The WB2 “REMote” Link

With this system going for you, you need never be out of reach of your radio station.

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“CQ 20 meters...this is WB2REM bicycle mobile remote.” In response to this call last summer, a VU2 came back to me via long path from India. He asked *“What type of mobile did you say?”* When he paused to listen, I knew he could hear my huffing and puffing into the microphone. Between pedaling my bike up a steep hill—and working my farthest bicycle-mobile contact ever—I had difficulty talking! I replied, *“Bike mobile...and I’m on my way to work!”* He couldn’t believe what he’d heard...

Who’s This Project For?

Certainly, it’s not for bicyclists only. Do you like to have ready access to your radio in case there’s an emergency in your community or your part of the world? Do you live in a community that has severe antenna restrictions? Are you like me in that it’s difficult for you to be away from your radio because you’re afraid to miss that rare DX station? If you’ve answered “yes” to one or more of these questions, then this project’s for you!

General Description

Figure 1 is a block diagram of the system that I’ve used successfully over a 15-year period. With it, I’ve made over 3000 contacts in over 200 countries. Basically, this system allows you to remotely control your HF station through a UHF uplink and a VHF downlink in half-duplex mode, or on 222 or 440-MHz simplex. You can use the link to turn your HF rig (or rigs) on and off, change operating frequencies and maintain access to your home station from as far away as your UHF/VHF system will reach—all by remote control.

There are a few things about this system that may surprise you. For one, it doesn’t require a computer or repeater. It’s powered solely by a 5-V dc supply. Most of the parts are available at Radio Shack and the system costs less than $150 to build. Sound interesting?

What Gear Do I Need?

You need a UHF receiver and a VHF transmitter to operate half duplex at your home station. For the remote station, you need a duplex UHF/VHF radio which should employ diode (fast) TR switching. The link has an on-board simplex sampler (explained later) that’s needed if you’re operating simplex. A time-out timer and beepers are included. These circuits are crucial in the event of signal fades, or if you get out of range of your home station. After a preset time, your HF rig is turned off completely. Once reactivated by DTMF commands, the link returns to operational readiness.

The HF End

For the remotely controlled HF transceiver, you’ll need a Kenwood TS-440S or similar rig. With the TS-440S, all HF station control is handled via the microphone jack. Voice-synthesized frequency readout is accomplished by using a negative-going signal to trigger the transceiver’s voice synthesizer. (If your radio doesn’t have a voice synthesizer, you’ll have to develop another approach to verifying the radio’s operating frequency.) The TS-440S has 100 frequency memories that can be selected via the microphone. If your radio doesn’t have this capability, you may be limited to single-frequency operation.

Construction

During the following discussion, refer to Figure 2. The easiest way to construct this project is on a PC board [1] or

circuit board(s). I used a Radio Shack 276-190 project board that's large enough to hold the circuit's 19 ICs and 5 relays. Unfortunately, this 22/44-pin plug-in board is no longer stocked. If you decide to use a prototyping board, use one that's equipped with ground and voltage buses near each row of chips so you can easily attach wires from the chips to either bus. With the PC board, all you have to do is put the parts in their proper positions.

Decoder

First, construct the DTMF decoder circuit. This consists of an SSI 202P decoder (U3), a 74154 multiplexer (U2) and a 7404 hex inverter (U1).

Once it's built, check the decoder by applying power (+5 V) and feeding audio to the junction of U3 and C7. If the decoder is working properly, LED DS3 will light up in response to each decoded tone. You can also test for proper operation by locating each tone's corresponding output pin on U2 and—while feeding in the appropriate tone—observe the voltage drop from 5 V to ground. **Caution:** Never apply voltage to pin 9 of U3! That'll ruin the decoder.

Incoming DTMF tones are used to turn switches on and off (2-tone and 3-tone latches). You select the *link on* code (ie, *54), and a *link off* code (ie, #79). Connect the designated outputs of U2 to the trigger inputs of the 556 timers (U4, U5 and U6) and their associated 7404 inverter sections. You'll need to assign transceive versus receive-only codes, too, although these require only two tones each. For security reasons, select your tone sequences for fast key-pad access. Ideally, you'll have about 1-1/2 seconds to enter three tones, and 1 second to enter two tones, so you don't want to have to hunt and peck all over the keypad.

Latches

Next, set up U4, U5 and U6. These three 556 dual-timer circuits determine the time value used for the latches or switches. To change the timing, alter the value of the resistors connected to the junctions of pins 1 and 2, and 12 and 13 of U4, U5 and U6. A 100-kΩ resistance change equates to a time change of approximately 1 second. After constructing the 556 timer circuits, test them individually by grounding pin 6 of U4, U5 and U6, and observe a 5-V timed response on pin 5 of each of the ICs. If you ground pin 8 of U4, U5 or U6, a similar timed 5-V response should occur on pin 9 of the tested IC.

The second tone of the two-tone sequence and the third tone of the three-tone sequence go directly through an inverter section of U1 or U10. When all conditions are satisfied, a section of a triple-input AND gate (U8) triggers a latch. The *off* code releases the latch. For the two-tone latch, two-input NAND gates (U7 and U9) provide the same effect. Sections of hex inverters (U7, U9 and U17) compose the latches. Once you've completed assembling and testing these two of the four conditions necessary to operate the link, begin working on decode verification, or DV.

Decode Verification

DV refers to verification that any particular tone has been decoded. The verification signal originates at U3, pin 14, and is visually identified by illumination of DS3 at U1, pin 8. Basically, this circuit prevents the DTMF tones from being transmitted on the low-frequency bands. Once a tone is sensed, the link's transceive mode is disabled temporarily. The circuit also corrects for any decoder falsing caused by voice-signal triggering.

Carrier-Operated Relay

Lastly, complete the carrier-operated relay (COR) circuit. I try to isolate my UHF/VHF rig from the link by having the high-going subaudible tone switch, or COR, trigger an external relay. This relay applies a ground connection to U1, pin 1. If you must apply a high-going signal, do so at U1, pin 2.

When a signal is present at the COR, K5 is energized. That applies +5 V to a carrier hang-time circuit. The **HANG-TIME DELAY** is controlled by R65. This circuit prevents the HF PTT line from chattering if you momentarily lose your UHF/VHF link.

The Four Conditions

Now, connect the decoder, latch, DV and COR sections to U14. When the *link on* codes are activated, the transceive mode is accessed and the COR is reflecting signal presence, pin 6 of U14 displays a high signal. This signal triggers the HF PTT relay (K2) and places the HF rig in transmit mode. Likewise, the rig's *on* code activates K4, which turns on the rig by energizing the coil of an externally mounted 12-V DPDT relay. The rig's *on* code also activates the simplex sampler. On the other hand, the COR relay (K5) signal and HF PTT inhibit the simplex sampler.

Simplex Sampler

Next, construct the simplex sampler, U12. R45 controls the **SAMPLING RATE**. R44 controls the sampling **WINDOW** (the amount of time allowed for recognizing an incoming signal). If you own a rig with diode TR switching, that window can be as short as 30 ms. However, if your UHF/VHF rig uses a mechanical TR relay, the window may have to be open for as long as 1 second. Set the rate so that sampling occurs every three seconds, for example. When the system is being used for half-duplex operation, the simplex sampler can be bypassed completely by merely closing the sampling window.

Timers and Oscillators

Now that you're able to turn on the equipment and trigger your PTT switch, you'll need to construct security devices, including a time-out timer, beeper oscillators to signal the threat of a time-out, and a beep to confirm HF-band transmission.

Time-Out Signal

The time-out signal originates on U13 pin 4. The time-out delay length is determined by **TIMEOUT DELAY** R54, and is activated by the loss of a 5-V signal, which accompanies the rig's *on* relay command. Likewise, the timer is reset by a 5-V signal whenever a COR signal occurs.

Beeper Timer

The same 5-V signal that triggers the main time-out timer also starts a beeper timer at U16, pin 10. This timer warns of an imminent time-out. The **TIME-OUT BEEPER START DELAY** is adjusted by R70, and the **TIME-OUT BEEPER RATE** is controlled by R69. A pulse on pin 5 of U16 is sent to an oscillator on U18, which produces the beep tone. R78 adjusts the **BEEPER PITCH**. The **BEEPER VOLUME** is controlled by R80. The beep that occurs following a low-band transmission originates at U18, pin 4. The **HF BEEP LENGTH** is altered by R79, **HF BEEP PITCH** is varied by R75, and **HF BEEP VOLUME** controlled by R81.

Frequency Up/Down

The HF rig's frequency changes are made by generating a negative-going signal on request and sending it to the rig's microphone up/down-frequency control lines. (I'm assuming, of course, that your rig is triggered by connecting the line(s) to ground.) Basically, you construct two 2-tone *on* latches. These latches are turned *off* by a 1-tone command. This allows you to scan up or down frequency. When you locate the desired spot or station, you can make a quick stop.

Momentary up and down frequency changes are provided to allow you to make minor frequency adjustments to the HF rig. This circuit is made up of U19, U17, U12, U10, U9 and U1. D4, D5, D7 and D8, prevent you from changing frequency when the rig's not on, and when the rig's in the transmit mode. Note: You can change the HF rig's frequency *only when the rig's in the receive mode*.

Hook-Up

As mentioned earlier, I constructed my link on a 22/44-pin plug-in board. This allows me to easily feed HF receiver audio, HF PTT and HF mike audio into the board along with UHF/VHF receiver audio, the PTT line and mike audio. An off-board-mounted, 12-V-coil relay equipped with 10-A-rated contacts (controlled by K4) can be used to turn on a 100-W rig. (Higher-power rigs may require a relay with a greater contact-current rating.) What I've done is to open the hot wire of an extension cord and use the relay contacts to close the wire in order to turn on the rigs. You can do the same thing with the 12-V line between your rig and its power supply.

Once all connections are made, attach the HF receiver audio line to the **VHF MIKE** audio. Connect the UHF/VHF receiver audio to the HF transmit audio line. This allows for cross-band linking. You may want to use additional filtering, variable resistors or other devices to smooth out or better control the audio levels.

Checkout

When all of the connections are made, activate the link with your *on* codes. Adjust the simplex sampler for the proper rate and window, set your time-out timer and beeper for a desired time-out period, adjust oscillator pitches and volume levels, and set the carrier-hold time.

Place the link into the transmit mode. The simplex sampler should stop sampling and K2 should energize, causing the HF rig to transmit. Adjust the HF-mike audio level for the lowest level that produces maximum output. This adjustment is sensitive and can be found near the beginning of the level-control's range. Adjust the VHF/UHF receiver audio for best level for tone decoding and audio retransmitting. Test your time-out timer to see if it shuts off the rigs after the desired time period.

If everything goes well, try contacting someone for an audio report and make further adjustments. It's important that you carefully shield the link from RF. A sure sign that RF is interfering with the link's operation is failure of the decoder, or feedback in the HF-mike audio. Use a metal enclosure or manufacture one from PC-board material. For external leads, use shielded wire or RG-174 coaxial cable.

To operate full duplex, you need to replicate a 2-tone latch circuit. You can use the latch to turn on and off a relay that activates the UHF/VHF rig's PTT line. Likewise, if you want to employ remote rotator control, I suggest you purchase a voice-synthesized digital rotator (Pro-search makes one) and design a relay matrix system to remotely activate the rotator.

Operation

You need to understand FCC Regulations concerning remote control linking. By law, all remote control must occur on frequencies of 222.15 MHz and above. Therefore, the link should be operated with 222 or 440 MHz used as the uplink (or simplex) and the downlink (if half or full duplex). Also, you need to avoid third-party agreement violations. For example, a codeless Technician-class operator operating on UHF can speak to somebody in the USA—or another country with a third-party agreement—when a control operator is present, but that Technician *can't* talk to someone—let's say in Europe—without violating a third-party agreement. *The control operator must be in control of the system at all times*. Of course, a Technician who has passed the code test and has HF privileges could work DX in the 28.3 to 28.5 MHz Novice/Technician phone band.

According to FCC Regulations, the VHF transmitter in your remote link needs to identify itself every 10 minutes. To accomplish this you can purchase or build one of the many available CW identifiers. [2] The COR or PL decoder line from your UHF radio can be used to trigger the IDer by sending your call immediately after your transmission to the link. Inject the CW IDer's audio into the VHF microphone audio connector. An in-line potentiometer (1 MΩ) can be used to control the volume level of the IDer. Some IDer boards have output-level control built in. Other ID methods could be tried such as using timers, but it is imperative that the 10-minute ID rule be followed. Also, check with your local frequency coordinator before deciding on which frequency (frequencies) you intend to use. A list of frequency coordinators and other useful information is contained in *The ARRL Repeater Directory*. [3]

Summary

I've enjoyed this mode of operation for the last 15 years. Where and how you operate is virtually unlimited. If you're in your car, on a bike or on a raft in your pool, your HF station is as close to you as your H-T!

Acknowledgments

I'd like to thank Jerry Lutin, N2ERB, for the help he provided producing my schematics and diagrams on his computer, and Glenn Belkin, KD2JA, for the photographic work.

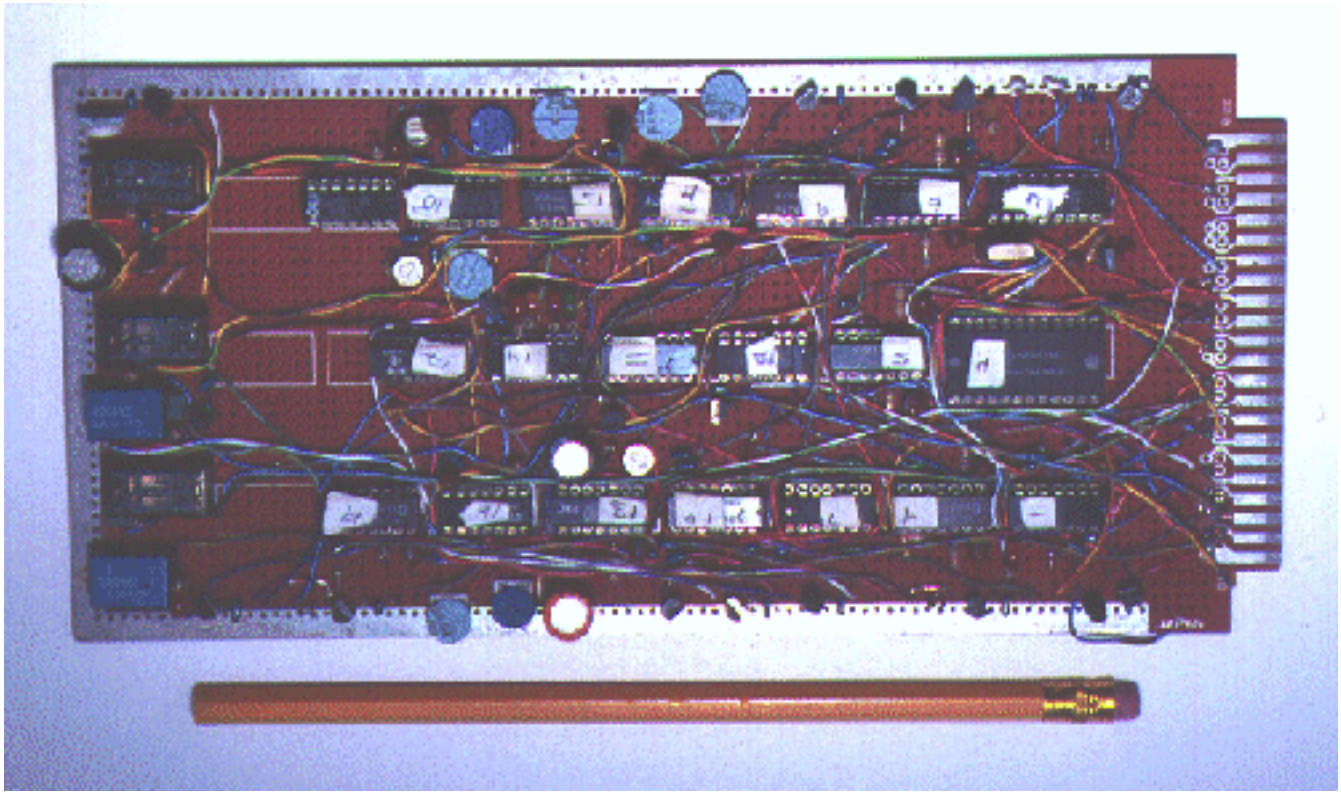
(1) PC boards had been anticipated for this project, but they are not available. See Feedback in June QST.

(2) See P. Bunn, “A CW ‘Stamp’ Identifier,” *QST*, Oct 1994, pp 41-42.

(3) Available from the ARRL Bookshelf. Call Publication Sales at 203-666-1541 and ask for publication #4246. Charge cards are accepted.

First licensed at age 11, Jim Millner has been a ham for 31 years and holds an Extra Class license. Although Jim has had no formal electronics training (he’s a child psychologist by profession), he designed his first remote control link in 1980. He published his first article on the subject entitled “The Missing Link” in the September 1986 edition of 73 Magazine. More recently, Jim and his link were seen in the ARRL video “The New World of Amateur Radio.” In addition to operating his remote-control HF station, he has recently incorporated it into his satellite station. You can find Jim operating ATV, packet radio and SSTV. Jim’s 10-year-old son, Matt, is following in his father’s footsteps. He is N2RSJ, and was licensed at age 7.

The author with the bicycle end of his remote station. *(photo by Glenn Belkin, KD2JA)*



WB2REM's remote control link. *(photo by Glenn Belkin, KD2JA)*

WB2REM's home station, the man and his H-T. At this range, there's no need for remote control! *(photo by Glenn Belkin,*

KD2JA)

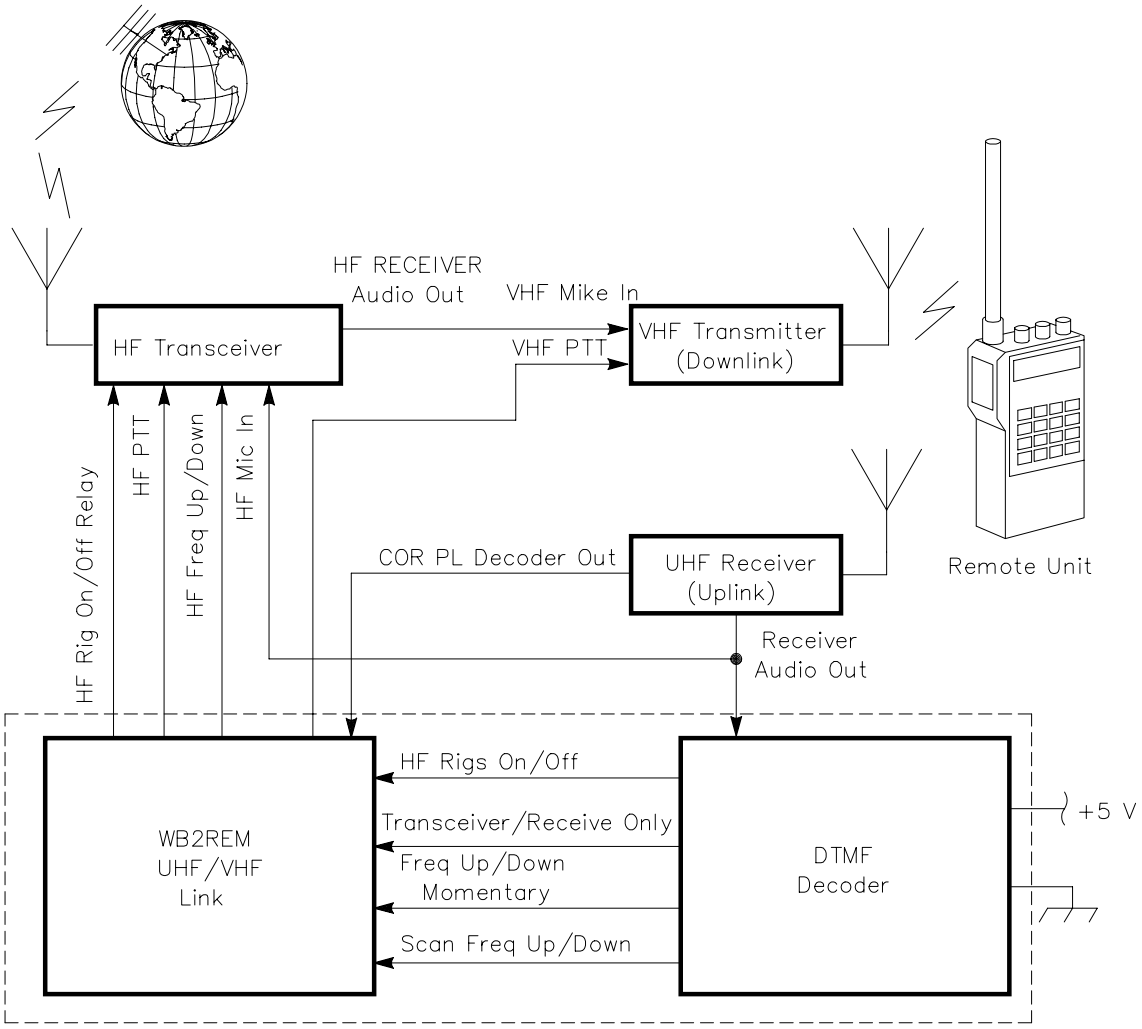


Figure 1—A block diagram of WB2REM's remote link.

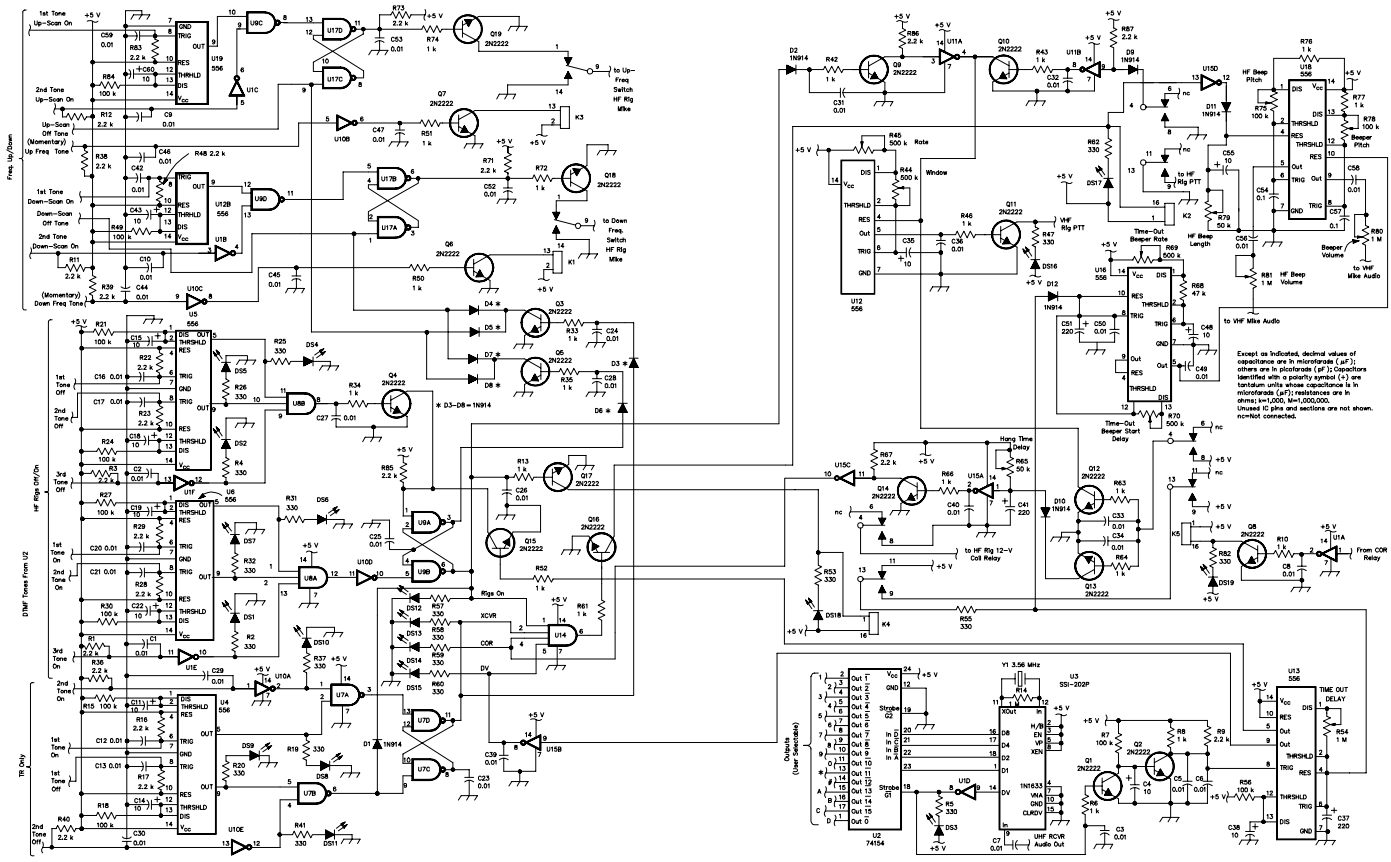


Figure 2—Schematic of the WB2REM remote link. All resistors are 1/4-W, 5%-tolerance carbon-composition or film resistors. Capacitors identified with a polarity symbol (+) are tantalum units whose capacitance is in microfarads (µF). Equivalent parts can be substituted.

C1-C3, C5-C10, C12, C13, C16, C17, C20, C21, C23-C34, C36, C39, C40, C42, C44-C47, C49, C50, C52, C53, C56, C58, C59—0.01-µF, 50-V, capacitor (Radio Shack 272-1065)

C4, C11, C14, C15, C18, C19, C22, C35, C38, C43, C48, C55, C60—10-µF, 16-V tantalum electrolytic capacitors (Radio Shack 272-1436)

C37, C41, C51—220-µF, 16-V, radial-lead electrolytic capacitor (Radio Shack 272-956)

C54, C57—0.1-µF, 50-V capacitor (Radio Shack 272-1069)

D1-D12—1N914 (Radio Shack 276-1122 [10 pack] or 276-1620 [50 pack])

DS1-DS19—T-1-3/4 red LED (Radio Shack 276-044)

K1, K3—SPDT relay, 5-V coil, 2-A contact rating (Radio Shack 275-243) (Note: 14-pin IC sockets can be used to mount these 12-pin relays. When inserting the relay, the normally closed contact rests in the pin-1 position, the normally open contact in the pin-14 position, the operating arm in the pin-9 position and the coil connections at pins 2 and 13, directly opposite each other.) Socket holes 7 and 8 are unused.

K2, K4, K5—DPDT relay, 5-V coil, 1-A contact rating (Mouser #431-OVR-SH-205L; Mouser Electronics, tel 800-346-6873,

817-483-4422, fax 817-483-0931)

Q1-Q19—2N2222 (Radio Shack 276-2009 or Mouser 333-KTN2222)

R14—1-MΩ, PC-board vertical-mount, single-turn potentiometer (Mouser 323-4295X-1MEG)

R44, R45, R69, R70—500-kΩ, PC-board vertical-mount, single-turn potentiometer (Mouser 323-4295X-500K)

R54, R80, R81—1-MΩ PC-board vertical-mount, single-turn potentiometer (Mouser 323-4295X-1MEG)

R65, R79— 50-kΩ, PC-board vertical-mount, single-turn potentiometer (Mouser 323-4295X-50K)

R75, R78—100-kΩ, PC-board vertical-mount, single-turn potentiometer (Mouser 323-4295X-100K)

U1, U10, U11, U15—7404 hex inverter (Radio Shack 276-1802)

U2—74154 4-line to 16-line decoder/demultiplexer (Mouser 526-NTE74154)

U3—SSI 202P DTMF decoder (Clem-Neff Enterprises, 305 University Blvd, Glassboro, NJ 08028, tel 609-881-6779, fax 609-881-0573, and B&G Micro, PO Box 280298, Dallas, TX 75228, tel 800-276-2206, 214-271-9834, fax 214-271-2462)

U4-U6, U12, U13, U16, U18, U19—556 dual timer (Radio Shack 276-1728)

U7, U9, U17—7400 quad 2-input NAND gate (Radio Shack 276-1801)

U8—7411 triple 3-input AND gate (Mouser 526-NTE7411)

U14—7421 dual 4-input AND gate (Mouser 526-NTE7421)

Y1—3.579-MHz crystal (available from Clem-Neff Enterprises, B&G Micro and Mouser Electronics 332-SM0357)