

ELECRAFT TRANSVERTER APPLICATION NOTES

Rev C

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Editors Note: This article was written before the introduction of the K60XV low level transverter output option for the K2 and before the introduction of our XV transverters. The Elecraft XV50, XV-144 and XV-222 may all be stacked and fed off of the same 28 MHz IF drive line. These transverters have internal switching relays that drop the unused transverters off the IF bus. No external switching is required. When connected to the K2's AuxBus via the KIO2 or KPA100, the Elecraft XV transverters will automatically turn on/off and connect to the IF bus as each transverter band is selected on the K2. The section on switching though is still a good description of how to switch non-elecraft transverters. Also note the the KRC2 band decoder for the K2 (and other rigs) provides switching outputs for the transverter bands.)

Transverter Overview

Transverter is a contraction of the term transmitting and receiving converter. It is easily visualized as a new "front end RF section for your existing HF radio and consists of a common local oscillator for receive and transmit, mixers, and assorted RF amplifier stages. The transverter will convert receive and transmit frequencies from one amateur band to another. The transverter typically has a means of being switched between receive and transmit, e.g., a relay or PIN diodes. By utilizing an existing HF radio as an IF amplifier, (typically on 28 MHz) the performance of the HF radio can be duplicated on any VHF band. Generally, a low level transmit signal/ receive connection, and TX/RX switching, will interconnect the HF radio and the transverter.

There are many advantages inherent in transverter operation on the VHF and UHF bands. The first and most obvious is the tremendous cost savings, by not having to duplicate an entire radio as you go to new bands. Other benefits will depend on your specific VHF application to some extent. As a K2 owner, you are no doubt well aware of the characteristics that make the K2 stand out among HF radios. Obtaining great performance on VHF/UHF can be elusive when multi-mode standalone commercial transceivers are employed. In almost all cases, there is little attention spent to CW operation. Filter options are poor or often non-existent. Receiver dynamic range can be quite poor. General ergonomics can be difficult with small boxes, multiple questionable features, confusing menus, and limited space for button pushing! A transverter will re direct the full feature set of your HF K2 to your favorite VHF band with little change in performance. Receive dynamic range difficulties on VHF can be significantly more pronounced than at HF due to increased antenna gain, propagation differences, and lower angle of radiation when compared to, say 20 or 80 meters. Having a crunch-proof receiver can pay great dividends for the VHF Dx'er or contest operator as well as the casual user. There are also some bands that are lacking in choices for standalone VHF/UHF radios. The 222 and 902 MHz bands are cases in point. The same can also be said of all the bands above 1.2 GHz. To get a good signal on any of these bands, a transverter is the only way to go.

The transceiver is often called the "IF" to reflect the role it plays. Common IF frequencies for transverters are 28 MHz and 144 MHz, although some other HF bands are also used in some instances. A 222 MHz transverter, such as the Downeast Microwave 222-28K, is connected to the RF output jack of an HF transceiver and to a 222 MHz antenna at its own RF output port. It receives a low level transmit signal from the HF transceiver in the 28 MHz range and converts the signal to 222 MHz and then amplifies its' own RF output. When not transmitting, the 222-28K receives 222 MHz signals and passes them along to the transceiver as a 10 Meter signal.

Transverter architecture will fall into two broad general categories. Category 1 uses a single RF connection and generally requires a few to ten watts of drive from the HF transceiver. TX RX switching can be obtained from RF sensing, or keying lines between transverter and HF transceiver. Such designs can allow a 10 watt 144 MHz transceiver to operate on 50 MHz for example with a minimum of fuss. A small 20 meter QRP rig can easily operate on 144 MHz. Simplicity is the rule. Such a setup is shown in FIGURE 1. Category 2 is somewhat more complicated by using separate receive and Transmit paths between the radio and transverter. The TX level is typically designed for somewhere near 1 milliwatt, but may accommodate ranges up to 500 mw or down to -20 dBm with pot adjustments in the transverter. This layout will allow for changes for station performance improvements. New receive preamps and transmit amps may be added without complex switching modifications. In many cases, a sequencer may be installed to control switching of coax relays, transverter, preamps etc. etc. FIGURE 2 demonstrates the Category II transverter

hookup.

The K2 does not allow for 1 milliWatt transverter operation directly as yet, but there is a simple remedy to allow K2 operation with split receive and transmit. (Ed. Note: The K60XV option for the K2 now provides a separate low level drive output for transverters.) The 160 meter band option includes a separate receive terminal that can be used on any HF band, so, by adding a 160 meter kit, the separate TX and RX path problem is resolved. Most operators install a plug in attenuator on the main output BNC jack. These may be simply made with carbon composition resistors. The value may be tailored to the power level required by the transverter, A 30 dB pad will attenuate one watt from the K2 to the one milliwatt level. This will be explained fully in the Transverter Connection Details section below.

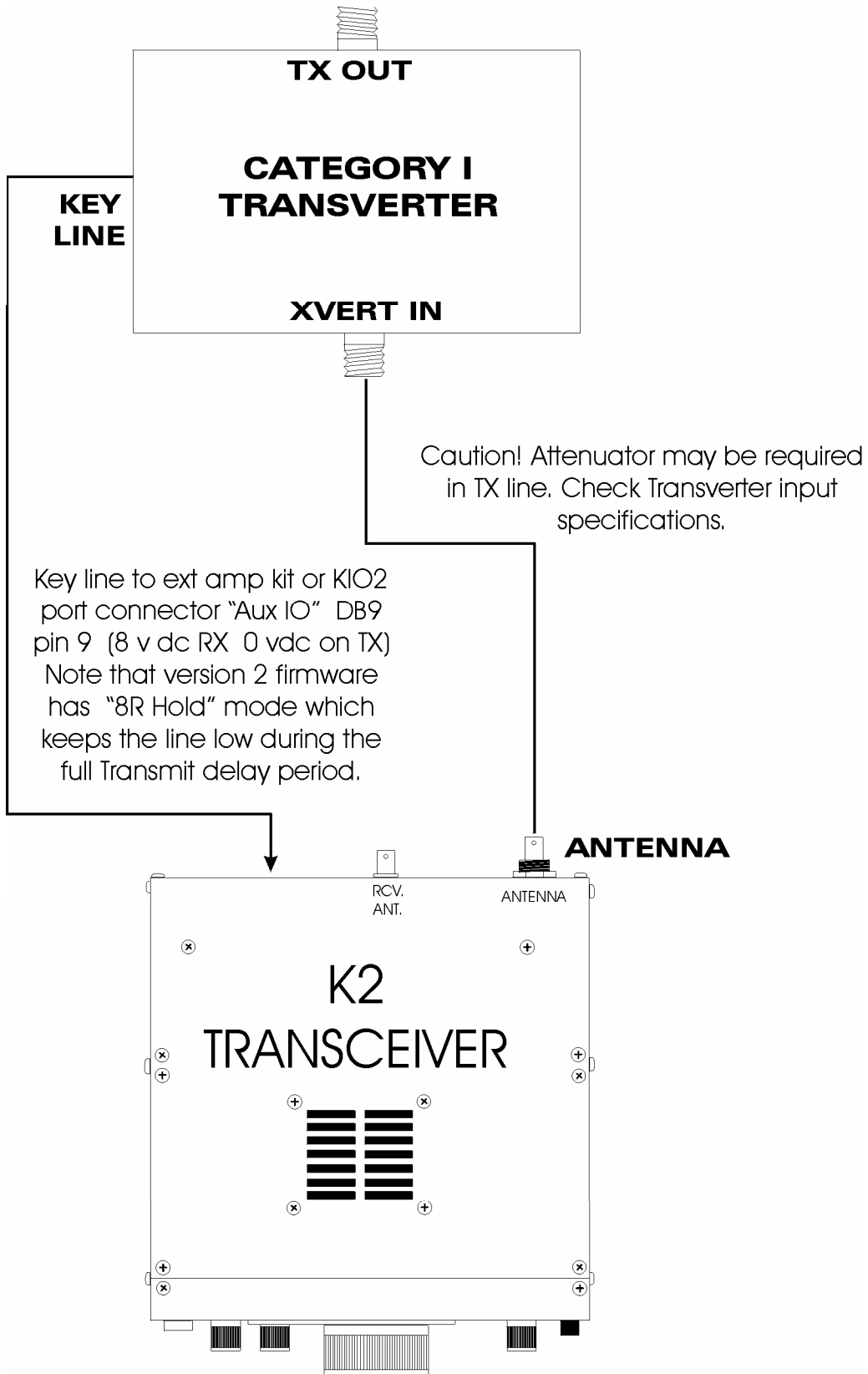


FIGURE 1.

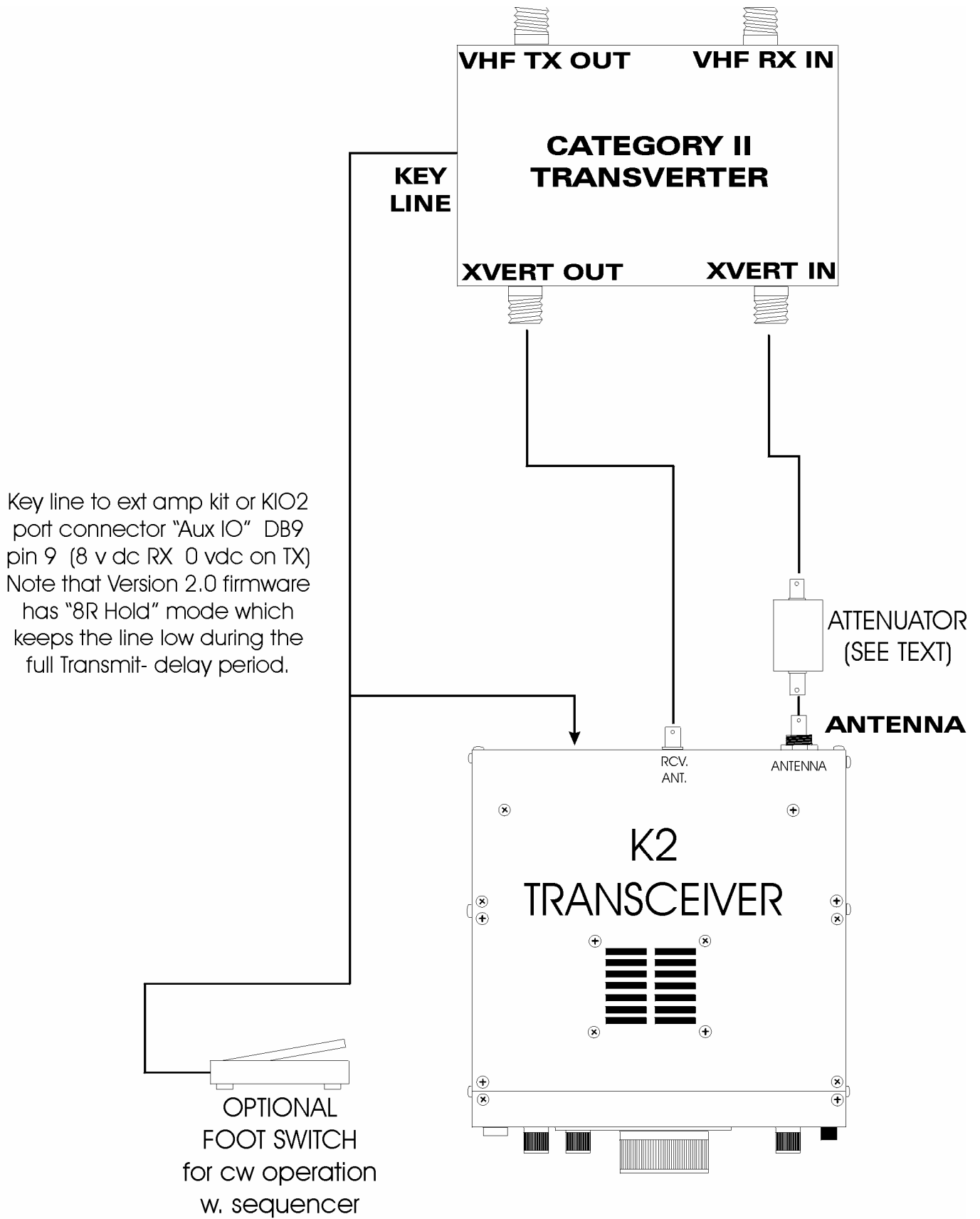


FIGURE 2.

K2 Support for Transverter Operation

Beginning with K2 Firmware Revision 2.0 and above, the K2 supports up to three different transverters and provides enhancements to facilitate their operation. For each of three transverters, the firmware supports (Ed. note: Current K2 firmware now supports up to 6 transverter bands.)

1. specifying the frequencies for the IF and RF interface between the transceiver and the transverter,
2. selecting a power level for the IF signal to the transverter,
3. an offset to compensate for slight inaccuracies in frequency, and
4. directly displaying the transverter frequency on the K2 display (if you have the KIO2 CAT control interface installed, sending the transverter output frequency to your logging program or CAT control program).

Setting the Firmware for Transverter Support

To set up the K2 for transverter operation, tap the **MENU** button and then tap **DISPLAY** to select the NEW secondary menu, labeled **SEC**. Turn the main dial until **Trn1** is displayed, then hold **MENU** to select transverter #1 and turn it to **On**. This enables transverter #1 support.

Setting the IF and RF frequencies

Once transverter #1 support is turned **On**, tap **DISPLAY** once to select the RF frequency. Turn the VFO dial until the RF frequency for your transverter is displayed. This can be any number between 0 and 999 MHz. Your transverter documentation will show the relationship between specific RF and IF frequencies. In our example above, set **rF** for 222 MHz. Tap the **DISPLAY** button again, **IF** will be displayed, and now you can enter the corresponding IF frequency that your transceiver supports. In the example, turn the VFO dial to select 28 MHz.

Setting the Offset

Tap **DISPLAY** again and the offset symbol, **OFS**, will be displayed, initially set to 0.00. You can use this adjustment to compensate for any discrepancies between the IF frequency of your transceiver and the RF frequency of your transverter. Although you may be able to adjust your transverter to not have any discrepancy between the IF and RF relationship, OFS offers a convenient way to make this adjustment based on measurements and on-air reports. The adjustment range for the offset is +/- 9.99 kHz. If you do not know what offset you might want at this point, simply leave this setting at 0.00.

As an example, suppose a 222 MHz transverter with a 28 MHz IF crystal oscillator frequency could be at 96.997 MHz. This will translate to an LO freq of 193.994 MHz. (multiplied X2 in the transverter) A signal on exactly 222.100 MHz will then appear on 28.106 on the K2. ($222.100 - 193.994 = 28.106$) If you apply a -6.00 kHz offset in the K2 firmware **TRN** menu, the K2 will read the frequency with no apparent error. The K2 dial will indicate 222.100 MHz.

Setting the Output Power Control

This setting allows you to set the IF power level from the transceiver to the transverter over a limit of 1 watt to the maximum your K2 is capable of supporting on the IF band. This setting is independent of the power control setting on your front panel. The K2 supports a different power setting for each supported transverter.

A transverter normally expects the IF power to be within certain limits, so this feature provides for close control of output power when on a transverter band. Without this feature, you would have to ensure that you had adjusted the Power knob to a proper level.

NOTE: The minimum Power Control Setting of 1 watt is the lowest reproducible level that the K2 supports reliably in all modes, although some transverters require a much lower power than this. Consult the documentation for your transverter to determine what the optimum and maximum power levels are that your transverter can handle before

transmitting into it with your K2. You may need to take steps to manage the IF power delivered to your transverter from the K2.

Tap **DISPLAY** once again until **Out** is displayed. Here you can set the output power for this transverter band to follow the Power knob on the front panel (for this, select **Pot**), or you can specify the actual power output from a range of 1.0 watt to 15.0 watts. Select the power level that is most appropriate for your transverter.

If you want to continue to review your settings, continue to tap the **DISPLAY** button to view them. Once you are satisfied with your settings, tap **MENU** to return to the Secondary menu.

Viewing the Results of your Settings

For each of the three transverters supported, an additional band is now available on your display. Tap **MENU** again to return to normal operation, and then tap **BAND+** or **BAND-** to view the list of bands your K2 supports. As you move through the bands, after the 10 meter band, the display will briefly indicate which transverter band you have turned on, and will then display the actual frequency of the transverter (within limits noted below). In the example we have used, the display will now read 222 MHz.

The K2 will support a display of up to seven digits, which on the HF bands, is a resolution of 10 Hz. When a transverter band is selected, if the RF frequency is 100 MHz or greater, the K2 is not capable of directly displaying the full frequency to a resolution of 10 Hz. Depending on your **rAtES** setting, the K2 manages RF frequencies of 100 MHz up to 999 MHz as follows:

- In the 1 kHz position, the display will show all the whole digits of the transverter RF frequency: 123456.
- In the 50 Hz position, the display will show all the digits to the nearest 100 Hz: 123456.7
- In the 10 Hz position, the most significant digit is dropped and the remainder of the frequency is displayed to a resolution of 10 Hz: 23456.78

Once you have activated one of the transverter bands, then you can use that band transparently on your K2. Of course, you will need to manage the connections to your transverter so that your IF signal is connected to the transverter. Some transverter interfaces provide for a bypass of the IF frequency to the HF antenna if turned off .

Transverter Connection Details

Typical transverters can be connected in a number of ways to the IF transceiver. The connection variations employed cover single or separate RX and TX cables between the units, as well as different ways to control the switching and power control operations. **(Ed. Note: The Elecraft XV50, XV-144 and XV-222 may all be stacked and fed off of the same 28 MHz IF drive line from the K2 or other rigs. These transverters have internal switching relays that drop the unused transverters off the IF bus when they are powered off. No external switching is required. When connected to the K2's AuxBus via the KIO2 or KPA100, the Elecraft XV transverters will automatically turn on/off and connect to the IF bus as each transverter band is selected on the K2.)** Downeast Microwave's web site has an excellent discussion on transverter interfacing. See <http://www.downeastmicrowave.com/Inter.htm>.

Single IF Cable Connection (Category I)

In this setup, a single cable carries the RX and TX signals between the transceiver and the transverter. As the K2 switches between RX and TX, a switching circuit in the transverter makes a corresponding change in the transverter. See Figure 1. On a K2 with the KAT2 auto-tuner, the best way to connect the two units is to dedicate the second antenna jack on the back of the K2 to the transverter. The transverter band on the K2 can be set to Antenna 2 (and the rest of the HF bands to Antenna 1) so that no switching of cables is necessary when using the transverter band; simply selecting the transverter band and transmitting would send the signal to the transverter.

Separate RX and TX Connections (Category II)

Some transverters can use (or require) separate coaxial cables for RX and TX. In this setup, the K2 will need to have the 160m / Receive antenna option installed so that the RX antenna can be used for receiving the signal from the transverter, while the regular antenna jack on the K2 can be used for transmitting to the transverter. This option would be of interest to those users who need to attenuate the TX signal from the K2 for proper drive levels to the transverter. Since one would not want to attenuate the received signals from the transverter, this is the only way to include the attenuator unless relay switching were used. Figure 2 shows a typical setup of this type.

Connecting Multiple Transverters to the K2

The K2 firmware will support up to three transverters, but today can only support one at a time without swapping cables on the rear of the unit. In order to support multiple transverters, the user would need to purchase or construct an appropriate switch box that switched the K2 between each transverter. Since the switch box will be switching RF, it will need to have appropriate (very high! –90 dB) isolation between the various receive lines. TX lines need low isolation. Also, it should be capable of providing power switching between transverters. The details of such a switchbox is beyond the scope of this note. Elecraft may produce an intelligent switchbox that would handle the switching chores automatically using the Aux I/O so that by simply selecting a transverter band, the switch box settings would be automatically managed at the same time.

Some Transverter “Philosophy”

The goal of any transverter / transceiver interconnection is to preserve the operating flexibility and performance of the stand alone HF radio. There should be no surprises or traps. In short we need a foolproof connection. Someone said that at 2 am after a marathon contest stint, anyone is a potential fool! Design your hookup to avoid overdriving the TX stages and possibly destroying the overloaded circuit. Set any attenuators to absorb the maximum power available in the transceiver so that, if that happens, the transverter will not be overloaded. ALC derived power control adjustments can have a nasty habit of delivering max power for a split second when first turned on. This can be time enough to pop something! Some radios actually put out a power spike when turned off! The K2 is well designed and suffers from none of these problems. It is still a good idea to plan on someone running maximum power into your transverter at 2 am. Plan accordingly. If someone keys the K2 while not changing bands to the required **trn** band, is it possible to overdrive a transverter? A simple attenuator and some thought can prevent these oversights from becoming bad events!

Gain distribution in the system should be taken into consideration. Any additional gain in the transverter (or ahead of it) will reduce your dynamic range in the K2. Generally, you want the minimum gain necessary in the transverter to set the input noise figure on the VHF/UHF band. More gain will only ruin the excellent dynamic range numbers in the K2. Here is where the K2 input attenuator can and should be used if you have too much transverter gain. While a full discussion of this point is beyond the scope of this application note, it is a good idea to mention it while discussing “philosophy”!

Modifications to K2 for milliwatt output for transverter output

The K2 may also be run with milliwatt output levels to drive a transverter. (Ed. Note: The K60XV option now provides low level transverter output from the K2.) The category II transverters have separate RX and TX ports and usually like to see around 1 milliwatt of 28 MHz drive. Running transverters at this level has several advantages. First and foremost, it is hard to damage anything with 1 milliwatt!

Another advantage of such low power levels involves reduced or eliminated interference between VHF IF radios when tuned to 28 MHz in multi transmitter situations (multi-op contests). Power consumption is reduced if the high power amplifier stages at 28 MHz can be turned off . The K2 does not support amplifier turn off at this time.

A simple method to obtain approximately 1 milliwatt, or “0 dBm” of transmit energy is easily accomplished. J-13, the future transverter jack and plug combination in the K2 has the low level transmit signal available on pin 3 & 5. The receive signal is also present there. A keying mod kit is available from Elecraft, (“AMP KIT”) which provides the plug and connector for J-13 as well as switching buffer transistors for attaching external amplifiers etc. It is a simple matter to install the 8 pin jack and plug assembly and run a small RG-174 coax cable from pin 5 and the ground on pin 4 to a BNC connector in one of the open transverter jacks. Be careful to also install a 1 nF capacitor in series with the RG-174 center lead as there is a +8 VDC switching voltage present on pin 3 & 5. You have enough room on the small perf board to hold the two switching transistors as well as the 1 nF blocking capacitor for the TX out signal. That is all that is needed! For receive, use the 160 M antenna jack.

The actual output available on J-13 pin 3, and pin 5 is about –10 dBm with the K2 output power level set at about 3 watts. Full power available at J-13 is about -5 dBm. Most transverters, including the Downeast Microwave VHF units, will accommodate this power level. Most newer Icom and Yaesu transceivers have similar, or even less, transverter drive levels, so almost all transverters of the category II type will accommodate these levels. If some older transverters cannot be driven fully with the drive available, a simple MMIC amplifier stage such as a MAR 6 can be installed in the transverter input line to increase drive by 10 dB or so. Remember to connect a 50 ohm load to the K2 output antenna connector whenever you utilize this low drive level port. There will still be RF appearing at the K2 antenna jack. The transmit connector must be terminated. The 50 ohm load can be constructed with simple carbon resistors in parallel to approximate 50 ohms.

To switch the K2 back to normal operation requires connecting the HF antenna to the K2, and turning off the transverter.

The Elecraft external amplifier switching partial parts kit, “AMP KIT”, when combined with the version 2+ firmware, is a very desirable addition to your K2 for switching functions, should transverter operation be contemplated. The KIO2 RS-232 computer interface option will also allow controlling your transverter. The TX RX line (8R) is present on the DB9 connector on pin 9. (+8 volts on receive, and 0 volts on transmit.) The version 2.0 firmware has added a new option to the **T-R** position in the K2 primary menu. **T-R**, as you may remember, controls the QSK delay. The new 2.0 firmware option allows turning off the QSK feature to allow control of the more complex VHF or microwave transverter setups. Generally, such setups contain expensive coax relays to switch high power on the VHF bands, and sequencers to manage switching times between coax relays, pre amplifiers, and the transverter itself. The normal QSK of the K2 would probably burn up most relays, or cause excessive relay switching noises. The 8R buffered line can control the sequencer directly as it will switch a positive voltage to ground on Transmit. Current available is about 2 ma., which is fine for most sequencers such as the DEM TRS sequencer. (It needs 1 ma to ground for proper keying) Sequencers allow the coax relay to switch and bounce a bit before RF power is applied to the relay contacts. Delays of 50 to 500 ms are typical in most installations. Sequencers will also protect low noise GaAsFET preamplifiers. Hot switching lots of RF energy can destroy fragile GaAsFETs.

To set the proper delay in your K2, proceed to activate the main menu by tapping the **MENU** button on the K2. Rotate the tuning knob until the **T-R** setting comes up. Push and hold the **MENU** button again to activate the **T-R** menu setting. You can tune the main tuning knob to change the QSK delay time from 0.0 to 2.55 seconds. At this time while **T-R** is activated, you can tap the **DISPLAY** button and the screen will toggle between **8r-Nor** and **8r- hold**. Use **8r-hold** for transverter operation. You can experiment with the T-R delay settings. The proper choice involves how much you want your coax relay to

work, and how responsive you want your receiver to be to quick exchanges.