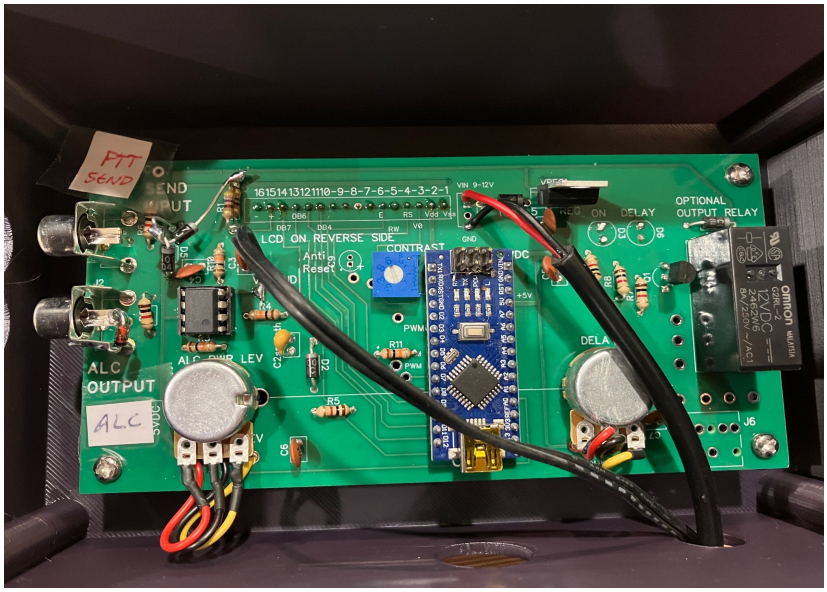
KX4Z Sequencer: Construction / Theory of Operation

by Gordon KX4Z

NOTE: *The Ver0.2 printed circuit board Gerbers, bill of materials (BOM) and schematic reflect improvements and corrections determined from the prototype unit (Ver0.1). Therefore they may be slightly different from the prototype unit in photographs.*



Version 0.1 populated and working prototype board

Access to Build Documents: https://github.com/docvacuumtubes/Sequencer

Includes

- Introductory/Operations Document;
- Construction/Theory of Operations
- Gerbers for PCB (including Drill File)
- STL file for enclosure
- STL file for back cover
- INO file for Nano Sketch (put in directory of same name)

Future additions will include a hinged cover for the M/S (Main/Sub) button on the ICOM 820H

Bill of Materials

Item	Qty	Value	Source	
LCD Display	1	2 line x 16 char	5V version https://www.amazon.com/dp/B00HJ6AFW6 MOUNT ON REVERSE OF PCB with slight elevation ~ 1/4-3/8"	
Arduino Nano	1		Solder or socket to suit Available from many suppliers Pack of 3 with programming cable	

			https://www.amazon.com/dp/B07G99NNXL	
Contrast trimmer	1	10K	trimmer to adjust contrast https://www.amazon.com/dp/B0F1S6NP3N	
R2, R11	1	10K	Delay pot (R2) and Power Level (R11) panel mount https://www.amazon.com/dp/B082FCRQS2 May need 6mm extensions on shafts to pass through box front	
D3, D6	1	LED	Choose desired colors to suit	
R1	1	200 ohms	Medium display brightness Use 470 for dim	
R5, R6, R7, R8, R9, R15.	6	1K	1/4w resistors	
R3, R4, R10, R12	4	10K	1/4w resistors	
D1, D2, D4, D5, D7	5	1N4007	Can use any silicon 1A diode	
D8	1	3.9V Zener	1W 3.9V Zener to prevent excessive ALC negative voltage	
K1	1		Relay OMRON G2RL-2-DC12 https://www.mouser.com/ProductDetail/Omron-Electronics/G2RL-2-DC12?qs=pWf36BUtxBhoQA0rBDBjsg%3D%3D	
C9	0		10uF anti-reset capacitor NOT USED as hasn't been needed PCB traces provided in case future need.	
J1, J2	2		RCA phono plug jacks, Mouser 490-RCJ-012 https://www.mouser.com/ProductDetail/Same-Sky/RCJ-012?qs=WyjlAZoYn53isKUFZudEAg%3D%3D Be careful that you plug into the correct jack!	
Screws to mount PCB and back cover	8	M3 x 5mm (approx)	Suggest using M3 screws approx 5-8mm	
M3 press-in threaded sockets	8	Suggest M3 x 6 or M3 x 8	Use medium heat soldering iron to gently press flush into plastic mounts This assortment includes multiple different kinds of threaded inserts:	

			https://www.amazon.com/dp/B0D5V3TZLB	
Additional Items for Simplex Fail-Safing				
-4 Volt Source			Can be provided by a small suitable wall wort or by three AA batteries in series.	
Approx 20K resistor			Connect -4V source at the DIN connector to the ALC input of the ICOM 820H. Adjust the voltage and resistance so that the Sequencer is able to bring the transmitter substantially to full power, but the -4Volt source is able to cut the power to nil if the sequencer's negative power supply fails. Likely that as little as -2V will substantially silence the transmitter.	

CONSTRUCTION

The parts list is provided in the bill of materials. Many parts are not crucial and can be obtained from Amazon or the junk box. Other than the LED's and zener, all the diodes can be virtually any silicon 1N400x diode, as the voltages here are minimal. Suppliers for the optional relay, the 2x16 LCD display, the 10K potentiometers, the contrast trimmer and the RCA phono jacks are provided in the BOM as these footprints must match the printed circuit board.

The value of R1 can be adjusted to provide the amount of brightness desired.

1. The SEND input of the Sequencer expects a POSITIVE voltage in receive, less than 5V. This is typical for most recent transceivers. Do NOT utilize the Sequencer on older vacuum tube transceivers with **very large negative voltages** on grid-blocked systems.

2. Don't solder in the LCD display (which goes on the bottom side of the board) until everything else has been soldered in, including the power supply wiring, as it covers up some of the board. The connections on the LCD display are close together -- be careful when soldering.

3. Use any 12-14V positive supply and any 5-10V supply for the negative source. They just have to be different supplies so you can provide the negative voltage for the op amp, and the positive supply must roughly match the relay requirements if you are using the relay.

4. When first turned on, the display may well be blank until the contrast potentiometer is adjusted properly to allow the characters to show.

5. The anti-reset capacitor (10uF electrolytic) has not been needed in this project, probably because the unit is normally operated NOT connected to any serial-communicating computer via the Nano USB port. It has been necessary in a rotator controller that uses serial control.

6. For simplex operation, or for additional failsafe protection, it is recommended that you use K1 contacts also to switch the +12 from your power system to provide downstream power for the preamps. Choose the NC (normally closed) contacts so that +12 (if it exists) is provided to the preamps' power input during RECEIVE. My preamp relay board (and many other designs) do not switch the preamp into the circuit unless this exists and also +12 is sent on the coaxial cable via a Bias Tee circuit.

7. There is a 2nd set of contacts on K1 which can be used for another purpose if desired.

8. **Test your transmitter (without sensitive downstream units connected) to verify that with full negative ALC input, the transmitter output is completely suppressed, and also that with the failsafe -4V supply system right at the accessory socket it is also suppressed.** It was completely suppressed on my IC-820H with only about -2 V needed.

9. Use Arduino IDE to load the sketch into the Nano and observe its operation.
https://downloads.arduino.cc/arduino-ide/arduino-ide_2.3.7_Windows_64bit.exe

10. The SEND input is biased by internal Nano resistors to start off in the RECEIVE state. You can test the system by simply shorting the input to ground. The DELAY LED should flash briefly depending on the length of delay requested, and the ON LED remain on afterwards while the SEND input is shorted.

INITIAL TESTING

1. Test the system with your transceiver with no preamp or other item at risk downstream, FIRST!
2. Verify that your SEND output is providing a small positive voltage (e.g. 2-5V) to the SEND input of this circuit. Be certain you have wired up the DIN connector properly! Verify that when the transceiver goes into transmit, the Sequencer detects the transition immediately. The DELAY LED should briefly flash and then the ON LED; screen display should show corresponding states.
3. Verify that with 0% power level requested, there is NO transmitter output. This is important to be sure that the ALC output is connected properly and that it has sufficient strength to completely suppress power output. In my IC-820H, power disappears below about 60% "power level"

OPERATION

1. Adjust desired **power level control** on the Sequencer as desired, for IC-820H. For 910 and 9700, can be set to 100% and power controlled with radio controls. This control will not be linear, just relative.
2. Adjust the delay as desired. Initially test with a very LONG delay so that you can visually confirm that the transmitter is initially suppressed and then power is allowed.
3. Some recommend a minimum of 29milliseconds if there are downstream relays that need to settle. The relays in my preamp design are smaller and faster so 29msec should be more than adequate.
4. The delay is open-loop; there is no confirmation that downstream units have switched, so don't try for excessively short delays.

5. At 20wpm, the length of a "dit" is 60milliseconds. If you set the delay for 40- 60milliseconds and send one "dit" at the beginning of your transmission, the next characters should be transmitted corrected. If you press the mic PTT and delay just an instant, the transmitter should catch your first word.

THEORY OF OPERATION

The .ino file includes a special watchdog timer that must be reset frequently. If not (due to program hanging) -- the program will be reset. I have been using Nano's for several years and I have yet to see a properly programmed file actually hang.

The SEND input has protection diodes to prevent it from going more negative than - 0.6V or more positive than 5.6V. The signal is then conducted to Nano D4, which is set as an INPUT with pull-up resistors to bias it HIGH.

The ALC output includes a zener diode to guarantee the output does not go more negative than -3.9VDC to protect a solid state transceiver in the event of circuit malfunction.

The DELAY and POWER LEVEL potentiometers provide variable voltages 0-5VDC and these are read by A/D converters at A0 and A1 inputs.

D5 output from the Nano is a pulse width modulated signal at 980Hz (approximately 1millisecond period) . The duty cycle of the square wave can be varied from nearly 0% to 100%. This is filtered by 10K R12 and 0.1 uF C2 (time constant 1 millisecond) to give a fairly steady variable DC level. (C2 can be increased to 0.47uF to reduce the ripple if desired). This voltage is then amplified by an inverting unity gain LM741 op amp to give a negative voltage to provide ALC control of the transmitter.

A3 is used as an output, and has lower resistance connection to C2, allowing it to very quickly establish near-maximum ALC output, rapidly suppressing transmitter output. Diode D2 acts like an "OR" circuit so either the A3 output or the D5 output can suppress transmitter output.

INITIALIZATION

The circuitry immediately sets near-maximum ALC output to suppress transmitter output, turns the LEDs off and printed suitable explanatory messages on the LCD screen.

LOOP

Once initialization is finished the software enters a loop. The desired delay and power level are continually re-measured.

If a transition to LOW on the SEND input is detected, the DELAY LED is lit up, the screen displays the delay state, and for the desired delay period, the ALC output remains at near-maximum negative for the requested delay time; relay K1 is energized at the transition.

After the expiration of the requested delay, the output ALC returns to the desire power level setting, the TX ON LED lights, and the screen displays the transmit state.

The system remains in transmit until the SEND input rises indicating the transmitter is off; at that point (RECEIVE state), the ALC is driven to near-maximum negative again, relay K1 is de-energized, and the display shows the receive state.