Bluetooth Radio Adapter

Build this unit to connect a standard Bluetooth headset to your radio

For the last few years Amateur Radio enthusiasts have connected cellular Bluetooth headsets to transceivers using the Jabra A210[1] or a device called TalkSafe[2]. However, at the inception of this article in the fall of 2011, this hardware has been discontinued and is hard to find. While some may question the utility of such a device, the idea is intriguing and useful on three levels. First, there have been many occasions during contests where I am operating two or more radios and hand turning antennas. The capability to monitor the band or conduct QSOs while away from the radio would come in handy. Second, the ability to have a hands-free QSO while operating a vehicle. And third, the prospect of adding another RF transmission link (complete with a transmit/receive antenna) into the normal radio communications process should appeal to most hams.

The recent discovery of audio Bluetooth modules from KC Wirefree[3] provided the final inspiration for this project. A module loaded with kcAudioGateway firmware provides a two-way audio communications link to standard off-the-shelf Bluetooth mono headsets for cell phones. The RF range of their class 2 module is listed as 25 meters and features a built-in antenna.

The Bluetooth Radio Adapter resides at the transceiver with its audio input connected to the transceiver audio output, and its audio output connected to the transceiver microphone connector. Front panel pushbuttons control the Bluetooth connection and volume. Power is supplied from a standard ham radio 12VDC power supply.

Circuit Description

M1, KC-6112-AG

M1 is a tiny (0.59" x 1.17") 40 pin SMD module that supports standard and custom Bluetooth profiles. With a recommended operating voltage of 3.3 VDC, this class 2 module uses the standard Bluetooth carrier frequency of 2.4 GHz with a transmit power of up to 8 dBm into a 50Ω load. The module is registered with and granted approval by the FCC and meets the conducted and radiated emission requirements of the FCC "Code of Federal Regulations" Title 47, Part 15, Subpart C, Section 15.247 for Bluetooth spread spectrum transmitters. KCWirefree has many firmware configurations and a PCB mounted mini USB jack (J4) allows the user to update the module firmware[4].

Once powered, S1 (Bluetooth) is used to enable the M1 module and establish the Bluetooth connection per Table 2. S2 (VOL UP) and S3 (VOL DN) raise and lower the received volume, respectively. Double pressing S2 and S3 will also raise and lower audio input gain.

M1 has a maximum audio input level of 0.4 Vrms. A typical transceiver headphone/speaker outputs about 1 Vrms of audio with the volume set to midpoint. Therefore, a -12 dB attenuator is placed on the input via R4-R5 to lower the transceiver audio level. 12 dB of attenuation equates to a 4:1 ratio.

$V_D = 4$
$V_D = 1 + (R5/R4)$
$dB = 20 * Log_{10} (V_D)$

R6 = 7,500
R5 = 2,200
$V_D = 1 + 3.02 = 4.4$
$dB = 20 * Log_{10} (4.4) = 12.9$

M1 has a typical audio output level of 0.75 V rms. In a similar fashion, R1 and R6 form a -30 dB attenuator to convert the line output level from M1 to transceiver microphone level.

R8 = 10K
R2 = 300
$dB = 20 * Log_{10} (33.3) = 30.46$

Two 3.5mm phone jacks supply the connections to the rig speaker/headphone output (J1), and the rig microphone (J2).

Power Supply
The voltage regulator accepts an input of 12 VDC and supplies the 3.3VDC required by the circuit. The regulator features short-circuit protection and supplies up to 500mA of current. Average current draw for the circuit is 26mA.

PC Board
Per the datasheet, the area around the M1 module should be free of any ground planes, power planes, trace routings, or metal. The recommended minimum clearance is 8mm, but additional clearance allows improved range and throughput. A PC board was designed and ordered from ExpressPCB[5]. I took advantage of their MiniBoard service which provides three 3.8 inch x 2.5 inch PCBs for $51. The Bluetooth Radio Adapter PCB is smaller than the standard MiniBoard size so it must be cut to fit the enclosure. Trim the PCB to size by removing the solid copper areas. Cut inside the copper areas (using a band saw or hack saw with a fine tooth blade) and finish removing the copper areas with a file.

Construction and Tools
All components are surface mount except J1-J4, S1-S3, D1-D3, and FB1. Since this was my first project to implement SMDs, I invested in a few tools and supplies:

- Magnifying lamp (3 diopter)
- Temperature controlled soldering station (Hakko FX-888)
- Soldering tips (Hakko T18-I, T18-C05, T18-B)
- Tweezers (DigiKey# EROP3CSA-ND)
- 0.020" diameter solder (Mouser# 533-24-6337-9702)
- De-soldering braid (Mouser# 5878-60-1-5)

Another option for SMD soldering is a hot air rework station[6]. It uses hot air to solder the components using solder paste. All components mount on the component side. Install all surface mount components first to allow room for the soldering iron. Inspect the PCB for correct components, component orientation, good solder joints, and remove any solder bridges using the de-soldering braid. Mount the two LEDs by bending the leads per the detail on drawing page 2 of 3. Also, remove the plastic tabs on the bottom of J1 and J2.

Tap the PCB mounting holes with a 4-40 tap and install the PCB using four nylon 4-40 x 3/16" machine screws. The use of nylon screws prevents shorting any of the PCB traces and reduces the amount of metal around the antenna. A drill template is provided for the enclosure front and rear panels to aid in hole cutting. Print the PDF template full size by selecting "None" under Page Scaling, align the template center lines with the panel center lines, and secure it to the panel using a temporary adhesive such as a glue stick. To complete the enclosure, add four sticky-back rubber feet on the bottom.

The cable for connecting the Bluetooth Radio Adapter audio input to the transceiver speaker/phone output is a standard shielded cable with 3.5mm mono phone plugs on each end. The cable for connecting the Bluetooth Radio Adapter microphone to the transceiver should have a 3.5mm mono phone plug on one end and the appropriate microphone connector on the other end. I prepared one cable for use with my Yaesu FT-817/857 and one for my Kenwood TS-480SAT (both rigs use RJ-45 microphone connectors). J2 tip is audio out to the rig microphone, and J2 sleeve is microphone ground. Cut a five foot CAT-5e cable in half and solder a 3.5mm mono phone plug on the cut end. Builders should consult their rig manual for microphone pinouts.

Bluetooth Headset

I chose the VXi Blue Parrott® B250-XT[7] to test the Bluetooth Radio Adapter as it has a boom that places the microphone near the mouth, increasing intelligibility. This headset combines a high-performance noise-canceling microphone and noise suppression technology to eliminate ambient noise. It features 16 hours of talk time on a single charge and up to 150 hours standby time.

Power Up and Connecting

Table 1 lists the LED event and state indicators. Table 2 lists the available button actions.

Event	LED Action	Specific
Powering On	Solid Blue	1s on
Powering Off	Solid Red	1s on
Discoverable	Fast alternate Red Blue blink	60ms on, 60ms off
Connectable	Slow double Blue blink	80ms on/off/on, 1200ms off
Connected	Blue blip	40ms on, 2300ms off
Connecting to Headset	Fast Blue blink	
Searching for new Headset	Blue Red Blue blink	
Reset Pairing	Triple Red + Blue flash	

Table 1

Feature	Button Action
Power On	Hold Bluetooth button 2.5 sec when off
Power Off	Hold Bluetooth button 2.5 sec when on
Connect Last	Press Bluetooth button
Search & Connect	Hold Bluetooth button 1 sec
Volume Up	Press VOL UP, hold for repeat
Volume Down	Press VOL DN, hold for repeat
Input Gain Up	Double press VOL UP
Input Gain Down	Double press VOL DN
Reset Pairing	Hold VOL UP and VOL DN 2 sec

Table 2

Operation
Upon power up, the Bluetooth Radio Adapter will search for any previously paired Bluetooth headsets and attempt to connect with them. The Bluetooth Radio Adapter is only discoverable and available for new pairings upon power-up if there are no previously paired devices in memory. Otherwise, the Bluetooth Radio Adapter can be put into discoverable pairing mode manually by pressing and holding the BT button through power up. After a 7 second hold the Bluetooth Radio Adapter will enter discoverable mode, beep twice, and flash an alternating red and blue light sequence. Press and hold the Blue Parrot Headset Bluetooth button for six or seven seconds and release. The headset will beep and the two units should connect in the next few seconds and display a slow flashing blue LED. Once paired, the unit can be powered up using a 2.5 second press of the BT button for instant connection.

Once connection is established between the Bluetooth headset and Bluetooth Radio Adapter, adjust the output volume using the VOL UP and VOL DN buttons. Also, adjust the input gain input using a double press of the same buttons. The KC Wirefree modules support PTT functions, but since cell phones (and cell phone accessories) are full duplex there is no need for a PTT button. Therefore, when using the Bluetooth Radio Adapter with a standard Bluetooth headset set your rig for VOX operation. As an aid to unwanted transmissions, the Blue Parrot Headset features a mute button. When transmitting from the Bluetooth headset there is a wireless delay of about 45ms that is unnoticeable unless the transceiver transmit monitor is turned on. It is therefore recommended that the transmit monitor be turned off to avoid this slight echo effect.

The highest signal to noise ratio on the Bluetooth headset is achieved by reducing the Bluetooth Radio Adapter input gain to minimum (double press the VOL DN several times). Then, adjust the transceiver output volume for maximum volume with minimum distortion.

The operating range depends on several factors. Best range is achieved with line-of-sight positioning of the Bluetooth headset and Bluetooth Radio Adapter. Certain conditions and obstructions, such as other wireless devices, microwave ovens, walls, or placing the device on a metal surface (such as your vehicle's hood), can inhibit radio wave transmission and reduce range. Officially, there are three classes of Bluetooth[8] radios:

Class	Maximum Permitted Power		Range
	mW	dBm	(Feet)
1	100	20	300
2	2.5	4	33
3	1	0	3

Table 3

Conclusion
I was pleasantly surprised at the ease of surface mount soldering. The magnifying lamp and tweezers made component placement a snap. The high quality temperature-controlled soldering iron and small diameter solder were instrumental in the completion of this project. My method was to lightly tin one pad with solder, place and align the component on the pads with tweezers, press down on the component, and heat the tinned pad. This levels and holds the component in place to allow soldering of the remaining pads. Finally, go back and resolder the first pad with additional solder. In order to clean up any solder bridges, place the solder wick over the solder bridge and hold the tip of the soldering iron on top of the solder wick. Excess solder is then pulled into the wick, eliminating the bridge.

The outdoor range of the Blue Parrot headset to Bluetooth Radio Adapter is over 50 feet and should provide complete local coverage. Users should be aware that Bluetooth transmissions do not always penetrate walls or ceilings and are therefore limited to relatively short line-of-sight ranges. Audio quality transmitted from the Bluetooth Radio Adapter to the Bluetooth headset is excellent, and the audio from the Bluetooth headset to the transceiver via the Bluetooth Radio Adapter easily meets the nominal 300-3 KHz communications bandwidth.

This project is among the most enjoyable and interesting Amateur Radio devices that I have developed. And, because there are a relatively small number of components, it presents an ideal introduction to surface mount soldering. Once the Bluetooth Radio Adapter has been paired with the headset and the levels set, the fun begins. The Amateur Radio operator, no longer glued to the transceiver, is now free to roam around. So, get off of your station chair, lace up your tennis shoes, and turn your sedentary radio time into a work out!

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