

Power jack

SMT phone jacks. Tin all three pads, then push lead down onto pad with iron, while adding a little solder.

Band module SIP header jack: Make sure this is square to the board before soldering more than one lead.

Board mounting spacers. These threaded spacers solder directly to the board in the four corner holes. It will take some heat to do this. The spacers mount on the front side of the board (side with switches on it) and solder on the back side of the board. Using this type of spacer eliminates the need for nuts on the mounting screws, which were a pain to do.

Filter boards:

First, separate the filter boards from the groups of three by snapping along the scored line. You should have five resistors (0805 size, each a different value) left over from the main board assembly. These will be used on the filter boards so that the processor can identify which module is for which band. The resistor can only go in one place, near the center of the bottom side of the board. All the other parts will go on the opposite, top side of the board. Once you have soldered one of these resistors to a board, use the table below to identify which band that board will be used on. Then cross out or scratch out all the band numbers but the one for which that board is for. See photo below, left. Using a indelible marker to indicate the band on the component (top) side of the board is also a good idea.

Band	80M	40M	30M	20m	17M	15M
Value	100 K (104)	22 K (223)	10 K (103)	2.2 K (222)	470 (471)	51 (51)

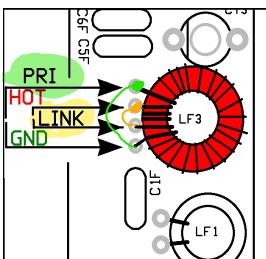


The table below lists the component values used for each band. (value marked on part) 1 turn on toroid = 1 pass through center of core. Wind wire on the core snugly, but not real tight. Wire lengths allow for $\frac{1}{2}$ " max starting pig tail. Note that #32 wire is used to wind the receiver input coils, this the smaller diameter (thinner) of the two wire sizes supplied.

Location	80 meters	40 meters	30 meters	20 meters	17 meters	15 meters
C1F	680 p (681)	330 p (331)	220p (221)	150p (151)	22p (22)	22p (22)
C2F	1500 p (152)	680 p (681)	560p (561)	330p (331)	220p (221)	220p (221)
C3F	100 p (101)	68 p (68)	47 p (47)	22 p (22)	15 p (15)	15 p (15)
C4F	680 p (681)	330 p (331)	220p (221)	150p (151)	100p (101)	100p (101)
C5F	100 p	NONE	NONE	NONE	NONE	NONE
C6F	15 p (15)	4.7 p (4.7)	4.7 p (4.7)	4.7 p (4.7)	2.2 p (2.2)	2.2 p (2.2)
C7F	22 p	NONE	NONE	NONE	NONE	NONE
CT2	brown	brown	green	green	green	green
CT3	brown	brown	green	green	green	green
LF1	T30-2 23T #30 (12")	T30-2 15T #30 (8")	T30-2 12T #30 (6")	T30-6 11T #30 (6")	T30-6 11T #30 (6")	T30-6 11T #30 (6")
LF2	T30-2 26T #30 (13")	T30-2 19T #30 (10")	T30-2 14T #30 (7")	T30-6 15T #30 (7.5")	T30-6 15T #30 (7.5")	T30-6 12T #30 (6")
LF3	T37-2 55T # 32 (28") 6 T link	T37-2 45T #32 (26") 4 T link	T37-7 (white) 50T #32 (27") 4 T link	T37-7 (white) 42T #32 (24") 4 T link	T30-2 27T #32 (16") 3 T link	T30-2 27T #32 (16") 3 T link
LF4 RFC	BRN/GRY/ BLK (18)	GRY/RED/ GOLD (8.2)	GRY/RED/ GOLD (8.2)	GRN/BLU/ GOLD (5.6)	ORG/ORG/ GOLD (3.3)	ORG/ORG/ GOLD (3.3)

Trimmer caps: make sure flat side faces line on location outline, towards center of board.

T-37-2 = large red, T37-7 = large white, T-30-2 = small red, T30-6 = small yellow



Tin wire ends before attempting to solder wire to pads on board!

LF3: This coil requires a secondary link winding. The link is wound between the ends of the primary turns. The best way to do this is to make a small loop at the end of the primary turns, then continue to wind the required number of link turns. Snip the loop to separate the primary winding from the link and twist the link wires together so they don't get mixed up with the primary. The link wires go into the two middle holes and the primary the two outer holes, as shown to the left. If these are mixed up, the trimmer won't peak the coil and receiver sensitivity will be very bad.

6 pin SIP pins mounted last, be sure it is flush and square to the board. Clip excess pin length and trimmer capacitor leads after soldering or they may short to lid of tin.

Check out and Calibration:

Clean the board of any flux residue. This will help in inspecting all the solder connections. "Electrical Parts Cleaner", available at most commercial electrical parts suppliers works well to remove flux. Denatured alcohol will also work. Avoid rubbing alcohol, as this leaves a white residue. Using your magnifier, inspect all the solder connections, looking in particular for any you might have missed making. Hopefully, you have all the ICs installed with the proper orientation and location, as this type of error is not easy to correct. Same goes with the caps, as it's now difficult to verify their correct values.

- If you have already installed L3, remove it before doing the initial power up tests.
- Use an ohm meter to check for shorts across the DC in, +3.5 and +5 regulator outputs to ground and between the regulator outputs and DC in, for both the 3.5 and 5 V regulators.
- Find and eliminate short if one is detected.
- Wire up a 9V supply to the power plug (Use 9V battery or current limited supply (set to 100 ma limiting) to start. This way, if there is a problem, its unlikely any damage will result from too much current being drawn.
- Plug a set of stereo headphones into the headphone jack.
- Plug in the power supply
- You should hear the power up message "8" in the headphones and see a "8" appear on the LED display. If you hear this message, you know the processor and audio amp are working fine.
- Check the voltage at TP1, it should be about 4 volts. If not, check connections on R19.
- Check the voltage on the PA gates, Q6 to Q8. This voltage should be zero (0) volts. If it is not, check solder connections on U8 pins.
- Plug a paddle into the paddle jack and send some dits and dahs. You should of course, hear them in the headphones.
- Connect a voltmeter between ground and the Drain of Q4, the PA keying transistor. (Large metal tab is Drain).
- Send a string of Dahs and watch the voltmeter. The voltage reading should go to near the DC supply input voltage. It should then slowly decay to zero when you stop sending. This is the voltmeter discharging the .1 uF bypass cap. Check the soldering in the keying circuit if there is a problem.
- Remove power from the board.
- You can now install L3.

Reference Oscillator Frequency Calibration:

The "ideal" reference frequency of 60.000000 MHz is initially assumed to calculate the DDS VFO frequency. In practice, the reference oscillator has a +/- 100 ppm tolerance. This tolerance can cause a fairly significant error between what the processor thinks the operating frequency is and what it really is. The error would be most noticeable on the higher bands, where the reference clock is less divided. Therefore, this calibration is provided to adjust the value of the reference frequency value used in the DDS frequency calculation to exactly match the actual oscillator frequency and therefore produce the expected operating frequency.

This calibration is most easily done with an accurate frequency counter. If you do not have access to one, but do have a rig with general coverage, good calibration and can tune to 10 MHz, then you can use that. If you can connect up a PSK program or other audio spectrum analyzer software which can show you the audio frequency of the signal from the rig's audio, this will help a lot. Set the rig to receive USB at 9.999,000 MHz. This will cause a 1 kHz beat note when a 10.000,000 MHz signal is received. The PSK waterfall can be used to show you when you have adjusted the DDS frequency to produce the exact 1 kHz beat note. A short pick up wire attached to a piece of coax going to the rigs antenna jack and placed near the TP1 test point should pick up plenty of signal. If you have no means of accurately measuring 10 MHz, skip through this procedure by clicking the **MENU** switch after step 6 and go directly to the LO cal procedure.

1. Click and hold closed both the **SPLIT** and **Tune DOWN** switches.
2. Apply power.
3. "V1" should be heard in the headphones. This is the firmware version number and can be used to determine which firmware version is in the rig. If the firmware has been updated, the number will change from 1 to 2 or 2 to 3 and so on as changes are made.
4. Continue to hold closed the SPLIT and Tune DOWN switches. Releasing the switches before the next CW annunciation will jump to normal power up sequence.
5. "CF" will be annunciated by the side tone and a "C" will appear on the LED display when calibration mode is enabled.
6. Release the switches.
7. Connect a frequency counter to DDS TP1.
8. Using the tune up and tune down switches, adjust the frequency at TP1 to exactly 10.000,000 MHz.
9. Once the frequency is adjusted, click the **MENU** switch to store the new reference frequency.

10. The side tone will now announce "CO" A low pitched tone will be heard in the headphones.

Local Oscillator frequency trim:

This is used to trim the LO frequency to exactly match the center response of the IF crystal filter. This will ensure the best sensitivity of the receiver. This adjustment is made with the help of an Oscilloscope. An audio spectrum analyzer program running on your PC would also work. A program of this type is located on the CD. If one isn't available, skip to step 5 and peak the BFO trimmer by ear. You can solder a short wire to TP2 and one of the headphone jack pins to hang a clip lead onto.

1. Connect a 'Scope to TP2 (pin 1 of U3) (2V / div, 1 ms / div sweep)
2. Preset the BFO trimmer cap (CT1) by giving it about a $\frac{1}{4}$ turn.
3. You should hear a pretty loud tone in the headphones.
4. Repetitively click the Tune Down switch to step the LO frequency through the pass band of the filter. Note when the signal at TP2 starts to decrease. Now start clicking the Tune Up switch and keep track of how many steps it takes before the signal starts to decrease again. This tells you how wide the filter is. (Each click (step) tunes about 10 Hz.) Divide the number of clicks by 2, then re-tune with the Tune Down switch that number of steps. The LO frequency will now be set to the center of the pass band of the filter.
5. Move the input to the Scope to one of the headphone jack pins.
6. Adjust the green BFO trimmer cap, CT1, and peak the audio signal at the headphone jack. This centers the beat note in the audio band pass filter.
7. Click the MENU button again to finish the calibration. The rig will reset and restart.

If the above calibrations worked, you know everything but the transmitter and filter boards are working properly. You can now go onto the testing and adjusting the band filters. Otherwise, go to the trouble shooting guide on page and track the reason the rig isn't working down.

Band filter test and adjustment:

Turn the power to the rig off and insert a band module. Temporarily connect an antenna jack to the antenna pad and ground on the main board, using short wires or coax. If possible, use regulated 9.0 volt supply or "AA" battery pack with new batteries.

1. Connect an antenna or signal generator to the antenna input.
2. Power up the rig. Peak the Rx input trimmer caps for best signal or peak band noise.
3. Turn rig off.
4. Disconnect the antenna and connect a power meter and dummy load.
5. Insert a straight key or paddle into the paddle jack. If using a paddle, hold the DASH paddle closed when turning the rig on, and hold closed until you hear the band annunciation. After that, the DOT paddle will work like a straight key.
6. Turn power back on. Key the rig and note power output. With a 9.0 V supply, power output should be 2 watts or more. With a 12.0 V supply, power out should be between 4 and 5 watts out.
7. If power output is off significantly, check capacitor values in the filter and number of turns on the coils. Make sure your using a watt meter which is accurate at these power levels.
8. Power output can be adjusted by changing the spacing between the turns on LF1 and LF2. LF1 generally has the most effect. Assuming the coils were wound with the wire more or less evenly spaced, you will find most of the coils need to have at least some of the turns moved closer together to archive at least 2.5 watts out. The 17 and 15 meter bands are most sensitive to these adjustments and will definitely need to be tweaked to achieve the desired power output.
9. You can remove and insert the filter board with power to the rig on, though moving the coils to the top of the board makes things easier. Ideally, you should shoot for about 2.5 watts out on all bands, using a 9.0 V supply and no more than 4.5 watts with a 12.0 volt supply.

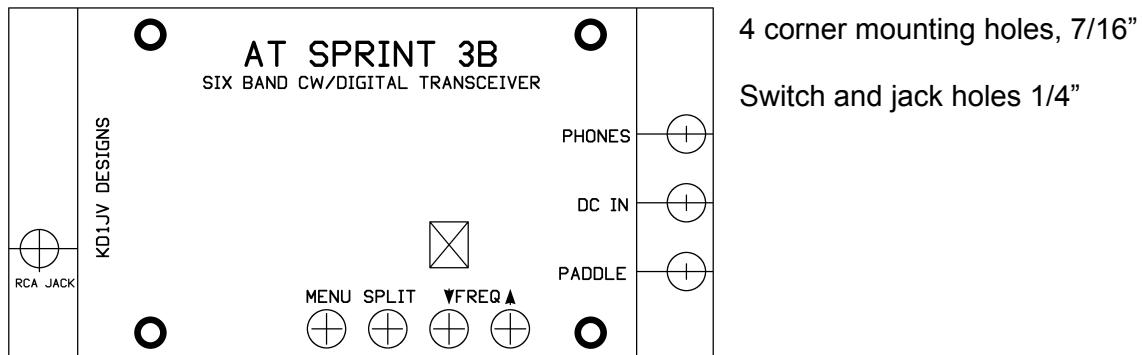
If you've gotten this far, Congratulations! Everything seems to be working and you can mount the rig into a tin and start operating.

Mounting the board into an Altoids tin:

Although other enclosures for the rig are possible, especially if ultra light weight is a goal, the board was designed to fit into the ubiquitous Altoids tin. The hinged lid of the tin makes it easy to get inside and change band filter modules. Don't worry about it not being rugged enough. I have carried my rig for literally 100's and 100's of miles along the Appalachian Trail,

though all kinds of weather. If it can stand up to this kind of abuse, it will defiantly stand up to typical daily use.

A drill template as shown below is included on the CD located in the "front panel templates" file folder so that the various holes can be marked on the tin for drilling. Both a bit mapped (.bmp) and .pdf version is included. The bit mapped file can be printed to scale using the "Paint" utility in Windows. [Start > all programs > Accessories > Paint] Before you print, check the Print Setup menu and make sure it is set to print 100% scale, not fit to page. You can also add color for making a front panel sticker. The .pdf version will also print to scale if the proper settings are used (print 100%).



Fold over the edge of the template at the line to the right of the "Phones, DC IN, Paddle" labels, then place the drill template on the outside, bottom of the tin. The hinge of the tin should be to the top. Carefully line up the template so that it is evenly spaced between the top and bottom edges of the tin and the folded in the template is directly over the right side edge of the tin, then tape it down. Use a sharp, pointed tool to mark the center of the holes on the tin and the center of the display window. Then use a sharp utility knife to cut out the display window to mark the edges of the window. Before drilling the switch and jack holes full size, drill 1/16" pilot holes first. Otherwise, the larger drill will "walk" when you drill and the holes will not be centered properly. Drilling a clean hole in the tin isn't easy. It helps to use a reasonably new and sharp bit. Clean up the edges with a small round file and square up the display window with a small flat file. The tin will likely deform some around the holes. I use the end of my Xacto knife to flatten it back out.

The .bmp drill template can also be used as front panel label. Background color can be added while in the Paint program, along with additional text or graphics if you desire. Printing on glossy photo paper with best quality print setting, then spraying a layer of clear Krylon makes a reasonably good looking and durable label.

A piece of red film is supplied to place over the display window. I tape it in place on the outside of the tin and then cover with the label. Double sided tape can be used to keep the edges of the label from curling up. A strip of felt can be placed over the switches before the board is mounted into the tin to help keep dirt out of them. Cut a small slit in the felt for the switch buttons to poke through.

Before the board will sit properly in the tin, the edges of the board on the side with the jacks will have to be rounded. Snip the corner off the board with your cutters and then round the edges with a file, back to nearly the edge of the mounting stand off. When putting the board into the tin, you will have to press slightly to make it snap past the rolled edges of tin. Secure the board to the tin with the four #2 screws. Install the RCA antenna jack and jumper the center pin to the "ANT" pad on the board and the ground lug to the near-by ground plane pad on the board.

Troubleshooting:

Hopefully, your rig performed flawlessly during the above tests and calibration. Unfortunately, this is not always the case. Specific trouble shooting advice is hard to give, the best we can do is go over some basics.

99.99% of the time, the reason a kit does not work is due to soldering issues. Therefore, this is the first thing to look for. Forgetting to solder one end of a chip resistor or cap is a common mistake. Sometimes, if a component is missing a solder connection, everything might seem to work alright at first, but then a problem shows up later after the board has been handled some. Twisting the board slightly can often make this kind of problem appear and disappear. A bad or missing solder connection to one or more of the 0603 pull up resistors for the MPU input pins can make it act strangely or lock up all together.

Sometimes an IC pin looks to be soldered, but the solder is just on the top of the lead and isn't actually connecting to the board pad. One way of identifying this problem is the "wiggle" the lead with the tip of an Xacto blade and see if it moves or not.

If the problem is not obvious from a simple visual inspection, try to localize the problem area. This is preferred to taking the "shot gun" approach of re-soldering everything. If all you have for test equipment is a DVM, you can only do a limited amount of troubleshooting. Ideally, you will have a 'Scope and a signal generator available for more intensive troubleshooting. If you don't own a 'Scope, maybe you can find someone local with one who would be willing to help you out.

When using a voltmeter or other probes on the 3.5 and 5 V regulator pins, be very careful. The input and output pins are adjacent, so there is a real possibility of shorting these together. If this happens and the raw DC is put on the regulator output, it will most likely fry all the ICs connected to that supply.

Specific problems:

Dead- D1 in backwards? 3.5 and 5.0 volt outputs from regulators okay?

Measure supply voltages at a place other than the output pin on the regulator it's self.

Power supply okay, no side tone on power up

Check solder connections on audio amp, U3 and surrounding part, headphone connector, side tone filter, R12, C51 and mute switch, U4. X6 connections, U6 connections, L7 etc.

Side tone okay, no audio during LO offset trim cal.

Check connections around mixers U1, U2 and mute switch, U4.

Check for DDS output

No DDS output

Check U7 for shorts between pins or pins not soldered to pads on board.

Check connections on all parts around DDS chip

Check for small DC bias voltage across R16. If there, set up data is getting to DDS chip.

Check connections on 60 MHz reference oscillator. NOTE: This is often the cause of no DDS output!

Little or no audio with antenna connected, okay during LO trim cal

Could be anywhere between antenna input and output of U1.

No transmit power out:

Check connections on keying transistors Q4, Q6 and associated parts. D4 maybe in backwards. Check solder connections on U8. Check connections on C48.

IC Voltage tables: Receive mode

P1	1.4V	RFIN	P8	5.0V	V+
P2	1.4V	RFIN	P7	4.3V	OSC
P3	0V	GND	P6	4.9V	OSC
P4	3.9V	OUT	P5	3.9V	OUT

U1/U2 SA612 mixer oscillator

P1	2.5V	OUT	P8	5.0V	V+
P2	2.5V	-IN	P7	2.5V	OUT
P3	2.5V	+IN	P6	2.5V	-IN
P4	0V	GND	P5	2.5V	+IN

U3 LM4808 audio amp

P1	5.0V	V+	P5	0.96V	Audio out
----			P4	0V	gnd
P2	0.34V	Vagc	P3	1.2V	IN

U5 Audio AGC

P1	2.2V	Audio in	P6	3.5V	Control
P2	0V	GND	P5	5V	V+
P3	0V	ST in	P4	2.2V	Audio out

U4 Analog SPDT switch

P1	0V	TEST	P28	3.5V	MUTE
P2	3.5V	V+	P27	3.5V	DDS
P3	0V	ST out	P26	3.5V	DDS
P4	0V	GND	P25	0V	DDS
P5	2.7V	osc	P24	0V	Tx key
P6	1.7V	osc	P23	3.5V	SPLIT
P7	3.5V	reset	P22	3.5V	TUNE DN
P8	3.5V	Dash in	P21	3.5V	MENU
P9	3.5V	Dot in	P20	0/3.5V	Band volt
P10	3.5V	Tune up	P19	.5 to 1.2	Batt V
P11	3.5V	7seg	P18	3.5V	7seg
P12	3.5V	7seg	P17	3.5V	7seg
P13	3.5V	7seg	P16	3.5V	7seg
P14	3.5V	7seg	P15	3.5V	7seg

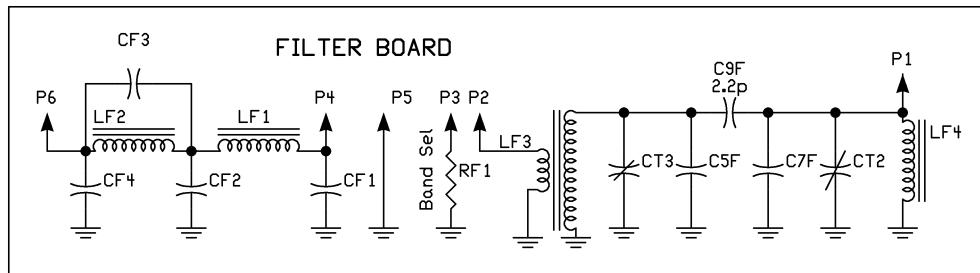
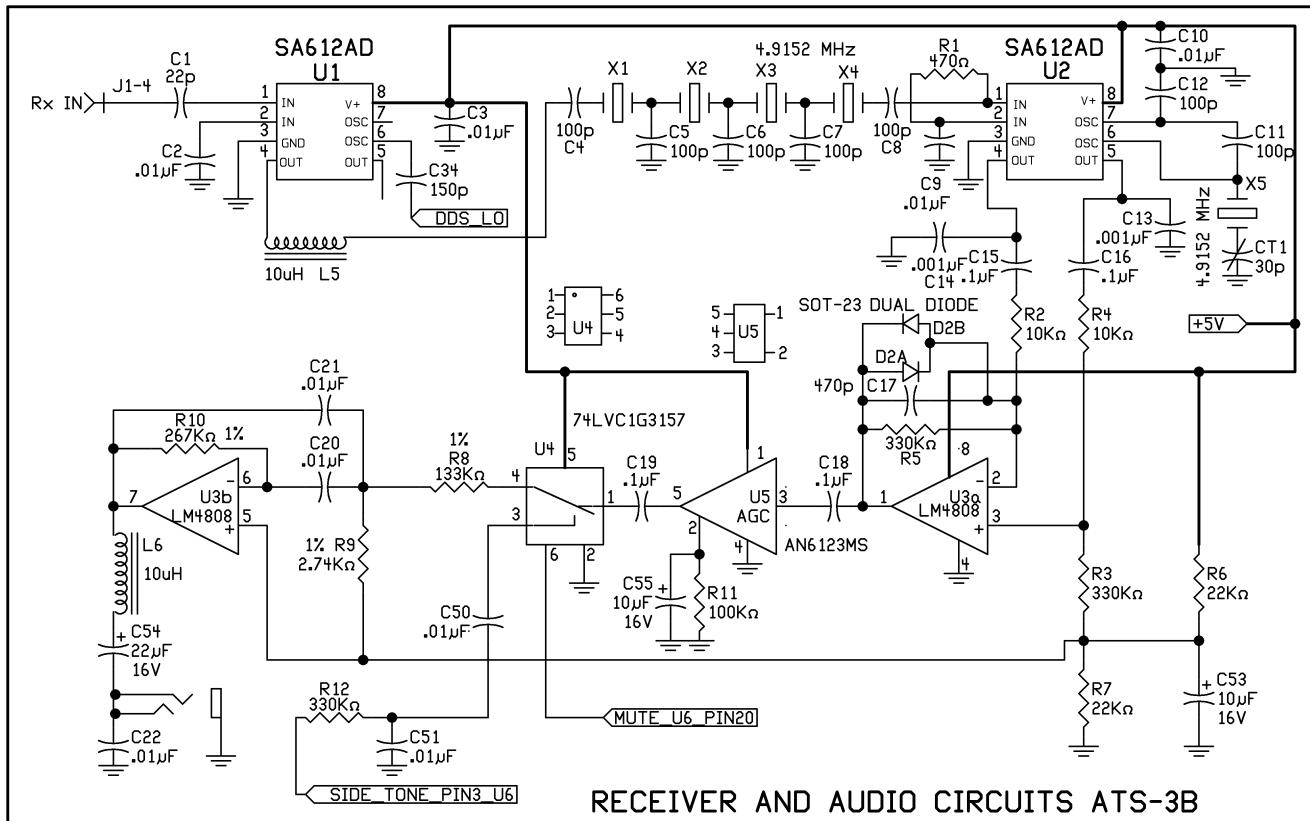
U6 MPS430 MPU

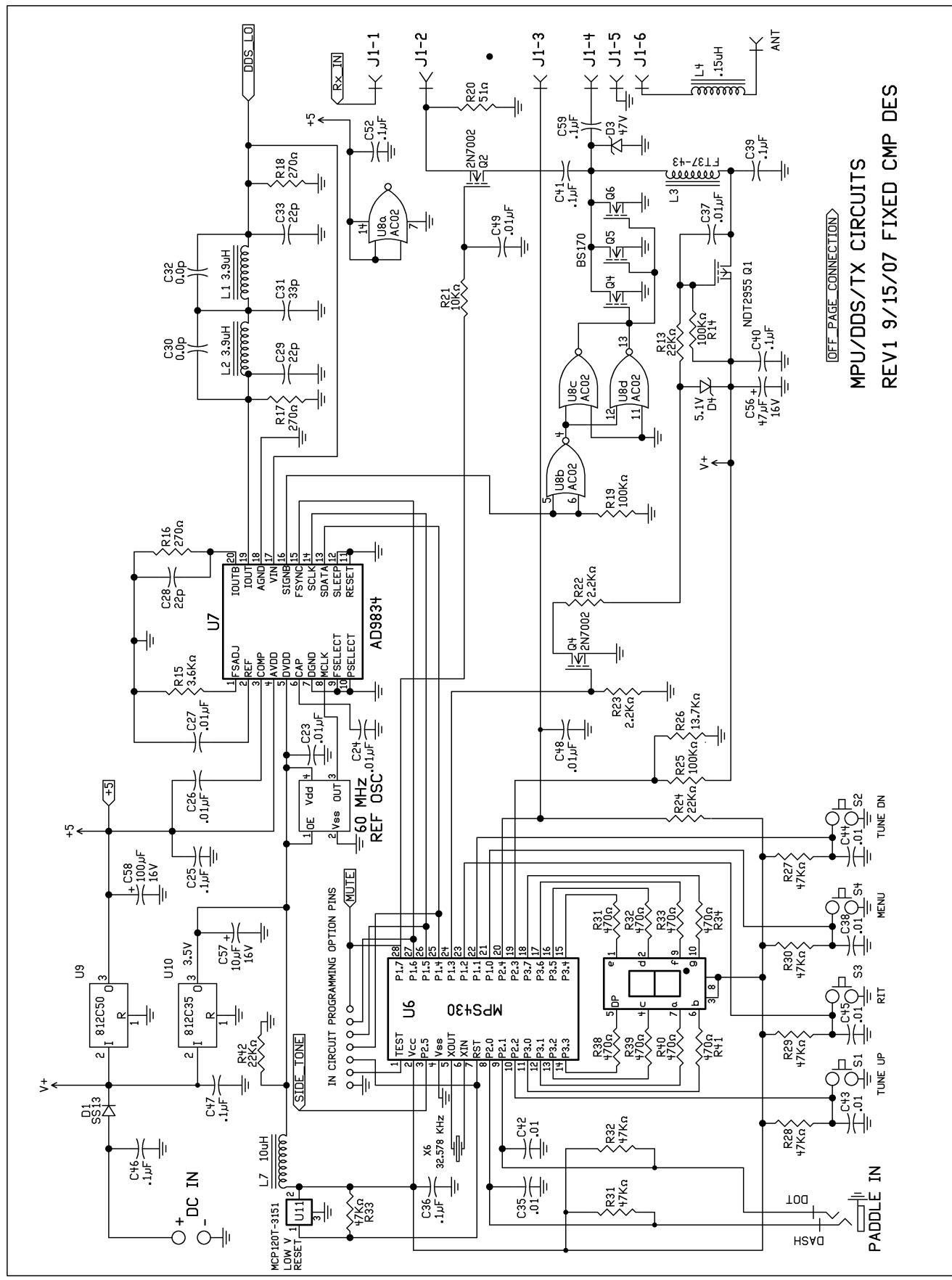
P1	1.13V	FS ADJ	P20	.75V	IOUTB
P2	1.17V	REF out	P19	.37V	IOUT
P3	3.54V	COMP	P18	0V	AGND
P4	5.0V	AVDD	P17	.37V	CMPin
P5	3.5V	DVDD	P16	3.75V	CMPout
P6	2.4V	CAP	P15	3.3V	FSYNC
P7	0V	DGND	P14	3.3V	SCLK
P8	1.7V	40 MHz	P13	0V	SDATA
P9	0V	Fsel	P12	0V	SLEEP
P10	0V	Psel	P11	0V	RESET

U7 AD9843 DDS

Schematics

Receiver section schematic;





Theory of Operation:

Controller:

A Texas Instruments MSP430 micro controller (MPU) is used to control the rig. This is a 16 bit processor, with 8K of Flash memory, 256 bytes of RAM, two 64 byte "information" Flash memory locations, 23 I/O ports, and internal 8 MHz R/C clock oscillator. The main reason this part was chosen was for its very low operating current, a mere 260 μ amps per MHz of clock frequency. An external 32.768 kHz watch crystal is used as a time base for the keyer and side tone oscillator. The internal 8 MHz R/C oscillator has a wide tolerance and is temperature dependent, making it less suitable for exact timing tasks.

The primary function of the processor is to control the DDS chip, which is the VFO for the rig. On power up, the processor looks at two pins on the filter board to determine which band is being used. From that, it then loads constants for the transmit frequency. The actual DDS phase accumulator data is then calculated for that operating frequency, based on the DDS reference oscillator frequency.

At the same time the transmit frequency is calculated, an IF offset is added or subtracted to the transmit frequency. This number is loaded into the DDS chip for use as the receiver's LO frequency. As the receiver is tuned up and down the band, a new phase word is calculated. This ensures that the actual operating frequency and the frequency the Audio frequency Announcer (AFA) closely match.

The secondary function of the processor is to implement an Iambic keyer, and to handle the various control functions which are needed to switch between receive and transmit. It also generates the side tone.

Power on reset:

The MPU will continue to run down to about 2 volts. Because of the MPU draws very little current, the filter cap across its supply line will keep it going for a while after power to the board is removed. Therefore, to ensure proper rest when power is quickly removed and restored, such as when changing band modules, a microprocessor supervisor reset chip is used to reset the processor when its supply voltage drops below 3.15 volts.

Software listing

There is a file on the CD called "ats3b_digi.s43" which is the program source code. The file can be opened and read by any word processing program. The software source code is included for those who might be interested in seeing what it takes to run this rig. Those who are into assembly language programming may want to get the IAR development package for the TI MPS430 processor so that they can modify and compile the program. The development program can be downloaded from the TI web site for free, but it's a big file. The board for the rig includes a place to connect an in-circuit programmer to (the row of holes above the MPU), so the MPU can be easily reprogrammed with the proper hardware.

DDS

The operating frequency of the rig is synthesized by an Analog Devices AD9834 DDS chip. This is a low power synthesizer, which can be clocked up to 75 MHz. The maximum output frequency in theory is $\frac{1}{2}$ the clock, but in practice it needs to be limited to about 1/3d to prevent the generation of difficult to filter spurious signals. The ATS-3B uses a 60 MHz reference clock, so that when producing a 21 MHz signal, it is near the 1/3d the clock limit. A 5 pole elliptical low pass filter smooths out the stepped DAC output of the DDS and removes harmonics.

The sine wave output of the filter is used to supply the LO signal to the receiver's first mixer. This signal is also fed back into the DDS chip, into a fast, on-chip comparator. This squares up the sine wave to produce a square wave output and is then used to drive the transmitter. This output can be conveniently turned on and off by software.

The DDS chip has two major sections inside, the digital side and analog side. This DDS chip can operate with different supply voltages on each section. Therefore, the digital side is powered by 3.5 volts and the analog side 5 volts. By running the digital section with 3.5 volts, lower operating current is achieved. This also keeps any digital noise on the 3.5 volts supply, which also powers the MPU, out of the analog section and reduces spurs. All in all, between the supply isolation, the low operating current of both the MPU and DDS, there is hardly a spur to be heard in the receiver.

Receiver:

The receiver is based on the classic NE602 (replaced by the SA612A) design, used in many QRP rigs. The receiver input signal from the antenna first passes through the transmitter's low pass filter. QSK switching is done by using a 2N7000 MOSFET transistors in a series between the PA output and receiver input.

The use of the MOSFET QSK switching greatly reduces or eliminates IMD problems which can be caused by a passive series L/C network with back to back limiting diodes at the L/C junction. This scheme is used in many QRP rigs, including the previous versions of this rig. It was found that even when using two diodes in series, enough voltage could be produced at the high impedance L/C junction by strong SWBC stations to cause the diodes to conduct. This would then cause IMD. To further improve performance in the presence of strong SWBC signals and to improve image rejection, double tuned input circuits are used on all bands. The first coil in the filter needs to be link coupled, so a toroid is used. The second coil in the circuit is directly coupled to the input of the first mixer, so a RFC is used here to eliminate the winding of six toroids.

The first mixer input is connected to the top of the tuned circuit, so it provides us with some passive gain. The input signal is then mixed with the LO frequency in U1 to provide an IF of 4.9152 MHz. The IF is filtered by four crystals. The filter is terminated by a 470 ohm resistor, which helps flatten out the filter response. Without the terminating resistor, the filter has noticeable peaks in the response.

The use of four crystals provides significantly better performance than the three crystals many other QRP rigs use. Four crystals provide somewhat more selectivity, but more importantly, they provide much better rejection of the opposite side band. You will be much less likely to be tricked into trying to contact a strong station on the wrong side band with the four crystal filter than with a three crystal filter.

The IF is then mixed in U2 with the BFO oscillator to produce the audio base band signal. 1000 pF caps from the output pins to ground helps eliminate RF mixer products and reduce high frequency hiss.

The output of the BFO mixer drives a differential input op amp. Using differential instead of single ended input effectively doubles the output of the mixer for a 6 dB voltage gain. It also eliminates any common mode signals which might be on the output of the mixer. This first stage provide a voltage gain of 33. A dual diode is connected across the amplifier feedback resistor to clamp strong signals. These diodes keep the following AGC amp from being overdriven, which causes distortion and charges the AGC hang cap to the point it takes a few seconds to recover.

The output of the first audio stage then goes into a Panasonic audio AGC amplifier, which provides an additional 26 dB of audio gain, before AGC action starts. This part was meant to be used as a microphone preamp and AGC in cell phones, but it works well here to eliminate the need for a volume control, which we have no room for.

The output of the AGC chip then goes into a SPDT analog switch. This switch is used to mute the receiver by disconnecting the preceding audio stages and connecting the side tone to the audio output stage.

Finally, the audio goes into the head phone driver stage, with up to 105 mw of output drive, which is also configured as audio band pass filter, with a gain of 1 and 600 Hz center frequency. The Q is a modest 5 and this helps to peak the CW beat note. A 10 uH choke and .01 uf bypass cap keeps RF out of the audio amplifier. Without this RF filtering on the audio output, RF pickup on the headphone leads could cause raspy side tone when using end feed or open wire feed antennas.

Transmitter:

The transmitter is about as simple as you can get. The square wave output of the DDS is buffered by a pair of 74AC02 NOR gates, connected in parallel. Since the output from the DDS is high impedance when turned off, a pull up resistor is added to keep the output of the NOR gates low when not transmitting. Two gates are used in parallel as that lowers the output impedance and is better capable of driving the gate capacitance of the power output FETs.

The RF power amplifier is comprised of three BS170 MOSFETs in parallel. The BS170's have a relatively high "on" resistance, so using three of them in parallel reduces their effective resistance and boosts efficiency. They also share the load, enabling higher power output. PA efficiency is about 70 to 75%

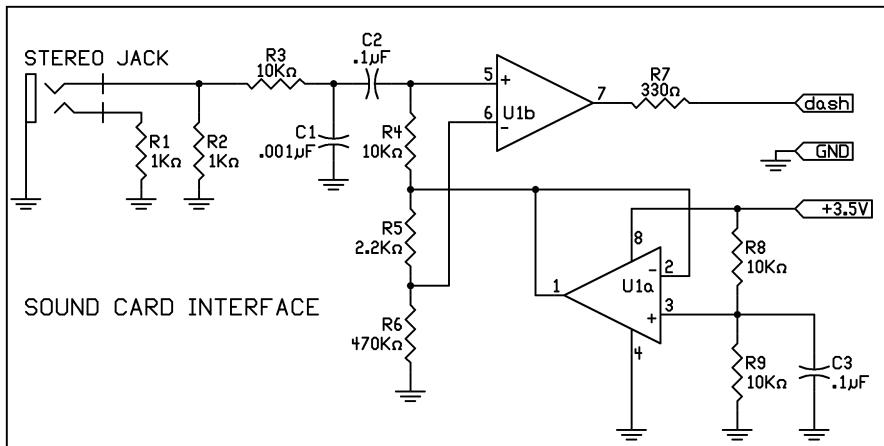
The drain to source break down voltage of the BS170's is a relatively low 60 volts. This can easily be exceeded when operating at 5 watts with a moderate SWR. Therefore, a 46 volt zener diode is added across the drain to clip the voltage. Even though a 1 watt diode is used, under conditions of very high SWR, the current can get high enough in the diode to cause it to short out. Therefore, very high SWR conditions should be avoided!

A low pass filter connects the output of the PA to the antenna. This filter provides both impedance matching and harmonic suppression. The second coil in the filter is tuned to the second harmonic with a parallel cap. This greatly reduces the second harmonic and helps increase efficiency of the PA. An additional small inductor, 0.15 uH is placed in series with the output of the LPF and the antenna terminal. This inductance, in combination with the connecting coax capacitance eliminates VHF spurs which can leak through the HF filter.

The PA is keyed by supplying power to the PA though a P Channel power MOSFET. A 0.01 ufd capacitor connected between the gate and drain output, in conjunction with the gate resistors develops a fairly linear 2 ms turn on and turn off ramp time so reduce keyclicks. A 5.1 volt zener connected between the supply voltage and the junction of two resistors in the gate leg resistor divider chain ensures a known voltage across the gate to keep the turn on and turn off ramp times consistent regardless of supply voltage.

Digital mode operation:

Before any digital mode can be used, you must build the digital interface shown below. The op amp must be a rail to rail output type which can operate at 3.5 volts, such as a ST microdevices TS-952. At the moment, kits are not available for this interface, but maybe at some time. If built with SMT parts, it can be made small enough to fit inside the Altoids tin along with the ATS-3B board, or it can be built into its own separate tin, which is likely the best way to do it. Two "AAA" batteries would power it for a long time, provided it has an on/off switch!



R1 and R2 are required when the interface is used in conjunction with a Pocket PC. Without these loads, the Pocket PC will turn the internal microphone off. R3 and C1 form a low pass filter, which cleans up the audio from the sound card, which has a lot of high frequency noise on it. R8 and R9 form a voltage divider to provide a bias voltage of $\frac{1}{2}$ the supply and is buffered by U1a to form a low impedance voltage source. R5 and R6 form another voltage divider so that the non-inverting (+) input to U1b is slightly more positive than the inverting input when there is no signal input. This ensures the output of U1b will be in a high state when not being used and will not interfere with normal paddle operation if it left connected to the dash input all the time. Like wise, R7 isolates the output of the U1b op amp from the dash input so it will not interfere with normal paddle operation. A sine wave audio input applied to the stereo jack will be converted to a square wave on the output of U1b. The input must be of sufficient amplitude to ensure switching occurs at or near the zero crossings so that a 50% duty cycle square wave output is obtained.

Entering ATS3-B into digital mode operation:

Click and hold the MENU switch until the letter "D" is sounded by the side tone and appears on the 7 segment display (as a lower case "d").

Once in digital mode, only the quick Menu functions of frequency and battery voltage are available. The Frequency tune switches work as normal. A direct frequency entry is available in the Pocketdigi application. A click and hold of the Menu switch exits digital mode.

Running Pocketdigi:

The Pocketdigi program is located in a folder on the CD. There are two zipped folders. The one which the names ends with _X86 is for use with Windows operating systems in either a Desktop or Laptop PC. The one which name ends with _ARM has versions for use a PDA using Windows CE or Window mobile. The file named "Pocketdigi" is used in a PDA. The one named htx2000 is for hand held PC's, which are larger than a PDA. Unzip the files in the folder to one on your PC. A good place to put it would be in "My Documents" so it can be easily found. Pocketdigi runs as an executable file. It does not install as a program file. Simply click on the file name to run it. If the Windows firewall is active, you will be asked if you really want to run it. Of course you do, click yes.

A comprehensive operations manual for Pocketdigi has yet to be written. Vojtech is waiting for someone to volunteer. Most of the functions are self evident and intuitive, working in much the same way as programs you are probably familiar with.

The screen is divided into three sections. The top is the waterfall. The operating frequency is set by tapping or clicking on the waterfall above the scale showing the frequency, or on a signal trail. The center section is the received text screen and the

bottom section is the transmitted text screen. If you're using a PDA, when you activate the on screen keyboard, these windows will shrink so the keyboard is not covering up anything.

Along the bottom of the screen are the menus. These are [Tools] [Channels] Macros] and [CAT] each has a pull up sub menu when selected. In the Desktop version, the menus are at the top of the screen.

Tools contains Tune, Replay, Setup, Waterfall, Tx Volume, About, Device info and Exit. It is best to use Exit when quitting the program, as this will shut it down.

Channels contains the mode selection sub menu, AFC control, Squelch and the like.

Macros contains the various macros which can be set and the edit macro function. More on this later.

CAT allows setting the frequency of the rig.

When you run the program for the first time, there are a few things you need to set up. First you might want to type in your station info. Next you need to tell it you want to use the ATS rig with it. Select Tools > Setup > TRX Control. When you select TRX Control, an error message saying it was unable to connect to Bluetooth system will appear. Simply click on the ok button and the TRX control setup screen will be shown. Select the "ATS3/Manchester" option.

Calibration:

NOTE: Since pocketdigi uses the sound card to communicate to the ATS3 rig, all program sounds, alarms, screen taps, etc must be turned off. These sounds can confuse the ATS3.

Connect the sound card interface to the ATS-3B rig, then connect the PC running Pocketdigi to the interface and set the ATS-3B into digital mode. Return to the TRX Control screen. There is a button labeled "TEST". Clicking this button should make the side tone in the ATS-3B annunciate the Morse letters "PDGI". If it does not, increase the speaker or Tx volume of the sound card until it does. The sound level should be set a little above the minimum needed to get the response from the rig. If you do not get the annunciation even with the volume turned all the way up, then there is likely a problem with the interface board.

Offset adjustment:

Below the ATS3/Manchester selection on the TXR Control screen, there is a field called "offset" and is set to 577 Hz. This offset number will have to be adjusted to exactly match the offset in the ATS-3B rig. There is likely to be some difference between the exact transmit and receive frequencies fall due to the setting of the BFO trimmer and tolerances in the capacitor values used in the audio filter.

In order to set the offset correctly, you need to set up a separate PSK31 station so that you can talk to yourself. Using dummy loads instead of antennas, of course. Since you're not actually transmitting on the air, you can use the default power up frequency of the ATS on the band you happen to choose to use, though it is best to use one of the higher bands, as this will compensate for any DDS calibration errors which are more pronounced on the higher bands. If you're using a Pocket PC (aka PDA) with the ATS-3B, receiver audio is coupled into the PDA using its built in microphone. Place an earbud from the phones jack of the ATS-3B over the microphone slots on the PDA. If you're using the Desktop program, you can jumper the headphone output directly into the MIC jack on the PC.

1. Set the marker on the Pocketdigi water fall to exactly 600 Hz. (tap the screen just above the frequency ruler)
2. In the Channels sub menu, verify Pocketdigi is in BPSK31 mode and AFC is turned off
3. Set the ATS-3B to transmit by clicking on the lightning bolt to the right of CAT. Note that when transmitting, the side tone reproduces the modulation tones and can be heard in the headphones.
4. Find the ATS-3B signal with the other receiver and select the signal on the waterfall. Its AFC should also be turned off.
5. Return to receive mode on the Pocketdigi by clicking the lightning bolt again.
6. Transmit a signal with the other rig.
7. Check the frequency of where the other rig is transmitting at on the Pocketdigi water fall. Tune the transmit frequency until it is centered at 600 Hz and note how far the frequency had to be changed to align it to 600 Hz.
8. Add (if you had to tune down in frequency) or add (if you had to tune up in frequency) the difference between the initial transmit frequency and final frequency to the offset value in the Pocketdigi set up menu. Tap on the number and use the keyboard to change it. You will have to go through and exit the setup > Tx control menu each time you need to change and then check the offset value
9. Repeat steps 3 to 8 until both rigs are transmitting and receiving on the exact same frequency.

Now that the offset has been set, you can talk between your other rig and the ATS-3B. Try sending the macros and try different modulation modes.

Using the CAT function.

This function allows for setting the operating frequency of the rig.

Selecting CAT then [Frequency] will bring up a numeric keypad. Five digits must be entered but the first one is a “don’t care” place holder digit. It can be any number other than zero. Do not use the decimal point. The remaining digits will be the 100 kHz, 10 kHz, 1 kHz and 100 Hz digits of the frequency you want to go to. Once you enter the frequency, tap on SET to transfer the information to the ATS-3B. It is possible to set the frequency of the rig outside of the normal tuning limits of the rig. Doing this is not recommended.

Using Macros:

Some of the Marcos are not complete and are missing the return to receive statement \$rx, so this will have to be added or the rig will stay in transmit. Here is a list of the various macro commands which can be inserted into the text.

\$\$ - The letter '\$'
\${autocq:xx} - Start tx. After \$rx macro, go to RX mode for xx seconds and then restart this macro again.
\$tx - Push the TX button.
\$rx - Switch to receive.
\$mycall - Call sign as defined in preferences.
\$myname - Name as defined in preferences.
\$myqth - QTH as defined in preferences.
\$myloc - Locater as defined in preferences.
\$myemail - Email address as defined in preferences.
\$time - Local time.
\$utctime - Universal Coordinated Time.
\$date - Local date.
\$utcdate - UTC date.
\$call - Other parties call sign taken from QSO data.
\$band - Band taken from QSO data.
\$rxrst - Received RST taken from QSO data.
\$txrst - Transmitted RST taken from QSO data.
\$name - Other parties name taken from QSO data.
\$qth - Other parties QTH taken from QSO data.
\$notes - Notes taken from QSO data.
\$soft - Software version.

Making QSOs:

Because the bandwidth of the ATS-3B is so narrow, you have to tune stations in to get them into the pass band. Once in the pass band of the receiver and you have good copy on them, you can match their frequency by tapping on the waterfall. This is very handy, as the 50 Hz tuning steps are a little too coarse to exactly match other stations frequencies. Even if they are using AFC, you have to be pretty close to begin with for them to know your trying to contact them.