

# Elecraft Transverter Models XV50, XV144, XV222, XV432

## Owner's Manual

Rev C, April 2006

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# Introduction

The Elecraft XV Series high-performance transverters may be used with any transceiver or transmitter/receiver pair that covers the 10 meter band. Separate transverters are offered for the following bands:

- Model XV50: 50 to 52 MHz.
- Model XV144: 144 to 146 MHz.
- Model XV222: 222 to 224 MHz.
- Model XV432: 432 to 436 MHz.

## Features

I.F. connections to the transceiver can be either single-port, using a single RF cable, or dual port, using separate receive and transmit cables.

The transverters include an adjustable input level control that will provide full output from the transverter with I.F. power levels as low as 0.01 watts up to 8 watts. Full protection against accidental high-power transmit of up to 100 watts into the I.F. port is also included.

The receiver features a very low noise figure with a PHEMT RF stage for weak-signal work. Relays are used for transmit/receive switching to avoid receive performance degradation by diode switches in the signal path.

The transmitter is conservatively rated at 20 watts output PEP SSB, CW or data modes. The RF output is displayed on the front panel with a 10-segment LED bargraph. The LED display may be switched between dot or bar modes. When used with an Elecraft K2 transceiver, the bargraph has two brightness modes.

The transverters are housed in attractive, low-profile enclosures that may be stacked for multi-band operation. An illuminated band label identifies the transverter in use. Several transverters may be connected to a single transceiver. Internal relays select only the transverter for the band in use, avoiding the need to switch I.F. cables.

## Using an Elecraft K2 as the I.F. Transceiver

While the transverters will work with nearly any HF transceiver, using them with our Elecraft K2 (or K2/100) offers additional benefits. The high-performance K2 provides:

- Low noise, single-conversion, wide dynamic range receiver.
- Four adjustable I.F. crystal filter bandwidths per mode.
- Automatic transverter band switching with individual menu-selected output power levels.
- Direct display of the transverter operating frequency to 10 Hz, including per-band adjustable offsets of +/- 9.99 kHz.
- Four RIT ranges from +/- 0.6 to +/- 4.8 kHz.

We recommend that K2's with serial numbers 3445 and below be equipped with Elecraft-approved modifications that reduce spurious responses and enhance frequency stability. See *Special Notes for Elecraft K2 Owners* on page 4.

## Customer Service and Support

Whether you build the kit or buy a factory-built transverter, you'll find a wealth of information on our web site at [www.elecraft.com](http://www.elecraft.com). Among the materials there you'll find the latest application notes, photographs, any updates to this manual, and information on new products. We also have a popular e-mail forum. You can sign up for it from the web site. It's a great way to interact with other Elecraft owners, exchange ideas and find answers to many questions.

You can also get assistance by telephone or by sending an e-mail to [support@elecraft.com](mailto:support@elecraft.com). E-mail is preferable because it gives us a written record of your question. Telephone assistance is available from 9 A.M. to 5 P.M. Pacific time, Monday through Friday (except US Holidays) at 831-662-8345.

## *Repair Service*

Contact Elecraft before returning your equipment to obtain the current information on repair fees.

To ship the unit, first seal it in a plastic bag to protect the finish. Use a sturdy packing carton with at least 3-in (8 cm) of foam or shredded paper on all sides. Seal the package with reinforced tape. (Neither Elecraft or the carrier will accept liability for damage due to improper packaging.)

### **Elecraft 1-Year Limited Warranty**

If building a kit, complete the assembly, carefully following all instructions in the manual, before requesting warranty service.

**What is covered:** During the first year after the date of first consumer purchase, Elecraft will replace defective parts free of charge (post-paid). We will also correct any malfunction caused by defective parts and materials. You must send the unit at your expense to Elecraft. We will pay return shipping.

**What is not covered:** This warranty does not cover correction of assembly errors or misalignment; repair of damage caused by misuse, negligence or builder modifications; or any performance malfunctions involving non-Elecraft accessory equipment. **The use of acid-core solder or any corrosive or conductive flux or solvent will void this warranty in its entirety.** Also not covered is any reimbursement for loss of use, inconvenience, customer assembly or alignment time, or cost of unauthorized service.

**Limitation of incidental or consequential damages:** This warranty does not extend to non-Elecraft equipment or components used in conjunction with our products. Any such repair or replacement is the responsibility of the customer. Elecraft will not be liable for any special, indirect, incidental or consequential damages, including but not limited to any loss of businesses or profits.

# Specifications

Numeric values are typical; your results may be somewhat different. Specifications may be affected by the options or accessories chosen. See [www.elecraft.com](http://www.elecraft.com) for details about options and accessories currently available. Specifications are subject to change without notice.

## General

### Size

Cabinet: 1.3" H x 7.8" W x 8.3" D  
(3.3 x 19.8 x 21 cm)

Overall: 1.5 H x 7.8 W x 9.5 D incl. feet and connectors  
(3.8 x 19.8 x 21 cm)

Weight: 2.5 lbs (1.1 kg)

Supply Voltage: 13.8 VDC

### Current Drain:

Receive: 250 mA (typical)

Transmit<sup>1</sup>: 6 A typical for XV432, 4 A typical for XV50,  
XV144, XV222

### Frequency Ranges:

XV50: 50 – 52 MHz

XV144: 144 – 146 MHz

XV222: 222 – 224 MHz

XV432: 432 – 436 MHz

T/R Switching Time: 3 ms (typical)

T/R Key Input: Ground for transmit: must pull 5 volt  
logic level to within 0.5 volts of ground  
at < 1 ma

I.F. Overload Protection: Survives 100 watts RF input at the I.F.  
Port without damage with transverter  
un-keyed (in receive mode)

Amplifier Key Output: Ground on transmit: 200 VDC at 1 A  
maximum

### Connectors:

K2 Interface: DB9

Keying Line Input: RCA

Keying Line Output: RCA

I.F. In/Out: BNC

Aux (Rx-Only Ant): BNC

Antenna: SO-239 (UHF) on XV50  
Type N on XV144, XV222 & XV432

## Transmitter

Power Out (50-ohm load): 20 watts SSB/CW  
10 watts continuous carrier modes

### Minimum Supply

Voltage Recommended: 12 VDC

Operating Modes: CW, SSB, AM, FM, Digital Modes

I.F. Input Frequency Range: 28 – 30 MHz (XV50, 144 & 222)  
28 – 32 MHz (XV432)

I.F. Input Power Range: 0.01 mW (-20 dBm) to  
8 watts (+ 39 dBm)

Harmonic Content: < - 60 dBc at 20 watts output

## Receiver

Noise Figure: < 1 dB

Conversion Gain: 25 dB typical for XV50, XV144,  
XV222, 20 dB typical for XV432

Image Rejection: > 60 dB

3rd-Order Intercept: +20 dBm (typical)

<sup>1</sup> Current varies with supply voltage, load impedance and power output.

# Installation

Your transverter is designed to integrate closely with the Elecraft K2 transceiver. Also, it will perform well with a variety of 28 MHz rigs and connection setups. Start with the Quick-Start Installation that matches your setup. Once you have the transverter working as desired, refer to the Installation Options below for ways you might better integrate the transverter into your station.

## *Quick-Start Installation*

Choose the setup you wish to use from the list below and go to that procedure for your initial setup. If you aren't sure which to choose, check the drawings associated with each of the following procedures to see which matches the 28 MHz rig you are using with your transverter.

1. Elecraft K2 with K60XV Adapter. Go to page 5.
2. Elecraft K2 With No K60XV. Go to page 6.
3. Non-Elecraft 28 MHz Rig – Separate Transmit and Receive RF Connections. Go to page 7.
4. Non-Elecraft 28 MHz Rig – Single Transmit and Receive RF Connection. Go to page 8.

## *Installation Options*

We recommend that you first use the appropriate Quick-Start Installation and verify that your transverter is operating as expected. Once that has been done, the following optional setup configurations may help you better integrate the transverter into your station:

1. *Daisy-Chaining Multiple Transverters.* Using multiple transverters without swapping cables. See page 12.
2. *Using an External Receive Preamplifier.* Using the transverter with an antenna-mounted preamplifier to optimize noise figure with long feed lines. See page 13.
3. *Using an External Power Amplifier.* Controlling an external power amplifier from the transverter. See page 13.

## *Special Notes for Elecraft K2 Owners*

Your K2 must be equipped with:

- KIO2 Interface. Either the stand-alone KIO2 interface for the QRP version of the K2, or the KIO2 interface built into the KPA100 amplifier is suitable.
- Revision 2 (or later) Firmware. To see your firmware version, hold any front-panel button while turning on the power to your K2. Upgraded firmware is available from Elecraft.

K2's with serial numbers 3445 and earlier should be equipped with the following Elecraft-approved modifications.

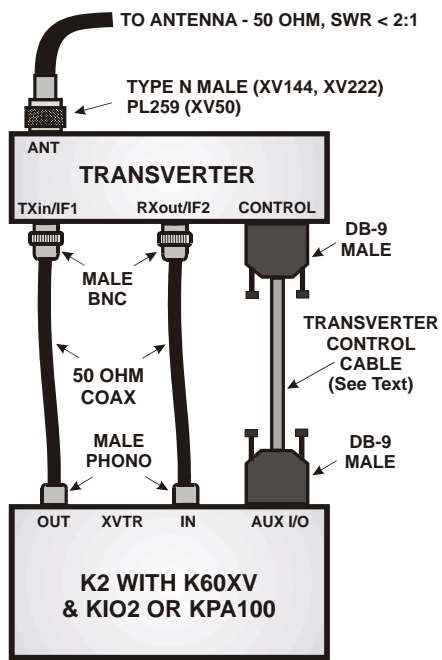
- 10 Meter Bandpass Filter and VFO/ALC modification, applicable to all K2's S/N 2999 and down. This modification reduces spurious signals. It is very strongly recommended.
- K2 BFO Toroid & PLL Ref Osc Xtal Upgrade, applicable to K2's S/N 2999 and down. This modification substantially reduces frequency drift in the K2's reference oscillator and BFO.
- Temperature-Compensated PLL Reference Upgrade, applicable to K2's S/N 3445 and down. This modification further reduces the K2's reference oscillator frequency drift.

The Elecraft K60XV 60-M and Transverter Adapter is highly recommended for use with the transverters. This adapter provides separate (split) receive transmit connections to the transverter. In addition, it provides a low-level (1 milliwatt) transmit drive that is independent of the K2 power amplifier stages. The adapter eliminates the need to switch between the transverter and an external antenna when using the K2 as both the transverter I.F. and as an H.F. rig.



## Elecraft K2 With K60XV Adapter

This setup uses the low-level transmit and separate receiver connections provided by the K60XV Adapter. The K2 must be equipped with an auxiliary input/output either through a KIO2 interface or the one built into the KPA100 amplifier.



**Figure 1. Connecting the Transverter to an Elecraft K2 With a K60XV Interface.**

Refer to the *Transverter Operation* section of the *Elecraft K60XV 60-M and Transverter Adapter Assembly and Operating Instructions* and use the K2's MENU commands to configure the K60XV for operation with the transverter:

- \_ Note the TRN number you have set up for the transverter.
- \_ Set the maximum output to: Out L 1.00 (1.00 milliwatts).

Refer to the following table and set the DIP switches on the RF PCB for the TRN number you assigned.

TRN	DIP SWITCH POSITIONS			
	1	2	3	4
1	ON	OFF	OFF	OFF
2	OFF	ON	OFF	OFF
3	OFF	OFF	ON	OFF
4	OFF	OFF	OFF	ON
5	OFF	ON	ON	OFF
6	OFF	ON	OFF	ON
7	OFF	OFF	ON	ON
8	OFF	ON	ON	ON

Place 2-pin shorting blocks on the transverter RF PCB jumpers shown below:

- \_ JP1: 1-2    \_ JP2: 2-3    \_ JP3: 1-2
- \_ JP4: 1-2    \_ JP5: 2-3    \_ JP6: 2-3
- \_ JP9: 1-2

Place a shorting block on 2-pin jumper JP8 (near the ON/OFF switch on the RF PCB) and verify that there is no shorting block on JP7.

Locate front panel PCB 2-pin jumper, JP1, at the end of the socket-mounted controller IC. Verify that there is no shorting block on this jumper. (Do not confuse this JP1 with JP1 on the RF PCB.)

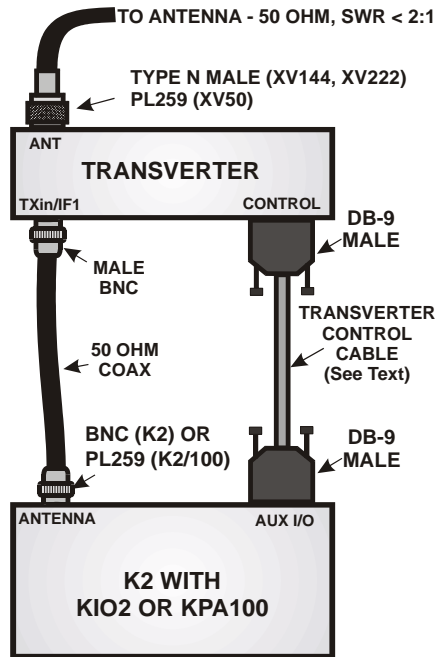
Refer to *Transverter Control Cable for Elecraft K2 or K2/100* on page 9 to make up a new transverter control cable or to add connections for the transverter to your existing Aux I/O cable.

Connect the cables as shown in Figure 1.

Connect a 13.8 VDC, 6 ampere power supply to the transverter using a cable equipped with an Anderson Powerpole® connector.

## Elecraft K2 With No K60XV

This setup uses the K2's antenna port for both the transmit and receive signal path to the transverter. The K2 must be equipped with an auxiliary input/output either through a KIO2 interface or the one built into the KPA100 amplifier.



**Figure 2. Connecting the transverter to an Elecraft K2 without a K60XV interface**

Refer to your K2 Operating Manual and the instructions that came with your current firmware and use the K2's MENU commands to do the following.

- \_ Note the TRN number you have set up for the transverter.
- \_ If using a K2/100, set the MENU command for PA OFF.

Refer to the following table and set the DIP switches on the RF PCB for the TRN number you assigned.

TRN	DIP SWITCH POSITIONS			
	1	2	3	4
1	ON	OFF	OFF	OFF
2	OFF	ON	OFF	OFF
3	OFF	OFF	ON	OFF
4	OFF	OFF	OFF	ON
5	OFF	ON	ON	OFF
6	OFF	ON	OFF	ON
7	OFF	OFF	ON	ON
8	OFF	ON	ON	ON

Place 2-pin shorting blocks on transverter RF PCB jumpers shown below:

- \_ JP1: 2-3
- \_ JP2: 1-2
- \_ JP3: 2-3
- \_ JP4: 2-3
- \_ JP5: 1-2
- \_ JP6: 1-2
- \_ JP9: 1-2

Place a shorting block on 2-pin jumper JP8 (near the ON/OFF switch on the RF PCB) and verify that there is no shorting block on JP7.

Locate front panel PCB 2-pin jumper, JP1, at the end of the socket-mounted controller IC. Verify that there is no shorting block on this jumper. (Do not confuse this JP1 with JP1 on the RF PCB.)

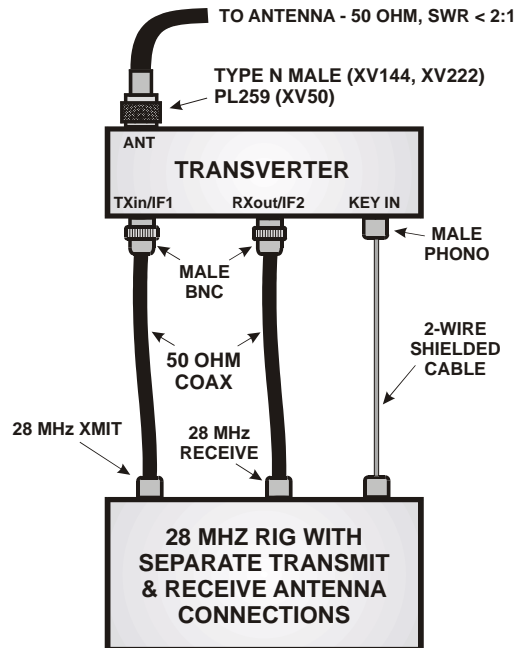
Refer to *Transverter Control Cable for Elecraft K2 or K2/100* on page 9 to make up a new transverter control cable or to add connections for the transverter to your existing Aux I/O cable.

Connect the cables as shown in Figure 2.

Connect a 13.8 VDC, 6 ampere power supply to the transverter using a cable equipped with an Anderson connector

## Non-Elecraft 28 MHz Rig – Separate Transmit and Receive RF Connections

This setup is for any 28 MHz rig capable of providing separate transmit and receive connections. The transmitter must be capable of providing a variable RF output of up to 1 milliwatt, 251 milliwatts or 5 watts, and provide a key line that will ground a 5 volt logic level on transmit.



**Figure 3. Connecting the Transverter to a Non-Elecraft 28-MHz Rig with Separate Transmit and Receive RF Paths.**


- On the transverter RF PCB, set all four DIP switches to OFF.

- Place 2-pin shorting blocks on the transverter RF PCB jumpers shown below:

\_ JP1: 1-2    \_ JP2: 2-3    \_ JP9: 1-2

- From the options below, choose the power output from your 28 MHz rig that will drive the transverter to full output. Place 2-pin shorting blocks on the corresponding RF PCB jumpers as shown:

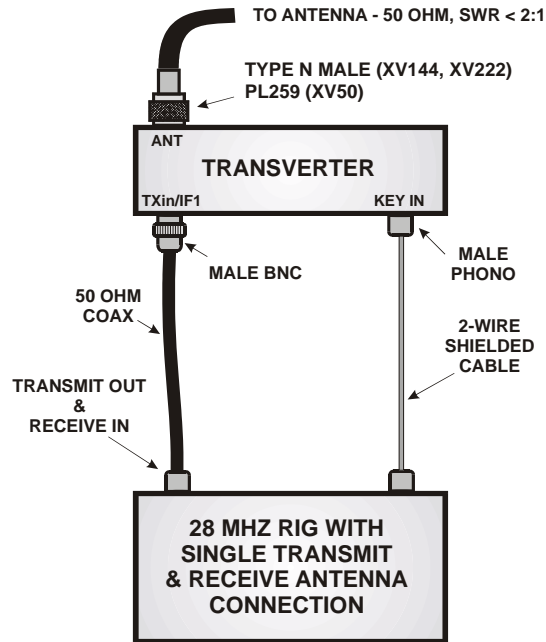
28 MHZ DRIVE LEVEL FOR FULL TRANSVERTER OUTPUT	JP3	JP4	JP5	JP6
1 milliwatt	1-2	1-2	2-3	2-3
251 milliwatts	1-2	1-2	1-2	1-2
5 watts	2-3	2-3	1-2	1-2

-  **Take care not to exceed the maximum power level you set up the transverter for in the previous step. Doing so may result in damage to the transverter.**

- Place a shorting block on 2-pin jumper JP7 (near the ON/OFF switch on the RF PCB) and verify that there is no shorting block on JP8.
- Place a shorting block on front panel PCB 2-pin jumper JP1 at the end of the socket-mounted controller IC. (Do not confuse this JP1 with three-pin jumper JP1 on the RF PCB.)
- Connect the cables as shown in Figure 3.
- Connect a 13.8 VDC, 6 ampere power supply to the transverter using the cable equipped with an Anderson connector

## Non-Elecraft 28 MHz Rig – Single Transmit and Receive RF Connection

This setup is for any 28 MHz rig with a single RF port for transmit and receive. The transmitter must be capable of providing a variable RF power output of up to 1 milliwatt, 251 milliwatts or 5 watts, and provide a key line that will ground a 5 volt logic level on transmit.



**Figure 4. Connecting the Transverter to a Non-Elecraft 28-MHz Rig with a Single Transmit and Receive RF Path.**


- On the transverter RF PCB, set all four DIP switches to OFF.

- Place 2-pin shorting blocks on transverter RF PCB jumpers shown below:

\_ JP1: 2-3    \_ JP2: 1-2    \_ JP9: 1-2

- From the options below, choose the power output from your 28 MHz rig that will drive the transverter to full output. Place 2-pin shorting blocks on the corresponding RF PCB jumpers as shown:

28 MHZ DRIVE LEVEL FOR FULL TRANSVERTER OUTPUT	JP3	JP4	JP5	JP6
1 milliwatt	1-2	1-2	2-3	2-3
251 milliwatts	1-2	1-2	1-2	1-2
5 watts	2-3	2-3	1-2	1-2

-  **Take care not to exceed the maximum power level you set up the transverter for in the previous step. Doing so may result in damage to the transverter.**

- Place a shorting block on 2-pin jumper JP7 (near the ON/OFF switch on the RF PCB) and verify that there is no shorting block on JP8.
- Place a shorting block on front panel PCB 2-pin jumper JP1 at the end of the socket-mounted controller IC. (Do not confuse this JP1 with three-pin jumper JP1 on the RF PCB.)
- Connect the cables as shown in Figure 4.
- Connect a 13.8 VDC, 6 ampere power supply to the transverter using the cable equipped with an Anderson connector.


## Transverter Control Cable for Elecraft K2 or K2/100

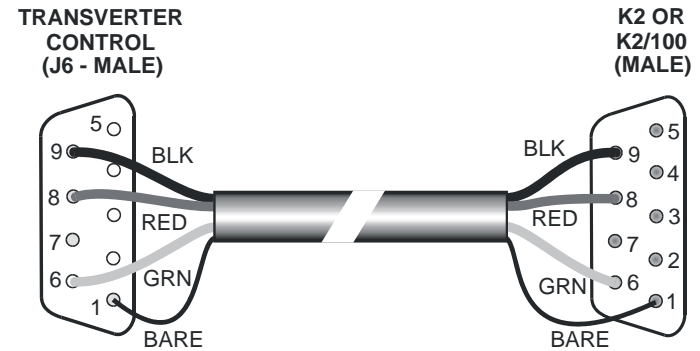
Your transverter was supplied with a DB-9 cable connector and a length of multi-conductor wire for making up the transverter control interface cable for use with an Elecraft K2 or K2/100. You will need the DB-9 connector that came with your KIO1 or KPA100 to complete the cable. Follow the procedure below to make up your control cable.

If you are already using the K2 Aux I/O port to control a KPA100 ATU or to communicate with your personal computer, you may add the transverter control cable to the existing cable at the DB-9 connector so you won't need to switch connectors when using the transverter (see Figure 7).

- Cut a length of the 4-conductor cable to suit the needs of your station layout. Keep the cable length as short as practical. A length of 2' (60 cm) is recommended. Longer lengths may be used, but you may need to supply a more heavily-shielded cable to avoid RF interference.
- If you are integrating two or more transverters into the station at this time, cut a length of cable to reach from the first transverter to the second transverter in a daisy-chain arrangement (see Figure 7).
- Remove 1/2" (12 mm) of the jacket from the cable at each end. Be very careful not to nick the individual wires.
- Peel back and cut away the foil shield. Do *not* cut the bare ground wire.
- Cut the white wire where it exits the jacket. It will not be used.
- Strip of 3/16" (5 mm) of insulation from the black, red and green wires.
- Twist the strands of each wire together. If you are daisy-chaining cables, twist the ends of leads with like colors together. Tin lightly with solder.

- Solder the wires to the male DB-9 connector supplied with your transverter as shown in Figure 5.

** Follow the color codes shown below when wiring the connector. The same color code is used in the control interface cables for other Elecraft equipment. Keeping a consistent color code will help avoid mistakes and make troubleshooting easier.**



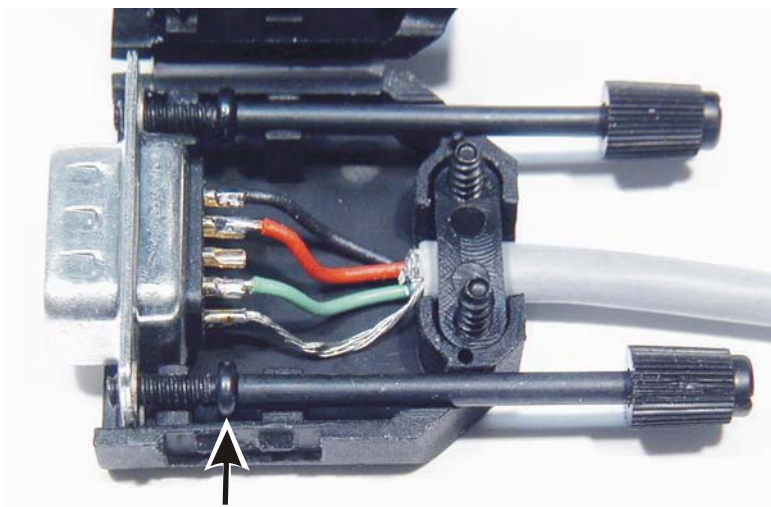
**Figure 5. K2 Control Cable Wiring.**

- If you have not built an RS-232 or control cable to connect other equipment to your K2, you should have an unused DB-9 male connector that was supplied with the KIO2 or KPA100 kit. In that case, wire the connector as shown in Figure 5. If you have wired the cable for the K2 and other accessories already, add the transverter extension(s) to it as shown in Figure 7.

□ Attach the connector housing to the transverter connector(s) as shown in Figure 6. The cable clamp has enough capacity to handle up to three cables. Before closing the housing, be sure that:

- The clamp holds the cables securely, so that strain cannot be placed on the soldered joints.
- The jack screws are positioned between the stops as shown so the flanges on the screws prevent the threaded ends from extending more than about 1/8" (3 mm) beyond the housing.

This completes your transverter control cable. If, in the future, you chose to add more transverters, add a KAT100 ATU interface to your H.F. station, or connect your K2 to a personal computer, you can add the connections to your existing cable as shown in Figure 7.



**THE JACKSCREW FLANGES MUST BE POSITIONED HERE. IF THEY ARE POSITIONED FORWARD BETWEEN THE METAL CONNECTOR AND THE PLASTIC BODY, THE CONNECTOR WILL NOT MATE PROPERLY PRODUCING INTERMITTENT OR OPEN CONNECTIONS.**

**Figure 6. Installing DB-9 Connector Housing.**

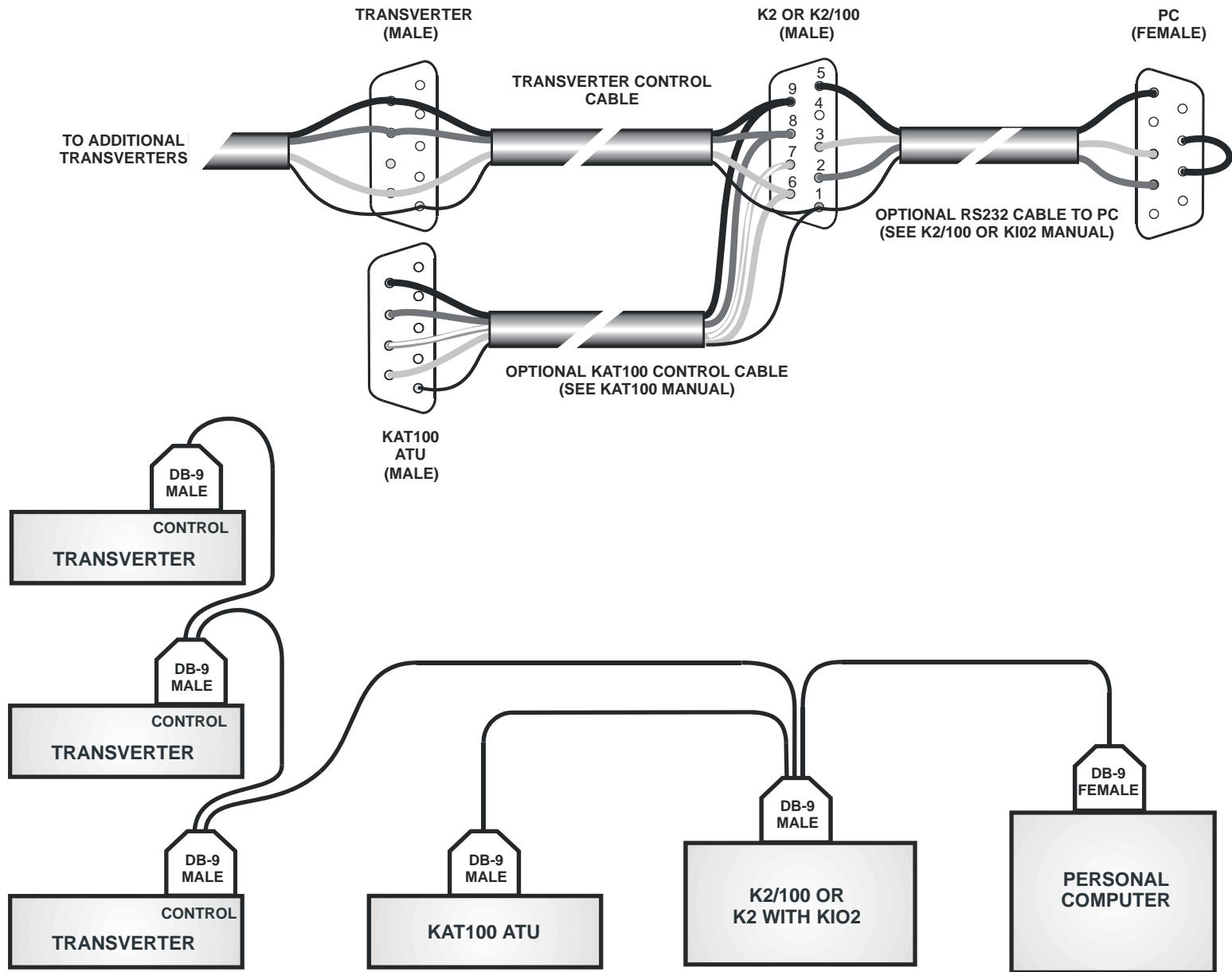


Figure 7. K2 Extended Control Cabling Hookup Diagram.

## Daisy-Chaining Multiple Transverters

You can “daisy chain” several transverters together as shown in Figure 8 to avoid swapping cables when switching between them.

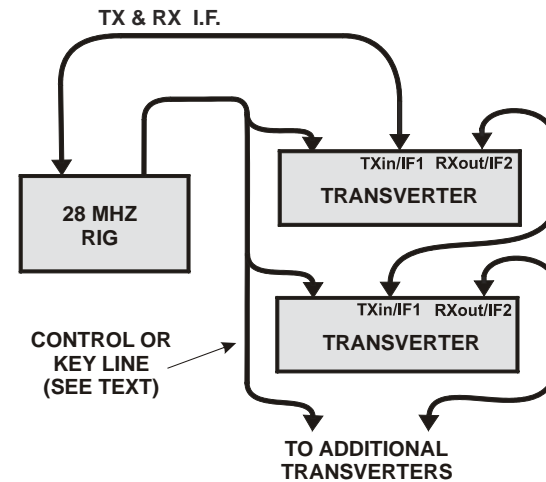
Relays inside the transverters disconnect the transverters not in use so they do not load the RF lines.

When using an Elecraft K2 for the 28 MHz I.F. rig, a multi-wire control cable is required. See Figure 7 for information on paralleling several cables. The control cable connects between the AUX I/O DB-9 connector on the K2 and the CONTROL DB-9 connector on each transverter.

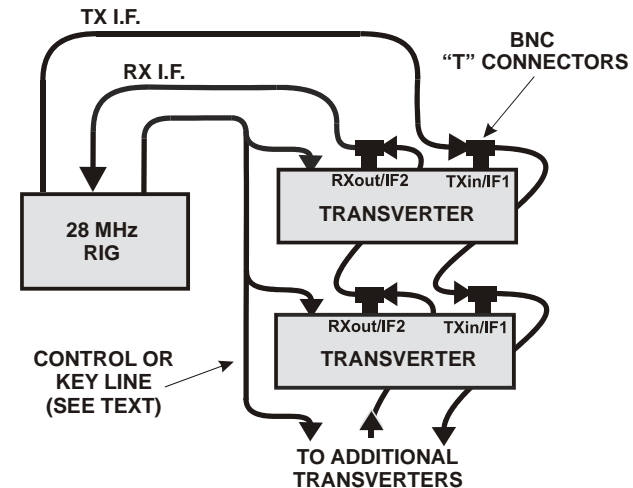
When using a non-Elecraft rig, the two-wire key line is connected in parallel to the KEY IN RCA connector on each transverter.

The transverter in use is selected as follows:

- When using an Elecraft K2, the active transverter is selected by the **BAND+** or **BAND-** switches on the K2.
- When using a non-Elecraft rig for the 28 MHz I.F., the desired transverter is selected by its front panel ON/OFF switch.



COMBINED RECEIVE AND TRANSMIT RF CONNECTIONS



SEPARATE RECEIVE AND TRANSMIT RF CONNECTIONS

Figure 8. Daisy-Chaining Transverters.

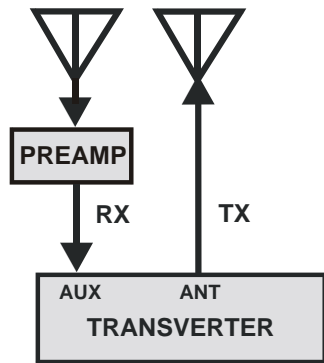


### Using an External Receive Preamplifier

An external receiver preamplifier is sometimes mounted at the antenna to offset transmission line losses and provide the best possible system noise figure.

When using an external receive preamplifier, you may want to reduce the transverter receive gain to maintain the best possible system dynamic range. A procedure for reducing the transverter receive gain without adversely affecting the noise figure is described in *Reducing Receive Gain to Preserve System Dynamic Range* on page 19.

If the external preamplifier does not provide a bypass switch when transmitting, separate transmit and receive antennas and transmission lines are required as shown in Figure 9. In this case, the transverter needs to be wired for separate transmit and receive antenna connections. See *Changing Between Split and Common Antennas* on page 18.



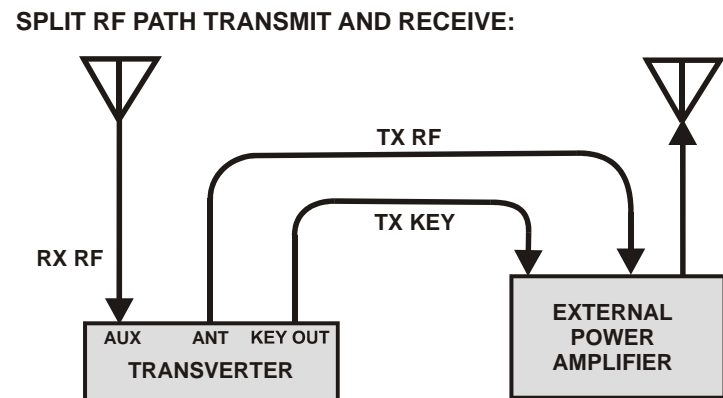
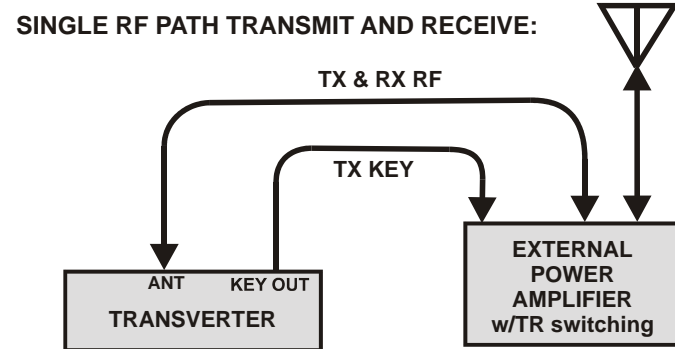
**Figure 9. Using an External Receive Preamplifier Without Transmit Bypass Capability.**

### Using an External Power Amplifier

The transverter may be used to drive an external power amplifier as shown in Figure 10.

- The external power amplifier must present an SWR of less than 2:1 to the transverter output.
- The external power amplifier must key with a closure to ground and present less than +200 volts to the transverter KEY OUT connector during receive.

See *Changing Between Split and Common Antennas* on page 18 for instructions on rewiring the transverter RF outputs as needed.



**Figure 10. Using an External Power Amplifier.**

# Operation

Once your transverter is hooked up to your antenna system and other equipment as described under Installation (page 4), operation consists of turning on the transverter and setting the output power.

## *Cautions to Avoid Spurious Emissions From Your Station*

Do not use an antenna relay to switch the 28 MHz rig output between an HF antenna and the transverter unless it has adequate isolation to ensure that no RF energy leaks to the antenna when it is not selected. Most normal coaxial relays do not provide adequate attenuation

When using a K2, do not use the 2nd antenna position. The K60XV Adapter provides a well isolated transverter interface allows you to have an HF antenna connected to the K2 without concern for spurious radiation when using the transverter.

## *Turning the Transverter On*

If an Elecraft K2 is being used for the I.F., the transverter power is turned on automatically when the band assigned to the transverter is selected at the K2 with the **BAND+** or **BAND-** buttons. The front-panel band label on the transverter will light indicating that power is applied and the transverter is operating.

When a rig other than an Elecraft K2 is used for the I.F., the transverter is made active by pressing the front panel switch to turn the transverter on. The front-panel band label on the transverter will light.

## *Power Output Control*

Set the output power on your 28 MHz rig for the transverter power output desired. Do not exceed 20 watts output from the transverter in CW or SSB. Limit the output to 10 watts in FM or data modes that require a steady carrier. On the transverter front panel, a yellow LED indicates 20 watts. Green LEDs indicate levels below 20 watts and red LEDs indicate levels above 20 watts.

## *Local Oscillator Power Control*

To minimize frequency drift you may want to have the local oscillator running at all times, even when the transverter is inactive. However, in some installations it is possible that a harmonic of the local oscillator may produce unwanted birdies when operating on other bands.

In the Installation section you set up the local oscillator to switch on and off with the transverter power.

The behavior of the local oscillator may be selected by a 2-terminal shorting block at JP9 as follows:

- JP9, 1-2: Default: The local oscillator power goes off whenever the power is turned off or, when used with an Elecraft K2, the transverter is deselected by changing bands.
- JP9, 2-3: The local oscillator power is on whenever the transverter power is on or, when used with an Elecraft K2, whenever the K2's power is on even though the transverter band may not be selected.
- JP9, 4-5: The local oscillator power is on whenever 12 volts is applied at J7 on the back panel regardless of the state of the power or band switches. This is the recommended jumper setting if you have installed the optional crystal oven so the oven will remain at operating temperature.

Regardless of the jumper setting you choose, power to the receive circuits (other than the local oscillator) is turned off except during receive mode. This avoids the possibility of strong signals leaking into the I.F system when several transverters are used with the same H.F. rig.

### *I.F. Overload Condition*

The transverter switches to transmit mode when the transmit enable signal is received from the 28 MHz rig. When used with an Elecraft K2, this signal is supplied through the DB-9 connector. When used with other 28 MHz rigs, this signal is supplied to the transverter KEY IN RCA jack.

If the transverter fails to switch to transmit mode before a high-level transmit I.F. signal is applied, a protective circuit will disable the transverter. All of the front panel power display LEDs will flash in unison to alert you that an overload condition has occurred.

An I.F. overload condition will occur if the transmit enable signal is not present whenever high-level transmit I.F. is applied to the transverter. This is normally the result of an unplugged cable or circuit failure, but it may also be caused by a timing problem with the 28 MHz rig being used. See *Transmit-Receive Switching Delay* below.

To clear the overload condition, turn the transverter power off, then on again. (If you're using the transverter with an Elecraft K2, turn the K2 power off then on again since the transverter power is controlled by the K2's power switch).

### *Transmit-Receive Switching Delay*

When the transverter is used with rigs other than an Elecraft K2, the transmit-receive switching is controlled by the signal furnished by the 28-MHz rig to the transverter TX KEY input. If the 28 MHz rig switches the TX KEY line to receive before it stops transmitting, it will trigger in I.F. overload condition in the transverter when using a high-level RF drive from the 28 MHz rig (see page 15 for details). In the Installation section, you set up the transverter for a 200 millisecond delay to avoid timing problems. If your 28 MHz rig can provide the switching speed needed, you can reduce the delay time to 50 ms by removing the shorting block on jumper JP1. JP1 is located on the back of the front panel PCB between the left side panel and socket-mounted processor U1.

JP1 Open – 50 ms delay.

JP1 Shorted – 200 ms delay (Default)

### *Front Panel Display Control*

When used with an Elecraft K2, the front panel LEDs are controlled by the K2 through the Menu commands. The Menu LCD DAY command provides full brightness and the LCD NIGHT command dims the LEDs. The GRPH Menu command controls the behavior of the K2 bargraph and the Power Output LEDs on the transverter as follows:

DOT: Just one LED representing the power output will illuminate.

BAR: All LEDs to the left of the current LED will illuminate, resulting in a more visible display.

OFF: The LEDs operate in DOT mode.

When used with other 28 MHz rigs, the brightness of all the front panel LEDs is fixed.

# Options and Modifications

The transverter is designed for the greatest possible flexibility when integrating it with other equipment in a high-performance station.

It is Elecraft's policy to encourage owners to experiment with their own (careful) modifications. You can build-in accessories and make changes to the circuitry if desired. However, this policy has one firm limitation: If you make a modification other than those described below that damages or alters normal operation, it may not be repairable by Elecraft.

Any personal modifications that you create should be installed in such a way that they can be easily disabled (turned off, unplugged, etc.). This will allow us to test and repair your kit if it becomes necessary. Repair charges will be higher if our technician has to *un*-modify your modification for any reason. Of course, any Elecraft-approved modification, such as those described below, may be left in place should you need to send in your transverter for repair. There will be no additional charges caused by the transverter having any of these modifications. They will not be removed by the Elecraft technician.

In addition to the options and modifications described here, check the Elecraft web site at [www.elecraft.com](http://www.elecraft.com) for the latest information about using your transverter with the latest systems and station equipment.

- **Optional Crystal Oven.** Improves the stability of the local oscillator by maintaining the crystal at a constant temperature.
- **Changing Between Split and Common Antennas.** Allows you to configure your transverter for use with a common transmit and receive antenna or with separate transmit and receive antennas.
- **Reducing Receive Gain to Preserve System Dynamic Range.** Reduces the gain of the transverter receive circuitry to help preserve the system dynamic range when an external preamplifier is used.
- **Optional Feet and Bail.** Elevates the front of the transverter to a convenient viewing angle.

## Tools Required

Some of these options and modifications require soldering. We recommend you use the following:

- Fine-tip temperature-controlled soldering station with 700 or 800°F tip (370-430°C). Do not use a high-wattage iron or gun to avoid damaging printed circuit board (PCB) pads, traces, or the parts themselves.
- IC-grade, small-diameter (.031") solder (Kester #44 or equivalent).
- A good vacuum desoldering tool such as the Soldapullt® model DS017LS.



**DO NOT use acid-core solder, water-soluble flux solder, additional flux or solvents of any kind. Use of any of these will void your warranty.**

In addition, you will need small hand tools including the following:

- Screwdrivers: a small, #2 Phillips and a small flat-blade for slotted screws.
- Needle-nose pliers.
- Small-point diagonal cutters, preferably flush-cutting.
- Digital Multimeter (DMM) for voltage checks and confirming resistance values.

Refer to [www.elecraft.com](http://www.elecraft.com) for tool sources and other information.

## Optional Crystal Oven

The crystal oven elevates the temperature of the local oscillator crystal and keeps it constant so long as power is applied. The oven greatly reduces frequency drift due to changes in the ambient temperature that affect the crystal. Contact Elecraft or visit the web site at [www.elecraft.com](http://www.elecraft.com) to order the crystal oven.

Install the oven as follows:



**The oven fits over the existing crystal. Be sure the crystal is installed before installing the oven.**

Remove the four screws and the top cover to gain access to the top of the RF PCB.



**In the following step, you will remove the 4-40 nuts holding the long screws at each end of the RF power module. Do not allow the screws to fall out of the bottom of the transverter.**

Remove the 4-40 nut and lock washer on each end of the RF power module.

Invert the transverter so the bottom side is up. Place it on a clean surface to avoid scratching the paint.

Remove the four corner screws holding the bottom cover.

Carefully lift the bottom cover off of the transverter. The two long screws that secure the RF power module should come out with the bottom cover. Be careful not to disturb the flat washers between the RF amplifier module and the PCB. If one does slip out of place, reposition it. The correct hardware placement is shown in Figure 11.

Remove the two long screws from the bottom cover and replace them through the holes at each end of the RF power module. Replace the nuts finger-tight to keep the washers and module in place while you work on the RF PCB.

Position the oven over the circle marked OV1 on the top of the RF PCB. The crystal will fit into a space on the bottom of the oven. The three leads on the oven fit into the +, - and NC pads on the PCB.

Bend the leads over on the bottom of the RF PCB to hold the oven in place, then tack-solder one lead.

Check to be sure the oven is fully seated down over the crystal and against the PCB. If necessary, re-heat the soldered lead and adjust the oven's position.

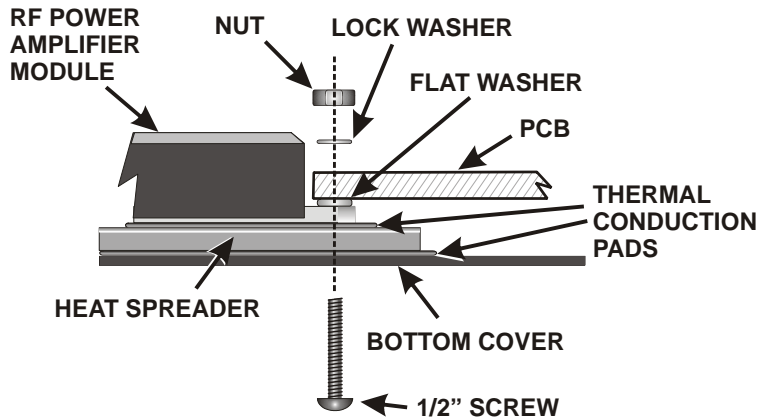
Solder and trim all three leads.

Remove the two screws you replaced at each end of the RF amplifier module. Be sure the flat washers are in place between the module and the PCB. If necessary adjust their position so the screws will drop through them when the bottom cover is replaced.

Set the bottom cover in place and drop the two long screws back through their holes. Replace the lock washers and nuts on the top of the PCB to hold the screws and hardware in place. Do not tighten the nuts yet.

Replace the four black screws at the corners of the bottom cover and tighten them.

Tighten the nuts at each end of the RF module. Inspect the RF module to ensure that both flat washers are between the module and bottom of the PCB (see Figure 11). Remove the cabinet side panel, if necessary, to get a clear view of the RF module mounting hardware.




**Figure 11. RF Module Mounting Hardware.**

- Configure the local oscillator power jumper, JP9, as desired (see page 14 for details). Normally you will want to place the jumper on JP9, pins 4-5. This will supply power to the oven whenever there is +12 volts at the rear panel connector, even if the transverter power is off. This will keep the oven and crystal warm and ready for operation at any time.
- Replace the top cover and tighten the four corner screws to secure it.

### *Changing Between Split and Common Antennas*

Your transverter may be configured to work with either a common transmit and receive antenna or with separate transmit and receive antennas. The procedure requires removing or installing a relay and two jumpers. The relay and jumpers are located in the upper left corner of the RF PCB, near ANT connector J1. Make the change as follows:

- Remove the four screws and the top cover to gain access to the top of the RF PCB.

** In the following step, you will remove the 4-40 nuts holding the long screws at each end of the RF power module. Do not allow the screws to fall out of the bottom of the transverter.**

- Remove the 4-40 nut and lock washer on either end of the RF power module.
- Invert the transverter so the bottom side is up. Place it on a clean surface to avoid scratching the paint.
- Remove the four corner screws holding the bottom cover.
- Carefully lift the bottom cover off of the transverter. The two long screws that secure the RF power module should come out with the bottom cover. Be careful not to disturb the flat washers between the RF amplifier module and the PCB. If one does slip out of place, reposition it (See Figure 11).
- Remove the two long screws from the bottom cover and replace them through the holes at each end of the RF power module. Replace the nuts finger-tight to keep the washers and module in place while you work on the RF PCB.
- If you are switching from a common antenna to split transmit and receive antennas, do the following. Otherwise skip this step.
  - Desolder and remove relay K1.
  - Install jumper W2. It is shown on the silkscreen on the top of the RF PCB next to the outline for K2 directly behind J8 (AUX).
  - Install jumper W3 between the solder pads shown in the space where relay K1 was sitting. Be sure to elevate W3 off of the PCB enough to avoid shorting to the solder pad underneath it.
  - Trim the excess wire for both jumpers on the bottom of the PCB.
  - Store the relay in a safe place in case you want to reinstall it at some future time.

- If you are switching from split transmit and receive antennas to a common antenna, do the following:
  - Remove jumper W2. W2 is next to the outline for K2 directly behind connector J8 (AUX) in the upper left corner of the RF PCB.
  - Remove jumper W3. W3 is also near relay K1.
  - Install relay K1. Be sure it is sitting solidly against the PCB when you solder it. Solder all five pins. **Do NOT trim the relay pins on the bottom side of the PCB.**
- Remove the two screws you replaced at each end of the RF amplifier module. Be sure the flat washers are in place between the module and the PCB. If necessary adjust their position so the screws will drop through them when the bottom cover is replaced.
- Set the bottom cover in place and drop the two long screws back through their holes. Replace the lock washers and nuts on the top of the PCB to hold the screws and hardware in place. Do not tighten the nuts yet.
- Replace the four black screws at the corners of the bottom cover and tighten them.
- Tighten the nuts at each end of the RF module. Inspect the RF module to ensure that both flat washers are between the module and bottom of the PCB (See Figure 11). Remove the cabinet side panel, if necessary, to get a clear view of the RF module hardware.  Replace the top cover and tighten the four corner screws to secure it.
- If you have configured your transverter for a common transmit and receive antenna, connect it to the ANT connector (J1). If you have configured your transverter for separate transmit and receive antennas:
  - Connect the transmit antenna to the ANT connector (J1).
  - Connect the receive antenna to the AUX connector (J8).

### *Reducing Receive Gain to Preserve System Dynamic Range*

Although your Elecraft transverter has a very low noise figure, it can be improved by using an external pre-amplifier at the antenna to overcome the losses in your transmission line. If you use an external preamplifier, you may want to reduce the overall gain to preserve the dynamic range of the receive system. You can reduce the receive gain about 12 dB by removing an amplifier stage in the transverter.



**The following procedure will destroy MMIC U1 in the transverter. If you decide to restore the transverter to its original configuration, order a replacement MMIC from Elecraft.**

- Remove the four screws at the corners of the top cover and remove the cover to gain access to the top of the RF PCB.
- Locate MMIC U1 on the RF PCB. It is in the upper left quadrant to the right of the Power Cal potentiometer.
- Use sharp diagonal cutters to clip off the leads to U1 and remove it.
- Inspect the PCB to be sure the solder pads for U1 are not shorted. If necessary use a desoldering tool to remove the remnants of the leads and excess solder to be sure there are no solder bridges between the pads.
- Use your DMM to identify the two pads for U1 that are *not* grounded. They are the pads closest to the back panel and the pad opposite, closest to the front panel.
- Install a short jumper across the pads that are *not* grounded. Be sure the jumper is not shorted to any other pads.
- Replace the top cover and tighten the screws.

### *Optional Feet and Bail Attachment*

A bail and feet that elevates the front of the transverter to a convenient viewing angle is available as an optional accessory from Elecraft. Contact Elecraft or visit [www.elecraft.com](http://www.elecraft.com) to order the feet and bail.

# Circuit Description

The circuits of the transverter for each band are similar. The signal flow is described below at a block diagram level. This is followed by details of the circuits based on the schematic diagrams.

## *Signal Flow*

Refer to the block diagram on the following page. Many of the circuits in the signal path are used for both receive and transmit. Switching between receive and transmit is done by relays to preserve the low noise figure of the receiver. The relays are shown in their de-energized state which puts them in receive mode position.

In receive mode, signals from the antenna are routed by relay K1 to the RF amplifiers and then through a band-pass filter to the mixer.

The local oscillator input to the mixer is 28 MHz below the signal frequency, producing an intermediate frequency (I.F.) output from the mixer in the 28 MHz range. Mixer responses outside of the 28 MHz I.F. range are attenuated by the filter at the mixer output.

Relays K6 and K7 route the 28 MHz I.F. signal to the port selector circuit. This circuit may be configured to work with an external rig that uses either a single connection for both transmit and receive or separate transmit and receive connections.

In transmit mode, the 28 MHz I.F. signal from the external rig is applied to the TXin/IF1 connector. Relay K7 routes the 28 MHz I.F. signal through the I.F. level control. The I.F. level control is adjustable to provide the correct drive to the mixer from a wide range of I.F. transmit levels from the 28 MHz rig.

Relay K6 routes the 28 MHz I.F. signal from the attenuator to the I,F, filter and limiter. The limiter is part of a protective circuit described below.

The mixer uses the local oscillator signal to convert the 28 MHz I.F. signal to the transmit frequency. The RF band-pass filter selects this frequency and attenuates the other mixing products.

Relay K2 routes the RF signal to the transmit driver. The transmit driver raises the signal level as required to drive the RF power module. The RF power module produces up to 20 watts output.

The output of the RF power module is routed through a low-pass filter and relay K1 to the antenna connector.

The power monitor samples the output of the RF power module and returns an analog signal to the controller. The controller illuminates the power level LEDs on the front panel to indicate the RF output power.

A DB-9 connector is provided for connection to an Elecraft K2 transceiver. This connection includes the control signals needed for the transverter to work with an Elecraft K2.

When used with rigs other than an Elecraft K2, the KEY IN line must be grounded by the external transmitter to switch the transverter from receive mode to transmit mode. When the transverter is used with an Elecraft K2, this command is furnished via the DB-9 connector and the KEY IN line is not used.

When the controller switches the transverter from receive mode to transmit mode, a transistor switch grounds the KEY OUT line to enable an external power amplifier, if used.

The overload detector protects the transverter in the event a high-level 28-MHz I.F. signal is applied while the transverter is in receive mode. The overload detector commands controller U1 to open relays in the I.F. port selector to disconnect the transverter from the I.F. rig and blink the front panel LEDs in unison to alert the operator. To reset the detector, the transverter must be turned off, then on again. When used with an Elecraft K2, the K2 must be turned off, then on again to reset the detector since the transverter power is controlled by the K2.

Since the attenuator is switched out of the signal path in receive mode, the mixer is vulnerable to damage from a high-level 28 MHz I.F. signal. The limiter keeps the signal at a safe level while the controller reacts to an overload condition.



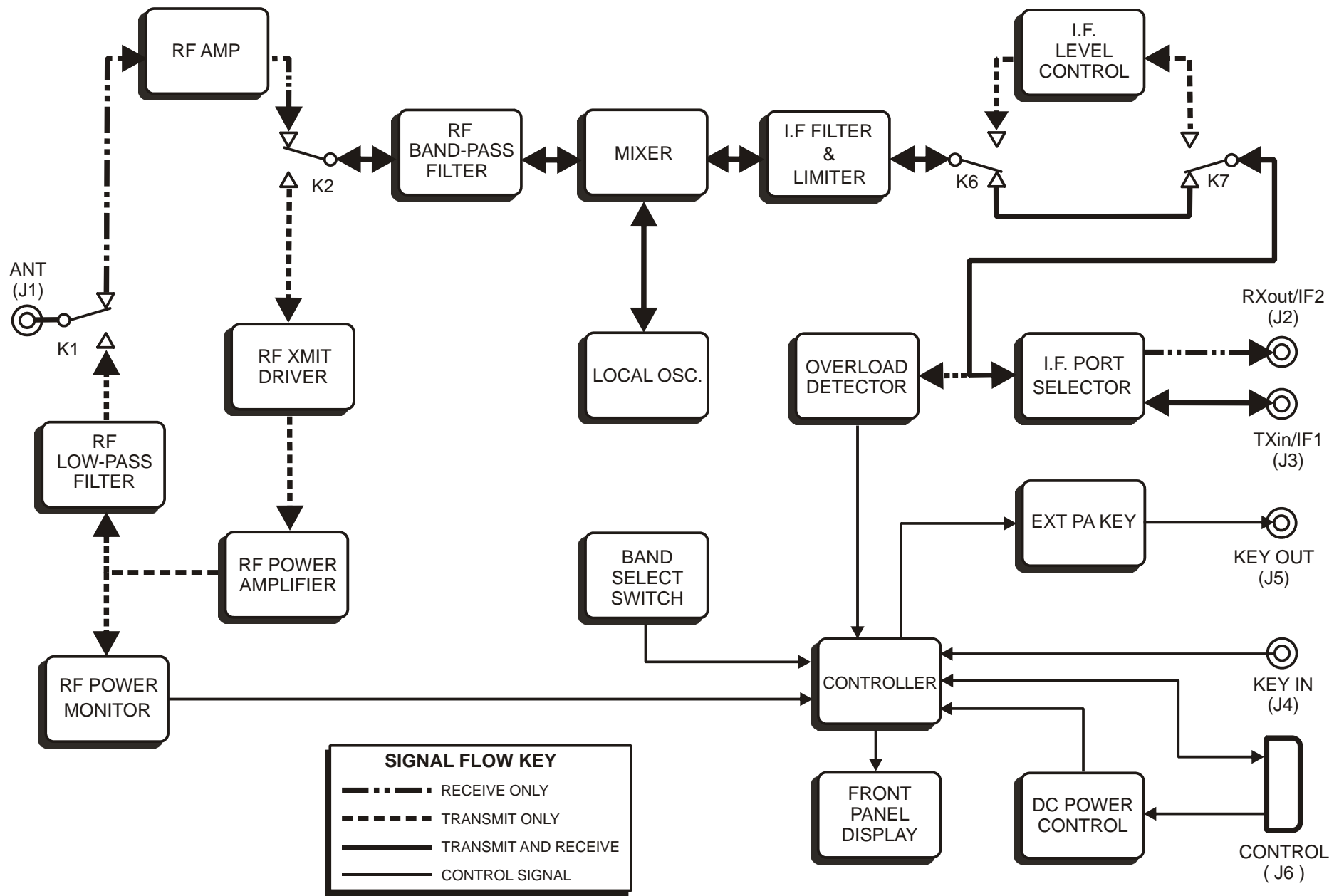


Figure 12. Transverter Block Diagram.

## *Circuit Details*

Separate schematic diagrams are provided in Appendix A for each of the transverter RF PCBs. The location of the circuits on the schematic diagrams is similar to the block diagram except for the control logic. The Controller, display LEDs and associated drivers are on the front panel PCB shown on a separate schematic diagram. The same front panel PCB is used on all of the transverters.

### **Receive Circuits**

The first active device in the receiver is Q3, a low noise PHEMT that provides an exceptionally low noise figure. The current through Q3 is set for optimum performance by potentiometer R13.

U1 further amplifies the incoming signal which is then passed on to mixer Z1 through relay K2 and an RF band-pass filter.

The local oscillator signal is generated by crystal oscillator, Q1. In the XV50, XV144 and XV222, the local oscillator signal is amplified by Q2, and in the XV432 by U9. The local oscillator signal is 28 MHz below the RF signal frequency on all bands.

In the XV50 the second harmonic of the local oscillator at 44 MHz is very close to the 50 MHz pass band, so a low-pass filter is used between amplifier Q2 and mixer Z1 to attenuate the 44 MHz signal.

The intermediate frequency (I.F.) output of mixer Z1 passes through another band-pass filter that includes a diplexer formed by C57, L17 and R25. C57 and L17 are series resonant at 28 MHz, so the I.F. signal passes through to the band-pass filter section. C57 and L17 present a high impedance to frequencies removed from the 28 MHz I.F. These signals are terminated by R25.

LEDs D10 and D11 are used as limiters to protect the mixer during transmit as described below. Inductor L9 resonates with the capacitance of the LEDs at 28 MHz to avoid attenuating the I.F. signal.

The 28 MHz I.F. signal is routed around the transmit signal attenuator to the I.F. port selector circuits by relays K6 and K7. Relays K8 and K9 disconnect the I.F. RX and TX/RX ports whenever the transverter is not in use as described below. This permits several transverters to be connected to the same external rig without loading the signal lines.

If separate transmit and receive connections are used for the 28 MHz I.F., the receive line is connected to J2. A jumper is placed across JP1 pins 1 and 2 and across JP2 pins 2 and 3. JP1 routes the receiver signal through relay K9 to K6. JP2 routes the transmit signal through the attenuator.

If the external rig uses a single connection for both transmit and receive, jumpers are placed across JP1 pins 1 and 2 and across JP2 pins 1 and 2. In receive mode, relay K7 routes the I.F. signal to the RXout/IF2 output at J3. In transmit mode relay K7 routes the 28 MHz I.F. signal coming in at J3 to the attenuator.

When the external rig uses a common I.F. connection for both transmit and receive, a cable connected to J2 will carry the transmit and receive I.F. signals to another transverter.

### **Transmit Circuits**

In transmit mode, the 28 MHz I.F. signal at J3 is routed through the I.F. port selector circuits to the I.F. level control. The I.F. level control either amplifies or attenuates the I.F. signal to the proper level for the mixer. The I.F. level control can handle signal levels of from -20 dBm to +39 dBm from the external rig. For low-level I.F. input levels amplifier Q6 may be switched into the circuit by jumpers JP5 and JP6. For higher level I.F. input levels, jumpers JP3 and JP4 permit adding or bypassing a fixed 30 dB attenuator as needed. Potentiometer R22 permits continuous adjustment of the attenuation.

Mixer Z1 uses the local oscillator signal to produce an RF output at the desired transmit frequency. Unwanted mixer products are attenuated by the RF band-pass filter.

Relay K2 routes the transmit RF signal to RF driver U6, which amplifies the signal to drive RF power module U7. A different RF power module is required for each band. The RF power modules for the 144 MHz and 220 MHz bands require a bias adjustment to set the amplifier current at the proper level. The bias is adjusted by R39, which is set for the proper total current drain on the 12 volt line. The current drain is measured by connecting a DMM to TP3 and TP4

RF from power module U7 passes through a low-pass filter and relay K1 to the antenna connector. In the XV432, an additional relay, K10, grounds the input to the receive RF amplifier during transmit.

## Control Circuits

**Power Control:** The DC power control circuit is configured with jumpers to allow it to work with an Elecraft K2 or any other suitable rig.

When used with a rig other than an Elecraft K2, a jumper is placed at JP5 to bypass Q5 and D16. The transverter power is then controlled by front panel power switch S2. Closing S2 enables relay K3, applying +12 volts to the transverter circuits.

When the transverter is used with an Elecraft K2, the control circuit automatically turns the transverter power off whenever the K2 is turned off. No jumper is used at JP7. As long as the K2 power is on, +12 volts is supplied via pin 9 of the DB-9 connector to Q5, which grounds the return side of power switch S2 through D19. When the K2 power is turned off, Q5 will turn the transverter off automatically.

Of course, power switch S2 on the transverter must be on. If desired, a jumper may be placed at JP8 to disable the transverter power switch. The transverter power then is controlled only by the K2.

Controller U1 on the front panel PCB enables the three-diode light bar D11 through Q6 whenever the transverter is active. If the transverter is used with an Elecraft K2, it is active whenever DC power is applied at J2 and it is selected by a K2 as described below. If the transverter is not used with a K2, light bar D11 is enabled whenever DC power is applied at J2 and power switch S2 is on.

**Fan Control:** The XV432 has an internal cooling fan that operates whenever +12 vdc is present at the transverter power connector.

**Transmit-Receive Switching:** Switching between receive mode and transmit mode is by a ground at the KEY IN connector or, if an Elecraft K2 is used, when the 8R signal at pin 6 of the DB-9 interface goes to a logic low.

When used with an Elecraft K2, the transverter is enabled automatically by the BAND switch on the K2. The K2 identifies the transverters as TRN1, TRN2 or TRN3. Switch SW1 associates the transverter with the corresponding number at the K2. SW1 selects an analog voltage level depending upon the position of the switches. This voltage is sent as the ID signal to controller U1. Controller U1 monitors the AuxBus signal from the K2 and enables transmit/receive switching when the transverter ID corresponding to the setting of SW1 is received.

When the transverter is used with rigs other than an Elecraft K2, all the switches are off. The transverter is enabled whenever the transverter power switch is on.

When a transmit mode command is received via the KEY IN connector or by the 8R line from a K2, controller U1 provides a ground return to close relay K5. Relay K5 provides +12 volts to relays K1, K2, K6 and K7 and supplies bias voltage to RF power module U7.

**I.F. Port Enable:** Relays K8 and K9 must be energized to connect the external rig to the transverter circuits. These relays are energized by controller U1 by providing a ground return on the IF EN command line.

When the transverter is used with an Elecraft K2, the controller enables the I.F. port only when the transverter is selected by the K2 band switch as described above. This feature allows several transverters to be “daisy-chained” together through the 28 MHz TX/RX and 28 MHz RX connectors.

When the transverter is used with other rigs, the I.F. port is enabled whenever power switch S2 is on. If several transverters are “daisy-chained” together, the desired transverter selected by turning its power switch on and leaving any other transverters off.

**I.F. Overload Protection:** If the transverter is not switched to transmit mode before a high-level I.F. signal is applied to the 28 MHz TX/RX input, mixer Z1 might be damaged. This will happen if the external rig does not supply a ground the KEY IN connector or, if a K2 is used, the 8R signal at the DB-9 connector does not go low to change the transverter into transmit mode. To prevent damage to the mixer, a protection system will automatically disconnect the external rig from the transverter circuits and limit the signal level at the mixer I.F. port.

Diodes D6 and D12 in the overload detector circuit rectify a sample of the transmit RF and produce a DC level that will cause the control circuits to open relays K8 and K9. This voltage is supplied as the ODET (overload detect) signal to controller U1 on the front panel PCB. Also, when an overload is detected controller U1 flashes the front panel LEDs at about a 1 Hz rate to alert the operator. The transverter will remain disconnected with the LEDs flashing until the controller is reset by turning the power switch off, then on again.

The control circuits may not release relays K8 and K9 fast enough to prevent damage to mixer Z1 from a high-level 28 MHz I.F. signal, so LEDs D10 and D11 are used to protect the mixer. LEDs D10 and D11 will conduct and limit the I.F. signal to a safe level. LEDs are used because their greater forward-conduction voltage avoids the need to use diodes in series.

**External PA Keying:** When the transverter switches to transmit mode, controller U1 sends a signal to Q4 that turns it on, providing a path to ground at EXT PA KEY jack J5 to key an external power amplifier.

**Power Monitor:** D1 produces a DC voltage proportional to the RF power output of U7. The voltage,  $P_o$ , is sent to controller U1 on the front panel. The controller drives D1 through D10 to indicate the RF power level from 1 through 30 watts. The LEDs below 20 watts are green. The 20-watt LED is yellow, and the 25 and 30 watt LEDs are red to indicate that the specified maximum power output is being exceeded.

The metering circuit is calibrated by potentiometer R10.

**Display Mode:** When the transverter is used with an Elecraft K2, the behavior of the LEDs on the front panel follows the display mode selected by the operator at the K2. These selections determine the LED brightness and whether the power output LEDs illuminate in a line extending from the left (bar mode) or if only one LED corresponding to the power output illuminates (dot mode). The display mode information is reported to controller U1 via the AuxBus. The controller changes the brightness by varying the bias on Q2 and Q5 on the front panel PCB.

## Alignment and Test

A complete alignment and test using the following procedures is essential after assembling your kit. These procedures can be repeated whenever desired to confirm that the transverter is working correctly and adjusted for optimal performance.

Perform the first seven parts of the procedure in the order given. Each part assumes you have completed the adjustments and set up your transverter as described in the earlier parts.

The following test equipment will be needed:

- 28 MHz transceiver or transmitter and receiver to use as the I.F. system, with interconnecting cables.
- Power supply capable of providing 13.8 VDC at 6 A, minimum.
- Digital Multimeter (DMM).
- Noise Generator (Elecraft N-Gen or equivalent) or signal generator with output in the RF frequency range of the transverter.
- RF Wattmeter capable of measuring 20 watts with good accuracy.
- RF dummy load, 20 watts minimum
- Adjustment tool for the inductors in the transverter (supplied with transverter).
- RCA plug with the center pin wired to the shell.

If you are aligning an XV50 or XV432 transverter and wish to perform the optional local oscillator frequency calibration, you will need **one** of the following:

- A frequency counter capable of measuring signals in the 22 or 50 MHz range for the XV50, or 404 MHz for the XV432.
- A calibrated signal generator capable of producing output with good frequency accuracy at 432 MHz (for the XV432) or at 50 MHz (for the XV50). An H.F. transmitter with a well-calibrated VFO that covers the 12 meter Amateur band may be used for the XV50.

### *Part I - Initial Setup*

- Pre-set the potentiometers on the RF PCB as follows:
  - R10 (Power Cal) at mid-range.
  - R13 (LNA Bias) XV50, XV144 or XV222: full CCW (counter clockwise). XV432: full CW (clockwise).
  - R22 (Input Atten Adjust) full CCW.
  - R39 (PA Bias) full CCW.
- Skip this step if you are aligning an XV432. On an XV50, XV144 or XV222, verify that the tuning slugs have been removed from the following inductors. If not, remove the cores and discard them. These slugs will not be used:
  - L1
  - L10
  - L17
  - L11



**In the next step you will use the alignment tool supplied with your transverter to preset inductor slugs a certain number of turns down from the top of the coil. You may find it easier to count the turns if you place a readily-visible mark on the alignment tool.**

Pre-set the inductors in the transverter as follows. Turns are measured down from the point where the slug is flush with the top of the coil.

COIL	XV50	XV 144	XV222	XV432
L3	N/A*	N/A*	N/A*	5.5
L4	N/A*	N/A*	N/A*	3.5
L5	N/A*	N/A*	N/A*	2.5
L12	0	6	6	N/A*
L13	3	6	6	N/A*
L14	1.5	6	6	N/A*
L15	2	2	2	1
L16	2	2	2	2
L17	2	2	2	0

\* Inductor not used on this model.

If you are aligning an XV222, set the slug in inductor L4A even with the top of the form. This slug will not be adjusted in the following procedure. L4A is used only in the XV222 transverter.

Connect an RF power meter and dummy load to the transverter ANT connector.

Verify that the transverter Power switch is off (button out).

If you haven't already done so, turn to the Installation section (Page 4) and hook up your transverter to your 28 MHz rig,

## Part II – Power Control

Apply power to your 28 MHz rig and verify that the transverter power control operates as follows:

- If you are using a non-Elecraft 28 MHz rig, press the transverter Power pushbutton in. Verify that the band label lights.
- If you are using an Elecraft K2, confirm that the transverter band label lights when you select the band assigned to the transverter on the K2, and that the band label goes off when you select any other band. The transverter Power pushbutton should be inoperative.

## Part III - Local Oscillator Level

Verify the proper local oscillator level as follows:

Connect your DMM between a ground test point and TP1 in the lower right quadrant of the RF PCB.

Apply power to your 28 MHz rig and verify that the transverter power control operates as follows:

- If you are using a non-Elecraft 28 MHz rig, press the transverter Power pushbutton in. Verify that the band label lights.
- If you are using an Elecraft K2, confirm that the transverter band label lights when you select the band assigned to the transverter on the K2, and that the band label goes off when you select any other band. The transverter Power pushbutton should be inoperative.

Verify that the local oscillator voltage levels are as follows. If you find no reading, make sure you have a 2-pin shorting block on JP9. The local oscillator is disabled if this shorting block is not installed. See *Local Oscillator Power Control* on page 14 to choose the correct position for the shorting block on JP9.

- **XV50:** 0.8 to 1.2 VDC (No adjustments).
- **XV144:** 1.2 to 1.8 VDC (No adjustments).
- **XV222:** 1.0 to 1.5 VDC (No adjustments).
- **XV432:** Adjust L3, L4 and L5 for maximum: The peak voltage should be between 1.5 and 3.0 VDC (nominally 2.5 VDC).

If aligning an XV432, turn the power off, then on again (either using the front panel switch or, if using an Elecraft K2 for the I.F., use the K2 BAND switch to deselect and select the transverter). Make sure the local oscillator voltage returns when power is turned off then on again. If not, adjust L4 for reliable starting each time power is turned on.

### *Part IV – Receiver RF Amplifier Bias Adjustment*

Adjust the receiver low-noise amplifier (LNA) bias current as follows:

- Connect your DMM to measure DC voltage between TP2 in the upper left quadrant and ground.
- Adjust R13 as follows:
  - XV50, XV144 or XV222: between 175 and 275 millivolts.
  - XV432: 5 volts.

### *Part V – RF Power Amplifier Quiescent Current Adjustment.*

Perform the following procedure only on the XV144, XV222 or XV432 transverters. The XV50 requires no adjustment.

- Attach a 50 ohm dummy load to the transverter ANT connector.
- Connect your DMM between TP3 (-) and TP4 (+) near J7 in the upper right corner of the RF PCB.
- If you are using an Elecraft K2 for the 28 MHz I.F., note the settings on the Band Select DIP switches. You'll need them later.
- Set all four Band Select DIP switches to Off (toggles toward the front panel). If you are using a non-Elecraft rig for the I.F., they will already be in the Off position.
- Disconnect the 28 MHz rig KEY IN line to the transverter, if used.
- Insert the shorted RCA plug into the KEY IN jack on the back of the transverter. This will put the transverter in transmit mode. The 28 MHz rig must not be keyed to provide RF drive to the transverter for this adjustment.
- Adjust R39 for a reading of 20 mV on your DMM.
- Reconnect the 28 MHz rig KEY IN line to the transverter, if used.
- Reset the Band Select DIP switches to their former positions.

### *Part VI – Filter Alignment.*

Align the tunable filters in the I.F. and R.F. path as follows:

- Adjust your 28 MHz rig output for the level chosen to drive your transverter to full output (normally 1 milliwatt, 251 milliwatts or 5 watts)
- Attach your DMM ground probe to one of the ground test points on the RF PCB.



**If you drive the transverter with 5 watts from your 28 MHz rig, you may notice that some of the 1-watt resistors are quite warm to the touch. This is normal. They are operating well within their design ratings. These resistors were mounted above the PCB to promote good cooling air circulation around them.**

- Connect your DMM to measure DC voltage between a ground test point and TP5 in the upper left quadrant near potentiometer R10.
- Set the 28 MHz rig frequency to transmit at 50.5 MHz, 144.5 MHz, 222.5 MHz or 432.5 MHz. If you are using an Elecraft K2 in transverter mode, the frequency display will show the actual transmit frequency. Other rigs must be set to 28.5 MHz.
- Key the 28 MHz rig to provide transmit RF to the transverter and advance R22 (Input Atten Adjust) until the DMM reads anywhere between 0.1 and 10 volts. Key the 28 MHz rig only as long as needed for each adjustment.



**While performing the alignment, take care not to overheat your 28 MHz I.F. rig by holding the key down too long.**

Key the 28 MHz rig to provide transmit I.F. to the transverter and adjust the following inductors for maximum voltage at TP5. If the voltage exceeds 10 volts, turn R22 (Input Atten Adjust) counter clockwise (CCW) to reduce the voltage. The front panel Power Output LEDs may begin lighting up as you peak the inductors:

XV50, XV144 or XV222:

L12, L13, L14, L15, L16 and L17. The adjustment of L17 is very broad.

XV432:

L15, L16, L17, the three adjustments in FL1 and the three adjustments in FL2. The adjustment of L17 is extremely broad because of the wide bandwidth of this filter. Maximum output may occur with the slug removed. If so, leave the slug out.

Repeat the above adjustments several times for maximum voltage at TP5. Some of the adjustments interact. Adjust R22 (Input Atten Adjust) CCW as needed to keep the voltage below 10 VDC.

### *Part VII – Power Display LED Calibration.*

Calibrate the front panel Power Output display as follows:

Set your 28 MHz rig transmit frequency to 28.0 MHz. If you are using an Elecraft K2 in transverter mode, the frequency displayed will be 50, 144, 222 or 432 MHz.

Set your 28 MHz rig to the transmit level that corresponds with 20 watts output from this transverter (1 milliwatt, 251 milliwatts or 5 watts). This depends upon how you configured the I.F. power level jumpers in the Installation procedure.



**Do not exceed the recommended maximum transmit power from your 28 MHz rig, depending upon how you configured the transverter jumpers. Exceeding the maximum level may damage the transverter.**

Key the 28 MHz rig to provide a transmit signal and adjust R22 (Input Atten Adjust) for 20 watts indicated on your external wattmeter. When finished, do NOT change the output power from your 28 MHz rig

before performing the next step.

Key the 28 MHz rig to provide a transmit signal. With the external wattmeter indicating 20 watts, adjust pot R10 (Power Cal) in the upper left quadrant of the RF Board so that the yellow (20 watt) LED on the transverter front panel just lights.

### *Part VIII – Receiver Input Alignment.*



**Accidentally transmitting while performing the following steps could destroy your noise generator.**

On your 28 MHz rig:

– If possible, turn the AGC off.

– Set the receive frequency to 29.0 MHz. If you are using an Elecraft K2 in transverter mode, the frequency display will be 51, 145, 223 or 433 MHz.

Place your DMM in AC volts mode and connect it across the phone or speaker output of your 28 MHz rig to measure the audio level.

Connect a noise generator to the transverter antenna input. Normally this will be the ANT connector unless you wired your transverter for separate transmit and receive connections (see page 18). In that case, connect your noise generator to the AUX connector.

Turn your noise generator on. You should see an increase in the AC voltage reading on your DMM.

Adjust trimmer capacitor C1 in the upper left quadrant of the PCB for maximum voltage shown on the DMM. You may need to reduce the input from the noise generator to see the peak clearly.





**Adjusting C1 for maximum conversion gain (noise) will normally result in a receive noise figure of less than 1 dB. However, the adjustment for maximum gain and minimum noise figure do not coincide exactly because the optimum impedance for lowest noise figure differs from an exact conjugate match. With the filter design used in the transverter, adjusting C1 for maximum gain 1 MHz above the lower band limit as described above produces very nearly the optimum noise figure at the bottom of the band. It may be possible to achieve an 0.1 to 0.2 dB improvement in noise figure by adjusting C1 with a calibrated Noise Figure Meter.**

### *Part IX - Overload Protection Circuit Test*

This test verifies that the transverter will protect itself in the event a high-level transmit signal is applied while the transverter is still in receive mode. This is an optional test that only checks the protective circuit. It is not required to properly align your transverter.



**Do not perform this test if you are using a low-level (1 milliwatt) output from your 28 MHz rig. The overload circuit will not respond to a low-level transmit signal.**

Disconnect the noise generator from the transverter Antenna output and reconnect the dummy load.

If you are using an Elecraft K2, temporarily change the XV configuration as follows, otherwise skip this step:

- Remove the jumper header from JP8 on the RF Board (near the front corner on the right side).
- Write down the settings of the Band Select DIP switch positions.
- Switch all four DIP switches off.

- Disconnect the transmit/receive control from the I.F rig as follows:
  - If you are using a non-Elecraft rig for the I.F., disconnect the Key In connector
  - If you are using an Elecraft K2, disconnect the interface cable at the Control connector.
- Momentarily key the transmitter. Verify that all of the Power LEDs begin flashing and keep flashing even after the transmit signal is removed. This is the Overload warning indicating that a transmit signal was applied to the transverter while the transverter was still in receive mode.
- Turn the transverter Power off, then on again to clear the overload display.
- If you are using an Elecraft K2:
  - Replace the jumper shorting block on JP8.
  - Switch all four DIP switches off, then reset the switches as they were before performing this test.
- Reconnect the Key In or Control line to the transverter.

## Local Oscillator Frequency Calibration (Optional)

The local oscillator frequency in the XV50 and XV432 transverters is adjustable over a narrow range to provide the best frequency calibration for both transmit and receive on the 28 MHz I.F. rig. Although the local oscillators in the XV144 and XV222 are not adjustable, the firmware in the K2 transceiver allows you to compensate for frequency errors using the menu commands. Once the proper compensation is entered, the K2 frequency display will show the actual transmit and receive frequencies accurately. The same menu commands may be used to correct for small errors in the XV50 and XV432 frequency as well. See the Revision 2 and up K2 firmware instructions for details.

The frequency adjustment range is limited and you may not be able to put the local oscillator exactly on the desired frequency. In most cases the local oscillator will stop oscillating when the frequency is adjusted too far. This is most likely to happen with the XV432. If the stock crystal supplied with your kit does not have adequate adjustment range, an optional high-accuracy local oscillator crystal is available for the XV432 transverter. This should not be a concern when using an Elecraft K2 for the I.F. because any remaining frequency error can be compensated for in the K2 using the menu commands as described above.

The following procedures allow you to calibrate the local oscillator in several ways:

- Use a counter to measure the local oscillator frequency at 22 MHz (XV50) or 404 MHz (XV432).
- Use a counter to measure the output frequency of the transverter.
- Use a received signal produced by a calibrated signal generator, transmitter or other known source.

### Using a Counter to Measure the Local Oscillator Frequency

- Turn the transverter power on and allow the transverter to stabilize for at least 5 minutes at room temperature (approx. 20 – 25° C).
- Connect a DMM set to measure DC volts between a ground point and TP1 in the lower left quadrant of the RF PCB.



**In the next step you will connect the frequency counter to a circuit that has a DC voltage. If your counter does not provide protection against DC voltages, or if you aren't sure, place a capacitor in series with the counter input. Any value from 100 pF to .01 µF is suitable.**

- Attach the frequency counter as follows:
  - XV 50: To either end of molded inductor L3 (near T1 on the RF PCB).
  - XV432: End of L22 closest to U9.
- Adjust the local oscillator frequency as follows:
  - XV50: Adjust trimmer capacitor C33 for a reading of 22.00000 MHz on the frequency counter. Make sure the voltage at TP1 remains between 0.8 and 1.2 VDC.
  - XV432: Adjust L4 for a reading as close as possible to 404.000 MHz on the frequency counter. Make sure the voltage at TP1 remains between 1.7 and 3.0 VDC.
- Monitor the voltage at TP1 while switching the transverter power on and off several times to be sure the local oscillator starts reliably.

### Using a Counter to Measure the Transverter Output Frequency

- Turn on power to the transverter and allow the transverter to stabilize for at least 5 minutes at room temperature (approx. 20 – 25° C).
- Attach a dummy load to the transverter output.
- Connect the frequency counter to sample the RF output from the transverter. **Do NOT connect your counter directly to the antenna output without a suitable attenuator to protect the counter input.** If you do not have a suitable attenuator, connect an insulated wire to the counter input and position the wire near antenna relay K1 on the RF PCB. You may need to experiment with the position of the wire to pick up enough RF to operate the counter. Do not wrap the wire around L10 or L11. That would detune the output filter and could damage the RF power module.

Set the 28-MHz rig to transmit at 28.0000 MHz. If you are using an Elecraft K2 for the I.F. and have the transverter menu enabled, set the K2 to display a frequency of either 50000.00 kHz or 432000.0 kHz and ensure that the Menu OFS (Frequency Offset) command is set to 0.00. (Refer to your Rev. 2 and up Firmware instructions for the procedure). Be sure that SPLIT and RIT are turned off.

Key the rig to produce a steady carrier and adjust the local oscillator frequency as follows:

- XV50: Adjust trimmer capacitor Z6 for a reading of 22.00000 MHz on the frequency counter. Make sure the voltage at TP1 remains between 0.8 and 1.2 VDC.
- XV432: Adjust L4 for a reading as close as possible to 404.000 MHz on the frequency counter. Make sure the voltage at TP1 remains between 1.7 and 3.0 VDC.

Monitor the voltage at TP1 while switching the transverter power on and off several times to be sure the local oscillator starts reliably.

### Using a Received Signal

Turn on power to the transverter and allow the transverter to stabilize for at least 5 minutes at room temperature (approx. 20 – 25° C).

Set up your external signal source to produce an audible signal as follows:

- XV432: 432.000 MHz.
- XV50: 50.000 MHz. If you use an HF rig transmitting into a dummy load for the signal source, set it at 25.000 MHz to produce a second harmonic at 50.000 MHz. If it won't transmit outside the 12 meter Amateur band, set it for 24.990 MHz to produce a second harmonic at 49.980 MHz.

Adjust the local oscillator frequency to bring the received signal into the center of the I.F. receiver band pass. If you are comfortable zero beating CW signals, you can listen in CW mode and zero beat the signal against the sidetone.

- XV50: Adjust trimmer capacitor Z6. Make sure the voltage at TP1 remains between 0.8 and 1.2 VDC.
- XV432: Adjust L4. Make sure the voltage at TP1 remains between 1.7 and 3.0 VDC.

Monitor the voltage at TP1 while switching the transverter power on and off several times to be sure the local oscillator starts reliably.

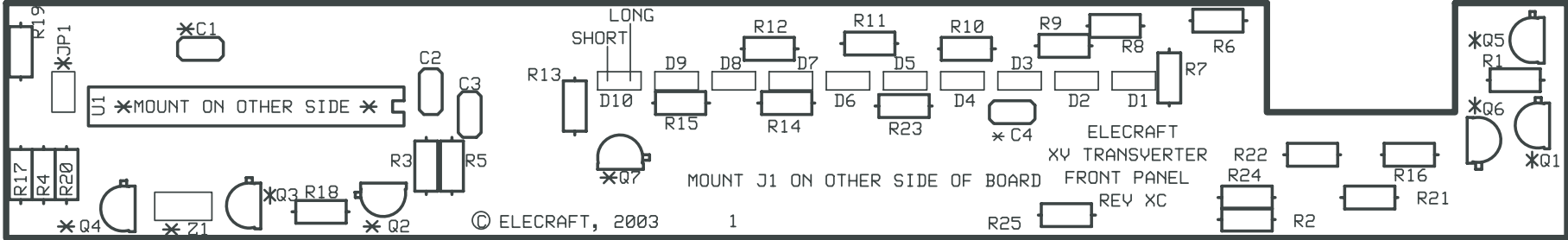
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This completes the alignment and testing of your transverter.

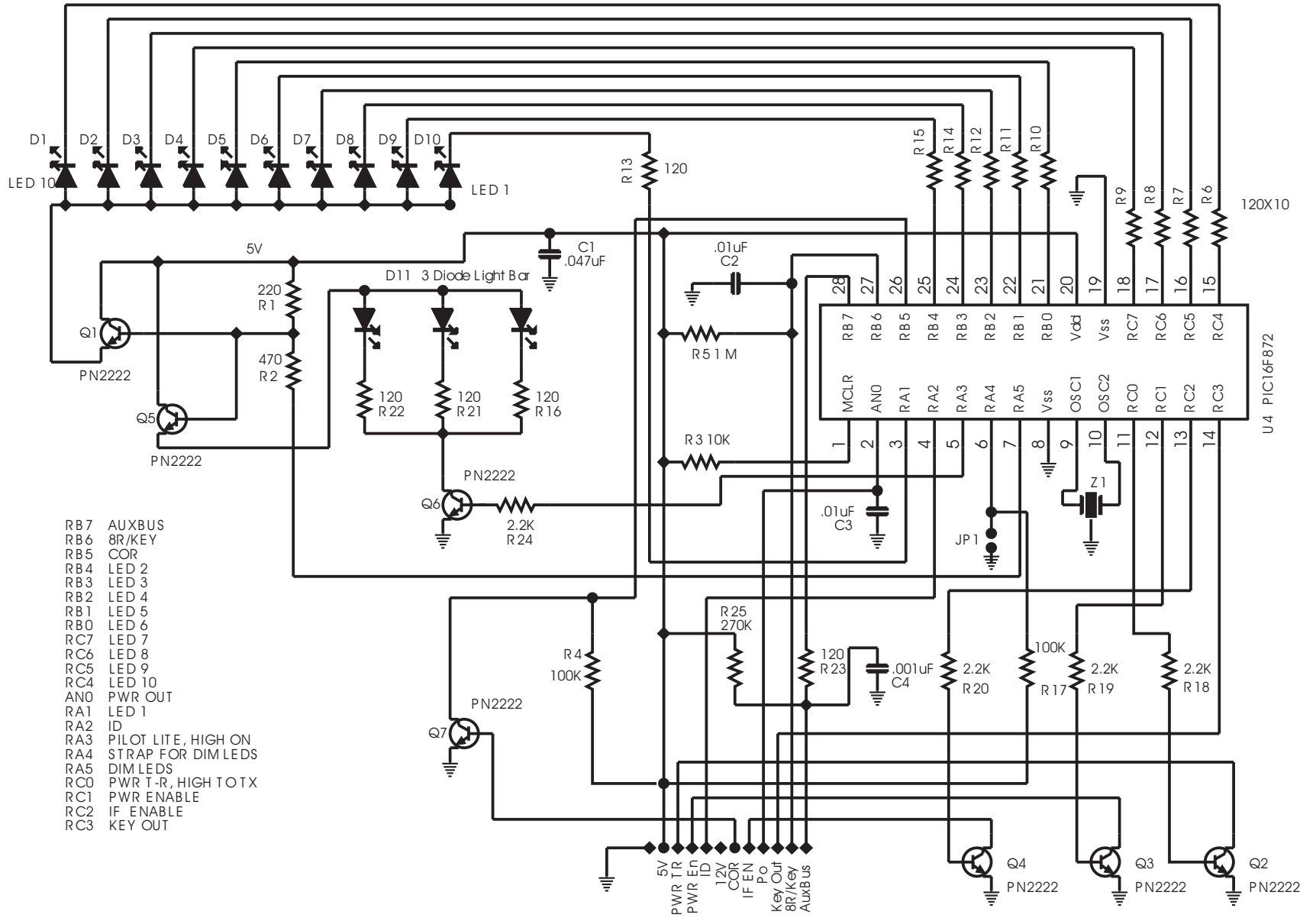
# Appendix A - Schematics and Parts Placement Diagrams

Front Panel Board Parts Placement Drawing (all models).....	A-2
Front panel Board Schematic Diagram (all models).....	A-3
XV50, XV144 and XV 222 Models Only:	
RF Board Parts Placement Drawing.....	A-4
RF Board I.F. and Control Circuits Schematic.....	A-5
RF Board XV50 Circuits Schematic.....	A-6
RF Board XV144 Circuits Schematic.....	A-7
RF Board XV222 Circuits Schematic.....	A-8
XV432 Model Only:	
RF Board Parts Placement Drawing.....	A-9
RF Board I.F. and Control Circuits Schematic.....	A-10
RF Board XV432 Circuits Schematic.....	A-11

Front Panel Board Parts Placement Drawing (All Models)



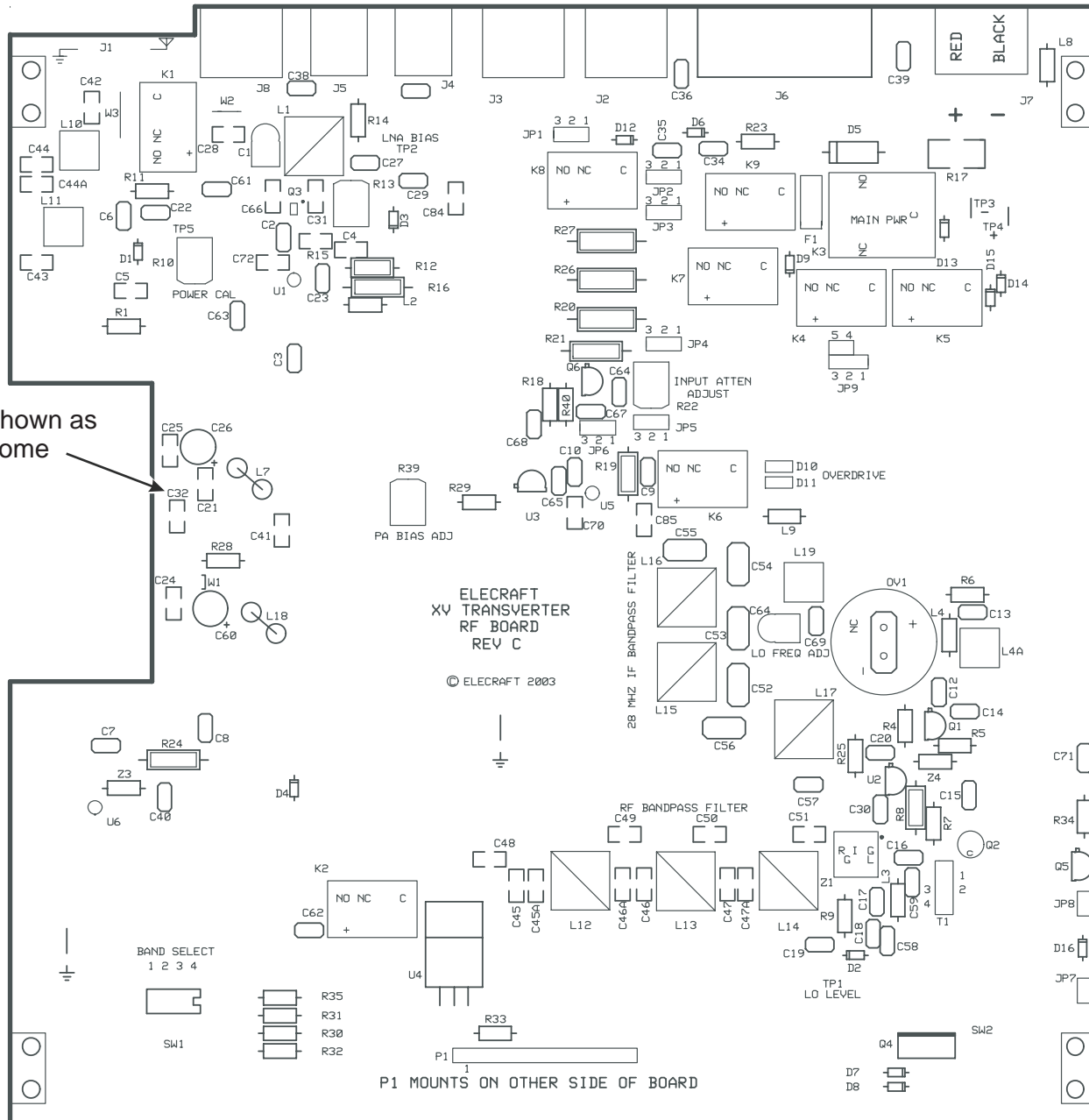
# Front Panel Board Schematic Diagram (All Models)



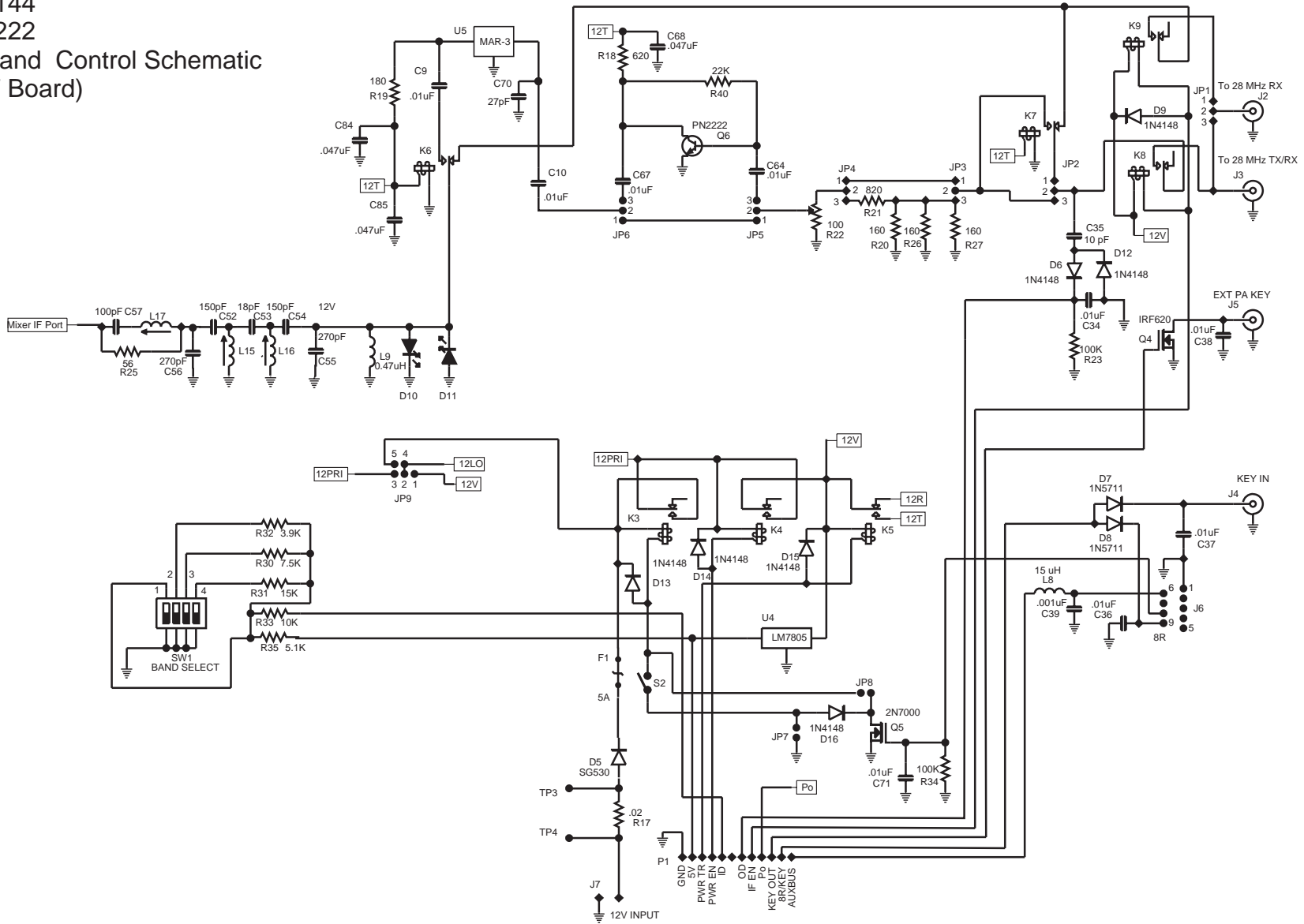
# RF Board Parts Placement Drawing

XV50  
XV144  
XV222

May be shown as  
C58 on some  
boards.

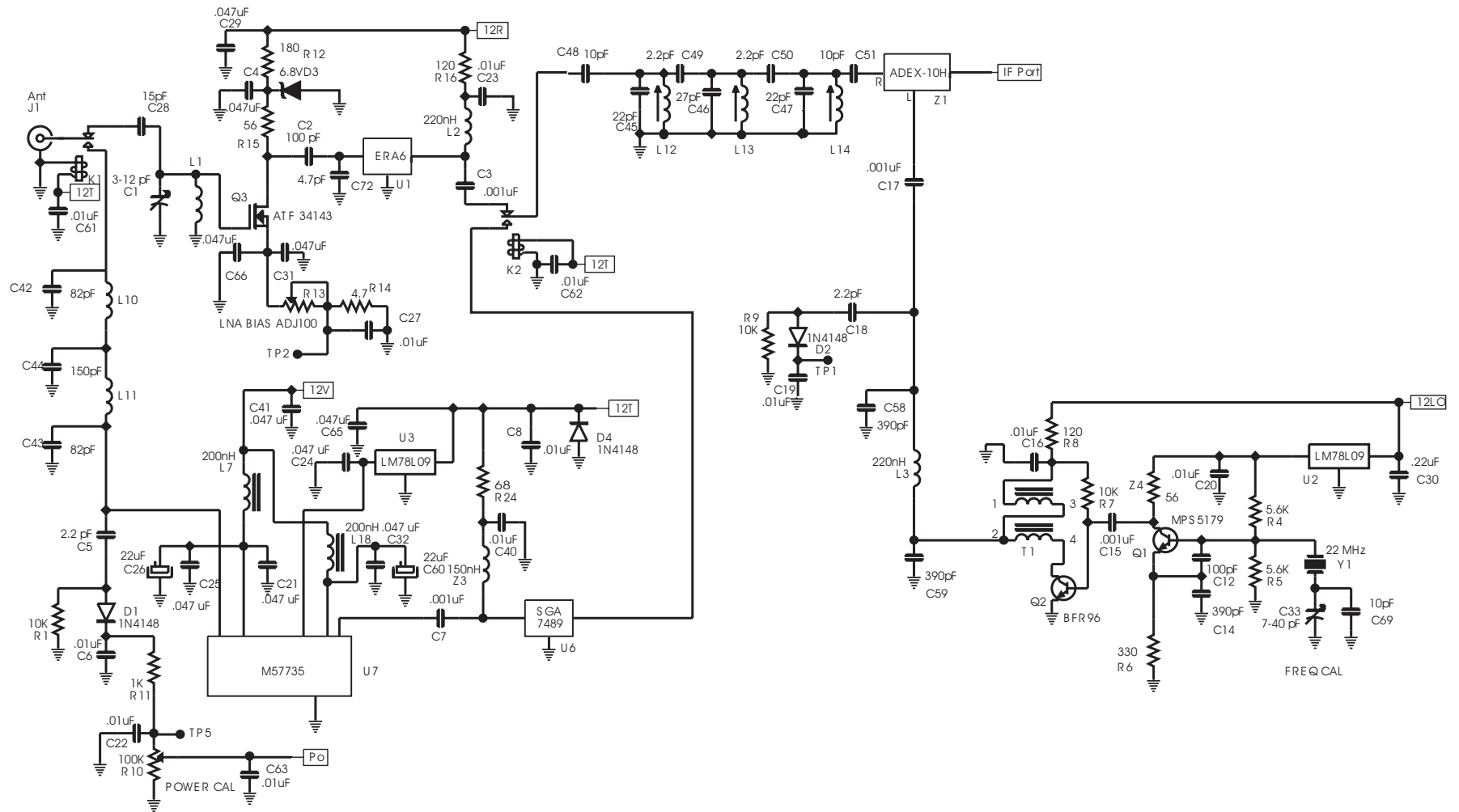


XV50  
 XV144  
 XV222  
 I.F. and Control Schematic  
 (RF Board)

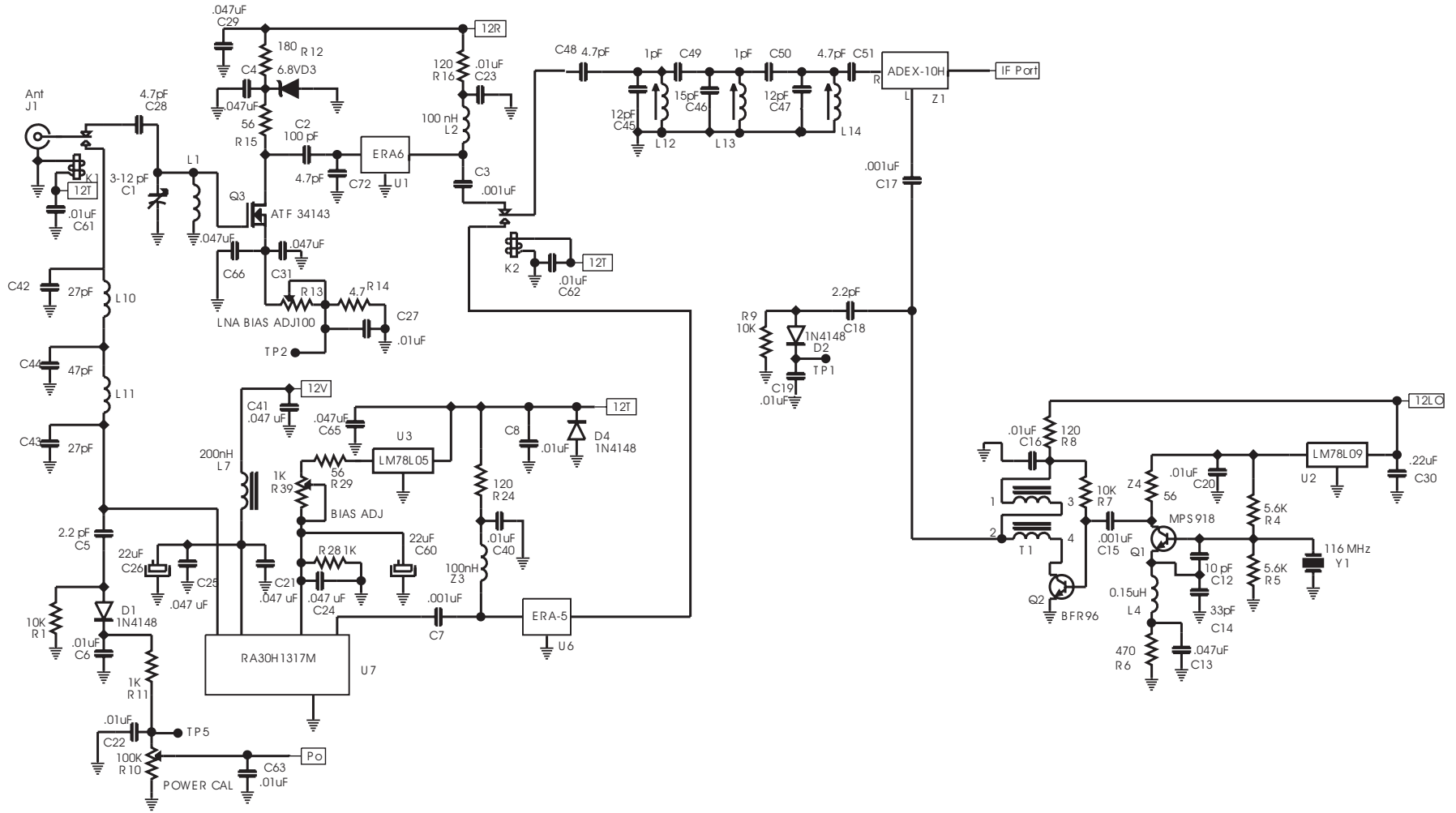




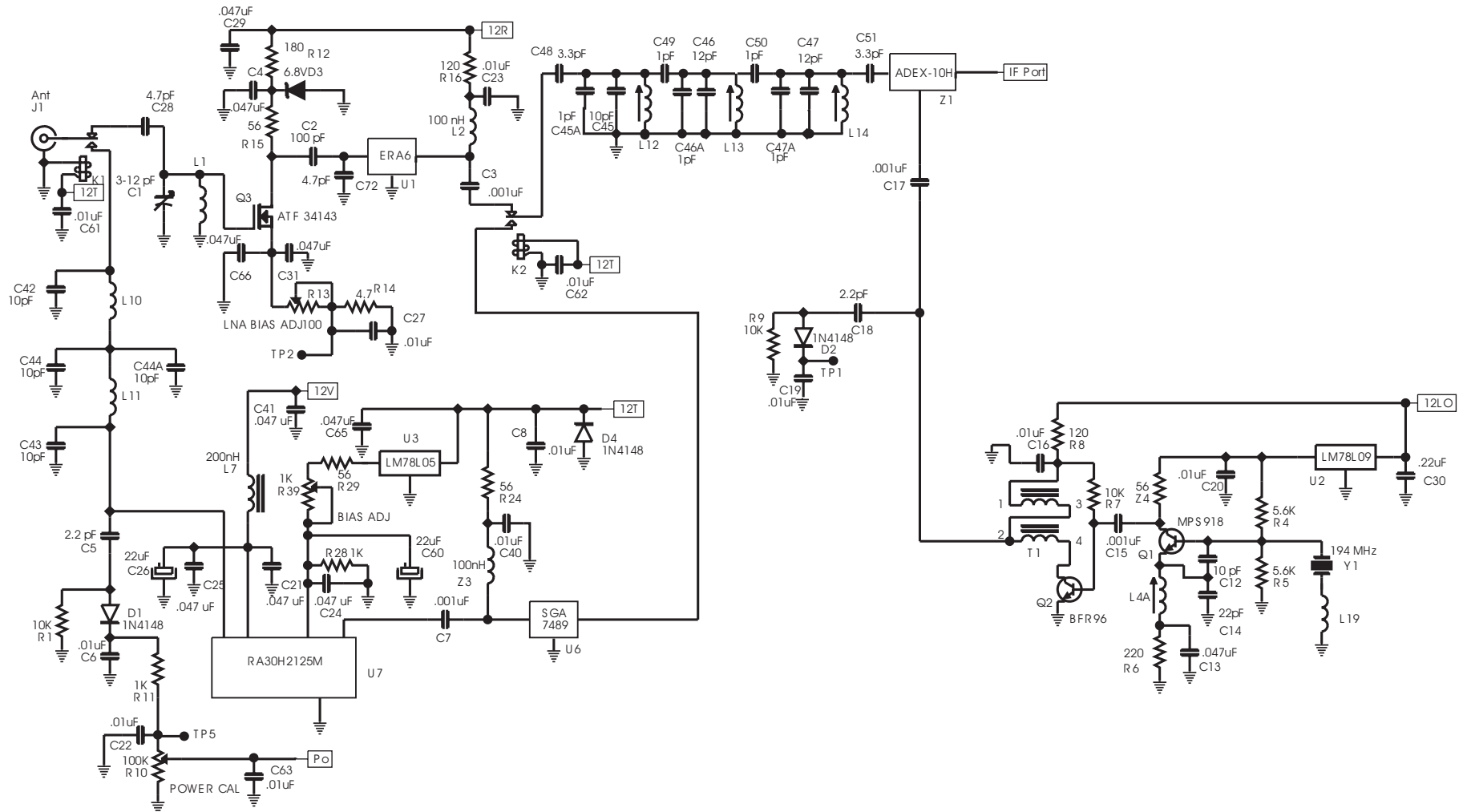
# XV50 R.F. Circuits Schematic (R.F. Board)



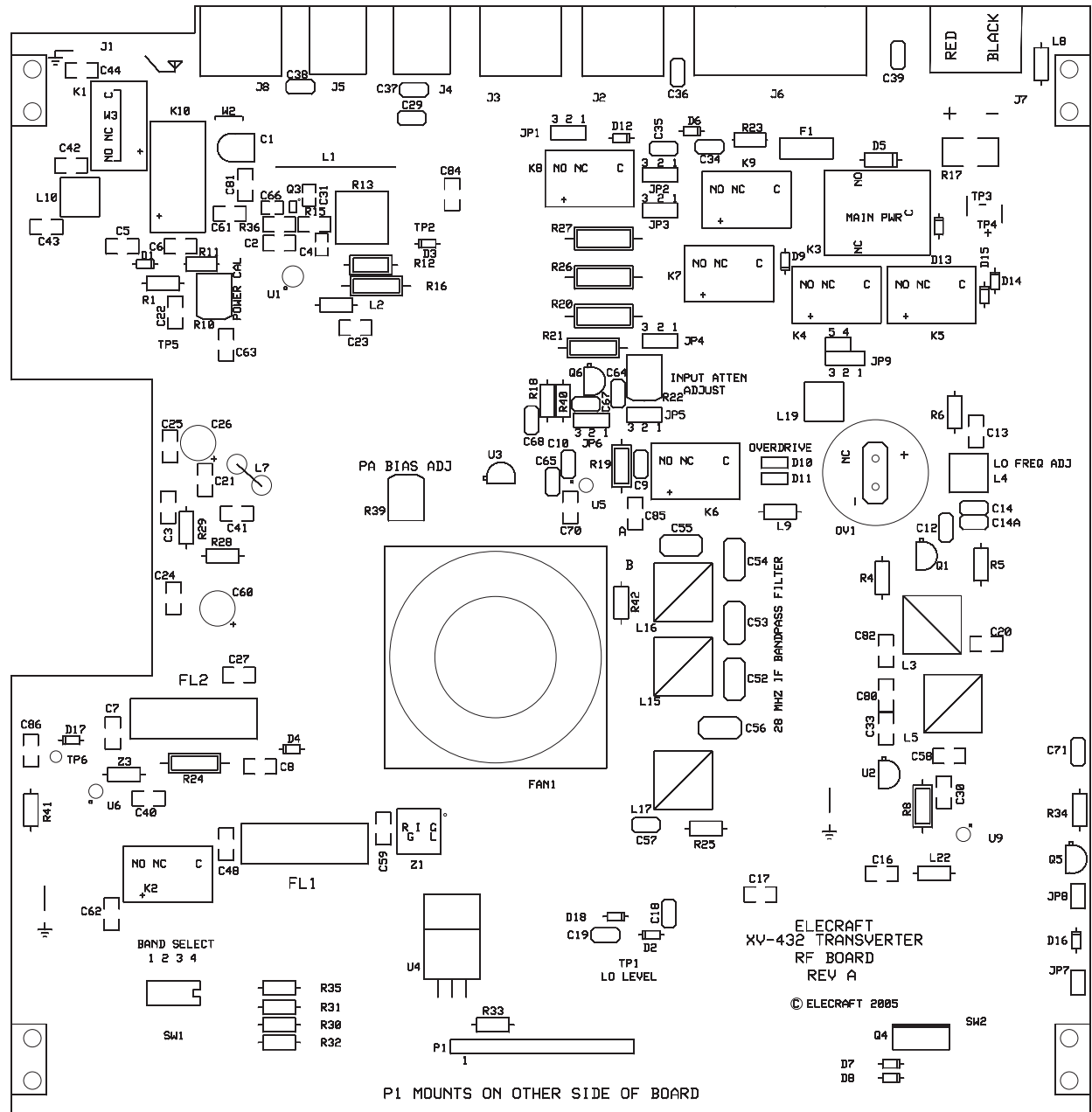
# XV144 R.F. Circuits Schematic (R.F. Board)



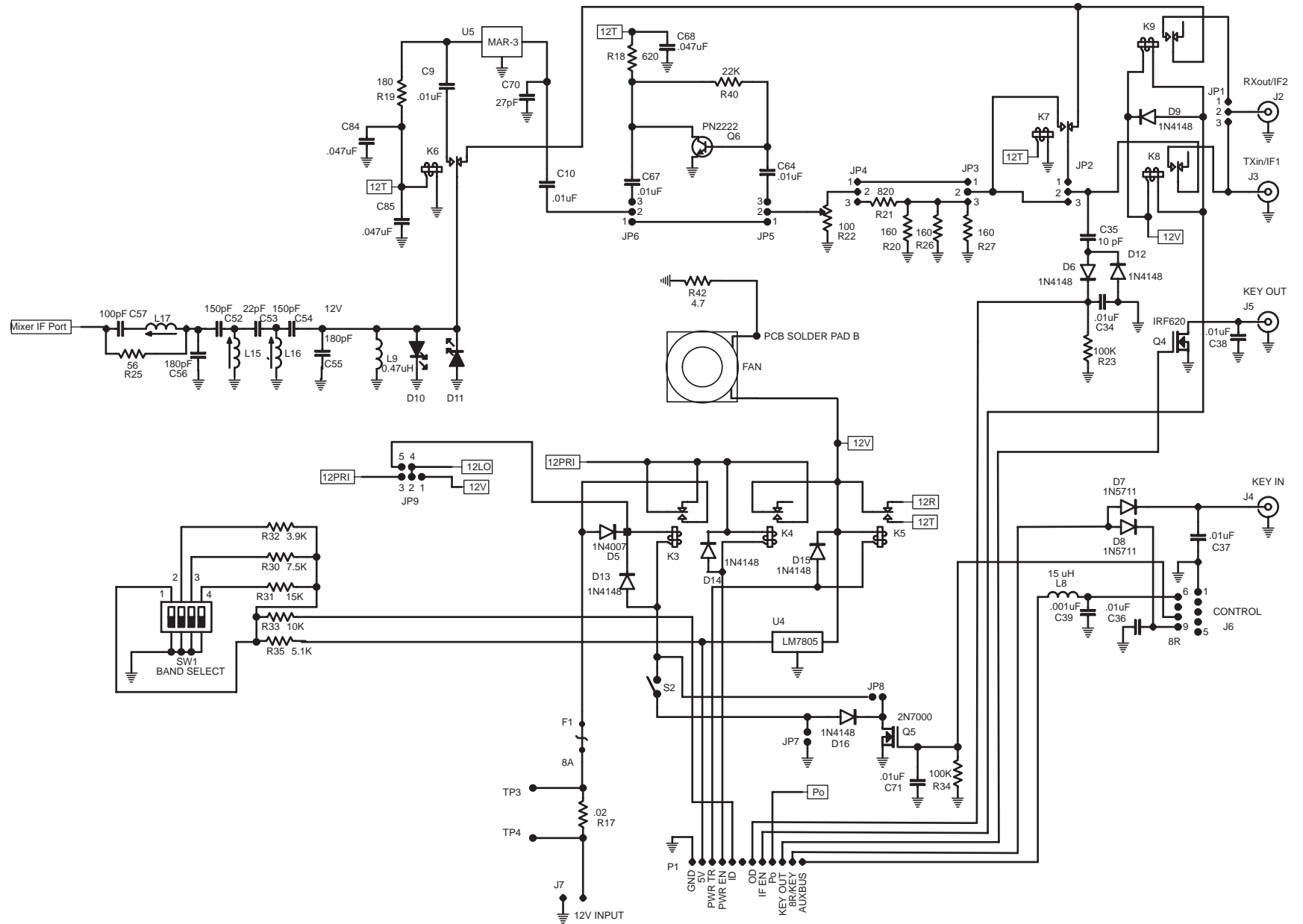
# XV222 R.F. Circuits Schematic (R.F. Board)



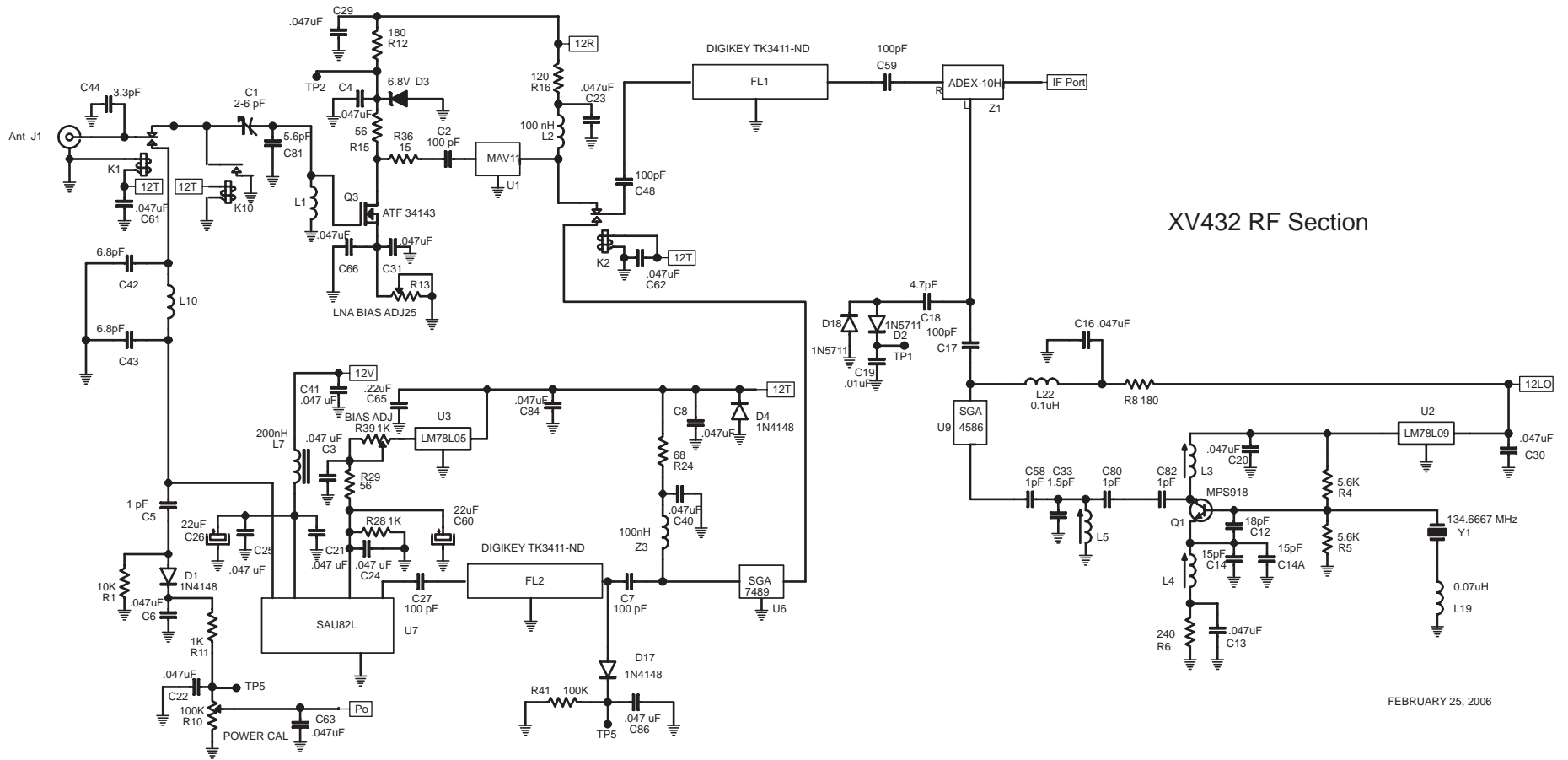
# RF Board Parts Placement Drawing XV432



# XV432 I.F. and Control Circuits Schematic (RF Board)



# XV432 RF Circuits Schematic (RF Board)



XV432 RF Section

FEBRUARY 25, 2006

## Appendix B – Troubleshooting

RF Power Module U7 voltages:

XV50	U7 Pin (from rear)	RX Mode	Tx Mode
	1	0	do not measure
	2	13.6	13.2
	3	0	9
	4	13.6	13.2
	5	0	do not measure
XV144, 222, 432	1	0	do not measure
	2	13.6	
	3	0	3.5 – 4.5
	4	0	do not measure

Typical Voltages at test points (VDC unless otherwise noted):

Location		Rx Mode	Tx Mode
TP1	XV50	0.8 – 1.2	0.8 – 1.2
	XV144	1.2 – 1.8	1.2 – 1.8
	XV222	1.0 – 1.5	1.0 – 1.5
	XV432	2.2 nom.	2.2 nom.
TP2	XV50, 144, 222	200-275 mV	N/A
	XV432	5.0 VDC	N/A
TP5	XV50	N/A	-
	XV144	N/A	-
	XV222	N/A	-
	XV432	N/A	9*
TP6	XV432 Only	N/A	1.5*

\* at 20 watts output.

Typical voltages active devices (VDC unless otherwise noted):

Location		Rx Mode	Tx Mode
U6	Output Pin	0	5
U4	1	13.6	13.6
	2	0	0
	3	5	5
Q2	B	0.25 – 0.8	0.25 – 0.8
	E	0	0
	C	6.5	6.5
Q1	B	4,1	4.1
	E	3.6	3.6
	C	8.5	8.5
U5	Output Pin	0	4.7
U1	Output Pin	3.0 – 6.0	3.0 – 6.0
U3	Input	0	13.6
	Output XV50	0	9
	Output XV144, XV222	0	5

# Appendix C – Jumper and DIP Switch Settings

## Jumpers

The following is a summary of all the jumpers and their functions. The recommended jumper settings are provided in the Installation instructions for most station configurations. This summary is provided for general information and to aid troubleshooting in case your transverter does not behave as expected.

### POWER SWITCH OPTIONS

These are two-pin jumpers. X indicates a shorting block in place. O indicates no shorting block.

Function	JP7	JP8	Notes
If 28 MHz Rig is <b>not</b> an Elecraft K2	X	O	If the transverter is connected to an Elecraft K2, be sure there is no jumper on J7. Possible damage to the transverter may result.
Disables the transverter On/Off pushbutton when an Elecraft K2 is used with the transverter.	O	X	Transverter power is turned On when the transverter is selected by the K2 BAND switches.
Enables the transverter On/Off pushbutton when an Elecraft K2 is used with the transverter.	O	O	<b>NOT RECOMMENDED.</b> This configuration will not damage the equipment, but may result in unexpected behavior of the transverter power switch.

### I.F. POWER CONTROL

The following jumpers are set according to the approximate driving power from the 28 MHz rig. Fine adjustment is done using Input Atten Adjust, R22, on the transverter RF board. If you find R22 is difficult to adjust because it is set too close to one limit of its range, adjust the jumpers accordingly.



**Do not exceed the maximum input power from the 28 MHz rig shown for each jumper configuration. Excessive power may damage the transverter.**

Transmit I.F. Power from 28 MHz Rig	JP3	JP4	JP5	JP6	Notes
-20 dBm (0.01 mw) to 0 dBm (1 mw) max.	1-2	1-2	2-3	2-3	JP3 and JP4 bypasses the fixed attenuator. JP5 and JP6 enables amplifier Q6.
Up to +24 dBm (251 mw) max.	1-2	1-2	1-2	1-2	JP3 and JP4 bypasses the fixed attenuator. JP5 and JP6 bypasses amplifier Q6.
Up to +39 dBm (8 watts) max.	2-3	2-3	1-2	1-2	JP3 and JP4 enables the fixed attenuator. JP5 and JP6 bypasses amplifier Q6.



## I.F. PORT CONFIGURATION

These jumpers configure the I.F. ports for either separate transmit and receive RF connections to the 28 MHz rig or common transmit and receive RF connection to the 28 MHz rig.

Function	JP1	JP2	Notes
Single I.F. Port Sharing Transmit and Receive	2-3	1-2	When single coaxial cable connects transverter to 28 MHz rig antenna connector.
Separate Transmit and Receive I.F. Ports	1-2	2-3	When separate coaxial cables are used for transmit and receive (e.g. K2 with K60XV module).

## LOCAL OSCILLATOR POWER CONTROL OPTIONS

These jumpers allow the local oscillator to be left operating at all times power is applied to the transverter for maximum stability, or to turn it off to avoid possible interference from the local oscillator on other bands.

Power Option	JP-9
Local oscillator power turns Off when transverter is deselected at the Elecraft K2 or when the transverter Power switch is Off (if the transverter Power switch is enabled).	1-2
Local oscillator power is On whenever transverter power switch is On (if the transverter Power switch is enabled) even when the transverter is not selected by the Elecraft K2.	2-3
Local oscillator power is On whenever +12 volts is applied to the transverter, regardless of the Power Switch setting or whether the transverter is selected by the Elecraft K2.	4-5

## TRANSMIT DELAY OPTION

This option allows holding the transverter in transmit mode for up to 200 milliseconds after the 28 MHz rig has switched the KEY line to receive to avoid timing problems with some rigs. It is not available when using an Elecraft K2. The K2 has the proper timing to work with the transverter as the fastest-possible speeds.



**This jumper is located on the front panel board, between the end of the socket-mounted processor and the side of the transverter. Do not confuse it with JP1 on the transverter RF board.**

These are two-pin jumpers. X indicates a shorting block in place. O indicates no shorting block.

Function	JP1
50 ms T/R delay	O
200 ms T/R delay	X

## DIP Switch

The DIP switch on the transverter RF board is used to identify whether the 28-MHz rig used with the transverter is an Elecraft K2 and, if the rig is a K2, which TRN number has been assigned to the transverter.

TRN	DIP SWITCH POSITIONS			
	1	2	3	4
NO K2	ALL SWITCHES OFF			
1	ON	OFF	OFF	OFF
2	OFF	ON	OFF	OFF
3	OFF	OFF	ON	OFF
4	OFF	OFF	OFF	ON
5	OFF	ON	ON	OFF
6	OFF	ON	OFF	ON
7	OFF	OFF	ON	ON
8	OFF	ON	ON	ON