The "Ugly Weekender"

Winter in Oregon brings rain showers and cool temperatures — a fine time to build ham gear! A QRP rig is a good choice for a rainy-weekend project, at any time of year.

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There are many obstacles for the builder in spite of the simplicity of a small QRP transmitter. Some published designs are less than optimum, having poor keying and chirps, perhaps a result of oversimplification. Other designs are mechanically complex, and parts procurement is an ever-present problem.

Simple transmitters often use crystal control, but today this is somewhat impractical, owing to the high cost of crystals: A VFO can be built for the price of but one or two crystals. The largest obstacle to some builders, however, is the circuit-board layout. The use of circuit boards has become so popular over the last decade that many amateurs are afraid to attempt a project that is not accompanied by a board layout or referenced to a source where an etched board may be purchased. This is unfortunate!

An Alternative

Numerous methods may be used in the construction of electronic equipment. The assumption that a design might function better if built on an etched and drilled circuit board is false.

The purpose of this article is to present a simple, good-performance QRP transmitter design, and to illustrate some "ugly" construction methods that may be used for whatever the builder might want to assemble. These methods are especially attractive for weekend projects that are to be completed while the weather is similarly ugly!

A virtue of "ugly" construction is great flexibility. The builder may use the parts on hand, something that is often difficult to do with projects utilizing etched boards. The circuit may be changed with ease to facilitate experimentation, as was done with the transmitter described here. The design can be duplicated easily. Speed is the greatest virtue of "ugly" construction. This transmitter was designed and built in two winter afternoons during the KA7EXM Christmas vacation from high school. Contacts were made before the end of that period. Estimated construction time was less than half that required for projects using boards that had been etched and drilled.

Overall Design

The transmitter, shown in Figs. 1 and 2, operates in the 7-MHz cw band. VFO control is utilized for operating flexibility and economy. The VFO is well buffered, then routed to a second enclosure containing a keyed driver and an output amplifier. Shaped keying is used to provide a click-free signal. The output power is 1.5 watts, low enough to add sport to the operation but high enough to be practical. Efficiency was considered important for battery conservation, as the authors often take their rigs into the mountains on backpacking or snowshoe trips (weather permitting). Finally, electronic transmit-receive switching is employed. This allows for near-QSK operation; it's also less expensive than using a relay. Slight modifications will allow the transmitter to be converted to a direct-conversion transceiver.

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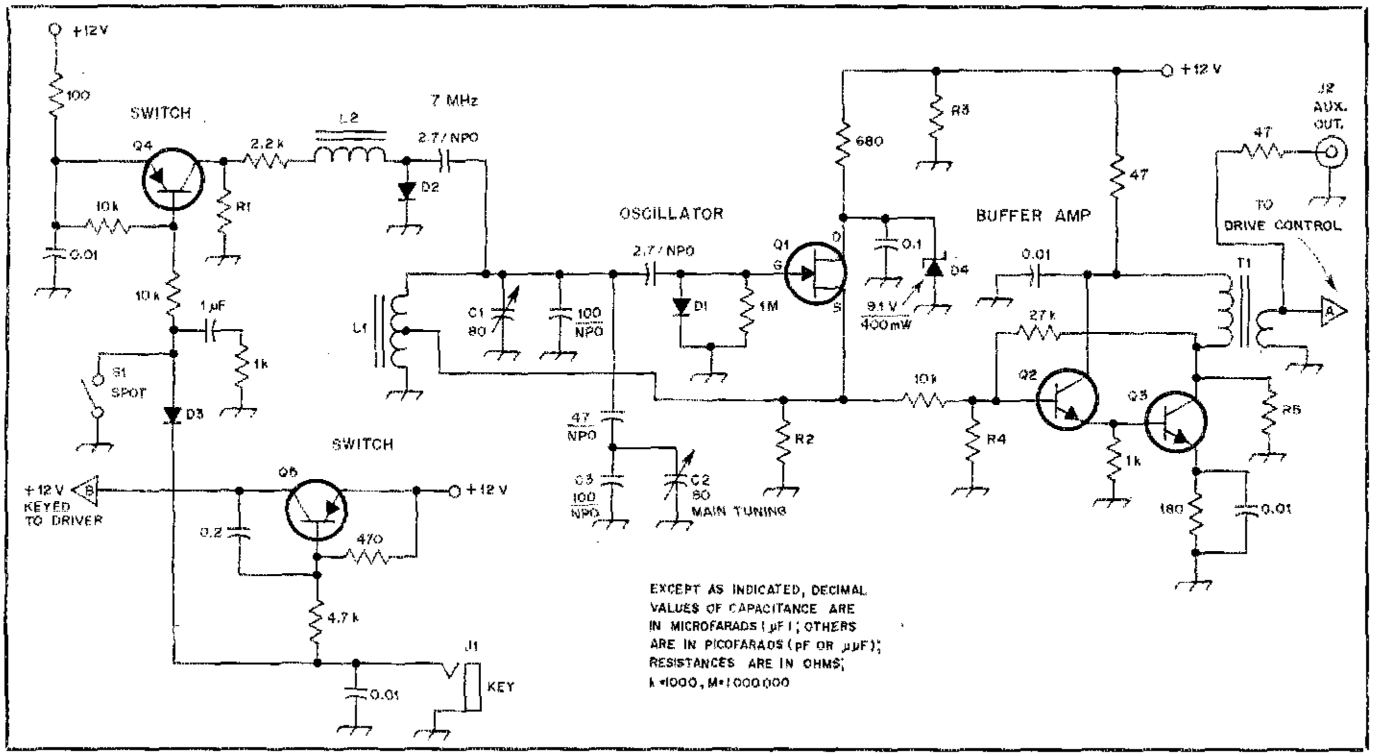

Fig. 1 — Schematic diagram of the VFO and control circuits for the QRP transmitter. Fixed-value capacitors are disc ceramic unless specified otherwise. Resistors are 10% tolerance composition.

C1, C2 — Miniature air variable, 75 pF max.
D1, D2, D3 — Silicon switching diode, 1N914, 1N4152 or equiv.
D4 — Zener diode, 1N937 or equiv.
J1 — Phone jack.
J2 — Phono jack or jack of builder's choice.
L1 — Toroidal inductor, 25 turns no. 22 enam. wire on Amidon T50-6 powdered-iron toroid core.
L2 — Toroidal inductor, 20 turns no. 26 enam. wire on Amidon ferrite toroid core, FT-37-43.
Q1 — JFET, 2N4416, MPF102, TIS88 or equiv. See text.
Q2, Q3 — General-purpose npn transistor, such as 2N2222 and 2N3904.
Q4, Q5 — General-purpose pnp transistor, such as 2N2907 and 2N3906.
R1-R5, incl. — Resistors as insulating tie points (see text).
T1 — Broadband ferrite toroidal transformer. Collector winding has 20 turns no. 28 enam. wire on Amidon FT37-43 toroid. J2 winding has 5 turns no. 28 enam. wire over primary winding.

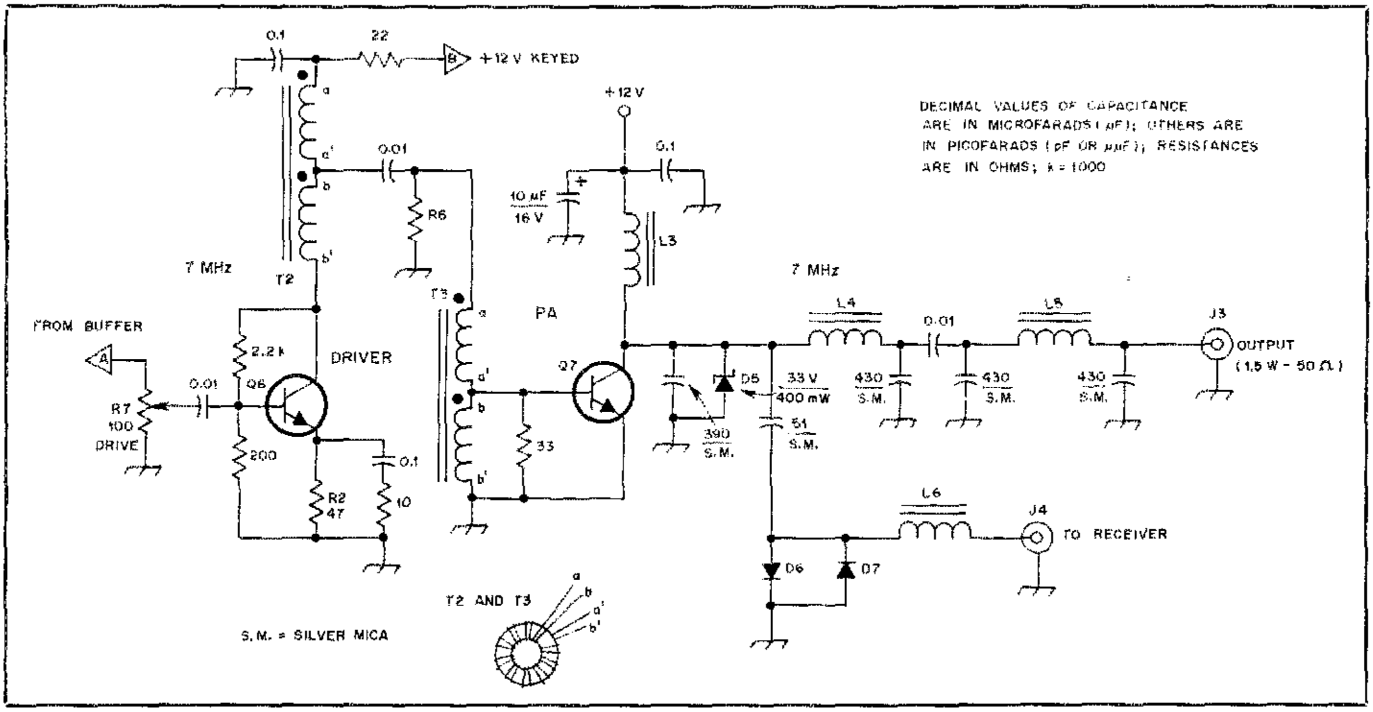

Fig. 2 — Schematic diagram of the driver and power-amplifier portion of the QRP transmitter. Fixed-value capacitors are disc ceramic unless noted otherwise. Polarized capacitors are electrolytic or tantalum. Fixed-value resistors are 10%, 1/2-watt composition.

D5 — Zener diode, 1N973B or equiv.
D6, D7 — Silicon switching diode, 1N914, 1N4152 or equiv.
J3, J4 — Phono jack or connector of builder's choice.
L3 — Collector rf choke, 35 turns no. 22 enam. on Amidon T68-2 toroid.
L4, L5 — 16 turns no. 22 enam. on Amidon T50-6 toroid.
L6 — 45 turns no. 26 enam. wire on Amidon T50-2 toroid.
Q6 — Npn transistor, 2N2222, 2N3904 or equiv.
Q7 — Rf power transistor, 2N3553, 2N3866 or equiv. Use small heat sink.
T2, T3 — Transmission-line broadband transformer, 10 bifilar-wound turns no. 28 enam. wire on Amidon FT37-43 ferrite toroid core.

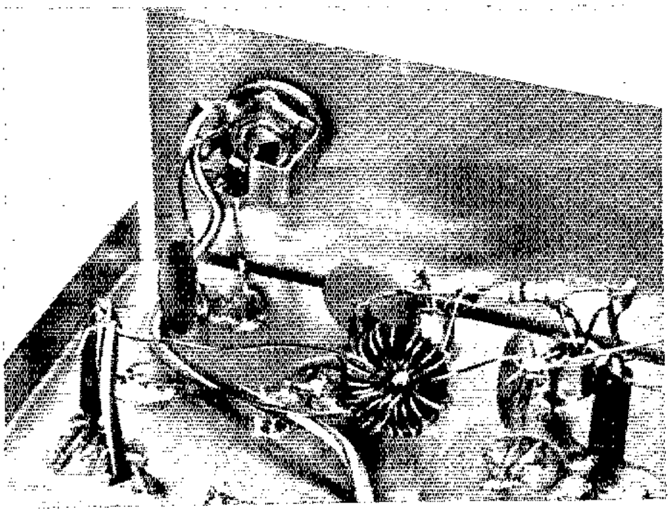

Fig. 3 — Close-up view of the assembly technique discussed in this article. Components are soldered to the circuit-board material and used as tie points.

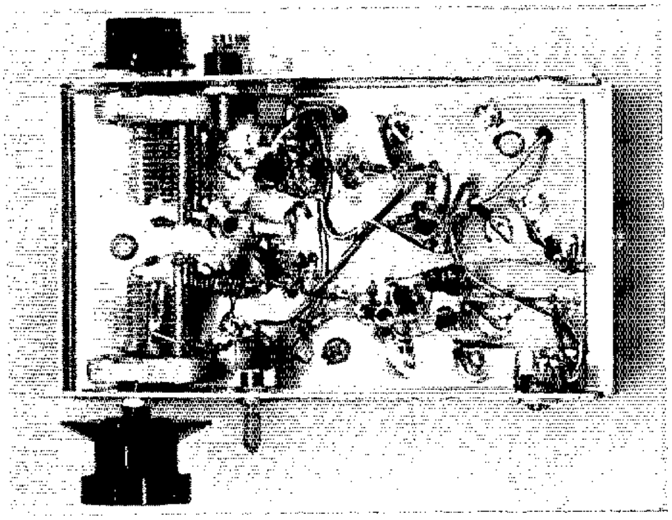

Fig. 4 — Interior of the VFO portion of the transmitter. The variable capacitors are shown at left.

This transmitter is based largely on a transceiver designed and built (with "ugly" methods) by a Field Day partner, Roy Lewallen, W7EL. The reader should review Roy's article for design details.[1] The writers mention those places where they have departed from the W7EL circuit. This transmitter is not as compact as Roy's is, but then few are!

Circuit Details and Construction

The transmitter is built by means of point-to-point wiring (Fig. 3). The foundation is a pair of small aluminum boxes, LMB type 139, 1-1/2 × 3 × 5-1/2 inches (38 × 76 × 140 mm). The boxes are bolted together, each containing a scrap of copper-clad circuit-board material. Bolted directly to the aluminum boxes, the boards serve as a low-impedance ground for all of the circuitry: They contain no etched patterns.

Examination of the circuit shows numerous components attached to ground. These serve their desired circuit function and provide mechanical support for the other components that are attached to the ungrounded ends (additional tie points are sometimes required). High-value resistors serve this function. The value is not critical if it is high enough not to disturb circuit operation. We used 1.1-MΩ, 1/2-watt parts. Any value from 220-kΩ upward (1/2 or 1/4 watt) will function well. The resistors are shown for reference in the schematic diagrams as R1-R7, inclusive. They have no bearing on circuit operation, but provide the needed mechanical support. Some builders may wish to insert resistors as tie points at other places in the circuit. Tuning is provided by a pair of 80-pF air variables from the authors' junk box. C2 is the main-tuning control, and C1 is a coarse band-set adjustment. C2 spans about 80 kHz with the components shown (see Fig. 4).

The FET type is not especially critical at Q1. However, reports from others indicate that the oscillator output may be low when the popular MPF102 is used: A 2N4416 is preferred. The TIS-88, essentially a plastic version of the 2N4416, is used in this transmitter.

All fixed-value capacitors in the VFO are NP0 ceramic types, chosen for optimum stability. Silver-mica capacitors should be avoided. Polystyrene capacitors would probably be suitable, but they may degrade the stability.

Most VFO drift occurs when the power is applied initially. This warm-up drift is minimized by allowing the VFO to operate continuously. The frequency is shifted downward by paralleling the oscillator tuned circuit with an additional 2.7-pF capacitor during key-down periods. This is added to the circuit by D2, a diode switch that is activated by Q4, a transistor switch attached to the key line. The timing components associated with Q4 force the oscillator frequency to be constant between characters, but to shift upward by about 25 kHz during longer key-up periods.

The VFO output is buffered with a two-transistor feedback amplifier, Q2 and Q3. This circuit provides an output of 10 to 15 mW, which is more than enough to drive the following stage. The reverse isolation is excellent. This circuit is a refinement of the first one by W7EL, and was published in a later *QST* "Feedback."[2]

The transistor type is not critical: 2N2222As or 2N3904s will work well at Q2, Q3 and Q6. The builder should be careful about transistors purchased at local electronics stores. Often devices sold as a "2N2222A" do not meet actual 2N2222A specifications.

The keying transistor, Q5, is also contained on the VFO board. The capacitor between collector and base forces an integrator action that ensures clean keying.

Construction of the VFO section is noncritical. Builders are often advised to keep all leads as short as possible. This is generally an exaggeration, especially for hf equipment. Some leads must be short, while others may be relatively long with no harm. Specifically, the leads on bypass capacitors should be short.

Consider the buffer amplifier, a circuit that has two bypass capacitors. One decouples the positive supply from the circuit. This capacitor should have a short lead to the ground foil. The other end should be connected directly to one end of T1 and to the collector of Q2. Similarly, the emitter bypass on Q3 needs to have reasonably short leads. Other leads may be longer, with no ill effects.

The output stages are shown in Fig. 2. This part of the circuit is built in the second box. The isolation aids in preserving VFO stability and preventing variations in output loading from shifting the oscillator frequency. Holes for leads (between sections) are drilled through the two boxes and the adjacent ground foil circuit boards. A bare wire is passed through the hole where the buffer output connects to R1, and is soldered to both ground foils. An insulated wire passes through the same hole, from T1 directly to R1.

The drive control, R7, is a necessary part of the circuit. Adjustment is described later. The value is not critical, with 100 to 1000 ohms being suitable.

The driver stage is a departure from the W7EL design: The original circuit was tuned. There is, however, no need for selectivity at this point, so a broadband design was adopted. The original circuit had a tendency toward instability (self-

[1]Notes appear on page 21.

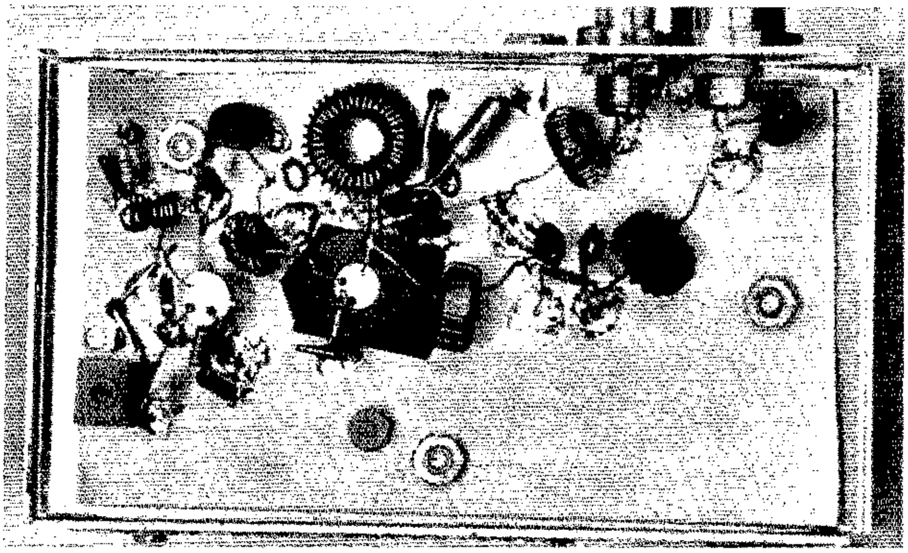

Fig. 5 — Photograph of the driver and PA assembly. Drive control R1 is visible at the lower left.

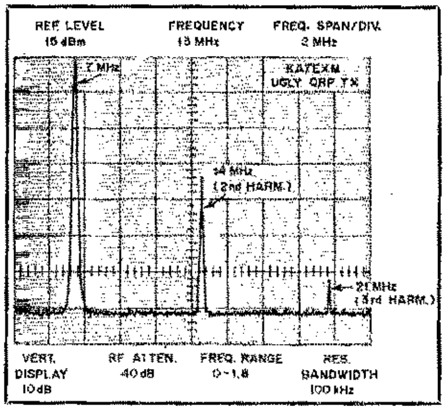

Fig. 6 — Spectral representation of the transmitter output energy. Worst-case harmonic data is presented with an operating voltage of 14. This presentation was made while using a Tektronix 492P analyzer, 4052 computer and 4662 plotter. The authors thank Dave Green, KA7IYT, for his assistance in doing the spectrum analysis.

oscillation). This is eliminated by using an amplifier with negative shunt feedback from collector to base, via the 2.2-kΩ resistor.

Two bifilar-wound transformers are used in this part of the transmitter (T2 and T3). The winding details are shown in the insert of Fig. 2. The two wires forming the bifilar windings may be twisted together, although this is not important at this low a frequency. Ferrite cores (*not powdered iron*) should be used for all three transformers.

The final amplifier is virtually identical to that described by W7EL. The emitter lead on Q7 should be short, although it is moderately long in this rig, owing to the method of transistor mounting. The 385-pF capacitor at the collector of Q7 should be attached close to the transistor.

L4 and L5 form a double pi-network for output filtering. The network is designed to present an impedance of 50 ohms to the collector of Q7. The T/R circuit is formed by L6 and the 51-pF capacitor. The two components are series-resonant at 7 MHz, so there is minimum attenuation during receive periods. High rf voltages appear at the collector of Q7 when Q6 is keyed on. This causes the T/R switching diodes, D6 and D7, to conduct alternately. The 51-pF capacitor now becomes part of the transmitter output network. There is less than 1 mW of power available at the receiver coax connector during key-down periods: This level will not damage most receivers. The receiver should have an excellent agc system or separate muting facilities if proper QSK operation is desired.

The beginning builder might be tempted to construct the transmitter using a "shotgun" approach. That is, the complete circuit would be built, then the power applied. The builder would be confused when the system did not work, or amazed if it did. This transmitter was built and tested in a sequential manner, exactly opposite to that outlined, which permits problems to be identified easily.

The VFO was built first. Power was applied, and the actions of C1 and C2 were checked by listening to the signal in the station receiver. The buffer (Q2 and Q3) was then constructed and tested. Output power into a 50-ohm load was measured using an rf probe and voltmeter. The keying circuit, including the frequency-offset components, was then built. It was tested with a dc voltmeter and by listening to the signal in the station receiver.

Next, the driver was built (see Fig. 5) and the output was measured into a 50-ohm load (about 70 mW with R7 at maximum). This measurement was performed with a diode detector and attenuators. Both are described in chapter 7 of *Solid-State Design for the Radio Amateur*.[3] The PA was constructed next. The output power was measured with the same home-built instrumentation. The total power-supply current was also monitored. The drive was set for an output of 1.5 watts with a corresponding current of 200 to 250 mA, indicating reasonable efficiency.

Power output may be increased to over 2 watts by advancing the drive control. The current rises to over 500 mA, however, indicating degraded efficiency. The output network should be redesigned if higher output is desired. A different transistor could then be used at Q7. Some of the devices intended for the output of CB transmitters should yield 5 to 10 watts. The available power from the driver is increased to 150 mW by changing R2 to 15 ohms.

What Next?

The transmitter is now ready for use. It yielded numerous contacts for the writers with stations up and down the West Coast of the U.S. and Canada in just a few days of casual operation. Reports indicated that the note was stable, clean and crisp — certainly far from ugly! (See Fig. 6.)

The builder may wish to convert this unit to a direct-conversion transceiver. An auxiliary VFO output is shown in Fig. 1. The power from this point is suitable to drive a diode ring product detector, as is used in the W7EL transceiver. The offset, now about 25 kHz, is easily reduced to the 800 Hz needed for a direct-conversion transceiver by shunting D2 with a capacitance of 150 pF.

Few of the components in this circuit are critical. Many substitutions are possible. For example, the main tuning capacitor, C2, may be a standard 365-pF broadcast-band replacement type. C3 should then be increased to 220 pF to retain the present 80-kHz tuning range. A vernier drive may be added. It is surprisingly practical (and simple!) to do without it, however, if the tuning range is restricted.

Whatever is being built, it is always worth questioning the need for an etched circuit board. More often than not the "ugly" methods presented here will do as well, with considerable savings in time and money and absolutely no compromise in performance. Construction is also simplified if extreme miniaturization is avoided.

The authors wish to acknowledge the comments of Roy Lewallen, W7EL. It's always enlightening to share experimental results with others who have similar interests.

Notes

[1] R. Lewallen, "An Optimized QRP Transceiver," *QST*, Aug. 1980, pp. 14-19.
[2] See "Feedback," *QST*, Nov. 1980, p. 53.
[3] W. Hayward and D. DeMaw (Newington, CT: The American Radio Relay League, Inc., 1977).