# A Bluetooth Radio Headset Adapter

## Build this compact unit to connect a standard Bluetooth headset to your radio.

This Bluetooth radio adapter connects wirelessly with the Bluetooth enabled headset providing hands free voice controlled operation with your radio.

**Allen Baker, KG4JJH**

In recent years Amateur Radio enthusiasts have connected cellular Bluetooth® headsets to transceivers using off the shelf hardware.[1] That hardware has been discontinued and is hard to find. Yet the idea of using a wireless headset is intriguing and useful on three levels. First, the capability to monitor the band or conduct contacts while away from the radio can come in handy during contests. Second, I can conduct a hands-free QSO while operating a vehicle. Third, adding another complete RF transmission link in the normal radio communications process appeals to me.

Audio Bluetooth modules from *kcWirefree* provide the final inspiration for this project.[2] The module loaded with *kcAudioGateway* firmware provides a two-way audio communications link to standard off the shelf Bluetooth mono headsets used with cell phones. 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 audio volume. A standard ham radio 12 V dc supply powers the adapter.

### Circuit Description

The 0.59 × 1.17 inch 40 pin surface mount KC-6112-AG module M1 supports standard and custom Bluetooth profiles. At the recommended operating voltage of 3.3 V dc this class 2 Bluetooth module operates in the 2.4 GHz band and delivers up to 2.5 mW of RF to its built-in meander line antenna for a range of up to 25 meters. [These modules use the BlueCore 5 multimedia chip from Cambridge Silicon Radio, and are FCC and CE listed for embedded applications like this one. — *Ed.*] I added a USB software programming jack, mini connector J4 in the schematic of Figure 1 and to the circuit board layout allowing the user to update the module firmware.[3]

Table 1 lists the module states and LED events, and Table 2 lists the features and button actions. Pushbutton S1 BLUETOOTH enables the module and establishes the Bluetooth connection. Pushbuttons S2 VOL UP and S3 VOL DN shown in Figure 2 raise and lower the received volume. Double pressing S2 and S3 also raises and lowers audio input gain.

A 12 dB attenuator, R4 and R5, in Figure 1 lowers the transceiver audio speaker/headphone level to the maximum 0.4 V rms audio input level for M1. R1 and R6 attenuate the 0.75 V rms line output level from M1 by 30 dB to the typical transceiver microphone level. Two 3.5 mm phone jacks provide connections to the radio speaker/headphone output J1 and to the radio microphone J2.

Voltage regulator U1 accepts 12 V dc from power jack J3 shown in Figure 3, and supplies the 3.3 V dc to the circuit. The regulator features short-circuit protection and can source up to 500 mA of current. The circuit draws about 26 mA.

### The Printed Circuit Board

The area 8 mm or more around module M1 should be free of any ground planes, power planes, trace routings or metal. I designed and ordered my printed circuit board (PCB) from ExpressPCB taking advantage of their MiniBoard service that provides three 3.8 ×

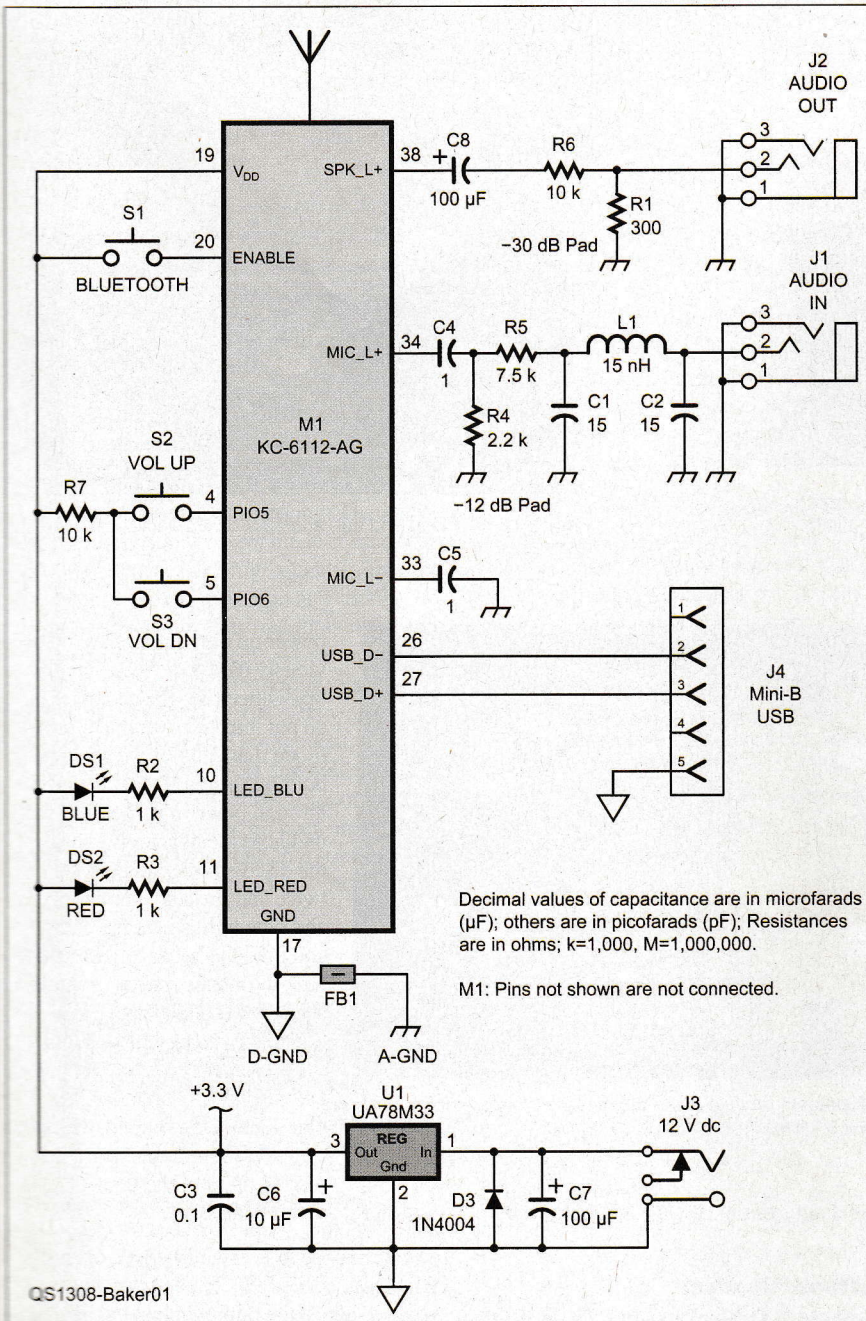
**Table 1**
**Bluetooth LED Display Events**

| LED Action | State Indicator | Specific Timing |
|---|---|---|
| Powering On | Solid blue | 1 s on |
| Powering Off | Solid red | 1 s on |
| Discoverable | Fast alternate red/blue blink | 60 ms on, 60 ms off |
| Connectable | Slow double blue blink | 80 ms on/off/on, 1200 ms off |
| Connected | Blue blip | 40 ms on, 2300 ms off |
| Connecting to Headset | Fast blue blink | – |
| Searching for New Headset | Blue/red/blue blink | – |
| Reset Pairing | Triple red + blue flash | – |

**Table 2**
**Bluetooth Button Features**

| Feature | Button Action |
|---|---|
| Power On | Hold BLUETOOTH button 2.5 s when off |
| Power Off | Hold BLUETOOTH button 2.5 s when on |
| Connect Last | Press BLUETOOTH button |
| Search & Connect | Hold BLUETOOTH button 1 s |
| 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 s |

[1]Notes appear on page 33.




Enclosure, 3.6" × 2.6" × 1.1", black ABS plastic (Mouser 546-1593LBK).
Four 4-40 × 3/16" nylon pan head machine screws (McMaster-Carr 94735A150).
PC board from author at **www.kg4jjh.com/Bluetooth.html** or *QST* in Depth web page.
C1, C2 — 15 pF 25 V multilayer ceramic capacitor SMT 1206 (Mouser 77-VJ1206A150KXXCBC).
C3 — 0.1 µF 25 V multilayer ceramic capacitor SMT 1206 (Mouser 77-VJ1206Y104KXXCBC).
C4, C5 — 1 µF 50 V multilayer ceramic capacitor SMT 1206 (Mouser 77-VJ1206V105MXATBC).
C6 — 10 µF 25 V multilayer ceramic capacitor SMT 1206 (Mouser 603-CC206K-KX5R8BB106).
C7, C8 — 100 µF 25 V electrolytic capacitor SMT (Mouser 140-VEJ101M1ETR0607).
DS1 — 2 mm pinhole blue LED (Futurlec LED2PINB).
DS2 — 2 mm pinhole red LED (Futurlec LED2PINR).
D3 — 1N4004 diode (Mouser 512-1N4004).
FB1 — 3 mm ID x 3.3 mm L mix 43 ferrite bead, (Mouser 623-2643000101).
J1, J2 — 3.5 mm 3-conductor jack (Mouser 806-STX-3501-3N).
J3 — 2.5 mm dc power jack (Mouser 163-7625E-E).
J4 —MiniB-USB jack (Mouser 710-651005136521).
L1 —15 nH inductor SMT 1210 (Mouser 871-B82422A3150K100).
M1 — Class 2 Bluetooth audio module with audio gateway firmware, (KCWirefree KC-6112-AG).
P1 — CAT 5e cable RJ-45 8-pin 5 ft (Mouser 601-73-7792-5).
P2 — 3.5mm 2 conductor phone plug (Mouser 568-NYS226).
P3, P4 — Cable, 3.5mm phone plug each end, 3 ft (Mouser 172-3536).
R1 — Thick film 300 Ω ¼ W 1% resistor SMT 1206 (Mouser 652-CR1206FX-3000ELF).
R2, R3 — Thick film 1 kΩ ¼ W 1% resistor SMT 1206 (Mouser 652-CR1206-FX1001GLF).
R4 — Thick film 2.2 kΩ ¼ W, 1% resistor SMT 1206 (Mouser 652-CR1206FX-2201ELF).
R5 — Thick film 7.5 kΩ ¼ W 1% resistor SMT 1206 (Mouser 652-CR1206FX-7501ELF).
R6, R7 — Thick film 10 kΩ, ¼ W 1% resistor SMT 1206 (Mouser 652-CR1206FX-1002ELF).
S1-S3 — SPST right angle momentary tactile switch (Mouser 655-FSMRA4JH).
U1 — 3.3V 500mA voltage regulator SOT-223-4 (Mouser 595-UA78M33CDCYR).

**Figure 1** — Schematic diagram of the Bluetooth radio adapter includes a 3.3 V dc power supply. Mouser parts available from **www.mouser.com**, KC Wirefree parts from **www.kcwirefree.com**, McMaster-Carr parts from **www.mcmaster.com**, Futurlec parts from **www.futurlec.com**.

2.5 inch PCBs for approximately $51.[4] You can obtain my PCB design from the *QST* in Depth web page.[5] My PCB adds a USB jack J4 and corrects some errors in the KC Wirefree documentation over the prototype board shown in Figure 4. The Bluetooth radio adapter PCB is smaller than the standard MiniBoard size so you must cut it 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 fine-toothed hack saw and finish removing the copper areas with a file.

## Construction and Tools

All components are surface mount devices (SMDs) except J1-J4, S1-S3, D1-D3, and FB1. Since this was my first project using SMDs, I invested in a few tools and supplies which you may find handy as well. My list includes a 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) and de-soldering braid (Mouser 5878-60-1-5).

You might opt for a hot air rework SMD soldering station which uses hot air along with solder paste.[6] All components mount on the component side of the PCB as shown in Figure 4. 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 de-soldering braid. Mount the two LEDs by bending the leads so that the LEDs match the openings in the front face of the 3.6 inch by 2.6 inch by 1.1 inch black ABS plastic enclosure


**Figure 2** — Select the Bluetooth features using the three front panel pushbuttons and observe the Bluetooth state indications on the red and blue LEDs.


**Figure 3** — Audio in and out, and 12 V dc connections are on the rear panel.

(Mouser 546-1593LBK). I show the LED bending dimensions and drawing on the *QST* in Depth web page. Also, be sure to 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 by 3/16 inch pan head machine screws (McMaster-Carr 94735A150). The nylon screws prevent shorting any PCB traces and reduce the amount of metal around the antenna. I provide a drill template for the enclosure front and rear panels to aid in hole cutting on the *QST* in Depth web page. Print the PDF template full size with no 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. Add four sticky-back rubber feet on the bottom to complete the enclosure.

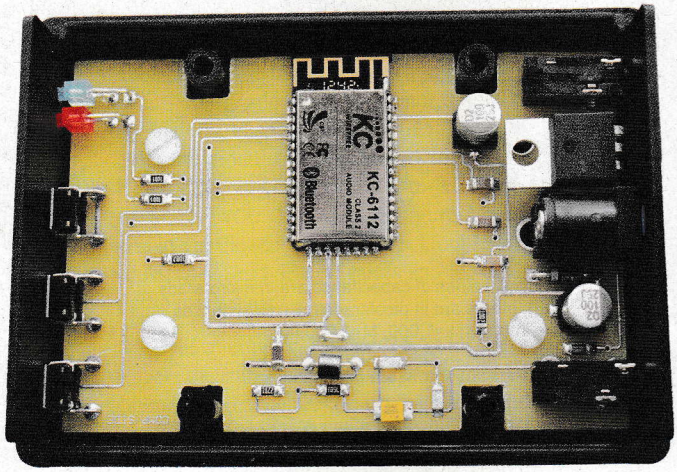



**Figure 4** — The Bluetooth module in the top center of this prototype circuit board sports a folded "meander line" antenna.

Use a standard shielded cable with 3.5 mm mono phone plugs on each end to connect the Bluetooth radio adapter audio input to the transceiver speaker/headphone output. The cable for connecting the Bluetooth radio adapter microphone to the transceiver should have a 3.5 mm 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 of my radios use RJ-45 microphone connectors. J2 tip is audio out to the radio microphone, and J2 sleeve is microphone ground. Cut a five foot CAT-5e cable in half and solder a 3.5 mm mono phone plug on the cut end. Builders should consult their radio manual for microphone pin-outs. I've included some cable diagrams on the *QST* in Depth web page.

## Bluetooth Headset

I chose the VXi BlueParrott® B250-XT shown in the article's lead photo to test my Bluetooth radio adapter as it has a boom that places the microphone near the mouth, increasing intelligibility.[7] 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.

## Powering up and Connecting

Refer to Table 1 for the LED event and state indicators and to Table 2 for the available button actions. Upon power up, the Bluetooth radio adapter will search for any previously paired Bluetooth headsets and attempt to connect with them. The adapter is discoverable and available for new pairings upon power up only if there are no previously paired devices in memory. Otherwise, the adapter can be put into discoverable pairing mode manually by pressing and holding the BLUETOOTH button through power up. After a 7 second hold the adapter will enter the discoverable mode, beep twice and flash an alternating red and blue light sequence. Press and hold the 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 slowly flashing blue LED. Once paired, the unit can be powered up using a 2.5 second press of the BLUETOOTH 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 configure your radio for VOX operation. As an aid to unwanted transmissions, the Blue Parrott Headset features a mute button. When transmitting from the Bluetooth headset there is an audio delay of about 45 ms that is not noticeable unless the transceiver transmit monitor is turned on. I recommend that you turn off the transmit monitor function to avoid the slight echo effect produced by the delay. You achieve the highest signal to noise ratio on

the Bluetooth headset by reducing the Bluetooth radio adapter input gain to minimum (double press the VOL DN button several times). Then adjust the transceiver output volume for maximum volume with minimum distortion.

Line of sight between the Bluetooth headset and Bluetooth radio adapter results in best range. 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.

## Final Thoughts and Conclusion

I was pleasantly surprised at the ease of surface mount component 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. Place the solder wick over any solder bridge to clean it up and hold the tip of the soldering iron on top of the solder wick. The wick pulls in the excess solder, eliminating the bridge.

The outdoor range of my Blue Parrott headset and Bluetooth radio adapter is over 50 feet. You should be aware that Bluetooth transmissions do not always penetrate walls or ceilings and are limited to relatively short line of sight ranges. I found that the 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. Because there are relatively few components, the project presents an ideal introduction to surface mount device soldering. The fun begins once the Bluetooth radio adapter has been paired with the headset and the levels set. Untethered from microphone and headset wires, you are now free to roam around. So, get out of your station chair, lace up your crosstrainers and turn your sedentary radio time into a workout!

**Notes**

[1]Bluetooth® is a trademark of the Bluetooth SIG, **www.bluetooth.com**.
[2]KC Wirefree Corporation, Bluetooth Wireless Audio Products, KC-6112 Datasheet, **kcwirefree.com/kc6112.html**.
[3]KC Wirefree Corporation, Firmware Update Tools, **kcwirefree.com/firmware.html**.
[4]ExpressPCB, **www.expresspcb.com/index.htm**.
[5]**www.arrl.org/qst-in-depth**.
[6]Hot Air Rework Station, **www.mcmelectronics.com/product/21-11425**.
[7]Blue Parrott B250-XT Headset, **www.vxicorp.com/products/blueparrott-bluetooth-mobile-solutions/bluetooth-headsets/b250-xt/**.

Allen Baker, KG4JJH, has been licensed since 2000 and loves to experiment with antennas and radio gear. He has authored numerous articles and maintains an Amateur Radio project website at **www.kg4jjh.com**. His other hobbies include fishing, camping and playing the guitar. You can reach him at 211 Brochardt Blvd, Knoxville, TN, 37934 or **kg4jjh@arrl.net**.

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## In The July/August 2013 Issue:

- Gary Richardson, AA7VM, wanted a better frequency counter than a previous project had been, and decided that a complex programmable logic device (CPLD) would be well suited to the task. This project was an opportunity to learn about what was to him a new class of ICs. The resulting frequency counter is described in his article, "Another Frequency Counter for the Experimenter."

- Hamish Kellock, OH2GAQ, describes a flexible, sophisticated way to control multiple transverters for use with a single transceiver in "A Microwave Transverter Controller."

- James Lee, N1DDK, introduces us to micro-electrical-mechanical systems (MEMS) inertial sensors and describes some ways we might use these devices with our Amateur Radio stations in "Motion Based Electrical Power Control." While a MEMS device may look like a *normal* surface mount IC, and be soldered into a circuit like one, these little building blocks are anything but normal!

- Ray Mack, W5IFS, takes a break from his "SDR: Simplified" column to explain "Using Time Domain Reflectometry for Transmission Line Impedance Measurement." Ray describes how a pulse generator and oscilloscope are used to make these measurements and reveal how the technique can reveal conditions on a remote piece of coaxial cable.

- Bob Simmons, WB6EYV, presents "A Two Meter APRS Beacon Transmitter." With RS232 input from a GPS unit, this 2 W transmitter will have you beaconing your position into the APRS network.

- Colin Horrabin, G3SBI, describes the design and construction of a receiver front end that could transform the state of art in receiver engineering. Colin used H-mode mixers and 4 × J310 transistor amplifiers for "The HF7070 Communications Receiver Prototype." While the HF7070 is not likely to become a commercial product, Colin's front end design gives the prototype receiver some outstanding performance. The measured IP3 dynamic range at 100 Hz signal spacing is 97 dB, and that measurement goes to 115 dB at 20 kHz spacing. If you are interested in receiver performance, you won't want to miss this article!

- Nickolaus Leggett, N3NL, presents an idea for "Getting Students Excited About Technology and Engineering" with a brief Tech Notes article. A simple shielded metal box, with easy access door and a rack to hold standard sized circuit board cards would provide a convenient way to experiment with RF circuits without the need to fabricate a chassis or enclosure for each project.

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