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Microwave Building Blocks: The Solfan Special

What started life as a meek intrusion alarm winds up as a hot 10-GHz transceiver.

Number 4 on your Feedback card

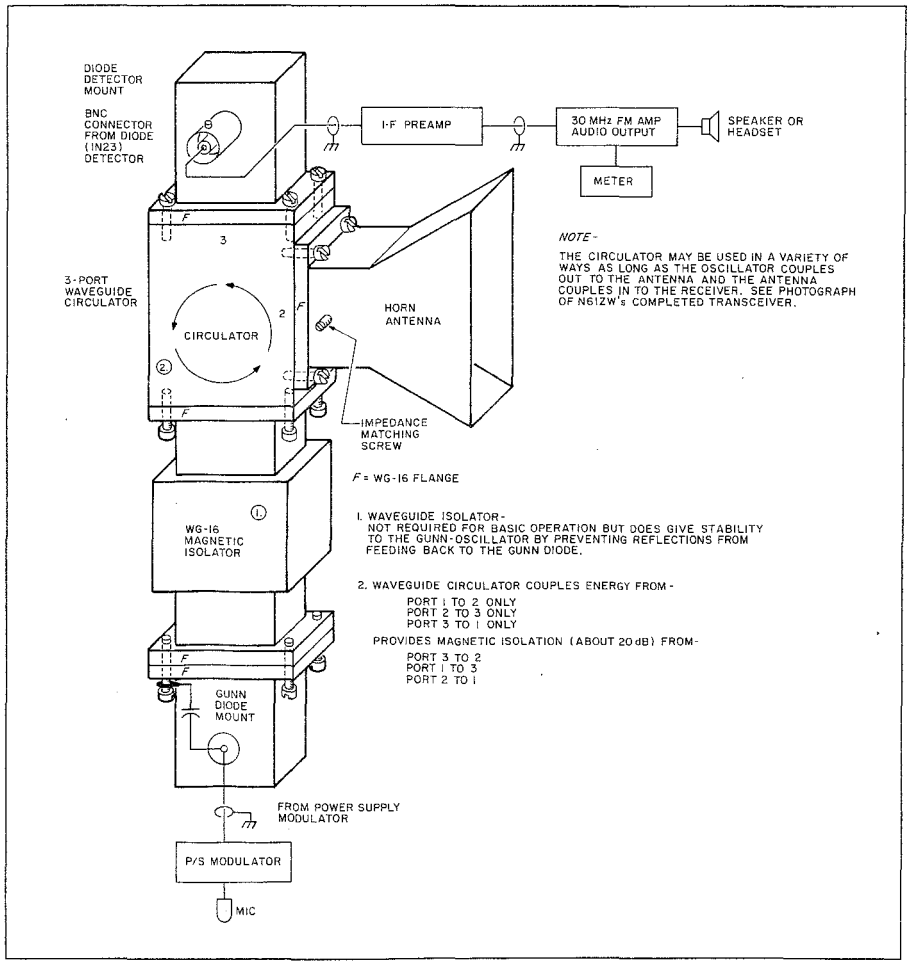


Fig. 1. Waveguide circulator 10-GHz transceiver.

It's not very hard to set up a station for 10 GHz. I have been experimenting with a portion of a Solfan Doppler-radar intrusion alarm that I converted for use at 10.250 GHz. These alarms can be found pretty easily at hamfests, and I have heard many people speak of the high availability of these units in Europe, where this type of alarm circuit is used extensively.

I have found two different types. Whatever unit you obtain can be used with the methods described here. The first unit that I'll describe is the Solfan Intrusion Alarm Gunn diode mount and detector assembly. This has both a Gunn diode and detector diode mounted in the same cast waveguide mount. The waveguide size is WG-16, or 0.4" high by 0.9" wide. It does not have varactor tuning for afc like the Microwave Associates Gunnplexer. The mount is about three inches long with the Gunn diode placed at the rear center of the cavity and coupled to the mixer diode by a small round waveguide iris midway between the two ends of the cavity.

The detector diode is mounted offset to one side of the forward waveguide cavity for low coupling. Both cavities have tuning screws for impedance matching and frequency adjustment. Photos A and B show the end and side views of the various Solfan units. Photo A shows the internal waveguide construction and where the diodes are mounted. Note that the Gunn diode is mounted dead center in the cavity, while the larger detector diode is mounted on the side of the cavity wall.

The second type of Solfan mount is a single Gunn diode transmitter-type unit. This

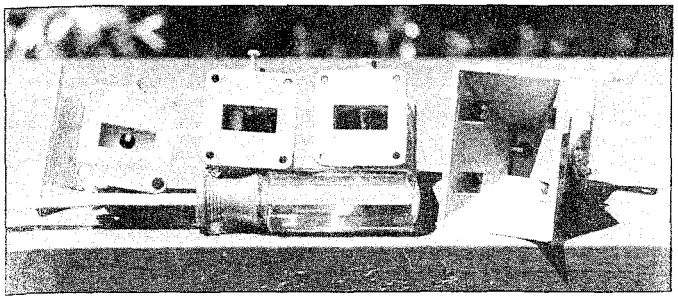


Photo A. Waveguide flange end showing from left to right: iris coupling from single Gunn mounts, detector diode on the side of the cavity, very small Gunn diode mounted in the cavity center, and another single Gunn mount with a small horn.

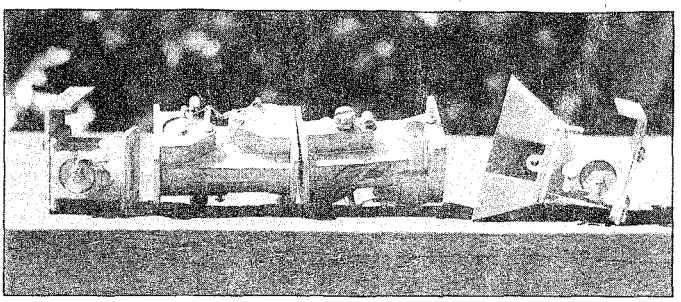


Photo B. Side view of the Solfan Gunn mounts. The ends are the single oscillator units. The center two units are the double mount (oscillator-detector assemblies). Various adjustments and connection terminals are visible.

device does not have a detector diode attached with its cavity. I don't know what the detector mount looks like, as I haven't run into one yet. I've used this mount as a single point source to test other transceivers and have mounted one unit into one port of a 3-port circulator, with a detector mount and an antenna tied to the third port. While sensitivity was slightly lower than on other models, it did perform quite well. See Fig. 1 for details on the circulator system.

"Operation during contest weekend may give some stations an edge of quite a few points by working a surprising number of different grid squares and contact points."

There are many different configurations of detectors, waveguides, and oscillators that will produce a working station. What your finished product looks like depends on the materials you are able to scrounge up from junk boxes and swap meets. Photo C of N6IZW's completed transceiver using a circulator and detector mount coupled with PC boards described in this article shows how simple components can be assembled into a complete system package. Photo D depicts a minimum transceiver.

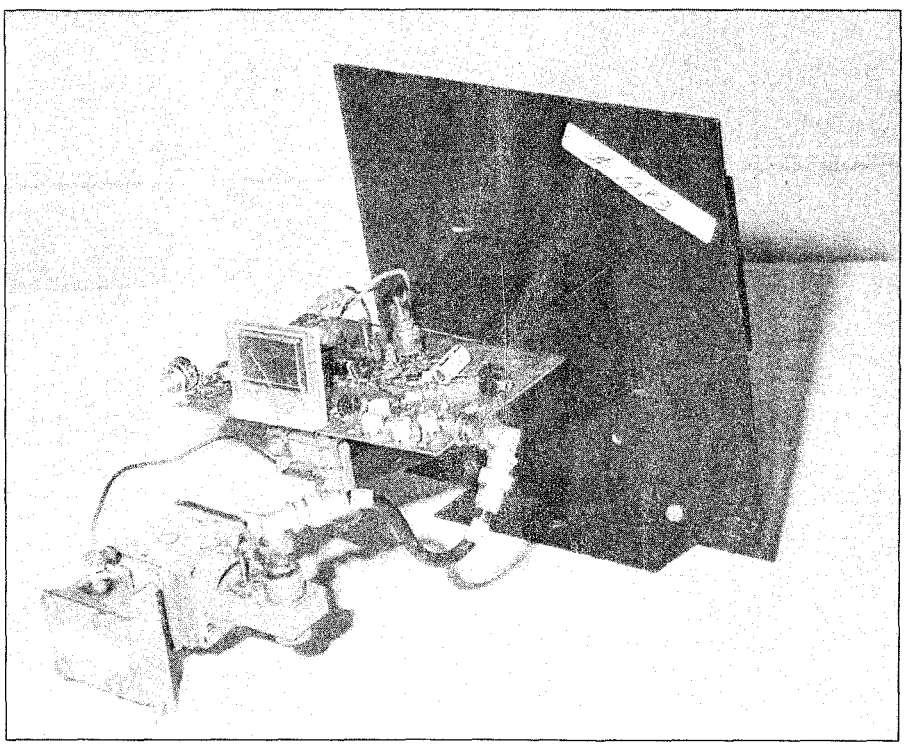


Photo C. 10-GHz transceiver (N6IZW) mounted on a large horn antenna. The system uses a single Solfan Gunn oscillator, circulator, diode detector, and the completed i-f amp, S-meter modulator circuit board.

System Description

To be able to construct a full-duplex transceiver for 10 GHz, you need four basic components: a 30-MHz i-f amp, a power-supply modulator, an i-f preamp, and a Gunn diode waveguide cavity/detector diode assembly. If you can find one of these units at your local swap meet, it will make this project very easy to build. If you cannot obtain one of the units, a suitable oscillator mount and detector assembly may be constructed

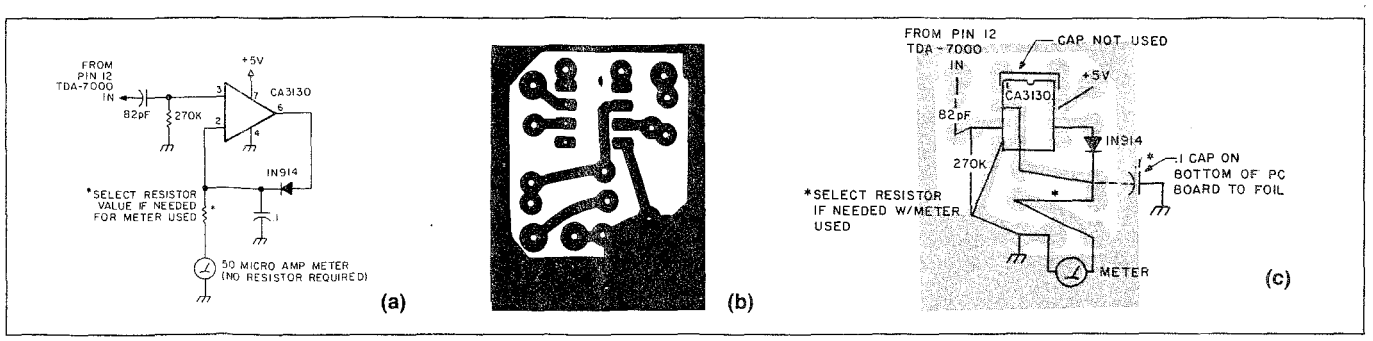
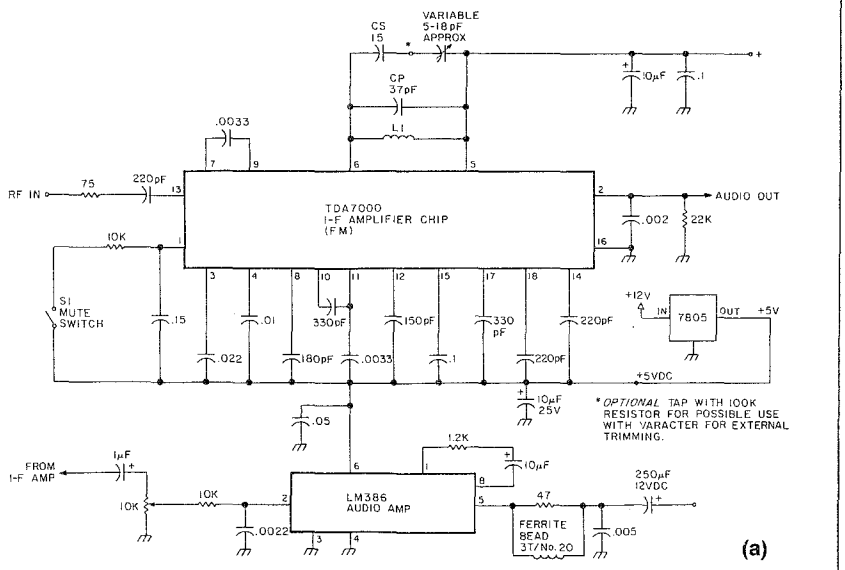
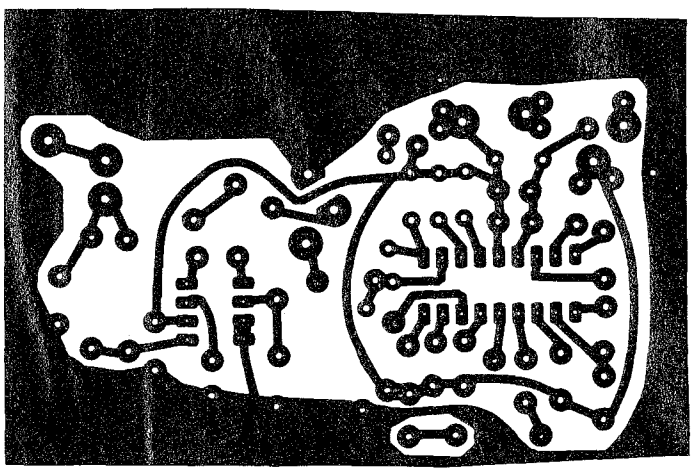


Fig. 2. Signal-strength meter circuit (a) schematic, (b) circuit board, foil side, and (c) parts placement.





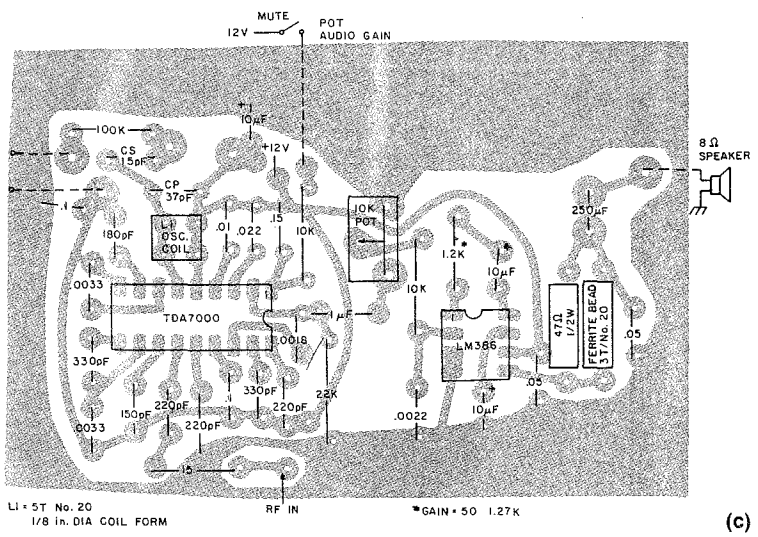


Fig. 3. 30-MHz FM receiver i-f amp (a) schematic, (b) circuit board, foil side, and (c) parts placement.

from a piece of scrap waveguide (WG-16), as described in the *RSGB VHF Handbook*, 4th edition, Chapter 9.43, Figure 99. Anyone should be able to construct the unit with simple tools.

Safety

One word of caution with microwave devices is that you should never look into the open end of a radiating waveguide, as serious eye damage can result. With low-power Gunn diodes, the safe distance is reached in a relatively short space—say several feet—but you should still never look into one.

I-f Amplifier

The i-f amplifier that I used was first published in the October, 1986, issue of *73*. This single-chip, 30-MHz i-f amplifier with its audio output stage occupies one small PC board. The design of the i-f amplifier was modified to provide a signal-strength tuning indicator, which ties to pin 12 on the TDA7000 with an 82-pF coupling capacitor. The addition of this CA3130 op amp greatly improved the system, allowing an indication of signal strength for antenna direction and an evaluation of system performance.

The modification was made by Kerry Banke N6IZW, who mounted the circuit dead-bug fashion next to the oscillator coil on the i-f amplifier board ground foil. The results were great; with this meter circuit to evaluate this system, we had a relative quality indication to adjust our system's operation.

I have provided a circuit board for this op-amp stage to simplify construction (see Fig. 2 for the artwork and layout of the signal-strength indicator assembly). The PC

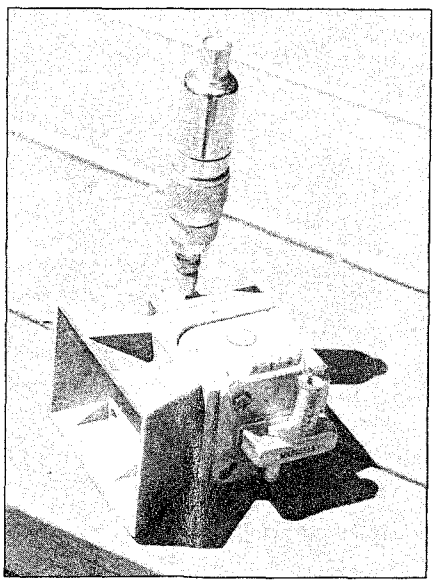


Photo D. Microwave circulator in its simplest use as a 10-GHz transceiver. This unit uses a Microwave Associates 10-mW Gunn source, a surplus circulator, a detector, and a small horn antenna. The impedance matching screw is also used for receiver "LO" injection into the detector.

board is mounted adjacent to pin 12 for short connection leads. The circuit is a simple peak detector and gives good results for tuning indications. See Fig. 3 for details on the 30-MHz i-f amplifier.

P/S Modulator

The power-supply modulator for the Gunn diode consists of a single op-amp microphone amplifier whose output is coupled to the ADJUST terminal of a variable voltage regulator. A very small change in ADJUST terminal voltage will produce a change in output voltage, causing the Gunn diode to be frequency modulated just fine. See Fig. 4 for modulator diagram and parts layout.

The power-supply modulator was used with a Radio Shack electret microphone (costing 99 cents) and attached to an alligator clip with some miniature coax—nothing said we had to use expensive components! Testing the power supply consists of making sure that the output voltage using the fixed resistors is about 8 to 8.5 volts. With a potentiometer tied from the output of the supply to ground (1 to 5k pot) and its center wiper tied to a series resistor back to the adjust terminal (3k, 1/4 W), you will be able to vary the voltage of the regulator over a range set by proper selection of the fixed 1/4-W resistor. You want the minimum voltage to be about 7 volts and the upper limit about 9.5 to 10 volts. This is the approximate range at which most Gunn diodes deliver power, and it allows a frequency-tuning control other than screws on the cavity for fine-frequency setting.

Modulation is applied in much the same manner as in the fine-frequency setting above, but follows the amplitude variations from the mike amplifier; it changes the voltage regulator ever so slightly, producing frequency modulation and deviating the Gunn diode. Needless to say, it is wideband operation; but it is simple and it works very well.

The total system was operated from a lead-acid, 12-volt battery (2-1/2-Ah capacity), which I obtained surplus. This provided many days of operation without recharging. Normal current drawn for a Gunn diode with an output of 10 mW is 140 mA, 25 mW is 400 mA, 50 mW is 600 mA, and 100 mW is 800 mA. As you can see, with higher-output Gunn diodes, thermal considerations become very necessary and improved heat sinks are needed to dissipate the heat.

Preamplifier

The i-f preamplifier that I used was created by Jim Fisk W1HR and appeared in the October, 1978, issue of *Ham Radio*. The article listed a special transistor for the input stage, which I was not able to obtain, so I used an MRF-901. With a little taming, it worked very well. I wish I could have tried the transistors specified, as they would be the best choice for optimum performance. Several other types of transistors have also been used with good results. The output transistor that I used was a plain old 2N2222. The preamp oscillated at first; in order for the MRF-901

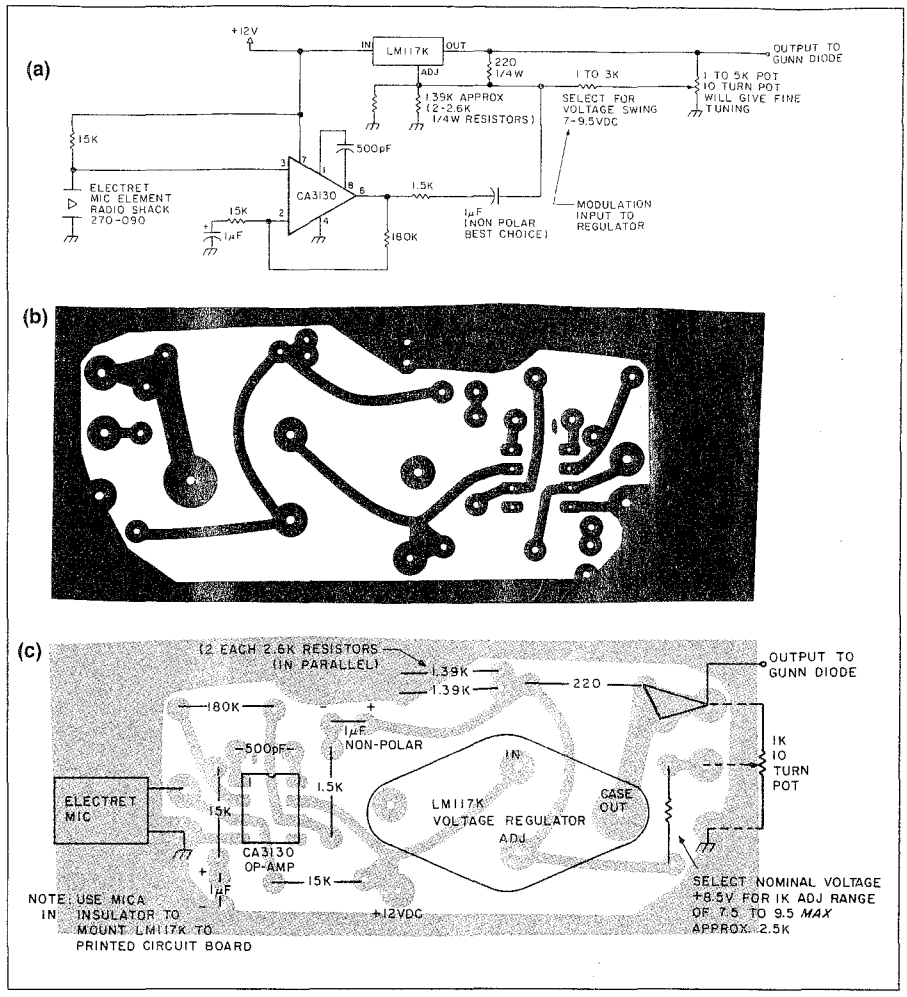


Fig. 4. Power supply modulator (a) schematic, (b) circuit board, foil side, and (c) parts placement.

transistor to be stable, its emitter lead had to be grounded right at its case. See Fig. 5 for the schematic diagram.

Many other amplifiers could be used (even the 40673 MOSFET), and I suspect most people will just pick up a pre-made 30-MHz amplifier from one of the many manufacturers of preamps. Their cost is so low it almost makes it too expensive to build one after you've gathered the parts. Whatever your choice, mount the preamplifier in a shielded box as close to the mixer diode connection as practical, keeping the leads very short to avoid stray i-f pickup.

Checkout

Each part of the system can be checked out by itself before you package the entire system. As squelch is not desired, disable the mute circuit on the i-f amplifier board by tying the 10k resistor on pin 1 of the TDA7000 amp to plus 5 volts. Couple a signal generator at 30 MHz into the amplifier and set the oscillator coil for output indication. Sensitivity should be about 2 to 3 microvolts for good quieting. Attach the preamplifier and check out its gain improvement to the system.

The completed system can be tuned up with some simple small horn antennas on a test range (I use my garage). To check the output from your Gunn diode transmitter, connect a small horn antenna to a diode detector to which a 50-microamp meter is tied. The meter reads the diode-rectified current that is developed from your transmitter. Start with your antennas spaced, say, at three feet (very small horn antennas) and find where the focus point is. Then, to tune for maximum output, secure your units with a vise or some suitable mount while you tune the adjusting screws to match your systems. If your meter is too sensitive, increase the distance between the antennas (power falls off as the square of the distance). With some experience, you can use the distance to estimate the power of your unit.

If you know that at four feet you produce 25 microamps of current with a 10-milliwatt Gunn diode and that at eight feet you get the same reading with the same antennas, you know that this source is about 100 milliwatts of power. Of course, this is a rather crude measurement, but if there is no other means of determining relative power, you use what you have available.

10-GHz Communications

Kerry N6IZW and I started out with a garage contact on 10 GHz, and before the day

was over we had worked up our distance to about three blocks. That was before we installed the i-f preamplifier. With the preamps installed, we worked a path of several miles with rock-crushing signals. The alligator clip mike worked so well we didn't change it; if you use shielded coax for the lead and a shielded box to house the components, interference should not be a problem.

With our system mounted on top of the diode mounts and the printed circuit boards unshielded for short contacts of four to five miles, it performed quite well. However, when we tried for a 15-mile path, we experienced severe FM broadcast interference feeding through the system. My system is still unshielded and I have yet to heed my own advice.

One particularly fun contact was when we went to our local San Diego swap meet and operated hand-held portable on 10 GHz. Kerry and I had mounted two 5-10-dB-gain horn antennas on the cavity for the Gunn diode transceiver and pointed them skyward while we walked around the swap meet. There were a lot of questions, and we hoped to increase interest in operation on 10 GHz. Though our contacts were short-range, we were provided with many great eyeball QSOs.

I will make Gunn diodes available to amateurs for $5 each postpaid in the continental U.S. These devices provide between 50 and 100 milliwatts of output power in a suitable Gunn mount as described in this article. The diodes are about .3 inches long—like a 3-48 screw without a head. A printed circuit board etched and ready for drilling is also available. It includes the original i-f amp, PS modulator, and S-meter circuit incorporated onto one PC board, plus the TDA-7000 chip. The cost is $10.

I would be happy to answer any questions concerning this or any other related project. Please enclose an SASE for a prompt reply. ■

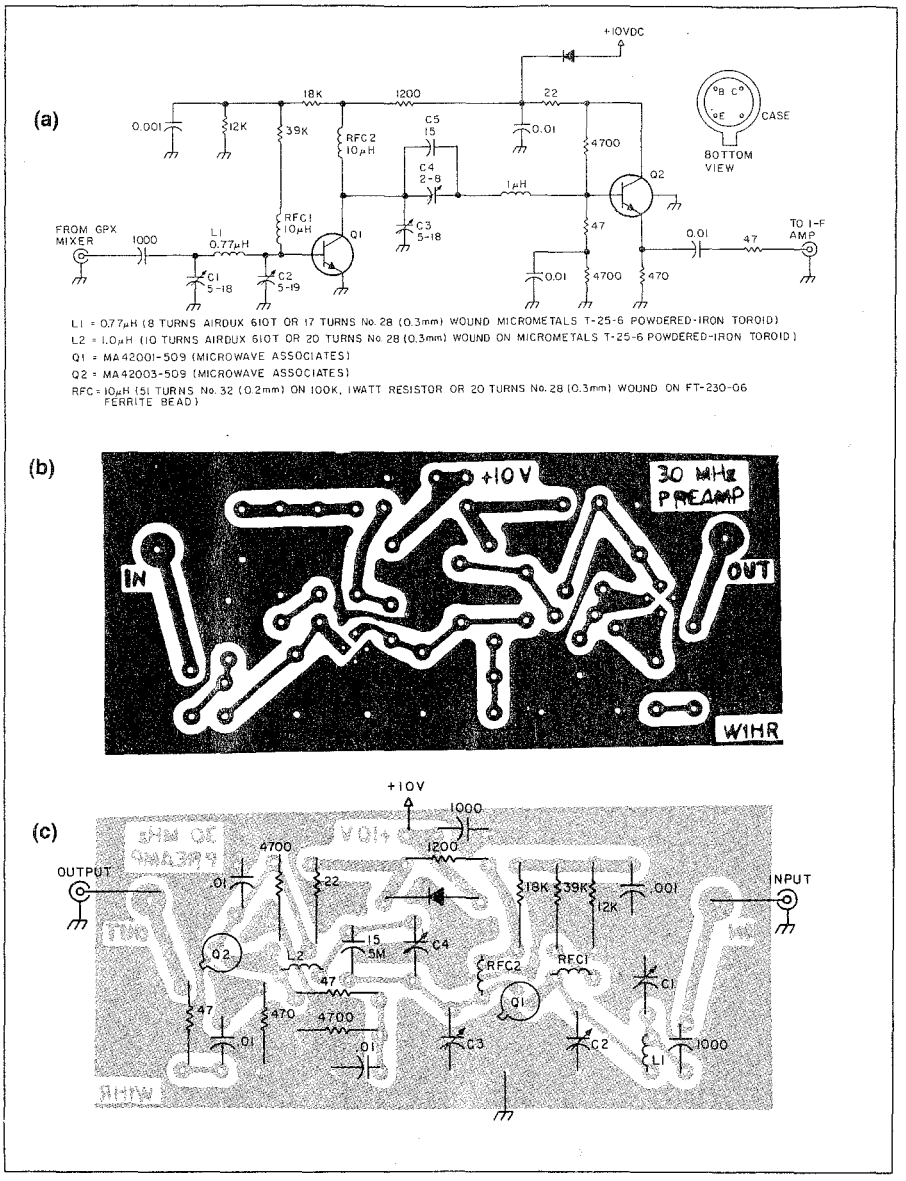


Fig. 5. 30-MHz i-f preamplifier (a) schematic, (b) circuit board, foil side, and (c) parts placement. Courtesy of Ham Radio *Magazine, J. R. Fisk W1HR, October, 1978, p. 38.*