Associazione Radioamatori Italiani * Sezione di Cassano delle Murge (Bari) – Italy
*** A.R.I. Member Club Founded on June 5th 2004 ***
"Amicizia Attraverso la Radio * Friendship Through Radio"
A.R.I. Associazione Radioamatori Italiani previously **A**ssociazione **R**adiotecnica **I**taliana (1927 – 1977)
IQRP#669 *Club Call-sign: IQ7MU * G-QRP#11827
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EXTENDING SOFTROCK40 OTHER QSD AND TAYLOE DETECTOR TO HF MULTIBAND COVERAGE

Giancarlo MODA, I7SWX

During our Radioclub General Annual Meeting, on June 18th 2005, a presentation on Software Defined Radio and in particular about the SoftRock40 kits was arranged. Club members and also visitors from some local radio clubs were very taken by this new technology. A decision was taken, as part of the Club activities, to help members and other Italian Radio Amateurs to get hold of the SoftRock kits. An agreement was arranged with Tony Parks, KB9YIG, to help our Club to manage the purchase and shipments of kits to Italy for those homebrewers not able to do it directly.

Normally people start eating chocolate formed with low cacao and high milk percentages moving to higher cacao and lower milk mixture till nearly 100% cacao and no milk. My feeling is that something similar has happen and is happening to hams that have discovered SDR technology and in particular to those that have purchase Tony's SoftRock40 monoband kits…. Now we want more flavors … we want to cover with these kits as many ham bands as possible. In theory it is quite easy to do it in real life it may not be so. Key point of an SDR solution is to get image rejection as high as possible but we do have to accept what components limits permits. The highest possible rejection is obtained if our detector or mixer has the output signals I and Q in the highest quadrature possible and also they amplitude must be 100% equal. In real life we are "forced to accept" an hardware image rejection that may be in the range of -25 to -30 dB. Those funny friends of ours that fiddle with software can help us to increase such image attenuation up to around -60 to -70 dB… not on the entire band but at the frequency of interest image. In the future we should be able to have better performances on this aspect. Our quadrature (90 degrees I and Q phases difference) is first produced by our QSD Local Oscillator quadrature signal. To help on the quadrature a Digital Quadrature Generator with a division by four counter is used. If we do need to cover from 1.7 MHz to 30 MHz we will need a variable oscillator generating a signal from below 7MHz to 120MHz. This is not an easy task with available oscillators. Now DDS, using AD9951 chip, may help to solve the problem as they can generate a signal up to around 200MHz, a limit that can help, eventually, to cover the 50MHz band too. We maybe able to fix the local oscillator but we may discover that our counter and QSD chips have something inside that does not permit to have real quadrature output and same amplitude signals. Faster and more performing chips are showing up but not always in a size manageable for a homebrewer…. These aspects force us to compromise as much as possible but, at the same time, trying to get as many benefits as possible too.
Recently I was able to implement and experiment one of my old projects I started on paper at beginning of 2003. The project has been adapted to the SoftRock40 Version 6 and it is the multiband Digital Quadrature Generator circuit diagram reported in Figure 1. This DQG maybe used also for other SoftRock kits like V7 and V5, other SDR like the SDRZero, FireFly, NorCal 2030 and the like.

CIRCUIT DESCRIPTION

Looking at the circuit diagram in Figure 1, we have on the left the Squarer using two XOR gates. This is followed by other two XOR gates forming the Splitter with two complementary LO signals (0° and 180°). The complementary LO signals are feeding the two flip-flops forming the real Digital Quadrature Generator in a configuration to divide by 2 the oscillator signal frequency, delivering 4 phases oscillator signal at fundamental frequency. Phases 0° and 90° form the quadrature LO signal necessary to drive the MUX FST3254 forming the SDR QSD or Tayloe Detector. Phases 180° and 270° are used when the I-Q mixer or QSD are formed by a Fast Bus Switch FST3125. For QSD or Tayloe Detector using the FST3125 a decoder formed by four NAND gates 74ACT00 has to be inserted between the DQG and the switches; such a circuit is reported in Figure 1 on the bottom right. If the FST3126 is used, the decoder requires AND gates 74ACT08.
An external control, employing a multiturns potentiometer, operating as a manual phases or quadrature balance is associated with the Squarer.

HARDWARE MODS TO IMPLEMENT

Modification should be applied in a non destructive form as to report the assembly to the original conditions.

1) Disconnect pins 2 (S1) [90°] and 14 (S0) [0°] of FST3253 from the PCB tracks. Be careful not to break these pins. Pins 2 and 14 will then be connected to the DQG as in circuit diagram (90° and 0°)

2) In the SoftRock kits replace the simple Band Pass Filter with a more suitable set of BPF for each band or octaves group.

3) Replace the input transformer T1 with a more suitable wide band transformer for full HF coverage.

4) Solder a wire to form a short circuit across the crystal in the oscillator. This will stop interferences.

WINDING A BALUN CORE TRANSFORMER

To implement full HF coverage it is necessary to replace the resonant transformer with a wide band transmission line transformer. This transformer is wound on a balun core type #43-2402 or #43-202. For the SR V6 do 3 windings of 4 turns each, while for SR V7 do 5 windings of 4 turns each. Use any enameled wire size that will permit the windings. Pay attention to the secondary windings phase. Drawing and picture should help.

GAIN REDUCTION

I have also implemented a drastic gain reduction on the SoftRock V6 to reduce ADC saturation. I have added a 1.2kohm resistor in parallel to each 49.9K feedback resistors on the OPAs.

HOW TO ADJUST IMAGE REJECTION

Once the SoftRock and any other SDR QSD Receiver becomes a multiband RX we have the necessity to tune to a strong signal on each band and look at its image while adjusting the multiturns potentiometer for the maximum image attenuation. Any type of marker should be valid.
To have an idea of how the regulation works and what is happening I have taken some screen shots on some bands using two tones signals. The adjustment is done as to have one of the two tones reduced as much as possible.
Then I have activated the software reduction functionality of Winrad on the 14MHz shots to increase image rejection.

BANDPASS FILTERS

Band Pass Filters should be implemented for each band and as required. SoftRock V6 input impedance is around 50 ohm with some reactance changing as bands are changed.

FINAL

I hope you will enjoy this modification to move your single SDR RX to HF multiband. Please keep on mind that as second as the 74AC86 manufacturer the maximum frequency limit is around 60 MHz and due to delay problems with Q and Not Q signals one of the 74AC-ACT74 flip flop may not have the right data input signal to switch at around 60MHz clock.
To facilitate looking at various SDQ QSDs I have added some circuit diagrams.

73

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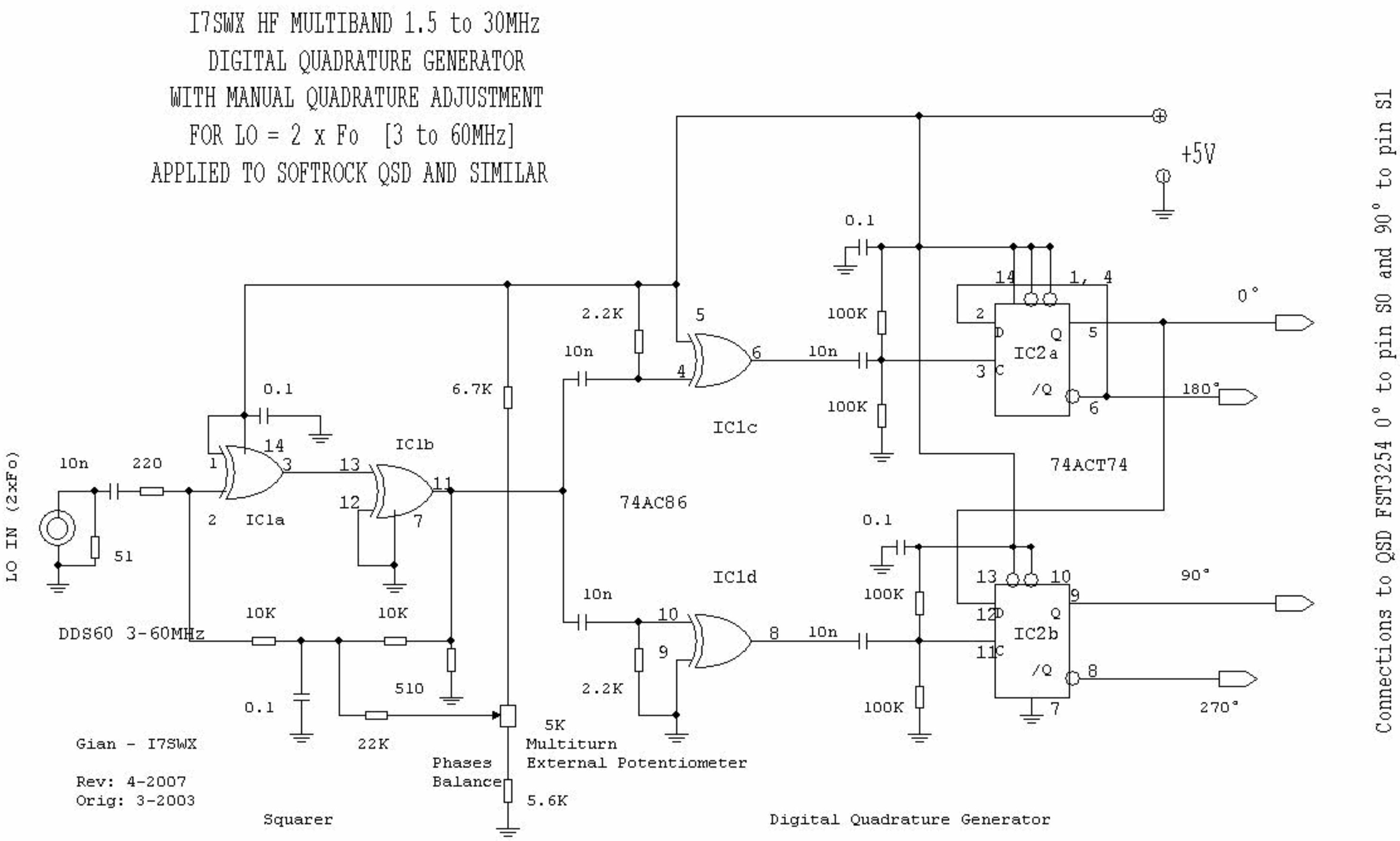
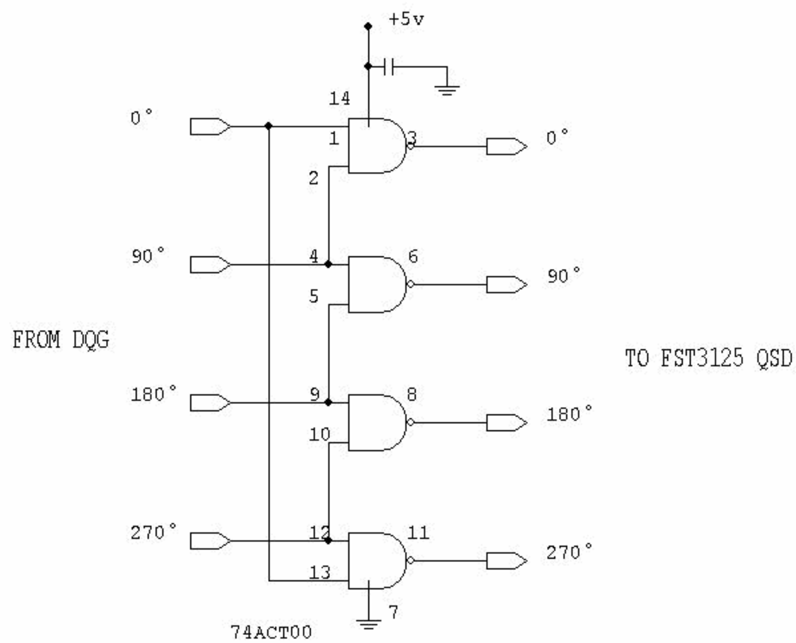
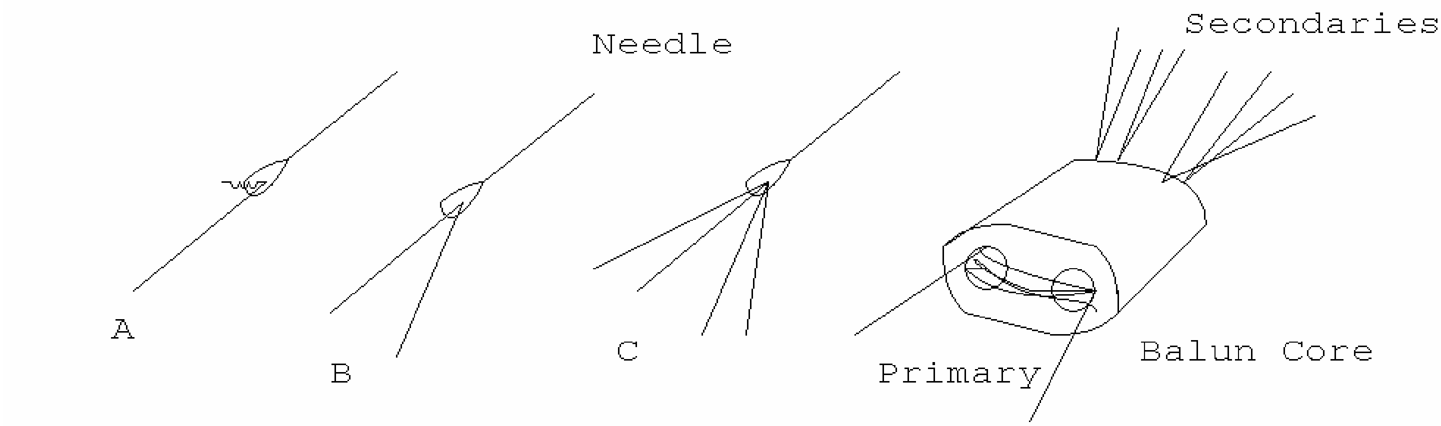
Articles expected to be published in English and Italian



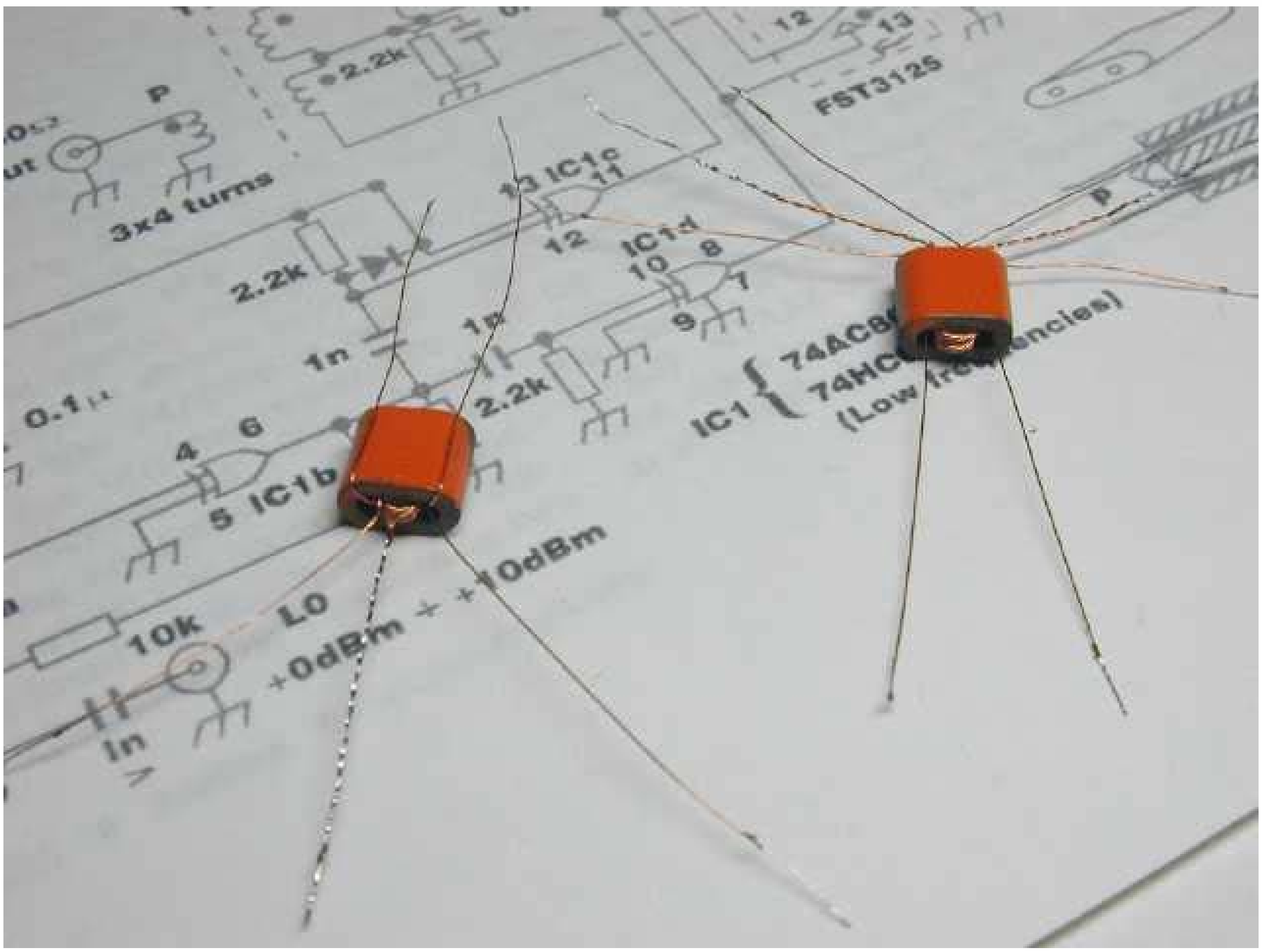


Decoder to drive FST3125 switches in QSD and Tayloe Detector applications.
When FST3126 are used the NAND 74ACT00 should be replaced by the AND 74ACT08.

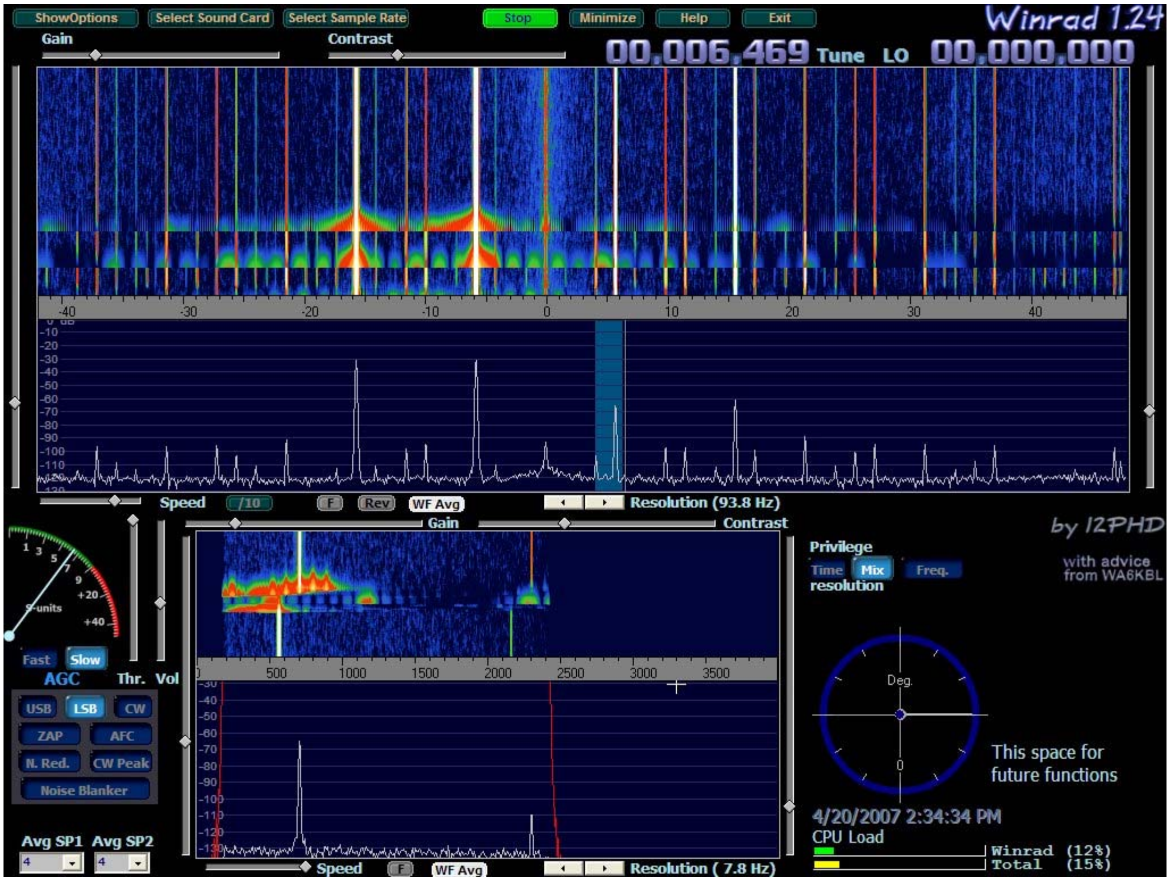
BALUN CORE TRANSFORMER WINDING



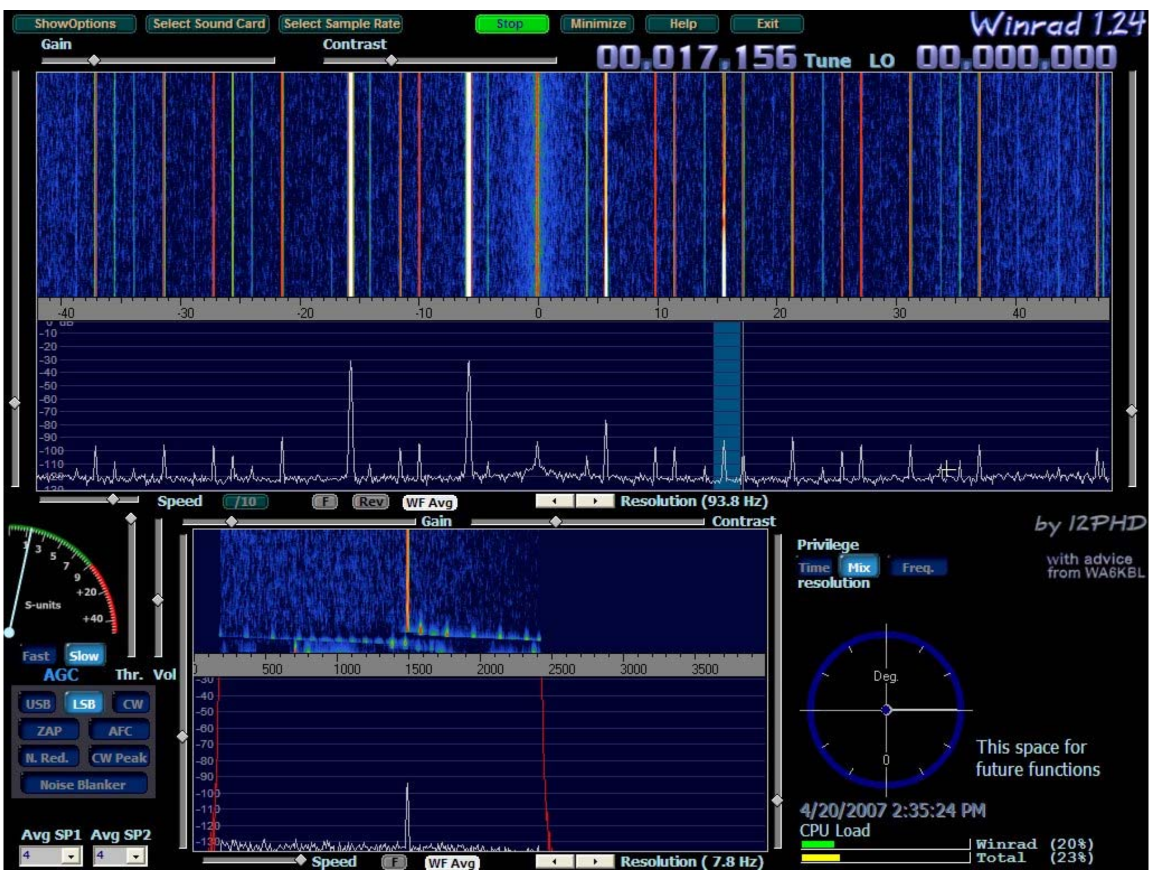
A = 1 Primary winding   B = 2 Secondary windings   C = 4 Secondary windings   Gian, I7SWX



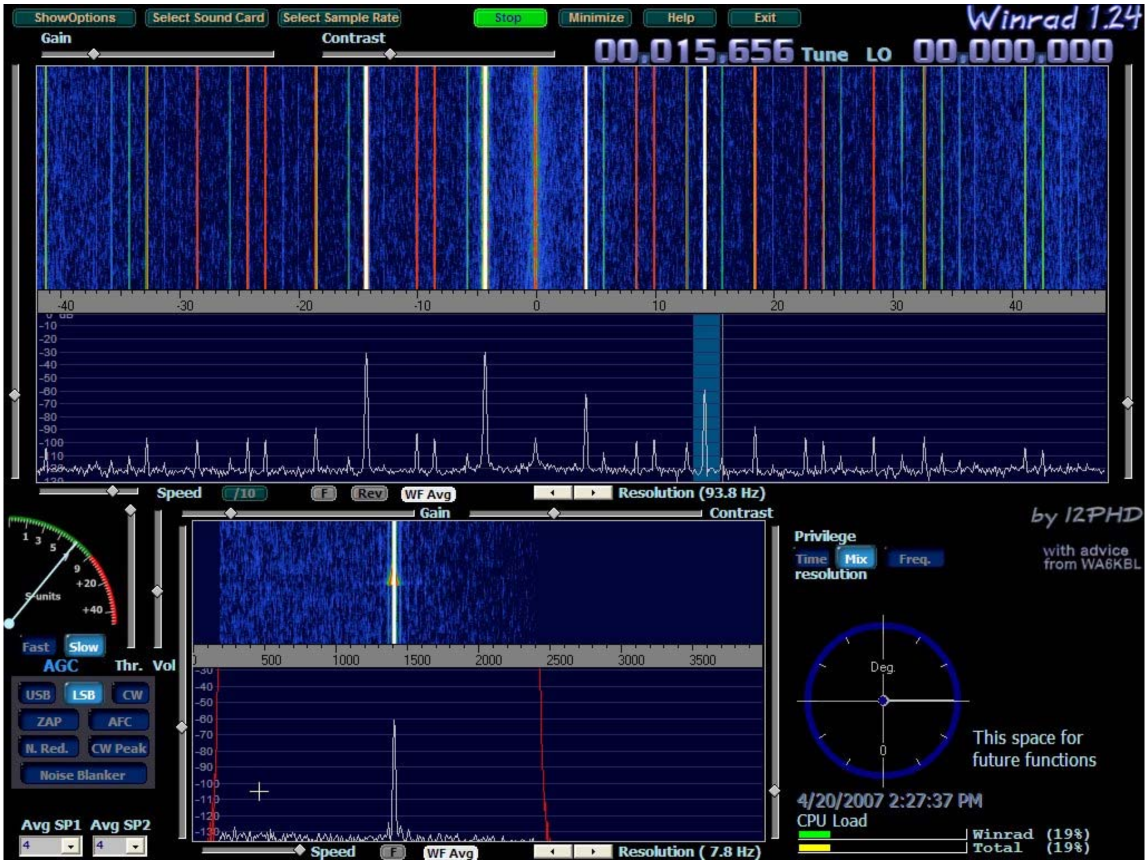
Drawing is illustrating how to wind balun transformers, while the picture should give an idea of the final products



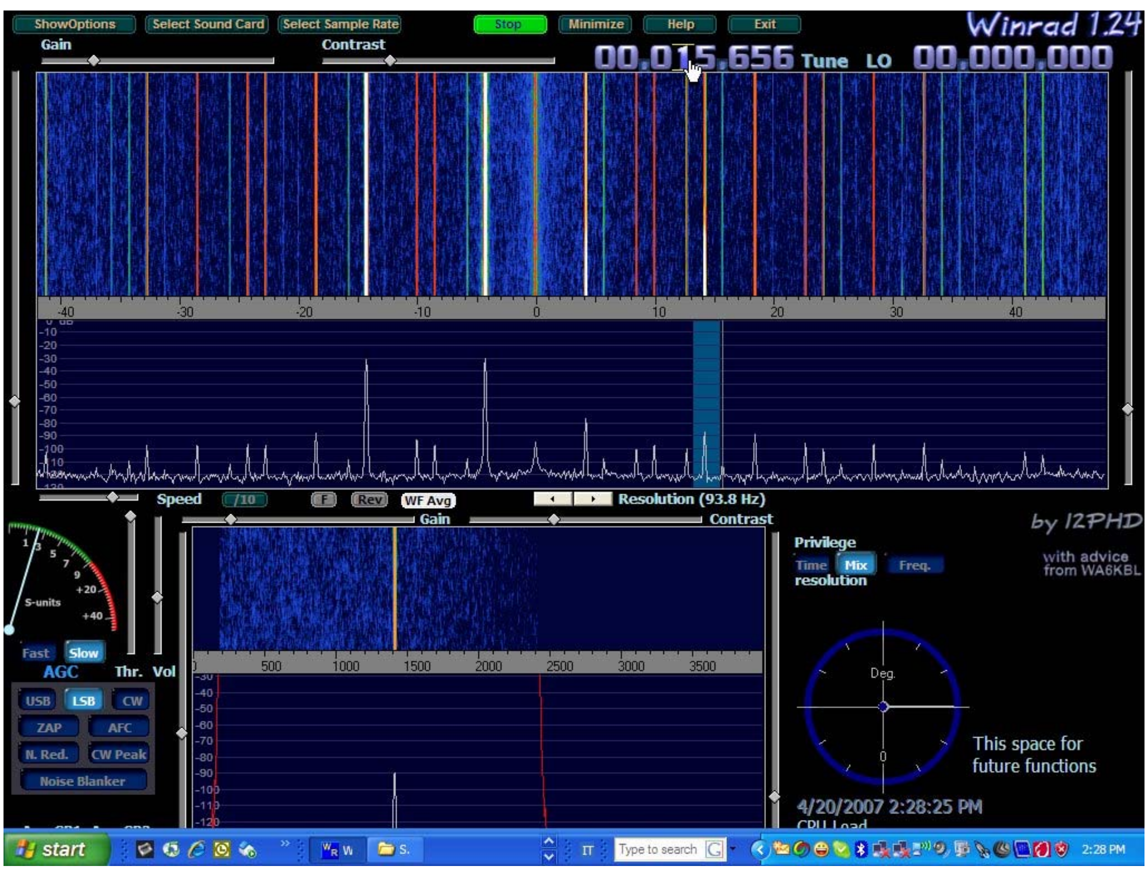
3.5MHz Two Tones before manual hardware adjustment @ -10dBm input



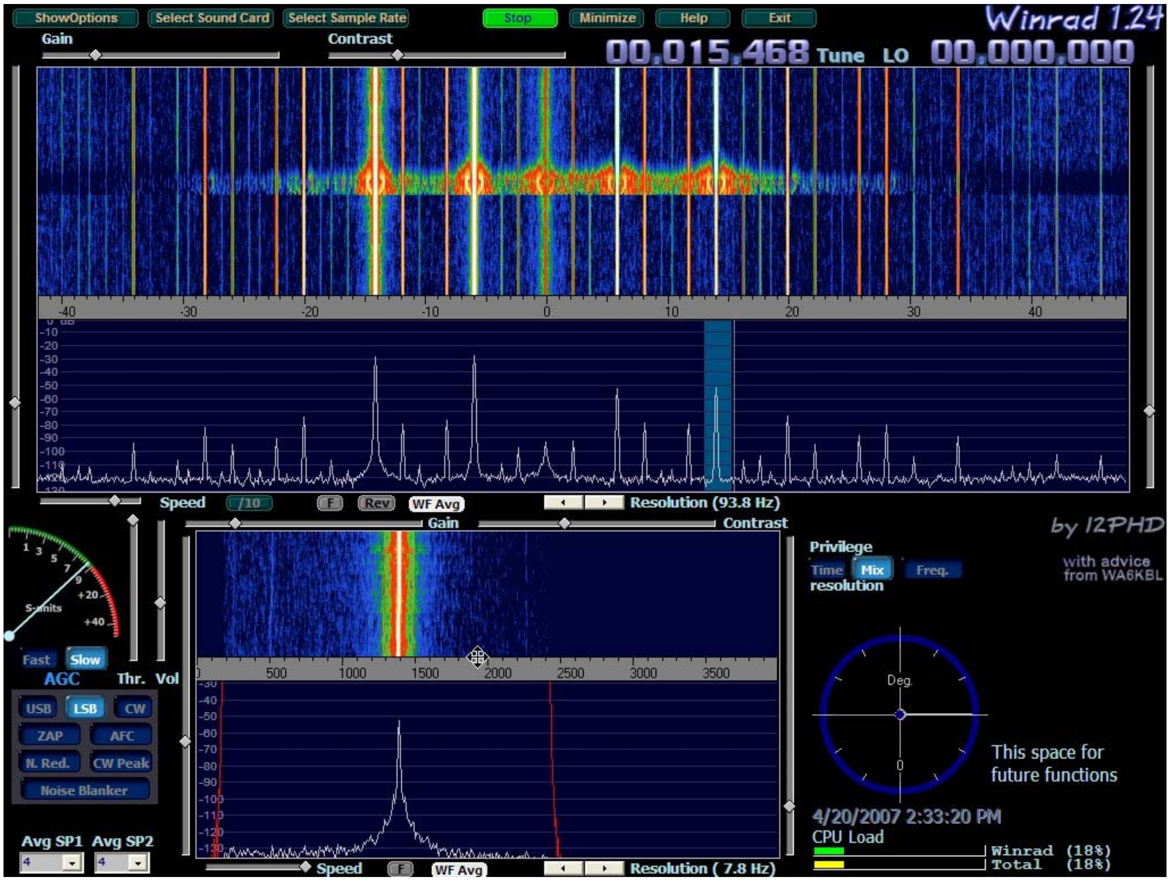
3.5MHz Two Tones after manual hardware adjustment



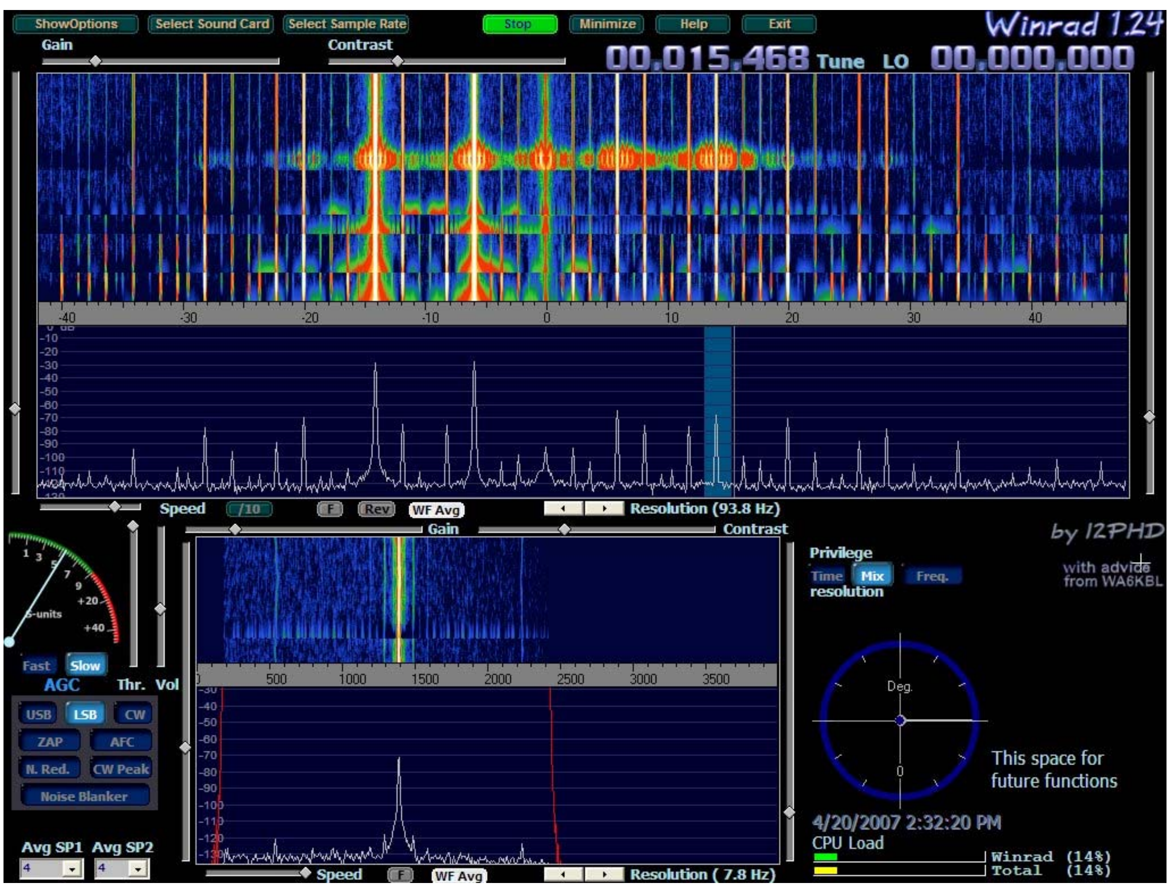
7MHz Two Tones before manual hardware adjustment @ -10dBm



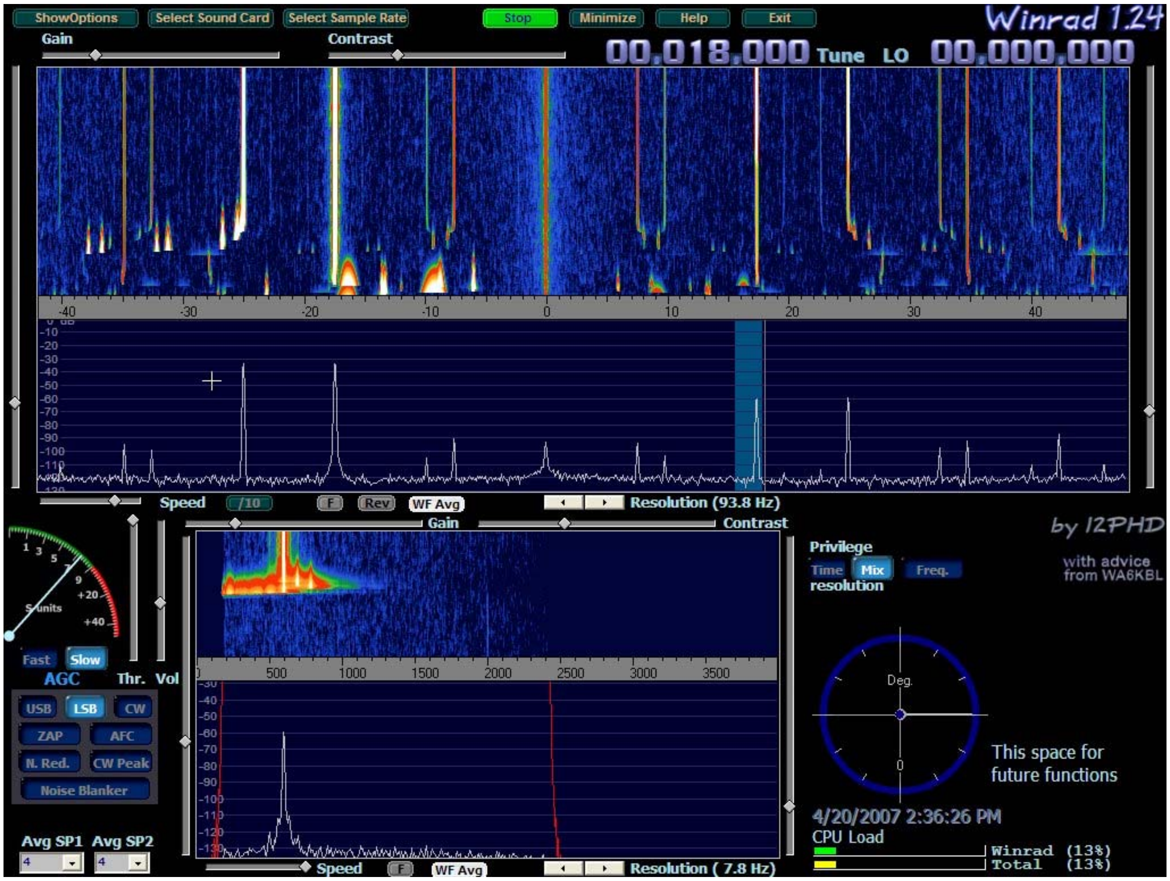
7MHz Two Tones after manual hardware adjustment



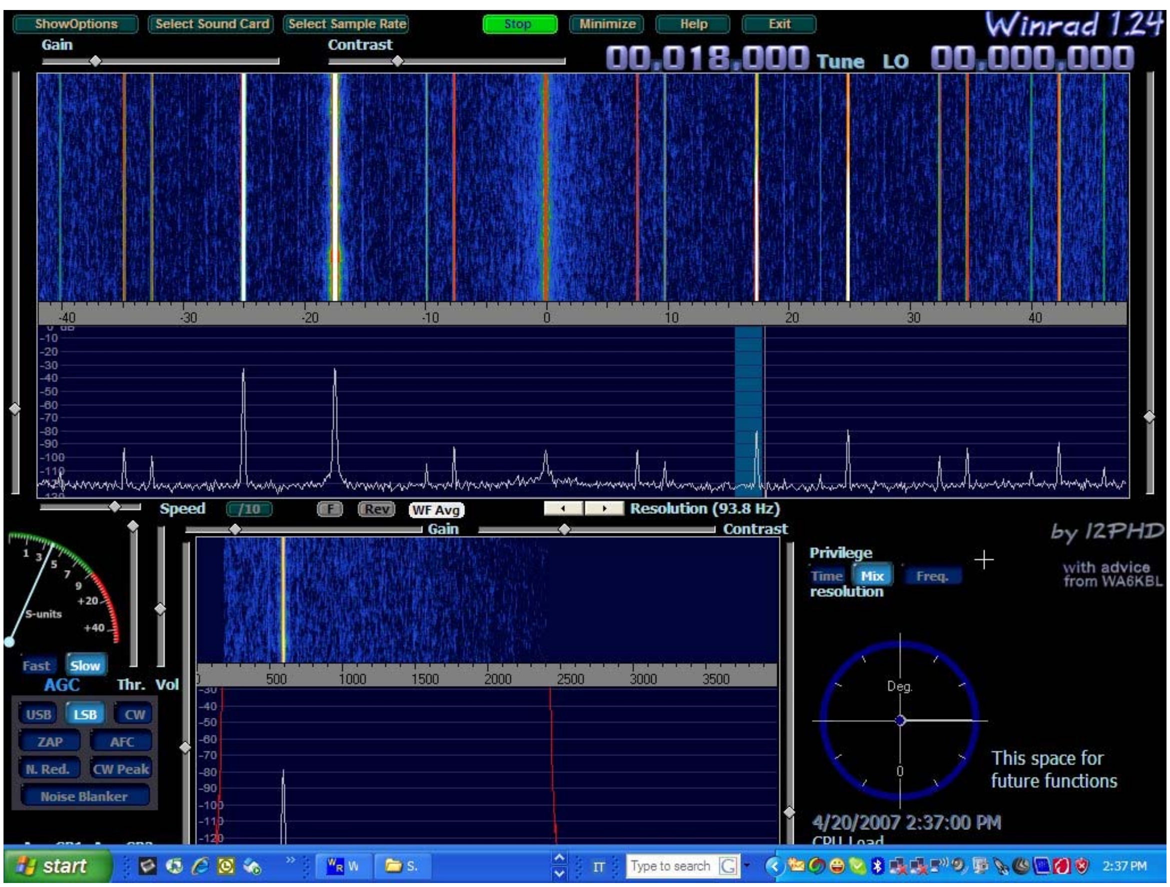
28MHz Two Tones before manual hardware adjustment @ -10dBm



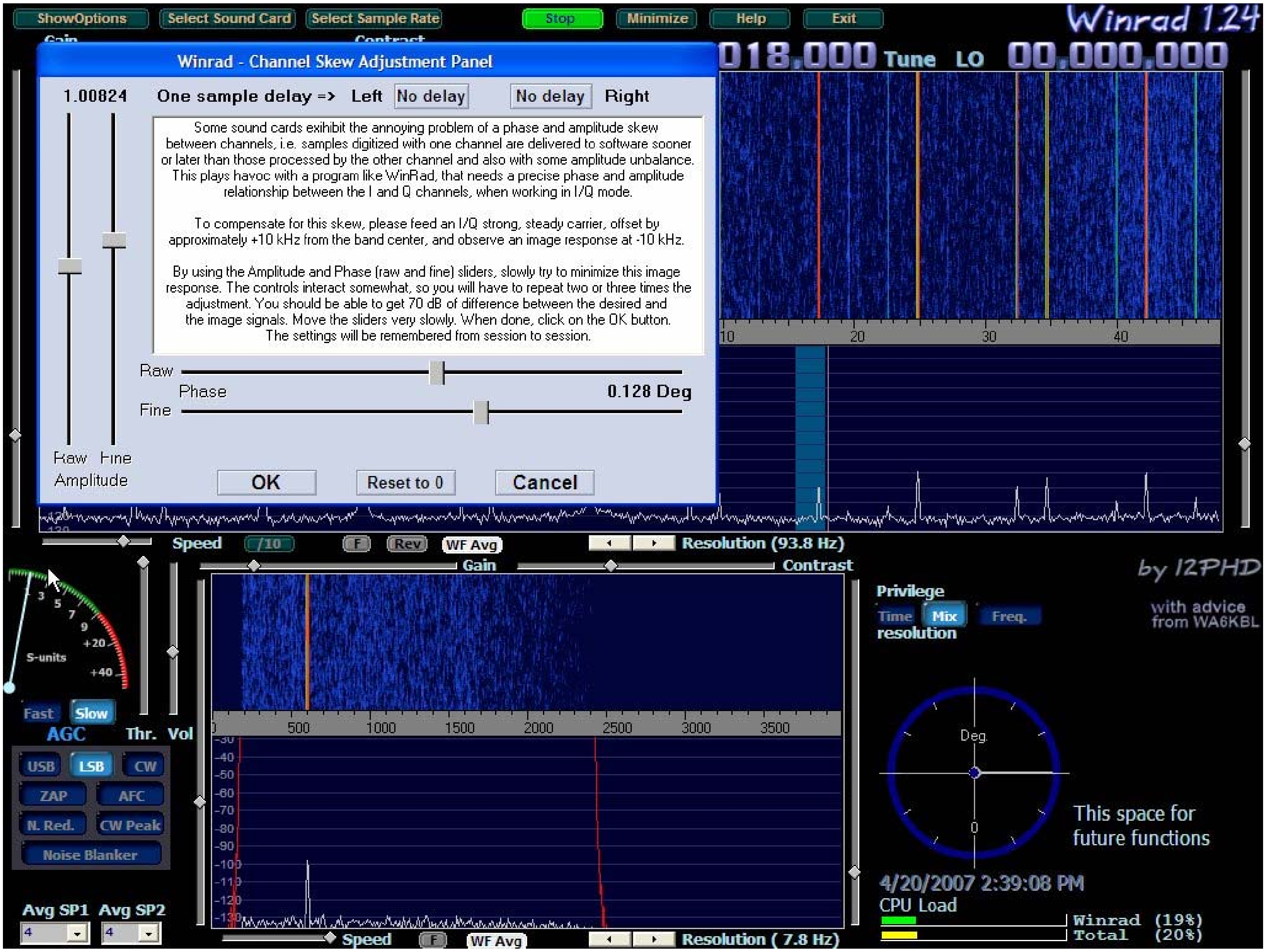
28MHz Two Tones after manual hardware adjustment



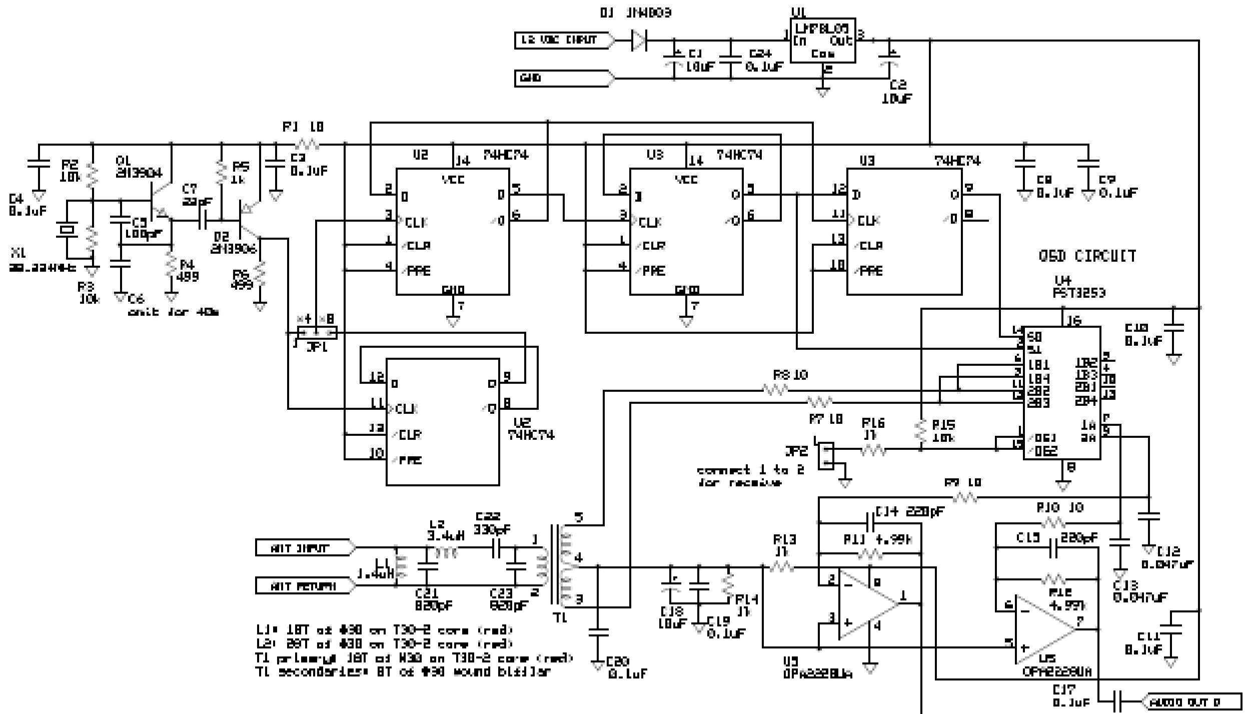
14MHz Two Tones before manual hardware adjustment @ -10dBm



14MHz Two Tones after manual hardware adjustment @ -10dBm with a total image attenuation of ca 50dB



14MHz Two Tones after manual hardware adjustment and Winrad software adjustment @ -10dBm
Here we have a total imaje reject attenuation of circa 70dB



The schematic shows 40m/80m component values.

The 160m component values are tabulated below.

X1 14.754 MHz crystal
C5 220 pF
C6 100 pF
C21, C23 6800 pF
C22 470 pF
L1: 16T of #30 on T30-2 core (red)
L2: 57T of #30 on T30-2 core (red)
T1 primary: 16T of #30 on T30-2 core (red)
T1 secondaries: 7T of #30 wound bifilar

FLEX RADIO FRIENDS		
SoftRock_v6.0 RX		
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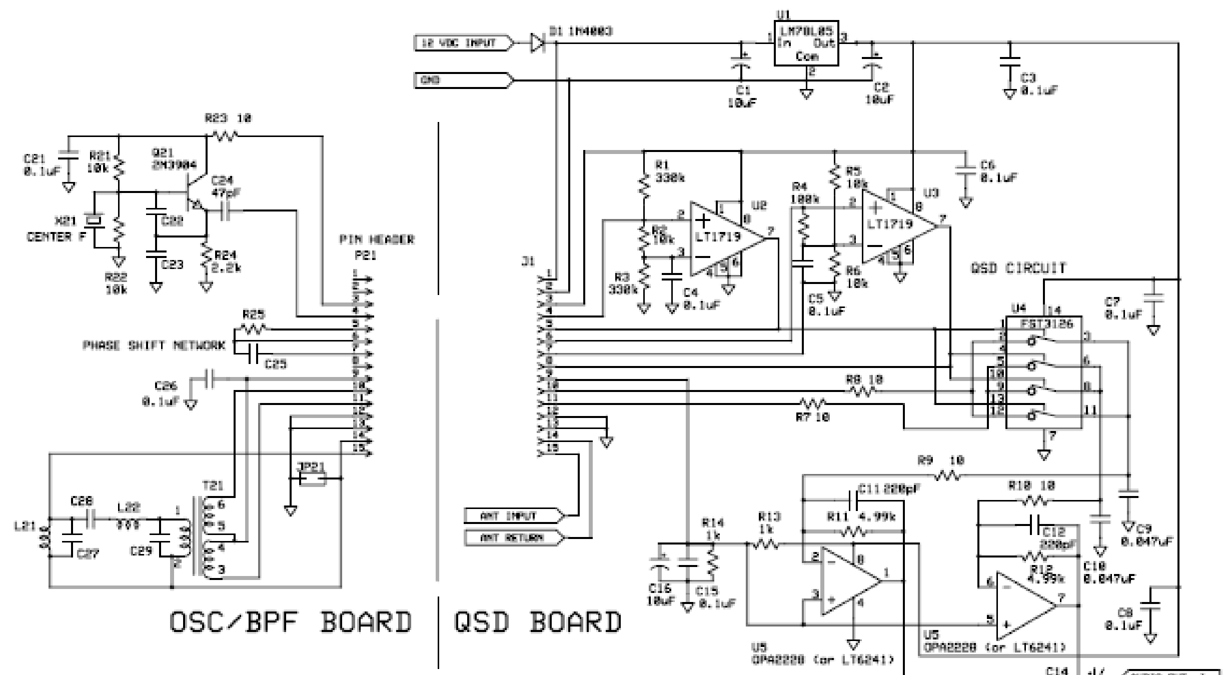
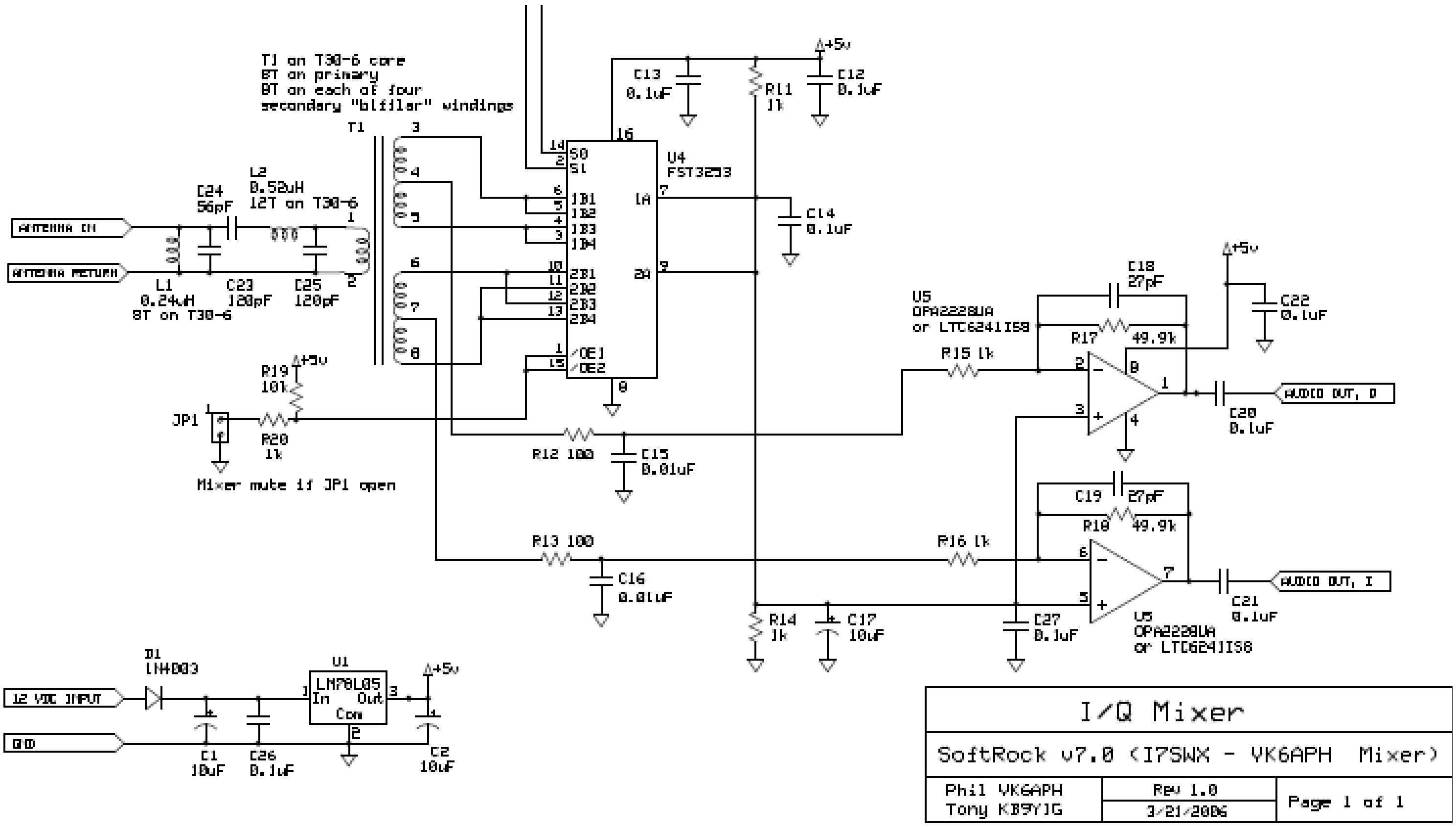


Band specific component values

Xtal	C22	C23	R25	C25	L21	C27	L22	C28	C29	T21
7.038MHz	270pF	270pF	1k	150pF	T30-2,13T	470pF	T30-2,21T	100pF	470pF	T30-2,13T/6T/6T
14.06MHz	180pF	180pF	1k	47pF	T30-6,10T	270pF	T30-6,16T	100pF	270pF	T30-6,10T/5T/5T

FLEX RADIO FRIENDS		
SoftRock_v5.0		
Tony KB9YIG	Rev 5.0 11/25/2005	Page 1 of 1


T1 on T30-6 core
8T on primary
8T on each of four
secondary "bifilar" windings
ANTENNA IN
ANTENNA RETURN
C24 56pF
L2 0.52uH 12T on T30-6
L1 0.24uH 8T on T30-6
C23 120pF
C25 120pF
U4 FST3253
C13 0.1uF
C12 0.1uF
R11 1k
C14 0.1uF
R19 10k
R20 1k
JP1
Mixer mute if JP1 open
R12 100
C15 0.01uF
R13 100
C16 0.01uF
R14 1k
C17 10uF
U5 OPA2228UA or LTC6241IS8
C18 27pF
R17 49.9k
R15 1k
C22 0.1uF
C20 0.1uF
AUDIO OUT, Q
C19 27pF
R18 49.9k
R16 1k
C21 0.1uF
AUDIO OUT, I
C27 0.1uF
D1 1N4003
U1 LM78L05
12 VDC INPUT
GND
C1 10uF
C26 0.1uF
C2 10uF
I/Q Mixer
SoftRock v7.0 (I7SWX - VK6APH Mixer)
Phil VK6APH
Tony KB9YIG
Rev 1.0
3/21/2006
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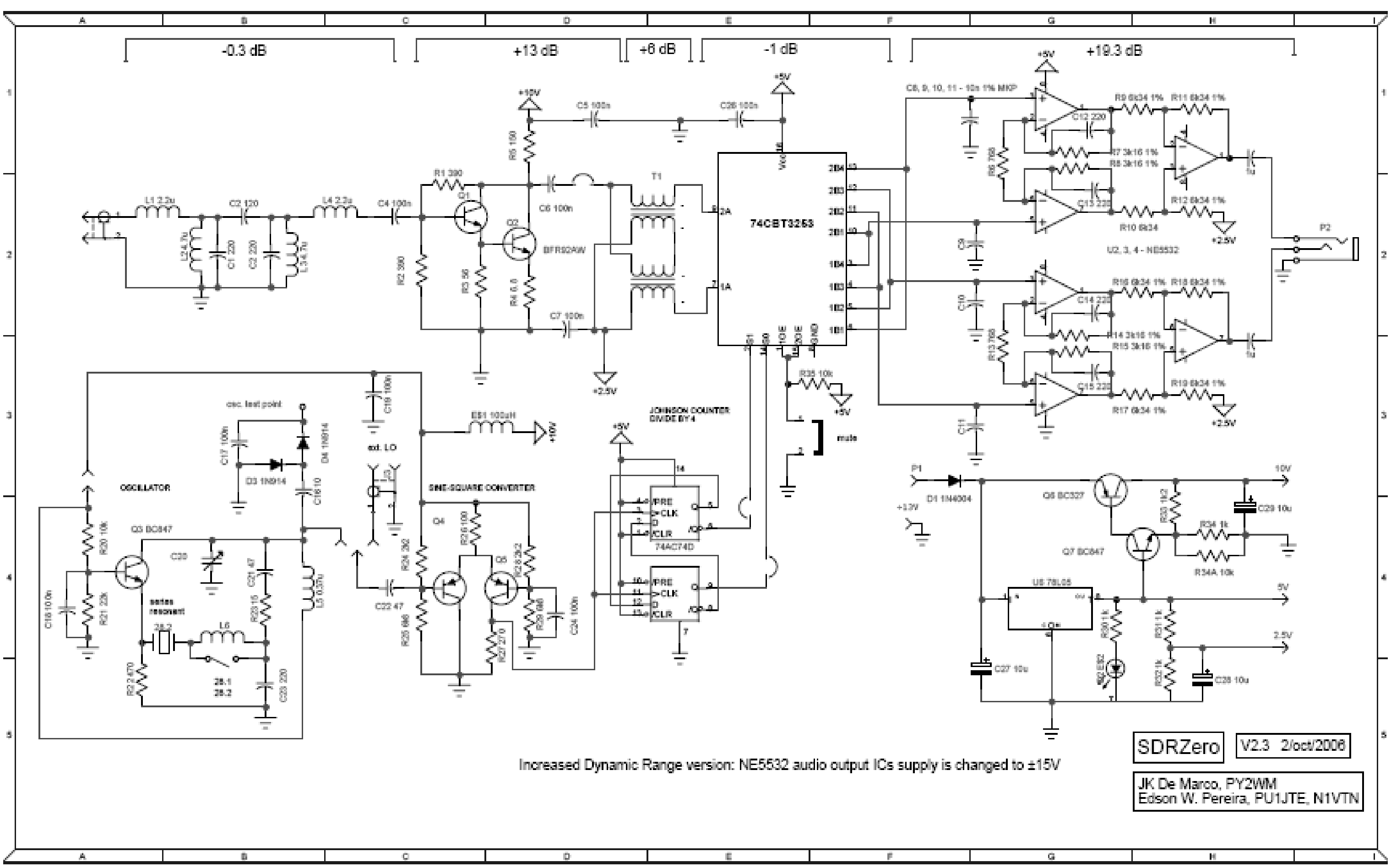
-0.3 dB
+13 dB
+6 dB
-1 dB
+19.3 dB
74CBT3253
JOHNSON COUNTER DIVIDE BY 4
74AC74D
OSCILLATOR
Q3 BC847
SINE-SQUARE CONVERTER
BFR92AW
ext. LO
osc. test point
series resonant
mute
U2, 3, 4 - NE5532
D1 1N4004
Q6 BC327
Q7 BC847
U5 78L05
Increased Dynamic Range version: NE5532 audio output ICs supply is changed to ±15V
SDRZero
V2.3 2/oct/2006
JK De Marco, PY2WM
Edson W. Pereira, PU1JTE, N1VTN

Detector/ AF pre-amp

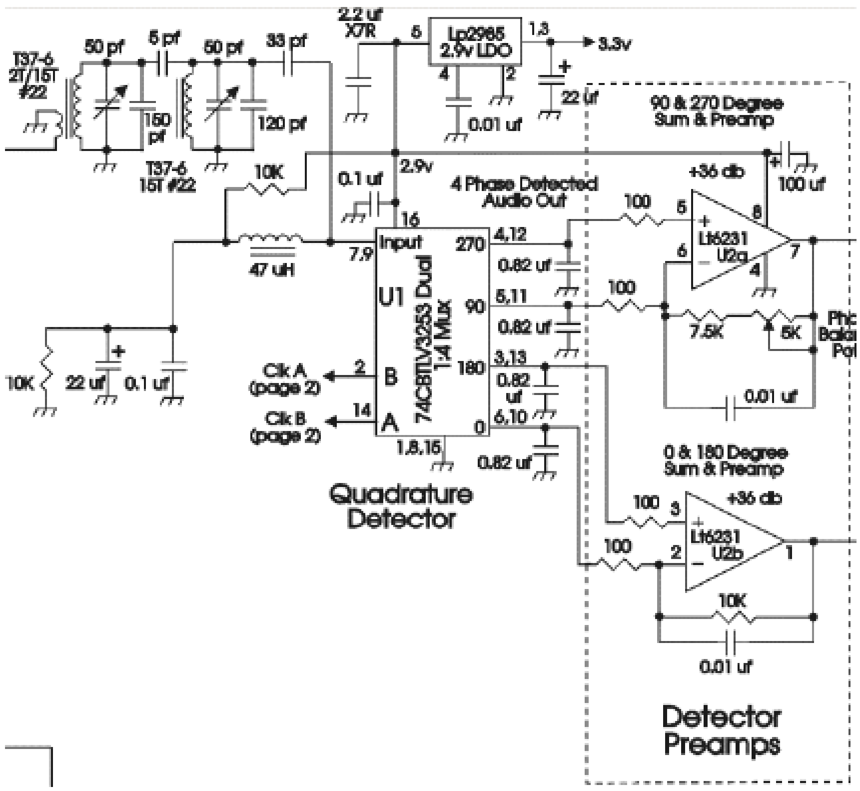

Figure 130. Tayloe quadrature detector and I/Q audio preamplifier schematic