By Dan Wissell, N1BYT

# The WBR Receiver


## Build this simple receiver and "bridge" the gap between regenerative and direct-conversion receivers!

Despite the well-known drawbacks of regenerative receivers, the elegance and simplicity of the regenerative detector is still appealing. I'm always looking for a better way to implement Armstrong's brilliant design, and with the introduction of the Optically Coupled Regenerative Receiver (OCR),[1] the major problems of the regenerative detector were overcome. The OCR receiver demonstrated the potential of this nearly 90-year-old design to hold its own as a simple all-mode receiver. The design is still quite complex, however, and relies on expensive, hard-to-find, electro-optical components with limited bandwidths.

The key to a simple regenerative receiver design is coupling the antenna directly to the oscillating detector. Anyone who has ever tried to couple an antenna directly to a regenerative detector has found that signals from dc to daylight show up everywhere on the tuning dial—and all at the same time! Overcoming this problem by isolating the antenna from the detector causes the design to become as complex, or more so, than that of a simple direct-conversion receiver. Because of this complexity factor, regenerative detectors have largely given way to other simpler circuits.

The future of Major Armstrong's namesake may be more open-ended, however, because a simple and effective solution to the coupling problem has been found. The method of coupling the antenna to the tank circuit described below is reminiscent of a Wheatstone Bridge circuit, and thus the receiver name, "Wheatstone Bridge Regenerative (WBR) Receiver." I'm reluctant to claim that this is a "new" detector design, even though an extensive search hasn't yielded anything similar. But with nearly 90 years of use, I'm sure every method of detector-antenna coupling has been tried at one time or another!

This WBR may very well be the ultimate simple, *high-performance* regenerative receiver. As an added plus, the design virtually eliminates the negative aspects of regenerative receivers such as antenna radiation, frequency pulling, microphonics and hand capacitance effects. A printed circuit board is available to speed construction of this project.[2]

### Design Overview

The schematic of the WBR Receiver is shown in Figure 1. The basic circuitry is the same as that used in the OCR Receiver. The two most significant differences are the removal of the optocoupler from the oscillator, and the oscillator tank circuit configuration.

The highly stable Colpitts oscillator and infinite-impedance detector have been retained in this design. The major difference is that the oscillation is now controlled by directly varying the base current of Q1 (with R5 and related components) instead of using photons from the optocoupler LED.

The tank circuit is comprised of inductor L1, capacitors C7 and C8, along with tuning diode D1. This circuit is redrawn in Figure 2 to highlight the unusual component arrangement. C7, C8 and D1 have been omitted in Figure 2 for clarity. As shown, Figure 2 represents a classic Wheatstone Bridge circuit. Inductor L1 is center-tapped, with equal inductance on both sides of the tap. Capacitor C1 represents the oscillator and detector load capacitance. Balancing capacitor C2 is selected to match the value of capacitor C1. In this ideal case, the bridge is balanced and there is no voltage present at the center tap. The full oscillator voltage appears at nodes V1 and V2. Because no voltage is present at the center tap, it could be grounded—*or an antenna could be directly connected to this point without impacting the oscillator signal.*

In this design, the antenna is coupled to the center tap of L1 through an impedance represented by Z1. This is simply a one-inch length of wire connected to ground. The antenna is connected at the midpoint of Z1. This provides a low-impedance connection point for the antenna, as well as providing a dc ground for detector Q2 and tuning diode D1.

In practice, the bridge can't be perfectly balanced because the oscillator load capacitance changes as the level of regeneration is changed. Despite that, this arrangement still yields a *significant reduction* in oscillator voltage at the center tap of L1. Voltage measurements taken at 7 MHz show that the voltage present at the center tap of L1 is about 46 dB less than at nodes V1 and V2. The practical impact of this is good antenna isolation. When monitoring the oscillator signal from a WBR on a communications receiver, the WBR antenna can be removed and reconnected *with no perceptible change in the audio beat note from the communications receiver!* It turns out that if the oscillator coupling capacitance and the balancing

[1]Notes appear on page 37.

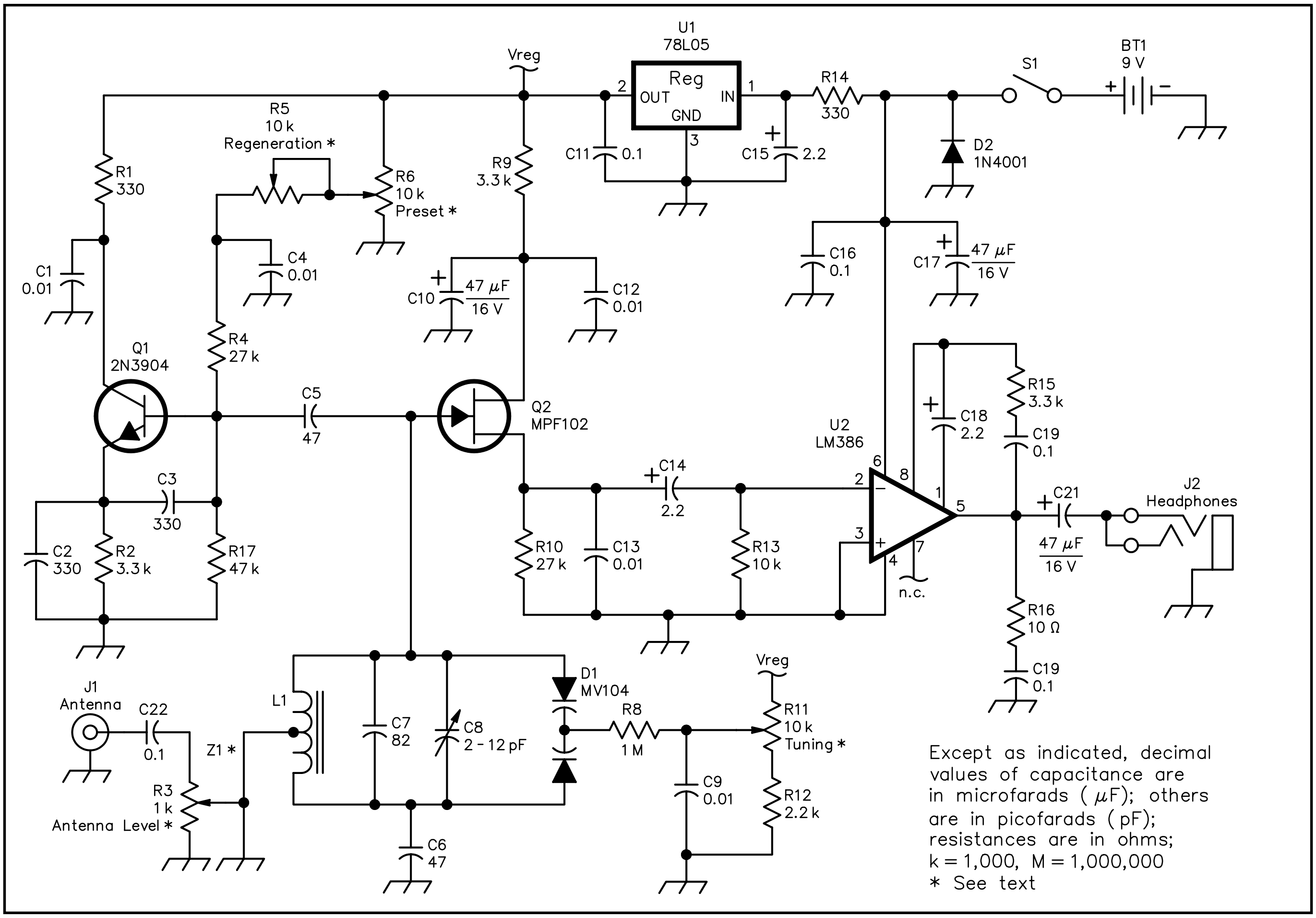


**Figure 1—Schematic of the WBR receiver. Unless otherwise specified, resistors are ¼-W 5% tolerance carbon composition.**

**C2, C3—330 pF, 5% NP0**
**C5, C6—47 pF, 5% NP0**
**C7—82 pF, 5% NP0**
**C8—2-12 pF NP0**
**C1, C4, C9, C12, C13, C19, C22—0.01 µF**
**C11, C16, C20—0.1 µF**
**C10, C17, C21—47-µF, 16-V electrolytic**
**D1—MV104**
**D2—1N4001**
**J2—Three-conductor phone jack, ⅛ inch.**
**L1—Approximately 3.7 µH: 28 turns of #22, center tapped, on T-68-6 core (yellow).**
**Q1—2N3819**
**Q2—MPF102**
**R1, R14—330 Ω**
**R2, R9, R15—3.3 kΩ**
**R3—1 kΩ linear-taper potentiometer. Panel mount.**
**R4, R10—27 kΩ**
**R5—10 kΩ linear-taper potentiometer. Panel mount.**
**R6—10 kΩ linear-taper potentiometer. Panel or PWB mount.**
**R7—47 kΩ**
**R8—1 MΩ**
**R11—10 kΩ, 10-turn potentiometer. Digi-Key # 3590S-1-103-ND.**
**R12—2.2 kΩ**
**R13—10 kΩ**
**R16—10 Ω**
**S1—SPST**
**U1—78L05**
**U2—LM386**

capacitor (C5 and C6 in Figure 1) are matched, a good balance can be obtained. If the oscillator design is changed, the balancing capacitor may have to be made variable to null the circuit.

Diode D1, a voltage-variable capacitor (VVC), is used to tune the oscillator. A low-cost plastic 10-turn potentiometer is used as the main tuning control (R11). Resistor R12 is used to set the lower voltage limit at D1 to about 0.9 V, below which the capacitance change of D1 is quite small. Regulator U1 is used to provide a stable voltage source for D1, Q1 and Q2. Regeneration is controlled by R5, a single-turn, panel-mounted potentiometer. R6 is used as a "preset" for R5 and allows for smooth regeneration control.

To keep the overall design simple, only a single stage of audio amplification is used (U2). This provides adequate volume for headphone operation when using a simple 40-meter dipole antenna. Reducing the signal level applied to the detector via R3 controls the headphone volume. A 9-V battery supplies power for the WBR. A well-filtered bench supply in the 8- to 13.8-V range may also be used. Diode D2 is added as a safety measure. The receiver works well with dipole or random wire antennas and an earth ground.

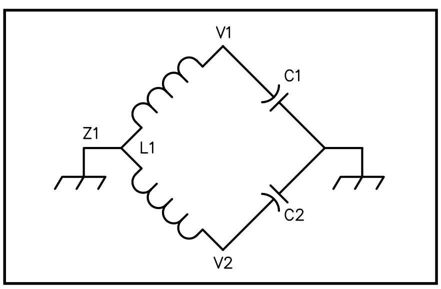


**Figure 2— The tank circuit is comprised of inductor L1, capacitors C7 and C8, along with tuning diode D1.**

## Constructing a 40-Meter WBR Receiver

The caption of Figure 1 contains the parts list for a 40-meter version of the receiver. The parts are available from a variety of suppliers. With the given values, the receiver will tune the entire 40-meter band.

A printed-circuit board is available and contains most of the components, but the circuit is quite simple and lends itself to "dead-bug"-style construction on a bare copper PC board. The only critical part is the oscillator circuit. Note that

NP0 capacitors are used to enhance frequency stability. Short, direct leads should be used in this part of the receiver. Make the circuit as mechanically robust as possible to improve stability. I typically use high-value resistors as standoff supports for signal components. For power-related parts of the circuit I often use ceramic capacitors in the range of 0.01 to 0.1 µF as supports. This also adds additional power-supply bypassing.

Inductor L1 is wound with #22 enamel wire. It's easy to create the center tap by using two separate windings. Start with two 15-inch lengths of wire. Wind the first 14 turns of L1, remembering that one pass through the center of the core is one "full" turn. Leave about 1 inch of wire for connections. The winding should fill about 40% of the core. Add the second 14 turns, as above, winding in the same direction as the first winding. The second winding should start next to one end of the first winding. Again, leave about 1 inch of wire for connections. Connect the end of the first winding to the start of the second to create the center tap.

As mentioned previously, Z1 is a one-inch length of #20 solid copper wire connected from the center tap of L1 to ground. The antenna connection is made at about the midpoint of Z1. While it's tempting to increase the amount of impedance at Z1, it's not a good idea because of the potential for detector overload, especially at 5 to 15 MHz, where strong AM stations dominate.

The regeneration preset control (R6) can be a small PWB-style unit or a standard panel-mount type. Because it's a "set and forget" control, it may be placed in any convenient location.

The hardware used for antenna connector J1 and switch S1 may be whatever the builder prefers. A fully enclosed case isn't required for good operation. My prototype WBR receivers are built as open breadboards and work well.

I have kept the complexity of the WBR design at a minimum to encourage builders to give it a try. For those wishing to add loudspeaker operation, however, or to increase the sensitivity of the receiver, I would recommend adding the audio preamp and volume control used in the OCR II receiver.[3] As presented, the basic oscillator will work up to about 18 MHz with D1 and C7 removed. The upper frequency is limited by the combination of capacitors C5 and C6. If desired, the frequency-dependent portion of the design (C7 and C8) can be scaled for other frequencies of interest in the lower HF region. The tuning voltage applied to D1 will need to be adjusted to provide the desired tuning range at other frequency ranges.

**A rear view of the WBR receiver.**

## Checkout and Operation

Carefully check your work before applying power for the first time. Once everything has been checked, plug in headphones at J2 and apply power. Advance the regeneration control (R5) to about 75% of its maximum setting. Adjust the regeneration preset (R6) until a distinct increase in background noise is heard. This indicates that Q1 is oscillating and that the audio section is working. Varying the regeneration control should produce a smooth transition when going into and out of oscillation. The oscillator can now be set to the correct operating frequency. Set the main tuning (R5) potentiometer to its minimum setting. With the regeneration control set to the point of oscillation, adjust C8 while listening for the signal on your station receiver or a communications receiver set for CW reception at 7.00 MHz. You will probably need to connect a short wire from the antenna connector on your station receiver and place it near the WBR to receive a signal. Once the frequency has been set, connect an antenna to J1 and you're all set! If a station or communication receiver isn't available, connect an antenna and adjust C8 until the CW portion of the band is found. Continue setting C8 until the lower edge of CW subband can be determined. This is best done in the evening when there is plenty of CW activity.

Using the WBR receiver will take some practice if you've never used a regenerative receiver before. Maximum sensitivity is obtained in the area just before oscillation (for AM reception) and just at oscillation (for CW). For SSB reception, the best operating point is usually found at a point that's just a bit past the setting required for CW reception. You will get the "feel" of the receiver quickly. The interaction of the regeneration, gain and selectivity controls will become apparent.

## Summary

The Wheatstone Bridge Regenerative Receiver works as well as its predecessor, the OCR. It has the added advantages of greater bandwidth, increased simplic-

**This ultra-tight close-up illustrates the so-called "dead-bug construction" that the author used in this version of the WBR. As an alter—native, a circuit board is available from FAR circuits.[2]**

ity and a much lower cost. It virtually eliminates the negative aspects of the regenerative receivers that came before it. This simple receiver is well suited for beginners who would like to build a simple all-mode shortwave receiver. QRP ops and home-brewers in general will also be interested in the WBR. Given that the antenna is quite isolated from the oscillator, the WBR can be used as a simple receiver for transmitter-receiver operation. It could easily be paired with a simple crystal-controlled transmitter, creating a small, portable "trans-receiver."

**Notes**

[1]Daniel Wissell, N1BYT, "The OCR Receiver," Jun 1998 *QST*, pp 35-38.

[2]Circuit boards are available for $4 (plus $1.50 shipping and handling) from FAR Circuits, 18N640 Field Ct, Dundee, IL 60118; tel 847-836-9148; **www.cl.ais.net/farcir/**.

[3]Daniel Wissell, N1BYT, "The OCR II Receiver," Sep 2000 *QST*, pp 35-38.

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# NEW BOOKS

## RADIO DATA CODE MANUAL

*Published by Klingenfuss Publications, Hagenloher Str 14, D-72070 Tuebingen, Germany; tel 49-7071-62830; fax 49-7071-600849;* **www.klingenfuss.org**. *Sixteenth edition, softcover, 9½×6½ inches, 788 pages with black and white illustrations. $32.80.*

*Reviewed by Steve Ford, WB8IMY*
QST *Editor*

The *Radio Data Code Manual* is a comprehensive reference aimed straight at the segment of our avocation that enjoys monitoring so-called utility stations—stations owned and operated by governments, military agencies, corporations and so on. In our increasingly digital communication environment, many of these services now use various digital formats to exchange information. From a monitoring station's point of view, untangling these signals, and the alphabet soup of abbreviations and acronyms carried in their transmissions, can be a daunting task.

Although the *Radio Data Code Manual* provides helpful descriptions of modulation and signaling schemes used by modes such as Piccolo and PACTOR II, that is not its primary purpose. Instead, the book concentrates on deciphering the actual information that is communicated by the individual services. For example, the *Radio Data Code Manual* offers an exhaustive list of aeronautical terms and abbreviations. You'll find 11,000 ICAO location indicators, 4300 addressee designators (organization symbols) and 1500 aircraft type designators.


The book spends quite a few pages on the *Unicode*—a standard data code for all commonly used languages (and some not-so-common languages) on the planet. The idea of the Unicode is to create a truly universal system for global electronic information exchange. The *Radio Data Code Manual* includes Unicode tables for 33 languages!

If you are tempted to go snooping outside the ham bands with your digital decoder, the *Radio Data Code Manual* is a vital reference that will make it possible for you to interpret the gibberish you often see on your monitor.

# NEW PRODUCTS

## ALL BAND SSB/CW TRANSCEIVER KIT FROM KANGA

◊ Kanga US has added the Hands Electronics RTX-109 SSB/CW transceiver kit to its line of kit products.

The RTX-109 is an amateur band SSB/CW transceiver with a direct digital synthesis VFO with a display resolution of 1 Hz. The VFO uses the AD9850 DDS clocked at 100 MHz with phase locked narrow band voltage controlled oscillators covering the 1.8 to 28 MHz amateur bands.

The RTX-109 is available in QRP (up to 6 W out) or medium power (up to 20 W out) versions. Construction is in a modular form, allowing the builder on a budget to start with a basic receiver and build up to the full transceiver.

A high level doubly balanced mixer in the front end is intended to enable the RTX-109 to deal with high signal levels—such as those encountered on 40 meters at night in Europe. The IF module includes a crystal filter, passive receive audio filtering and SSM2166 transmit speech processor.

Spare band positions and TTL drivers are built into the control microprocessor to allow configuration for transverter driving. The master VFO display can be offset up to 4.5 GHz to give the actual frequency display of the resulting frequency rather than the drive IF frequency.

Price: RTX-109, $538 (6 W); $598 (20 W). Kanga US carries the entire line of Hands Electronics Kits. For further information contact Kanga US, 3521 Spring Lake Dr, Findlay, OH 45840; tel 419-423-4604; **kanga@mail.bright.net**; **www.bright.net/~kanga/**.

◊ A few errors have crept into both the schematic and parts list for the WBR Receiver (August 2001 *QST*, Figure 1, page 35). In the parts list, Q1 is a 2N3904, and C14, C15 and C18 are all 2.2-μF, 16-V electrolytic capacitors. C22 is 0.1 μF. In the schematic diagram, C19 (connected between R14 and pin 5 of U2) should be 0.01 μF. This is the first occurrence of C19. The second occurrence of C19 between R15 and ground should be C20. The value is correct. R17 should be R7. In addition, Z1 should have been drawn as a 1/8-inch wide × 1/2-inch long strip connected to the center tap of L1 and grounded with a standard wire. The antenna should be connected at the midpoint of Z1, again with standard wire. —*Dan Wissell, N1BYT*