Milliwatting with the K2

This modification has not been tried yet, but it's pretty simple, so some of you might want to give it a go. In theory, can convert the K2's normal 0.1->15.0 W power range into 0.01-1.50 W or even .001-.150 watts... HOWEVER, there are definite limits to low-end power-setting resolution, and the results won't be perfect. See below.

Once again, these mods have NOT been tested by Elecraft, so consider them experimental and proceed at your own risk (/reward). Have fun!

Changing the K2 Power-Setting and Display Range

It's possible to fool the K2 firmware into changing the power control and display range by adding a DC gain stage following the RF detector (D9 on the RF board). The change doesn't have to be permanent: you can switch it in and out using a switch mounted on the right side panel of the K2.

Before you rush back to your work bench, there are some limiting factors to consider. These are listed at the end of the application note.

Power Scaling to 0.01-1.50 Watts

Let's say that the DC voltage seen at the cathode of D9, the RF detector, is 0.4 volts. To the firmware, this looks like an A-to-D converter count of 0.4V / 5V * 256 = 20 counts (integer math rounds down.)

The firmware then uses the formula P = N * N / 339 to come up with power in tenths of a watt:

20 * 20 / 339 = 1.2, but rounded down it's 1, or 0.1 watts

As you can see, the equation is not accurate at very low power levels.

But suppose that we make the RF detector sqr(10) = 3.16 times more sensitive, by adding an op-amp such as an LM358 and two resistors chosen for a DC voltage gain of 3.16. In this case, 0.4 volts at D9 becomes 1.26 volts at the A-to-D input:

1.26 / 5 * 256 = 64 counts

64 * 64 / 339 = 12, which the firmware displays as 1.2 watts

Since we know we've got the "x10" (voltage x 3.16) gain stage turned on, the *actual* power can be interpreted as 0.12 watts. If you wanted 0.1 watts, you'd set the POWER control for 1.0 watts, etc. We've just improved the accuracy of the setting by a factor of 10, and changed the K2's power
setting range to 0.01 to 1.50 watts (approx.).

Power Scaling to .001->.150 Watts
Let's say we make the gain of the op-amp 10 rather than sqr(10). Your 0.4
volts at D9 now becomes 4.0 volts:

4 / 5 * 256 = 204 counts

204 * 204 / 339 = 122, which the firmware displays as 12.2 watts

But with our "x100" gain stage in (voltage x 10), we know that the actual power is 100 times lower, or 122 milliwatts. If you want 100 milliwatts, you'd set the POWER control to 10 watts. The accuracy has now improved by a factor of 100, and the range of power output is 1 to 150 milliwatts.

Building the Power Scaling Circuit
The x10 (and/or x100) power scale components could be mounted on a small PC board, then attached directly to a slide or toggle switch mounted on the right side panel of the K2, so that you could select the power range easily. If you do this, use REALLY short leads everywhere, and you might want to start with small trimmer potentiometers for calibrating the new ranges to an external milliwattmeter.

The op-amp should be inserted into the circuit at the junction of R66 and R69. First, cut the trace from R66 to R69. Then: Pin 4 of the LM358 goes to ground, pin 8 to 8V (or 8T), pin 1 goes to R66, and pin 3 to R69. For a gain of 3.16: connect about 22k between pins 1 and 2 (call this R1), and 10k from pin 2 to ground (call this R2). For a gain of 10: connect about 90k between pins 1 and 2, and 10k from pin 2 to ground. If the LM358 is more than 1.5" from D9, put a .001uF bypass from pin 3 to ground.

Note: You could alternatively build the scaling circuit on the control board. See Limiting Factors (below), #5.

You can use other resistance values. The general formula for the pin 1->2 resistor (R1) vs. the pin 2->ground resistor (R2) is:

R1 = R2 * (Gain - 1)

Example: **R2 = 10K, gain = 3.16: R1 = 10K * 2.16 = 21.6k.**

Limiting Factors to Power Scaling

#1: Even if you change the power control range, the *resolution* of power setting at the low end will not improve, since that is determined by the 8-bit DAC that sets the power level. (The resolution will be worst on 40 meters, best on 10 and 160 meters).

Workaround: You can switch in a small resistor across R99, on the bottom of the PC board. Some experimentation will be required. Use VERY small tip jacks (IC socket pins), accessible from under the rig. Long leads will make problem #2 even worse...

#2: There's some signal leakage *around* the BFO attenuator, which puts a lower-limit on how far down you can go.
Workaround: This leakage can be reduced by about 10 dB by changing the BFO inductor to a toroid (26 turns #26, FT37-61; or 45 turns of #28 on a T44-8/90). In fact, this will also improve carrier suppression on sideband. The toroid should be mounted securely, and you'll have to re-run CAL FIL. (Write down your present BFO frequencies before making the change.)

#3: The readings at D9 are only accurate when the K2 is working into 50 ohms, and the indicated power falls off faster at the low end because of the diode's voltage drop.

Workaround: You could build a new, very-low-power RF detector circuit. That's beyond the scope of this document. Consider the Tandem Match (ARRL Handbook).

#4: The decimal point will not move if you make these changes. This may seem trivial, but it can be confusing.

Workaround: None. We'll have to do this in firmware. But you could add an LED to your power-scaling switch that's visible from the front of the K2 as a reminder.

#5: If you install the KAT2 antenna tuner, it takes over the RF detection function, and would bypass the effect of the added hardware.

Workaround: You could build the RF detector voltage scaling circuit on the control board instead of the RF board, in series with pin 2 of the micro controller (U6). But where to mount the in/out switch? We'll leave this as an exercise for the experimenter.

If the above factors leave you less interested in making these power-scaling mods, just use a calibrated attenuator at the TX output instead! You'll need to attenuate 10 dB or 20 dB to obtain the ranges described here. The advantage is that power setting will be more accurate; the disadvantage is that you'll burn up a lot of power in your attenuator. You could combine a 10 dB attenuator with 10 dB of power scaling as a compromise. One other suggestions: You can use the attenuator in combination with the K160RX option's receive antenna switch so that the receiver will not suffer much attenuation--just the transmitter.

Someday we may modify the firmware to give you menu selection of the power range. We can then put the decimal point in the right place and do all of the math in firmware (i.e., divide by 33.9 or 3.39 instead of 339). No additional components would be needed in this case, and the ATU could also be used with no additional mods. You'd still have the low-power reading accuracy problem, but we can compensate to some degree in firmware by averaging.