BUILDING THE SDRZero

PLEASE READ THIS MANUAL BEFORE YOU START TO ASSEMBLE THE KIT!

Welcome to the SDRZero kit manual. By following the steps described below your SDRZero will be working in no time!

If you have any question don't hesitate to email me right away! This manual is under constant revision with information received from builders
e-mail: *py2wm@arrl.net*

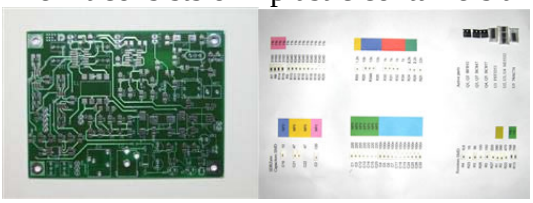
Important links:
SDRZero on Internet (http://ewp.homelinux.net/SDRZero/)
PY2WM (http://py2wm.qsl.br/SDR/SDRZero-2.html) - SEE THE SDRZero FAQ in Portuguese
SDR-BR - (http://br.groups.yahoo.com/group/sdr-br/) English is also welcome.

TASKS

1º - PCB PREVENTIVE REPAIR
2º - PLACING THE SMD PARTS
3º - COIL AND RF TRANSFORMER
4º - REMAINING PARTS
5º - LOCAL OSCILLATOR TRIMMER ADJUST AND FINAL TESTS

Tools you will need: 20 ~ 50W soldering iron with small conical tip, long-nose pliers and diagonal cutter, fine tweezers, headband binocular magnifier and/or magnifying glass, multimeter with 20V and 200mA scales.

The kit consists of 2 plastic containers and 1 CD-ROM:



Container A contains 1 PCB - printed circuit board, and a paper sheet with the SMD parts: resistors, capacitors and semiconductors.

Container B

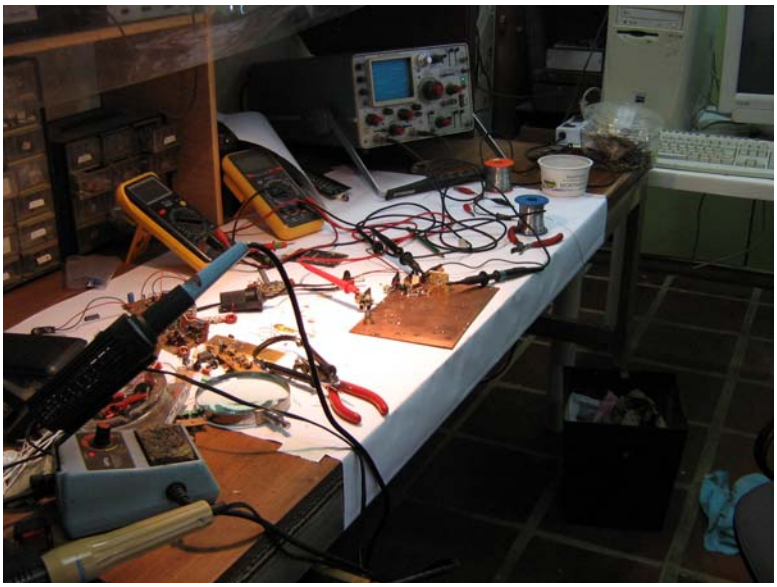
contains:

40 cm of enamel coated bifilar twisted wire #26/30
20 cm of enamel coated wire #26
10 cm coaxial cable RG-174
2 m solder 0,5 mm 63/37 flux 2,4%
2 capacitors MKT 1 uF - C30, 31
3 capacitors electrolytic 10 uF - C27, 28, 29
4 capacitors 10 nF MKT matched 1% - C8, 9, 10, 11
1 capacitor trimmer 30 pF – C20
1 crystal 28.200 or 28.224 or 28.356 MHz
1 RF choke inductor 100 uH – E$1
2 inductors 2,2 uH – L1, 4
2 inductors 4,7 uH – L2, 3
1 binocular core for T1
1 oscillator coil base L5
1 polypropylene cylinder L5
1 female connector P2 stereo – P2
1 conector VDC – P1
2 diodes 1N4148 – D3, 4
1 diode 1N4004 – D1
1 LED – E$2
1 transistor BC327 SOT54 – Q6
1 regulator IC 78L05 SOT54 – U6

THE WORKING PLACE

SMD parts are small and easy to lose. That is why a suitable work place is important. It is also important to be able to see well. A table with a free area of around 1x1 m (3x3 feet) will do nicely.

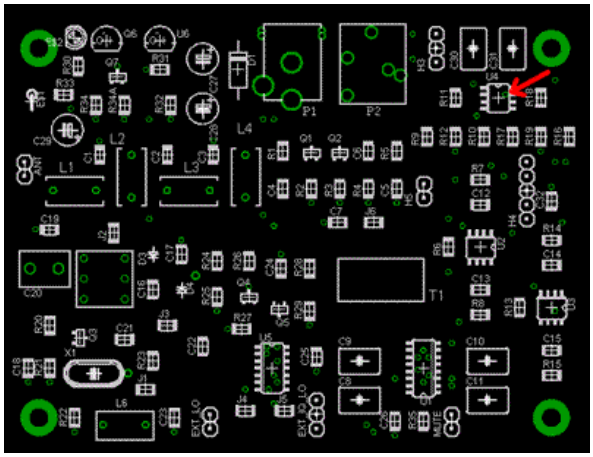
Covering the table with white paper will make it easier to spot the tiny SMD parts.



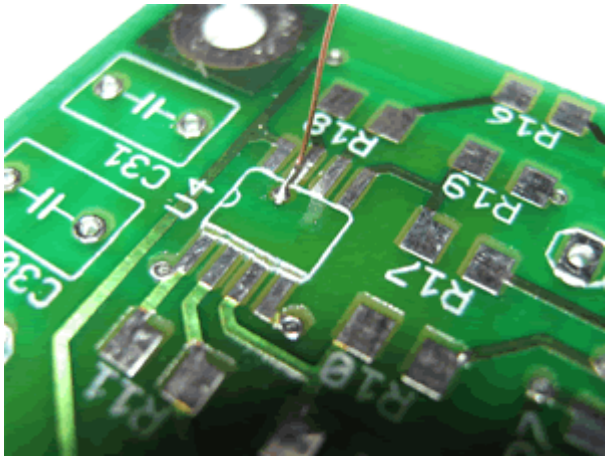
The photo shows the "building area" of my workbench.

1º - PCB PREVENTIVE REPAIR

There is a problem on the through-hole (via) connected to pin 7 of U4. A faulty copper trace between the pin pad and the via was detected in some PCBs. A cautionary repair is recommended even if a multimeter shows continuity.



The repair is easy and should be done before doing anything else. Examine the PCB and the photo below.
Take the RG-174 coaxial cable piece and strip 1 cm from the outer insulation. Cut a single wire from the braid and put the piece of cable aside as it will be used later on. Place the wire into the via, solder it with a very small quantity of solder, then bend the wire in the direction of R18 and over the pad of pin 7. Now solder it to the pad, again using a very small quantity of solder. Remove excess wire. Ensure that the wire seats flat against the PCB or it will be difficult to position IC U7.



2º - PLACING THE SMD PARTS

For this task we will use parts in **container A**.

Follow the same order of the part on the paper sheet, from top to bottom and left to right. The capacitors come first, then resistors, then the semiconductors.

If you cut the paper sheet in 6 sections along the main folding lines it will simplify the task.

How to pick SMD parts:
Using tweezers and a hobby knife, grab and lift the transparent plastic tape. Carefully turn the paper over and the part will drop onto the work bench.

SEE VIDEO CLIP: PICKING SMD PARTS

How? In Word press Ctrl+click, in Adobe Reader go to the "vídeos" directory on the CD-ROM and click on "videos/Movie-retirando-SMD.wmv"
On the clip PY2WM describes the picking process. Be especially careful not to lose the tiny parts when they tumble out.

Don't hurry, go slow to avoid errors, use ample illumination and keep the workplace clean!

CAUTIONARY MEASURES:

1 - THE CAPACITORS ALL LOOK SIMILAR, WITH NO IDENTIFICATION.
LOCATE THEM ONE BY ONE, CHECKING CAREFULLY TO ENSURE EACH IS IN THE CORRECT PLACE.

2 – CHECK THE TWEEZERS.
AVOID TWEEZERS WITH SMOOTH INTERNAL SURFACES AT THE TIPS. RATHER SELECT TWEEZERS WITH A ROUGH FINISH. A PART THAT SPRINGS FROM UNSUITABLE TWEEZERS MAY GET LOST!

Watch the video clips:
How to place and solder SMD resistors and capacitors - videos/smd_Movie.wmv
How to place and solder SMD transistors - videos/transistor.wmv
How to place and solder SMD ICs - videos/CI.wmv

How? In Word press Ctrl+click, in Adobe Reader go to the "vídeos" directory on the CD-ROM
The clip shows PY2WM describing the processes, and emphasizes the importance of carefully examining each pin.

MORE ON SMDs. Here is a soldering guide by Infidigm
http://www.infidigm.net/articles/solder/

When you reach this point, all SMD parts should have been positioned and soldered.

Here are some hints to overcome an unsteady hand:

One technique is to glue the part to the board, then solder it. Ensure the glue does not contaminate the soldering area.

Fast curing glues based on cyanoacrylate are likely to be too fast to be useful. A trial-and-error approach is recommended.

Another technique is to build a small jig to hold the part in place while leaving the hands free for soldering.

Articles and photos on the CD:

1 – SMD HOLD-DOWN.htm
2 - Building_an_SMD_Soldering_Tool.pdf
3 - The KD1JV AT Sprint 2 SMD Transceiver.htm
4 – Foto - Soldering_Jig.jpg

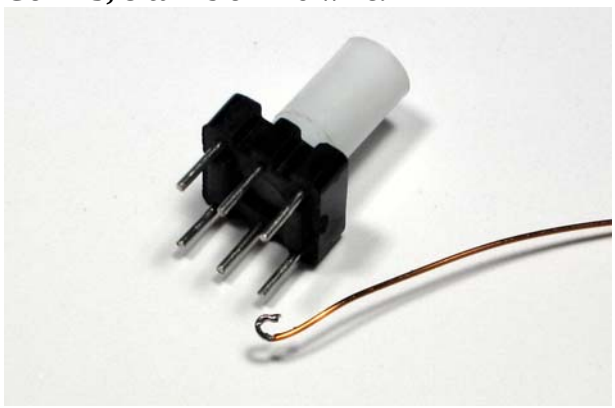
More advanced techniques can be found on the Internet, using modified home ovens and solder paste, but are unlikely to be necessary for this project.

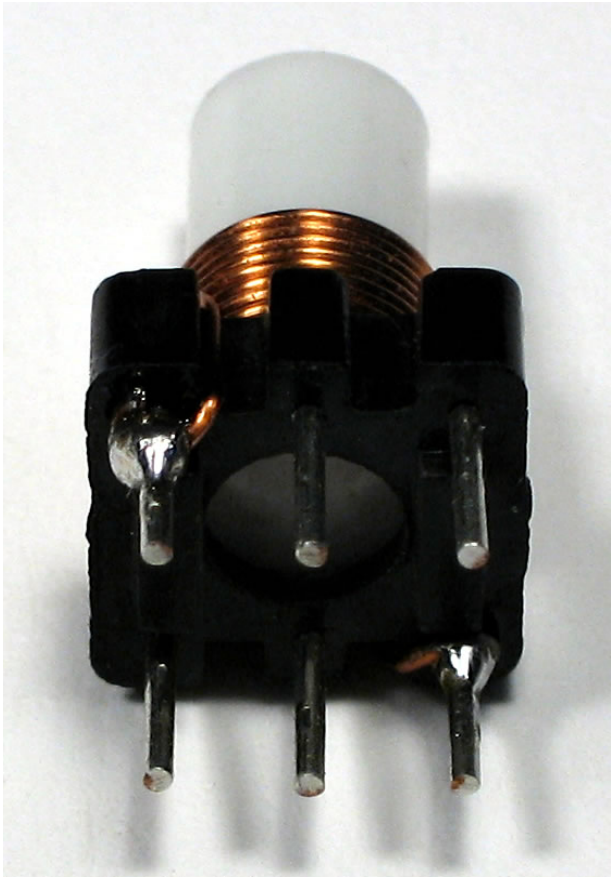
3º - COIL AND RF TRANSFORMER

Tasks Wind L5. T1 - cover the ferrite core and wind.

The enamel covered copper wire furnished is easy to solder. Holding a hot soldering iron makes the enamel fuse, then the melted hot solder wets and covers the exposed copper.

Coil L5, 8 turns of #26 wire.





The coil base doesn't fit well on the PCB. Before winding, place the coil base on the board and twist as you force it down until all 6 pins enter their holes and appear on the other side of the board.
Now take the #26 wire, prepare one end as described above, measure 18 cm and cut. Solder to corner pin. Wind 8 turns and then solder the wire onto the opposite corner pin, making 8 ½ turns.

Don't let the solder flow along the pins as the holes in the PCB are a snug fit. Don't try to enlarge the holes either, as this will destroy the metallized vias.

Transformer T1, 8 + 8 bifilar turns.

Each time the wire passes through the hole counts as one turn

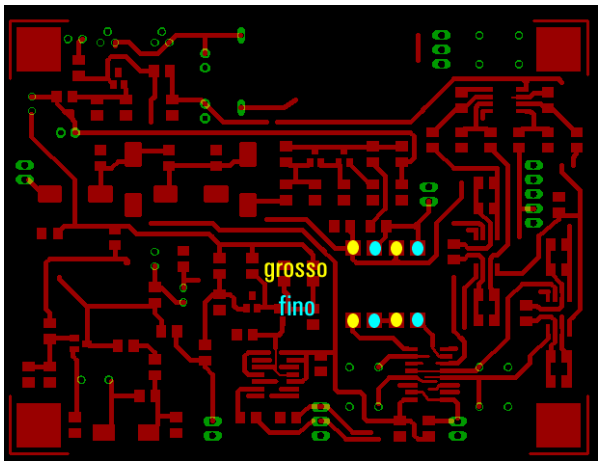
Preparing the core: First cover the core with plastic adhesive tape and then clear the tape over the apertures on both sides. The objective is to protect the wire from scratching on the rough ferrite surface as this could lead to short-circuits that are difficult to locate.

Core recovered with plastic adhesive tape.

Cut the previously twisted pair of #26/#30 wire in half. The first winding comprises 8 bifilar turns. Then complete the second winding on the other side/hole, as a symmetrical mirror image of the first winding.

Each winding is only 8 turns. The photo above is of other similar transformer, comprising more turns.

The two lines point to the start of each winding (one is completed, the other just started). Note how one winding is the mirror image of the other.



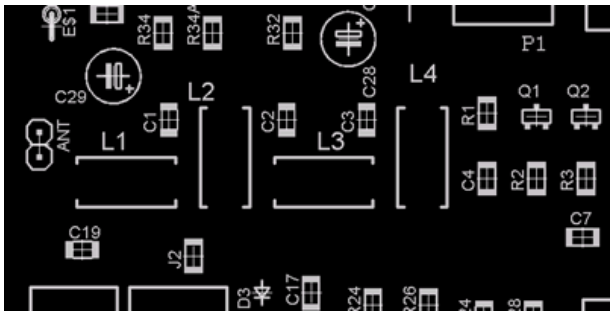
The bifilar twisted wire is made with #26 (thick) and #30 (thin) wires.

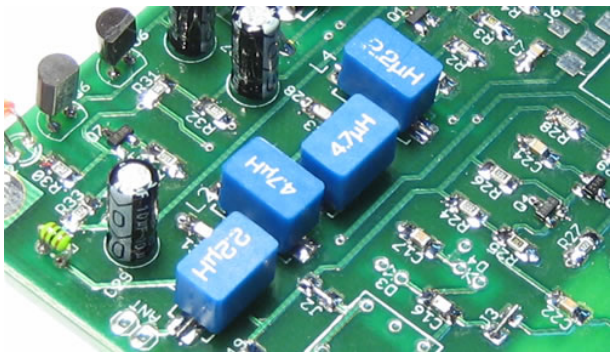
Solder the wires according to the color code.

4º - REMAINING PARTS.

POSITION AND SOLDER:

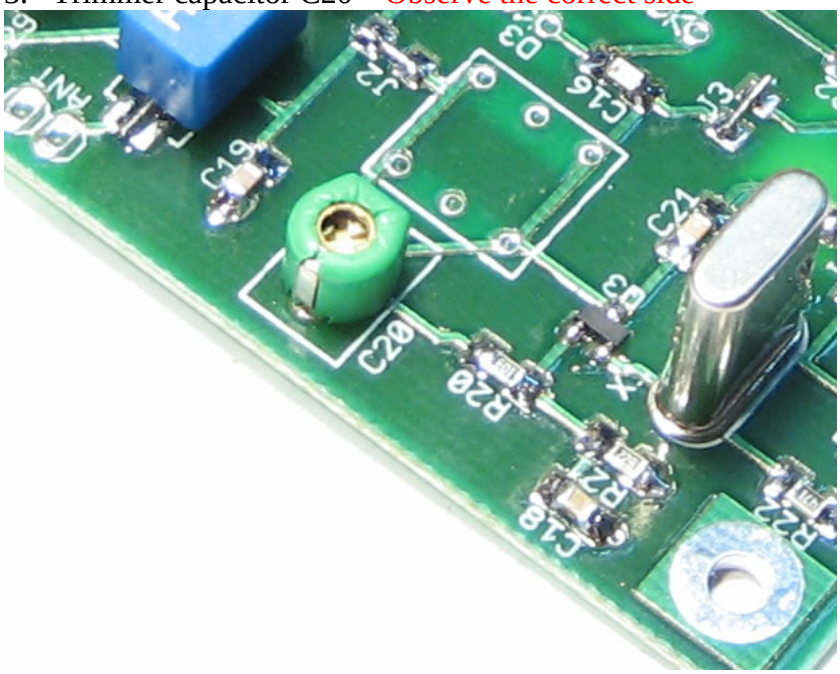
1. First do **L1** (2,2 uH) and **L3** (4,7 uH) , then L2 and L4. NOTE: the inductor leads are too thick and don't pass through the holes. Fold, then cut and solder them SMD style (zoom in to better see how this is done). Do not try to enlarge the holes as this would destroy the metallized vias.



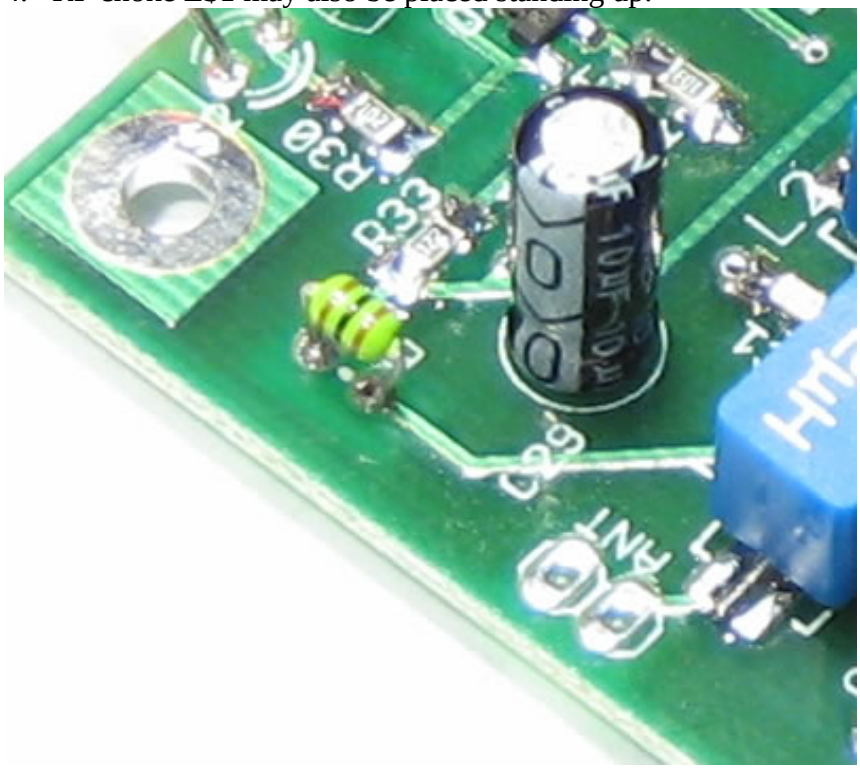


2. 10 uF capacitors – Observe the correct polarity.

3. Trimmer capacitor C20 – Observe the correct side



4. RF choke E$1 may also be placed standing up.

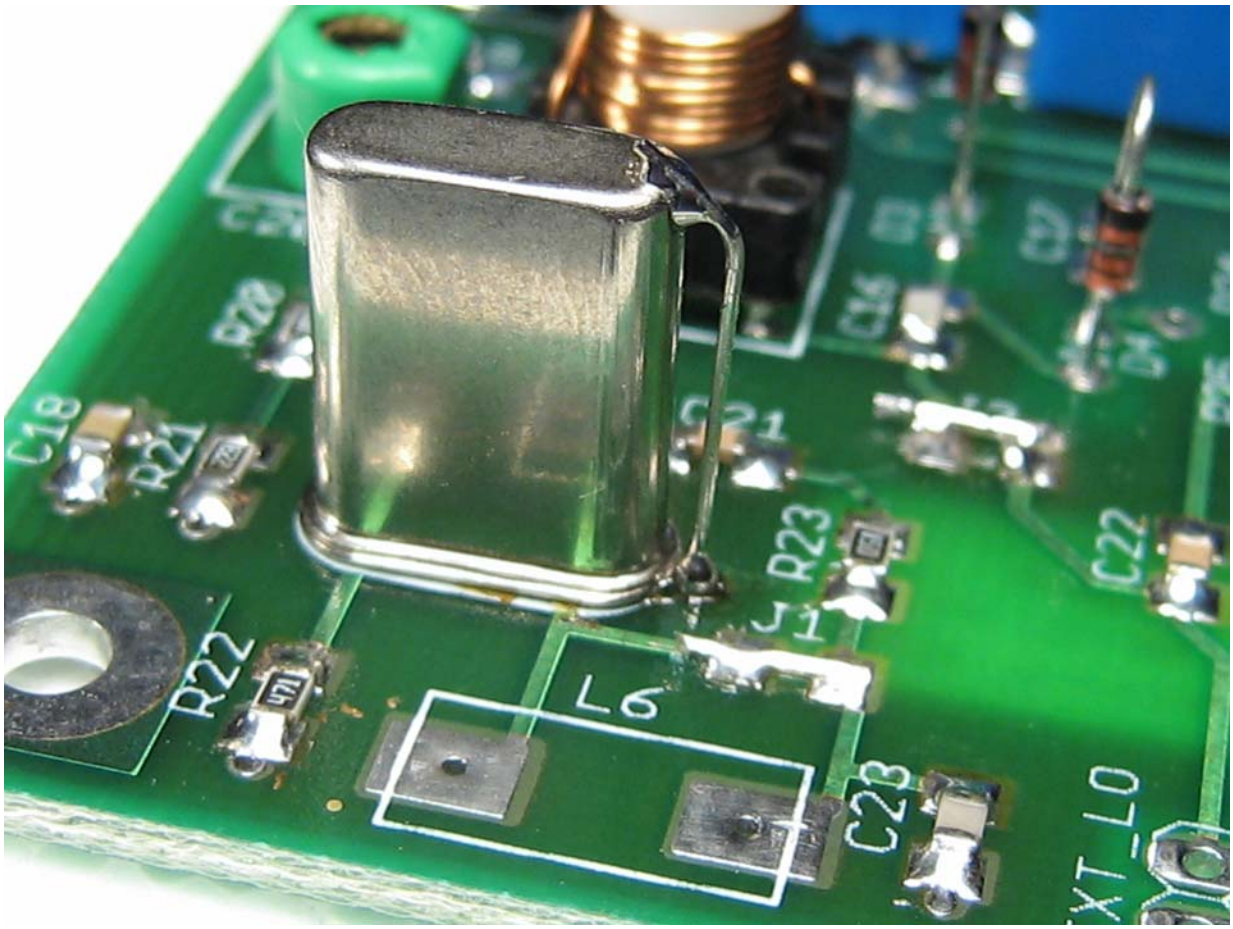


5. LED E$2. The shorter lead enters the hole connected to ground, closer to the corner of the PCB.

6. Q6 and U6. See the video clip "videos/78L05.wmv"

How? In Word press Ctrl+click, in Adobe Reader go to the "videos" directory on the CD-ROM

7. Now do the remaining components and connectors. When placing the output connector P2, first remove the nut or the connector will not seat well on the PCB.
   Take the piece of RG-174 coaxial cable that was left over, position and solder it onto the PCB antenna pads. Identify the two pads. One is a grounded pad, the other connects to L1. Insert inner and outer coaxial cable wires accordingly. The other cable edge should be soldered to the antenna jack (only furnished in the complete kit version).
8. Insert the crystal and solder the 2 leads. The case is grounded using a discarded component lead off cut. Do not solder the ground via directly to the crystal case as the result is likely to prove mechanically unsound.



9. Jumpers. Use the off cuts from components leads. **All jumpers must be connected for the radio to work**.

J1 (xtal)
J2 (oscillator supply)
J3 (internal oscillator)
J4 (oscillator output IQ)
J5 (oscillator output IQ)
J6 (QSD RF input)
MUTE (to the side of U1 e R35)

5º - ADJUSTING THE OSCILLATOR TRIMMER

Insert a power supply plug into the VDC jack (tip - positive, ring - negative, the circuit is reverse polarity protected). Voltage should be 12 to 15V at 120 mA. The LED should light. If it doesn't, trouble-shoot the PS circuit.

Connect a multimeter with the 20Vdc scale selected onto the test point on the PCB, on the trace from D4 to C17. (Use the crystal case for ground). Adjust the trimmer for maximum voltage which should be around 6~7.5V. Disconnect the power supply and connect it again and verify that the oscillator starts and the same voltage appears again. If not, turn the trimmer slightly to one side or the other. The oscillator should then start. Leave the trimmer in this position.

Now the SDRZero can be connected to a computer sound card (to the line input jacks). Also connect a good antenna. Launch you favorite SDR software and enjoy!

JUMPERS

J1 (xtal) - Opening this jumper allows the insertion of an inductor, capacitor or both in series with the crystal, for frequency trimming or to transform the oscillator into a VXO.

J2 (oscillator supply) - Open this jumper to disable the internal oscillator.

J3 (internal oscillator) - Disconnects the internal oscillator from the sine-square converter.

J4 and J5 (oscillator output IQ) - Disconnect IQ oscillator signals.

J6 (QSD RF input) - Disconnects the QSD from the RF amplifier. Allows direct QSD input, bypassing the RF amplifier and antenna filter.

MUTE (to the side of U1 and R35) - Opening this jumper mutes the receiver.

HEADERS

H3 - IQ output to sound card. The center pad is ground. These are the same connections afforded by the P2 jack.

H4 - IQ differential (balanced) outputs 0º, 90º, 180º e 270º, used with sound card or dedicated ADC with balanced inputs.

H5 - Allows direct QSD input bypassing the RF amplifier and antenna filter.

ext_lo - external oscillator input (in four times final frequency).

ext_iq_lo - external quadrature oscillator input.

TROUBLESHOOTING

If the radio doesn't seem to work and the LED is lit, take the following steps:

Check the existence of 10V, 5V and 2.5V at C29, U6 and C28 respectively.

Check the oscillator test point for around 6~7.5V. If there is no DC signal here then the oscillator may not be working. Solder a small wire across the crystal leads, short-circuiting the crystal. This will turn the oscillator into a free running LC oscillator. If now there is a DC voltage at the test point either the crystal is defective, has too high a series resistance or the trimmer tuning is not reaching the correct frequency. Connect a frequency counter to the collector of Q5 (with a small series capacitor to block the DC). Read the frequency, give the trimmer a complete turn and check the frequency range. It must extend from around 26 MHz to 30 MHz. Pre-tune it to 28 MHz. Remove the short across the crystal. Try bypassing R23 and measure the test point. If DC is now present, then the crystal series resistance is a bit higher than expected. Adjust the trimmer and leave R23 bypassed. Without R23 and with a higher Rs crystal the oscillator will be marginally noisier but still better than simpler designs.

A table with DC measurements at several points of the circuit can be found in the FAQ page: http://py2wm.qsl.br/SDR/SDRZero-2.html (Portuguese text but numbers are universal!).

Other reasons for non-working include the incorrect placement of parts, or bad soldering. Contact me for help.

Q1 and Q2 run mildly warm. R5 runs warm to hot. U6 runs hot depending upon the DC voltage, which should be 12 to 15 V. There is no need for concern. Under normal conditions the radio draws around 120 mA.

IMPROVEMENTS AND MODIFICATIONS

The SDRZero was designed to be connected to an average sound card, which will limit its maximum attainable performance. However, provision has been made to work with good or excellent sound cards, resulting in appropriate performance improvement. However, some modifications are required.

1 - Increasing dynamic range by raising maximum output voltage (enabling native capability).
Average sound cards clip the input signal at around 1~2 Vrms. Better sound cards can tolerate input signals to 4 Vrms or more. SDRZero dynamic range is limited to about 1Vrms by the NE5532 Vcc supply of 5V. To increase headroom it is necessary to feed the 3 NE5532 with a dual supply of ±12V (up to ±18V). The supply does not need to be symmetrical nor regulated, but should be well filtered to avoid introducing hum.

To do this, locate pin 4 on the three NE5532 ICs. On the side of the PCB opposite to the components cut around the vias to disconnect pins 4 from ground. Connect the three number 4 pins together with wire. Connect a 100 uF 25V electrolytic capacitor with the + lead to the ground foil and the - lead to the wire connection just made. Run a lead from here to a suitable jack for the minus (-) power supply.

Locate the 5V trace going to the three NE5532. This trace leaves U4 and runs alongside P2 and P1 and then ends in a via. Open this trace somewhere alongside of P2. Connect another 100 uF capacitor with the + lead to the trace and the - lead to ground. Now connect the trace to the + (plus) Vcc (it may be used the same voltage feeding the radio, taken from D1).

Tests at PY2WM showed that a Delta 44 sound card started to clip before the SDRZero modified as above.

2 - Some workarounds.
a - One easy way to boost the dynamic range by 12 dB is to invert T1, feeding the QSD with a 12.5 ohms impedance. As there is a front-end RF amplifier sensitivity will not be impaired, at least on 7 MHz where tests were run at PY2WM.

The schematic of this modification can be found on the FAQ page (http://py2wm.qsl.br/SDR/SDRZero-2.html click FAQ).

The pads for T1 won't fit when this modification is performed. T1 must be prepared and the bifilar lines connected and soldered appropriately before positioning on the PCB. It may then be soldered to the pads as needed. Each winding is a transmission line. On one side the lines are connected in parallel, on the other side they are connected in series. This is the classic Guanella 1:4 RF wideband transformer.

b - Bypassing the RF amplifier. Without the RF amplifier the QSD will present an unsuitable impedance to the antenna filter. It is recommended to insert a 3 dB resistive pad between C4 and C6 in order to provide the filter with an impedance not too far from the 50 ohms required.

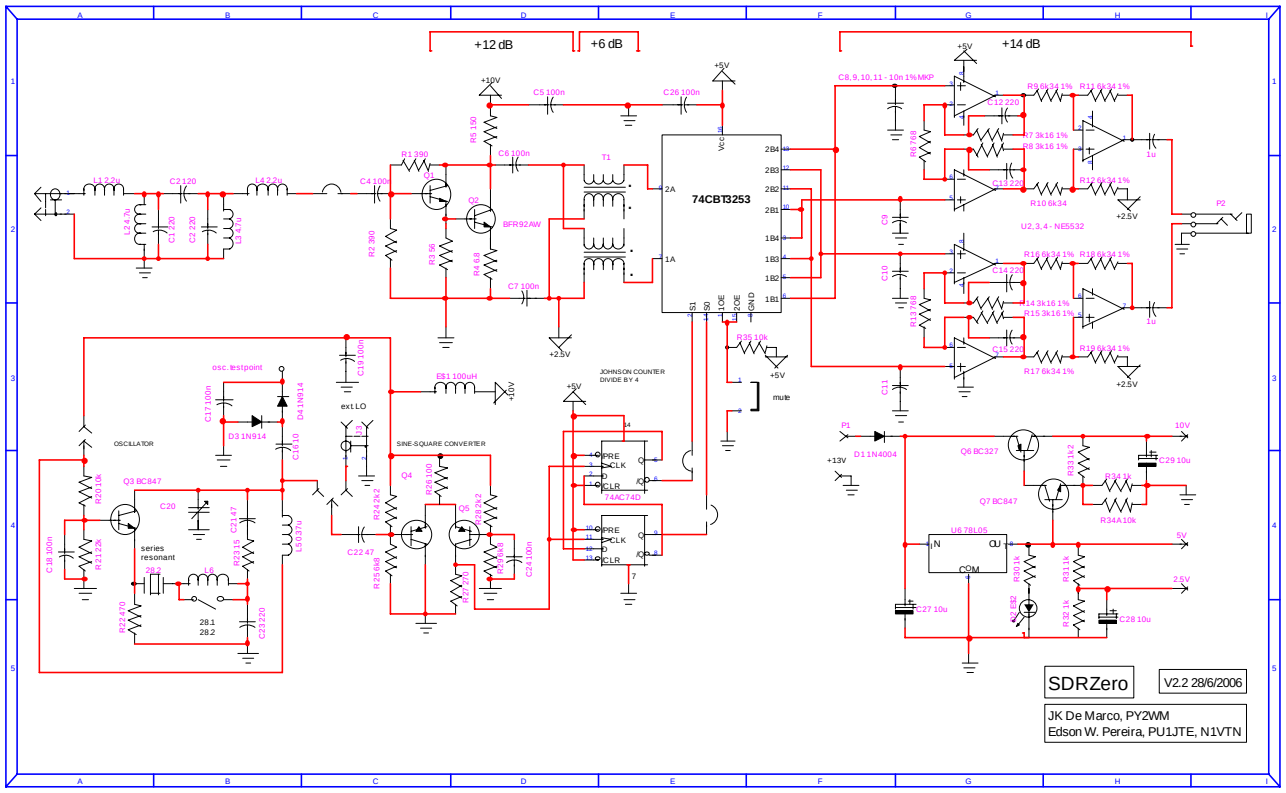
This is a good option when using the SDRZero as an IF DSP add-on for a receiver or converter. The antenna filter should also be bypassed in this application. A jumper and header are provided on the PCB for this purpose.

3 - Changing the frequency.
With the SDRZero crystal oscillator it is easy to change the oscillation frequency. It will generally oscillate with a crystal in an overtone mode even when the crystal was not intended to be used this way.

The oscillator was tested from 500 kHz to 56 MHz. For higher frequencies it is recommended to substitute a BFR92 for Q3. Bias resistors are fine. Q4 and Q5 work fine up to 100 MHz (for a final 25 MHz). Above this the recommended transistor is the BFT92, which is pin to pin compatible and does not require any other changes. The circuit will then be limited at around 180 MHz (45 MHz final) by the 74AC74.

To change frequency, re-scale L5, C21 and C23 proportionally. Short-circuit the crystal and verify oscillation. The circuit oscillates very easily in the free run LC mode. Pre tune to the intended frequency. Then open the short and verify again. If the circuit won't work with the crystal try shorting R23.

SCHEMATIC (See on the CD-ROM a higher resolution file).



This text was written by João De Marco, PY2WM. Thanks to Eric, ZS6BUJ for proof-reading, revising and making appropriate corrections. 27/nov/2006