AT SPRINT III

An ultra small, ultra light, trail friendly rig.

Users manual

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REV C 1-13-05
REV D 2-4-05

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Introduction:

The AT Sprint 3 is designed to provide the greatest amount of performance in the smallest and lightest package. This is achieved by using a relatively simple, but very effective, receiver and transmitter design, built with extensive use of surface mounted parts. The use of a Direct Digital Synthesized VFO and Microprocessor allows for simple multi-band operation with an exceptionally stable VFO. All this makes the rig an ideal choice for use while backpacking or traveling. Due to its exceptionally light weight, previous versions of the AT Sprint have become popular with those who wish to be very competitive in the monthly ARS "Spartan Sprint" contests. ATS rigs seem to always place in the top 10. This new -3 version will be even harder to beat!

Specifications:

General

- 80, 40, 30 and 20 meter operation
- Direct Digital Synthesizer VFO
- Push button operation
- Size: 3.2" long X 2.1" wide x 3/4 " tall
- Weight – 1.0 oz with one filter board installed
- 5.5 to 12 volt operating voltage
- Receive current, 25 ma typical, no signal

Receiver

- Super-Heterodyne, single conversion, 4.9512 MHz IF
- 0.2 uv typical MSD
- Four crystal IF filter, excellent opposite side band rejection.
- Audio band pass filtering, peaked at 600 Hz
- 300 Hz band width. (@ -15 dB)
- "wide band signal" DSB receiver mode
- Audio AGC
- 100 mw headphone driver amplifier

Transmitter

- Efficient FET RF power amplifier, up to 5 watts out with 12 volt supply, 2.5 watts output at 9 volts, 900 mW at 6 volts. Power output consistent on all bands.
- 500 ma typical Tx current at 9V, 2.5 watts out
- Spurious: -40 dBc max.

CW

- Iambic keyer, 10 to 40 wpm in 1 wpm steps, selectable A or B mode Iambic operation
- Auto straight key detect (on power up)
- 124 character Keyer message memory, with paddle controlled pause, stop and beacon mode.
- Up to three separate keyer messages possible
- 600 Hz side tone

Operation:

Band selection:

Disconnect power if the rig is on and plug the desired operating band module into the main board. Restore power and the rig will power up on one of the following QRP frequencies. (as determined by the installed band module)

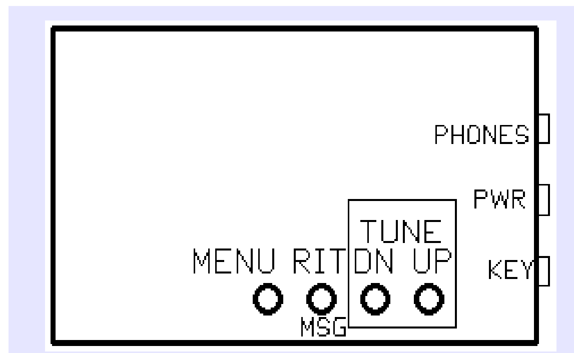
80M: 3.560 MHz **40M:** 7.040 MHz **30M:** 10.110 MHz **20M:** 14.060 MHz

Power on/off

Power is applied and removed by using the external power jack and plug.
On power up, the message ATS-X will sound, with X being the band module in use, 8 for 80M, 4 for 40M, 3 for 30M and 2 for 20M.

Controls:

The rig is operated by using four push button switches, locations shown in diagram to right. These are best operated by "clicking" them side to side, rather than actually pushing down on them. Switches may have more than one function, depending on the option selected by the "MENU" switch.



<u>Tune up / Tune down</u>

The operating frequency is tuned in 50 Hz steps by clicking the "Tune up" or "Tune down" switches. A single click of the switch will tune in a single 50 Hz step. If the switch is held closed for longer then one (1) second, the frequency will automatically start to tune at about a 10 step per second rate, until the switch is released.

Band limits:

A double beep ("I") will sound by the side tone at the upper and lower limits of the CW segment of the band in use. However, the rig will not stop tuning at these limits. This allows tuning into the phone segment of the band, or out side of the ham bands completely.

<u>RIT (Receive Incremental Tuning) and XIT (Transmitter Incremental Tuning)</u>

RIT: Click and hold the RIT switch for about one (1) second until "R" is annunciated. RIT is now active. Tuning the rig will now change the receiver frequency, leaving the transmitter frequency set to where it was when RIT was enabled.

XIT: Click and hold the RIT switch for one (1) second past the annunciation "R", until the letter "X" is sent. XIT is now active and now the transmitter frequency changes with tuning and the receiver frequency stays fixed. Be careful when using XIT, as there is no way to check the new transmit frequency to see if it is being used by someone else, though this isn't too much of a concern if your using XIT during a DX pile up or chasing the QRP-L FOX.

When RIT or XIT mode is entered, the frequency readout is zeroed. In addition, 1 kHz marker "beep" will sound each time you move 1 kHz from the initial start frequency. A double beep will sound when you hit the original start frequency again. This makes it easy to "go up" or "go down" 1 or 2 kHz. When tuning below the start frequency, the AFA will read out "99--", so you have to do a little mental arithmetic if you want to know exactly how far you've moved down in frequency.

Exiting RIT/XIT

Click and hold RIT again until a beep sounds. The keyer memory is still active while in these modes, so be sure to hold the switch closed long enough as to not send the message (if there is one stored)

NOTE: Since there is no visual indication RIT/XIT is active, be sure to exit RIT mode before starting to tune around the band again!

MENU:

This switch is used to access the various options available. Clicking and **holding closed** the menu switch will scroll through the options. A single Morse character will be annunciated by the side tone to indicate the option. Release the menu button after the desired option character sounds, and before the next, to activate that option. Note that the MENU switch must be held closed for 1 second before the Set Speed options letter "S" is annunciated. If the switch is released before 1 second has elapsed, the frequency reads out.

Options are selected in the following order:

1. **F – Frequency readout**
2. **S – Set Keyer Speed**
3. **E – Direct Frequency Entry (Skipped if in Straight key mode)**
4. **T – Antenna Tune Mode (Skipped if in Straight key mode)**
5. **M – Enter Keyer Memory Mode (Skipped if in Straight key mode)**
6. **W – Wide band reception mode**
7. **P -- Program user preference, Iambic A/B mode, Morse annunciation speed.**
8. **X – eXit menu selections**

***Frequency readout:* (F)**

A short, quick click of MENU switch will annunciated the current operating frequency in Morse by the side tone. Zeros are sent as the cut number "T" (dash) and the 100 Hz digit is separated from the kHz digits with an "R". Therefore, the frequency 7.0400 will be sent as "T4TRT" When is RIT or XIT mode, the 100 kHz digit is replaced by the letter R or X, and the frequency indicates the amount the current frequency has moved from the initial operating frequency.

Set Keyer Speed: ***(S)***

Keyer speed can be set between 10 and 40 wpm, in 1 wpm increments. (power up, 20 wpm)

Dash paddle increases speed.
Dot paddle decreases speed.

A dot will sound at the new code speed each time it is changed. A dash will sound when the upper or lower speed limit is reached. Speed mode automatically exits when paddle or switches left open for a second. The selected code speed is stored in memory, so the rig will power up at the last used code speed setting.

Alternately, the Tune up (increase) or Tune down (decrease) switches can be used. This allows for changing the code speed if the rig is in Straight key mode.

Direct Frequency Entry: ***(E)***

This mode allows you to jump directly to a desired operating frequency by entering it in with the paddle. This can be any frequency between 000.0 and 999.9 kHz. Key in all four digits, 100 kHz digit first. Zeros can be entered full length or as the cut number "T". If a character is not recognized as a valid number, a "?" will be sent and that number needs to re-entered. Once all four digits have been entered, the rig will jump to that frequency and the new frequency will be annunciated by the side tone. This mode can be escaped by clicking the MODE switch anytime before all four digits have been entered. DFE mode is not available when RIT or XIT is active.

Antenna Tune Mode: ***(T)***

This mode is used to facilitate adjusting an antenna tuner. The transmitter is toggled on and off by using the paddles. Tapping the DASH paddle toggles the transmitter ON. Tapping the DOT paddle toggles the transmitter OFF.

When finished with tune mode, return to normal operation by clicking MENU.

Enter Keyer Memory Mode: ***(M)***

In this mode, a message is keyed into memory, using the paddle. "Ideal" timing is used to determine letter and word spacing. If you do not pause sufficiently between letters and words, the message will come out garbled. To insure inserting word spaces, it is a good idea to pause slightly longer than you might otherwise do so between words.

Up to 124 characters (including word spaces) maybe stored in the memory. This can be divided up into three separate messages. All the messages must be entered at the same time. To indicate a new message is to be started, key in seven (7) dashes, then continue with the next message.

Review and storing the message:

Once the message(s) have been keyed in, click the MENU button. The message(s) will now be repeated, so you can hear if they were keyed in properly or need to be re-entered. If more than one message was entered, you will here the seven dash break separating the messages.

If the message(s) play back the way you want to hear it, click the **MENU** button again to store the message(s) in Flash memory. If you need to re-enter the message(s), press the **RIT** button. The side tone will annunciate "EM" for Enter Message" and you can start to key in the messages again. If more than one message is desired, they all have to re-entered. Repeat as needed until you get it all right and press **MENU** to store.

Sending the message from memory:

A short click of the **RIT** switch will start sending message 1. Message 2 is sent if the **TUNE DOWN** button is clicked within 1/3d second of releasing the RIT switch. Message 3 is sent if the **TUNE UP** switch is clicked within 1/3d second of releasing RIT.

Stop, Pause and Beacon Mode:

Once the message has started sending, the paddle can be used to stop, pause or enable beacon mode. Paddle state (open/closed) is tested during letter spaces.

Pause:

Close and hold the Dash Paddle. Message will pause once a character being sent is finished. Releasing the Dash paddle will resume sending of the message.

Stop:

Close and hold the Dot paddle. This will terminate the sending of the message, once a character currently being send it finished. If sending a message in Straight Key mode, closing the SK will also stop the message at the first letter space.

Beacon Mode:

Close and hold the Dash Paddle to pause message. While holding closed the Dash paddle, tap the Dot paddle closed. A "beep" will sound in the side tone and beacon mode initiated. There is a fixed 4 second delay at the end of the message before it starts to repeat. Using the paddle during the pause will terminate the beacon mode and jump directly into keying the rig. Pause and stop functions work as above while the message is being sent.

NOTE: Beacon mode can only be used with message 1. If it beacon mode is enabled while sending message 2 or 3, message 1 will still be sent.

Beacon mode may also be enabled by using the menu switch. Click and hold the Menu switch as the message is being sent as above.

***Wide Band Reception Mode:* (W)**

In Wide Band Reception mode, the IF crystal filter is bypassed. This results in double side band reception. Both SSB and AM signal can be tuned in. In this mode, signals are zero beaten at the BFO offset frequency. Return to narrow band CW reception by accessing this option again.

NOTE: While in Wide Band Mode, the AFA will read 600 Hz low, as your now tuned to the BFO oscillator offset frequency and this is not corrected for.

Cross mode communication:

While in wide band mode, it is possible to talk to a SSB station using CW. The CW Tx offset is automatically adjusted to produce a 600 Hz tone in a SSB receiver. Simply tune in the station for best clarity of speech and they will hear a proper CW note when you transmit. Note that in wide band mode, you will be zero beating to the BFO frequency, which will make the frequency readout appear to be off by that amount (600 Hz)

Tuning outside of the nominal 1 MHz band window.

The DFE function gives quick and direct access to any frequency inside a 1 MHz window, set by the particular band module installed at the time. However, you may want to tune outside that window to listen to a SWBC station in say the 31 or 49 meter band. To do this, use the DFE function to tune to the upper or lower limit of the 1 MHz window, 000.0 or 999.9 kHz. Then manually tune up or down to get into the next 1 MHz window. Once this is done, you can again use DFE to go to a specific frequency.

NOTE: The transmitter is NOT locked out when you are tuned outside the ham bands. Therefore, be careful not to key the transmitter when you are!

***Program User preferences:* (P)**

Iambic keying mode: The Tune Down switch will toggle between mode A and B. The letter A or B will be annunciated to indicate which mode will be active.

Annunciator code speed: Clicking the Tune Up switch will store the current keyer speed to be used for all non transmitted Morse character annunciations, AFA, Menu selections, etc.

Once your selections have been made, store them by clicking the MODE switch.

Iambic A and B modes

When using Iambic or “squeeze” keying, that is, both paddles are closed at the same time, the keyer produces alternating elements, starting with the element which was closed first. In “A” mode, the keyer will stop sending when the paddles are released and any element which is currently being send is finished. In “B” mode, if both paddles are closed at the very start of a space, an opposite element will be tacked onto the end of the string when the paddles are released. If an extra element is not desired, release the paddles before the start of the space.

Straight Key Mode:

The rig will automatically enter Straight Key Mode if a monaural plug is used in the paddle jack on power up. As noted above, menu options which require a paddle to use are locked out in Straight key mode. If a message has been programmed into memory, it can be used as usual. The code speed at which the message is sent can be changed by using the Tune up and Tune down switches, by selecting the Code Speed option with the Menu switch.

MENU function cheat sheet

Frequency 100 kHz first, 100 Hz last, “R” before 100 Hz
S – Keyer speed Dash/Tune up increase Dot/Tune down decrease
E – Direct Frequency Entry (use paddle) Menu to escape
T – Tune mode, dash on / dot off MENU to end
M – Keyer Memory Memo – review / RIT- re-enter / Menu – Store
W – Wide band reception – toggle on, toggle off
P – User preferences Tune up – toggle A/B iambic mode Tune down – store current code speed for annunciations Menu – store and activate

Printed out, this will fit inside the lid of an Altoids tin.

Various considerations:

SWR

The ATS-3 transmitter can be keyed into an open circuit (no antenna connected) indefinitely. It will also tolerate a short circuit for relatively short periods of time, say 30 seconds. After this, the PA transistors start to get alarmingly hot! However, highly reactive loads need to be avoided. Highly reactive loads can possibly cause the PA stage to become unstable. Although the PA is protected by a 46 volt zener diode across the drain/source terminals, very high SWR can cause the zener to heat up excessively and fail, usually by shorting. Possible problems with high SWR are most likely to happen if the rig is powered by a 12 volt supply and the transmitter producing a full 5 watts out.

Intermod problems.

The receiver may experience intermod problems, noted by hearing a heterodyne at 5 kHz intervals. This is mostly a problem at night on 40 M, when we encounter strong SWBC stations. The extent of the problem depends greatly on where in the country you live and the type of antenna you use. If you use a resonate dipole antenna, its unlikely you will note any problems. A non-resonate antenna, such as an “88” and tuned with a Z-match tuner seems to have the greatest amount of trouble.

Paddle jack wiring:

“Standard” wiring is used. Dot = tip, Dash = ring, Sleeve = ground.

Power Supply:

Operation with a 13.8V bench supply is not recommended, as this may stress the RF output transistors. Drop the voltage down to about 12 volts using a string of two or three 1A silicon rectifier diodes in series. Gell cells are okay, as once off the charger, they quickly settle down to just over 12 volts. A 9V alkaline battery will power the rig nicely for a 2 hr sprint. A “AAA” battery pack will give a solid weekend of performance and six “AA” alkaline or lithium batteries will supply better than 3 watts out for a good long time.

DC Power plug – Mouser part # 171-3218 .7mm

Working with SMT parts:

If you have never worked with surface mounted parts before, it's not very difficult and can be an enjoyable experience. This section describes the tools and techniques you will need.

Tools:

At a minimum, you will need:

1. Tweezers
2. Magnifier (visor, lighted, hand held glass, etc.)
3. Hobby knife, such as Xacto™ with #11 blade
4. Small tipped soldering iron, (1/16" conical or chisel) 25-30 watts or temperature controlled.
5. Needle noise pliers, diagonal cutters, small screw driver.
6. Good light
7. Steady hands.
8. Optional SMT part hold down device.

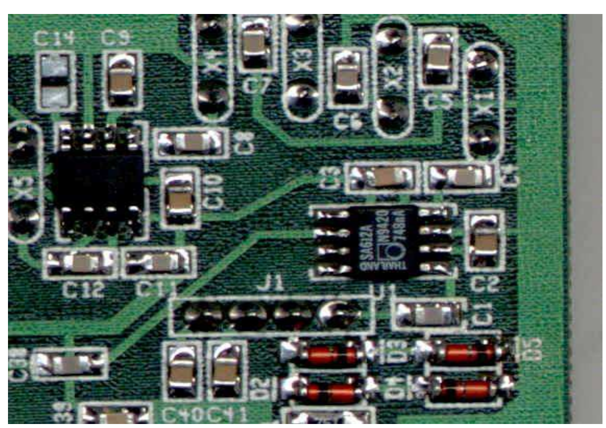
Instead of, or in addition to the tweezers, you can use a tooth pick with a dab of bee's wax on the end to make it sticky. With this, you can pick up the small parts and hold them down while you solder. A problem with tweezers can be if you grasp the part too tightly, it can spring out and go flying, never be seen again.

Removing the parts from the carrier

Many of the parts need to be removed from their carriers before use. A clear strip of plastic needs to be peeled off to expose the part for removal. To avoid loosing a part, this is best done by holding the carrier in one hand, in front of you and against your work surface, then peel off the plastic cover using your tweezers. Once the plastic is peeled off, tip the carrier over to drop out the parts in front of you.

Soldering:

Some very thin (.010") solder is supplied with the kit for use with the SMT parts. (If you need more, Radio Shack sells this) Very little solder per connection is needed. Ideally, you want just a tiny concave fillet between the end of the part and the pad. The picture to the left shows examples of SMT soldering.



Chip caps, resistors and other two leaded parts.

1. Lightly tin one of the two pads.
2. Use the tip of your hobby knife or tweezers to peel back the clear cover on the parts carrier and then spill them out onto a clear work space above the board.
3. Pick up the part and place it over the pads. Try to keep it centered and squared over the pads.
4. Apply a little heat with the iron to tack the part to the tined pad.
5. Solder the other end, be sure to heat both the end of the part and the pad at the same time.
6. If needed, return to the tacked end and apply a little fresh solder. Resistors are more likely to need this than capacitors.
7. When placing a number of the same value part to the board, you can speed things up a bit by tinning the pads for several locations at once. Tack the parts down and go back and do the other end. Just be sure not to miss any!

Soldering IC's

1. Lightly tin one corner pad.
2. Place the IC and line up the pins over the pads A little dab of Bee's wax under the chip can help hold it in place.
3. Tack down the corner pin to the tinned pad.
4. Verify the lead alignment on the pads. This is very important!
5. Proceed to solder the rest of the pins to the pads, usually starting at the opposite corner from the one you just tacked down. Ideally, you want a little solder to flow between the IC pin and pad. Therefore, don't hold the IC against the board very tightly, just enough pressure to keep it from moving as you tack the first pin.
6. Don't worry much about making solder shorts, especially with the fine lead spaced parts. See step #7.
7. Inspect the soldering with your magnifying glass. If there are any solder shorts, use solder wick to remove the bridge. Use the tip of the hobby knife to gently 'Nudge" the leads. If any of them move, you didn't get them to stick to the pad and need to be touched up.

Removing IC's

Should you ever need to remove a SMT IC, with out damage to the part or the board tracks, this is the way to do it. First, wick as much solder as possible from the leads. Now feed a piece of #32 magnet wire between the leads and the body of the IC. Secure one end of the wire to something on the board. Now grab the free end of the wire and as you heat the first pin on the IC, pull the wire out between the lead and the track. Keep doing this for each pin in line down the chip. Repeat for the other side. The IC will now pretty much just pop off the board. (But you might have to loosen up one or two of the end pins with a tad more heat)

Using Liquid Solder Flux:

Please don't! Its impossible to fully clean out from under parts and will cause leakage paths in high impedance areas which will cause the circuits to misbehave be erratic. The stuff is nothing but trouble so avoid it. Save it for pluming jobs.

Before starting the kit:

Before you start "melting solder", be sure to read all the assembly instructions first. Familiarize yourself with the order in which the board is assembled. **Parts are installed on both sides of the board, so be sure you note which ones these are.**

Having the manual in electronic format makes it possible to include many more pictures and diagrams than a simple manual done with a copy machine would have allowed. However, it does make things a little more difficult for you, as not all of you will have a PC and monitor at your work bench. If you have a lap top, that's an option. Many of you will want to print out parts of the manual to refer to. There is no real need to print the entire manual, just the pages with the parts placement information. A large parts layout is found in the next section which can be printed out with best quality printer setting as an aid to parts placement.

Parts packaging

To prevent losing any of the small parts, it is a very good idea to empty the contents of the bags into soup or cereal bowels. This is especially important for the SMT parts, which can very easily become misplaced. (You can use paper bowels, unless the XYL don't mind you using the good china, hi)

All the main board parts are in one set of heat sealed bags, the filter parts and assorted hardware, etc. in the other. The filter boards snap apart from the main board and each other on the score lines.

Replacing lost or missing parts:

If you find a part is missing or has been lost, it can be replaced most quickly by sending a SASE to me with a note indicating what it is you need. Send the SASE to :

Steven Weber
633 Champlain St
Berlin, NH 03570

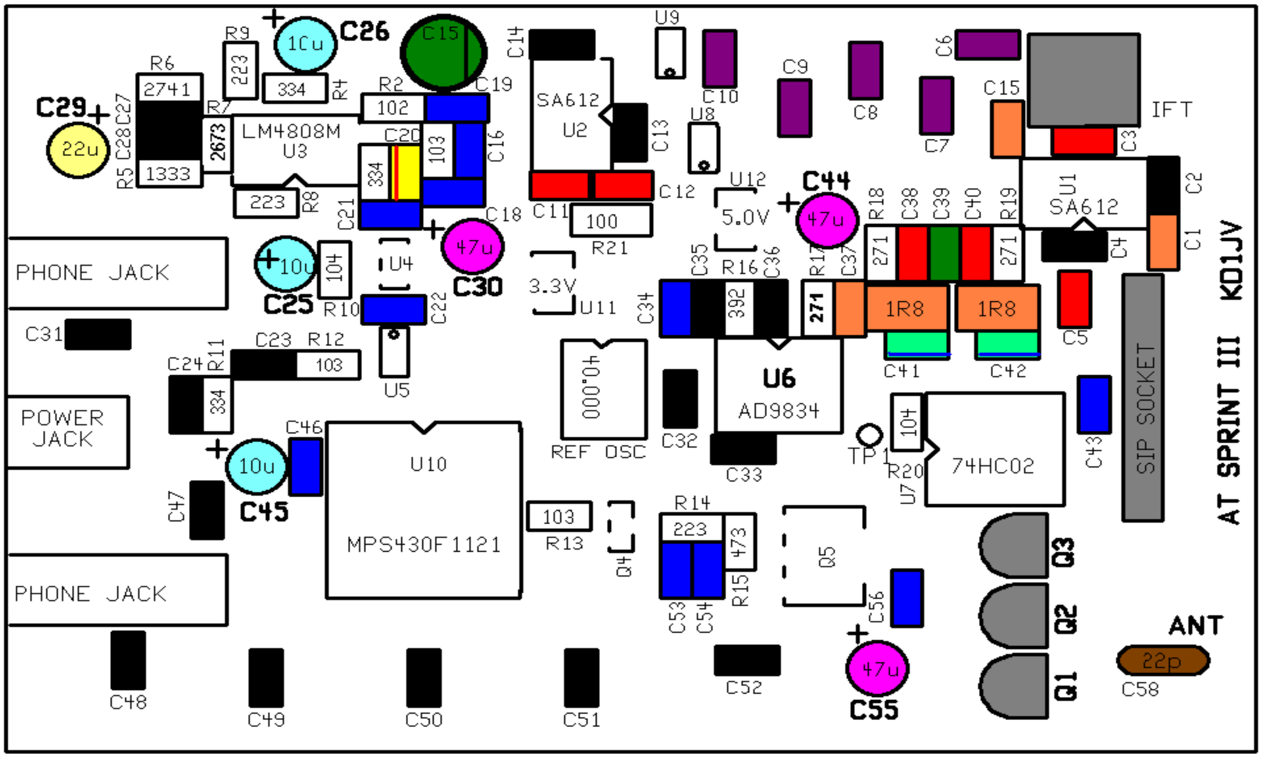
Getting help:

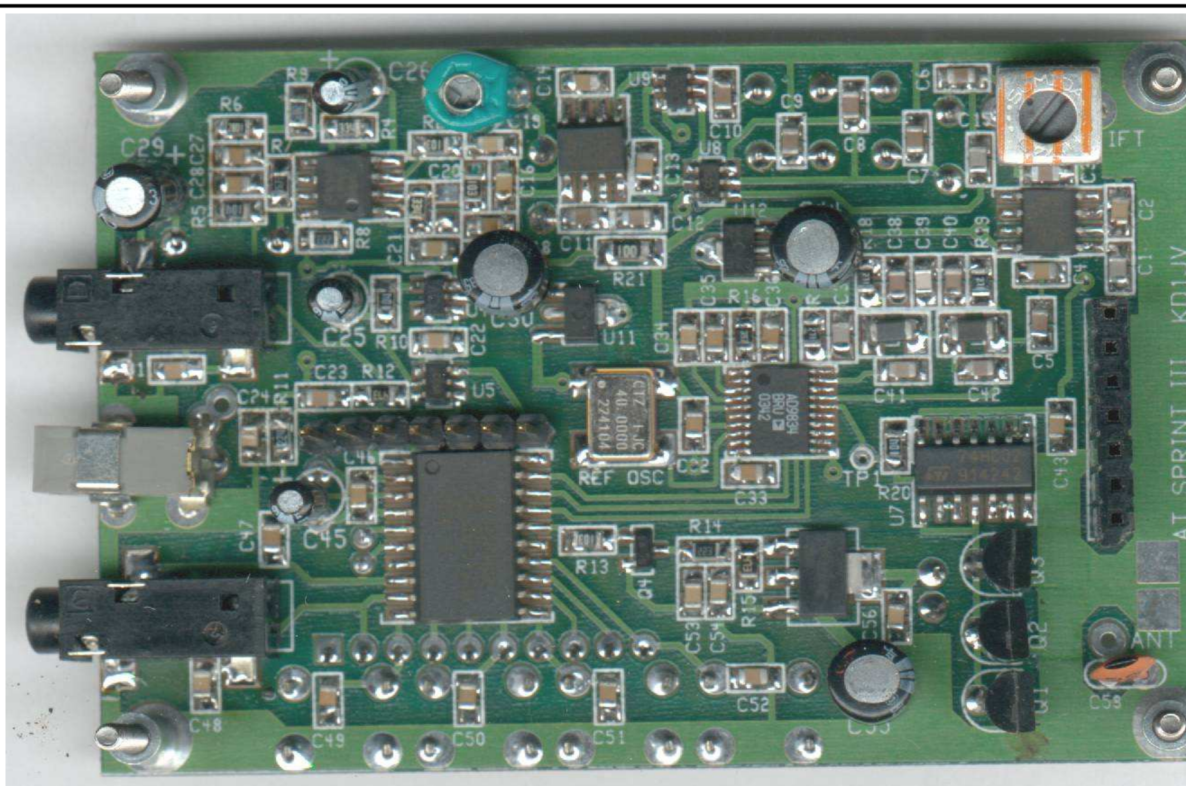
I can be contacted at kd1jv@moose.ncia.net by email for help in answering questions about assembly or trouble shooing. Trouble shooting by email can be difficult. Try to make you questions as specific as possible, and try to narrow down the problem area as best you can first. If you get into real trouble, you can return the kit for repair, but there will be a fee for this service. Price depends on circumstances.

Parts placement over view,

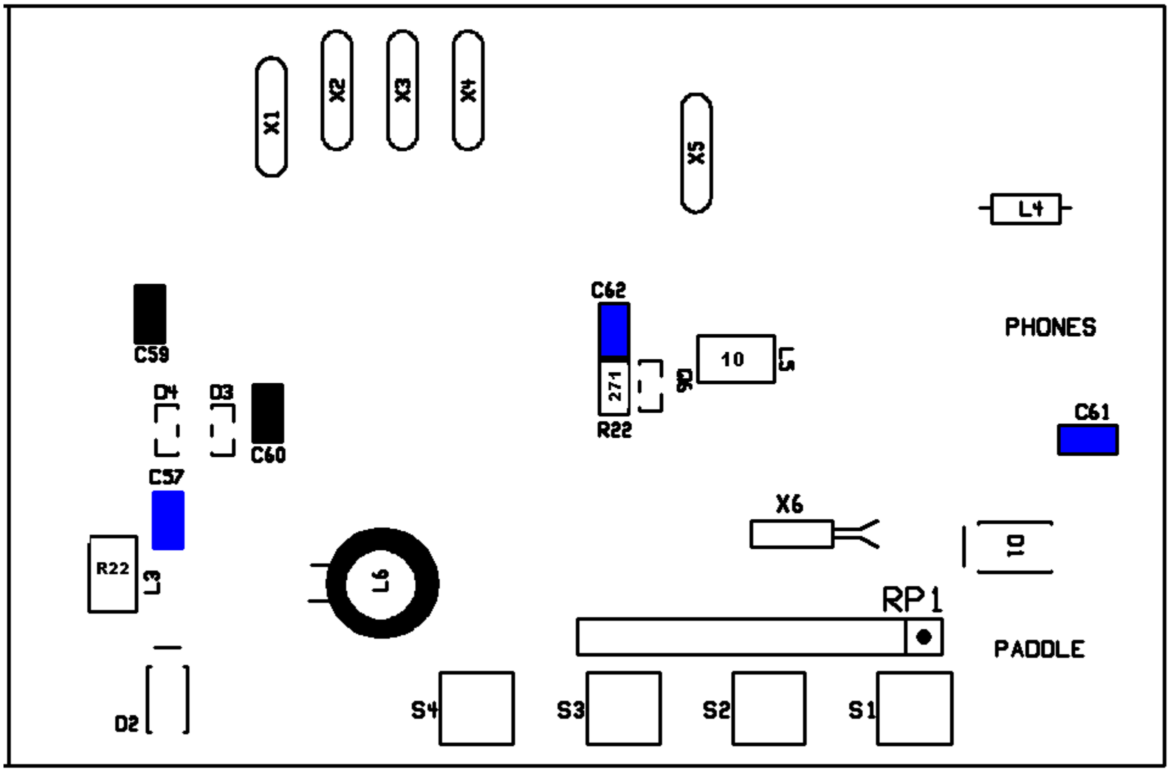
These diagrams and pictures show the placement of the parts on the top and bottom side of the board and should be printed out for handy reference while building the kit.

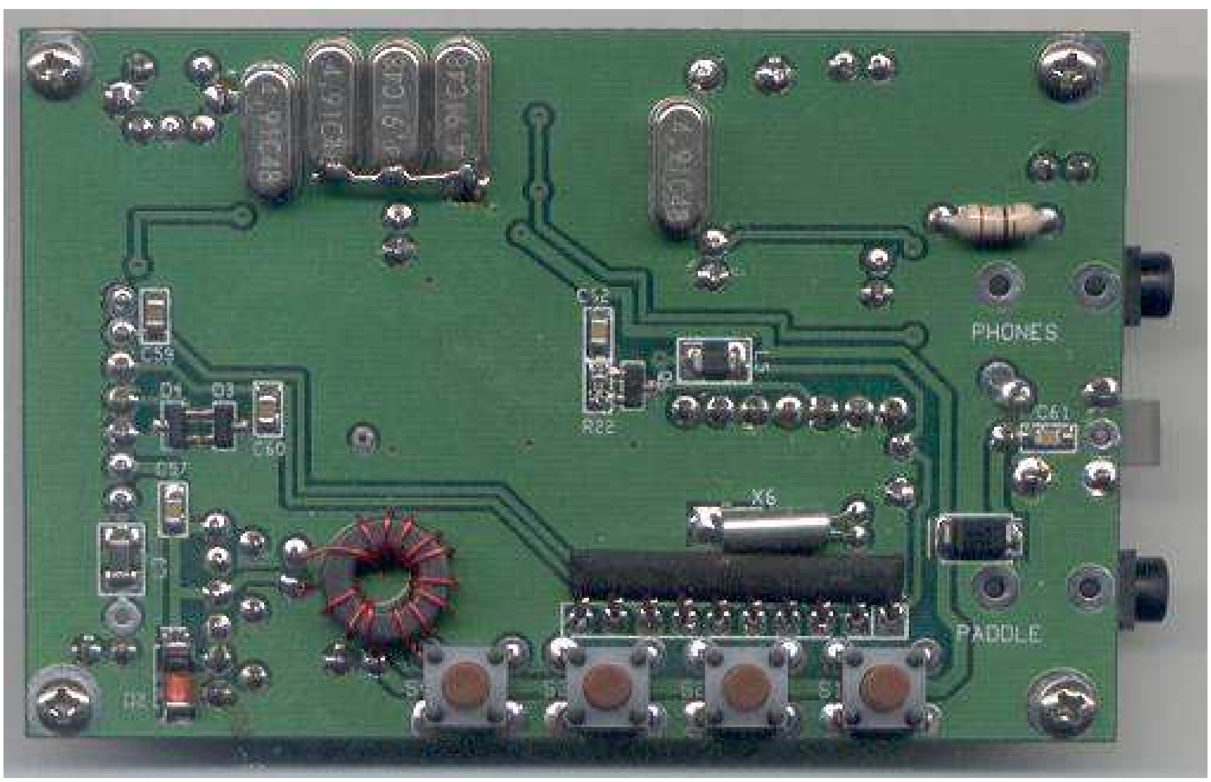
Top parts placement





Bottom parts placement





Semiconductors.

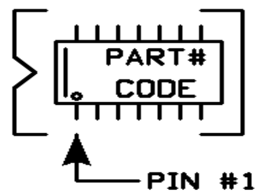
The semiconductors will be soldered in place first, as the pins on some of the ICs can be difficult to access once the chip caps and resistors are soldered down around them.

Static considerations:

Nearly all the semiconductors are sensitive to static damage, aka ESD. It is a good practice to treat them all as if they were. Those that live in high humidity areas have little to worry about here. However, those of us who live in cold, dry, low humidity climates (and run forced hot air heat) need to take some precautions. Wear cotton cloths. Discharge yourself to an electrical earth ground or large metal object before handling the semiconductors. Consider running a humidifier near your work area if you have static problems in your house.

Finding IC Pin 1.

Only three of the ICs (U3/6/10) have a dimple marking Pin 1. With the remaining ICs, you will have to go by the way the writing is printed on the part. When the printing is orientated so that it reads “proper”, i.e., left to right, top to bottom, **Pin 1 is ALWAYS in the LOWER LEFT CORNER.** Often, the manufacturers logo will appear at the pin 1 location, there maybe a line on the pin 1 end, and on many parts, the pin 1 side of the package has a slight bevel to it. Pin 1 is mounted on the board facing the notched end of the outline. Pay attention here, as Pin 1 faces in different directions.



Diodes: D1 and D2 are in a rectangular package and the cathode end is marked by a white line. D3/4 are dual diodes in an SOT-23 package and identified by an Orange sticker as not to confuse them with the SOT-23 transistors, of which there are also two of.

Transistors: Q4 and Q6 are small SOT-23 marked “1P”. These are marked with a PINK sticker. Q5 should be obvious, being a much larger SOT-233 marked 2955 in small letters.

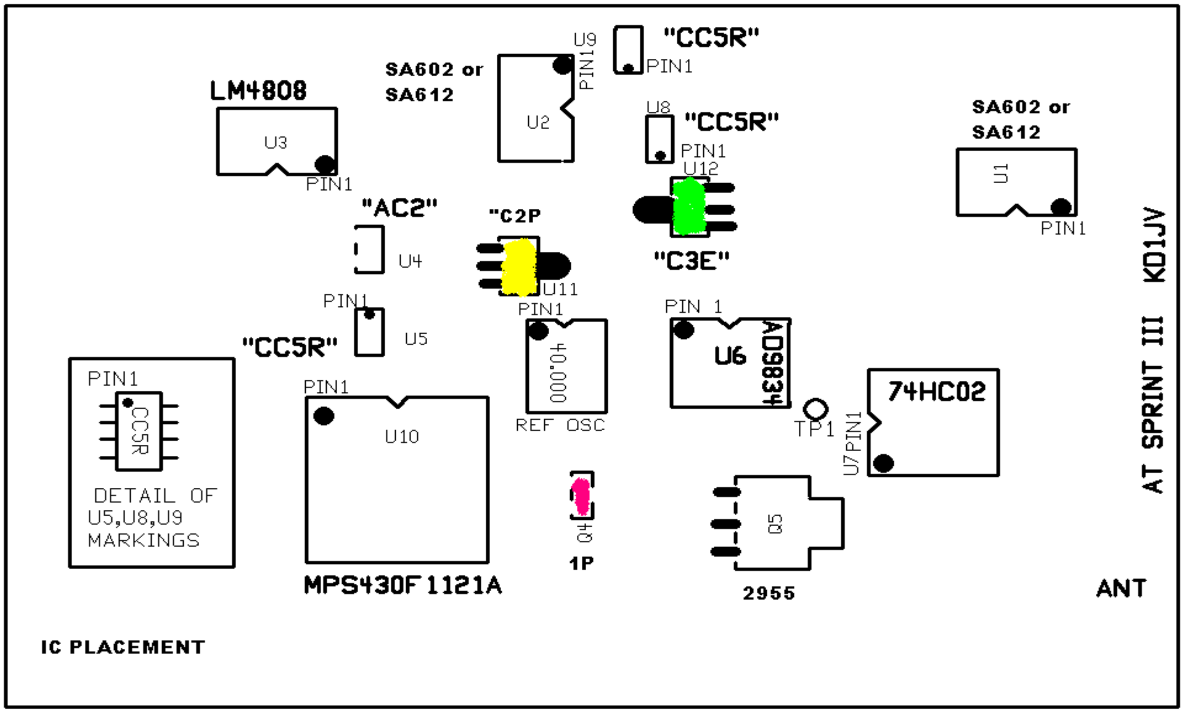
Regulators: To make them easier to identify, the 3.3 V regulator (U11) has been marked with YELLOW sticker and the 5 volt regulator, U12 with a GREEN sticker. You don’t want to mix these up! Center the body of the package in the outline on the board. If soldered too far forward, it's possible for the center tab to short to the outer lead pads.

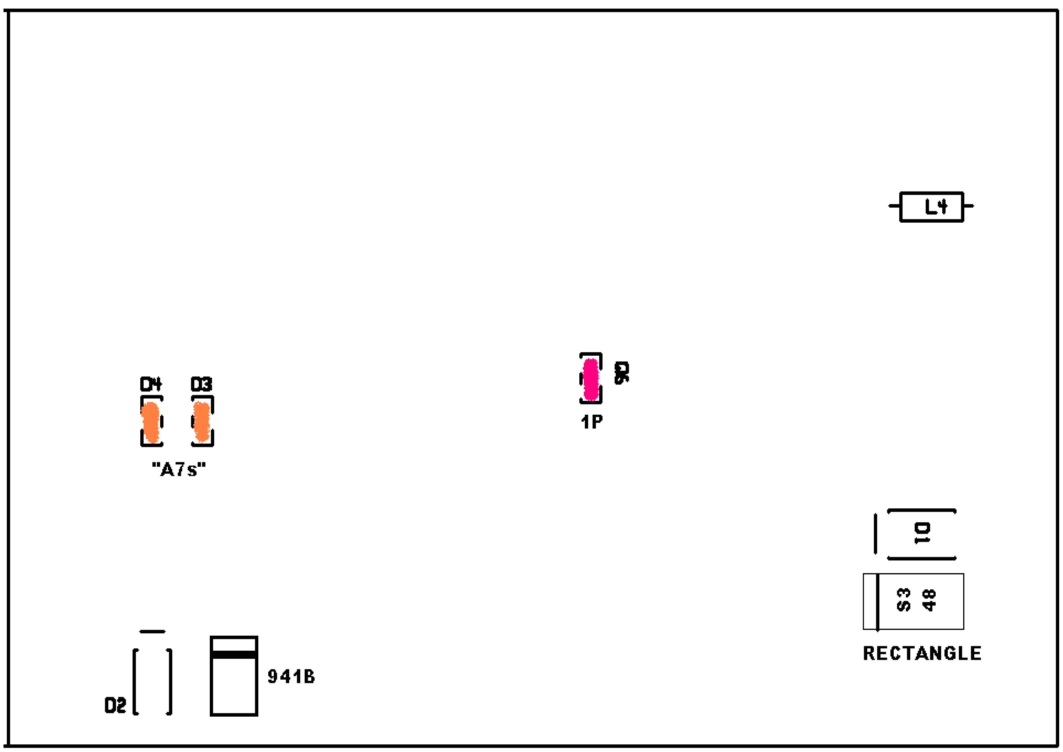
Clock Oscillator: U11- This is the little silver box. Pin 1 is marked with a faint dot, or go by the printing, just like ICs. Soldering is a little tricky, be sure to make it wick onto the pads on its sides. A common reason there is no DDS output is failure to get a good solder connection to the clock oscillator pins.

U5,8 and 9. Careful attention is required for these parts. Having three legs on each side, the orientation isn't obvious without carefully looking for the dot marking the pin 1 end of the chip. See the detail drawing in the placement diagram below.

U4. Orientation of this part is obvious, due to the fact it has three legs on one side and two on the other.

Placement diagrams on next page.


LM4808
U3
PIN1
SA602 or
SA612
U2
U9
PIN1
"CC5R"
PIN1
U8
"CC5R"
PIN1
U12
SA602 or
SA612
U1
PIN1
"AC2"
"C2P
U4
"C3E"
PIN1
U11
PIN1
U5
"CC5R"
PIN 1
U6
AD9834
74HC02
PIN1
CC5R
DETAIL OF
U5,U8,U9
MARKINGS
PIN1
U10
40.000
REF OSC
TP1
U7PIN1
Q4
1P
Q5
MPS430F1121A
2955
AT SPRINT III KD1JV
ANT
IC PLACEMENT

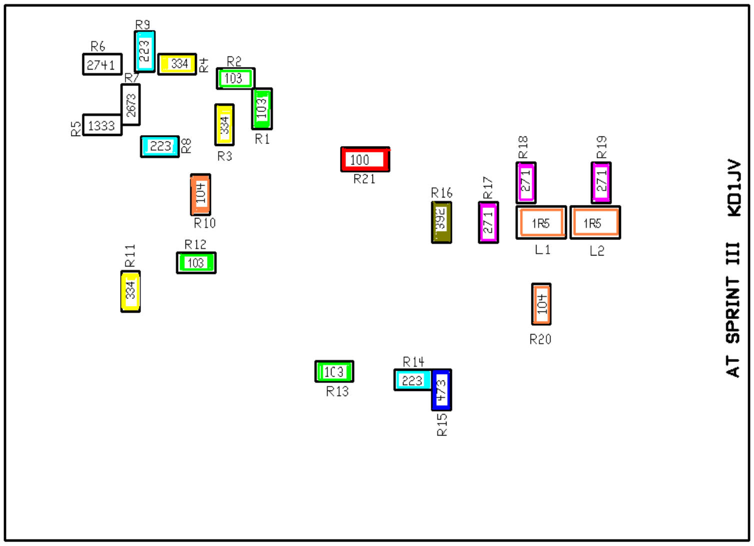

L4
D4
D3
"A7s"
Q6
1P
D1
S3
48
RECTANGLE
D2
941B

Resistors:

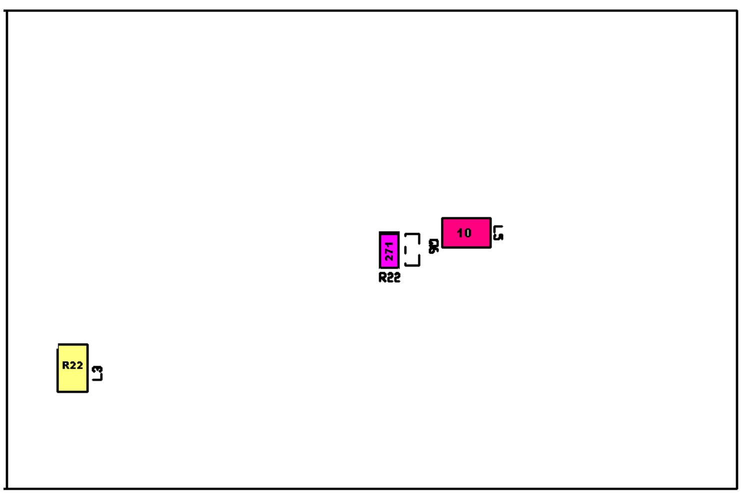
Locations are color coded to aid in finding location. Resistor carriers are not color coded. Use of a magnifying glass maybe needed to aid in reading the part value. 5% parts use three numbers, 1% parts use four numbers.

Inductors: There are four inductors in the board which are a solid gray in color. The value is not marked on the part, so a color label has been stuck to the carrier to identify them. See chart.

Top side resistors and inductors:



Bottom side resistor and inductors:



COLOR	LOC	MARKING	VALUE
GREEN	R1/2/12/13	103	10K
YELLOW	R3/4/11	334	334K
-------	R5	1333	133K 1%
-------	R6	2741	2.74K 1%
-------	R7	2673	267K 1%
LIGHT BLUE	R8/9/14	223	22K
ORANGE	R10/20	104	104K
BLUE	R15	473	47K
OLIVE	R16	392	3.9K
VIOLET	R17/18/19/22	271	270Ω
RED	R21	100	10 Ω
ORANGE	L1/2	1.5 uH	inductor
YELLOW	L3	0.22 uH	inductor
PINK	L5	10 uH	inductor

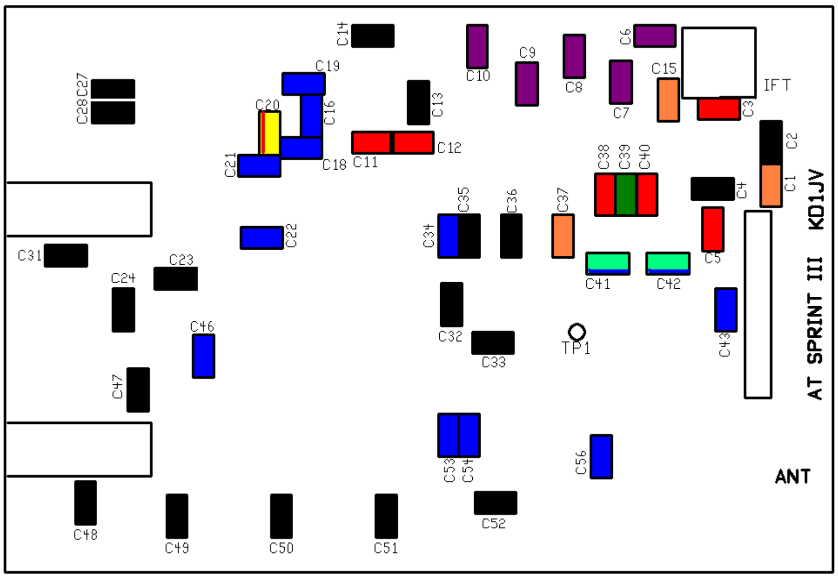
The inductors are in a plastic carrier, to which a colored label has been affixed to the back of, to help identify them.

Caution! Both the 0.22 inductor and .001 cap are identified by the color yellow. It should be obvious which is which, but to be sure, the inductor is in a clear plastic carrier with a yellow stick-on label, while the cap is in a paper carrier marked with yellow marker ink. The inductor is also much larger than the cap and solid black in color.

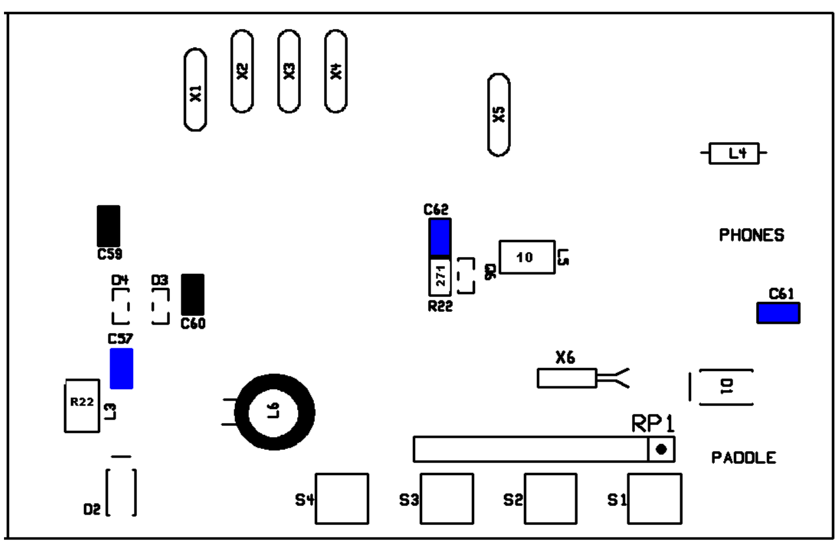
Capacitors:

Since capacitors do not have their values marked on the part, so the carriers have been color coded and correspond to the colors shown in the layout diagram.

color	*quanity*	*value*
BLACK	21 places 19 top 2 bottom	.01uF
BLUE	14 places 11 top 3 bottom	.1uF
RED	6 places	150p
VIOLET	5 places	100p
ORANGE	3 places	22p
Light Green Blue stripe	2 places	8p
Dark Green	1 places	220p
Yellow Red stripe	1 place	.001uF



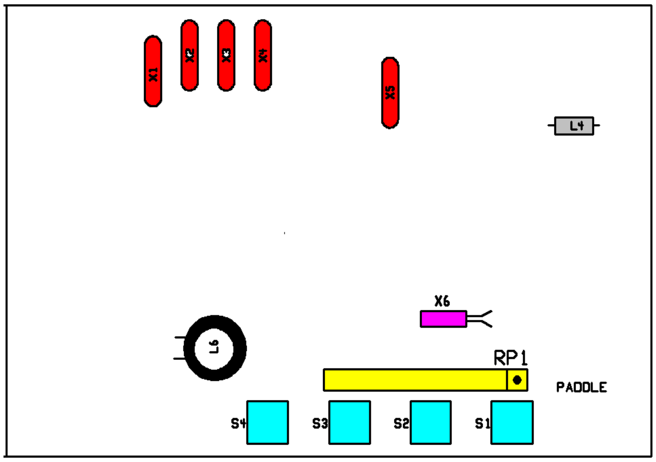
Top Side



Bottom Side

Black .01 C2,4,13,14,23,24,27,28,31,32,33,35,36,47,48,49,50,51,52,59,60
Blue .1 C16,18,19,21,22,34,43,46,53,54,56,57,61,62
Yellow / Red stripe on top edge of carrier .001 C20
Dark Green 220p C39
Red   150p C3,5,11,12,38,40
VIOLET 100p C6,7,8,9,10
Orange 22p C1,15,37
Light Green /Blue stripe on top edge of carrier 8p C41,42

Through hole parts:



These parts go on the bottom

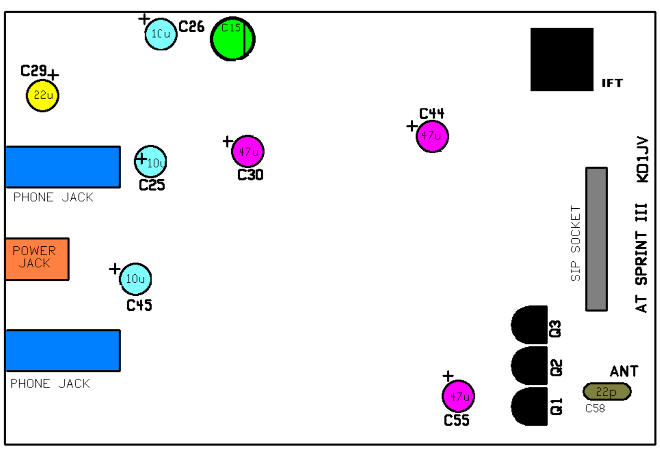
color	*ref*	*value*	
red	X1-5	4.95 MHz	
violet	X6	32.7 kHz	Silver cylinder
gray	L4	10uH	Brn/blk/blk/gld
black	L6	13 T (7")	FT37-43 (black)
Blue	S1-4	switches	
Yellow	RP1	47K	10 sip

Note: tack solder end of X6 to tinned area of board.

Fold RP1 back at 45 degree angle towards X6 before soldering. Writing on Rpack faces AWAY from switches.

L6 core packaged with filter parts

The IF filter crystals may be grounded to the board by soldering a wire to the case and connecting it to the exposed pad below X4. Grounding is not required, but can reduce stray pick up at the IF frequency. See photo on page 12 for wire placement. "Rough" up the edge of the crystal with a file first, it will make it easier to stick solder to.



These parts go on the "TOP" of board

Violet 47 uF C30, C44, C55

Light Blue 10 uF C25, C26, C45

Yellow 22 uF C29

Olive 22p C58, ceramic disk

Blue Stereo phone jacks

Orange 0.7mm power jack

Green C15, Green trimmer cap Flat side of trimmer goes towards line in outline.

Black IF224 IF Xformer. NOTE: Tilt the body slightly towards the top edge of the board. This will give the filter board a little more clearance when set into the SIP jack pins. .

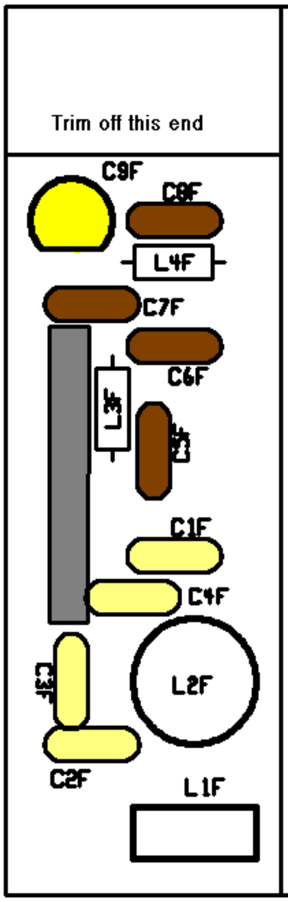
Black – Q1-3, 2N7000. NOTE: Top of package should be no more than 1/4" high from board.

Gray - 7 pin SIP jack. Solder just one end pin and make sure its square and parallel to the board. Adjust if needed and solder then reaming pins.

Filter boards:

The band for which each filter board is intended to be used on is printed on the board. It is important to place the part values for the band indicated on that board. This is because the MPU will read a code from the board to determine which band is in use.

Before installing parts, trim top end of board off with heavy duty scissors at white line near C9F end of board. All parts are installed on the component screened side of board. Trim all leads after soldering, including the SIP pins, as flush as possible. Wind wire snug to outside of core, or the wire lengths won't be right. Lengths assume no more than 1/2" starting pig tail. Remember, one pass through center of core is one turn.



loc	80M	40M	30M	20M
C1F	560p (561)	220p (221)	150p (151)	100p (101)
C2F	1500p (152)	680p (681)	560p (561)	330p (331)
C3F	220p (221)	100p (101)	68p (68)	33p (33)
C4F	680p (681)	330p (331)	220p (221)	150p (151)
C5F	100p (101)	47p (47) D	33p (33) D	22p (22) D
C6F	1000p (102) D	220p (221) D	150p (151) D	150p (151) D
C7F	33P (33) D	15p (15) D	15p (15) D	4.7p (4.7) D
C8F	68p (68) D	none	15p (15) D	none
C9F	Yel trimer	Yel Trimer	Yel Trimer	Yel trimer
L1F	23T Red T30-2	15T Red T30-2	12T Red T30-2	11 T, Yel T30-6
L2F	24T Red T30-2	17T Red T30-2	14T Red T30-2	15T, Yel T30-6
L1/2	12 1/2"	8" L1 9" L2	7" L1 7 3/4" L2	6" L1 8" L2
	#28 wire	#26 wire	#26 wire	#26 wire
L3F	18uH	12 uH	8.2uH	5.6u
L4F	18uH	10 uH	8.2uH	5.6u

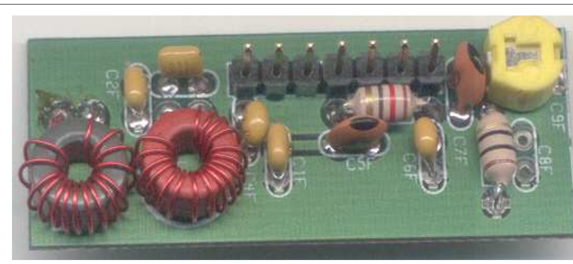
Caps noted with a "D" are ceramic disk, all others monolithic

Coil wire must be tinned before soldering to board!

Mount L1F flat to board, not standing up as shown on layout. See picture to right.

5.6 uH = Green/Blue/Gold/Gold
8.2 uH = Gray/Red/Gold/Gold
10 uH = Brown/Black/Black/Gold
12 uh = Brown/Red/Black/Gold
18 uH = Brown/Gray/Black/Gold

Trim cap mounts with flat towards C7F



Typical filter board

Check out and Calibration:

Clean the board of any flux residue. This will help in inspecting all the solder connections.

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.

- Use an ohm meter to check for shorts across the power supply rails.
- Find and eliminate short if one is detected.
- Wire up a 9V supply to the power plug
- Plug a set of stereo headphones into the headphone jack.
- Plug in the power supply
- You should hear the power up message "ATS-2" in the headphones. If you hear this message, you know the processor and audio amp are working fine.
- Remove power from the board.

Reference Oscillator Frequency Calibration:

The "ideal" reference frequency of 40.000000 MHz is initially assumed to calculate the DDS VFO frequency. In practice, the reference oscillator has a +/- 20 ppm tolerance. This calibration is provided to adjust the value of the reference frequency used in the calculation to exactly match the actual oscillator frequency and therefore produce the exact expected operating frequency. If you have no means of accurately measuring 10 MHz, skip through this procedure by clicking the MENU switch after step 2 and go directly to the LO cal procedure. Even if left uncalibrated, the frequency error is pretty much trivial.

1. Click and hold closed both the RIT and Tune Up switches.
2. Apply power."CF" should be heard in the headphones.
3. Connect a frequency counter to DDS TP1.
4. Using the tune up and tune down switches, adjust the frequency to exactly 10.000,000 MHz.
5. Once the frequency is adjusted, click the MENU switch to store the new reference frequency.
6. The side tone will now announce "CO" A low pitched tone will be heard in the headphones. You can tweak the BFO trimmer cap to get a higher pitched tone now, which will make the following adjustments easier.

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. If one isn't available, you might use an AC volt meter, on its most sensitive scale, though you might be better off going by ear. Its also possible to use your PC with an audio spectrum scope program. You can solder a short wire to Pin 1 of U3 and of the headphone jack pins to hang a clip lead onto.

- Connect a ‘Scope or AC voltmeter to pin 1 of U3. (.5V / div, 1 ms / div sweep)
- Preset the BFO trimmer cap by giving it about a ¼ turn.
- Preset the IF transformer by turning the core clockwise one turn.
- Skip this next step if you don't have a 'Scope.
- Use the Tune Up and Tune Down switches to get the maximum audio signal at pin1 of U3. Be sure not to tune too far and get into the wrong side band. The tuning rate is about 10 Hz in this calibration and you shouldn’t have to tune too far to find the peak in the response. Just a few clicks of the tuning buttons should do it.
- Move the input to the Scope or voltmeter to Pin 7 of U3 or one of the headphone jack pins.
- Adjust the BFO trimmer cap, C15, and peak the audio signal at the headphone jack. This centers the beat note in the audio band pass filter.
- Peak the IF transformer.
- Click the MENU button again to finish the calibration.
- The rig will reset and restart.

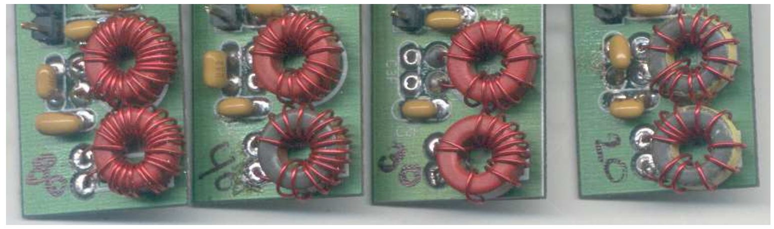
If the above calibrations worked, you know everything but the transmitter and filter boards are working properly. You can now go onto the testing and adjusting the band filters. Otherwise, go to the trouble shooting guide on page and track the reason the rig isn’t working down.

<u>Band filter test and adjustment</u>:

Turn the power to the rig off and insert a band module. You might as well start with the 80 meter module and work you way up. Temporarily connect an antenna jack to the antenna pad and ground on the main board, using short wires or coax.

1. Connect an antenna or signal generator to the antenna input.
2. Power up the rig. Peak the Rx input trimmer cap, C9F for best signal or peak band noise.
3. Peak the IF transformer on the main board.
4. Turn rig off.
5. Disconnect the antenna and connect a power meter and dummy load.
6. Insert a straight key into the paddle jack (you could use a paddle, but it’s easier with a straight key)
7. Connect amp meter in series with positive supply lead.
8. Turn power back on. Key the rig and note power output and supply current.
9. Power output can be adjusted by changing the spacing of the turns on L1F and or L2F. Power output should be adjusted to be about 2.5 watts with about 500 ma or less of board current at 9 volts supply or no more than 5 watts with 12 volt supply. 20M current will be slightly higher than than the lower bands, You can remove and insert the filter board with power to the board on.
10. Repeat for the remanding band modules. You should be able to get about 2.5 watts at 9 volts on all bands.
11. 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.

Photo to right shows how wire on cores was spaced to obtain 2.5 watts out. Your may of course, vary. Yes, there's a missing cap on the 30M 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.

99.9% 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. Also, 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 as see if it moves or not. An other potential problem are shorts between the through hole pads and the surrounding ground plane on the bottom of the board. If you used too much solder, there is a chance of shorting to the edge of the ground plane surrounding the pad.

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 resoldering 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.

Specific problems:

Dead-

Power supply getting to regulators? 3.3 and 5.0 volt outputs from regulators okay?

Power supply okay, no side tone on power up

Check solder connections on audio amp, U3 and surrounding part, headphone connector, side tone filter, C24, R11, C23, R12 and mute switch, U5.

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 for shorts or pins not soldered to pads on board.
Check connections to inductors, L1 and L2.
Check for small DC bias voltage across R20. If there, set up data getting to DDS chip.
Check connections on 40 MHz reference oscillator.

No audio with antenna connected, okay during LO trim cal

Check solder connections to toroid coil wires. You did remember to tin the wires first, didn't you?

No transmit power out:

Check connections on keying transistors Q4, Q5 and associated parts. Check for voltage at collector of Q5 when keyed. Check solder connections on U7. Check for continuity through low pass filter.

IC voltage charts.

Receive mode, no signal, no band module installed

U1 and 2 SA612AD MIXERS

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

U3 LM4808 AUDIO AMP

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

U4 AUDIO AGC

P1	0V	Vagc	P5	1.3V	Audio in
----			P4	0V	GND
P2	5.0V	V+	P3	0.96V	Audio out

U5 MUTE SWITCH

P1	2.5V	Audio in	P6	3.5V	Control
P2	0V	GND	P5	5V	V+
P3	0V	ST in	P4	2.5V	Audio out

U10 MPS430 MPU

P1	0V	TEST	P20	3.5V	MUTE
P2	3.5V	V+	P19	3.5V	DDS
P3	0V	ST out	P18	3.5V	DDS
P4	0V	GND	P17	0V	DDS
P5	2.7V	osc	P16	0V	Tx key
P6	1.7V	osc	P15	3.5V	Tunedn
P7	3.5V	reset	P14	3.5V	MENU
P8	3.5V	Dash in	P13	3.5V	band
P9	3.5V	Dot in	P12	3.5V	band
P10	3.5V	Tune up	P11	3.5V	RIT

U6 AD9834 DDS

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

Packaging the rig:

The board is sized to fit comfortably inside a standard Altoids tin. Other enclosures are of course possible, but the Altoids tin will no doubt be the most popular way to go. A much lighter weight enclosure is a sardine can!

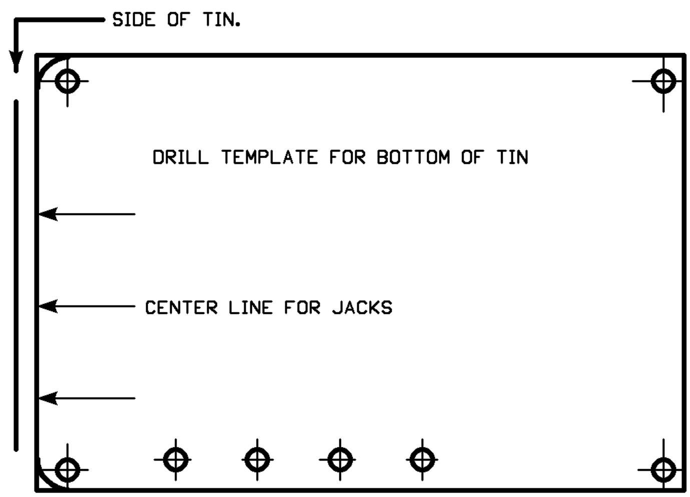
For the board to fit against the side of the tin where the jacks are located, the corners of the board need to be trimmed. The corners of the board can be snipped off with a pair of heavy duty scissors and then rounded with a file.

An RCA jack is supplied for use as an antenna jack. There is enough room on the side of the tin to replace it with a BNC jack if you prefer. Use short lengths of wire to jumper to the antenna output pad on the board and the jack center pin, and from the ground lug on the jack to the tined ground area near the antenna pad on the board.

The board mounts into the bottom of the tin. The switches are accessed through holes drilled into the bottom of the tin. Therefore, the lid of the tin is the bottom. This arrangement allows changing the band modules by opening the lid of the tin.

3/16” #2 threaded spacers, 1/2” #2-56 screws and nuts are supplied for mounting the board. The screws are a little long, so there is a trick to using them. Thread the spacers onto the screws, leaving just a little bit of the end of the screw protruding past the end of the spacer. Now set the board into the tin, line up the screws in the board holes and add the nuts. By putting a little pressure on the board, you can now tighten the screws, then the nuts.

This drill drawing can be used to locate the mounting and switch holes. Place in bottom of Altoids tin and mark hole locations and use jack center lines to position holes on side of tin for jacks. The board sits back 0.1” from side of tin, reference line is used to located side of tin.



Drill Template

To locate the holes for the jacks on the side of the tin, put the template on the outside, bottom of the tin. (printing down, as its now reversed) Use the jack center line guides on the template to mark the location of the jacks on the bottom edge of the tin. A square can be used to extend these marks up the side of the tin. The holes will be located 5/16” up from the bottom edge of the tin.

Before mounting the board in the tin, a small piece of felt cloth can be placed over the switches (cut a slot in the cloth for the buttons to stick through). This will act as a grommet of sorts to help keep dirt and grim out of the box.

location	value	type	location	value	type
C1	22p	0805 NPO	C32	.01uF	0805 chip
C2	.01uF	0805 chip	C33	.01uF	0805 chip
C3	150p	0805 NPO	C34	.1uF	0805 chip
C4	.01uF	0805 chip	C35	.01uF	0805 chip
C5	150p	0805 NPO	C36	.01uF	0805 chip
C6	100p	0805 NPO	C37	22p	0805 NPO
C7	100p	0805 NPO	C38	150p	0805 NPO
C8	100p	0805 NPO	C39	220p	0805 NPO
C9	100p	0805 NPO	C40	150p	0805 NPO
C10	100p	0805 NPO	C41	8p	0805 NPO
C11	150p	0805 NPO	C42	8p	0805 chip
C12	150p	0805 NPO	C43	.1uF	0805 chip
C13	.01uF	0805 chip	C44	47uF	Alum electrolytic 16V
C14	.01uF	0805 chip	C45	10uF	Alum electrolytic 16V
C15	22p	0805 NPO	C46	.1uF	0805 chip
C15A	30p	Green trimmer	C47	.01uF	0805 chip
C16	.1uF	0805 chip	C48	.01uF	0805 chip
C17	skipped	(C15 duped)	C49	.01uF	0805 chip
C18	.1uF	0805 chip	C50	.01uF	0805 chip
C19	.1uF	0805 chip	C51	.01uF	0805 chip
C20	.001uF	0805 chip	C52	.01uF	0805 chip
C21	.1uF	0805 chip	C53	.1uF	0805 chip
C22	.1uF	0805 chip	C54	.1uF	0805 chip
C23	.01uF	0805 chip	C55	47uF	Alum electrolytic 16V
C24	.01uF	0805 chip	C56	.1uF	0805 chip
C25	10uF	Alum electro 16V	C57	.1uF	0805 chip
C26	10uF	Alum electro 16V	C58	22 pFd	Disk
C27	.01uF	0805 chip	C59	.01uF	0805 chip
C28	.01uF	0805 chip	C60	.01uF	0805 chip
C29	22uF	Alum electro 16V	C61	.1uF	0805 chip
C30	47uF	Alum electro 16V	C62	.1uF	0805 chip
C31	.01uF	0805 chip			

Parts List

location	*value*	*type*	*location*	*value*	*type*	
R1	10 K (103)	0805 5%	U1	SA612AD (SO-8)	MIXER	Phillips
R2	10 K	0805 5%	U2	SA612AD (SO-8)	MIXER	Phillips
R3	330 K (334)	0805 5%	U3	LM4808M (SO-8)	AUDIO	National
R4	330 K	0805 5%	U4	AM6123MST (SOT-23)	AGC	Panasonic
R5	133 K (1333)	0805 1%	U5	74LVC1G3157DBVR	Ana SPDT	TI
R6	2.74K (2741)	0805 1%	U6	AD9834BRS (TSSOP-20)	DDS	ADI
R7	267 K (2673)	0805 1%	U7	74HC02M (SO-14)	NOR	STmicro
R8	22 K (223)	0805 5%	U8	S/A U5		
R9	22 K	0805 5%	U9	S/A U5		
R10	100 K (104)	0805 5%	U10	MPS430-1121A (SO-20)	MPU	TI
R11	330 K	0805 5%	U11	812C33AUA (SOT-89)	3.3V LDO	SEKIO
R12	10 K	0805 5%	U12	812C50AUA (SOT-89)	+5V LDO	SEKIO
R13	10 K	0805 5%	D1	SS13 Schottky diode	1A/30V	Vishay
R14	22 K	0805 5%	D2	1SMB5941BT30S Zener	47V 3W	MELF
R15	47 K (473)	0805 5%	D3	BAV99IN (SOT-23)	Dual diode	
R16	3.9 K (392)	0805 5%	D4	S/A D3		
R17	270 Ω (271)	0805 5%	Q1	2N7000	MOSFET	Fairchild
R18	270Ω	0805 5%	Q2	S/A Q1		
R19	270Ω	0805 5%	Q3	S/A Q1		
R20	100 K	0805 5%	Q4	MMBT2222A	NPN	
R21	10 Ω (100)	1206 5%	Q5	NDT2955 (SOT-233)	P MOSFET	Fairchild
R22	270 Ω	0805 5%	Q6	S/A Q4		
RP1	47 K x 8	10 pin SIP	Ref Osc	3.3 V , 40.000 MHz	40.00 MHz	
L1	1.5uH	1206	X1-5	4.9152 MHz	HC-49SUA	
L2	1.5uH	1206	X6	32.752 kHz	cylinder	
L3	0.22uH	1206	S1-4	Tactile SW 6mm x 7mm		
L4	10uH	RFC	J1	7 terminal SIP jack		
L5	10uH	1206	2	SMT Stereo jack		
L6	13T	T37-43	1	0.7mm PWR jack		
IFT	IF222	10.7 MHz	4	#2-56 3/8” Phillips screws		
1	RCA jack		4	#2-56 nuts		
	Circuit	Boards	4	0.187” 2-56 threaded	spacer	

Filter board parts check list

qty	***monolithic***	***qty***	***disk***
1	1500p (152)	1	1000p (102)
2	680p (681)	1	220p (221)
2	560p (561)	2	150p (151)
2	330p (331)	1	68p (68)
3	220p (221)	1	47p (47)
2	150p (151)	2	33p (33)
3	100p (101)	1	22p (22)
1	68p (68)	3	15p (15)
1	33p (33)	1	4.7p (4.7)
		2	18uH choke
4	40p yel trim	1	12uH choke
4	7 pin SIP	1	10uH choke
6	T30-2 (red)	2	8.2uH choke
2	T30-6 (yel)	2	5.6uH choke

Theory of Operation:

Controller:

A Texas Instruments MSP430 micro controller (MPU) is used to control the rig. This is a 16 bit processor, with 4K of Flash memory, 256 bytes of RAM, two 64 byte “information” Flash memory locations,15 I/O ports, and internal 4 MHz R/C clock oscillator. The main reason this part was chosen was for it very low operating current, a mere 260 u amps. An external 32.756 KHz watch crystal is used as a time base for the keyer and side tone oscillator. The internal 4 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. Subsequent tuning of the frequency is calculated simply by adding (or subtracting) a constant which represents a 100 Hz tuning step to the accumulator phase word.

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 receivers LO frequency.

The secondary function of the processor is to implement an Iambic keyer, and to handle the various control functions which are need to switch between receive and transmit. It also generate 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. If power is restored before the MPU completely stops running, it can glitch when power is restored. Therefore, a power on reset circuit, comprised of Q6, C62 and R22 is included in the design. When power is applied to the board, C62 pulses Q6 on for brief time, triggering the rest pin of the MPU, ensuring proper start up.

Software listing

There is a file on the CD called “ats3_xit.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 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 50 MHz. The maximum output frequency in theory is ½ 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 AT Sprint II uses a 40 MHz reference clock, which pushes this 1/3d rule slightly. A 40 MHz clock is used as it draws significantly less current than a 50 MHz clock. An aggressive 5 pole elliptical filter is used on the output of the DAC to eliminate spurs.

The sine wave output of the filter is used to supply the LO signal to the receivers first mixer. This signal is also feed back into the DDS chip, into a fast, on chip comparitor. This squares up the sine wave to produce a square wave output and is 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 3.3 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 3.3 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 transmitters low pass filter. From there it goes through a series resonant circuit, which is designed to have about a 500 ohm series reactance at the operating frequency. A set of back to back diodes at the junction of the capacitor and inductor comprising the series resonant circuit act to limit the input signal to the first mixer during transmit. Two diodes are used in series as the limiters, as there can often be enough signal during receive at this point to cause a single diode to conduct. This is mostly a problem on 40 M, where there are strong SWBC stations in band. If these QSK limiting diodes were to conduct during receive, inter-modulation becomes a problem. The Rx attenuator is also connected to this point.

After passing through the series resonate QSK circuit, a capacitive matching circuit is used to couple into a parallel resonant tuned circuit. Since the input to the first mixer is connected to the top of this tuned circuit, 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. An IF transformer on the output of the 1^{st} mixer couples the output of the mixer to the crystal filter.

The IF is filtered by four crystals. 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.

Wide band signal reception is achieved by using a pair of analog DPST switches to bypass the crystal filter. Two switches are used since only one did not produce enough isolation when there were a lot of strong signals on the band. When the switches are in the normal position enabling the crystal filter, the center connection between the two switches is grounded, preventing any signal leakage between the input and output of the crystal filter.

The switches are controlled by the Side Tone output pin of the MPU. Although this causes the switches to get turned on and off when the side tone is active, it is not a problem, as the audio is muted while side tone is active.

The IF is then mixed in U2 with the BFO oscillator to produce the audio base band signal. A .1 uF across the output pins helps eliminate the 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.

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, 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. This part is a 105 mw head phone driver amplifier. It was discovered in the ATS-2 rig that RF pickup in the headphone cable could cause problems with the audio amp. This occurred when using open wire feed line or an end feed antenna in close proximity to the rig. This problem was fixed by adding an RF choke and .01 uF bypass cap to the headphone output.

Transmitter:

The transmitter is about as simple as you can get. The square wave output of the DDS is buffered by a pair of 74HC02 NOR gates, connected in parallel. Singe 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 2N7000 trench FETs in parallel. The 2N7000'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 between 80 and 75%, depending on band. 80 meters has the best efficiency

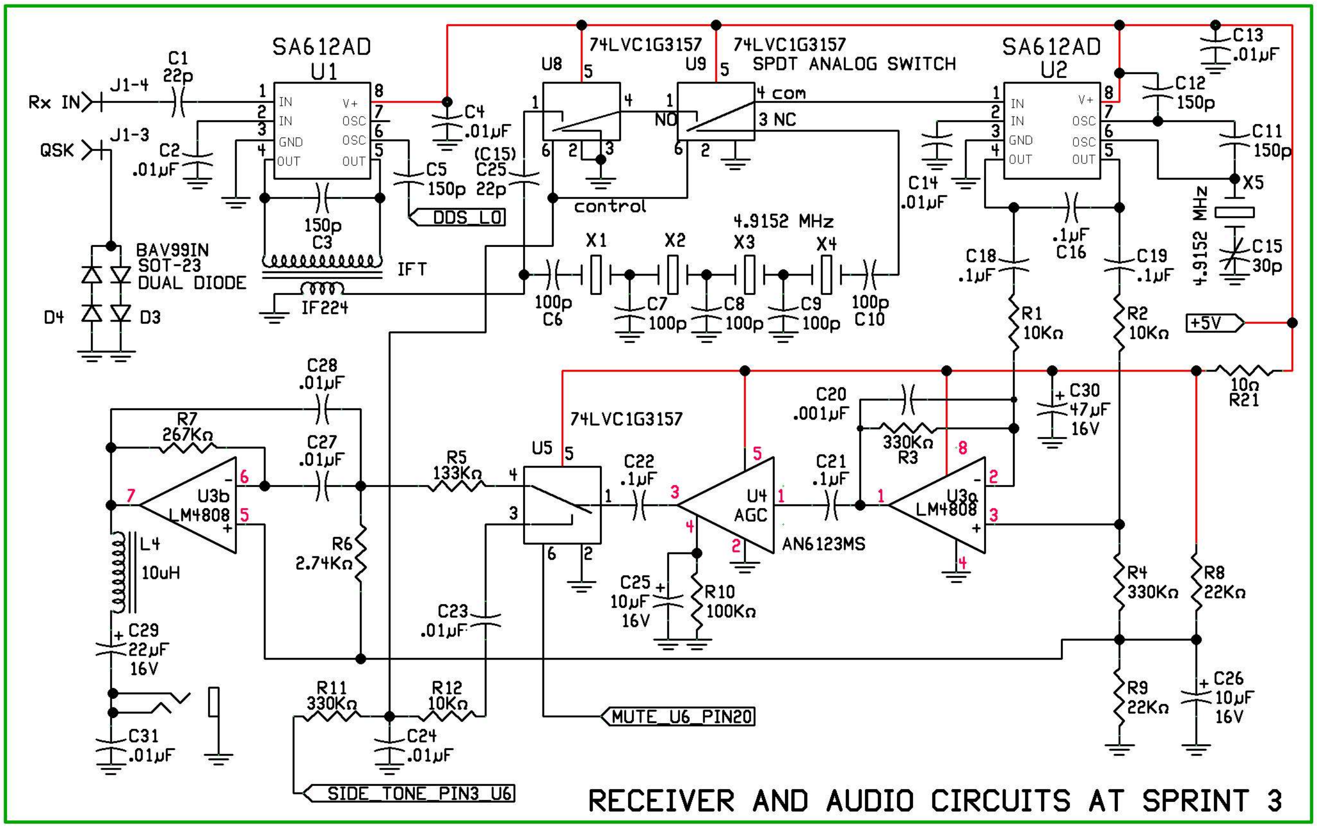
The drain to source break down voltage of the 2N7000 is a relatively low 60 volts. This can easily be exceeded when operating at 5 watts with a moderate SWR. Therefore, a 46 volt zener diode is added across the drain to clip the voltage. Even though a 1 watt diode is used, under conditions of very high 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. A third section to the basic filter is added on the main circuit board to suppress VHF spurs, which are a little on the high side with out it.

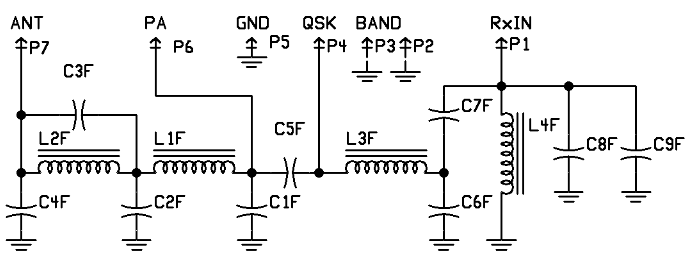
The PA is keyed by supplying power to the PA though a P Channel power MOSFET. This is done in order to produce some wave shaping of the keyed output signal. Resistors R14, R15 and capacitors C53,54 form a RC time constant which provides for about a 5 ms rise and fall time of the output signal, as it is keyed.

Schematics:

Receiver section:

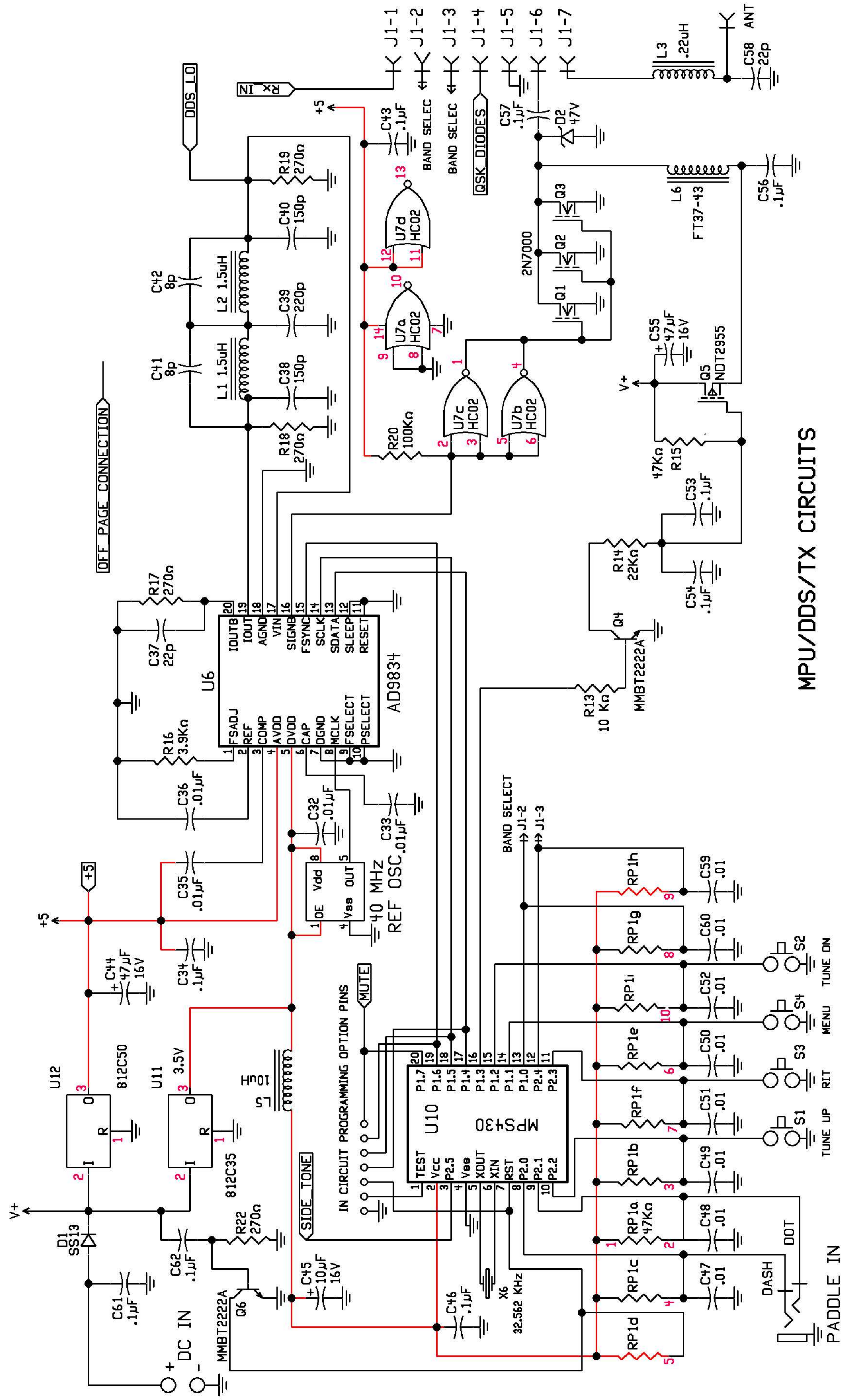


Filter board



BAND FILTER MODULES

MPU/DDS/Transmitter (next page)



MPU/DDS/TX CIRCUITS

Builders Notes: