NorCal QRP Club Presents

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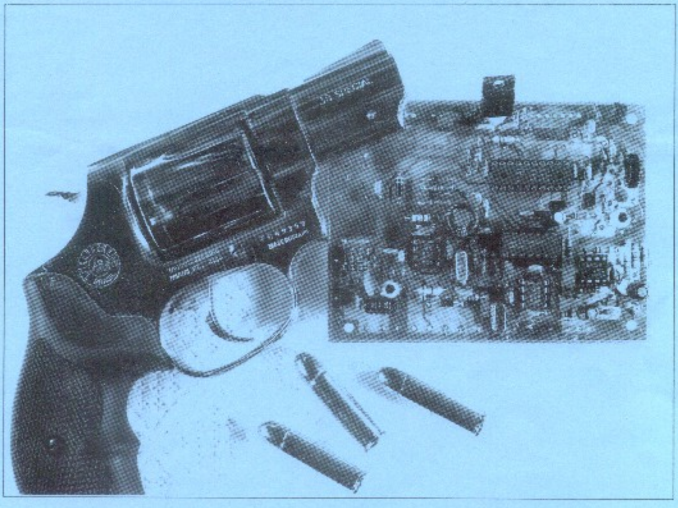
# 38 SPECIAL

## 30 Meter Superhet QRP Transceiver Kit

By Ori Mizrahi-Shalom, AC6AN





**Manual by**
Ori Mizrahi-Shalom, AC6AN
and
Doug Hendricks, KI6DS

**INTRODUCTION**

NorCal would like to say thank you for purchasing the "38 Special" 30 meter transceiver kit. The kit is a result of a lot of hard work by the project committee. There is much more that goes into production of a kit than just putting down a design on paper. When you design something and only plan on making one of the design, it is a fairly simple matter to tweak it and get it to work, most of the work is trial and error, trying and testing parts until you get it to work the way that you want.

But when you do a kit for the masses, it is a different story. You have to design a reproducible design, reproducible by the average ham. One who does not have a lot of experience in testing or aligning electronic equipment. We have a system that we use at NorCal that has proven very effective for us in the past.

The following steps are followed in order to become a NorCal kit. First, a design proposal is presented. Jim Cates and Doug Hendricks decide if it is a viable kit. If it is deemed a viable project, we ask the designer to build a prototype that works. The second step is to transfer the design to a circuit board. While this might seem like a very simple procedure, it is not. We use a board house in Canada that will produce prototype boards for a reasonable fee. We make four boards for the first design of the board. The four boards are built and the design checked for reproducibility.

This was the step that gave us the problems with the "38 Special". Ori's "ugly construction" style prototype worked fine, as did Dave Fifield's, KQ6FR, who helped Ori with building and testing his design. But when we built the 4 prototype circuit boards, we had problems. there was an oscillation and it was causing problems. There was an oscillation and it was causing problems. Dave and Ori worked many long hours finding and fixing the problem. When they had it fixed, we sent off the revised board to the prototype house for four more boards. Again, we built the boards to test the layout. This time we built 3 of them, saving 1 for an independent builder, Paul Harden. NA5N to build and test. Paul works for the National Radio Astronomy Observatory, and is very competent technician. We all held our breath with the second round of boards. there was only one insignificant problem, one of the IC pins needed to be routed to ground, otherwise, the board was perfect.

Throughout the process, from the time that Ori submitted his original prototype, we had two board revisions and 29 parts changes. That is a lot of hard work and effort on the part of the 38 Special team. But we were not finished. Now we had to find sources for the parts and a commercial board house to produce the boards. We are able to produce the kit for only $25 because of the fact that all labor is donated. The kits that NorCal produces are first quality, and we guarantee satisfaction. If you get your kit and decide that you are not satisfied, you may return it for a full refund within 30 days of purchase, provided that you have not started to build the kit. No questions asked. Since we are not a company, we do ask that you bear with us. The kits were kitted by Jim and I, and we are human. If we have left out a part, please notify us and we send you the new part, again, no questions asked. But, we do ask that you be patient and work with us. We will make it right. Remember that you are buying the kit at a reduced price because of the volunteer labor involved.

**BUILDING KITS**

There are probably as many reasons for building kits as there are people who buy them. We would like to give you a few hints that will help you insure the success of your kit. Please read the following hints and apply them where appropriate.

**Soldering:** You will need a fine tipped 15 to 25 watt soldering iron, DO NOT USE a soldering "gun". The soldering gun will ruin the board because of excessive heat. If you have never soldered before, please find someone who has experience and have them show you the correct way. 30 minutes of practice may make the difference between a successful kit or a failure.

**Parts Identification:** Make sure you put the right parts in the right place. We have provided a full page parts overlay so that you may easily identify where the parts go. Mark each part on the schematic and overlay as you install them with a red pen so that you will keep track of what goes where. We have also provided a parts identification page. Make a copy of that and use it to sort the parts.

**IC Identification:** There are 5 IC's in this kit, plus a 3 legged voltage regulator. Please check and double-check these parts before you solder them. The voltage regulator goes into the board with the lettering facing the parts on the board, and the flat back side towards the outside of the board. Dual in-line IC's are pin specific. Pin 1 is identified either by a notch on the end of the IC or by a dot over pin 1. The parts overlay has the notch and the dot, plus the hole that pin 1 goes in has a square pad. Your radio will not work if the IC's are not put in correctly.

**Alignment:** Every radio needs to be "tweaked" and aligned. Ori has made the 38 Special one of the easiest to align radios ever. There are only two alignment steps. One TC-1, is peaked for the loudest audio. We suggest that you use the RTTY signal that is present at the top of the tuning range of your radio around 10.130 MHz. The transmitter tune-up is also very simple. The rig has a built in sidetone that is very sensitive to a clean signal alignment. When you are ready to align the transmitter section, use the sidetone as an indicator, peaking for the purest sounding tone. Of course you may use an oscilloscope, but it is not absolutely necessary.

On behalf of Jim Cates, I would like to say thank you to the following "38 Special" team members: Ori Mizrahi-Shalom, AC6AN, designer, David Fifield, KQ6FR, prototype building and testing, Paul Harden, NA5N, testing for FCC spectral purity, Preston Douglas, WJ2V, manual proofing and testing. Jim and I were the other members of the team. Jim was in charge of the finances and the shipping of kits. I was responsible for parts procurement, kitting of parts, and cheerleading and promotion. It was fun. We hope you enjoy your kit. Let us know if you come up with mods! 72, Doug, KI6DS

# The "38 Special"

**A 30 Meter Superhet Transceiver**

by Ori Mizrahi-Shalom, AC6AN
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The "38 Special" is an exercise in minimization. It is "special" because of the following:

* It works on the under-utilized 30M band
* Runs of f a 8V supply
* Special in its architecture
* Excellent price/performance ratio
* Last, but not least, it offers a great platform for another year of hacking...

The "38 Special" is the result of an effort, which started with hacking the 40-9er transceiver. A novelty radio, the direct-conversion 40-9er was quite limited, especially for weak signal work. The "38 Special" rectifies most of these problems and adds many nice features.

It came to life due to the Dayton design contest challenge and the never ending enthusiasm and encouragement by Doug, KI6DS, who is also the one to 'blame' for the "38 Special" name.

## GENERAL DESCRIPTION

The "38 Special" is a superhet transceiver for the 30M band. The first thing you'll notice looking at the schematics is that there aren't many discrete transistors. I have been playing with the concept of a radio made of only integrated circuits for some time and the "38 Special" was the right vehicle (we ended up with one transistor for a safer design - it is a kit and a clean reproducible design is the number one priority).

The transmit section relies on a digital CMOS buffer. I extended this concept to utilize the same CMOS chip for other tasks. Although it's an NE602-based superhet transceiver, the "38 Special" incorporates only two NE602s. I re-use the product-detector as the transmit mixer by channeling different signals to that chip on receive and transmit. Also, the traditional LM380/386 is gone in favor of a more versatile dual op-amp circuit for the audio section.

## RECEIVER FRONT-END AND MIXER

The receiver front-end starts with a back-to-back diode switch. The "38 Special" utilizes a 1N4007 diode for the T/R switch. This diode has a PIN structure that provides low insertion-loss, although it suffers from a poor zero bias isolation and does not offer a strong IMD performance like an RF-rated PIN diode (1). It is superior to the 1N914 or similar diodes in this type of a design. Next to the T/R switch is a toroidal impedance transformer with a 10.1 MHz tuned circuit at its output, providing additional front-end selectivity to that offered by the transmit output network. Provisions were made to include a 1K Ohm pot for RF-GAIN control. The 10.1 MHz RF signal is fed to the input of the NE602 receive mixer, where it is mixed with the 22.1 MHz VXO to generate the 12.0 MHz IF frequency.

## THE VXO

The superhet circuit enabled me to use standard crystals and avoid the high price of custom ham-band crystals. Many crystal combinations work for most HF bands. I chose a high frequency first crystal to achieve a high frequency swing, which translates to a wider tuning range (2). This required a relatively high IF in the simple receiver. The NE602 Collpits oscillator required a high DC bias for a large swing, provided by a 3.9 KOhm resistor at pin 7. Although well below the value recommended, this resistor provides stable operation of the NE602. "Rubbering" the crystal with a varicap allows relocating the tuning pot away from the oscillator, if desired. A 1N4004 diode works here nicely as a varicap (3).

A little assist from a molded inductor yields a tuning range of 20-25 KHz. The low Q of the molded inductor seems to help increase the pulling range. The VXO signal is mixed inside the NE602 with the received signal to produce an IF output of 12.0 MHz, which is the difference between the VXO and the RF frequency. During transmit, a 22.1 MHz signal is taken from the Collpits oscillator and injected into the input of the transmit mixer.

## IF FILTER

The IF filter utilizes a single crystal with two tuning caps. It is a bit wide but still very effective (provisions for a better IF filter are included on the board). The main selectivity is achieved at the audio stage and the wide IF filter greatly simplifies the alignment of the IF and audio filters.

The wide IF filter has only 12 dB nominal sideband attenuation, so the "38 Special" in its stock form cannot be classified as a single-signal receiver (it takes a much sharper IF filter to achieve a true single-signal reception). Although you will hear the two sidebands (not simultaneously), there is enough attenuation at the IF stage to clearly tell which is the "right" one.

## PRODUCT DETECTOR

In the cost cutting tradition I left out the "traditional" third NE602 for the transmit mixing. Instead, the "38 Special" re-uses the product-detector for the same function. On receive, an oscillator (IF frequency) is mixed with the IF signal to produce a low-level audio signal. On transmit, a signal from the VXO is mixed with the IF frequency oscillator in the second NE602 to produce a low-level transmit signal.

The selection of the input signal to the second NE602 is done by means of a CD4066 analog multiplexer. Other than the switching of signals with the analog multiplexer, the receiver is similar in concept to most NE602-based superhet radios.

## RECEIVE OFFSET

Sharing the product-detector and transmit mixer circuits required a "trick" to achieve a receive offset. The "38 Special" pulls the IF frequency oscillator up about 600 Hz on receive with a small capacitor in series with the 12.0 MHz oscillator crystal. During transmit, this capacitor is shunted to ground with a parallel forward-conducting diode, so the crystal oscillates close to its fundamental frequency, resulting in a zero-beat transmit signal. The high VXO frequency (relative to the RF) at the first mixer and this oscillator pulling up on receive combine to yield the "right" receive sideband at the higher frequency (USB).

## AUDIO AMP/FILTER

The audio is filtered and amplified by an NE5532A dual op-amp, instead of the "traditional" LM380 or LM386 chips (4). The 5532A requires more external components, but it gives a higher gain, and more important, the circuit also forms a sharp band-pass filter. From that point of view, the "38 Special" is superior to most NE602-based radios.

This amp delivers about 60 dB of gain while driving walkman-style headphones. The filter offers a 200 Hz -6 dB bandwidth and about 1500 Hz at -30 dB. Sharper filters were tried but their high Q caused excessive 'ringing' and the receiver tuning became very critical. The 5532A circuit uses a dozen more components than an LM386. But they are probably the most cost-effective components in the whole radio!

## TRANSMIT CHAIN

As mentioned before, the product-detector doubles as a transmit mixer. The signal on the output is filtered by a 10.1 MHz tuned circuit. The output (about 50 mV) is amplified by a (one and only) transistor amplifier to a sufficient level to drive a digital CMOS gate. Two CMOS buffer stages complete the transmit amplifier (5).

The most interesting article on the subject was written by Len Smith N7KSB and appeared in November '94 QST. Len used an octal inverting buffer with eight individual active devices, but really utilized only five of them. His circuit gave me the idea of using the leftover devices for sidetone generation and other tasks.

Originally I used one of the CMOS buffers as a high-gain linear amplifier. As it turned out, the circuit was very sensitive and not suitable for a kit. It oscillated in two modes (oddly enough, HF and LF simultaneously) and took a lot of "tuning" to make it work.

The design was changed to include a much cleaner low-level transistor (oops...) amplifier. The output of this amplifier is sufficient to directly drive a single CMOS buffer, acting as a pre-driver. The final stage is made of four parallel CMOS buffers. Depending on the output matching, this circuit can deliver well over half a watt of output power. I chose to leave it at 300 mW for the sake of cool and safe operation of the final. The board supports additional circuitry (low-cost parts, but not supplied with the kit) for a higher output up to 5W.

## THE OUTPUT NETWORK

The low 8V supply required very low impedance for the final stage to yield any appreciable output power. The matching is easily done by an L-C-L-C type network (6). This network was synthesized with a moderate Q so it is not too critical. In addition, the output network provides excellent harmonics attenuation (the "38 Special" complies with FCC regulations for spectral purity).

## SIDETONE

Two inverters combine in a simple audio oscillator circuit. The oscillator is disabled during receive but is free-running during key-down. The audio frequency output is attenuated and lightly filtered. The low level sinusuidal sidetone is mixed with the receive audio and then amplified by the audio stage.

## ADDITIONAL LOGIC

One buffer of the octal buffer chip is used for the receive/transmit logic. It inverts the logic state of the "key" line, so when key is down, this signal is at full 8V supply voltage and when key is open, this signal is at 0V. The availability of the two signals (T- and R-) simplifies the implementation of the T/R circuitry.

Other T/R circuits worth pointing out "tune" the delays between the receiver switching on and the transmit chain switching off and vice versa. This is done by means of resistor/capacitor/diode combinations, driving the CD4066. These delays eliminate audio thumps and provide a smooth QSK operation.

## ALIGNMENT

The "38 Special" was designed with a novice builder in mind. There are only two alignment steps (although more parameters could be tweaked by the experienced builder). The receiver alignment consists of peaking the front-end trimcap for the highest receive audio.

The transmitter alignment is a bit more tricky. The radio transmits a 10.1 MHz signal, while it has a 12.0 MHz IF oscillator signal at the output of the transmit mixer. This requires some care when tuning the transmit filter trimcap.

One way of doing this is by listening to your signal on another receiver. Tune close to your center frequency and look for the adjustment that results in an output with the least close-in spurs (least noise around the carrier).

What if you don't have another receiver or test equipment? We found a 'neat trick' how to tell that the transmitter is tuned correctly. As explained earlier, the sidetone is generated in the same chip that produces the high-level transmit signal.

Any gross mismatch at the input or output of the transmit chain will generate a distorted sidetone (both level and pitch change). This 'feature' can be used to adjust the transmit trimcap when the output is terminated into 50 ohm. Simply key down and adjust the trimcap for the cleanest sounding sidetone.

As a result, both alignment steps can be done without any test equipment, not even a power/SWR meter! Of course, better equipment will yield a better alignment, but we found the "poor man's alignment procedure" above very satisfactory.

**THE NEXT STEP**

The final kit reflects cost-cutting and other changes to simplify the alignment and kitting of the design. It is a superhet with offset and sidetone at a bargain price! As such, it has limitations, of course. I view it as a product but also a development platform. Many people will assemble the basic unit and have a lot of fun with it in the stock form but there are those who want to do things their way.

This radio was designed for both. I don't intend to continue its development. I leave that to the hackers and tinkerers out there. The "38 Special" was designed to continue the tradition that started with the 40-9er - mods by the dozen. There are many possibilities to improve the "38 Special" and I certainly encourage people to do just that. All I ask is that you share your findings with the QRP community and let us all know of your adventures...

For those that build it stock or custom, plain or modified, hot or low key - I hope you have fun and find it a useful radio, as I did. I can't wait to see the entries for Dayton and Pacificon buliding contests next year. I also hope that the "38 Special" will spark more activity on the 30M band. Maybe we will finally know what the propagation properties really are on 30...

**ACKNOWLEDGEMENTS**

Again, many thanks to Doug Hendricks for the encouragement and for writing the manual. To Jim Cates and Doug on the hard work of the kit 'production'.

Special thanks to Dave Fifield, KQ6FR, who built the second prototype and beat me to the first QSO - 549 on 200 mW from San Jose to Spokane! Dave is a master builder, both of circuits and enclosures. He came up with many additions and suggestions, that made the "38 Special" much nicer and a more a 'robust' design.

There are a few people that (quietly) contributed to the design and testing efforts, most notably Paul Harden, NA5N.

Very special thanks go to the XYL, who became a "radio-widow" for a few months...And many thanks to all the people on the QRP-L server. I appreciate very much the nice words and the offers by many to help with the design and testing of the "38 Special".

**NOTES:**

(1) QST, Dec 1994 pp. 25-27.

(2) A similar concept is used in the Mizuho MX7S radio.

(3) See Jim Pepper's Deluxe QRP station, although not for "rubbering" a crystal.

(4) 40-40 single board kit by Dave Benson, NN1G uses a 5532A for an audio amp/filter.

(5) QRPp Mar. 1994 p. 58 and W1FB's Design Notebook p. 156.

(6) Solid State Design p. 53.

# Building the 38 Special

by Doug Hendricks, KI6DS

**CONSTRUCTION**

The first thing that you should do is unpack your kit. Take inventory of the parts, and make sure that none are missing. We have prepared a parts inventory sheet for you, and it is the last page of this manual. You may either make a copy of that page or tear it off the manual, but you will need to lay it flat on the table and use it to identify and inventory the parts. You will also note that there may be additional parts in the kits. This is a result of early changes after we started to kit the kits. Please do not return these, just add them to your junk box. If you are missing any parts, please let us know at NorCal and we will send them to you immediately.

When you inventory the parts, put them in the boxes that have been provided to put them in order. We also suggest that you use an ohm meter to make sure that you have the right resistor and have read the resistor code correctly. Also, make sure that you don't mix the 4.7 uH inductor with the resistors. The inductor is slightly larger than the resistors, and has a green body with yellow, violet, gold and silver stripes to identify it.

We will provide boxes so that you can check the step off when you have completed it. Ok, now that we have the parts inventoried, lets get started.

☐ Prepare toroids: Toroids have a bad name or reputation when it comes to kits. People don't like them and say that they are hard to do. Nothing could be farther from the truth. It is very simple to wind and prepare toroids. All that you have to remember is that every time the wire passes through the center of the donut shaped toroid it counts as one turn. Before we get started winding our toroids, lets go through an example so

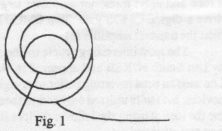


Fig. 1

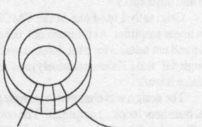


Fig. 2

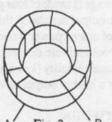



Fig. 3

that we can make sure that you understand the process.

When winding a toroid, you put the toroid in your left hand, and the wire in your right hand. Toroid coils are nearly always wound with wire that has enamel paint on it for insulation. Bring the wire up through the middle of the toroid from the bottom and hold the wire and toroid with the left hand. That counts as the first turn. See Fig. 1. Next we will wind three more turns by taking the wire around the toroid and up through the hole of the toroid, much like sewing a button. Keep the wire firmly against the toroid as you wind, but not too tight. Now we have a total of 4 turns on the toroid. See it is very simple, and not hard to do at all. See the example in Fig. 2.

Fig. 3 is an example of a completed toroid with 10 turns on it. Lead A is one end of the wire, lead B is the other end. When you finish winding the correct number of turns on the toroid, you need to "finish" the ends of the wire. To "finish" the ends of the toroid coil, you must remove enough enamel insulation to insure a good solder joint when the toroid is installed. I do this by trimming the wire so that there is a 1" piece of wire at A and B. Then I unwind the wire 1 turn on each end, and I take a "Bic" lighter and burn the insulation back 1" from each end so that when I rewind it, the insulation will be off back to the edge of the toroid. I use a piece of sand paper to take off the burned insulation. When the insulation is off and the bright, shiny wire is visible, I tin the ends of the wire by using an iron and applying solder. Tinning is a term used to describe the action of applying solder to wire.

You are now ready to prepare the 3 toroids that are in the basic kit, L2, L3, and L4. We will begin by taking one of the 5 donut shaped red colored toroids in the parts kit. These are called T37-2 toroids because they are .37" in diameter and because they are of mix -2. A T50-2 toroid would be .50" in diameter and also have a -2 mix. The red color is the manufacturer, Micrometal's way of identifying the type -2 mix. They use yellow for type -6, and white for type -7. See you have just learned something while building a kit, and it didn't hurt at all. This kit only uses one type of toroid, the red T37-2, so don't worry about selecting the wrong toroid core. And, there is one extra included for the high power mod discussed later.

☐ We will start by preparing L2, which the parts list says is 20 turns of wire. This means that you wind 20 turns of the wire on the form just as we have learned how to wind. Start by taking a red toroid from the parts. Use the enameled wire supplied in the kit. Cut a piece that is 14" long. Wind the coil, trim and tin the ends of the wires and set it aside.

☐ Next we will wind L3. Take another red toroid. This coil will take 8 turns of wire. Cut a piece of wire that is 10" long. Wind the coil, trim and tin the ends of the wires and set it aside.

☐ We are now ready to wind the final coil, L4. This one uses 12 turns of wire. Again, use a red toroid. Cut a peice of wire that is 12" long. Wind the coil, trim and tin the ends of the wires and set it aside. That takes care of the winding of the coils for the basic radio.

There is one transformer in the radio, T1, and it is very easy to wind. The primary is 2 turns, and the secondary is 19 turns. We will use two separate wires, one for the primary and one for the secondary. We will be winding a coil that looks like

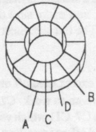



Fig. 4

Fig. 4. The primary wire has ends C and D, the secondary has ends A & B. When you install the transformer, the easiest way is to put the primary wires in first and then the wires for the secondary. More on that later. Now we are concerned with winding the transformer.

☐ Take another red toroid, and start by winding the secondary first. Cut a piece of wire that is 14" long, and wind 19 turns on the toroid. Trim and tin the wires as before. Next take a piece of wire that is 4" long, Wind two turns as shown in Fig. 4 between A and B. The idea is to have the primary portion of the transformer between the ends of the secondary portion of the transformer, A and B.

Set aside the coils and transformers at this time. We will install them later.

☐ Next take the two 12.000 MHz. matched crystals and install them as indicated on the board. Be sure to ground the outside of the cans to the ground plane after you install them by connecting to the nearest opening. Use a short bare wire lead to connect the cases to ground. The trimmed lead from a resistor installed later will do if you haven't any "trimmings" handy, but in that case, remember to come back to do this step. Solder the wire to the base of each case and to a nearby unused ground hole. This will help prevent instability. The two crystals go in positions X2 and X3. Solder the leads, getting a good connection, but do not leave the iron on the leads too long. Trim the leads flush with the bottom of the board.

☐ Install the 5 IC's, the 2 NE602's, NE5532, CD4066 and the 74HC240 where indicated. Make absolutely sure that you have the IC's orientated correctly. The silk screen shows the correct way to install the chips. Also, there is a square pad for pin one of each IC. The IC's have a notch on the end with pin 1. If you are not sure about this part, find someone to help you verify that you have the IC's right before you solder them. Be sure to solder every pin on the IC's and check carefully for solder bridges.

☐ The two trimcaps, TC1 and TC2 are installed next. Pay particular attention to be sure to install them the same way as the silk screen shows, with the flat side of the cap aligned with the pattern on the board.

☐ The diodes and transistor come next. You must be extremely careful to have the correct orientation for the diodes and the transistor. When you install the diodes, the banded end is the cathode, and goes the same way as it is indicated on the silk screen. Do not install the diodes backwards, or your rig will not work. Pay particular attention to the number markings on the diodes. There are two 1N4007s and one 1N4004. Place them correctly! The transistor is installed as close to the board as it will go easily, and make sure that it matches the shape of the silk screen. The flat side must be matched to the pattern.

☐ Install the resistors.

☐ Install the disc caps, except hold off on installng the following ones to give you room to work: C28, C29 (the silver micas or polystyrenes) and C7, C11 which with electrolytic C40 surround crystal X1. Hold off on installing all electrolytics at this time.

☐ Install X1, the 22.118 crystal. Be sure to solder the outside of the can to the opening in the ground plane.

☐ Install C7, C11 and C40 at this time. C40 is the 220 uF electrolytic. It must be oriented correctly, with the positive lead in the hole marked with a + sign.

☐ Install the other 3 electrolytics, (C15, C37, and C38 -- orient these correctly!) and the two silver mica caps (C28 and C29).

☐ Install L1, L2, L3, and L4.

☐ Install T1, and we suggest that you do it this way. Place the leads C & D in the middle two holes first, then the outer two leads, A & B. Make sure that you get a good connection with the toroids. Almost every problem that I know of with kits comes from not cleaning the ends of the wires on toroid coils and transformers.

☐ Install the 7808. Make absolutely sure that you put the "flat" back of the 7808 to the back of the board. You may want to heatsink the regulator to the back of the case.

THIS COMPLETES THE INSTALLATION OF BOARD MOUNTED PARTS. TAKE A BREAK AND COME BACK LATER! The following parts are off-board, and not included with your kit. These are the controls and connectors.

P1 - 1K Pot
P2 - 100K Pot
Antenna Connector - builder's choice
Power Connector - builder's choice
Key Jack - builder's choice
Audio Jack - builder's choice

We also recommend you connect them "loose" first before you installthe board with its controls and connectors into a cabinet. Use short lengths of insulated stranded wire. The "38 Special" will work fine for testing and alignment purposes with its off board parts laid out on the desk, and it is much easier to troubleshoot that way, if you have any problems. To prevent shorts, make sure you have nothing underneath the board before you connect power. One good safety tip is to put the standoffs on the bottom at his point to make sure the board stands above your bench, just incase you have left a cut lead under there!

☐ Connect a 1K pot to the RF gain pads on the board. Connect the low end of the pot to pad 11, the middle of the pot to pad 12 and the high end to pad 13.

☐ Connect a 100K linear tuning pot to the Tuning pot pads on the board. The low end goes to pad 16, the middle to pad 17 and the high end to pad 18.

☐ Connect an antenna connector of your choice. Connect the ground to pad 2, the hot lead to pad 1.

☐ Next comes the power connector. The ground to pad 3, the hot lead to pad 4.

☐ I suggest that you use a stereo connector for the key line if you are going to use the TiCK keyer. If not, you may use a mono jack. The key jack connects to pin 9 for the hot lead, and pin 10 for the ground.

☐ Use a stereo jack for the audio. Use pin 19 for the audio, pin 20 for the ground.

☐ Now that everything is hooked up, it is time to align the rig. Do this outside the case, as it is easier if you have problems. Connect 12Volts to the power jack. Connect an antenna that is resonant on 30 meters. Put the headphones on and you should hear hissing in the phones. Tune until you find a signal. I like to use a RTTY signal that is near the top of the band. Tune TC1 for a peak , there should be two of them. Use the one that gives the loudest signal. Once you have peaked the signal for loudness, the receiver is aligned. Simple huh?

☐ Aligning the transmitter is somewhat more difficult, but not much. If you have access to a scope, it is very simple. Remove the antenna and connect to a dummy load. Place the probe on the output at the antenna. Connect a key to the key jack. Hold down the key and transmitTune TC2 for the cleanest signal on the scope. That is all there is to it. The transmitter is aligned.

If you don't have a scope, use another receiver that will receive 30 meters. One way of doing this is by listening to your signal on another receiver. Tune close to your center frequency and look for the adjustment that results in an output with the least close-in spurs (least noise around the carrier). Then when you get the chance, check your rig on a friend's scope. It is very easy to do.

What if you don't have another receiver or test equipment? We found a 'neat trick' how to tell that the transmitter is tuned correctly. As explained earlier, the sidetone is generated in the same chip that produces the high-level transmit signal.

Any gross mismatch at the input or output of the transmit chain will generate a distorted sidetone (both level and pitch change). This 'feature' can be used to adjust the transmit trimcap when the output is terminated into 50 ohm. Simply key down and adjust the trimcap for the cleanest sounding sidetone. If you use this method, please be aware that you should test the alignment by tuning around with a general coverage receiver and you should check it out with a scope. There is a possiblity of aligning the transmitter and having two waveforms present, one in the 9 - 9.5 MHz range and one where it is desired at 10.1 MHz. Obviously if this happens, the rig is not aligned and must be corrected. This will show up quite readily on a scope, or you can tune the general coverage receiver and hear it.

☐ Install the board in the case of your choice.

☐ Check the tuning range on your rig. Use a calibrated receiver and verify the tuning range of your rig. All of the prototypes tune from 10.110 to 10.132, but your's may vary due to the variance in 1N4004 diodes.

## MODS:

This radio was designed to be modified and to experiment with due to its low cost. Ori has put pads and traces on the board so that the radio can be easily modified. We will discuss 3 of them in this manual; the 5 Watt Power Amp, the RIT, and the TiCK keyer. You will notice additional pads that are not used. They are for an improved crystal filter but it has not been checked out and will not be in this manual. Please check the Spring issue of QRPp for 1997.

### The 5 Watt Power Mod

You can increase the output power of your radio with a very simple mod. The parts are readily available at Radio Shack and Mouser. The additional parts neede are: IRF510 transistor, 10 ohm resistor, 220 ohm resistor, 10K resistor, 18K resistor, three 0.1 mono caps, T37-2 toroid (in the kit) and a ferrite bead (also in the kit.)

☐ Remove the board from the case. Refer to the bottom board pattern on page 12 and find the area marked by 1. Cut the trace where it narrows.

☐ Install the IRF510, making sure to orient it correctly. The flat side of the transistor goes to the outside of the board. You will also need a TO220 insulator kit and a nylon 4-40 screw and nut to mount the Transistor to the back panel. When you put the rig back in the case, be sure to use heatsink compound on both sides of the insulator. Do not fail to insulate the transistor, as it will be destroyed if the back of the transistor contacts the case. Do not use a metal screw or nut as it will provide a connection to the back panel.

☐ Install the 4 resistors: R101 = 18K, R102 = 220 ohm, R103 = 10K. R104 is a 10 ohm resistor with a ferrite bead on it. Slide the ferrite bead (it looks like a bead!) onto the lead of R104 that goes in the hole nearest R103 before you solder in R104.

☐ Install the 3 caps: C101, C102 & C103, all 0.1 uF mono caps.

☐ Prepare L101 by winding 27 turns on a red T37-2 toroid using a piece of wire 18" long. Trim and tin both ends, and install.

☐ That completes the mod. Now, connect a dummy load, and using a scope, retune TC2 for the cleanest signal, not the greatest output power.

## RIT MOD:

This mod is one of the easiest to do, and it makes your transceiver much more usable. This mod actually does two things. It gives you RIT and will give you the lower portion of the band. The prototype rigs that it was tested on gave a tuning range of 10.102 to 10.125 MHz., which is ideal for the 30 meter band. Here are the necessary parts: 1 6.8uH molded choke (Mouser# ), 1 SPDT toggle switch, 1 10K pot, 2 1N914 diodes, 1 5.1K resistor.

☐ Remove the board from the case. Turn it over, and cut the trace marked by 3 on the bottom board pc pattern on the pc board pattern page.

☐ Install diodes D301 and D302. (1N914)

☐ Install resistor 301 (5.1K)

☐ Wire the switch with one side to pad 14, the center to pad 15.

☐ Connect the center tab (wiper) and one end of the pot together.

☐ Wire the other side of the switch to the side of the RIT pot that is connected to the center wiper of the pot.

☐ Connect the other end of the pot to the tuning pot.

☐ Carefully remove the inductor, L1 and replace with the 6.8uH inductor.

That completes the mod. Now you will need to check the tuning range. It should be 10.102 to 10.125. If the coverage is below the band edge, you will need to try another inductor. Remember it is your responsibility to be in band.

## TiCK KEYER MOD:

The TiCK (tm) keyer is a very neat 8-pin pre-programmed PIC microcontroller with all the features you could ask for from a $5.00 part. The 38 Special PCB was layed out to accept the TiCK and its associated circuitry to enable simple modification with just a handful of parts.

You will need:

| Qty. | Part No. | Circuit Ref. | Description |
|---|---|---|---|
| **** | ******** | ************ | *********** |
| 1 | TiCK chip | U201 | Keyer chip from Embedded Research |
| 1 | DIP 8 Socket | U201 | 8 pin DIL low profile I.C. socket |
| 1 | 10K Ohm | R202 | 1/4W, 5% resistor |
| 1 | 270K - 1M | R17 | 1/4W, 5% resistor (see text) |
| 1 | 0.1 uF | C202 | 50V monolythic capacitor |
| 1 | 2N2222/2N3904 | TR201 | General purpose NPN |
| 1 | 78L05 | VR201 | +5V, 100mA voltage regulator |
| 1 | Normally Open pushbutton switch - to program the Tick | | |
| 1 | Mini-stereo jack socket - for the key input | | |

NOTE: R201& C201 are not used.

All the above items except the programming pushbutton switch and the key input jack are mounted directly onto the 38 Special PCB. The PCB legend shows the positions of all these components.

☐ Start the modification by removing the original 38 Special sidetone circuit. Remove the following components from the PCB:

| Circuit Ref. | Description |
|---|---|
| ************ | *********** |
| ☐ R15 | 150K Ohm resistor |
| ☐ R16 | 68K Ohm resistor |
| ☐ R17 | 2.2M Ohm resistor |

☐ C31 0.01 uF capacitor

☐ D8 1N914 diode

☐ Next, turn the PCB over and find the modification track which is between U4, 74HC240 (near pins 4 and 5) and U2, CD4066. The modification track has two little bars on it for easy identification and is marked with #2 on the bottom pcboard pattern in the manual. Cut the signal track (with a hobby knife) between the two bars (which are at right angles to the direction of the signal track. Be careful not to cut any other track nearby. When you have cut the track, use a meter to check that there is NO continuity between U4 pin 3 and R17. This disconnects the old sidetone circuit completely. The reason for this part of the modification is that U4 pin 3 and the TiCK pin 3 sidetone output cannot be connected together.

☐ Next you need to make a decision. Do you like your sidetone to be loud, medium or quiet? Choose a new value for R17 from the following table or, of course, any in-between value which gives you the sidetone level you like best (you could fit a small 1M Ohm preset potentiometer in place of R17 if you want to be able to continually adjust the sidetone level):

| Sidetone Level | R17 value |
|---|---|
| *************** | ********* |
| Loud | 270K Ohm |
| Medium | 560K Ohm |
| Quiet | 1M Ohm |

☐ Solder the new R17 resistor to the PCB.

☐ You don't have to fit U6 in an 8 pin DIL socket, but it is recommended. If you are going to use a socket, solder it in now and pay attention to the orientation so that the notch on the socket matches the notch on the silkscreen.

☐ Solder in the following parts. R127, R128, C133, C144.

☐ Orient VR2 with the flat side matching the flat side on the silkscreen and solder it in.

☐ Orient TR3 with the flat side matching the flat side on the silkscreen and solder it in.

☐ Lastly, push the TiCK chip into its socket very carefully (this device has fairly fragile leads) or solder it directly in place.

☐ Then all you have to do is wire up the push-button switch and the key input jack and you are done. Below is a table to help you wire things up correctly:

| PCB pin # | Signal | Connects to... |
|---|---|---|
| ********* | ****** | *************** |
| 5 | Ground | Ground pin key input socket |
| 6 | DAH | Dit paddle pin on key input socket (usu ally tip) |
| 7 | DIT | Dah paddle pin on key input socket |
| 8 | PGM | One side of the push-button programming switch |
| 9 | Key | This is the old key input, no longer used |
| 10 | Ground | The other side of the push-button programming switch |

Before powering up the 38 Special, go make yourself a cup of coffee/tea, take a 15 minute break, then come back and check over your work one more time! Have you fitted VR2 the right way round? How about the TiCK chip, pin 1 in the right place? If all is well, plug in a set of paddles, headphones and an antenna (or dummy load) then power it up.......

No smoke? Great!! Hit the paddles: the 38 Special should immediately start transmitting and you should hear nice crisp sidetone in your headphones. If not, check your wiring first before you start ripping out components - this is normally where problems are found. If you're happy with the wiring, you can check a few things on the PCB next. Measure the voltage from Ground to pin 1 of the TiCK - it should be +5V. If not, then you have a voltage regulator problem, check the orientation of VR2 and check for shorts underneath the PCB. If you have +5V, then check the voltage at pin 4 - it should also be +5V. If it's 0V then you may have the wrong type of push-button switch fitted (it should be a push-to-make switch, not a push-to-break). If there's +5V on pin 4, then measure the voltages on pins 7 and 6 of the TiCK - these should be +5V too, and should go to 0V when you hit the DIT/DAH paddles respectively. If these inputs are not wiggling properly, you have a key/paddles connection problem (most likely a wiring error on the mini-stereo jack socket - the connections to these are not always obvious!). Lastly, monitor the voltage on pin 5 of the TiCK - it should go from 0V to +5V every time you key. If, after all these tests, you still can't get it working, enlist the help of your local electronics expert or send me email and I'll try to sort it out (fifield@pacbell.net).

**Programming the TiCK**

At power-on, the TiCK will always be in default mode. It does not remember the settings you had programmed into it the last time you used it (it doesn't have any non-volatile memory in it). In practice, this is very easy to get used to.

After you apply power to the 38 Special, you can program the TiCK as follows:

1. Press and hold down the push-button programming switch, let it go when you hear the CW letter/s for the function you'd like to change, then use the paddles to make the change. The TiCK will always start at "S" (speed adjust) and will rotate through the list, so if you miss the function you want to change, just keep pressing and it'll come round again:

"S" Speed Adjust - hold the current DIT paddle down to increase speed, DAH to decrease speed

"T" Tune - transmitter will key until you hit a paddle or the PGM button again

"P" Paddle select - hit the current DIT paddle to toggle paddles for lef/right handed operation. This control reverses the dit and dah paddles.

"A" Audio - hit DIT to enable sidetone, DAH to disable

"SK" Straight Key - either paddle will toggle between iambic and straight key modes. Your straight key can be connected to either the DIT or the DAH inputs.

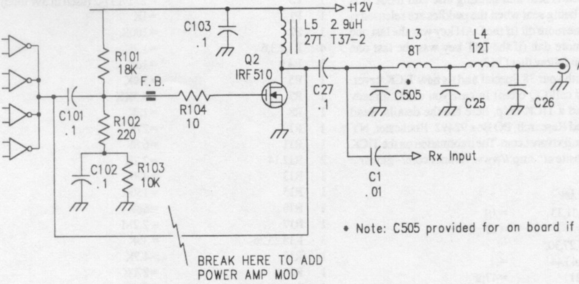
"M" Iambic Mode - hit current DIT paddle for mode A, DAH for mode B. (Mode A is where a dit or dah being sent when the paddles are released is sent and nothing else and mode B is where a dit or dah being sent when the paddles are released is sent followed by one more dit (if the DAH key was the last one released) or one more dah (if the DIT key was the last one released).....did you follow that OK?)

Have fun with your 38 Special and its new TiCK keyer. Get on the air and call CQ often! In case you didn't already know where to find a TiCK chip, here are the details. Send $5.00 to: Embedded Research, PO Box 92492, Rochester, NY 14692 Email gmdsr@vivanet.com The information on the TiCK is also on their website at: http://www.vivanet.com/~gmdsr

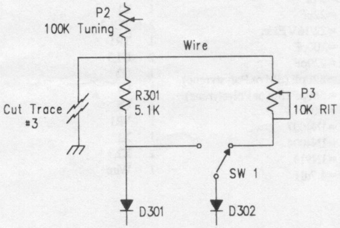
**38 Special Parts List**

| | | |
|---|---|---|
| 8 | C1,2,4,6,14,25,31,33 | =.01 |
| 1 | C3 | =150pF |
| 14 | C5,12,13,18,24,27,30, 35,36,39,41,42,43,44 | =.1 |
| 6 | C7,8,17,19,20,21 | =47pF |
| 1 | C9 | =39pF |
| 1 | C10 | =12pF |
| 1 | C40 | =220/16V Elect. |
| 1 | C11 | =5 pF |
| 3 | C16,23 | =22pF |
| 3 | C15,37,38 | =22/16V Elect. |
| 1 | C22 | =100pF |
| 2 | C26,32 | =220pF |
| 1 | C28 | =820pF (SM or Polystyrene) |
| 1 | C29 | =560pF (Sm or Polystyrene) |
| 1 | C34 | =.001 |
| 2 | D1,2 | =1N4007 |
| 1 | D3 | =1N4004 |
| 5 | D4,5,6,7,8 | =1N914 |
| 1 | L1 | =4.7uH |
| 1 | L2 | =20T T37-2 |
| 1 | L3 | =12T T37-2 |
| 1 | L4 | =15T T37-2 |
| 1 | L5 | =27T T37-2 (used in 5W mod) |
| 1 | P1 | =1K |
| 1 | P2 | =100K |
| 4 | R1,2,3,6 | =1.3K |
| 2 | R4,9 | =10K |
| 1 | R5 | =3.9K |
| 1 | R7 | =3.3KK |
| 1 | R8 | =18K |
| 1 | R10 | =27K |
| 1 | R11 | =6.8K |
| 2 | R12,14 | =2.2K |
| 1 | R13 | =470 |
| 1 | R15 | =150K |
| 1 | R16 | =68K |
| 1 | R17 | =2.2M |
| 3 | R18,25,26 | =30K |
| 1 | R19 | =4.7K |
| 1 | R20 | =270K |
| 1 | R21 | =510 |
| 1 | R22 | =390 |
| 1 | R23 | =33K |
| 1 | R24 | =47 |
| 1 | T1 | =2T Pri : 19T Sec. T37-2 |
| 2 | TC1,2 | = 5-60 pF Trimcap |
| 1 | TR1 | =2N3904 |
| 2 | U1,3 | =NE602AN |
| 1 | U2 | =CD4066BE |
| 1 | U4 | =74HC240 |
| 1 | U5 | =NE5532 |
| 1 | VR1 | =7808M |
| 1 | X1 | =22.118MHz |
| 2 | X2,3 | =12.000MHz |
| 1 | Wire | =#26 Magnet |

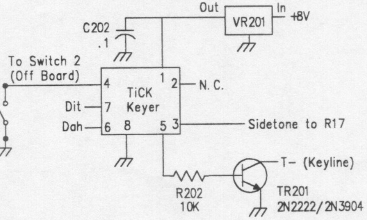
# "38 Special" 5 WATT POWER AMP MOD

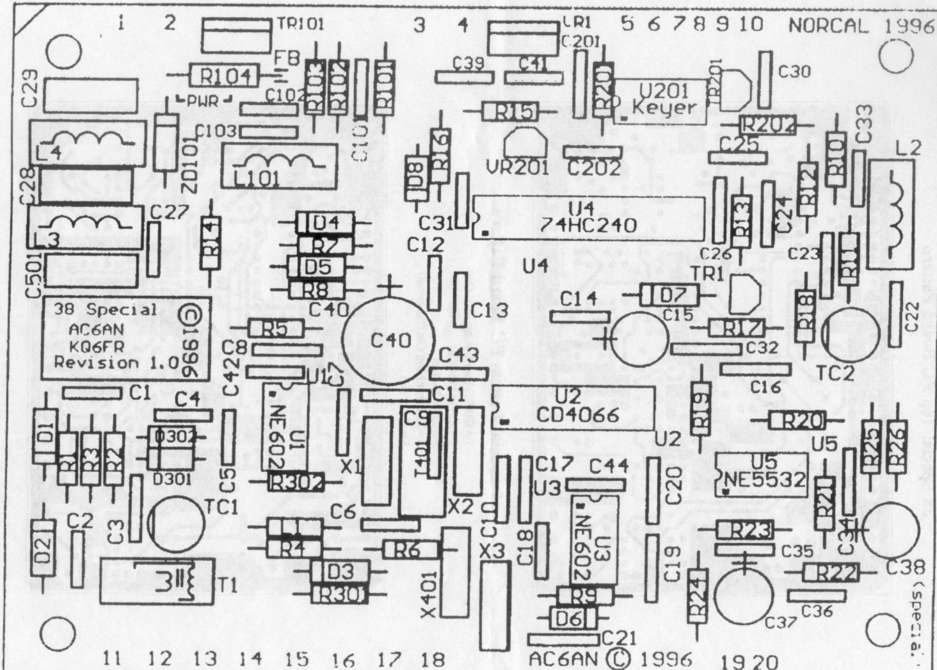



# RIT MOD

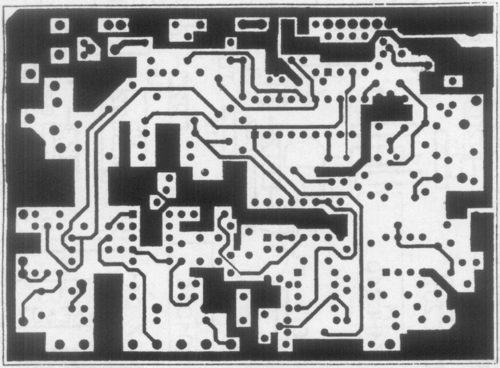



# TiCK KEYER MOD



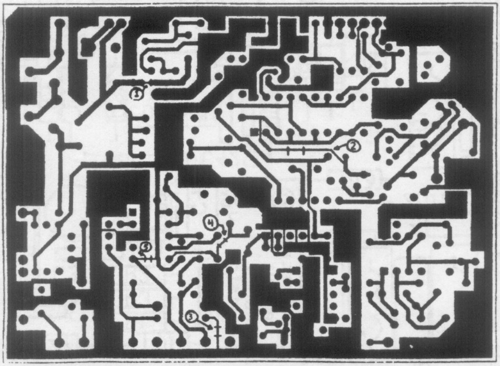

NORCAL 1996
38 Special
AC6AN
KQ6FR
Revision 1.0
© 1996
AC6AN © 1996
U4
74HC240
U2
CD4066
U5
NE5532
U1
NE602
U3
NE602
U201
Keyer
(special)

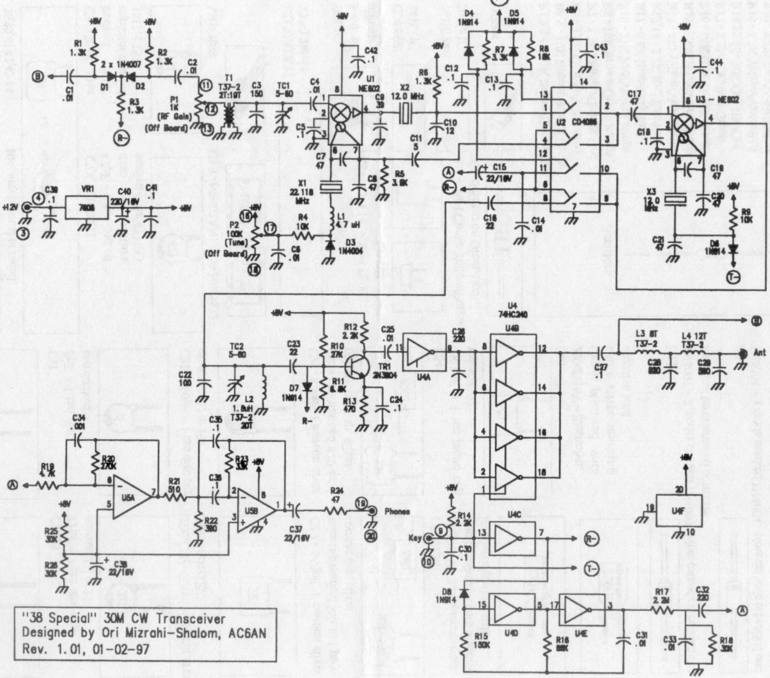
## 38 Special Top PC Board Pattern



## 38 Special Bottom PC Board Pattern

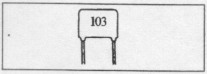
1 = IRF510 Power Amp Mod Cut
2 = Keyer Mod Cut
3 = RIT Mod Cut
4 = IF Filter Mod Cut (Reserved)
5 = Reserved





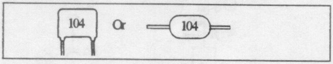

"38 Special" 30M CW Transceiver
Designed by Ori Mizrahi-Shalom, AC6AN
Rev. 1.01, 01-02-97

C1,2,4,6,14,25,31,33
.01 uF = 8 blue or tan bodied caps marked 103




C5,12,13,18,24,27,30,35
36,39,41,42,43,44

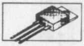
.1uF = 14 Tan bodied caps marked 104, may be axial or radial.



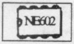

C3 - 150pF - 1 tan bodied disc capicitor marked 151J or 151


C7,8,17,19,20,21
47pF - 6 tan bodied disc capacitors marked 47J or 47 NPO


VR1-7808



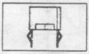
U1,3 - NE602AN



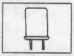

U5 - NJR5532


L2,L3,L4,L5,T1
T37-2 Toroid

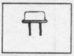
TC1,2
5-60 pF trimcap



X1 22.118 Crystal



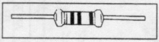
X2,3 12.000 Crystal



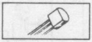
CD4066BE
14 Pin IC

74HC240
20 Pin IC

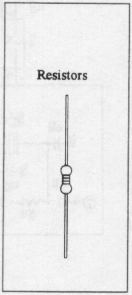
L1 4.7uH Choke Yellow/Purple/Gold/Silver on Green Body



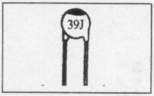
2N3904



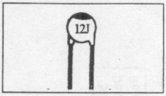
R1,2,3,6 - 1.3K Brown/Orange/Red
R4,9 - 10K Brown/Black/Orange
R5 - 3.9K Orange/White/Red
R7 - 3.3K Orange/Orange/Red
R8 - 18K Brown/Gray/Orange
R10 - 27K Red/Violet/Orange
R11 - 6.8K Blue/Gray/Red
R12,14 - 2.2K Red/Red/Red
R13 - 470 Yellow/Violet/Brown
R15 - 150K Brown/Grn/Yellow
R16 - 68K Blue/Gray/Orange
R17 - 2.2M Red/Red/Green
R18,25,26 - 30K Org/Blk/Org
R19 - 4.7K Yellow/Violet/Red
R20 - 270K Red/Violet/Yellow
R21 - 510 Green/Brown/Brown
R22 - 390 Orange/White/Brown
R23 - 33K Orange/Orange/Orange
R24 - 47 Yellow/Violet/Black



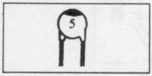

C9 - 39pF = 1 tan colored disc cap marked 39J




C10 - 12pF = 1 tan colored disc cap marked 12J

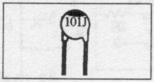



C11
5pF = 1 tan disc cap marked 5

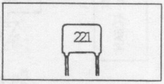



C16,23
22pF = 2 tan disc caps marked 22J or 22

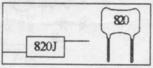

C22 - 100pF = 1 tan disc cap marked 101J or 101



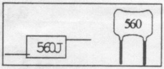

C26,C32 - 220pF = 2 tan mono caps marked 221



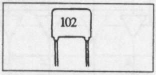

C28 - 820pF, 1 maroon silver mica cap marked 820 or 1 polystyrene cap, silver.



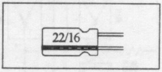

C29 - 560pF, 1 maroon silver mica cap marked 560, or 1 polystyrene cap, silver.



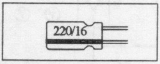

C34
.001uF = 1 tan mono cap marked 102



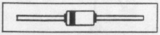

C15,37,38
22uF/16V = 3 Blue electrolytics. Cap is polarized with negative lead having white stripe



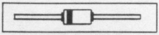

C40
220uF/16V = Electrolytic. Cap is polarized with white stripe marking negative lead




D1,2
1N4007 = 2 diodes marked 1N4007. Note cathode is banded end and must be orientated correctly.



D3
1N4004 = 1 diode marked 1N4004. Note cathode is banded end and must be orientated correctly.



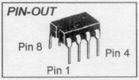
D4,5,6,7,8
1N914 = 5 diodes marked 1N914. Note cathode is banded end andmust be orientated correctly.

# COMPONENT DATA SHEETS FOR THE "38 SPECIAL"

## NE602A - Balanced Mixer/Oscillator

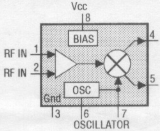
The **NE602** is a low-power VHF double-balanced mixer with input amplifier, on-board oscillator and voltage regulator. It uses a "Gilbert Cell" mixer, producing a conversion gain of 18dB. The gain, low power, low noise and small packacing makes the NE602 a popular choice for high-performance battery operated communications equipment.

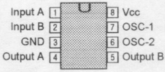
| *SPECIFICATIONS* | NE602A |
|---|---|
| Vcc Range | +4.5 to +9 v |
| DC current drain | 2.4-2.8 mA |
| Input signal frequency | to 500 MHz |
| Oscillator frequency | to 200 MHz |
| External LO injection | 200 mVpp |
| Noise figure (45 MHz) | 5.0 dB |
| Mixer gain (45 MHz) | 17 dB |
| 3rd order intercept | -13 dBm |
| RF input overload | -13 dBm |
| RF input resistance | 1.5 KΩ |
| RF input capacitance | 3.0 pF |
| Output resistance | 1.5 KΩ |
| Min. detectable signal | -119 dBm |
| Signal-to-noise ration | 12 dB |




***In the 38S*** - NE602 U1 is the receive mixer, converting the 10MHz input RF to a 12MHz IF (by mixing with the 22MHz LO). NE602 U3 is the product detector in the receive mode, and the transmit mixer in the transmit mode.

FUNCTIONAL CIRCUIT

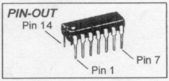



## CD4066B - CMOS Bilateral Switch

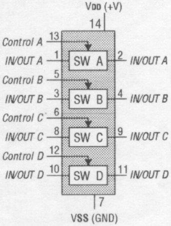
The **CD4066B** is a CMOS bilateral switch (meaning signals can be routed through the switches in either direction) and designed for both digital and analog signals. It is an improved version of the CD4016 switch by having a lower "on" resistance. The 4066 is used for the switching and multiplexing of digital, analog and video signals up to 40MHz.

***In the 38-S*** - it is used for switching the IF and LO signals into the product detector/xmit mixer, (U3) and routing the resultant audio or transmit frequency outputs, depending whether in the receive or transmit mode. Less than 0.2dB loss was measured through the switches on the RF signals.




***SPECIFICATIONS***

```
VDD Voltage ......+3-18V
Device Current ...   <1uA
Control Inputs:
 Vin for"Off"  ... <4.5V
 Vin for "On"  ... >5.5V
 Input current ...<0.1uA
"On" resistance ..   80Ω
"Off" Leakage ....  0.1nA
Switch-to-Switch
 Isolation ...... >50dB
```




## T37-2 Toroidal Cores

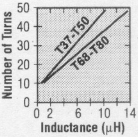
The T37-2 is a high-permeability iron powder toroidal core that allows relatively high inductance coils and transformers to be wound on a small form. It is .375" in diameter (hence, the T*37*; a .5" dia is a T50, etc.). The -2 identifies the core as suitable for 2-30MHz, μ=10 and a 95ppm temp. coefficient. The -2's are also color coded red. The Inductance Index ($A_L$) of the T37-2 is 40, which allows determination of the inductance and number of turns required as follows:

$$L(\mu H) = \frac{A_L \times N^2}{10{,}000}$$

$$N = 100\sqrt{\frac{\text{desired } L(\mu H)}{A_L\ (\mu H/100\ \text{turns})}}$$

Where:
N=number of turns
$A_L$=Inductance Index
=40 for T37-2 (=49 for T50-2)

**INDUCTANCE vs. TURNS (Approximate) For T37-2 to T80-2 Cores**




## 74HC240 CMOS Octal Bus Driver

The **74HC240** is the high-speed CMOS version of the TTL 74LS240, an array of inverters intended for 8-bit bussed systems. When the ENBL pins are LO (0V) the outputs are active; with ENBL HI (+V), the outputs are open (hi-Z). The 74HC240 version can be operated in the linear mode (as amplifiers).

***In the 38S*** - the RF is applied to IN5 (pin11) as a digital "square wave" inverter with a capacitive load (C26) to form a sinewave. This is applied to four sections in parallel for 7Vpp output at increased current drive to produce about 350mW at 10MHz. This is the "PA" amplifier. The two remaining sections, pins 15 and 17, are operated in the linear mode with RC feedback to form an audio oscillator.

***SPECIFICATIONS***

```
VDD Voltage .... +2 to 8V
LO Input ......... <0.9V
HI Input ........ >3.1V
Propagation delay  20nS
Max. Frequency ... 20MHz
```