External QSK T/R Switch for HF Amplifiers

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Like many HF amplifiers, my Ameritron ALS-600 uses a power relay for T/R switching. The long 15-20ms enable/release time of this relay makes the amplifier unusable for QSK operation. Therefore, I decided to build an external relay-based QSK T/R switch.

Design Considerations: QSK switch timing is critical. Basically, the relays must engage prior to application of RF, and disengage after RF from the transceiver ceases. And if the amplifier output relay disengages slightly after the transceiver relay, there is no chance of hot-switching the amplifier. A transceiver's amp-enable output to RF output varies from unit to unit. My measurement on several transceivers found it to be 5-ms minimum on a Yaesu MKV (menu adjustable to longer delays), 10-ms for an IC-7000, and 15-ms for a IC-706MKIIG. So you can see that there is almost always RF power available from the transceiver before these relays fully operate.

In QST, January 1994 pages 30-34: The Nearly Perfect Amplifier, AG6K discussed powering a series-connected vacuum relay and reed relay from a high voltage power supply. The high voltage enables the relays to switch faster, and current limiting resistors protect the relays from over-dissipation. I used this configuration along with AG6K's idea of "tuning" the drop-out time of the vacuum relay to ensure it disengages just slightly after the transceiver reed relay. I found a very fast Omron signal relay that switches 250VAC at 2-amps, and handles 3-amps of current when enabled. This 12V DPDT relay handles both the RF power of a 200 watt transceiver, and provides contact closures for controlling amplifier bias if desired. ***NOTE:*** **The relay coil is polarity sensitive** (polarity shown in Photo D). Using an approach similar to AG6K, I decided on a 50 volt power supply since that is the ALS-600 internal voltage. This leaves me the option of possibly building the QSK circuitry into the amplifier some day.

My final circuit is shown in Figure 1, and Photo A shows the unit with my ALS-600. It is quite simple, yet it works very well. Use of the bias control is optional, as you can just key your amplifier on all the time and suffer the extra power dissipation of the amplifier when it is always biased up. This extra power dissipation can be pretty low. As an example, my ALS-600 draws about 15 watts extra when the bias is applied to the PA.

The external amplifier keying circuit must key 52 volts at 100ma. If this exceeds the solid-state amp-control output of your radio, you can either build a higher voltage/current switching circuit into the QSK switch or use an external transceiver/amp interface available from several different sources. I use an Ameritron ARB-704 that I'd previously modified to automatically disable the amplifier when my auto-tuner is enabled. The ARB-704 easily handles the voltage/current requirements of this QSK switch.

The relays are shock mounted to minimize switching noise. The vacuum relay mounting bracket consists of a piece of 0.032" thick sheet brass (Photo B & Figure 2). The 7/8" diameter relay mounting hole is a little large for the relay, letting me wrap electrical tape through the hole to provide a first level of sound damping. Then I mounted 3/16" grommets in the 5/16” diameter mounting holes, and fastened the assembly to the chassis using #6 screws, washers, lockwashers and nuts (Photo B & Figure 3).

Insert the signal relay into a 16-pin IC socket and mount it upside down to a piece of PC board material using double-sided tape. Mount the printed circuit board on ½” spacers and shock mount it with grommets as discussed earlier. Mount the terminal strip on this PC board for the relay DC interconnections. Mounting details are in Photos B & C. I built the power supply filtering circuitry on a small piece of perf-board and mounted it to the front panel with the #4 threaded bracket (Photo C). I put solder lugs under one mounting screw on each RF connector and soldered a ground wire from each of these lugs to the signal-relay pc board. The final front and rear panels of the QSK switch can be seen in Photos D & E, respectively. For labeling the unit, I used a Casio labeler and “Black on Clear” labeling tape – all available from Staples and other office supply stores.

Timing Measurements: I built the test circuit of Figure 4 to measure the relay speeds and sequencing. The “Test Voltage Out” is an isolated 12-volt output that connects to the relay common pins to display this voltage as the relays switch. Photo F is the actual timing. The upper trace is the vacuum relay, and the bottom trace is the reed relay. The trigger, or keying input, is indicated in the center of the display. I placed a 1K pot in series with the diode across the vacuum relay coil and adjusted it so that the vacuum relay dropped out about 1-ms after the reed relay. Then I replaced the pot with a fixed 200 ohm resistor (the measured value). As discussed by AG6K, this resistor keeps the diode across the vacuum relay from significantly delaying the drop-out time of this relay. As you can see, both relays engage simultaneously about 5-ms after the QSK switch is keyed. You can see the approximately 1-ms additional drop-out delay of the vacuum relay determined by the diode/200 ohm resistor. The up-tick in the displays about 5-ms before the end of each trace is due to the unloading of the test circuit 13.8V source feeding the 10K isolation resistor. This conveniently shows the turn-off time of the trigger/keying input and the resultant turn-off delay of the relays – approximately 5-ms.

Parts Substitution: All parts were ordered from Allied Electronics (www.alliedelec.com), Mouser Electronics (www.mouser.com), and All Electronics (www.allelectronics.com). I used a Kilovac HS-11 vacuum relay (picked up at Dayton a few years ago) which has a 250 ohm coil. You will need to change the two 180 ohm series and shunt resistors to a 160 ohm series resistor and a 270 ohm reed-relay shunt resistor if you use a vacuum relay with a 350 ohm coil resistance like the Gigavac GH1 (available from www.gigavac.com). You can use aluminum sheet or pc board material for either relay mounting brackets if desired. And you may wish to substitute an easier to mount power switch.

Operation: Simply connect the transceiver, switch and amplifier as shown in Figure 5. The amplifier keying input is shorted to enable the amplifier whenever the amplifier is in the OPERATE position. With the amplifier enabled, it is just being switched in and out of your coax feed line along with your CW keying. If you wish to control your amplifier bias with the QSK switch, you will need to break the bias control voltage inside the amplifier and feed it to the stereo jack on the switch. I mounted a 1/8” stereo jack on the back of my ALS-600 for this purpose (same jack as called out in the parts list). This stereo jack has two normally closed switches built into it, so the amplifier bias control works normally if the bias interface cable is unplugged. I use a standard 1/8"-to-1/8" stereo cable for bias control between the QSK switch and the amplifier.

Conclusion: For a total cost of just over $100 you can build a stand-alone relay-based QSK switch that will handle full legal limit amplifiers. And since it is an external switch, you can move it from amplifier to amplifier as you change and upgrade your station. Construction is not difficult - it is just time consuming do to the metal work involved. However, if you are a CW operator you'll find this project to be well worth the effort.

Parts List

QTY	Description	Source/Part Number	Price ea.
1	DPDT signal relay (RL1)	Mouser 653-G6A-274P40-DC12	$4.57
1	SPDT Vacuum Relay (RL2)	Kilovac HC1, Jennings RJ1, or Gigavac GH1	$69.00
4	SO-239 connectors	All Electronics SO-239	$1.00
1	Perf Board	All Electronics PC-3	$1.50
1	Single-sided PC board	All Electronics PCB-46	$2.00
2	Terminal strip	All Electronics TP-70	10/$1.00
1	16-pin IC socket (optional)	All Electronics HRICS-16	$0.55
1	Phono Jack	All Electronics RCMJ	$0.40
1	AC Line Cord	All Electronics LCAC-167	$2.75
1	120VAC/40VAC XFMR	All Electronics TX-4025	$2.25
1	Diode Bridge	All Electronics FWB-15	2/$1.00
2	2200uf 63VDC elec. cap.	All Electronics EC-2263	$1.40
1	200 ohm ½-watt resistor	All Electronics 200-1/2	10/$0.50
1	1N4007 diode	All Electronics 1N4007	6/$1.00
1	Ultra-bright Blue LED	All Electronics LED-122	$0.75
1	LED Holder	All Electronics HLED-4	10/$1.20
1	1/8" stereo jack	All Electroinics MJW-20	$0.50
1	GMA Fuse Holder	All Electronics FHPM-45	2/$1.00
1	1-amp GMA Fuse	All Electronics GMA-1	5/$0.75
1	2.125x3.25x6.25" Box	Mouser 537-138-P	$12.63
1	Switch	Mouser 540-GRF22N2BBBNN	$0.75
2	180 ohm 3-watt resistor	Mouser 594-5093NW-180R0J	$0.54
1	6.2K ohm 3-watt resistor	Mouser 594-5093NW-6K200J	$0.54
1	2.7K ohm 3-watt resistor	Mouser 594-5093NW-2K700J	$0.54
4	#4 solder lug	Mouser 534-7325	$0.14
2	56pf 500V SM capacitors	Mouser 5982-15-500V56	$0.55
1	0.1uf 100V capacitor	Mouser 581-SR211C104KAR	$0.16
2	0.01uf 100V capacitor	Mouser 581-SR211C103KAR	$0.12
2	0.01uf 1KV capacitor	Mouser 539-GP110	$0.47
1	#4 threaded Bracket	Mouser 534-612	$0.23
4	3/16" Grommet	Mouser 5167-211	$0.06
2	½" #6 stand-off	Mouser 534-2210	$0.38
1	0.032" thick brass sheet	ACE Hardware	
Miscl.	#4 and #6 hardware	ACE Hardware/Mouser Electronics	

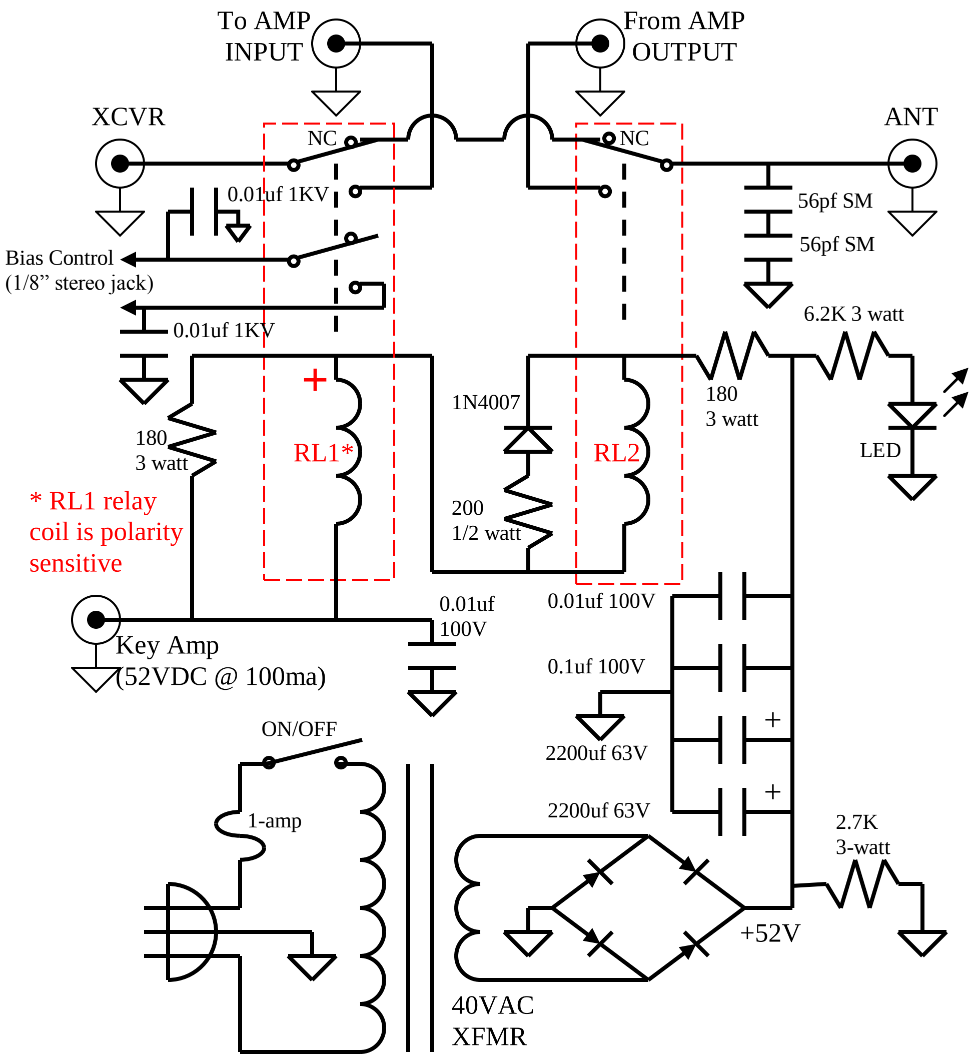

Figure 1: QSK Amplifier T/R Switch

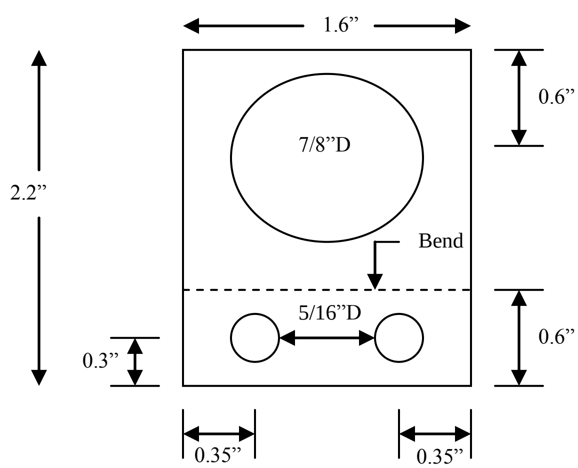

Figure 2 – Vacuum Switch Mounting Bracket

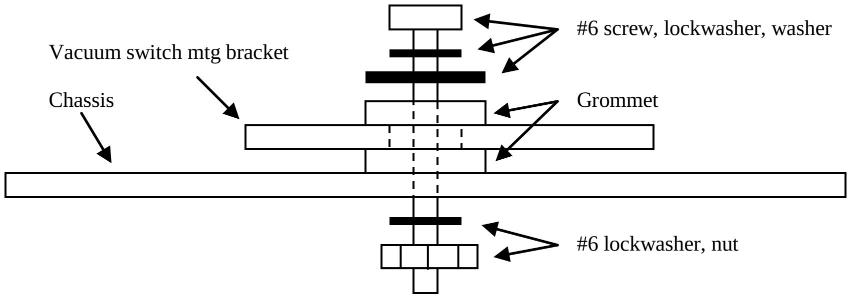

Figure 3 – Shock mounting method

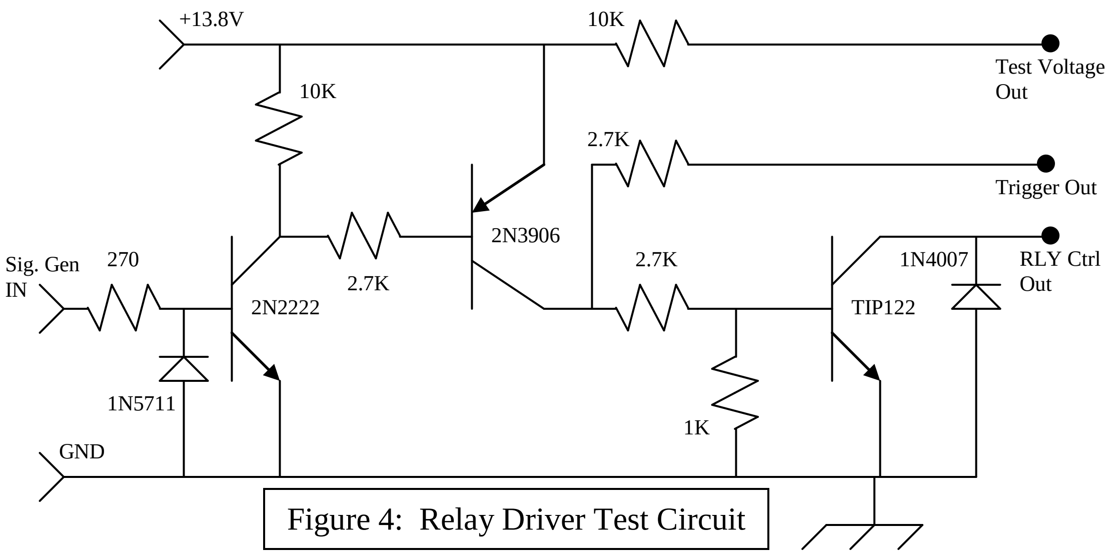

Figure 4: Relay Driver Test Circuit

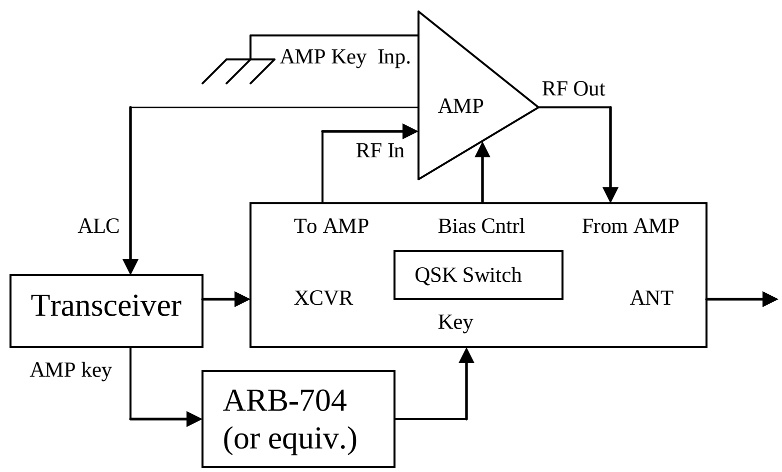

Figure 5 – Interconnect Block Diagram


Photo A: QSK switch and ALS-600


Photo B: Vacuum relay mounting bracket.

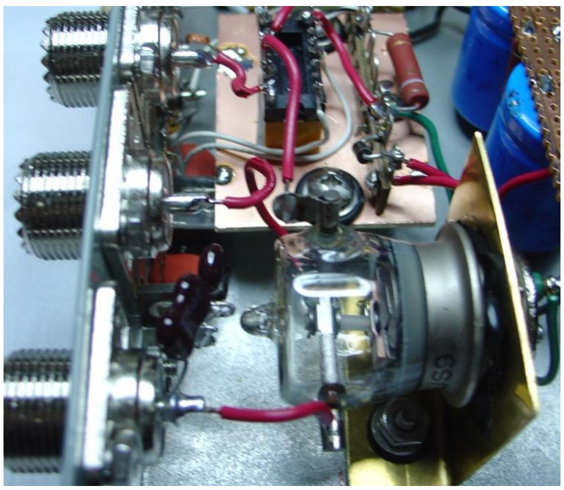
Photo C: Vacuum & reed relay mounting.

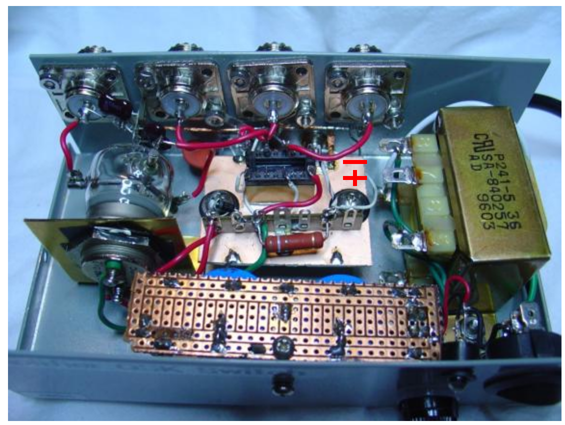
Photo D: Inside view. Note relay coil polarity.

Photo E: Front View of the QSK Switch.

Photo F: Rear view of the QSK switch.

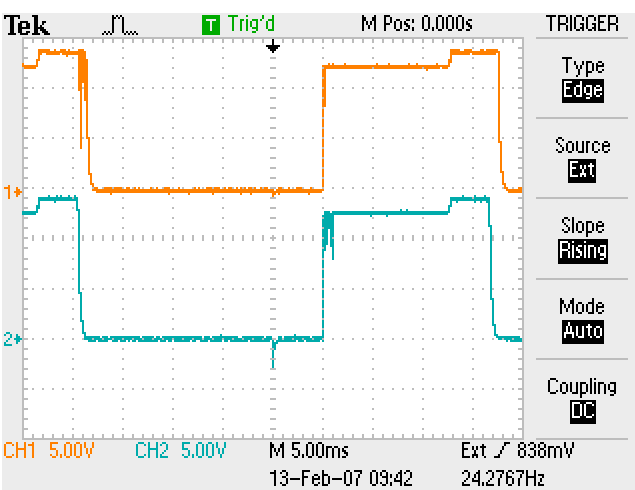

Photo G: Vacuum relay: Upper trace. Reed relay: Lower trace.