Auto-tuner Feedline Management and Station Protection Accessory
Phil Salas – AD5X

Introduction

Most desk-top auto-tuners include more than one switched antenna port in order to handle multiple antenna feeds. For example, my Elecraft KAT500 three switched antenna ports are perfect for selecting my 43-foot vertical, a 20-6 meter trapped dipole, and a 6-meter beam. But as is always the case, I needed one more port - a fourth port for my Ameritron ADL-2500 high power dummy load. And even though the KAT500 provides gas discharge tubes (GDTs) and static bleed resistors on all three ports, I wanted some additional in-shack protection for my expensive ham station.

The Feedline Management and Protection Solution

The schematic of Figure 1 illustrates my KAT500 auto-tuner solution. Normally-closed switch S1 is mounted at the operating position. When the station DC power supply is turned-on the three KAT500 antenna ports are automatically connected to the three antenna coax feeds, thus permitting antenna selection via the KAT500. When S1 is opened and/or the station DC power supply is turned-off, the dummy load is selected on the KAT500 Antenna 1 port and all antenna feeds are grounded. The small value capacitors on the coax outputs compensate for the impedance bump due to the internal wiring. Without the capacitors the SWR of the unit degrades to about 1.3:1 on 6-meters when the unit is perfectly terminated. With the capacitors, the SWR is less than 1.03:1 (36dB return loss) on 6-meters. Of course these capacitors are not really necessary as the management box follows the antenna tuner. However any impedance bump can degrade a less-than-perfect feed-line SWR enough to make the difference between bypassing the tuner and the need for the tuner to be in-line, especially at the higher frequencies.

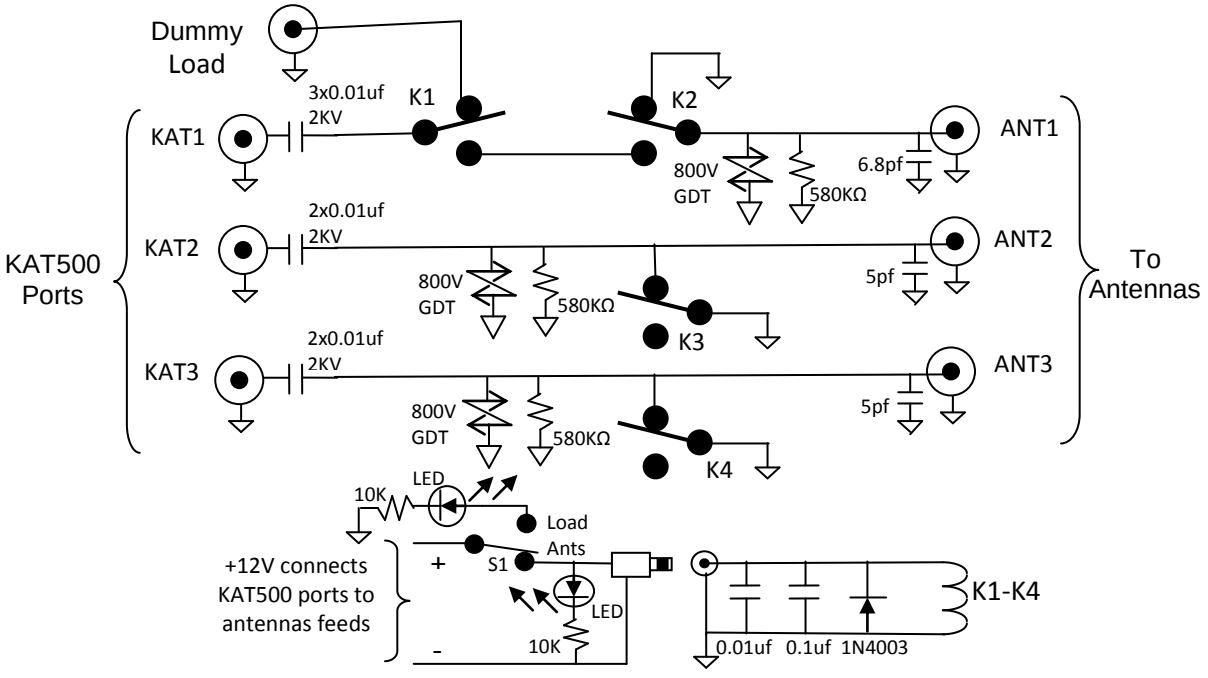

Figure 1: Schematic - Coax Feedline Protection and Management Box

Of course, proper station grounding must always be employed for safety and lightning protection as discussed in the ARRL Handbook and other publications. However, the feed-line management box does provide good secondary in-shack equipment protection by shorting the antenna feeds to ground when not operating. And gas discharge tubes, blocking capacitors and static-bleed resistors provide some protection when the antenna feeds are selected. As most energy in a lightning strike is found well below 500 KHz[1,2], the blocking capacitors attenuate much of this low frequency energy while the GDTs will fire for any voltage impulses greater than about 800V. I paralleled three 0.01uf capacitors on the KAT1 input as this feeds my 1.8-54 MHz dummy load and a 160 meter antenna. The resulting 0.03uf improves 160 meter SWR a little, but mostly spreads out capacitor power dissipation due to the capacitor dissipation factor (DF), which is inversely proportional to frequency ($P_{DISS} = I^2 \times ESR = I^2 \times DF/2\pi FX_C$). Two paralleled 0.01uf capacitors are used on the KAT2 and KAT3 inputs since these feed higher frequency antennas in my station. The blocking capacitors are rated at 2KV so the GDTs will fire well before capacitor voltage breakdown occurs. Finally, the 580KΩ 3.5KV resistors continually bleed-off any static build-up on the antennas.

Switching and grounding is provided by the four Potter and Brumfield RTB14012F power relays. These inexpensive (less than $3) relays work well through 6-meters, provide 1KVrms contact-to-contact isolation, 5KVrms contact-to coil isolation, and have contacts rated at 12-amps continuous current. This is perfect for the 500-watt rated KAT500. As an example, at 500 watts the output voltage into 50 ohms is 158Vrms at an RF current of 3.16Arms. At the rated 10:1 SWR matching range of the KAT500, the worst case voltage could be 500Vrms or the worst-case current could be 10Arms.

I built the unit into a cast aluminum box that has a mounting bracket that permits it to be rigidly mounted in place. Physical assembly details are shown in Figures 2 and 3. The relays (with pins up) are hot-glued to the aluminum box. A step-drill or 5/8" Greenlee punch works well for cutting the SO-239 connector holes. Note that there is also a ground stud consisting of a #8 stainless steel screw, nut, lockwasher and wing-nut for connecting to your station's single-point ground. Figure 4 shows the remote switch control.

Table 1 - Parts List

QTY	Description	Mouser Part Number
1	4.3x3.3x1.6" AL box	563-CU-5471
7	SO-239 connector	601-25-7350
4	SPDT power relay	655-RTB14012F
2	2.1x5.5mm DC jack	163-1060-EX
1	0.01uf capacitor	140-100Z5-103Z-RC
1	0.1uf capacitor	140-50U5-104M-RC
1	1N4003 diode	512-1N4003
3	580KΩ 1/2-Watt 3.5KV res	594-HVR3700005903FR5
2	10KΩ ¼-w resistor	66-CMF1/41002FLFTR
2	Green LED	941-C5SMFGJSCV14Q7S1
3	800V GDT	652-2095-80-BLF
2	5pf/1KV capacitor	75-561R10TCCV50
1	6.8pf/1KV capacitor	75-561R10TCCV68

7	0.01uf 2KV capacitor	594-S103M69Z5UP63K7R
1	SPDT toggle switch	108-0009-EVX
1	1.38x1.38x0.79” plastic box	546-1551MBK
1	2.1x5.5mm x 3ft DC cable	172-4204

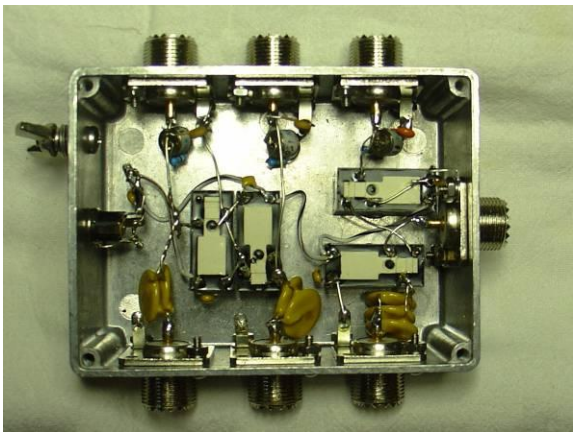

Figure 2: Inside view

Figure 3: outside View

Figure 4: Remote switch-control

Finally, I measured the isolation between the different ports of the completed unit as I wanted to ensure no degradation of the KAT500 port-to-port isolation. The worst case isolation was 54dB on 6-meters and better than 60dB on 10 meters between antenna ports 1-2 and ports 2-3. The best isolation was between ports 1-3, where the isolation was 75dB on 6-meters and about 83dB on 10 meters. Table 2 documents my isolation measurements and calculated composite isolations rounded to the nearest tenth of a dB. As you can see, the accessory box degrades the KAT500 port-to-port isolation by 0.2dB or less.

Table 2: Isolation Measurements and Composite Isolation Calculations

Ports	KAT500 10M/6M	Accessory 10M/6M	Composite 10M/6M
1-2	42/40dB	60/54dB	41.9/39.8dB
1-3	69/53dB	83/75dB	68.8/53dB
2-1	37/34 dB	60/54dB	37/34dB
2-3	38/34 dB	60/54dB	38/34dB
3-1	37/34 dB	83/75dB	37/34dB
3-2	36/32 dB	60/54dB	36/32dB

Only the 10- and 6-meter isolation numbers are displayed as isolation gets much better as you go lower in frequency. For reference, stand-alone Accessory Box isolation return loss plots are

shown in Figure 5 for ports 1-2 and Figure 6 for ports 1-3. The return loss degradation at the low frequency end is due to the blocking capacitor roll-off.

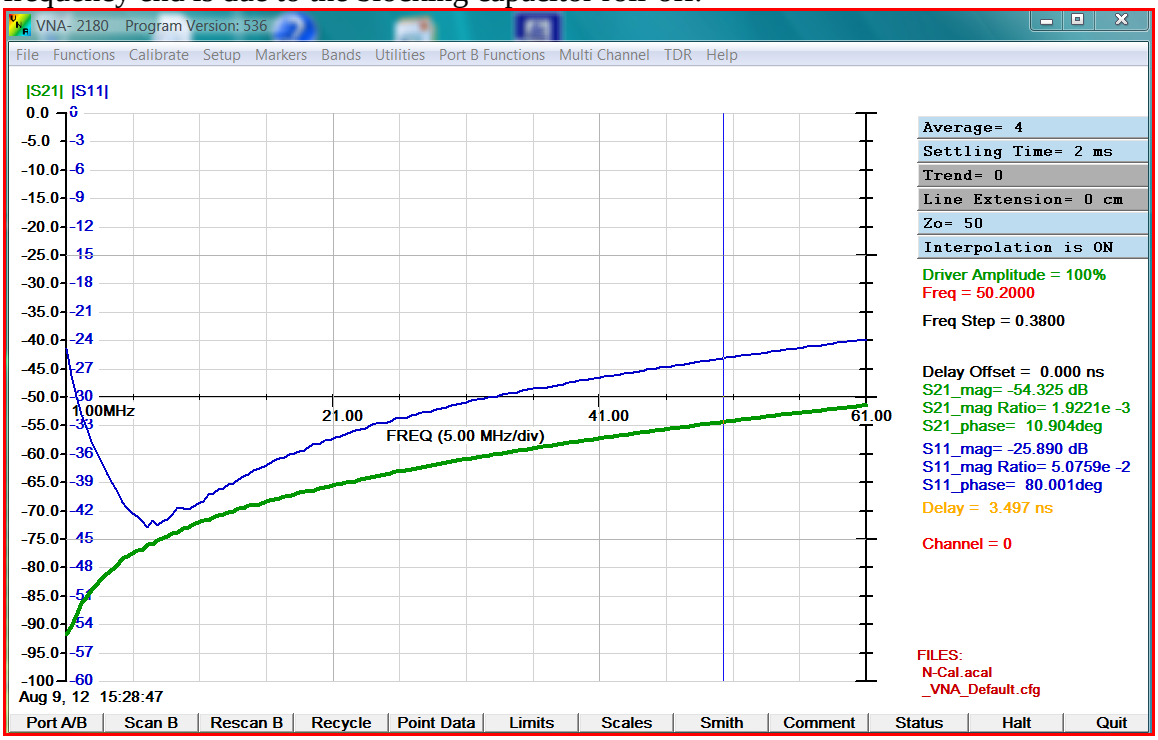

Figure 5: Port 1-2 isolation (green) and port 1 return loss (blue)

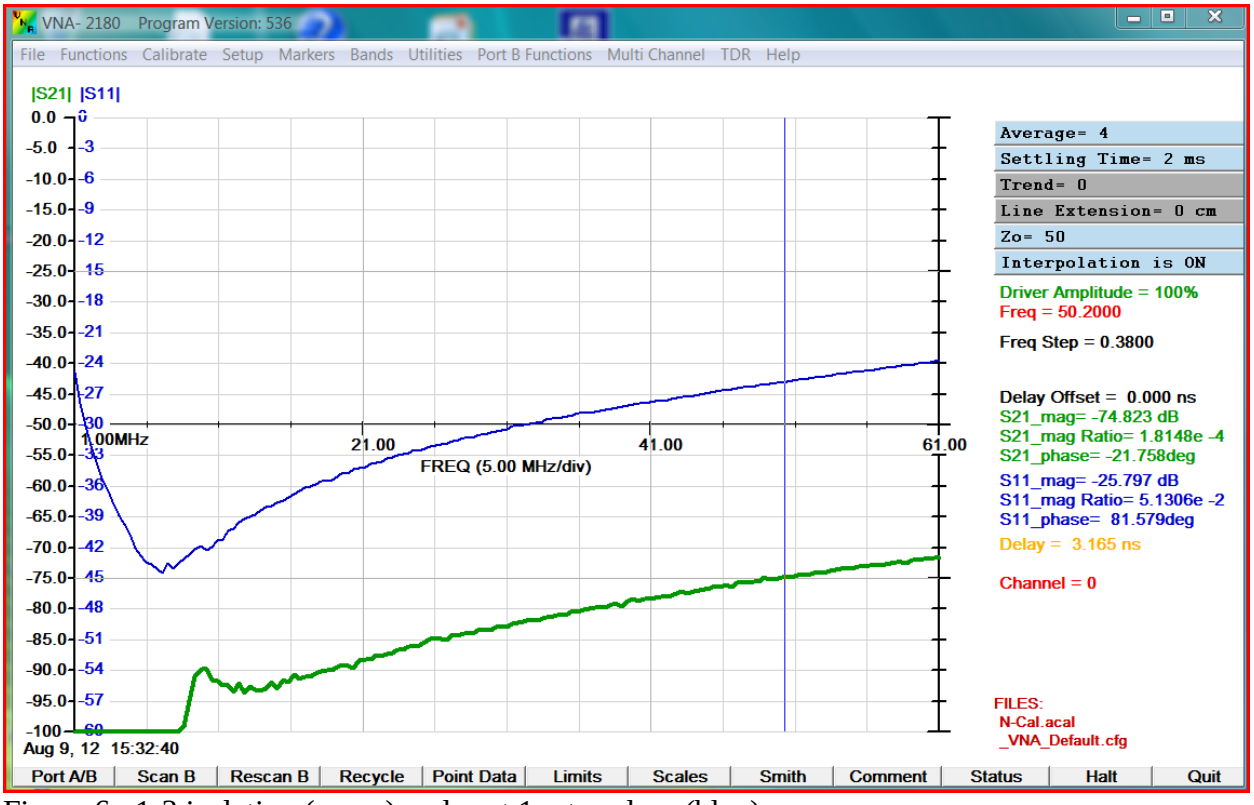

Figure 6: 1-3 isolation (green) and port 1 return loss (blue)

Finally, figures 7 and 8 show my station and close-up of the Accessory Box control, respectively. And figure 9 shows the Accessory Box mounted under my desk. It may look a little cluttered, but it is not normally visible!

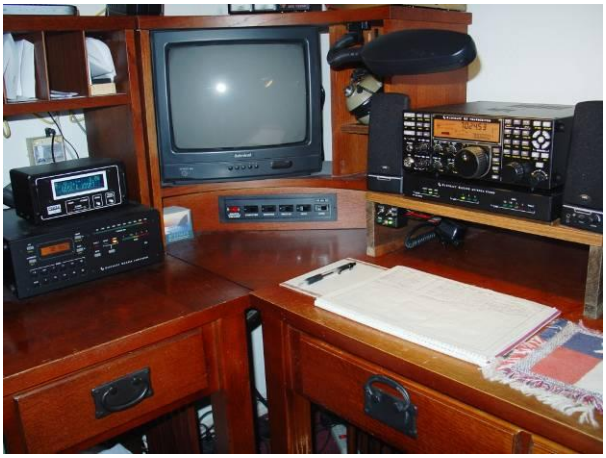

Figure 7: Left - KPA500, Right - K3/KAT500

Figure 8: K3, KAT500 & Accessory Box control

Figure 9: Accessory Box mounted under operating desk

Using the Antenna Management Box

Operation of the unit requires little thought. Simply turning on your station power supply automatically connects the three KAT500 ports to the three antenna feeds thus permitting antenna selection from the KAT500. Should there be any static build-up or induced voltage from nearby lightning events on any antenna, the GDTs, DC blocking capacitors and 580K ohm resistors will provide some protection. If you wish to test your transceiver and/or amplifier into a dummy load, just open remote switch S1 and select the KAT500 ANTENNA 1 port. And finally, whenever you turn off your station DC power supply the three antenna feeds are grounded by the 12-amp contacts of relays K2-K4.

Conclusion

The auto-tuner feedline management and protection accessory described here provides automatic lightning and static protection for your station, and adds a dummy load connection to your antenna switch if you are limited in switching ports. This unit can be modified to include more or less ports as needed. And with the relays and components used, you can even use this unit with legal limit power up to a 3:1 SWR. You can increase the legal limit capability to 10:1 SWR for high impedance loads, or a 5:1 SWR for low impedance loads by changing the 580K resistors to 1MΩ 1W resistors (Mouser 594-VR681M1%), and the GDTs to 1500V units (Mouser 650-GTCA28-152L-R03). However, transmitting legal limit power into a 10:1 SWR makes me a little nervous!

References:

[1]NASA Technical Memorandum 87788, "Review of Measurements of the RF Spectrum of Radiation from Lightning", David M. Le Vine MARCH 1986.

[2]George M. Kauffman, "Using commercial lightning protectors in defense applications", RF Design June 2006, pp 16-21.

Phil Salas AD5X, an ARRL Life Member, has been licensed since 1964. He holds BSEE and MSEE degrees from Virginia Tech and Southern Methodist University, respectively, and is now retired after a 33-year career in Microwave and Lightwave product development. Phil enjoys retired life with his wife Debbie N5UPT, as well as operating (mostly CW) and tinkering with ham-related projects.