Computer Headset Junction Box for TM-D710GA Radios

Al Taylor, KN3U

8 Nov 2020

Front and rear panels of junction box

At two of our local hospitals, Kenwood TM-D710GA radios are installed in wall cabinets in the room that serves as the hospital's emergency operations center (EOC) during a large-scale incident. The EOC serves double duty as a conference room or training room.

The wall cabinet keeps radios, power supply, and ancillary equipment hooked up and ready to go at a moment's notice, while secure and out of the way during normal use of the room. A bundle of cables runs from the wall cabinet to the operating position, where it is discreetly tucked under the table when not in use. When the radios are needed, we pull out the radios' control heads, microphones, headsets, footswitches, and documents – which are stored in a tote box in a nearby closet – plug them in, and apply mains power to the wall cabinet. We can be on the air within a few minutes of arrival at the facility.[1]

Figure 1 shows an operating position in one of these hospitals. Ron Adams, KB3SYA, is sitting at the operating position, running Winlink on a laptop computer and simultaneously using a computer headset and footswitch to participate in a voice net. The TM-D710GA makes an ideal radio for a hospital station because its design enables us to operate in a UHF voice net while simultaneously passing messages via Winlink on 2m. The radio's control head (out of sight in this photo) takes up little space adjacent to the laptop.[2]

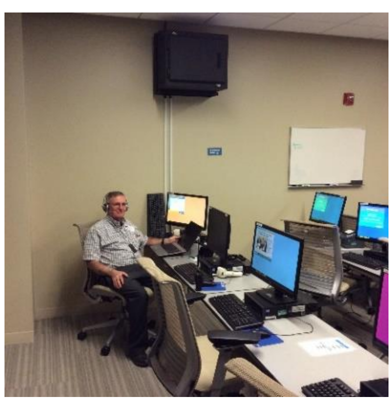


Figure 1 *Radio installation at hospital EOC*

It is convenient to be able to use a headset with boom microphone to talk on the radio. Among other benefits, this allows the operator to hear the radio better, and by using a footswitch to key the radio, one's hands are freed up to use the computer. Most importantly, others in the room ae not distracted by the chatter on the radio. On the other hand, it is sometimes necessary to share the radio with another person, either another ham or one of the hospital staff. While one can buy an off-the-shelf adapter cable that allows you to plug the headset into the radio's microphone and speaker jacks, we wanted a way to connect the headset, microphone, and speaker simultaneously. I developed a simple junction box (lead photo) to accomplish this.

Circuit description

The schematic of the junction box, shown in Figure 2, is easy to follow. Looking at the receive audio path first, the radio's external speaker output is fed in parallel to the headphones and an attached loudspeaker. I installed a toggle switch on the side of the loudspeaker to turn it on and off. (It is more intuitive to have this switch located on the speaker than on the junction box, which has no user controls and can be placed in an out-of-the-way location.) The received audio is always available at the headphone jack on the junction box, with a series resistor (R7) whose value was selected so that the volume in the headphones is lower than the volume of the loudspeaker. This protects the hearing of the operator wearing the headset. The value of R7 was determined experimentally using the chosen loudspeaker and headset. R6 places a minimal DC load on the radio's audio amplifier. With some radio designs, this prevents a loud pop when the speaker or headset is connected to the radio.

The transmit audio path is also very simple. The cable from the microphone connector on the radio base unit plugs into the junction box, as does the radio's hand microphone and a footswitch. Under normal conditions, all eight signal lines on the hand microphone pass through the junction box to the radio mic jack.

Closing the footswitch (connected to the PTT jack) energizes a relay that switches the radio's microphone input line from the hand microphone to the headset microphone. All other features of the hand microphone remain functional, so that you, for example, can use the hand microphone's DTMF keypad to place an autopatch call, even while using the computer headset.

As an example of what this provides, suppose that a physician at my hospital needs to consult directly with her counterpart at another facility. I can make the arrangements with the distant station using my headset. Then, when the other physician comes on line, I can give my doctor the hand microphone and flip a switch to turn on the external speaker. My physician can now speak directly with her colleague. I can monitor the conversation in my headset and interject when necessary by depressing my footswitch.

In addition to use at our hospitals, I'm using one of these junction boxes at my home station, tucked behind the radio and out of sight. It is very convenient to be able to use the headset when serving as net control, and simply pick up the hand mic to make a casual contact.

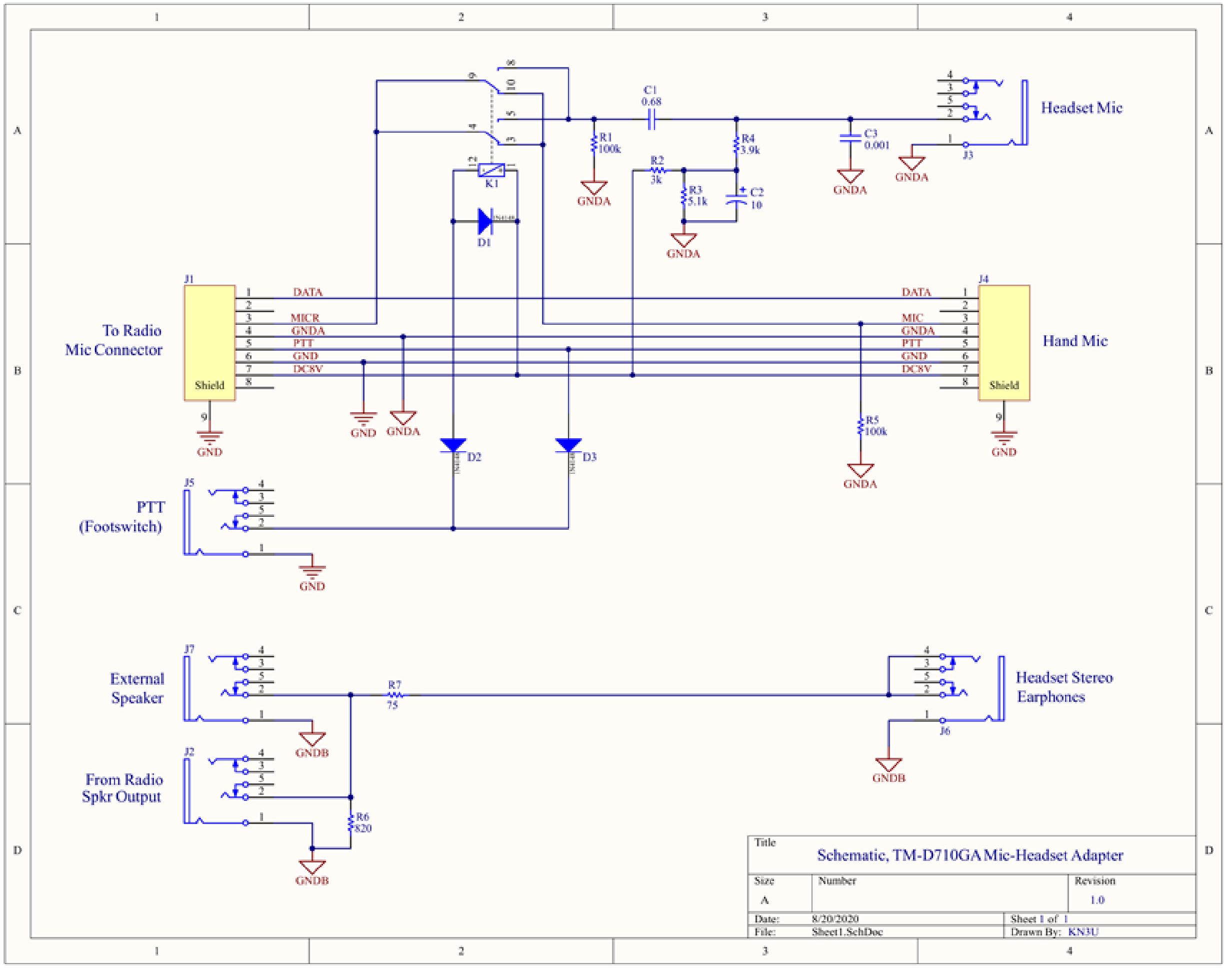


Figure 2 *Junction Box Schematic Diagram*

Speaking of the hand mic, the one that ships with the TM-D710 is an interesting design. The radio supplies a nominal 8VDC to the microphone to power the mic's backlight. It also powers a digital circuit that scans the mic's keypad to detect key presses and sends the relevant information back to the radio as a serial data stream. Finally, the same DC voltage also powers an audio preamplifier built into the electret microphone element.

The junction box closely mimics the circuitry built into the Kenwood hand microphone. Resistors R2 and R3 form a voltage divider that reduces the 8 VDC supply to approximately 5 volts, which is applied to the electret microphone in the headset through R4. More importantly, there is quite a bit of digital switching noise present on the 8V power supply, which can couple into the microphone circuit.[3] The voltage divider in conjunction with C3 forms a low-pass filter to eliminate the switching noise, resulting in a clean transmitted audio.

R1 and R5 play a subtle but important role. C1 is a DC blocking capacitor. When the headset microphone is connected to the radio, the right side of C1 is charged up to 5V, while on the left side of C1, the audio signal is centered at ground potential. When the headset microphone is disconnected in favor or the hand microphone, the charge would eventually bleed off C1, and there would be a loud pop in the audio line when the relay reconnects to the headset microphone and C1 charges back up to 5V. R1 ensures that C1 remains charged whether or not the headset microphone is connected to the radio. R5 does the same for the DC blocking capacitor in the Kenwood hand microphone.

Note that there are three separate "grounds" shown on the schematic. The microphone's analog ground is isolated from the digital ground to help keep digital switching noise from coupling into the sensitive microphone circuitry. The topside ground plane on the PCB is analog ground, and the bottom ground place is digital ground. The receive audio return is similarly isolated from the other two grounds as a best practice. (All three grounds are connected together inside the radio.)

You might have noticed that I used a double-pole double-throw (DPDT) relay when a single-pole double-throw (SPDT) relay would have sufficed. I also used stereo jacks where mono jacks would have sufficed. That's for a practical reason. I always buy a few extra parts for future projects, and I might need that extra set of contacts next time around. Since the cost difference is negligible, I selected the more versatile parts.

I chose color-coded 3.5 mm phone jacks for the audio inputs and outputs. Following the personal computer convention, the headset mic connector is pink and the earphone connector is green. Also, these jacks are electrically isolated from the aluminum enclosure, preserving the separate grounds shown in the schematic. The PTT jack is a conventional 3.5 mm jack with a metal bushing. It connects the enclosure to digital ground.

This circuit could be adapted to work with other radios whose microphones have electret elements. The 5V relay is specified to operate reliably with a coil voltage between 3.75 and 10.9 VDC. If your radio provides a different bias voltage to the electret microphone element, you might have to select a relay having a higher coil voltage and adjust the value of R2. If your radio does not provide a DC voltage on the mic connector, you could power the circuit from four AA cells, a 9V battery, or even your 12V power supply. The current drawn from an 8-volt power supply is only about 6 mA when the relay is energized.

Construction

All components mount on a small PCB using through-hole construction. Parts cost, excluding the enclosure and PCB, run just over $20. I was able to obtain five bare PCBs from an online PCB vendor for well under $20. My PCB layout is available on Altium's CircuitMaker website, an online maker community.[4] The design is covered by a Creative Commons non-commercial license, as detailed on the website.

I wanted the finished units to look nice since they will be installed at served agencies, so I designed the PCB to fit in a standard extruded aluminum case. There are several manufacturers who make extruded aluminum cases designed to accommodate circuit boards that are 100 mm wide. I found that I could purchase one stock enclosure and cut it on a bandsaw to the exact depth needed to sandwich the circuit board between the front and rear end panels.[5] Better yet, there was enough case material left over to make a second enclosure. Extra end panels, screws, and bezels can be purchased from the enclosure manufacturer, or you can easily cut your own end panels from a scrap of sheet aluminum.

When using these extruded aluminum enclosures, getting everything to fit together requires careful measurement. If you prefer, you can fabricate your own enclosure, or simply sandwich the circuit board between two pieces of sheet aluminum or PCB material.

The RJ45 jacks require rectangular holes in the front and rear panels. A $15 hand-operated nibbling tool, GC Electronics Model 12-1806 or equal, makes short work of this task. Every maker should have one. Drill a pilot hole sized to fit the tooth of the tool – or two holes on opposite corners of the intended cutout. Insert the tool and start nibbling. You can find how-to videos on the web.

Figure 3 shows the PCB during assembly. All components are through-hole and installed on the top side of the board. Assembly time is on the order of a half-hour. Figure 4 shows the finished PCB and its enclosure prior to final assembly, and Figure 5 shows the finished unit connected for use. I used photo paper to print overlays for the front and rear panel lettering, as described by KL7GQ in a recent issue of ***QST***.[6]

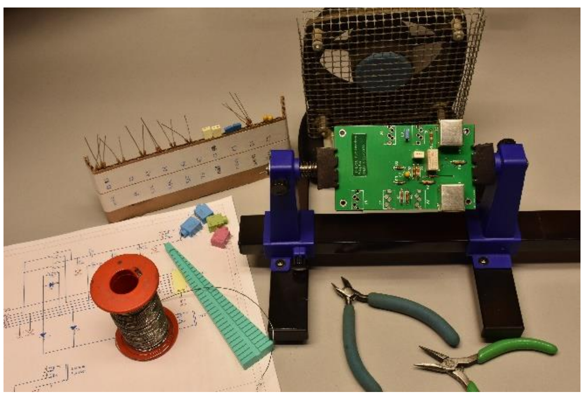


Figure 3 *Installing parts on the PCB. Note the homemade " fume extractor" and a simple system for identifying parts.*

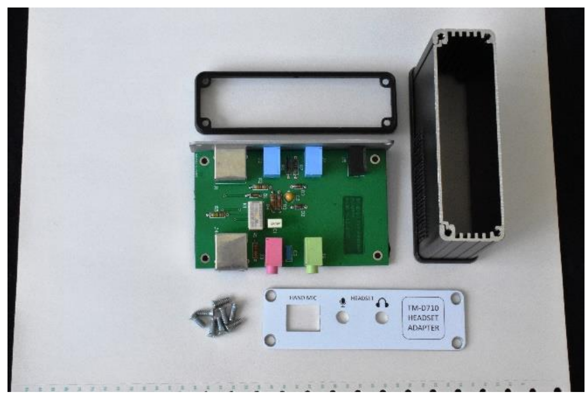


Figure 4 *Finished PCB and enclosure prior to final assembly*

Figure 5 *Junction box connected for use.*

Modifying the Speaker

I selected a Midland Model 21-406 loudspeaker to use at the operating position. It is a straightforward task to add a small toggle switch to the side of the enclosure to turn the speaker on and off, as follows:

1. Remove back cover of speaker housing.
2. Place white artist's tape or masking tape over the edge in vicinity of switch location.
3. Make a mark 26 mm from top edge of enclosure (see Figure 6a).
4. Extend line vertically down side of enclosure and mark drill position 15 mm below the edge (see Figure 6b).
5. Drill a 6 mm (0.25") hole at the mark.
6. Mount the switch and wire in series with the speaker.

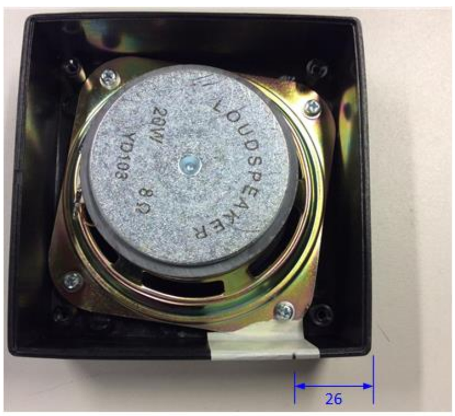


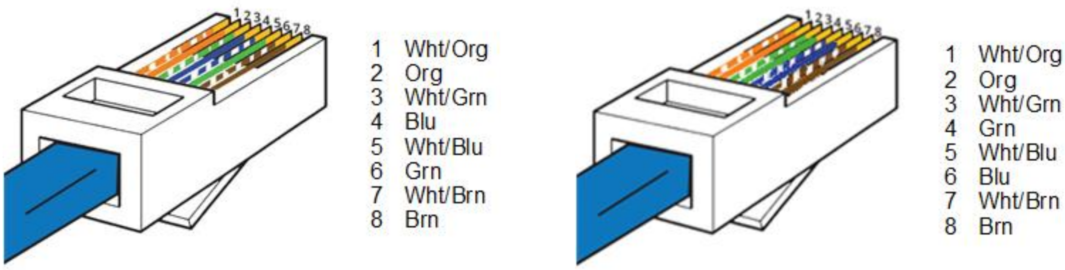
Figure 6 *Marking the mounting location for the switch. Please see text for details.*

(a) ***(b)***

Making the connections

In the cable that comes attached to the stock Kenwood microphone, the microphone audio is routed through a shielded cable whose ground connection is maintained separate from the return path for the digital circuitry. This keeps the woodpecker at bay. Kenwood, and at least one third-party vendor in the UK, sell an extension cable that maintains the shielded microphone line, but these are expensive. A regular CAT-5 cable can be substituted, but the unshielded twisted pairs of the CAT-5 cable allow some digital switching noise to couple into the audio line, producing the woodpecker effect.

Figure 7(a) shows the common T568B wiring arrangement that is used by most CAT-5 and CAT-6 ethernet cables. Note that the pins are numbered from left to right, looking from the back of the plug with the tab down. I followed that convention when I drew the junction box schematic. In Kenwood's documentation, the pins are numbered from right to left. Don't let that trip you up.



(a) ***(b)***

Figure 7 (a) *Standard (T568B) CAT-5 pinout.* ***(b)*** *Alternative pinout for microphone extension cable places the microphone audio signal and its return ground path on a twisted pair (pins 3 and 4).*

Should you use a conventional CAT-5 numbering scheme as shown above, the mic audio signal appears on pin 3 and its shield is connected to pin 4. Note that in a standard CAT-5 cable, these two pins are connected to two different twisted pairs. While experience has shown that a regular CAT-5 cable works, best practice would dictate making up a custom RJ-45 cable with the pairs arranged as shown in Figure 7(b). This will ensure that the noise-sensitive mic audio line will be twisted with its return ground connection on the green pair. Experience has shown that this doesn't eliminate the woodpecker noise, but it reduces it to a tolerable level. For best performance, purchase the recommended extension cable or make your own using shielded wire for the mic audio signal.

A standard mono or stereo 3.5 mm audio cable is used between the radio's speaker output and the junction box. Plug a headset, such as the Yamaha CM-500 or one of the many compatible computer headsets, into the front-panel jacks. Finally, plug a footswitch or thumb switch into the PTT jack on the rear panel of the junction box, and you are ready to operate.

Endnotes

[1] Responding operators bring their own laptops with the Winlink Express software and reference materials preinstalled. Hospital IT managers are understandably reluctant to install "our" software on "their" computers.
[2] In our more recent installations, we have found it ideal to set up in an adjacent room rather than the EOC itself. This places us at arms' length to the EOC but out of earshot, enabling us to converse on our radios without disrupting the frequent meetings that take place within the EOC. We may be joined in the "comm center" by the hospital's logistics staff, who have a similar need to converse with outside entities via telephone.
[3] Some observers have likened this to a ticking or woodpecker noise. Google "kenwoodpecker" for more information.
[4] https://circuitmaker.com/. After registering, search the project listings for "TM-D710."
[5] You can make the cut using a hacksaw if you are careful. The plastic bezel will hide an edge that is slightly uneven. You will need a small file to clean up the rough edges. A wire brush also helps.
[6] QST, June 2020, Hints and Hacks, page 53.