Hendricks QRP Kits
BITX20A to BITX17A
Conversion Instructions

30 November 2008

Converting your BITX20A Kit to a BITX17A Kit is not all that complex. It only requires that you change crystals and some resonance components to values used in the BITX17A design. The basic design for both 20 meters and 17 meters is the same, thus DC voltages and troubleshooting methods remain the same except for obvious frequency differences.

There is a BITX discussion group available at: http://groups.yahoo.com/group/BITX20/
Doug Hendricks KI6DS web site for kit sales is at: http://www.qrpkits.com
Farhan's original BITX20 design web site is at: http://www.phonestack.com/farhan/bitx.html

Your BITX20A to BITX17A Conversion Kit will include a decal sheet, crystals, inductors, and various capacitors needed for the conversion.

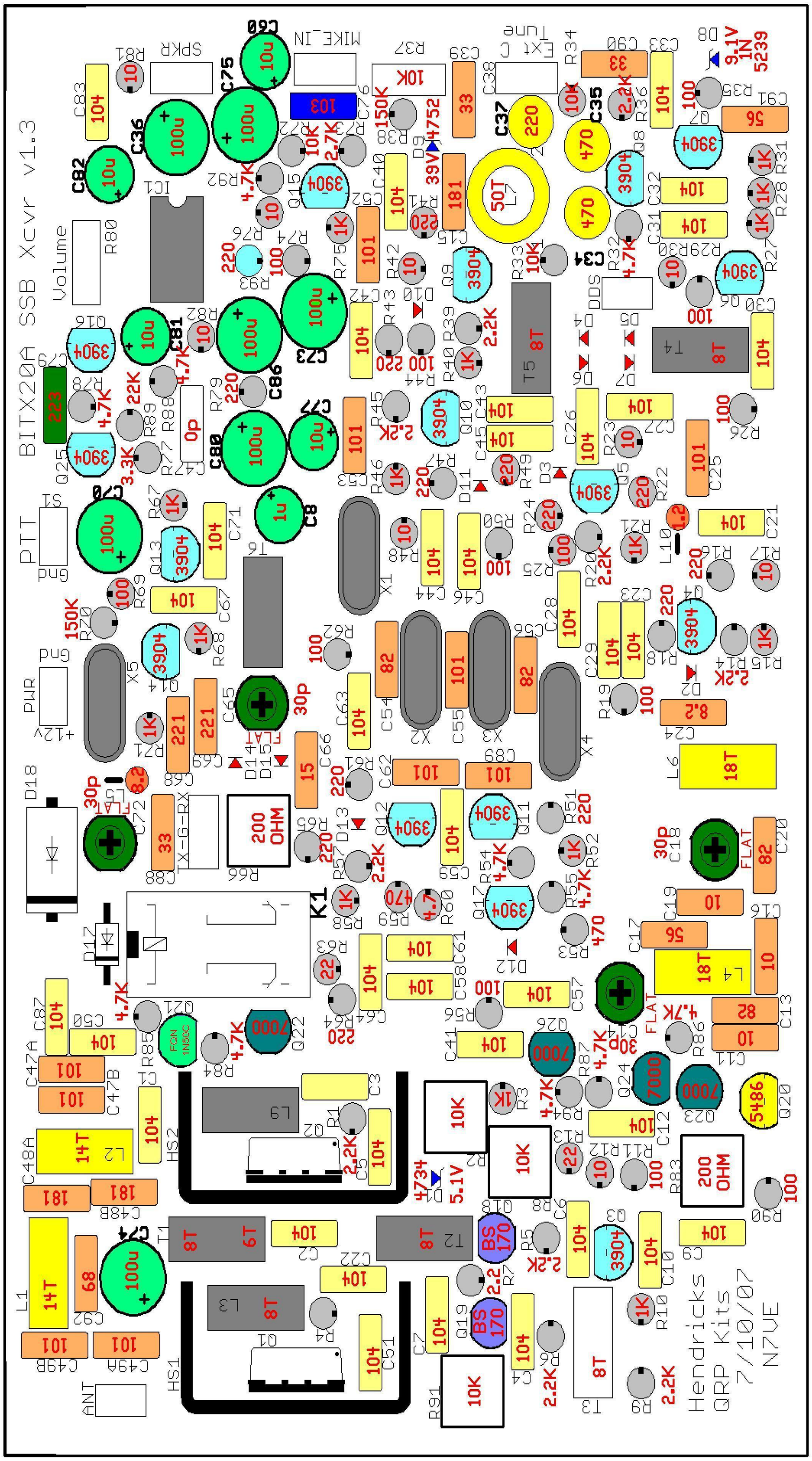
You will be removing installed components (unless your are converting an as-yet unfinished BITX20A kit) and installing replacement components in their place. Some care is required to avoid damaging the PCB in the un-soldering and re-soldering process. Solder wick (or a section of braid salvaged from a length of coaxial cable shield) helps to remove excess solder, as does a spring-driven "solder sucker" tool. The round type of wooden toothpicks can also be used to push through heated holes where components have been removed. This opens the holes for installation of new components.

Conversion Parts List:

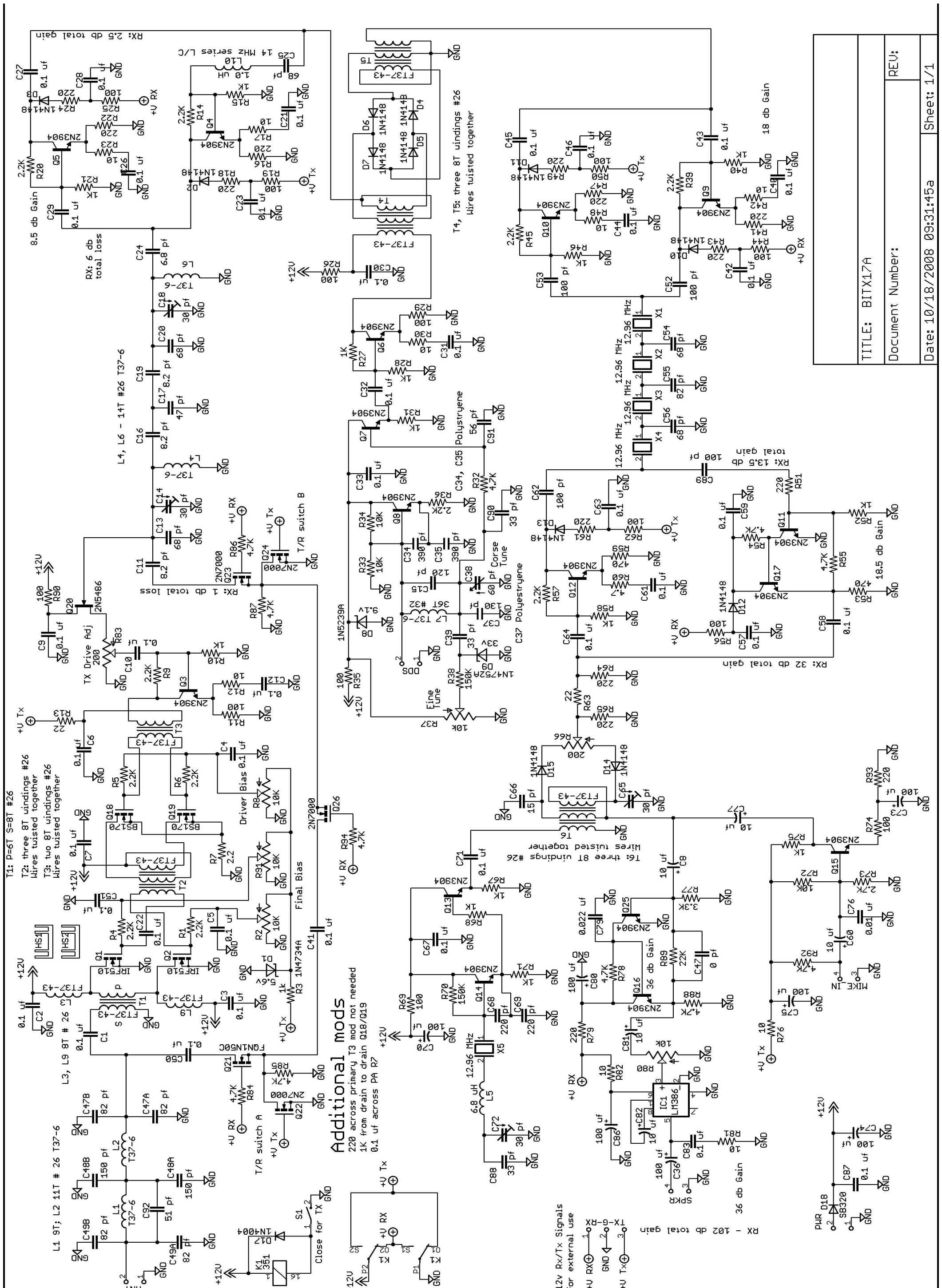
Part Number	17 Meter Parts	20 Meter Parts	Part Description
X-1	12.96 MHz	11.0 MHz	Crystal
X-2	12.96 MHz	11.0 MHz	Crystal
X-3	12.96 MHz	11.0 MHz	Crystal
X-4	12.96 MHz	11.0 MHz	Crystal
X-5	12.96 MHz	11.0 MHz	Crystal
L-10	1.0 uH	1.2 uH	Molded Choke
L-5	6.8 uH	8.2 uH	Molded Choke
C-92	51 pf	68 pf	Ceramic Capacitor
C-54	68 pf	82 pf	Ceramic Capacitor
C-55	82 pf	100 pf	Ceramic Capacitor
C-56	82 pf	100 pf	Ceramic Capacitor
C-47A	82 pf	100 pf	Ceramic Capacitor
C-47B	82 pf	100 pf	Ceramic Capacitor
C-48A	150 pf	180 pf	Ceramic Capacitor
C-48B	150 pf	180 pf	Ceramic Capacitor
C-49A	82 pf	100 pf	Ceramic Capacitor
C-49B	82 pf	100 pf	Ceramic Capacitor
C-34	390 pf	470 pf	Polystyrene Cap
C-35	390 pf	470 pf	Polystyrene Cap
C-37	130 pf	220 pf	Polystyrene Cap
C-11	8.2 pf	10 pf	Ceramic Capacitor
C-13	68 pf	82 pf	Ceramic Capacitor
C-15	120 pf	180 pf	Ceramic Capacitor
C-16	10 pf	8.2 pf	Ceramic Capacitor
C-17	47 pf	56 pf	Ceramic Capacitor
C-19	8.2 pf	10 pf	Ceramic Capacitor
C-20	68 pf	82 pf	Ceramic Capacitor
C-24	6.8 pf	8.2 pf	Ceramic Capacitor
C-25	68 pf	100 pf	Ceramic Capacitor

Parts Placement Diagram:

(Drawing by KD1JV)



BITX17A Schematic Diagram:



(Drawing by N7VE)

Conversion Steps

> ***Now might be a good time to check R-2. R-8, R-83, and R-91 to insure that they are turned totally counter-clockwise. This is to make sure that the transmitter RF drive level is at minimum, and that the MOSFET bias levels are also at minimum. During the alignment procedure you will readjust these potentiometers to their proper levels.***

BFO Components:
[ ] Remove L-5 (8.2 uh molded inductor) marked Gray-Red-Gold-Gold
[ ] Install new L-5 (6.8 uh molded inductor) marked Violet-Gray-Gold-Gold

[ ] Clip excess lead length.
[ ] Inspect solder connections.

[ ] Remove X-5 (11 MHz Crystal)
[ ] Install new X-5 (12.96 MHz Crystal)

> NOTE: Before you install the new crystal for X-5, you may want to temporarily insert each new 12.96 MHz crystal into the BFO oscillator position (X-5) and measure the default frequency for each crystal (measure BFO frequency at the top of R-67). Mark each crystal with it's frequency. Now select the 4 crystals which are closest in frequency for use in X-1, X-2, X-3, and X-4. The remaining 12.96 MHz crystal will be your X-5 crystal for the BFO oscillator. While not absolutely necessary, this procedure may provide steeper sidebands on your crystal filter than would a random selection of crystals.

[ ] Remove X-1 (11 MHz Crystal)
[ ] Install new X-1 (12.96 MHz Crystal)

[ ] Remove X-2 (11 MHz Crystal)
[ ] Install new X-2 (12.96 MHz Crystal)

[ ] Remove X-3 (11 MHz Crystal)
[ ] Install new X-3 (12.96 MHz Crystal)

[ ] Remove X-4 (11 MHz Crystal)

[ ] Install new X-4 (12.96 MHz Crystal)

[ ] Clip excess lead length.
[ ] Inspect solder connections.

VFO Blocking Filter (L-10 & C-25):
[ ] Remove L-10 (1.2 mh molded choke)
[ ] Install new L-10 (1.0 mh molded choke)

[ ] Remove C-25 (100 pf Ceramic Capacitor)
[ ] Install new (C-25 (68 pf Ceramic Capacitor)

[ ] Clip excess lead length.
[ ] Inspect solder connections.

[ ] Remove C-92 (68 pf Ceramic Capacitor)
[ ] Install new C-92 (51 pf Ceramic Capacitor)

[ ] Remove C-54 (82 pf Ceramic Capacitor)
[ ] Install new C-54 (68 pf Ceramic Capacitor)

[ ] Remove C-55 (100 pf Ceramic Capacitor)
[ ] Install new C-55 (82 pf Ceramic Capacitor)

[ ] Remove C-56 (100 pf Ceramic Capacitor)
[ ] Install new C-56 (82 pf Ceramic Capacitor)

[ ] Clip excess lead length.
[ ] Inspect solder connections.

[ ] Remove C-47A (100 pf Ceramic Capacitor)
[ ] Install new C-47A (82 pf Ceramic Capacitor)

[ ] Remove C-47B (100 pf Ceramic Capacitor)
[ ] Install new C-47B (82 pf Ceramic Capacitor)

[ ] Remove C-48A (180 pf Ceramic Capacitor)
[ ] Install new C-48A (150 pf Ceramic Capacitor)

[ ] Remove C-48B (180 pf Ceramic Capacitor)
[ ] Install new C-48B (150 pf Ceramic Capacitor)

[ ] Remove C-49A (100 pf Ceramic Capacitor)
[ ] Install new C-49A (82 pf Ceramic Capacitor)

[ ] Remove C-49B (100 pf Ceramic Capacitor)
[ ] Install new C-49B (82 pf Ceramic Capacitor)

[ ] Clip excess lead length.
[ ] Inspect solder connections.

[ ] Remove C-34 (470 pf Polystyrene Capacitor)
[ ] Install new C-34 (390 pf Polystyrene Capacitor)

[ ] Remove C-35 (470 pf Polystyrene Capacitor)
[ ] Install new C-35 (390 pf Polystyrene Capacitor)

[ ] Remove C-37 (220 pf Polystyrene Capacitor)
[ ] Install new C-37 (130 Polystyrene Capacitor)

[ ] Clip excess lead length.
[ ] Inspect solder connections.

[ ] Remove C-11 (10 pf Ceramic Capacitor)
[ ] Install new C-11 (8.2 pf Ceramic Capacitor)

[ ] Remove C-13 (10 pf Ceramic Capacitor)
[ ] Install new C-13 (8.2 pf Ceramic Capacitor)

[ ] Remove C-15 (180 pf Ceramic Capacitor)
[ ] Install new C-15 (120 pf Ceramic Capacitor)

[ ] Remove C-16 (10 pf Ceramic Capacitor)
[ ] Install new C-16 (8.2 pf Ceramic Capacitor)

[ ] Remove C-17 (56 pf Ceramic Capacitor)

[ ] Install new C-17 (47 pf Ceramic Capacitor)

[ ] Clip excess lead length.
[ ] Inspect solder connections.

[ ] Remove C-19 (10 pf Ceramic Capacitor)
[ ] Install new C-19 (8.2 pf Ceramic Capacitor)

[ ] Remove C-20 (82 pf Ceramic Capacitor)
[ ] Install new C-20 (68 pf Ceramic Capacitor)

[ ] Remove C-28 (8.2 pf Ceramic Capacitor)
[ ] Install new C-28 (6.8 pf Ceramic Capacitor)

[ ] Clip excess lead length.
[ ] Inspect solder connections.

[ ] Remove L-7 (VFO Oscillator Coil) Remove 14 turns. This should leave 36 turns on the core.
[ ] Re-install L-7

[ ] Remove L-6 (RF Filter Coil) Remove 4 turns. This should leave 14 turns on the core.
[ ] Re-install L-6

[ ] Remove L-4 (RF Filter Coil) Remove 4 turns. This should leave 14 turns on the core.
[ ] Re-install L-4

[ ] Clip excess lead length.
[ ] Inspect solder connections.

[ ] Remove L-1 (Antenna Filter) Remove 3 turns. This should leave 9 turns on the core.
[ ] Re-install L-1

[ ] Remove L-2 (Antenna Filter) Remove 3 turns. This should leave 9 turns on the core.
[ ] Re-install L-2

[ ] Clip excess lead length.
[ ] Inspect solder connections.

Congratulations. You have completed converting your BITX20A to a BITX17A, and are ready to proceed with alignment of the transceiver, including transmitter driver stages and the MOSFET power amplifiers.

> ***Now might be a good time to check R-2. R-8, R-83, and R-91 to insure that they are turned totally counter-clockwise. This is to make sure that the transmitter RF drive level is at minimum, and that the MOSFET bias levels are also at minimum. During the alignment procedure you will set these potentiometers at their proper levels.***

To proceed with transceiver alignment you will need the following tools:

- <u>50 ohm Dummy load.</u> This can be an actual dummy load, or a bank of non-inductive resistors which will withstand 12 watts or more for up to one minute.
- <u>An Oscilloscope, or Diode Voltage Probe and Voltmeter</u> for measuring RF voltage levels at 18 MHz.
- <u>A DC Ampere Meter</u> capable of measuring 0 to 300 ma, and 0 to 2 amperes. There is an alternative way to measure the 0 to 300 ma levels using voltage across a resistor. This will be discussed in the alignment procedures.
- <u>The Microphone</u> that you are going to use with this transceiver, or an audio signal generator and suitable attenuators to adjust it's output to normal microphone signal levels (nominally 40 to 50 millivolts).
- <u>A Frequency Counter</u>, or other means to determine VFO frequency and tuning range. A receiver with accurate frequency readout may be suitable.

<u>Initial Alignment Procedure:</u>
These steps will get you on the air. A more detailed alignment method is documented in the troubleshooting section.

1. Set the BFO and carrier oscillator frequency:

   Adjust the BFO (C-72) so that when you tune across a steady carrier you can hear the zero-beat on each side of that carrier frequency. Then adjust C-72 to a slightly lower frequency where you can hear the upper-sideband zero-beat tone but the lower-sideband one is either gone or very much attenuated. Now tune in an on-air SSB signal and adjust C-72 very slightly for best audio quality.

2. Set the carrier balance:

   <u>STEP-1:</u> With an detector probe or oscilloscope monitoring the 12.96 MHz signal at

R-64, carefully adjust R-66 and C-65 for minimum signal level. There is some interaction so you will need to re-adjust these several times in order to get the best signal null.

STEP-2: Move your oscilloscope probe or diode detector to pin-2 of X-4 (the junction of X-4, C-62, and C-89), and again adjust R-66 and C-65 for the best carrier null while in transmit mode (PTT operated).

3. Determine and adjust the VFO frequency and tuning range:

   Set your Fine Tuning potentiometer to mid-range. Leave it there for the following procedure. Since the BFO and IF sections operate on 12.96 MHz, your BITX17A VFO must tune between 18.068 – 12.960 = **5.108 MHz** and 18.168 – 12.960 = **5.208 MHz**. Set your Course Tuning adjustment (the polyvaricon capacitor) fully to the left. Adjust the trimmer on the back of your polyvaricon variable capacitor so that with the knob turned fully left (minimum capacitance) your VFO is at or slightly above 5.208 MHz. Then rotate the polyvaricon fully to the right (maximum capacitance) and verify that the VFO is now below 5.108 MHz. This insures full 17 meter band coverage.

4. Align the front-end bandpass filter:

   While listening to a signal generator or received carrier beat note, carefully adjust C-14 and C-18 for maximum received signal level. There is some interaction between these 2 capacitors, so you may need to re-peak each capacitor adjustment several times to reach maximum sensitivity. You should see two positions on these capacitors where the signal peaks. This indicates that you are actually tuning to the maximum sensitivity point, instead of just approaching resonance at the end of tuning range.

5. Adjust the transmit driver bias:

   Temporarily short the microphone audio input connection. Connect an ammeter capable of measuring approximately 200 ma in series with power to the transceiver. Key the microphone PTT and note the idling current of your transmitter. Now slowly rotate R-8 clockwise until the idling current has increased by 20 ma. Un-key the transmitter and remove the temporary short across the microphone audio input.

   NOTE: It is possible to measure the combined current flowing in Q-18 and Q-19 by measuring the DC voltage across R-7 with a sensitive digital voltmeter. This is a 2.2 ohm resistor, so 20 ma through this 2.2 ohm common source resistor would occur at a voltmeter reading of 0.20 X 2.2 = 0.044 volts.

6. Adjust the transmit power amplifier bias:

   Temporarily short the microphone audio input connection. Connect an ammeter capable of measuring approximately 300 ma in series with power to the transceiver. Key the microphone

PTT and note the idling current of your transmitter. Now slowly rotate R-91 clockwise until the idling current has increased by 50 ma. Note the new idling current. Slowly rotate R-2 clockwise until the idling current has increased by another 50 ma. Un-key the transmitter and remove the temporary short across the microphone audio input.

7. Drive level adjustment:

Monitor transmitter output with a 50 ohm termination and watt-meter, or dummy load and scope or diode detector probe and DC voltmeter.

Temporarily connect an audio signal generator to the microphone audio input connection (if R-92 is installed you will need to use capacitive coupling to keep DC out of the signal generator). Adjust the signal generator for 1000 Hz and 40 to 50 mv output level.
NOTE: The time honored method of speaking a prolonged "Aaaaaaaaaaah" into the microphone will also work if you do not have an audio signal generator.

Key the transmitter and slowly rotate R-83 to the right while watching the transmitter RF output. An RMS voltage reading of 22.4 volts indicates power output of 10 watts. If your equipment is reading in peak volts, 10 watts will be at an indication of 1.4 * 22.4 = 31.3 volts.

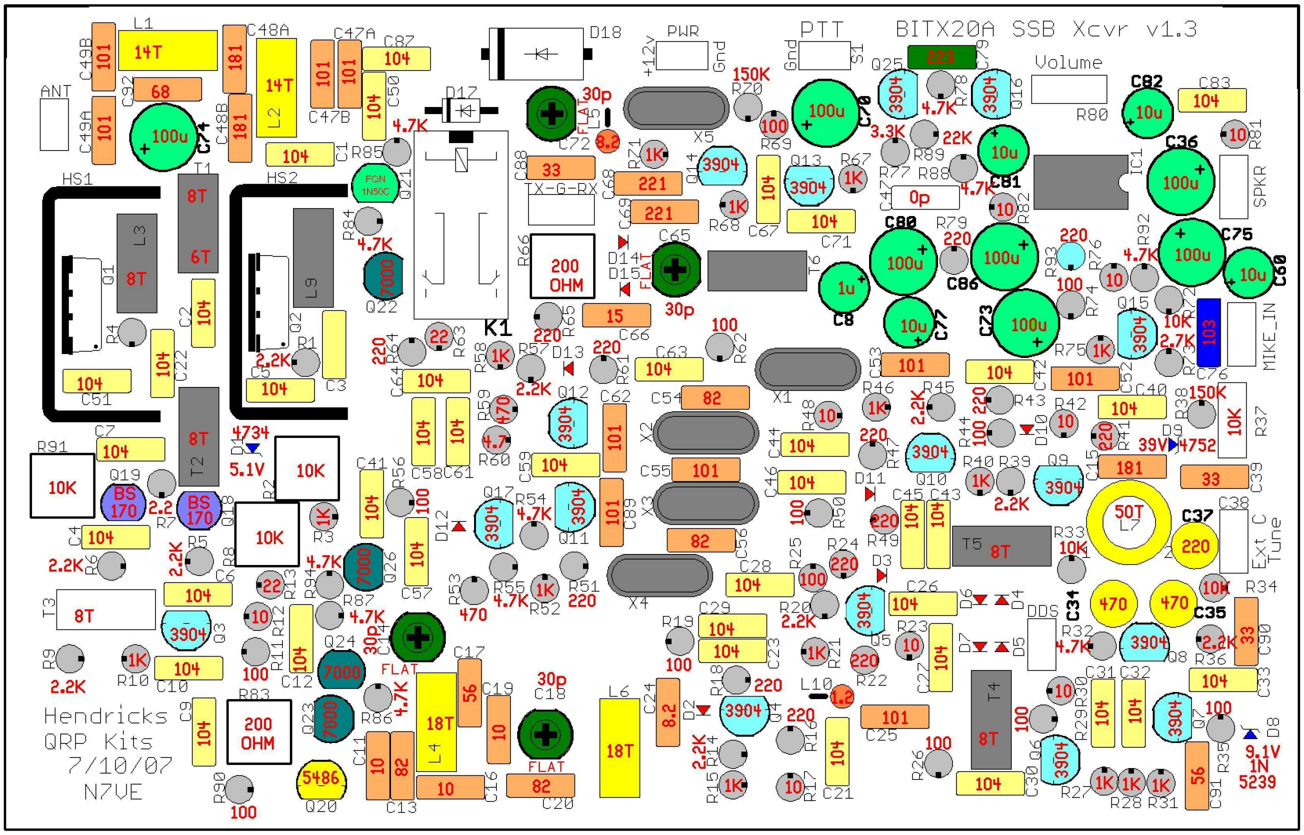
50 OHM VOLTAGE CHART

Watts	Volts RMS	Volts PEAK
1	7.07	9.9
2	10	14
3	12.25	17.15
4	14.14	19.8
5	15.81	22.14
6	17.32	24.25
7	18.71	26.19
8	20	28
9	21.21	29.7
10	22.36	31.3
11	23.45	32.83
12	24.49	34.29
13	25.5	35.69
14	26.46	37.04
15	27.39	38.34

This completes the initial adjustment and alignment of your BITX17A transceiver kit.

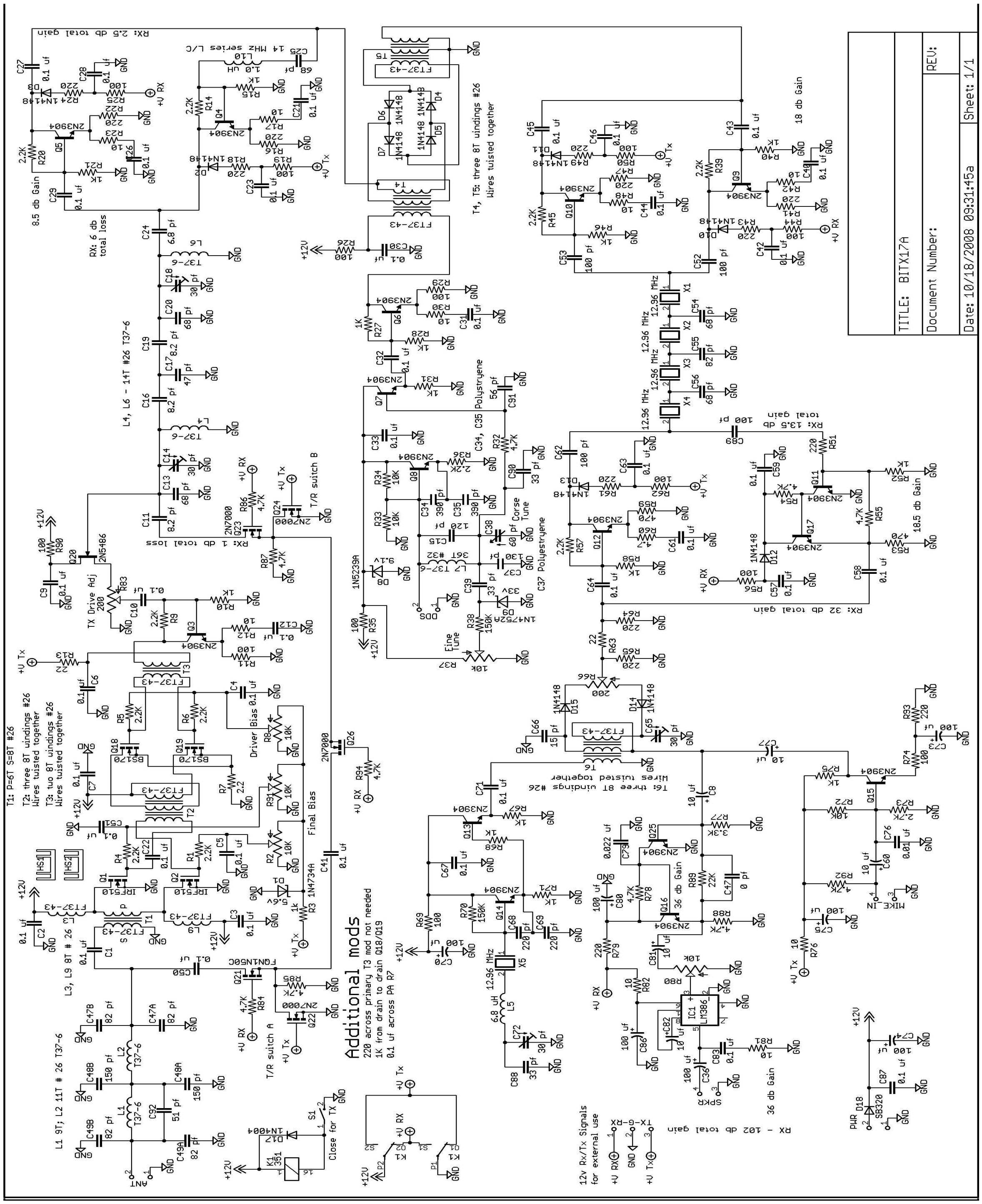
The following document sections provide additional information for education and for troubleshooting. The parts placement drawing and schematic drawing have been duplicated in this section so you will have a copy to write notes on as a future reference for your particular BITX17A transceiver.

Parts Placement Drawing:



Drawing by KD1JV

Schematic Diagram:



Schematic by N7VE

Detailed Alignment Method:

BFO/Carrier Oscillator:

There are several ways to adjust the BFO/Carrier Oscillator frequency.

1. Rough alignment may be made by adjusting C-72 while listening to a received SSB signal on 17 meters. This is a two-handed operation as you have to use the VFO Fine Tuning to keep the VFO frequency set for best intelligibility while searching for the best quality audio with C-72.

2. Instrument alignment is done by monitoring carrier attenuation while adjusting the BFO/Carrier Oscillator relative to the crystal filter sideband shape factor. The oscillator frequency needs to be 24 to 40 db down the lower side of the filter passband.
    - Disconnect the microphone or short it's audio output so that there is no audio coming through the microphone amplifier.
    - Set up an oscilloscope or RF detector and voltmeter to monitor the transmit 2nd IF amplifier output (the exposed lead on R-45, near Q-10).
    - Connect a frequency counter to the exposed lead of R-67 to monitor BFO/Carrier Oscillator frequency.
    - Operate the PTT switch and un-balance the balanced modulator by turning R-66 until you have a measurable signal. Un-key the transmitter.
    - Key the transmitter again and adjust the BFO/Carrier Oscillator frequency (C-72) for maximum signal level, note the frequency on the counter, and then adjust C-72 for a lower frequency and a 24 to 40 db decrease in monitored signal level. Un-key the transmitter. The BFO/Carrier Oscillator frequency needs to be just outside the lower frequency edge of the crystal filter for USB operation.
    - Disconnect the frequency counter, key the transmitter and re-check to see that you are still at the same signal attenuation point on your scope or voltmeter. Un-key the transmitter. This checks to make sure that your counter was not pulling the BFO/Carrier Oscillator off frequency by any significant amount.
    - Key your transmitter and adjust the modulator balance (R-66 and C-65) for minimum RF indication. Un-key your transmitter.
    - Re-connect your microphone or remove the short from it's output.

There are several additional ways to adjust the BFO/Carrier Oscillator frequency. If you have the knowledge and equipment it might be an interesting exercise to try these methods as well. However, even the Rough Alignment method outlined above will usually provide adequate setting for good reception and transmission.

VFO:

VFO components provided in the kit have been chosen in an attempt to insure that your tuning range will be within the 17 meter band. However, this is not guaranteed. You should check the VFO frequency with a counter connected the exposed lead of R-27, or use a well calibrated receiver. Trimmer capacitors on the back of the main tuning capacitor will provide some adjustment but you will need to select which capacitor sections are connected to set the minimum & maximum tuning limits and the tuning range.

Polyvaricon Section	Capacitance Range	Trimmer Open Tuning Range	Trimmer Closed Tuning Range
=========	=========	===========	============
Section-A	4 to 80 pf*	60 KHz	58 KHz
Section-B	5 to 160 pf*	124 KHz	120 KHz
Sections A+B	9 to 240 pf*	155 KHz	147 KHz

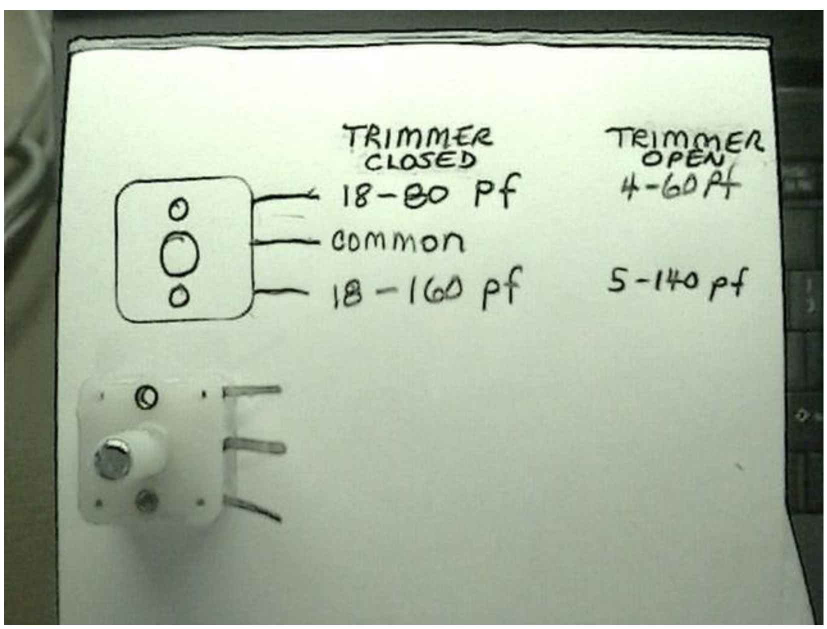
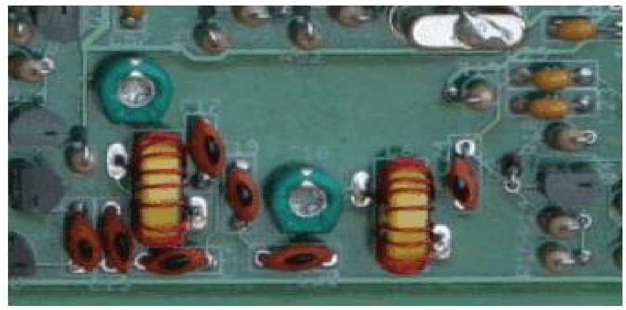


*Illustration 1: *VFO Tuning Capacitor Parameters(K7HKL Photo)*

Since the IF frequency is 12.96 MHz, the VFO needs to tune 12.96 MHz below your desired tuning range on 17 meters (18.000 -12.96 = 5.04 MHz). You can use this method to calculate the frequency of the VFO for your particular tuning selection.



Receiver & Transmitter RF Filter:

The easiest way to tune the RF input filter is to peak C-14 and C-18 in receive mode for loudest signal while listening to a relatively constant carrier from your antenna. This provides both receive and transmit mode alignment of this filter.

Transmitter Driver

There is no tuning involved in adjusting the transmitter drivers section, but you do have to set the bias adjustment. Drive level adjustment will be done in the RF PA alignment section.

1. Connect a 2 to 3 ampere DC ammeter in series with the +12 volt line to your transceiver.
2. Disconnect the microphone or short it's output so there will be no audio entering the microphone amplifier.
3. Key the transmitter and note the idling current. Un-key the transmitter.
4. Key the transmitter and slowly adjust R-8 for an increase of 20 ma. Un-key the transmitter.

NOTE: You can alternatively monitor the voltage drop across R7 to measure idling current in the PA driver amplifier. This is a 2.2 ohm resistor so 20 ma of current would equal a voltage drop of (0.02 X 2.2 =) 0.044 volts.

RF PA

There are no tuning adjustments in the RF PA section, but you do have to adjust the idling current on the two IRF510 MOSFET devices and then set the drive level for best output linearity. To do this you will need an ammeter with a capability of reading 2.5 or 3 amperes.

PA Idling Current Adjustment:

1. Connect an ammeter in series with the power lead that supplies 12 volts to your transceiver.
2. Disconnect the microphone, or short it's audio output so that no audio is going to the microphone amplifier.
3. Key the transmitter (use a dummy load please) and note the idling current. Unkey the transmitter.
4. Key the transmitter and slowly adjust R-91 until this current increases by 50 ma. Unkey your transmitter. Note the new idling current.
5. Key the transmitter and slowly adjust R-2 until the idling current increases by another 50 ma. Unkey the transmitter.

Drive Level Adjustment:

RF output level can be adjusted for over 10 watts in some transceivers, but compression of the RF envelope usually starts at about 10 watts. To preserve output linearity you should set the RF output level no higher than the point where RF compression becomes apparent. As you monitor the RF output and simultaneously increase the drive level, you should see the output rise fairly fast, with the rate of rise decreasing after you pass some point on the adjustment. This is the setting where RF compression starts. For best transmitted signal linearity you should set the drive level just below this start of compression point.

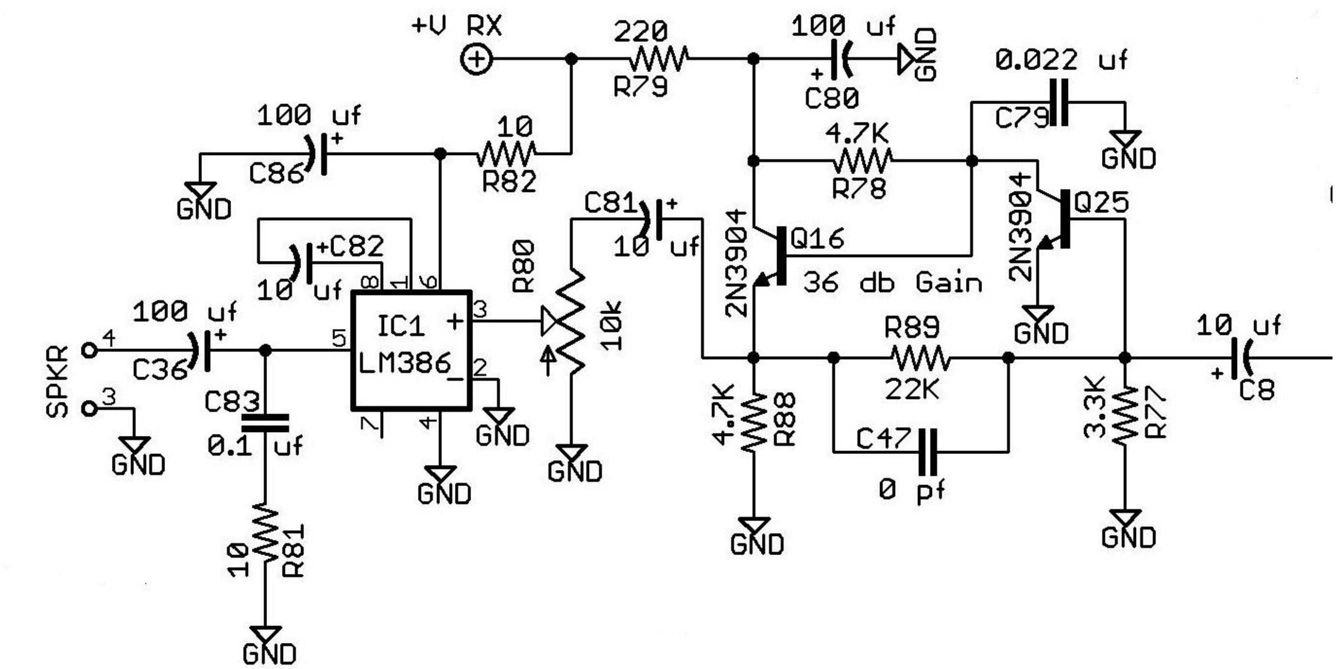
1. You can insert an audio tone (approximately 50 mv) via the microphone jack of your transceiver or use the time-honored method of saying a long "Aaaaaaaaaaaaaah" while monitoring the RF output with a scope, diode detector and voltmeter, or watt meter.
2. Key your transmitter and insert the tone while monitoring the RF output and slowly adjusting the RF drive pot (R-83) for an increase in output. Identify the adjustment position where rate of output increase seems to slow. Back the drive level back down by ½ watt or so. This is your position of best output signal quality. Un-key your transmitter.

NOTE: Do not keep the transmitter keyed for more than a few seconds with a tone input. Steady tones exceed the duty cycle designed into the RF PA amplifiers and their heat sinks, and may damage the IRF510 MOSFETS.

Troubleshooting Section

This section contains isolated sections of the total schematic, voltage charts, and a few words regarding each section. Voltages shown are based on 12.0 volts supply for the transceiver.

Receive Audio Amplifier

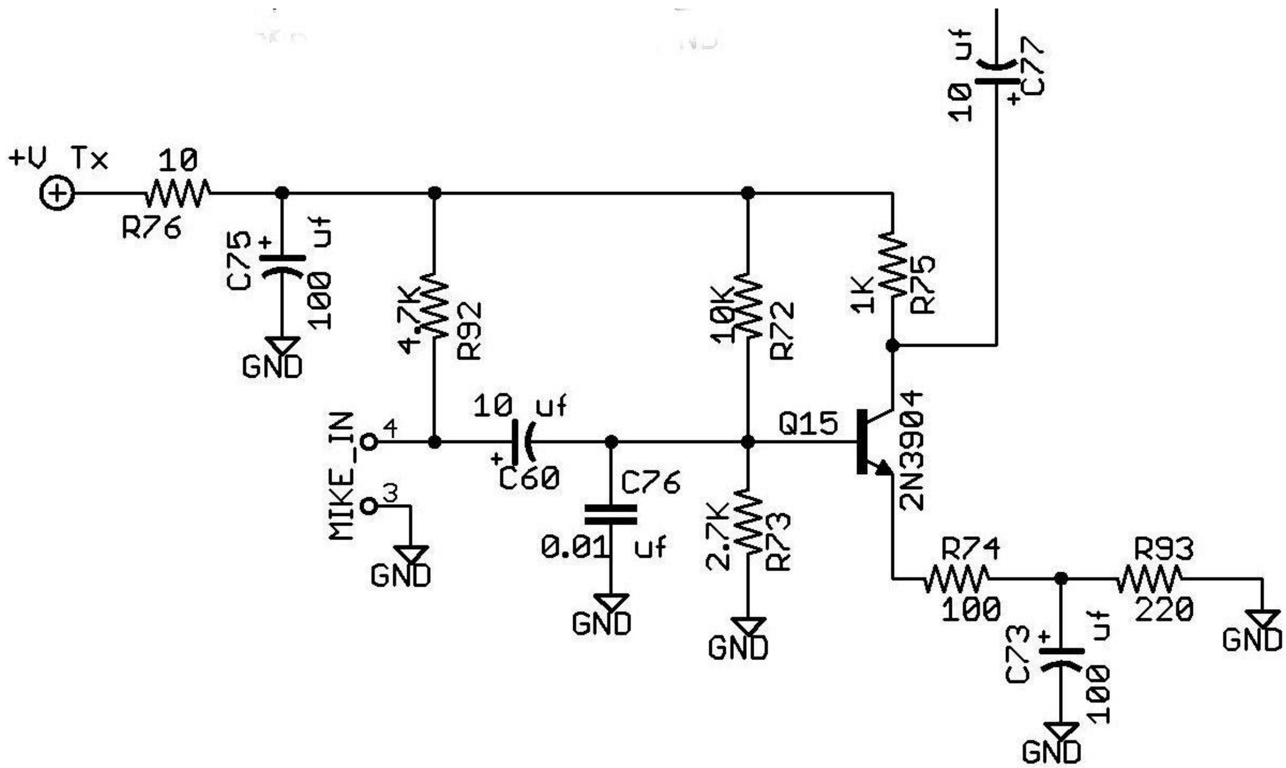


NOTE: The following voltage measurements are made in receive mode

LM386 Voltages		*Q-16Voltages*		*Q-25 Voltages*	
Pin-1	1.34 VDC	Collector	10.97 VDC	Collector	5.94 VDC
Pin-2	0.0 VDC	Emitter	5.26 VDC	Emitter	0.0 VDC
Pin-3	0.0 VDC	Base	5.94 VDC	Base	0.67 VDC
Pin-4	0.0 VDC				
PIN-5	1.34 VDC				
Pin-6	5.72 VDC				
Pin-7	11.5 VDC				
Pin-8	5.63 VDC				

C-47 is an artifact of early PCB layout and testing. No capacitor should be inserted in this position.

Microphone Amplifier



<u>*Q-15 Voltages*</u> (transmit mode)

Collector 6.29 VDC

Emitter 1.63 VDC

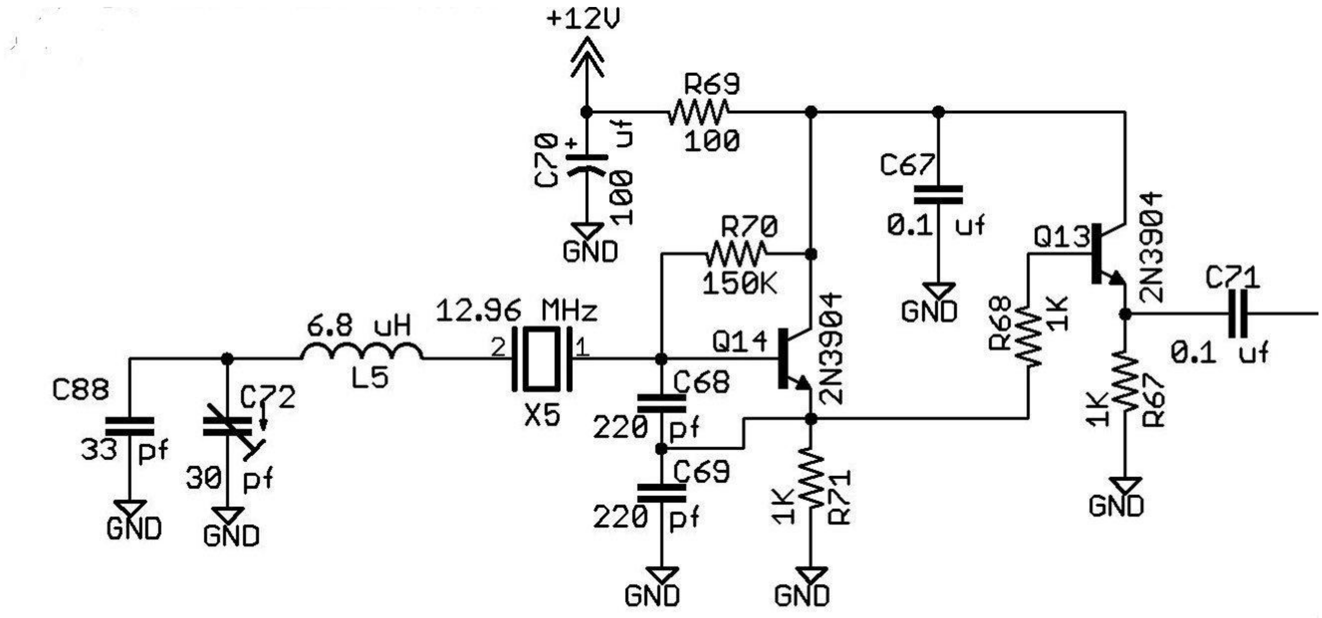
Base 2.34 VDC

R-92 provides DC voltage to operate an Electret type microphone, which uses a thin metalized mylar foil capacitive transducer driving an internal FET amplifier. Audio AC voltage is amplified and appears across R-92, where it is coupled through C-60 to the base of Q-15. If you are not using this type of microphone you should not install (or should remove) R-92. Electret microphones are common in inexpensive audio devices (tape recorders, etc.) or can be purchased directly from component suppliers. Most inexpensive computer microphones are Electret types.

Audio input level for transmitter testing should be 50 mv or less. Use capacitive coupling (10 mfd) if R-92 is in place, or temporarily lift one end of R-92 to avoid sending DC power into your test oscillator.

Microphones used with this transceiver should be capable of providing 40 to 50 mv of audio output. If using a Electret microphone you will need R-92 in circuit to power the microphone. Overdriving the audio input may cause harmonics of audio frequencies to be generated in the balanced modulator.

BFO and Carrier Oscillator



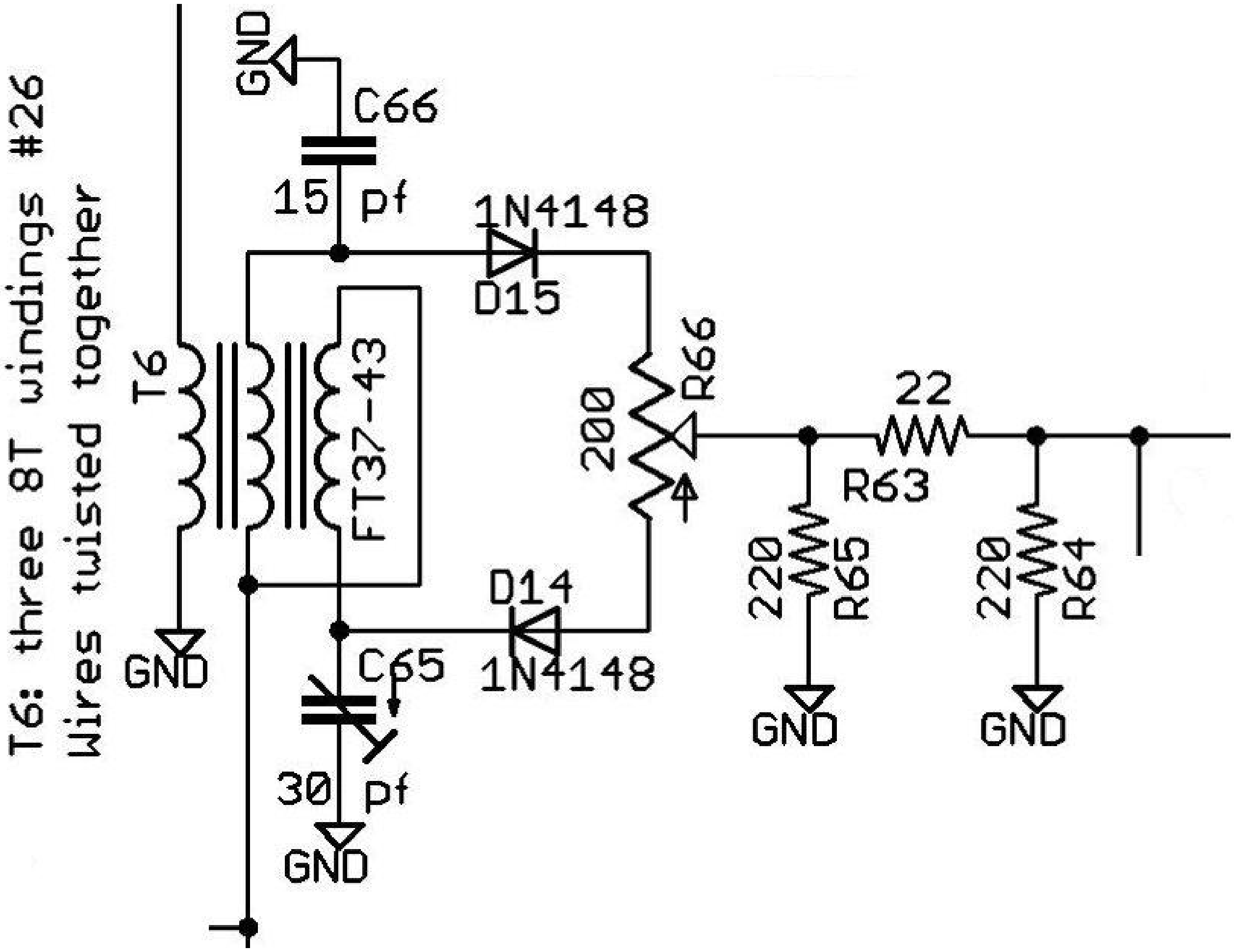
C-88 (33 pf) may not be required to properly set your BFO frequency. It is provided for use in case you need to pull the BFO lower in frequency than can be done with just C-72 (5-30 pf) alone. In this type circuit, the various capacitances C-68, C-69, C-72, C-88, and C_{X5}, along with inductance L-5 make up a series-tuned circuit which resonates close to the crystal frequency. As C-72 is changed, the crystal is pulled a few KHz from it's normal series-resonance point. This VXO adjustment allows you to set the crystal oscillator to it's proper frequency, which is 12 to 20 db down the lower sideband skirt of the crystal filter.

Because the oscillating waveform will affect DC meter accuracy, it is necessary to stop the oscillator in order to make meaningful DC measurements. This is done by temporarily disconnecting or removing the BFO crystal (X-5). Now you can measure the DC operating parameters of this stage.

Q-14 Voltages (receive mode)		*Q-13 Voltages* (receive mode)	
Collector	10.55 VDC	Collector	10.55 VDC
Emitter	5.35 VDC	Emitter	4.63 VDC
Base	5.50 VDC	Base	5.31 VDC

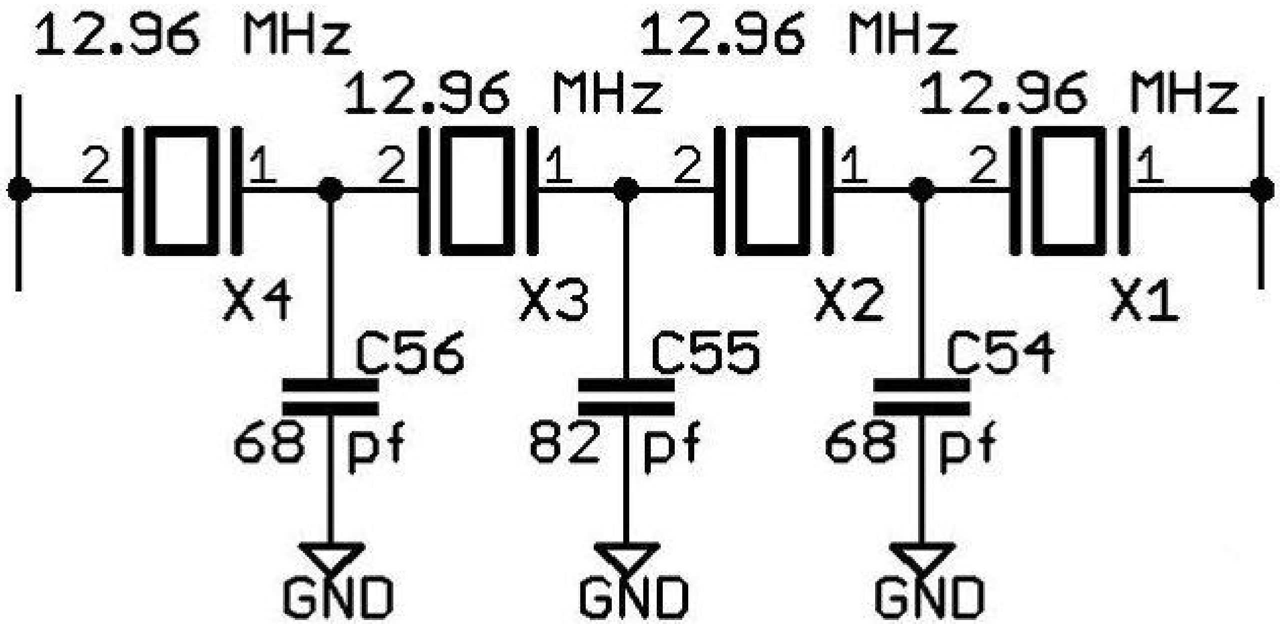
(Remember to reinstall the crystal that was removed for making these measurements.)

Balanced Modulator



You can adjust the balanced modulator in receive mode. Connect an oscilloscope or diode probe and DC voltmeter across R-64. Then adjust C-65 and R-66 for minimum output. There should be two points on C-65 where the R-64 voltage is at minimum (this verifies that you are not at the end of the adjustment range). The dip in voltage across R-64 should occur at approximately mid-point on R-66. There is some interaction between these two adjustments so you need to re-adjust each several times to obtain the best dip.

Crystal Filter



The crystal filter appears quite simple and easy to build. Testing it to verify performance though is a bit more complex. To determine the passband characteristic for your crystal filter it should be tested in the circuit where it will be operated. In the BITX designs this means that you need to have the IF amplifiers on each side of the filter wired and working properly.

Insert a low level signal at the input of the receiver 1st IF amplifier. Monitor the output at the top of R-64 which is located at the output side of the 2nd receive IF amplifier. Decrease input signal until the output decreases as your decrease input (this avoids working through a saturated amplifier).

As you tune very slowly across the IF passband, note and record R-64 signal levels at every 200 Hz frequency step. For a rather crude looking chart you can simply plot the voltage readings on graph paper to determine your filter passband, but the graph will not look like the classic ones in radio handbooks. To improve your chart's appearance and to look like the commercial diagrams, you need to convert each reading into decibels and then plot the response with DB as the vertical axis of your graph.

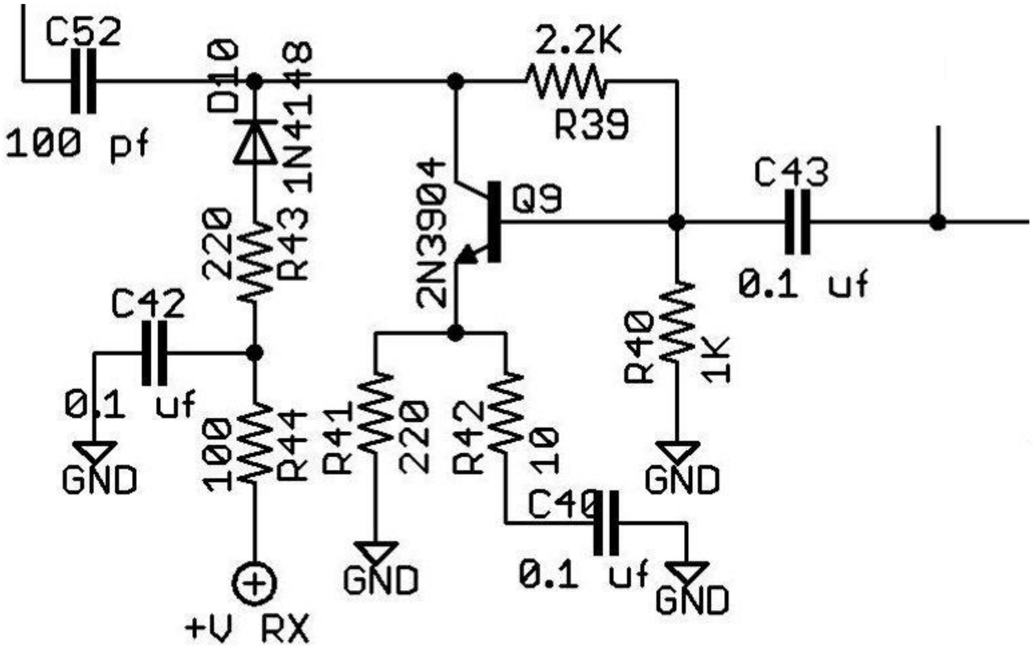
Mark the -6 db points (or half-voltage points if you are plotting raw voltage readings) on upper and lower skirts of the filter response curve. The frequency range between these points is your filter 6-db bandwidth.

Note the points of -12 and -20 db down the lower sideband skirt of filter response. Somewhere between these points is where you should set the BFO frequency for best audio and good LSB and carrier suppression.

The bandwidth and response curve of a crystal filter can be adjusted to some extent. In building your filter you may have picked the 4 crystals which were closest in frequency and used these for the filter. This will give you the steepest sideband skirts. The capacitors to ground inside the filter diagram (C-54, C-55, and C-56) may be changed to alter the overall filter bandwidth. While it may seem counter-intuitive, increasing capacitance decreases the filter bandwidth. The value of C-55 should equal approximately twice the value of C-54 or C-56, but there is some room to experiment to see how changes affect the ripple factor across the passband and steepness of sideband skirts.

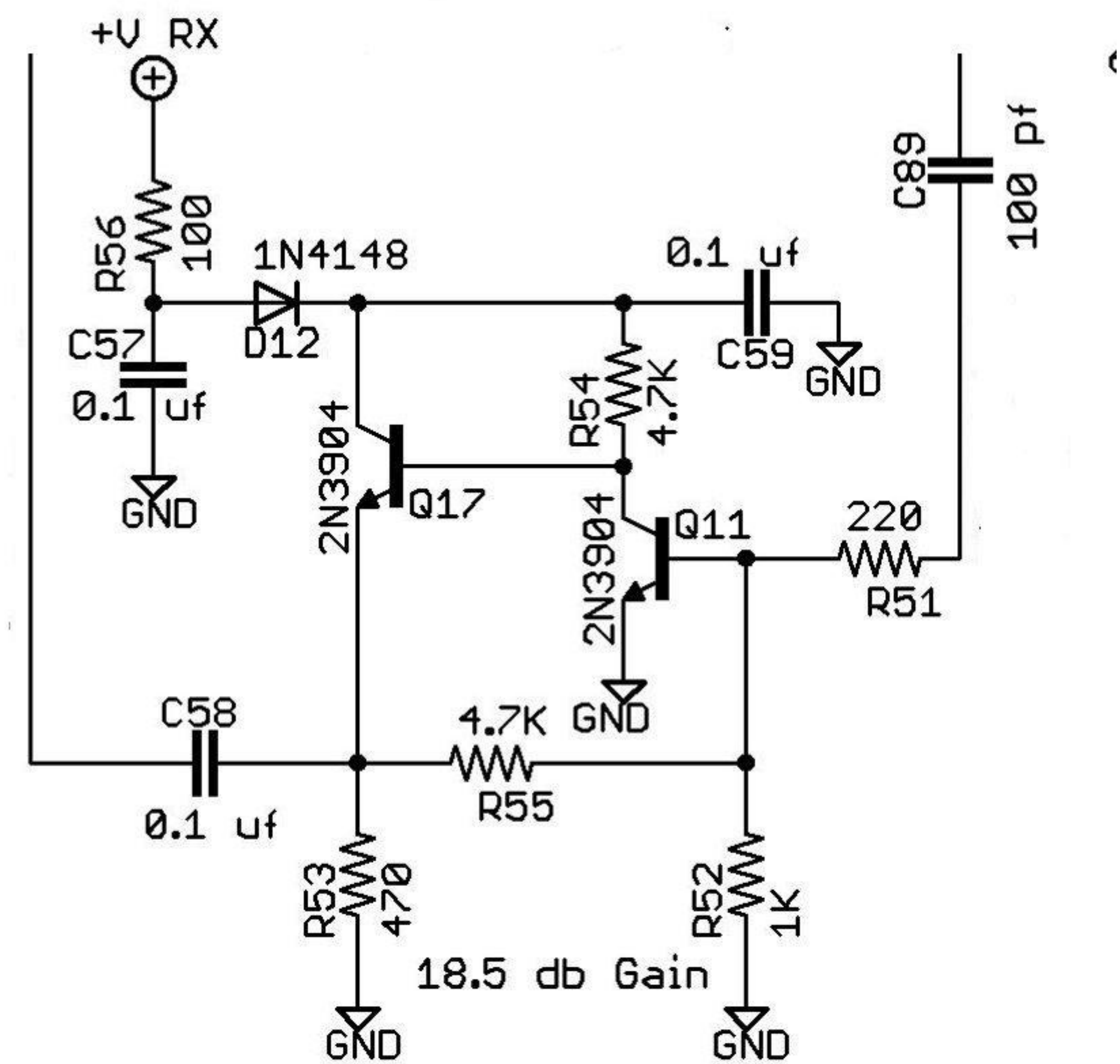
There are several mechanized ways to monitor your crystal filter passband, including use of a Spectrum Analyzer, a swept frequency source with RF detector and oscilloscope display, or using a PC sound card with one of the AF Spectrum Analysis software packages. These have the advantage over manual measurement and manual production of graphs because they allow you to see a real-time result from any changes you might make.

Receive 1st IF Amplifier



Q-9 Voltages	(voltage measurements are made in receive mode)
Collector	7.62 VDC
Emitter	1.62 VDC
Base	2.35 VDC

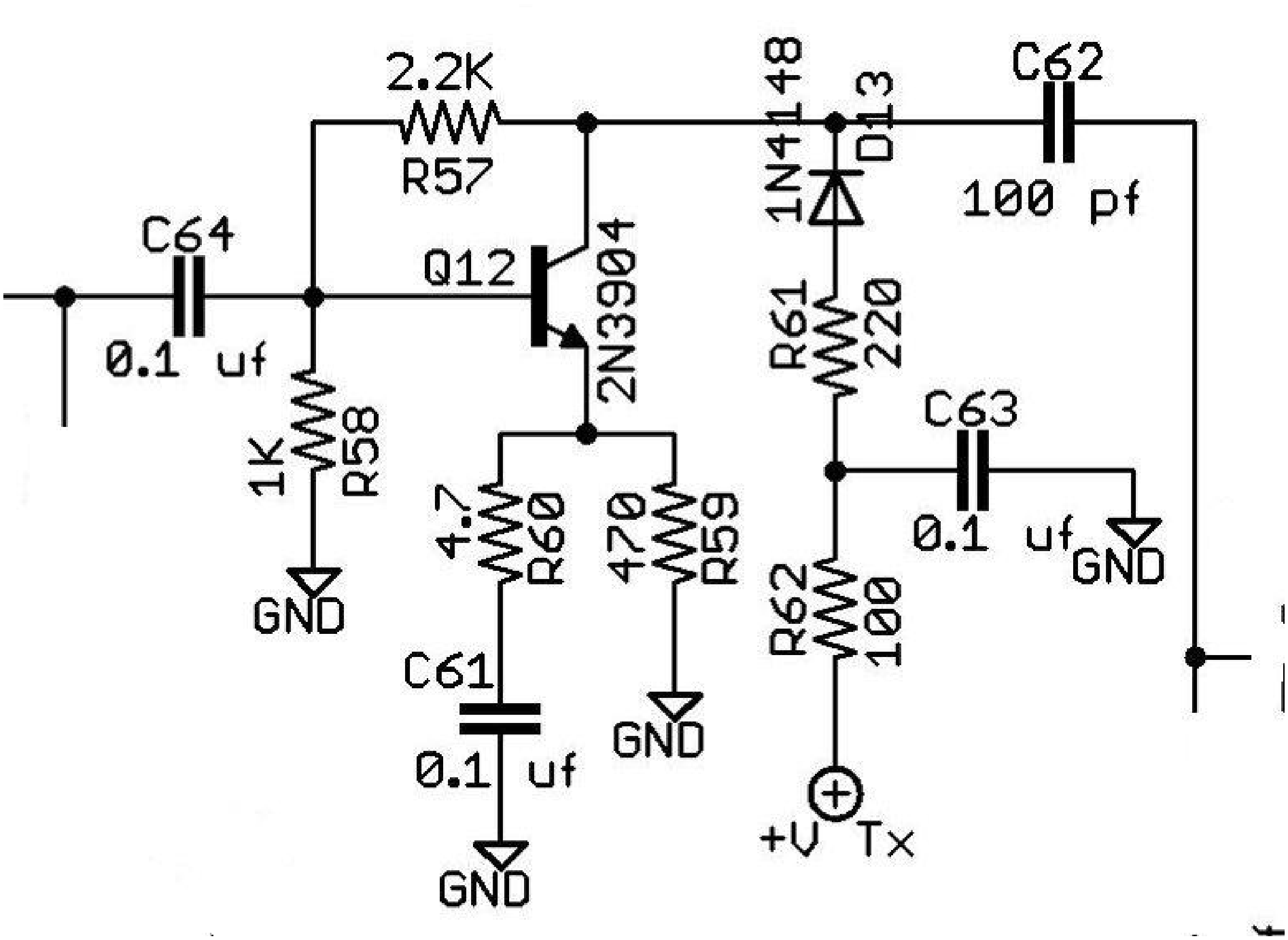
Receive 2nd IF Amplifier



This section is a compound amplifier with Q-11 providing voltage gain and Q-17 providing current gain. Overall amplification is controlled by feedback divider made up of R-52 and R-55.

<u>Q-11 voltages</u>		<u>Q-17 voltages</u>	(voltage measurements are made in receive mode)
Collector	4.61 VDC	Collector	9.77 VDC
Emitter	0.0 VDC	Emitter	3.88 VDC
Base	0.68 VDC	Base	4.60 VDC

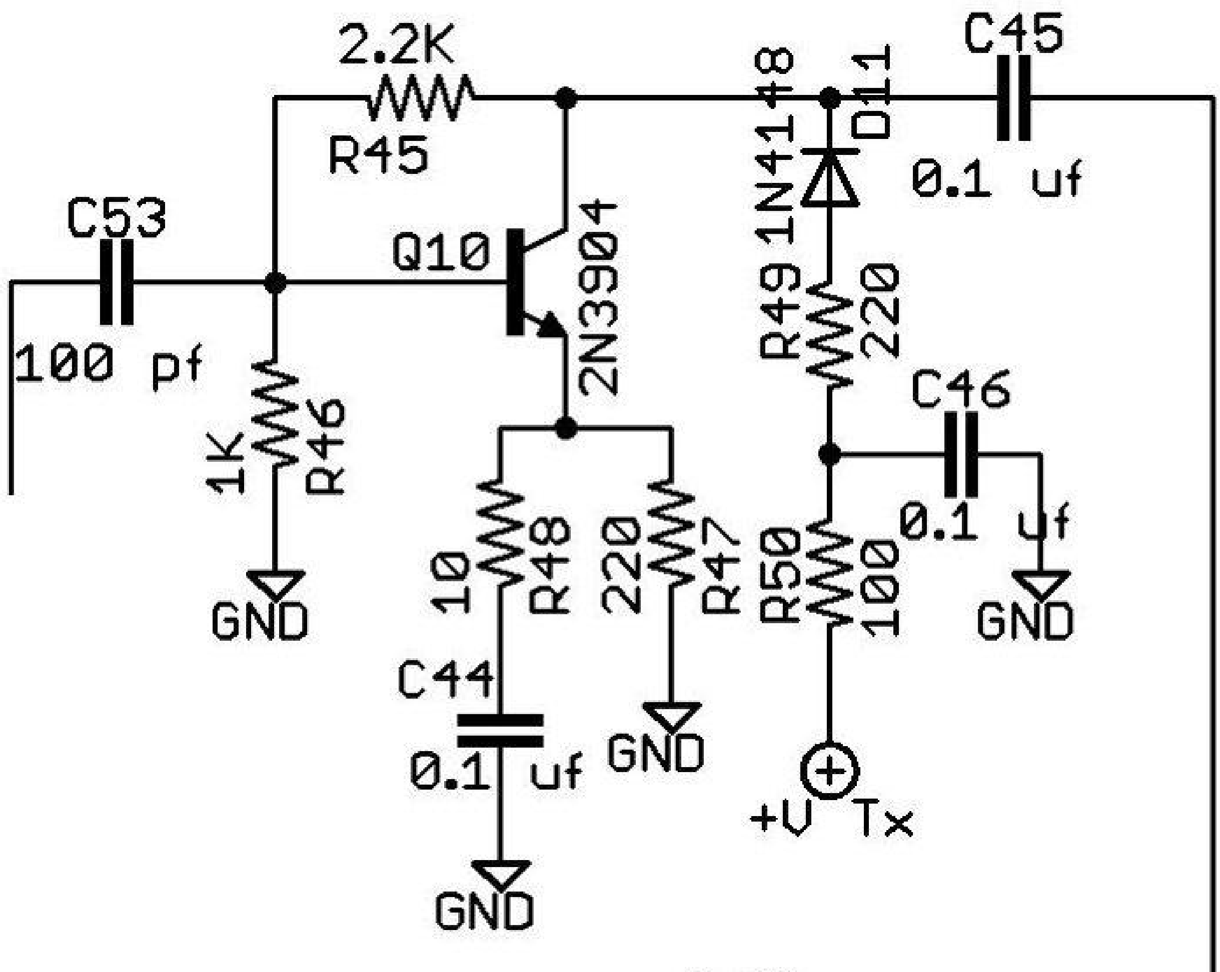
Transmit 1st IF Amplifier



Q-12 Voltages (measured in transmit mode)

Collector	8.57 VDC
Emitter	1.93 VDC
Base	2.65 VDC

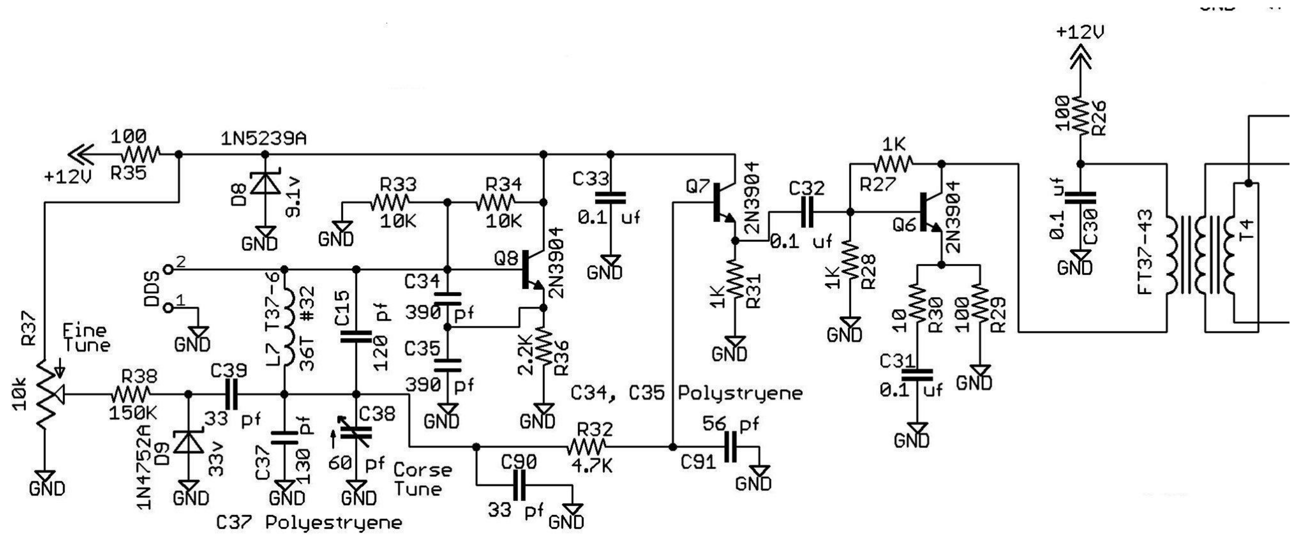
Transmit 2nd IF Amplifier



Q-10 Voltages (measured in transmit mode)

Collector	7.59 VDC
Emitter	1.63 VDC
Base	2.35 VDC

VFO Circuit



Bias for Q-7 is developed from the same two resistors (R-33 and R-34) that provide bias for Q-8.

Main frequency determining components of the VFO include L-7, C-34 & C-35, C-15, C-37, C-90, and C-38. D9 acts as a voltage variable capacitor in series with C-39 to provide Fine Tuning control. For adequate VFO stability C-34, C-37, and C-35 should be polystyrene types (these are semi-transparent plastic). C-15, C-39, and C-90 should be NPO types (they have a black band on the top section).

For operation on 17 meters, the VFO operates 12.96 MHz below the desired frequency (18.068 – 12.96 = 5.108 MHz and 18.168 -12.96 = 5.208 MHz) so the VFO needs to tune over the range of 5.108 to 5.208 MHz. VFO alignment steps are:

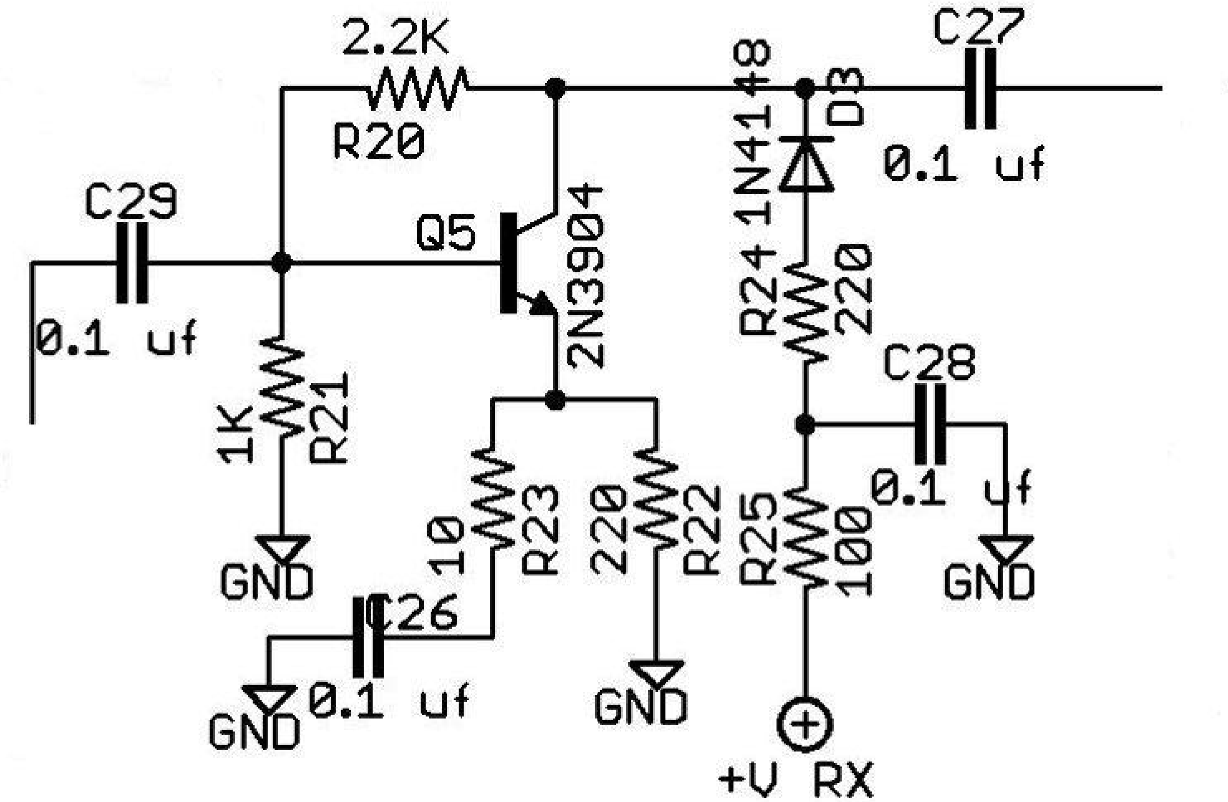
1. Set the Fine Tune potentiometer to mid-point.
2. Open C-38 (the polyvaricon) to minimum capacitance.
3. Adjust C-38 trimmer capacitor so the VFO is operating at or just above 5.208 MHz. If you cannot reach that frequency, try changing the values of C-90, then C-37, and lastly C-15.
4. Close C-38 (the polyvaricon) to maximum capacitance and verify that your VFO frequency is now below 5.108 MHz.

Waveforms present in this oscillator will affect the accuracy of DC voltmeters. In order to measure these potentials you should stop the oscillator by temporarily connecting a 0.1 mfd capacitor across R-36.

Q-8 Voltages		*Q-7 Voltages*		*Q-6 Voltages*	
Collector	9.13 VDC	Collector	9.13 VDC	Collector	7.98 VDC
Emitter	3.75 VDC	Emitter	3.64 VDC	Emitter	3.16 VDC
Base	4.40 VDC	Base	4.29 VDC	Base	3.88 VDC

(Remember to remove the 0.1 that was installed to stop the oscillator)

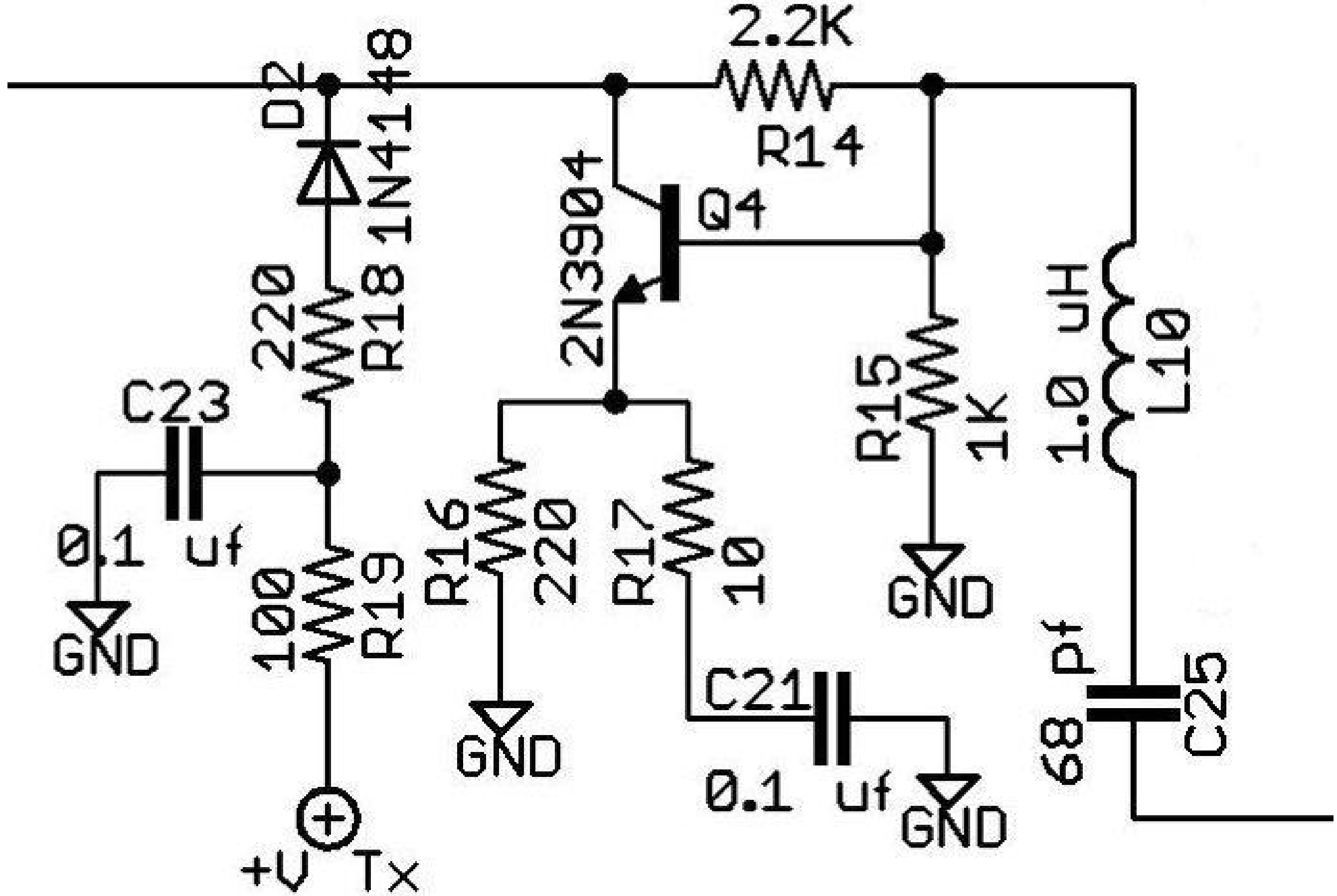
Receive RF Amplifier



<u>*Q-5 Voltages*</u> (measured in receive mode)

Collector	7.62 VDC
Emitter	1.65 VDC
Base	2.36 VDC

Transmit RF Amplifier

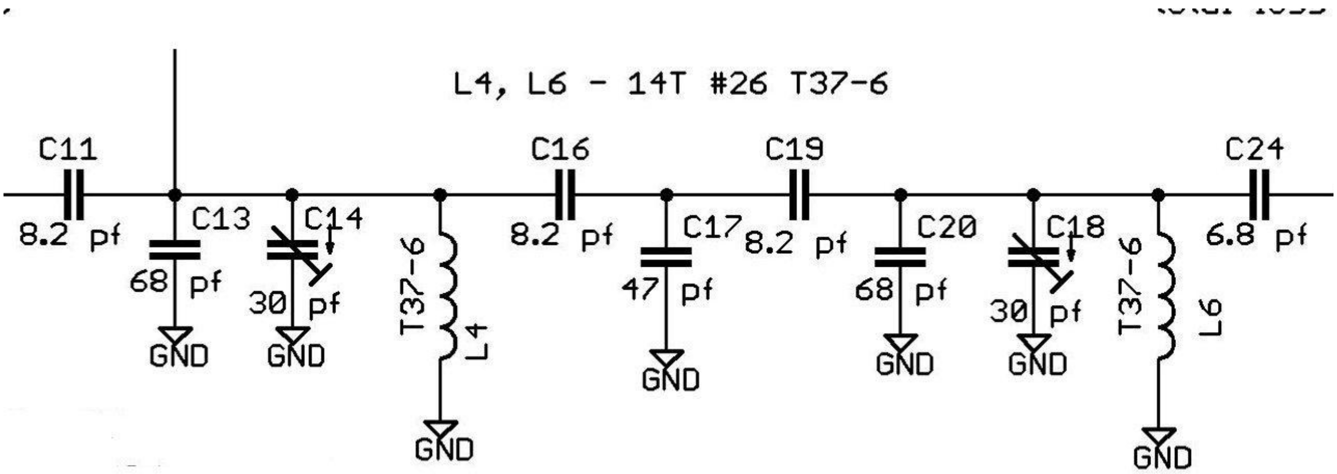


C-68 and L-10 form a series resonant bandpass filter to block VFO and IF energy from reaching the transmit amplifier stages.

<u>Q-4 Voltages</u> (measure in transmit mode)

Collector	7.60 VDC
Emitter	1.61 VDC
Base	2.33 VDC

RF Filter



The RF filter is critical and must be correctly tuned for the transceiver to perform properly.

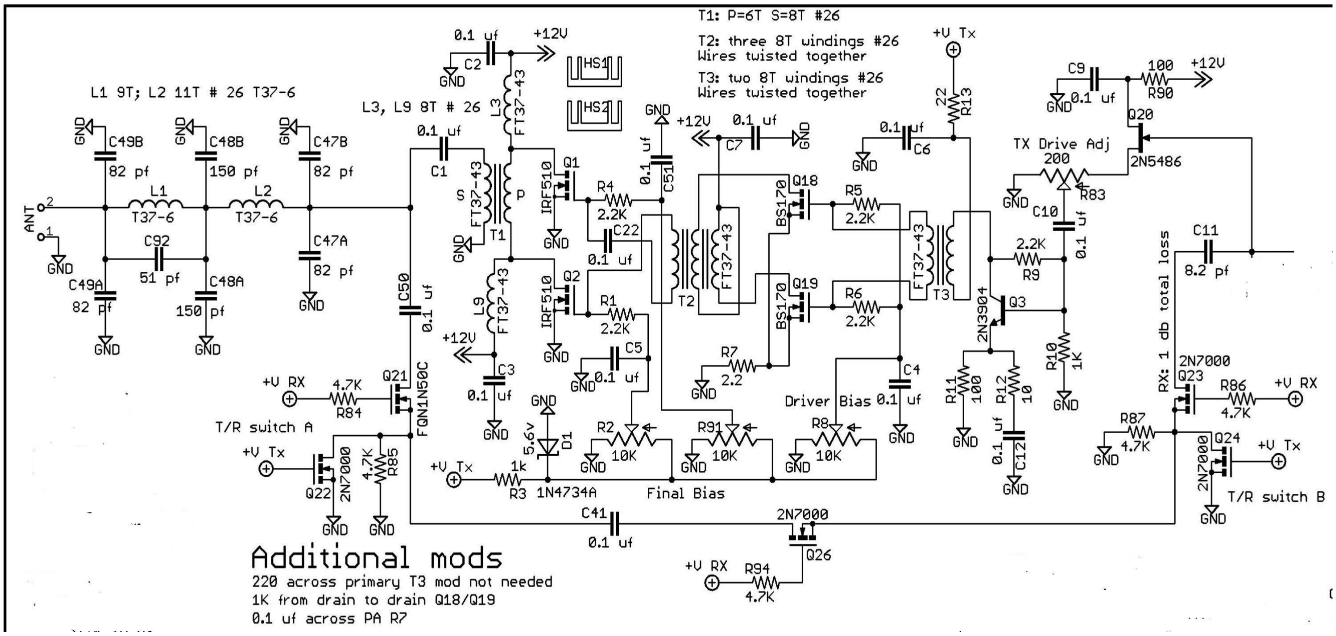
C-16, C-17, and C-19 form an impedance transformation that was used to avoid using very tiny capacitance coupling between L-4 and L-6.

If C-13, C-14, and L-4 will not tune to midpoint in the 17 meter band, adjustment should be made by adding or subtracting turns on L4.

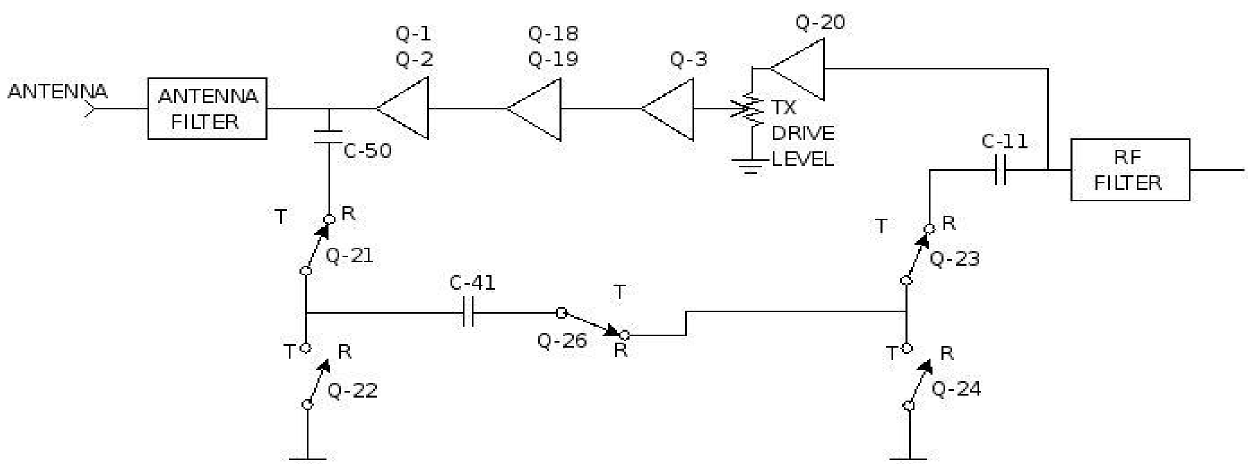
If C-20, C-18, and L-6 will not tune to midpoint in the 17 meter band, adjustment should be made by adding or subtracting turns on L-6.

When adjusting C-14 or C-18, you should find 2 rotation positions which peak the signal. This is to insure that you are not at an extreme end of rotation and not really at a peaking point.

Transmit RF PA, T/R Switching, and Antenna LPF



Transmit/Receive Antenna Switch: This part of the circuit is a set of on/off switches implemented using MOSFET transistors. Q-21 (FQN1N50C) has a 450 volt breakdown capability and is in OFF mode during transmit. Q-22 (2N7000) is ON during transmit and shunts RF to ground during that period. Q-26 (2N7000) is in OFF mode during transmit and blocks RF during transmit. Q-24 (2N7000) is in ON mode during transmit and shunts RF to ground during that period. Q-23 (2N7000) is in OFF mode during transmit and blocks RF when transmitting. Together these switches pass received signals around the RF PA section during receive and block high power RF feedback from entering the RF PA input side during transmit.



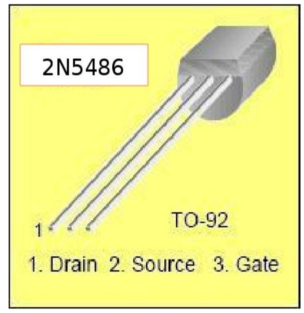
Voltages *(Transmit Mode)*

Q-20 (2N5486)

Drain 10.77 VDC

Source 1.27 VDC

Gate 0.0 VDC



Q-3 (2N3904)

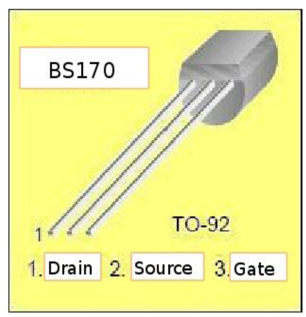
Collector 10.83 VDC

Emitter 2.52 VDC

Base 3.27 VDC

Q-18 (BS170)	Q-19 (BS170)
Drain 11.46 VDC	Drain 11.46 VDC
Source **0.044 VDC	Source **0.044 VDC
Gate (adjust) VDC	Gate (adjust)VDC

** *20 ma = 0.044 volts DC*



Q-1 (IRF510)	Q-2 (IRF510)
Drain 11.46 VDC	Drain 11.46 VDC
Source 0.0 VDC	Source 0.0 VDC
Gate (adjust)VDC	Gate (adjust)VDC