

Ensemble RXTX 09_TX Mixer (QSE)

[Home](#) [Bill of Materials](#) [Power Supply](#) [USB Power Supply](#) [Local Oscillator](#) [Dividers](#) [RF I/O and Switching](#) [RX Mixer \(QSD\)](#) [RX Opamps and Output](#) [TX Opamps](#) [TX Mixer \(QSE\)](#) [Driver/PA](#) [External Connections](#) [Comments](#)
[Acronyms](#) [Inventory](#) [Revisions as of 3/21/2011](#) [Components By Stage](#) [WB5RVZ Main Website](#)

Search:

Search selected SDR sites

TX Mixer (QSE) Introduction

General

This stage adds the TX Mixer to the board and provides the modulation of the Dividers' output signals by the 4 I and Q signals from the [TX OpAmps](#) (Quadrature Sampling Exciter - QSE). The result is a double sideband RF waveform that will be coupled into the [PA Stage](#).

Theory of Operation

Let's suppose you were working 40m with a SDR center frequency of 7.056 MHz. You have tuned your SDR (via the software) so that you are listening to a CW station on 7.066 MHz (10 kHz up from the center frequency).

If you were to listen to the I and Q signals from the hardware RX via an amplifier or headphones (assuming there were no other signals and little noise) you would hear a single 10 kHz CW signal on both channels. Your ears may or may not be able to detect the fact that the tone in one ear is 90 degrees out of phase (I.e., In quadrature) with the tone in the other ear.

By comparing the phase difference between the I/Q signals the SDR RX software determines that this signal is 10KHz higher than the center frequency and displays the CW signal as a broken line on the waterfall. It also frequency shifts this signal at the output of the soundcard so it is heard at as normal CW tone from the speakers.

Now, assume you decide to transmit on that frequency where you have placed your cursor (7.066 MHz). Your SDR software will emit a 10 kHz signal (the delta between the center frequency and the selected TX frequency) in both the I and Q outputs, again, in quadrature. This will go into the SDR hardware on the TX side, through the [TX OpAmps](#) and into the [TX Mixer](#), where it will beat up against the LO center frequency of 7.056 MHz. The input to the mixer is 10KHz from the soundcard; the output from the mixer is the RF product of the LO and the input 10 kHz signal. If you were to listen to the input 10 kHz signal you would hear a tone. This tone is audible simply because it represents the delta between the center frequency and the desired transmit frequency, in this case, only 10 kHz, and, since it is in the range of audio frequencies, is audible. If you were to select a higher frequency on which to transmit, say 7.080 MHz, the resultant signal would be a 24 kHz signal; perhaps your dog would hear it, but you certainly would not! However, the [TX Mixer](#) will happily upconvert this to an RF product!

The [TX OpAmps](#) are unity gain and serve to split the incoming I and Q signals into 4 components: 0, 180, 90, and 270 degree phase. Each of the four are then input to the [TX Mixer](#) and are switched ("mixed" by the LO signals which are 90 degrees apart in phase). The two outputs of the mixer are the up-converted RF products, in anti-phase (I.e., 180 degrees apart). These RF products are fed to the [Driver/PA Stage](#). Via a transformer (T2) that will cancel out one or the other of the anti-phased RF signals out, depending upon which is leading and which is lagging. This is just like the RX, any minor phase errors are compensated. The software will make the phase and

level of the I/Q signals such that the mixing product 10KHz below 7.056 is cancelled leaving a signal 10KHz above 7.056 at the output of the [TX Mixer's](#)T2..

The SDR software sends two suitably phased signals from the soundcard it is not that tone that is transmitted, but an up-converted mixer RF product, amplified and filtered in the PAF board.

Note: the above description relates to the traditional "Softrock/Rocky/Winrad/Genesis fixed center frequency" paradigm. In the PowerSDR paradigm, things are a little different. On receive, all versions of PSDR (other than the Genesis version) make use of a pseudo IF system, nominally set at 9kHz. When you go to transmit, the LO frequency is shifted by 9kHz so that it is actually at the wanted TX frequency. That has the distinct advantage that the TX image rejection is always carried out at the same sound card frequency range, i.e. DC to say 3 or 4kHz.

For Rocky and the Genesis PSDR version, both use a 'fixed' LO for their centre frequency, so when you transmit, the sound card has to generate an output at whatever frequency offset you are 'tuned' to, so if you were 30kHz below the centre frequency, then the soundcard I/Q output would be 30kHz and the TX 'audio' signal. Doing it that way means the TX image rejection is always compromised as it cannot be optimised at a single point, as you could be transmitting anywhere +/- the sound card sampling rate.

[\(go directly to build notes\)](#)

TX Mixer (QSE) Schematic



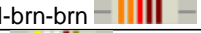




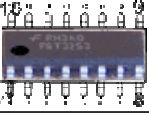
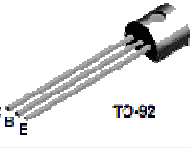
(Resistor testpoints (hairpin, top, or left-hand lead), as physically installed on the board, are marked in the schematic with red dots)

(go directly to build notes)






http://www.wb5rvz.com/sdr/ensemble/09_qse.htm



Stage Bill of Materials

(resistor images and color codes courtesy of [Wilfried, DL5SWB's R-Color Code program](#))

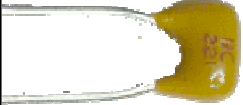
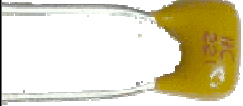
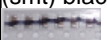




Check	Count	Component	Marking	Category
<input type="checkbox"/>	1	2.21 k 1/4W 1%	r-r-br-br-br 	1/4W
<input type="checkbox"/>	1	22.1 k 1/4W 1%	r-r-brn-r-br 	1/4W
<input type="checkbox"/>	1	3.32 k 1/4W 1%	ora-ora-red-brn-brn 	1/4W
<input type="checkbox"/>	1	4.99 k 1/4W 1%	y-w-w-br-br 	1/4W
<input type="checkbox"/>	2	49.9 ohm 1%	yel-wht-wht-gld-brn 	1/4W
<input type="checkbox"/>	1	4.7 uF 10% 16V X7R RAD		Ceramic
<input type="checkbox"/>	1	band-specific		misc
<input type="checkbox"/>	6	band-specific		misc
<input type="checkbox"/>	2	0.1 uF	(smt) black stripe 	SMT 1206
<input type="checkbox"/>	1	FST3253 mux/demux switch	 FST3253	SOIC-16
<input type="checkbox"/>	1	2N3904 NPN Transistor	 2N3904	TO-92

Band Specific Items for 160m Band


Check	Designation	Component	Marking	Category	Orientation	Notes	Circuit
<input type="checkbox"/>	C20	1000 pF 5%	102 	Ceramic			TX Mixer (QSE)
<input type="checkbox"/>	C21	270 pF 5%	271 	Ceramic			TX Mixer (QSE)
<input type="checkbox"/>	C64	0.1 uF	(smt) black stripe 	SMT 1206			TX Mixer (QSE)
<input type="checkbox"/>	L1	30 uH 83T #30 on T30-2 (red) (44")	 red	Coil			TX Mixer (QSE)
<input type="checkbox"/>	L1-core	T30-2 toroid core	 red	Toroid			TX Mixer (QSE)







<input type="checkbox"/>	T2	7.1 uH 20T bifilar/40T #30 on T30-2 (red) (22")	red 	Xfrmr			TX Mixer (QSE)
<input type="checkbox"/>	T2-core	T30-2 toroid core	red 	Toroid			TX Mixer (QSE)

Band Specific Items for 80, 40m Band



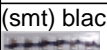



Check	Designation	Component	Marking	Category	Orientation	Notes	Circuit
<input type="checkbox"/>	C20	220 pF 5%	221 	Ceramic			TX Mixer (QSE)
<input type="checkbox"/>	C21	220 pF 5%	221 	Ceramic			TX Mixer (QSE)
<input type="checkbox"/>	C64	0.1 uF	(smt) black stripe 	SMT 1206			TX Mixer (QSE)
<input type="checkbox"/>	L1	4.7 uH 33T #30 on T30-2 (red) ("19")	red 	Coil			TX Mixer (QSE)
<input type="checkbox"/>	L1-core	T30-2 toroid core	red 	Toroid			TX Mixer (QSE)
<input type="checkbox"/>	T2	5.0 uH 17T bidfilar/34T #30 on T30-2 (red) (19")	red 	Xfrmr			TX Mixer (QSE)
<input type="checkbox"/>	T2-core	T30-2 toroid core	red 	Toroid			TX Mixer (QSE)


Band Specific Items for 40, 30, 20m Band

Check	Designation	Component	Marking	Category	Orientation	Notes	Circuit
<input type="checkbox"/>	C20	100 pF 5%	101 	Ceramic			TX Mixer (QSE)







<input type="checkbox"/>	C21	100 pF 5%	 101	Ceramic		TX Mixer (QSE)
<input type="checkbox"/>	C64	0.1 uF	 (smt) black stripe	SMT 1206		TX Mixer (QSE)
<input type="checkbox"/>	L1	2.3 uH 25T #30 on T30-6 (15")	 yellow	Coil		TX Mixer (QSE)
<input type="checkbox"/>	L1-core	T30-6 toroid core	 yellow	Toroid		TX Mixer (QSE)
<input type="checkbox"/>	T2	2.43 uH 13T(bi)/26T #30 on T30-6 (18")	 yellow	Xfrmr		TX Mixer (QSE)
<input type="checkbox"/>	T2-core	T30-6 toroid core	 yellow	Toroid		TX Mixer (QSE)

Band Specific Items for 30, 20, 17m Band

Check	Designation	Component	Marking	Category	Orientation	Notes	Circuit
<input type="checkbox"/>	C20	82 pF	 82J	Ceramic			TX Mixer (QSE)
<input type="checkbox"/>	C21	82 pF	 82J	Ceramic			TX Mixer (QSE)
<input type="checkbox"/>	C64	0.1 uF	 (smt) black stripe	SMT 1206			TX Mixer (QSE)
<input type="checkbox"/>	L1	1.6 uH 21T #30 on T30-6 (yellow) (14")	 yellow	Coil			TX Mixer (QSE)
<input type="checkbox"/>	L1-core	T30-6 toroid core	 yellow	Toroid			TX Mixer (QSE)
<input type="checkbox"/>	T2	1.74 uH 11T bifilar/22T #30 on T30-6(yellow) (14")	 yellow	Xfrmr			TX Mixer (QSE)

<input type="checkbox"/>	T2-core	T30-6 toroid core	yellow 	Toroid			TX Mixer (QSE)
--------------------------	---------	-------------------	---	--------	--	--	----------------

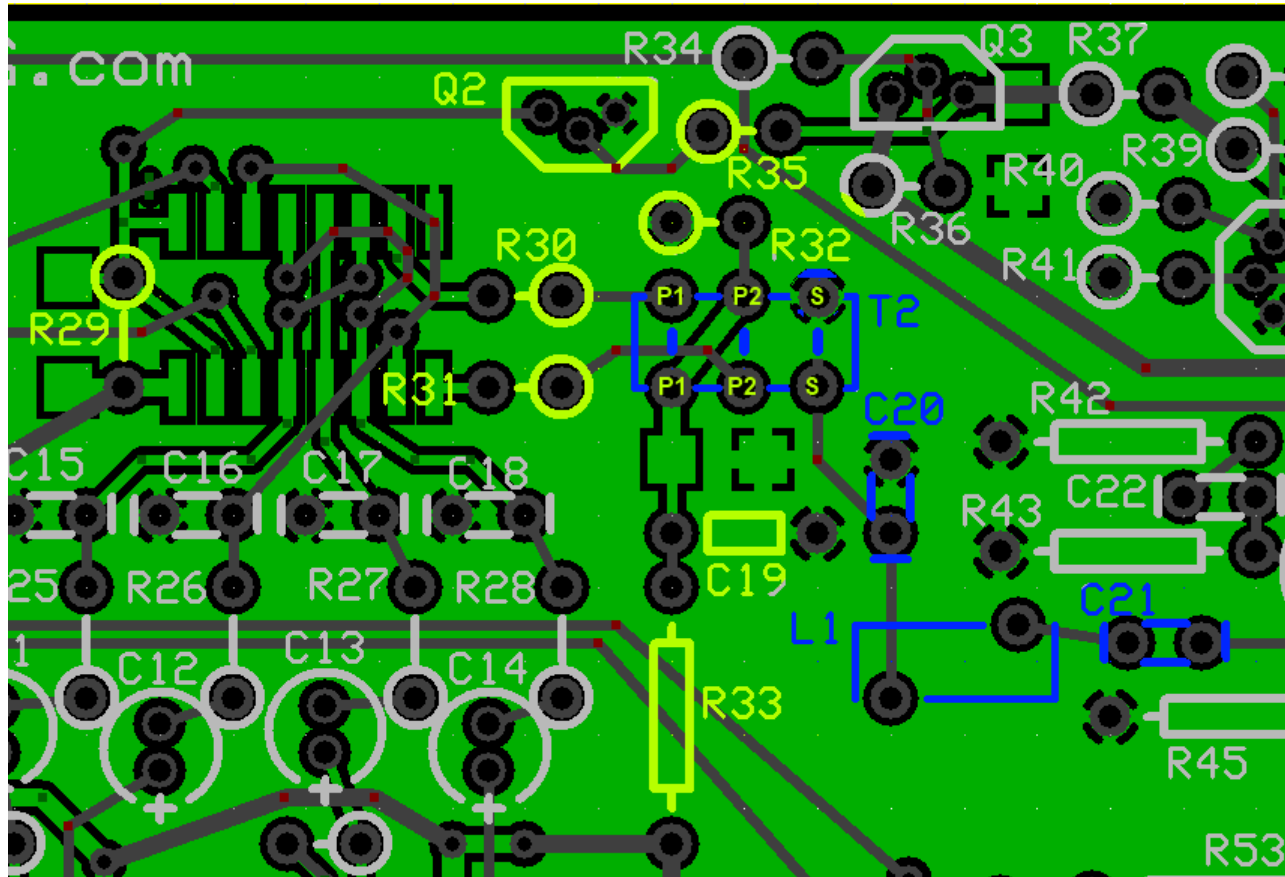
Band Specific Items for 15, 12, 10m Band

Check	Designation	Component	Marking	Category	Orientation	Notes	Circuit
<input type="checkbox"/>	C20	47 pF 5%	47J	Ceramic			TX Mixer (QSE)
<input type="checkbox"/>	C21	22 pF 5%	22J 	Ceramic			TX Mixer (QSE)
<input type="checkbox"/>	C64	0.01 uF	(smt) 	SMT 1206			TX Mixer (QSE)
<input type="checkbox"/>	L1	2.1 uH 24T #30 on T30-6 (yellow) (15")	yellow 	Coil			TX Mixer (QSE)
<input type="checkbox"/>	L1-core	T30-6 toroid core	yellow 	Toroid			TX Mixer (QSE)
<input type="checkbox"/>	T2	0.81 uH 8T bifilar/15T #30 on T30-6 (yellow) (11")	yellow 	Xfrmr		2223 and 2225	TX Mixer (QSE)
<input type="checkbox"/>	T2-core	T30-6 toroid core	yellow 	Toroid			TX Mixer (QSE)

TX Mixer (QSE) Summary Build Notes

- Wind and Install Inductors
- Install Topside Components
- Install Bottomside Components
- [Test the Stage](#)

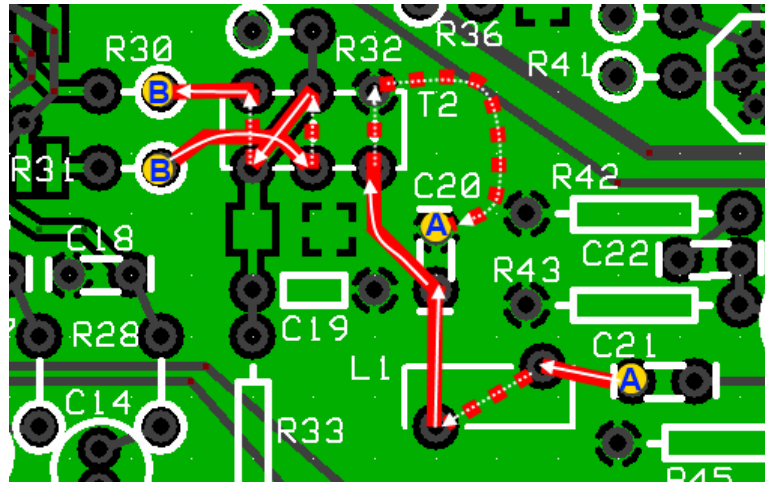
Top of the Board



See [WB5RVZ Inductor Construction Hints](#) for hints on winding and installing inductors.

Inductor Continuity Tests

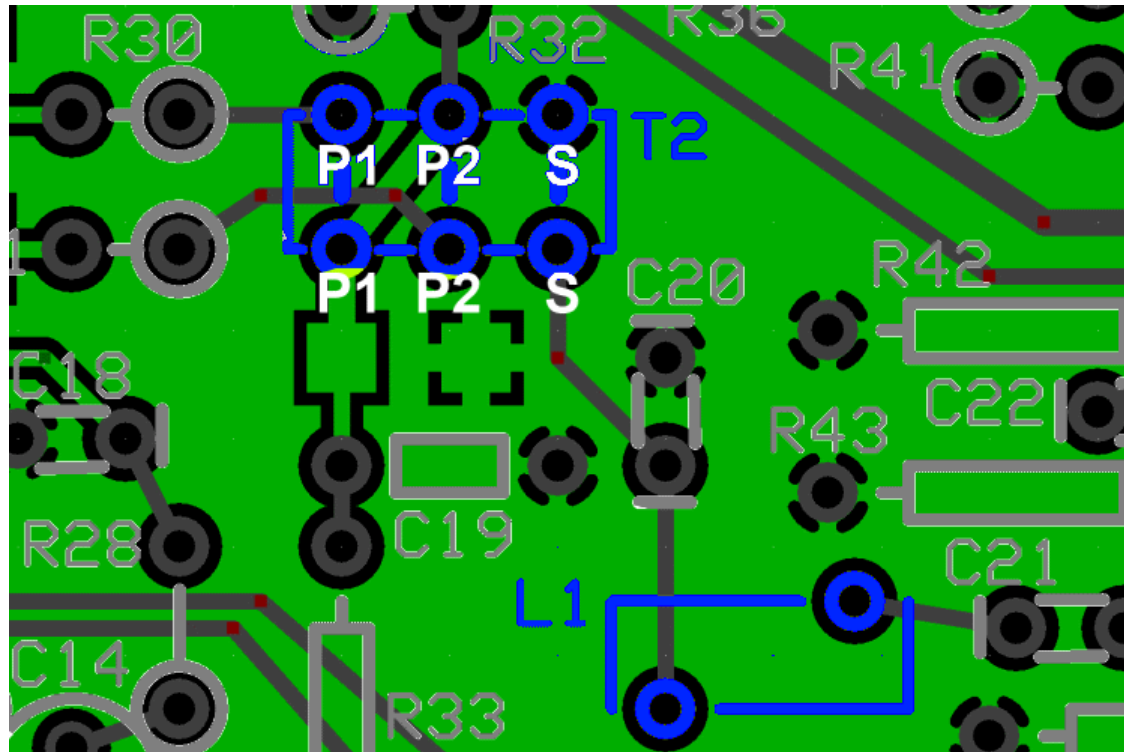
http://www.wb5rvz.com/sdr/ensemble/09_qse.htm































Decoding the trqansformer specifications:

- "nn" is the number of turns in the single winding
- "mm" is the number of turns in the multiple windings
- "w" = the number of multiple windings (e.g., 2 = bifilar; 3 = trifilar, etc.)

Thus, e.g., "18T/2x9T bifilar #30" means, using #30 wire, produce a single 18 turn primary winding and two 9-turn secondary windings; "2x9T bifilar/ 18T #30" means, using #30 wire, produce two 9-turn primary windings and a single 18 turn secondary winding.



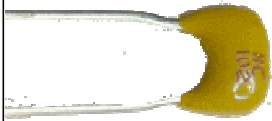



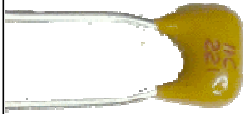



Check Designation Component			Marking	Category Orientation Notes																	
☐	L1	band-specific	<table><tr><th>Band</th><th>Component</th><th>Marking</th></tr><tr><td>160m</td><td>30 uH 83T #30 on T30-2 (red) (44") (Coil)</td><td>red </td></tr><tr><td>80, 40m</td><td>4.7 uH 33T #30 on T30-2 (red) ("19") (Coil)</td><td>red </td></tr><tr><td>40, 30, 20m</td><td>2.3 uH 25T #30 on T30-6 (15") (Coil)</td><td>yellow </td></tr><tr><td>30, 20, 17m</td><td>1.6 uH 21T #30 on T30-6 (yellow) (14") (Coil)</td><td>yellow </td></tr></table>	Band	Component	Marking	160m	30 uH 83T #30 on T30-2 (red) (44") (Coil)	red 	80, 40m	4.7 uH 33T #30 on T30-2 (red) ("19") (Coil)	red 	40, 30, 20m	2.3 uH 25T #30 on T30-6 (15") (Coil)	yellow 	30, 20, 17m	1.6 uH 21T #30 on T30-6 (yellow) (14") (Coil)	yellow 	misc		
			Band	Component	Marking																
			160m	30 uH 83T #30 on T30-2 (red) (44") (Coil)	red 																
			80, 40m	4.7 uH 33T #30 on T30-2 (red) ("19") (Coil)	red 																
			40, 30, 20m	2.3 uH 25T #30 on T30-6 (15") (Coil)	yellow 																
30, 20, 17m	1.6 uH 21T #30 on T30-6 (yellow) (14") (Coil)	yellow 																			









<input type="checkbox"/>	L1-core	band-specific	15, 12, 10m	2.1 uH 24T #30 on T30-6 (yellow) (15") (Coil)	yellow 																					
						misc																				
<input type="checkbox"/>	T2	band-specific	<table><thead><tr><th>Band</th><th>Component</th><th>Marking</th></tr></thead><tbody><tr><td>160m</td><td>7.1 uH 20T bifilar/40T #30 on T30-2 (red) (22") (Xfrmr)</td><td>red </td></tr><tr><td>80, 40m</td><td>5.0 uH 17T bidfilar/34T #30 on T30-2 (red) (19") (Xfrmr)</td><td>red </td></tr><tr><td>40, 30, 20m</td><td>2.43 uH 13T(bi)/26T #30 on T30-6 (18") (Xfrmr)</td><td>yellow </td></tr><tr><td>30, 20, 17m</td><td>1.74 uH 11T bifilar/22T #30 on T30-6(yellow) (14") (Xfrmr)</td><td>yellow </td></tr><tr><td>15, 12, 10m</td><td>0.81 uH 8T bifilar/15T #30 on T30-6 (yellow) (11") (Xfrmr)</td><td>yellow </td></tr></tbody></table>	Band	Component	Marking	160m	7.1 uH 20T bifilar/40T #30 on T30-2 (red) (22") (Xfrmr)	red 	80, 40m	5.0 uH 17T bidfilar/34T #30 on T30-2 (red) (19") (Xfrmr)	red 	40, 30, 20m	2.43 uH 13T(bi)/26T #30 on T30-6 (18") (Xfrmr)	yellow 	30, 20, 17m	1.74 uH 11T bifilar/22T #30 on T30-6(yellow) (14") (Xfrmr)	yellow 	15, 12, 10m	0.81 uH 8T bifilar/15T #30 on T30-6 (yellow) (11") (Xfrmr)	yellow 			misc		
Band	Component	Marking																								
160m	7.1 uH 20T bifilar/40T #30 on T30-2 (red) (22") (Xfrmr)	red 																								
80, 40m	5.0 uH 17T bidfilar/34T #30 on T30-2 (red) (19") (Xfrmr)	red 																								
40, 30, 20m	2.43 uH 13T(bi)/26T #30 on T30-6 (18") (Xfrmr)	yellow 																								
30, 20, 17m	1.74 uH 11T bifilar/22T #30 on T30-6(yellow) (14") (Xfrmr)	yellow 																								
15, 12, 10m	0.81 uH 8T bifilar/15T #30 on T30-6 (yellow) (11") (Xfrmr)	yellow 																								
<input type="checkbox"/>	T2-core	band-specific				misc																				

Install Topside Components

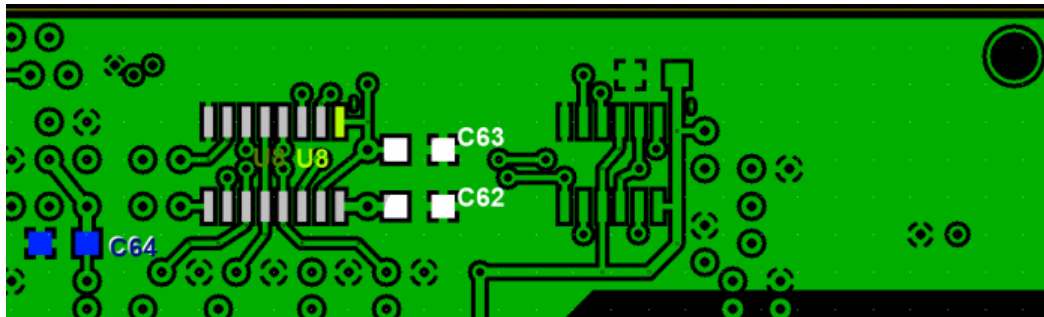
Be careful and do not get the 2N3904 transistor (Q2) mixed up with the 2N3906 transistor (Q3).

Check	Designation	Component	Marking		Category	Orientation	Notes
<input type="checkbox"/>	C20	band-specific	Band Component	Marking	misc		




□	C21	band-specific	160m	1000 pF 5% (Ceramic)	102 
			80, 40m	220 pF 5% (Ceramic)	221 
			40, 30, 20m	100 pF 5% (Ceramic)	101 
			30, 20, 17m	82 pF (Ceramic)	82J 
			15, 12, 10m	47 pF 5% (Ceramic)	47J
			Band Component		Marking
			160m	270 pF 5% (Ceramic)	271
			80, 40m	220 pF 5% (Ceramic)	221 
			40, 30, 20m	100 pF 5% (Ceramic)	101 
			30, 20, 17m	82 pF (Ceramic)	82J 
			15, 12, 10m	22 pF 5% (Ceramic)	22J 
					misc

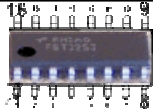


<input type="checkbox"/>	Q02	2N3904 NPN Transistor	 2N3904	TO-92		
<input type="checkbox"/>	C19	4.7 uF 10% 16V X7R RAD	 475	Ceramic		
<input type="checkbox"/>	R30	49.9 ohm 1%	yel-wht-wht-gld-brn 	1/4W	E-W	
<input type="checkbox"/>	R31	49.9 ohm 1%	yel-wht-wht-gld-brn 	1/4W	E-W	
<input type="checkbox"/>	R32	2.21 k 1/4W 1%	r-r-br-br-br 	1/4W	W-E	
<input type="checkbox"/>	R33	3.32 k 1/4W 1%	ora-ora-red-brn-brn 	1/4W	flat-vert	
<input type="checkbox"/>	R29	4.99 k 1/4W 1%	y-w-w-br-br 	1/4W	N-S	
<input type="checkbox"/>	R35	22.1 k 1/4W 1%	r-r-brn-r-br 	1/4W	W-E	

Bottom of the Board



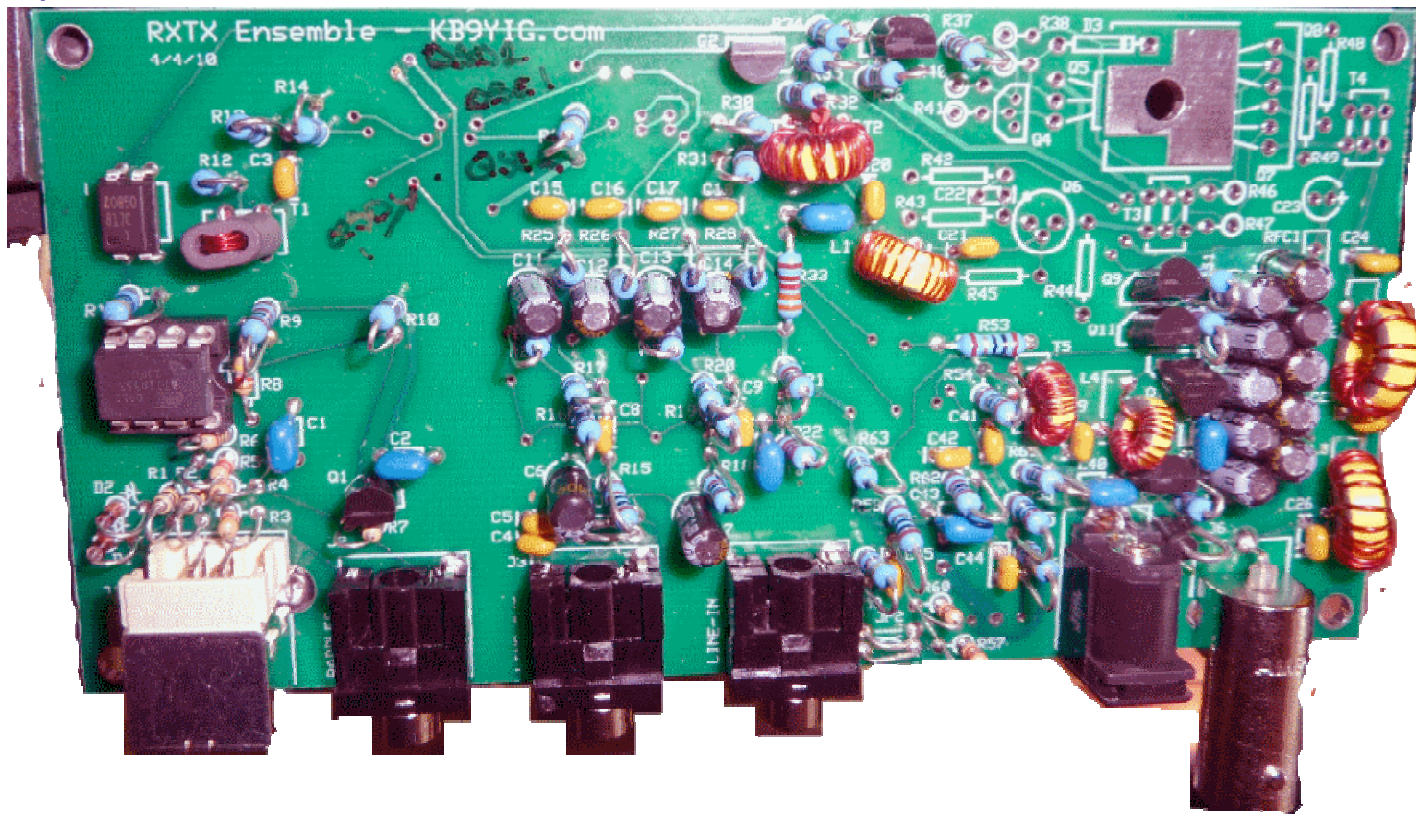
Install Bottomside Components

Check	Designation	Component	Marking	Category	Orientation	Notes
<input type="checkbox"/>	C64	band-specific	Band Component Marking	misc		
			160m 0.1 uF (SMT 1206) (smt) black stripe 			
			80, 40m 0.1 uF (SMT 1206) (smt) black stripe 			
			40, 30, 20m 0.1 uF (SMT 1206) (smt) black 			

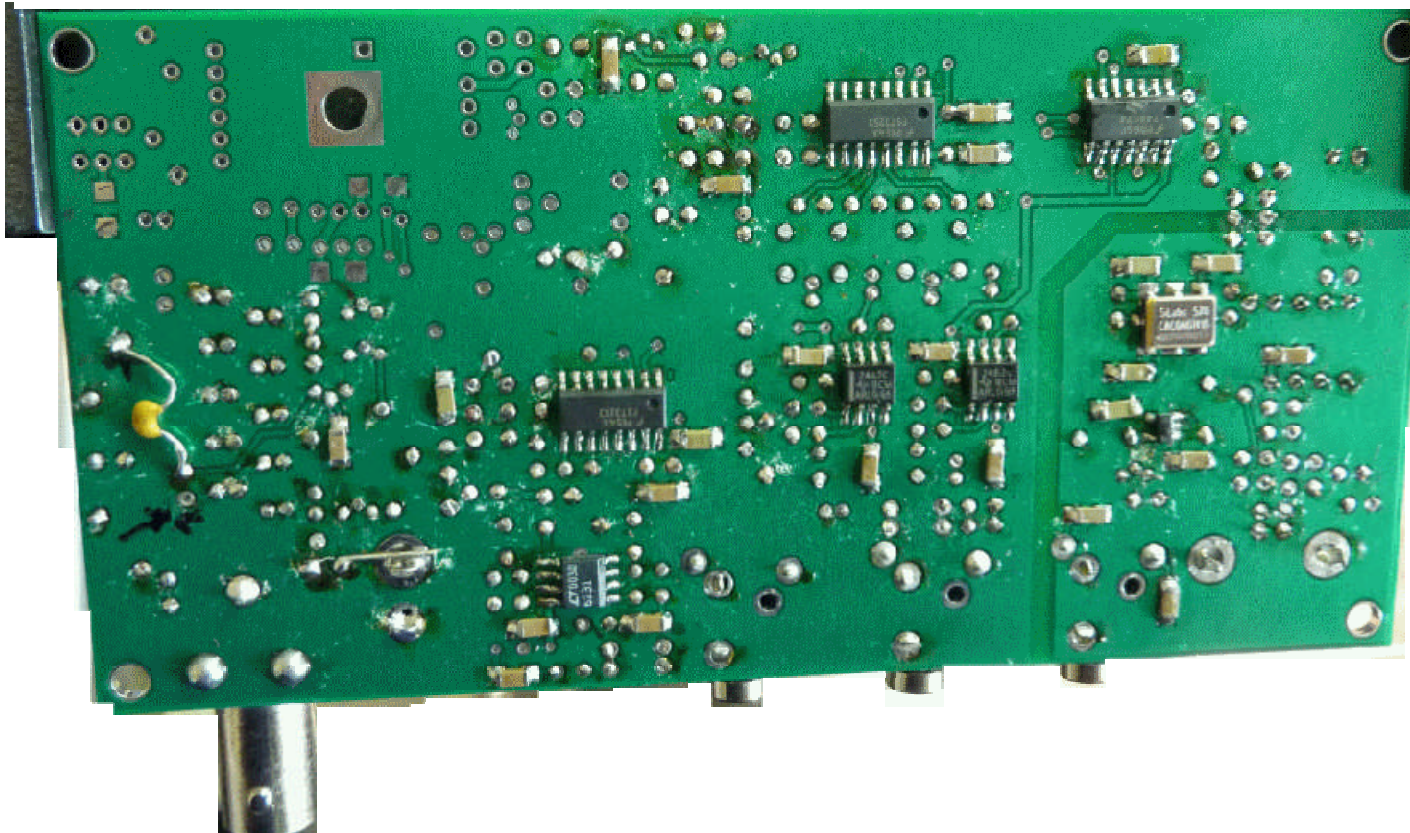
				<div><div>30, 20, 17m</div><div>0.1 uF (SMT 1206)</div><div><div>stripe</div><div>(smt) black stripe</div></div></div>		
			<div><div>15, 12, 10m</div><div>0.01 uF (SMT 1206)</div><div>(smt)</div></div>			
<div>❑</div>	U08	<div>FST3253 mux/demux switch</div>	<div>FST3253</div> <div></div>	SOIC-16	<div>Take ESD precautions</div>	
<div>❑</div>	C62	0.1 uF	<div>(smt) black stripe</div> <div></div>	SMT 1206		
<div>❑</div>	C63	0.1 uF	<div>(smt) black stripe</div> <div></div>	SMT 1206		

TX Mixer (QSE) Completed Stage

Top of the Board



Bottom of the Board



TX Mixer (QSE) Testing

Current Draw

Test Setup

Measure the current draw of the board with 12V power and with 12V power AND USB Power

Test Measurements

Testpoint	Units	Nominal Value	Author's	Yours
Current draw with 12V Power only	mA	< 35	27.5	
Current draw with 12V Power AND USB power	mA	< 33	25.1	

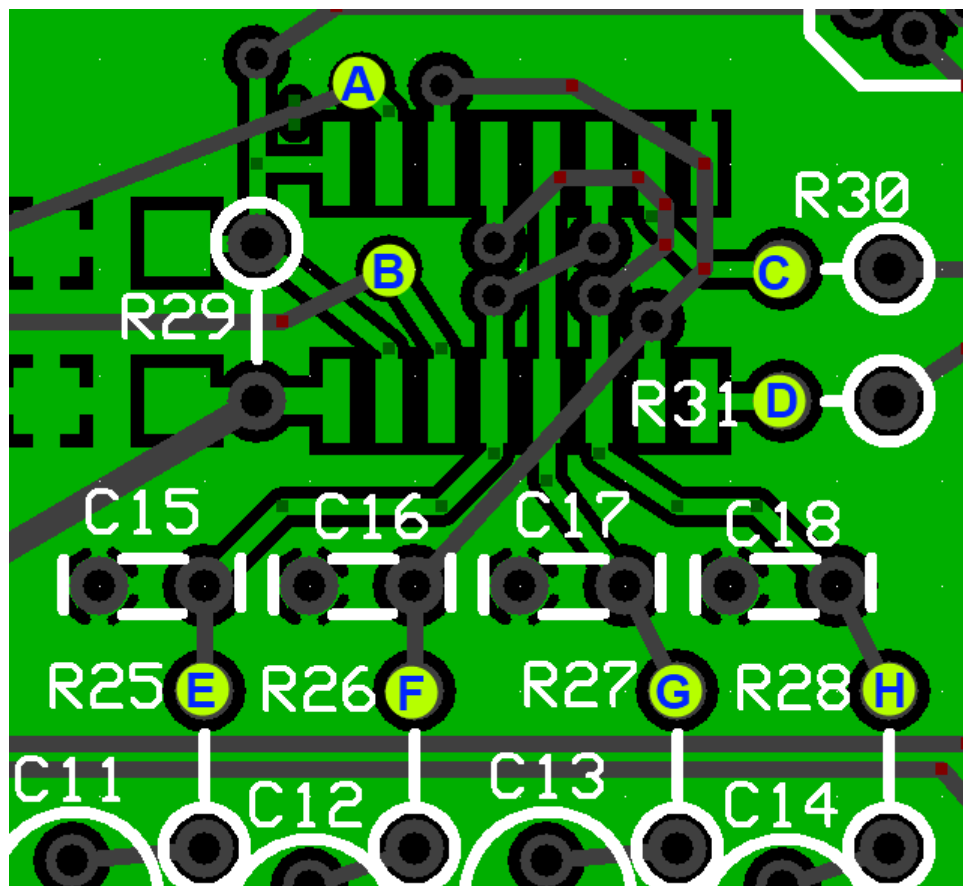
Pin Voltages

Test Setup

Activate PTT. (As an alternative to using the SDR Software to activate PTT, you can use a cliplead to ground the top left-hand lead of U4, activating PTT.)

Connect USB and apply power

Measure the voltages at the noted pins (and their pads) for the FST 3253 (U8)



Test Measurements

Testpoint	Units	Nominal Value	Author's	Yours
A: Pin 2	Vdc	2.5	2.47	
B: Pin 14	Vdc	2.5	2.47	
C: Pin 7 (R30 hairpin)	Vdc	2	1.99	
D: Pin 9 (R31 hairpin)	Vdc	2	1.99	
E: Pin 13 (R25 hairpin)	Vdc	2	1.99	
F: Pin 10 (R26 hairpin)	Vdc	2	1.99	
G: Pin 12 (R27 hairpin)	Vdc	2	1.99	
H: Pin 11 (R28 hairpin)	Vdc	2	1.99	

[Home](#)
[Bill of Materials](#)
[Power Supply](#)
[USB Power Supply](#)
[Local Oscillator](#)
[Dividers](#)
[RF I/O and Switching](#)
[RX Mixer \(QSD\)](#)
[RX Opamps and Output](#)
[TX Opamps](#)
[TX Mixer \(QSE\)](#)
[Driver/PA](#)
[External Connections](#)
[Comments](#)
[Acronyms](#)
[Inventory](#)
[Revisions as of 3/21/2011](#)
[Components By Stage](#)
[WB5RVZ Main Website](#)