QST Issue: Jun 1995
Title: Build a Super-Simple SWR Indicator
Author: Tony Brock-Fisher, K1KP

Build a Super-Simple SWR Indicator

You don't need an actual *meter* to indicate reflected power if all you want to do is dip it. Here's a simple HF SWR indicator that provides positive indication of the matched-antenna condition down to very low power levels.

By Tony Brock-Fisher, K1KP
15 Webster St
Andover, MA 01810
e-mail: fisher@hp-and.an.hp.com

As a club project, the Hewlett-Packard ARC decided to build copies of the 40-40 QRP rig by Dave Benson, NN1G.[1] Many club members were interested in using this rig backpack or vacation style, with simple wire antennas and tuners, so the need for a companion SWR bridge arose. The resulting design is a simple, but effective, SWR indicator that can be used with a tuner to tune wire antennas, and is useful down to very low power levels (about 200 mW). The circuit can easily be squeezed into all but the smallest of QRP rigs, or it can be packaged into its own enclosure with a 9-V battery for a completely self-contained SWR indicator.

To save cost, we investigated the idea of using LEDs as indicators, instead of the traditional panel meter. In this application, it isn't really necessary to know exactly what the SWR is. We're more interested in just minimizing reflected power than in knowing that the antenna has an SWR of, say, 1.569:1. So we added a simple op-amp circuit to a traditional SWR-bridge design to create a much less expensive SWR indicator than the usual panel-meter approach. Additionally, the high-impedance LED driver circuit we developed allows the bridge to work down to very low power levels.

How It Works

See Figure 1. The bridge circuit is similar to the one described in *QST* and several editions of *The ARRL Handbook*,[2] but simplified (by the omission of a trimmer capacitor on the **XMTTR** side of T1) in that we don't need the bridge to be precisely balanced in this application. D1 and D2 act as half-wave diode detectors for the forward and reverse voltages. In traditional SWR-meter circuits, the output of these detectors feeds a panel meter via a

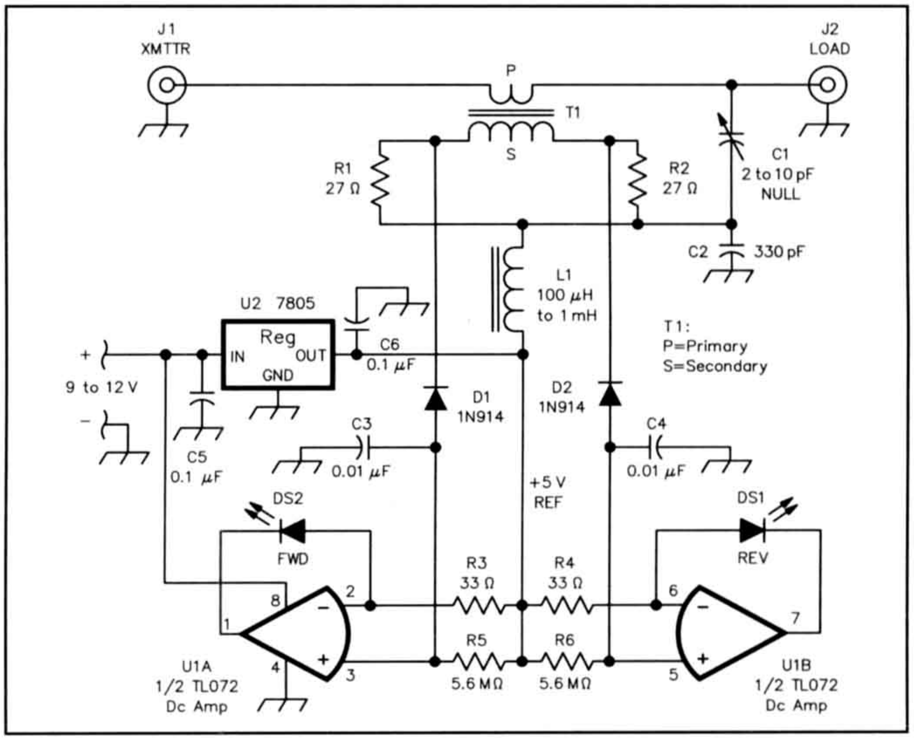

Figure 1—A standard directional coupler design teamed with a TL072 dual operational amplifier work together in this simple SWR indicator.

C1—Ceramic, plastic or air-dielectric trimmer
C2-C6—Ceramic
D1, D2—1N914 (or equivalent) silicon switching diode
J1,J2—Coaxial jacks
L1—RFC choke, 100 µH to 1 mH.
DS1, DS2—Light-emitting diodes (LEDs); red for **REV** and green for **FWD** suggested
R1, R2—5% or 10%-tolerance carbon film or composition
R3, R4—5% or 10%-tolerance carbon film or composition. The value of these resistors sets the bridge's power sensitivity; see text
T1—Toroidal transformer wound on a T-50-2 powdered-iron core. Secondary: 30 turns of #30 enameled wire; primary: 1 turn (just pass the wire through the core)
U1—TL072 dual JFET-input operational amplifier IC
U2—7805 or 78L05 5-V regulator IC

FORWARD/REFLECTED switch and a scaling resistor, which typically provides the detector diodes with a load on the order of 25 kΩ. This relatively low load impedance limits the diodes' performance at low power levels because it causes their forward voltage drop to be higher than the sampled RF voltages to be detected.

To use LEDs (DS1 and DS2) as indicators, some sort of dc amplifier was needed.

[1]Notes appear on page 41.

We decided to use operational amplifiers because their high input impedance lets us load the diodes so lightly that their detection range can extend down to about 50 mV. U1A and U1B, halves of a TL072 dual JFET-input op amp (Figure 1), do the dc amplification.

The dc voltage developed by each detector is presented to its op amp across a 5.6-MΩ resistor. The 5.6-MΩ input resistor reduces the offset voltage, caused by input offset currents, to a negligible value. Each op amp operates at a voltage gain of 1 (unity), but provides enough current gain to drive an LED and to cause a matching voltage to appear across R3. (The current gain of the op amp is 5.6 MΩ ÷ 33 Ω, or about 170,000.) The LED's forward voltage drop is absorbed automatically by the op amp.

To provide each half of U1 with split (positive and negative) power supplies in environments in which only single-polarity, negative-ground supplies are typical, it was necessary to provide an artificial ground. U2 provides a stiffly regulated dc voltage between ground and the positive supply. (Note that the bridge circuit's dc reference is also set to +5 V because the RF-grounded end of L1, which is connected to dc ground in traditional directional-wattmeter circuits, is also connected to the +5 V supply provided by U2.)

Because we intended to use the bridge with a particular QRP transceiver design that operated at a known output power, Figure 1 includes no provision for adjusting the bridge's sensitivity. The overall sensitivity of the circuit can be adjusted to match the power level expected by changing the values of R3 and R4 to drive the LEDs with an appropriate current level. If you use different LEDs or want to use the bridge at a different power level, you may want to adjust these resistor values according to the formula

$$\text{R3 and R4 (ohms)} = \frac{\sqrt{P_0 \times 50}}{30 \times I_{f(LED)}}$$

where P_0 is the transmitter power in watts (1.5 W for the NN1G transceiver), 50 is the system impedance in ohms, 30 is T1's turns ratio, and $I_{f\,(LED)}$ is the current level (in amperes) that produces the LED brightness you need (we designed for an $I_{f(LED)}$ of 10 mA, or 0.01 A). With the resistor values chosen to light the **FWD** LED (DS2) brightly, the **REV** LED (DS1) will be easily visible at SWRs around 2:1, allowing no-guess SWR dipping with tuner adjustment.

Construction

Construction is straightforward—especially because an etched, drilled PC board is available.[3] The title photo and Figure 2 show this version of the SWR indicator. We built our first prototypes dead-bug style. If you decide to build it this way, construct the circuit's bridge portion on the copper ground plane afforded by a piece of unetched PC-board material for good RF integrity. U1 and U2 can be arranged to suit the enclosure used. The unit has been tested with 9 and 12-V power supplies. It draws about 10 mA from a 9-V battery, which should provide about 10 hours of use—but shut it off between uses to save the battery. The unit can be combined inside your favorite QRP rig or built into an enclosure of its own, with 9-V battery and power switch.

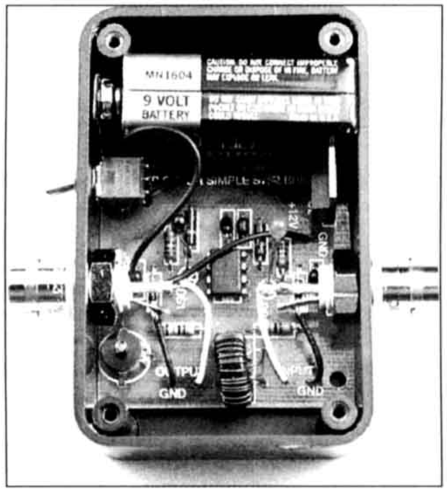

Figure 2—The PC-board version of the SWR indicator fits neatly into a Radio Shack 270-230 box with room to spare for a 9-V battery.

Adjustment

C1, **NULL**, must be adjusted so the SWR indicator can correctly indicate minimum reflected power. To do this, connect a QRP transmitter or transceiver to the **XMTTR** jack and connect a 2-W, 51-Ω resistor between the **LOAD** jack's center pin and chassis. Power up the indicator circuit and put the rig into transmit on its highest-frequency HF band. Adjust the **NULL** trimmer to the center of the range over which the **REV** LED is dimmest. (Because we're not adjusting the bridge for the absolute best balance possible, if you view the indicator in a darkened room, you may see the **REV** LED still lighting dimly at an SWR of 1. Also, if you can't make the **REV** LED go out by adjusting C1, you may have T1's secondary leads reversed. Interchange them and try again.) Remove the load resistor, connect the rig to the **XMTTR** jack, and you're ready to go.

One for the Road

This circuit's meterless reflected-power indication is all that's necessary for many ham radio applications, and its circuitry can be made small and compact for excellent portability. Using LEDs as indicators instead of a meter or meters keeps its size down and makes it inexpensive, too. I hope you'll find it a useful addition and companion to your travel/QRP rig.

Acknowledgment

I thank Paul Kranz, W1CFI, for his advice and encouragement in this project.

Notes

[1]First described in the April 1994 issue *72*, the QRP 40-40 appeared in November 1994 *QST* in "A Single-Board Superhet QRP Transceiver for 40 or 30 Meters" and in the 1995 *ARRL Handbook* as "A Compact Single-Band Transceiver for 80 through 20 M."

[2]Doug DeMaw, W1FB, "QRP Person's VSWR Indicator," Hints and Kinks, *QST*, Aug 1982, p 45. This circuit also appeared in the *ARRL Handbook* as follows: on pp 34-11 to 34-12 of the 1985 through 1987 editions, and pp 34-9 to 34-10 of the 1988 through 1991 editions.

[3]PC boards are available from FAR Circuits, 18N640 Field Ct, Dundee, IL 60118-9269. Price, $4, plus $1.50 shipping (one to four boards).

First licensed in 1968 as WA1IKP, Tony Brock-Fisher got his Extra in 1976. Tony received a BS in physics from Southeastern Massachusetts University in 1972 and an MS in ocean engineering in 1976 from the University of Rhode Island. He is currently working as an R&D engineer for the Hewlett-Packard Company, where he designs medical ultrasound systems. He enjoys contesting, DX, QRP and home brewing, and is treasurer of the Hewlett-Packard Andover Radio Club.

New Products

SOLAR POWER CONTROL CENTER

◊ Simple solar power is the aim of APT's new PowerCenter 2-4X. The 2-4X combines charge controlling, system monitoring and solar system protection in one self-contained, easy to operate and install enclosure. The PowerCenter is weatherproof, UL listed and meets all national electrical safety codes.

For a catalog illustrating APT's complete product line, contact Sales Engineer Jeffrey Philpott, N6QYS, at Ananda Power Technology, 14618 Tyler Foote Rd, Nevada City, CA 95959; tel 916-292-3834, fax 916-292-3330.