Integrating the K2 and Transverters Using the KRC2 Band Decoder and Transverter Interface K60XV

By Mike Lewis, K7MDL
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Introduction

I desired to build a K2 based high performance portable station that would serve my VHF, UHF, and microwave needs, but preserve the full HF capability, Additionally I wanted it to be simple to operate requiring no more than pressing the K2's BAND UP and BAND DOWN buttons to select the right band's equipment lineup.

I wanted to use any digital mode such as meteor scatter and EME, which required that I set certain drive levels for external power amplifiers and TR/relays mounted on my tower. If that was not enough, I wanted to be able to lift this system off my desk and drop into my truck for a VHF or microwave contest in less than 10 minutes. Just add the antennas on the truck (which are generally pre-mounted to removable poles) and I am off to a remote mountain top somewhere.

My station is built to cover the following frequency bands:

1. 160M through 10M using my QRP K2 with the KAT2 and battery
2. 144MHz, 222MHz, 903MHz, 1296MHz, and future microwave bands such as 2304MHz and 3456MHz.
3. Possible expansion for 50MHz and 432MHz later. I already had those bands adequately covered with other gear so my priority was on other bands for now.

I could have optimized the 2M setup to just drive transverters since I had several other radios with 2M capability; however I wanted to take advantage of the K2's crunch proof front end. During VHF contests when I am on a mountain top and other contest rovers are line of sight from me, and kilowatt contest stations are running in the valleys below me, my other rigs caved in with front end overload and operating on 2M was useless for a period of time. With the K2, that has changed.

Requirements

Here is a list of the general requirements that I needed to satisfy:

1. The K2 is the IF and HF radio anchoring my setup. An IF radio means that the K2 28MHz output is used to drive a transverter to put me on a VHF or microwave band and preserve the features and performance of my K2.
2. All relay switching, antenna selection, and transverter enabling would need to be coordinated through the radio interfaces.
3. For portability and speed, mount everything in one compact box. It needed to look nice and match my home office furniture well.

4. All power distribution would use Power Pole connectors where possible. The house and the truck are equipped with distribution this way. I use RIGRunner panels in the box and at home and some standard heavy red/black wire jumpers. For 24VDC power I also use the Power Poles, but they are oriented 90 degrees from the 12VDC configuration so I cannot mix them up. The 24VDC 900MHZ amp has a Power Pole connector on it. I use a 29amp 24VDC power supply at home, and batteries when mobile.
5. Antenna connectors are easy to get at for rapid hookup.
6. I standardized on Type N for antenna connections on all bands above 30MHZ.
7. My jumpers are all N to N reducing the chance of not having the right kind of coax jumper handy.
8. Internal jumper connections I standardized on RG-142 and RG-316 Teflon coax with SMA, BNC and N connectors.
9. Computer hookup through an appropriate interface.

Here is a list of my detailed requirements:

1. For 144MHz SSB/CW
    a. Using the XV144 transverter. This would be used with or without amplifiers.
    b. 300W external amplifier with a drive level at 7W (stays at home with split TX/RX) with PTT.
    c. 80W amplifier mounted it the same box as the radios, with PTT. A 10W input model was chosen to match the 7W drive level needs of the 300W amp. I modified this amp for separate TX/RX feed and common RF output.
    d. Tower mounted T/R relay switchover on 2M for EME preamp and separate receive coax.
2. 222MHz SSB/CW using the XV222 transverter. This would drive an external 120W amplifier with PTT keying. 12W drive level
3. A 1296MHZ DEM transverter with a DEM 18W amplifier and T/R relay
4. A 900MHz DEM transverter with a 100W Motorola amplifier with a T/R relay
5. 28MHz IF switching to the right transverter (144 and 222MHZ) or HF
6. 144MHz IF switching and attenuation to the right transverter or amplifier and antenna connection, with T/R switching
7. Front panel ¼” headphone jack

Looking at the above list of requirements you can imagine the need for a bunch of switches to align all the right parts at the right time. I wanted to eliminate having to be sure to manually hit the right combination of manual switches to prevent missing a quick contest QSO on any rapid band change and to avoid equipment damage. I used to manually align one or more switches. That is no longer needed with the KRC2 band decoder integrated into my station. Some of these requirements are unique to my station layout and VHF interests, but many aspects of this may apply to most anyone. A complete interconnect drawing is at the end of this document.

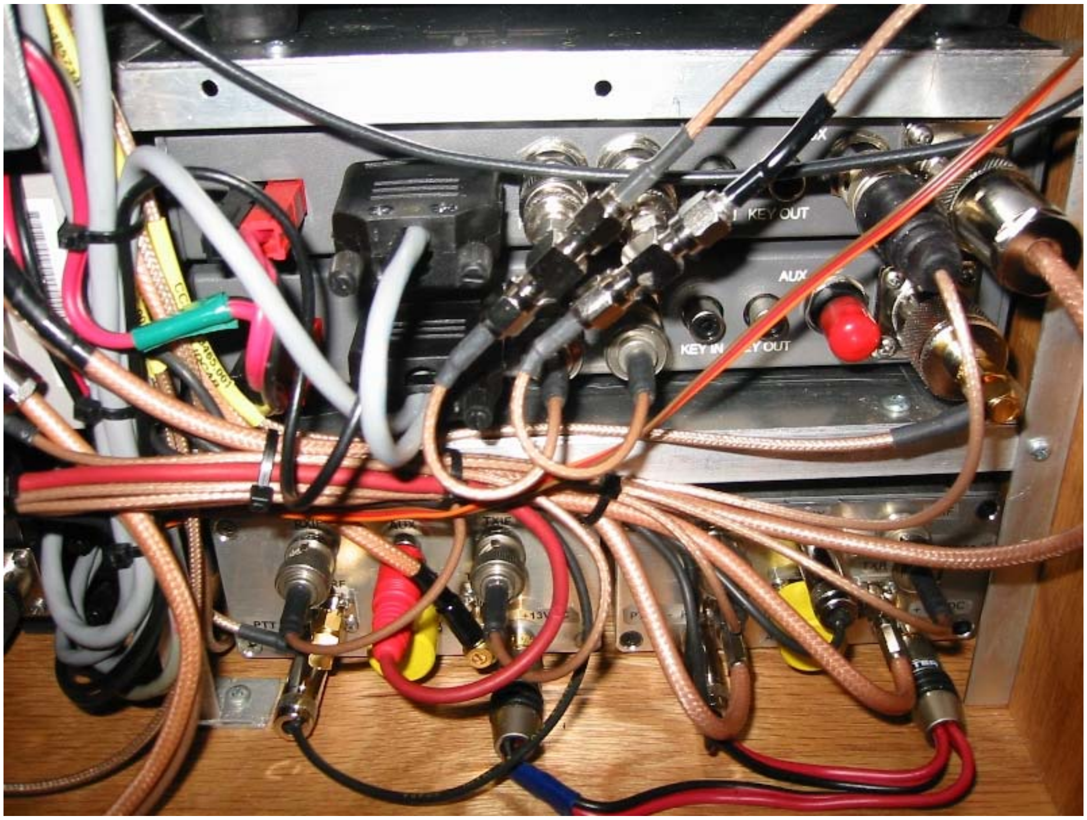
The K2 and associated equipment are housed in a box made from oak plywood to match my desk. Small aluminum angle stock is used for shelf supports and aluminum sheet is used as the shelving. The small panel to the left of the speaker used to be the manual transverter switch – now it only supports the ¼" headphone jack connected to the external speaker circuit. Behind that panel and speaker is a 1296MHz amplifier and power distribution box. The KRC2 is visible on the left side of the 80Watt 144MHz brick amplifier and computer interface box in the right side compartment. The small gray cable in the computer interface next to the mic plug is the RS232 pass though to the KIO2 for computer control.

Band Selection and the K60XV

The K2 firmware (2.04P or newer) supports 6 transverter bands. With the K60XV installed each band can store the direct frequency readout (first 3 digits, 0 to 999MHz), maximum power level in 2 ranges (high level 0-12.7 Watts or low level .01 to 1.27mW), IF frequency (I use 28MHz), a display correction offset to account for transverter LO frequency misalignments, and Transverter control address selection which plays an important role in my solution.

28MHZ and transverter/HF selection

See the station drawing for reference to the cabling needs. I chose to use the Elecraft XV144 and XV222 transverters to ease the 28MHz switching needs and eliminate extra external relays and control wiring,. These transverters offer internal relays that can be automatically selected by either the K2 aux bus commands, or a 12V enable signal. I use both ways for reasons discussed later.



This close-up shows the grey wires daisy chaining the transverters to the KRC2 (barely visible on the left lower corner), and the use of BNC to SMA adaptors on the IF IN and IF OUT connectors allowing use of smaller SMA connectors. This reduces the crowding that BNC Tee connectors cause. RG-316/U Teflon cable is used for most low power circuits for flexibility. RG-142/U Teflon cable is used for higher power circuits. The 2 small brown RG-316/U cables in the upper right connect to the K60XV BNC output jacks on the K2 back panel. A crimp tool and several crimp SMA and BNC connectors make this job a lot easier and is well worth the modest investment. I do not like excess cable so I cut to fit. Note the power cables (red and black) cables to all transverters are also daisy chained to share limited fuse positions. This works fine since only 1 transverter can be keyed up at any time and they share similar current draw. Colored tape color codes the power so I can find the other end at the fuse panel. I use split RF and IF for all transverters except the 222MHz output. T/R relays are downstream after power amplifiers. This keeps the relay count to a minimum at the higher frequencies where loss and availability of quality RF power switches are a concern.

I use the K60XV 60M and transverter level interface to provide 60M coverage on HF, and for the VHF band transverters, it provides an adjustable 1mW level split path (TX/RX) output at 28MHz. The radio will automatically switch between the transverter output and the normal power amplifier and KAT2 outputs, so I have 3 possible HF signal connections to choose from. For HF I happen to have a 20M inverted vee on ANT 1 connector, and a remotely tuned long wire for all other HF bands on the ANT 2 connector. I daisy chain the 28MHz transverter outputs (RX and TX) RG-316 cables with SMA T connectors and BNC connectors.

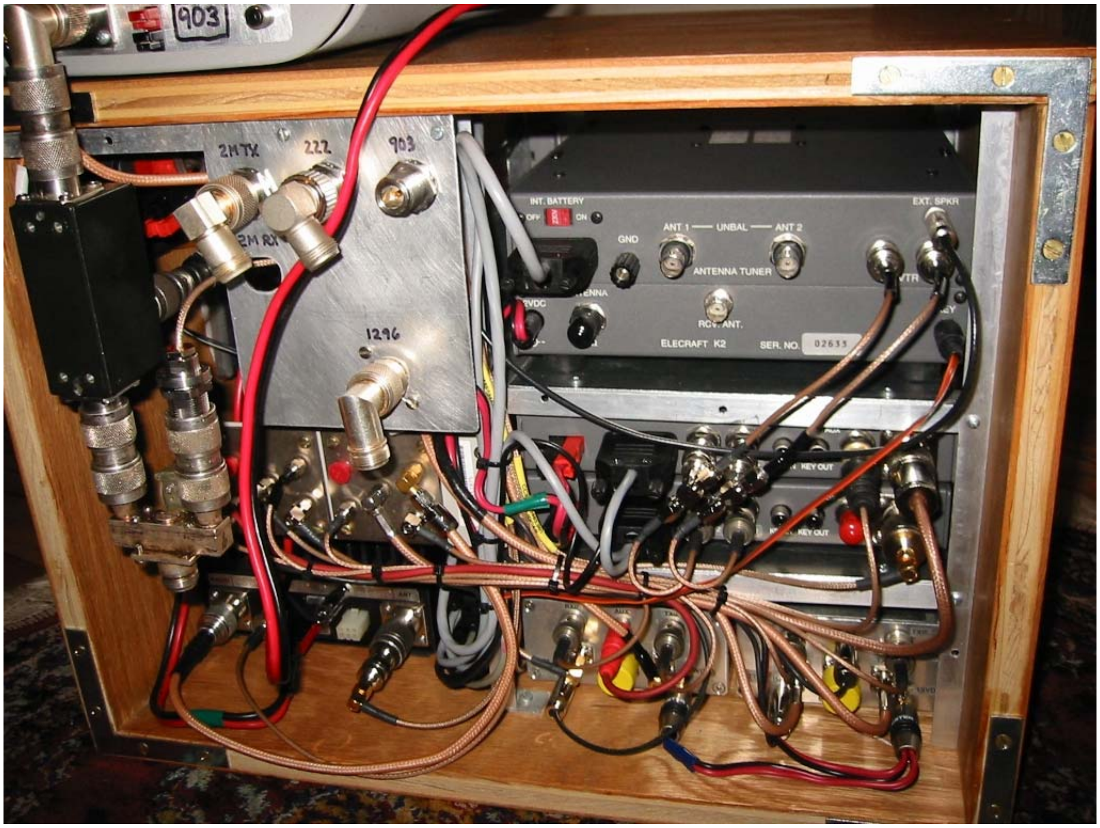
144MHz and 144MHz IF Switching

I use 144MHz output to drive microwave transverters and for direct 2M communications. Because I am using the 144MHz band in several different ways, things are a bit more complicated. You could just equip the K2 with an internal or external low level 28MHz to 144MHz transverter unit (~100mW), such as that available from DEM. Since I wanted to operate the K2 on 2M band directly and I needed 10W for amplifier drive, I decided this was not the way to go for me. Instead I used the XV144 to take advantage of the integrated 28MHz switching, and get up to 20 watts output to drive an amplifier or operate barefoot on 2M.

For driving the microwave transverters I wanted to use a low level output to minimize signal leakage on 2M that might interfere with other adjacent 2M gear. All of my transverters can accept a drive level from 1mW to 10W. In the end I compromised and chose a max drive of 3W. This level was chosen to match the usable range of attenuation the K60XV can provide, and achieving my need for 10W output for amplifier drive. I use high quality Teflon cable to help reduce signal leakage, particularly on the 144MHz high output cables, where I tend to use double shielded silver braided RG-142.

The K60XV will attenuate the 28Mhz TX signal up to 20dB so this would give me a good range to limit the maximum drive level for each transverter and downstream amplifier (each has different needs), and set my XV144 and XV222 for about 12W at max drive (1.27mW). For each transverter band I can program in a lower limit such as 0.30mW and limit the resulting XV144 output on 2M to a lower level such as 1W. The trick to the setup is establishing a system level plan for drive levels to eliminate as many extra external attenuators and switching as possible.

To route the 144MHz output to each transverter I use a pair of SP4T coaxial SMA RF switches. Mine happen to be TTL controlled (~4 to 5VDC to select) and use 28VDC for the relay power. I use a pair of them since I am using split path TX and RX to satisfy my need for an external 300W amplifier and tower mounted preamp and T/R switch to a RX only coax. I happen to have 120ft to my antennas and use 7/8” heliax for the TX leg and also share this heliax run with my 1296 and 900MHz antennas. The preamp drives the 9913 RX cable so loss is no issue there. To support adding additional microwave bands I plan to change to a pair of smaller 28VDC SP6T coaxial switches later. This will affect the KRC2 hookup described later. To add 50Mhz or 432MHz transverters, they use 28MHz IF so I can daisy chain them to the existing arrangement if I use the XV50 and possible future XV432.



This view shows the complete rear wiring and the SP4T SMA RF switches used for 144MHz IF signal routing to the microwave transverters. 2 SMA switches are used, one for TX and the other for RX. Position 1 routes directly to the 144MHz brick amplifier in the lower left corner. Transverter output power levels are chosen to drive the external amplifiers. The K60XV attenuates the 28MHz input reducing the 144MHz transverter output to 2 to 3 Watts to drive the microwave transverters.

KRC2 Band Decoder Configuration

Combined with the K2 firmware and K60XV features, adding the KRC2 band decoder give you great flexibility to control equipment as you change to a new band. Here I describe the control wiring and modifications I made to achieve complete band switching using only the BAND UP and BAND DOWN buttons on the K2.

For the XV222, and future usage of an XV50 or XV432, I use the K2 aux bus control method and set their transverter address IDs to 4, 5, and 6. The reason for starting with 4 is to keep addresses 1, 2 and 3 free to use the 3 standard high and low side XVTR drivers in the KRC2. Since the XV series transverters auto select the 28MHz IF, and provide a PTT output I did not need to drive any more external equipment. For the 144, 903, 1296, and other microwave transverters I needed to:

a. Switch the coaxial RF switches to route 144MHz to the right transverter
b. Route PTT signal to the right transverter or 2M 80W internal amplifier
c. Enable the XV144 when any of these bands are selected.

The current K2 firmware (2.04p) provides that each transverter band can be assigned to the same or different transverter address (ADDR). I configured my bands like this

K2 Band	Freq	rF	IF	OFS	Out	Adr	2M Pwr Output	Xverter/Brick Pwr Out
TRN1	144Mhz	144	28	-0.40	L1.00	trn1	10W	10W/80W/300W
TRN2	222MHz	222	28	-1.87	L1.16	trn4	12W	12W/120W
TRN3	903MHz	903	28	-0.40	L0.30	trn2	2W	2W/100W
TRN4	1296MHz	296	28	-0.40	L0.31	trn3	2W	0.5W/16W
TRN5	Not Assigned							
TRN6	Not Assigned							

Table 1

The default KRC2 high and low side output configuration is configured to respond as follows:

Outputs	Adr value
XVTR1 and /XVTR1	trn1
XVTR2 and /XVTR2	trn2
XVTR3 and /XVTR3	trn3

Table 2

Using the KRC2 jumper W5 these outputs may be configured into a binary coded output. This would give you the ability to control an output for each of the 6 transverter bands, but requires that you build a decoder and driver circuit. In my scenario, I was able to avoid that by strategic Adr assignments, assigning the XV series transverters to the address 4 and higher.

In the Table 1 example above, I might assign an XV50 to address trn5 and to keep the displayed band order correct by slide up all the settings to the next higher transverter band slot so I would hit band up and see 50, then 144, 222, 903, 1296 (296 on display) in that order. When I want to add another microwave transverter I need to either switch to binary coded output and build a 3 line to 8 line decoder and buffer circuit into the KRC2, or new KRC2 programming software could be used to remap an unused HF band outputs to TRN4, 5 and 6 addresses.

I did not use aux bus addressing for the XV144. The reason for this is that the KRC2 currently responds to only the trn address, not the band selected. In the case were you share the same XV144 transverter among many microwave transverters, one and only one KRC2 output would be activated – trn1 in the example in Table 1 above. To work around this I set the XV144 ID DIP switch for "No K2" and instead use the KRC2 XVTR high side outputs to enable the XV144 using its 12V control signal 12CTRL at the D-Sub connector pin 8. Disconnect the original 12VCTL signal from pin 8 in the connector cable at the XV144 only. Make sure the 12VCTL signal from the K2 reaches all other XV transverters.

Transverter	Transverter Band Select DIP Switch SW1
XV144	No K2
XV222	trn4

Table 3

Inside the KRC2 I used a small piece of perf board and mounted some diodes from XVTR 1, 2, and 3 high-side drivers for a wired-OR circuit driving a circuit borrowed from the K2's 8R/8T switching system - a 2N7000 switching on a 2N3906 to pass 12V from the KRC power supply to the XV144 12VCTL signal via a piece of RG-174. See the Figure 1 for more details. For the TTL controlled 144MHZ IF switching, I used the internal KRC2 5VDC power connected to J5 Vbb connector. The high side outputs drive the TTL switches and the Wired-OR diodes inputs. In my arrangement no external power was required for the KRC2 box. The K2 supplies the necessary power from its connecting cable at J2.

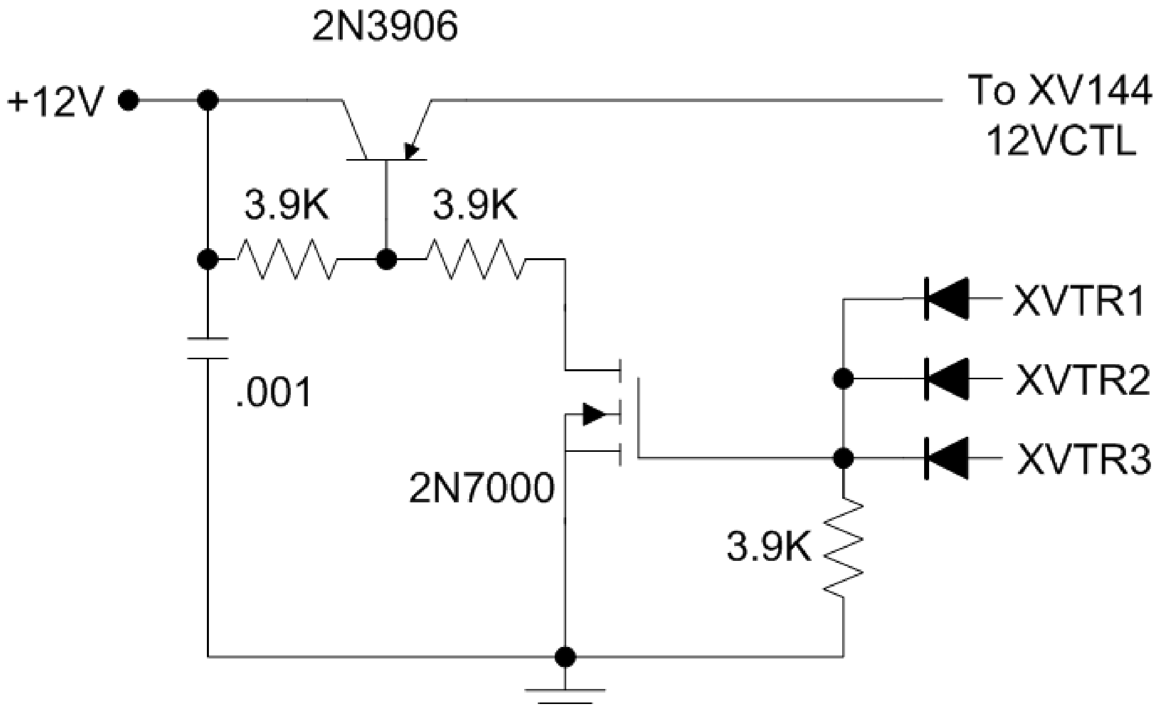


Figure 1

PTT Switching

For PTT routing I modified the KRC2 slightly to use the 8R signal on pin 9 of the KRC2 J2 connector to enable/disable the low side outputs /XVTR1, 2 and 3. This involves cutting free from ground pin 9 (/G) of each TPIC6595 driver chip (U6 and U7) and connecting to AN1 of the CPU U1. I used a very sharp fine pointed blade and carefully cut free the pin and bent it up parallel to the PC board. You want to be careful you do not break off the pin, or crack the casing materials around the PIN while doing this. It is easiest to bend the pin out before assembly, or cut the pin 9 pad free of ground on both sides before installing the chip when building the KRC2. You cannot simply cut the ground trace from pin 9 PCB pad after installation because there is a ground connection under the chip from pin 9 that is not visible or accessible once assembled.

I tapped into AN1 at the junction of R6 and R10. Signal 8R from the K2 supplies 8V on RX for 4 to 5 volts at AN1, and no voltage on TX. In TX mode R10 and other resistors pull down AN1 (now the same as /G) to ground so it enables the U6 and U7 outputs. In

RX mode the 4 volts at /G disables the U6 and U7 outputs. My equipment needs a solid ground for TX PTT so this works fine.

T/R Relay Switching

I happen to have several 12VDC coaxial high and medium power T/R relays with N connectors. My 144MHz, 903Mhz, and 1296MHz RF outputs are split path to simplify connecting high power amplifiers with the fewest relays for the lowest loss, highest reliability (I can never transmit into a receiver, fewer parts to fail and spare), and lower control power consumption (fewer parts to drive). I use 28VDC SMA latching relays and transfer switches at times to further reduce control power drain and I can use a very small 2amp 12 to 24 VDC converter I found at a Microwave flea market. The KRC2 low side outputs are wired to the transverters PTT input, and I use the aux relays in the DEM transverters on 903 and 1296 to supply +12VDC on TX to turn on the amplifier output T/R relays. These relays are mounted right at the output of the amplifiers.

For the 144MHz 80W amplifier I modified an old Mirage B108 that I found. I replaced the final amplifier transistor. The preamp was toast, but I had a better plan for that. I replaced the 3 pin power connector with a Power Pole connector, added a RCA phone jack for PTT switching, and replaced the round fuse holder with a BNC chassis connector for split path RX in. I used an insulated chassis type connector since it fit better the existing fuse hole size. I connected the BNC to the output side of the preamplifier and lifted the preamp output capacitor and inductor so that the RX path was now switched in and out of circuit with the PTT signal in place of the preamp circuit. This gives me a common 80W 2M RF output for feeding a backup loop antenna at home, and when operating mobile. I can bypass or turn down the power control in the K2 if I want to drive a 30Watt or 50Watt input brick amp. The PTT jack on the back of each XV transverter is free to connect to the optional external amplifiers and in my case a tower mounted T/R and preamp switch on 144MHz when at home.

Sequencing

When I am using the 144MHz tower mounted relay I control it with the transverter PTT output to a control box. The box switches the relay to TX, and the indicator contacts drive an opto-coupler and LED, which in turn keys the PTT on the external amplifier so there is not chance of hot switching the RF relay. My amplifier is tolerant of the low drive level input that could be present if the relays we slow to operate but you should consider your own situation carefully. There are several good sequencer designs and kits available. One thought I considered was using the KIO2 or K60XV 8R/PTT, buffer it, and disconnect it from the XV144. The K2 would drive the sequencer and the sequencer outputs would key the T/R relay, PA, and finally the transverter via the PTT IN jack on the back panel of the XV144.

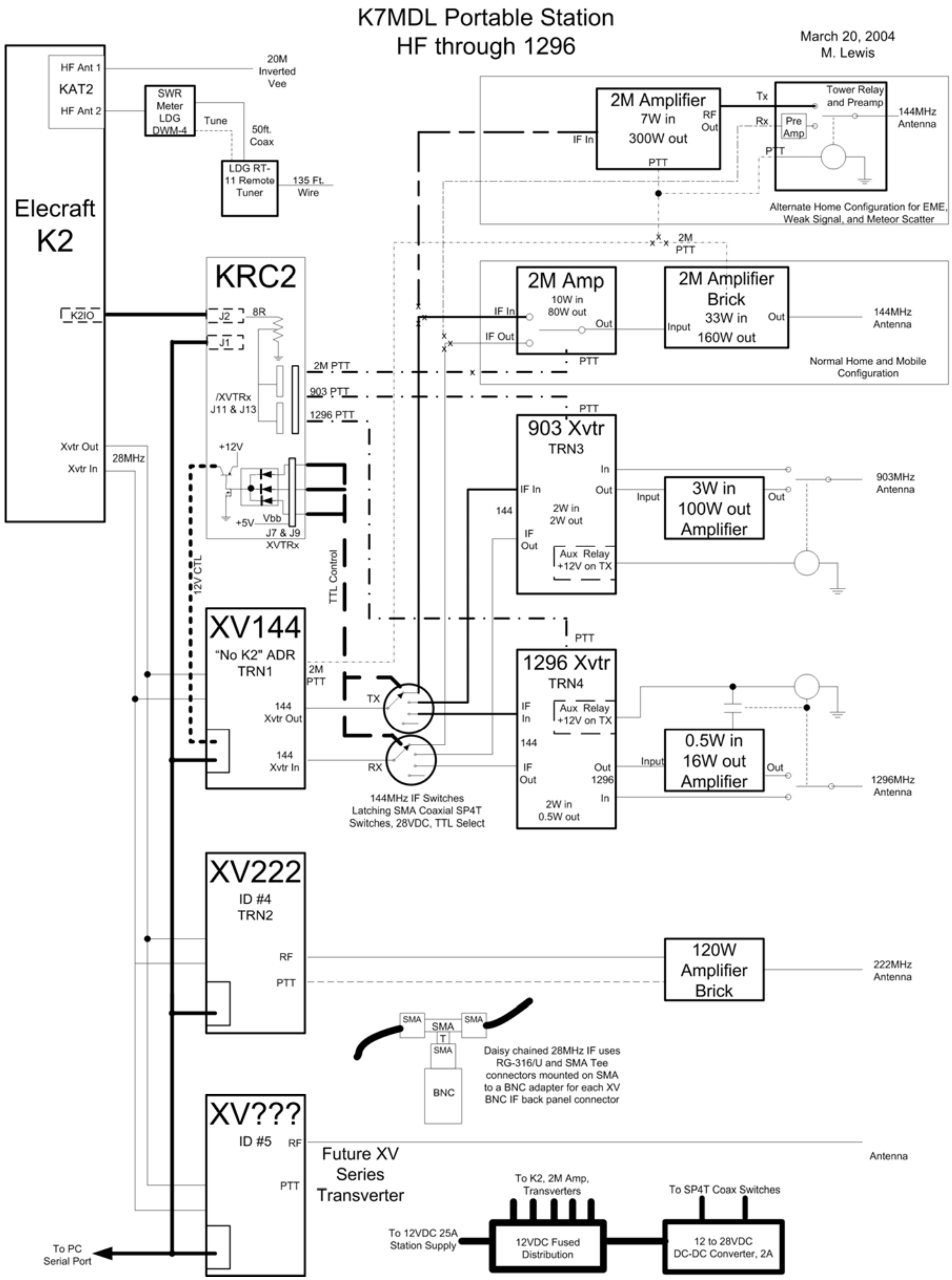
Antenna Connections

Reaching into a box amongst many cables and tight spacing make quick relocation of the portable station difficult. So I chose to build a bulkhead panel using a piece of aluminum sheet and mounting N chassis connectors for most all bands except the 2 K2 BNC HF jacks, which were easy to access. For placing the station on my desk close up to a wall, I use high quality Teflon right angle connectors so the ½" coax cables route down and away to the floor. When the station is in my truck, it is normally positioned in the passenger seat facing me, and the K2 is mounted on the left upper side so it is easy to control and see over the armrest. A microphone holder is on the top left side and the microphone cable runs to a RIGblaster computer audio interface for my digital modes.

HF Use

Since I am using the K60XV transverter interface for my IF output, this frees up the HF outputs at the back of the K2. Each HF and transverter band automatically selects the KAT2 antenna connector or transverter IO connector as appropriate, no extra relays required and no high power 28MHz IF leakage to worry about going to an HF antenna. For quick QRP HF outings, I can quickly disconnect the cables at the back of the K2 and slide the K2 out of the box and use it as a stock rig in less than 1 minute. All the original K2 features are preserved. I might choose to add a KPA100 amp someday, and would probably choose the internal arrangement to maintain compactness and switch the lids if QRP was needed. I would need to drill holes and relocate my IF outputs to the lower back panel (or get a replacement panel with the holes available from Elecraft).

My web site at http://mysite.verizon.net/michael_d_lewis/index.html has more information and pictures which may be updated from time to time. I make regular small improvements.



K7MDL Portable Station
HF through 1296
March 20, 2004
M. Lewis
Elecraft
K2
HF Ant 1
KAT2
HF Ant 2
20M
Inverted
Vee
SWR
Meter
LDG
DWM-4
Tune
50ft.
Coax
LDG RT-11 Remote Tuner
135 Ft.
Wire
2M Amplifier
7W in
300W out
IF In
RF
Out
PTT
Tx
Rx
Tower Relay
and Preamp
Pre
Amp
144MHz
Antenna
Alternate Home Configuration for EME,
Weak Signal, and Meteor Scatter
2M
PTT
KRC2
K2IO
J2
J1
8R
2M Amp
10W in
80W out
IF In
IF Out
Out
2M Amplifier
Brick
33W in
160W out
Input
Out
144MHz
Antenna
Normal Home and Mobile
Configuration
2M PTT
903 PTT
1296 PTT
/XVTRx
J11 & J13
+12V
+5V
Vbb
J7 & J9
XVTRx
Xvtr Out
Xvtr In
28MHz
903 Xvtr
TRN3
IF In
144
IF
Out
In
Out
2W in
2W out
Aux Relay
+12V on TX
3W in
100W out
Amplifier
Input
Out
903MHz
Antenna
12V CTL
TTL Control
XV144
"No K2" ADR
TRN1
2M
PTT
144
Xvtr Out
144
Xvtr In
TX
RX
144MHz IF Switches
Latching SMA Coaxial SP4T
Switches, 28VDC, TTL Select
1296 Xvtr
TRN4
IF
In
144
IF
Out
Aux Relay
+12V on TX
Out
1296
In
2W in
0.5W out
0.5W in
16W out
Amplifier
Input
Out
1296MHz
Antenna
XV222
ID #4
TRN2
RF
PTT
120W
Amplifier
Brick
222MHz
Antenna
SMA
SMA
SMA
T
SMA
BNC
Daisy chained 28MHz IF uses
RG-316/U and SMA Tee
connectors mounted on SMA
to a BNC adapter for each XV
BNC IF back panel connector
XV???
ID #5
RF
PTT
Future XV
Series
Transverter
Antenna
To K2, 2M Amp,
Transverters
To SP4T Coax Switches
To 12VDC 25A
Station Supply
12VDC Fused
Distribution
12 to 28VDC
DC-DC Converter, 2A
To PC
Serial Port

Figure 2