

HF Rig Display Accuracy

We occasionally receive emails from customers stating their Kx33 Low-RFI Power Supplies are outputting low voltage. They state that the voltage indication on the rig itself shows that under transmit, for instance, the voltage drops to less than 13.8 V, which is often the voltage stated by manufacturers as the desired DC input voltage. We have carefully designed the Kx33 to meet or exceed these stated specifications:

Output Voltage @ plug (+/- 0.1V): DC 14.4 V no load,
DC 14.4 V at 0.2 A load,
DC 14.0 V at 4.0 A load.
DC 13.9 V at 5.0 A load

Output Current: 4 A maximum continuous, 5 A for 30 seconds minimum.

Looking into the issue reveals that the voltage reading shown on the display of all rigs we have examined is sensed internally after several devices which incur voltage loss. The DC input plug/jack interface can have as much as 0.1 V drop, the polarity protection diode in series can incur a 0.3 to 0.6 V drop, a switching FET which turns the power on and off can drop 0.1 V or more, and resistance in the internal wiring and PCB traces further drop the voltage.

This made us curious if all displayed rig parameters were correct or even valid. A good example is output power; what is displayed is often just the setting, not the actual power output. To determine if we could trust our rig's displays we performed some testing.

Test Setup

To obtain data we set up a test bench with the following equipment:

Power Supply: PAE Kx33 Low-RFI Power Supply.

Voltage Readings: Fluke 8060A 4-1/2 digit DVM verified with an Agilent 34401A with recent NIST calibration.

Current Readings: Because all common DVMs in DC Current mode have excessive voltage drop for our test purposes, we monitored the current with a Tektronix P6042 Current Probe feeding a separate Fluke 8060A. In the pictures below the short red wire on the DC input assembly is the clamp-on shunt for the Tektronix P6042.

Output Power: Bird 43 with a 25H 25 W slug, connected with 18" (450 mm) RG-58 coax.

We then set up the rigs to be tested at the 10 W power level so we could get comparative data from all the rigs. The Elecraft KX3 and Xiegu G90 were capable of 15 and 20 W respectively so we tested them at those power levels as well. The test setup measured the input voltage directly at the DC power plug for the Elecraft rigs, and at the input to the adapter for the Icom and Xiegu rigs. The pictures which follow show the setup done initially for the Elecraft KX3, the other rigs were similarly connected and monitored. A summary table is presented at the end. The pictures below were taken before we decided to test more than voltage so only the Fluke 8060A for voltage reading is shown. The beige wire shown extending to the left out of picture frame is the RF output coax of our test jig. It is connected to our Tektronix 2712 Spectrum Analyzer, and every Kx33 we ship is checked for RF output in this manner.

This first picture shows the Kx33 delivering 14.408 V to the KX3 which is turned off, so there is no current drain:



We then turned on the KX3, so this picture shows the DC voltage at the DC input jack with the KX3 drawing an indicated 0.195 A (195 mA):



The PAE Kx33 supply is delivering 14.383 V to the KX3 DC power jack, so it has dropped by only 0.025 V at 195 mA output current. This is entirely due to the small resistance of the Kx33 DC output cable and the resistance of the Kx33 plug to the measuring fixture jack. The Kx3 shows the DC voltage as 14.1 V, so it's indicated voltage is 0.283 V lower than the actual input voltage when in receive at 195 mA current draw.

We then put the KX3 into transmit mode, outputting 10 W on the 10 m band in CW mode, effectively key-down. The 50 ohm load on the KX3 RF output allows for an indicated 1.0:1 SWR, and in this mode the KX3 draws 2.135 A:



The Kx33 supply is delivering 14.113 V to the KX3 DC input jack, and the KX3's internal voltage displayed is 13.4 V, which is 713 mV less.

A similar test was performed to the Elecraft KX2, Icom IC-705 and Xiegu G90, the summary results are shown on the next page.

HF Rig Display Test Results

Power Supply: PAE Kx33, no load DC voltage : 14.404 V

All tests performed at 14.100 MHz

RECEIVE

Mfgr	Model	S/N	No-load DCV In Measured (V)	Rcv. DCV In Measured (V)	Rcv. DCV Display (V)	Rcv. DCV Display Error (V)	Rcv. DCI In Measured (A)	Rcv. DCI Display (A)	Rcv. DCI Display Error (A)
Elecraft	KX3	7420	14.404	14.383	14.1	0.283	0.199	0.195	0.004
Elecraft	KX3	7420	14.404	14.383	14.1	0.283	0.199	0.195	0.004
Elecraft	KX2	330	14.404	14.393	14.4	-0.007	0.166	0.157	0.009
Icom	IC-705	12003818	14.405	14.385	14.3	0.085	0.195	0.2 ¹	na ¹
Xiegu	G90	X...00218	14.405	14.32	14.1	0.22	0.0578	na ²	na ²
Xiegu	G90	X...00218	14.405	14.32	14.1	0.22	0.0578	na ²	na ²

TRANSMIT

Mfgr	Model	S/N	Xmt. DCV In Measured (V)	Xmt. DCV Display (V)	Xmt. DCV Display Error (V)	Xmt. DCI In Measured (A)	Xmt. DCI Display (A)	Xmt. DCI Display Error (A)	Xmt. RF Out Measured (W)	Xmt. RF Out Display (W)	Xmt. RF Out Display Error (W)
Elecraft	KX3	7420	14.113	13.4	0.713	2.135	2.02	0.115	8.5	10	-1.5
Elecraft	KX3	7420	14.101	13.4	0.701	2.584	2.46	0.124	13	15	-2
Elecraft	KX2	330	14.125	13.8	0.325	2.141	1.92	0.221	9	10	-1
Icom	IC-705	12003818	14.103	13.9	0.203	2.553	2.6 ¹	na ¹	9	10	-1
Xiegu	G90	X...00218	13.974	13.5	0.474	3.429	na ²	na ²	8	10.2	-2.2
Xiegu	G90	X...00218	13.873	13.1	0.773	4.338	na ²	na ²	17	19.9	-2.9

Notes:

1 : The Icom IC-705 has only a bar graph for current, so the displayed reading is an estimate.

2: The Xiegu G90 does not have a current display.

Summary:

I would state the instrumentation displayed on these rigs tested is there more for relative readings and convenience than absolute accuracy, they spare us from dragging along DVMs and watt meters when doing QRP ops. However, 2 or 3 tenths of a volt can make a big difference in operating time remaining when running QRP from batteries. Current lithium batteries have such stable output voltage until they are almost depleted, it can be hard to tell how much reserve is left without accurate metering. The voltage readings especially suffer from a variety of factors reducing the accuracy if indeed one is interested in knowing the applied voltage, either from a battery or line-powered supply.

From this standpoint it can be useful to note the error in the displayed voltage and adjust your expectations accordingly.

Voltage Error: The typically indicated voltage on these rigs is 0.3-0.4 V less than the DC input voltage in receive, and 0.6-0.7 V less in transmit.

Current Error: Where available, the indicated currents are quite a bit more accurate than the voltage errors.

Power Errors: The power indications were 10-15% high compared to the actual power output.

Power Supply Errors: The initial reason for these tests was to verify and document the PAE Kx33 Low-RFI Power Supply performance under a variety of load conditions. We verified it is not the cause of the low voltage readings seen on some rigs, especially in transmit.

Specifically regarding the performance of the PAE Kx33 powering the Xiegu G90 at the 20 W output setting, the Kx33 delivered 4.33 A current, and the PAE Kx33 output voltage at the plug was 13.873 V, exceeding the HF rig manufacturer's specifications which typically state a 13.8 V requirement. We can confidently state that for any HF rig up to and including 20 W power level, the Kx33 will have no problem providing the low-RFI power needed.