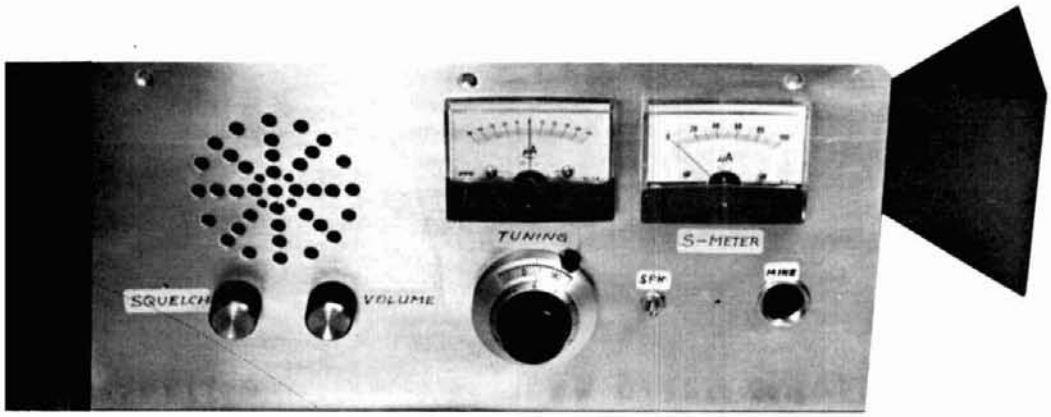

10-GHz transceiver

for amateur microwave communications

Construction of a complete 10-GHz Gunnplexer transceiver with 30-MHz i-f and automatic frequency control

A little over a year ago Microwave Associates introduced a new component for amateurs which greatly simplifies the construction of a 10-GHz transceiver for operators who are interested in microwave communications but don't have experience with microwave construction techniques. Without special knowledge or an extensive test setup amateurs can now use a Microwave Associates MA-87127 Gunnplexer to operate on the 3 cm (10 GHz) amateur band. No special mechanical work is required. The Gunnplexer is a complete transceiver which consists of a varactor-tuned Gunn diode rf source, a ferrite circulator which decouples the transmit and receive functions, and a Schottky mixer diode for the receiver signal.[1] A diagram of the basic Gunnplexer system is shown in **fig. 1**; a block diagram of the complete transceiver is shown in **fig. 2**.

The Gunn diode oscillator requires a regulated 10 Vdc source which is capable of supplying 200 mA. The rf output power is approximately 20 mW;* a 17 dB gain horn antenna is available from Microwave Associates. The frequency of the Gunn diode can be tuned with the built-in varactor diode over a frequency range of 60 MHz minimum (100 MHz typical). The required varactor bias is +1 volt to +20 volts and should be controlled by a good quality multi-turn potentiometer.

The Gunnplexer can be easily frequency modulated with a small modulating voltage (mV range) which is superimposed on the varactor's dc bias supply. Since a very small modulating voltage is required, the

*Three models are available: the 15-mW MA-87127-1, the 25-mW MA-87127-2, and the 40-mW MA-87127-3. Units are stocked by Glen Whitehouse, Newbury Drive, Amherst, New Hampshire 03031, and in Europe by Microwave Associates, Munich.

This article was translated from German by Konrad Benz, Microwave Associates, Inc., Burlington, Massachusetts 01803

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amplification factor of a single-transistor microphone amplifier is sufficient.

i-f amplifier

To complete the 10-GHz transceiver, an i-f amplifier is required. Because the antenna and Gunnplexer and its antennas are normally physically separated from the operating position (for roof or tower mounting), an i-f amplifier with a low noise figure should be connected directly to the Gunnplexer's mixer diode. A noise figure of 1.5 dB or less and a good impedance match ($Z = 200$ *ohms* at 30 MHz) is requried to obtain an overall system noise figure of 12 dB or better. With careful design, a system noise figure of less than 10 dB can be achieved.

The coaxial connection between the i-f preamplifier and the post amplifier/receiver at the operating position is not critical; a proven design is presented later in this article. When considering the noise figure of a Gunnplexer system it's important to remember that the receiver has no preselection so the two receiver sidebands (carrier plus *and* minus the i-f) contribute equally to the overall noise figure.

Standardization of a single i-f system is essential for the operation of a 10-GHz system among a large group of amateur microwave enthusiasts. A 100-MHz i-f has been recommended by several German amateurs,[2] but this is useful only if communications between two fixed stations is all that you want. The result is a full duplex system without transmit-receive switching where the Gunn oscillator operates simultaneously as a receiver local oscillator and frequency-modulated transmitter. Each partner operates at a different frequency, which results in the intermediate frequency as shown in **fig. 3**.

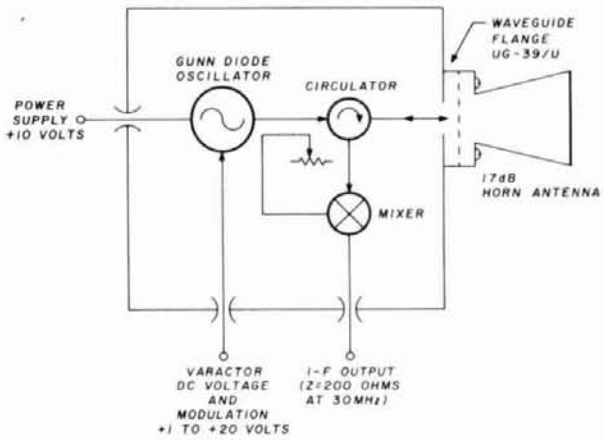
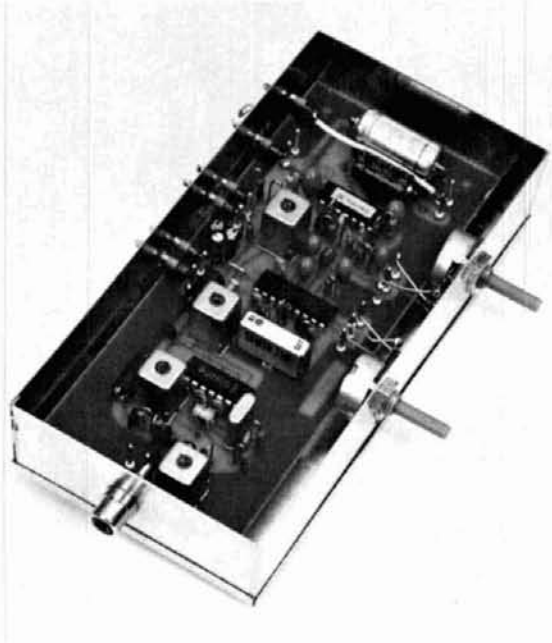


fig. 1. Basic Gunnplexer system showing the varactor-tuned Gunn-diode oscillator, ferrite circulator, and Schottky mixer diode. A portion of the rf power from the oscillator is coupled to the mixer through the circulator. The i-f output impedance at 30 MHz is 200 ohms; a 4:1 transformer is required to provide a good match to 50 ohms (see fig. 2).

In most cases, however, amateurs want to contact as many other 10-GHz stations as possible. This requires that each station must be able to transmit and receive on either frequency. Since the varactor diode provides a maximum frequency tuning range of only 60 MHz, the use of a 100-MHz i-f would require mechanical tuning of the Gunn oscillator. Mechanical tuning of the Gunnplexer provides a tuning range of ± 100 MHz minimum, but this would unduly complicate a two-way communications set-up. By choosing a 30-MHz i-f, however, you can switch frequencies with a simple voltage change on the varactor diode.

In the Rhein-Main area in West Germany various Gunnplexers are operated at 10350 MHz (transmit) with + 4 volts of varactor bias; with + 10 volts on the varactor the transmit frequency is 30 MHz higher at 10380 MHz. If an operator knows whether the other station is using the lower (10350 MHz) or higher (10380 MHz) frequency, it is only necessary to tune the receiver over a small range of frequencies.

The instability of the self-oscillating Gunn diode requires wideband frequency modulation; a transmit bandwidth of 75 kHz and an i-f bandwidth of 200 kHz gives satisfactory results.



Construction of the 30-MHz receiver designed by DJ7OO. At the bottom left is the mosfet input stage, followed by the 40.7 MHz local oscillator and mixer, TDA1047 fm i-f strip, and TAA611 audio power amplifier. The two potentiometers are for squelch and audio gain.

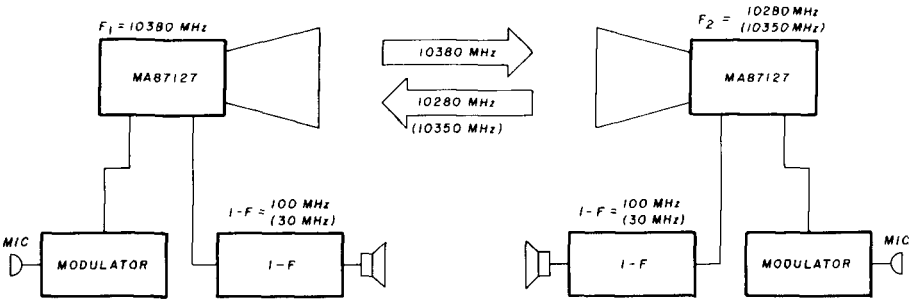


fig. 3. Duplex operation of the 10-GHz Gunnplexer system, showing the oscillator frequencies for 100-MHz and 30-MHz intermediate frequencies. As discussed in the text, a 30-MHz i-f is preferred because of the 60-MHz tuning range provided by the varactor; the use of a 100-MHz i-f would require mechanical tuning of the Gunnplexer.

i-f post-amplifier

The 30-MHz i-f post-amplifier and receiver shown in **fig. 4** was developed by the Zweite Deutsches Fernsehen amateur group. More than fifty of these receivers have been built and used on the air, and all operate well.*

The first 30-MHz amplifier stage uses a dual-gate BF900 MOSFET transistor (similar to the RCA 40673). The self-oscillating mixer is based on a Siemens SO42P IC and translates the 30-MHz input signal down to the 10.7-MHz i-f. The parallel tuned circuit (L1-C1) resonates at 40.7 MHz, the frequency of the third-overtone crystal. Without inductor L1 in the circuit the oscillator has a tendency to run at the crystal's fundamental at approximately 13.56 MHz; this can result in unwanted modulation products (*13.56 + 10.7 = 24.26 MHz*).

The Murata SFW10.7MA ceramic filter determines the i-f response characteristics of the receiver; the 3 dB bandwidth is 220 ± 40 kHz. The Siemens TDA1047 IC, which was developed for fm broadcast radios, is used as an amplifier and fm demodulator; it has excellent limiter capabilities and includes a built-in squelch circuit — its symmetry guarantees trouble-free operation.

An S-meter is connected to pin 14 of the TDA1047

*Kits to build your own 30-MHz post-amplifier are available from Elektronik Laden, Wilhelm-Mellies-Strasse 88, D4930 Detmold 18, West Germany; the price is 89 DM ($45) postpaid.

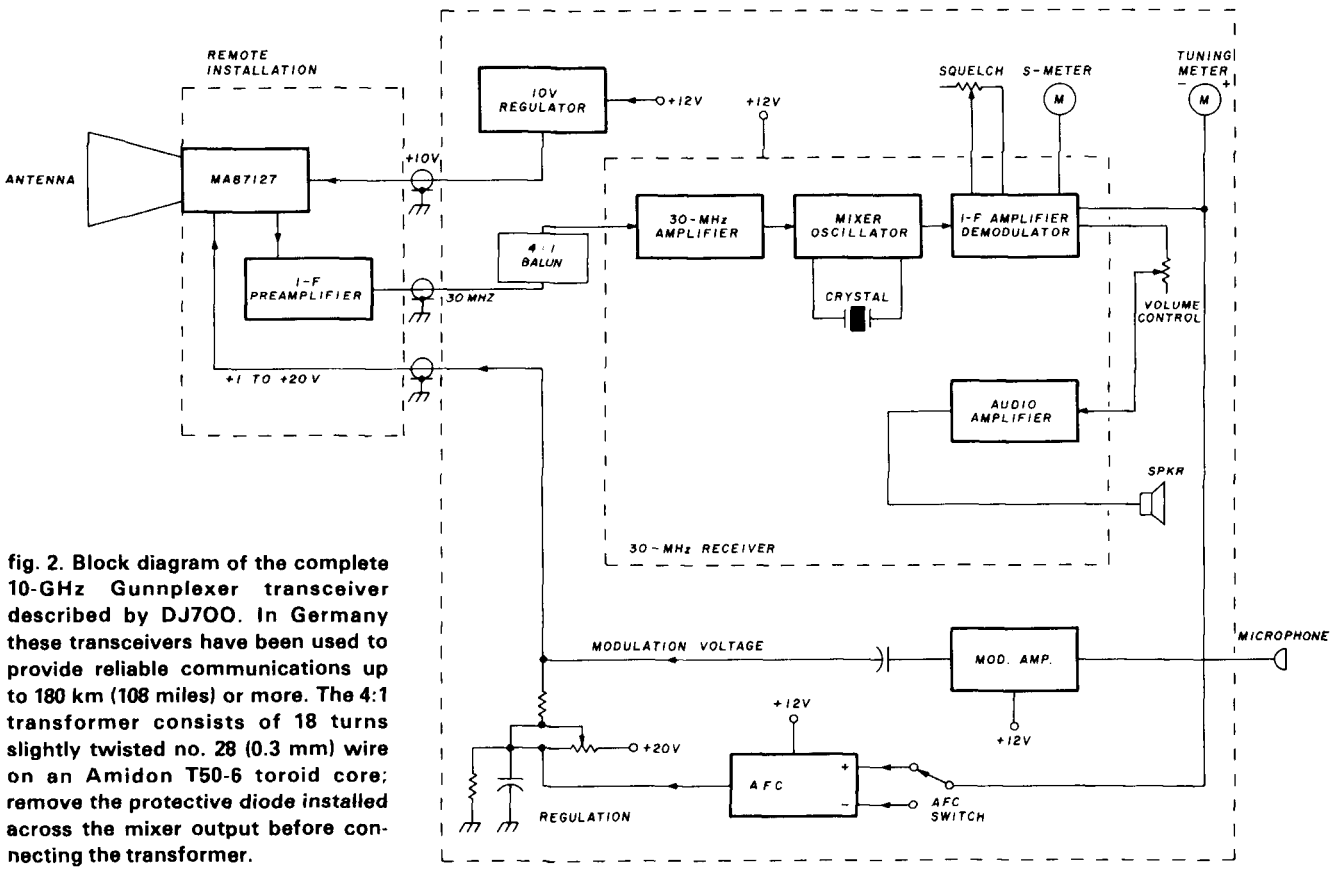
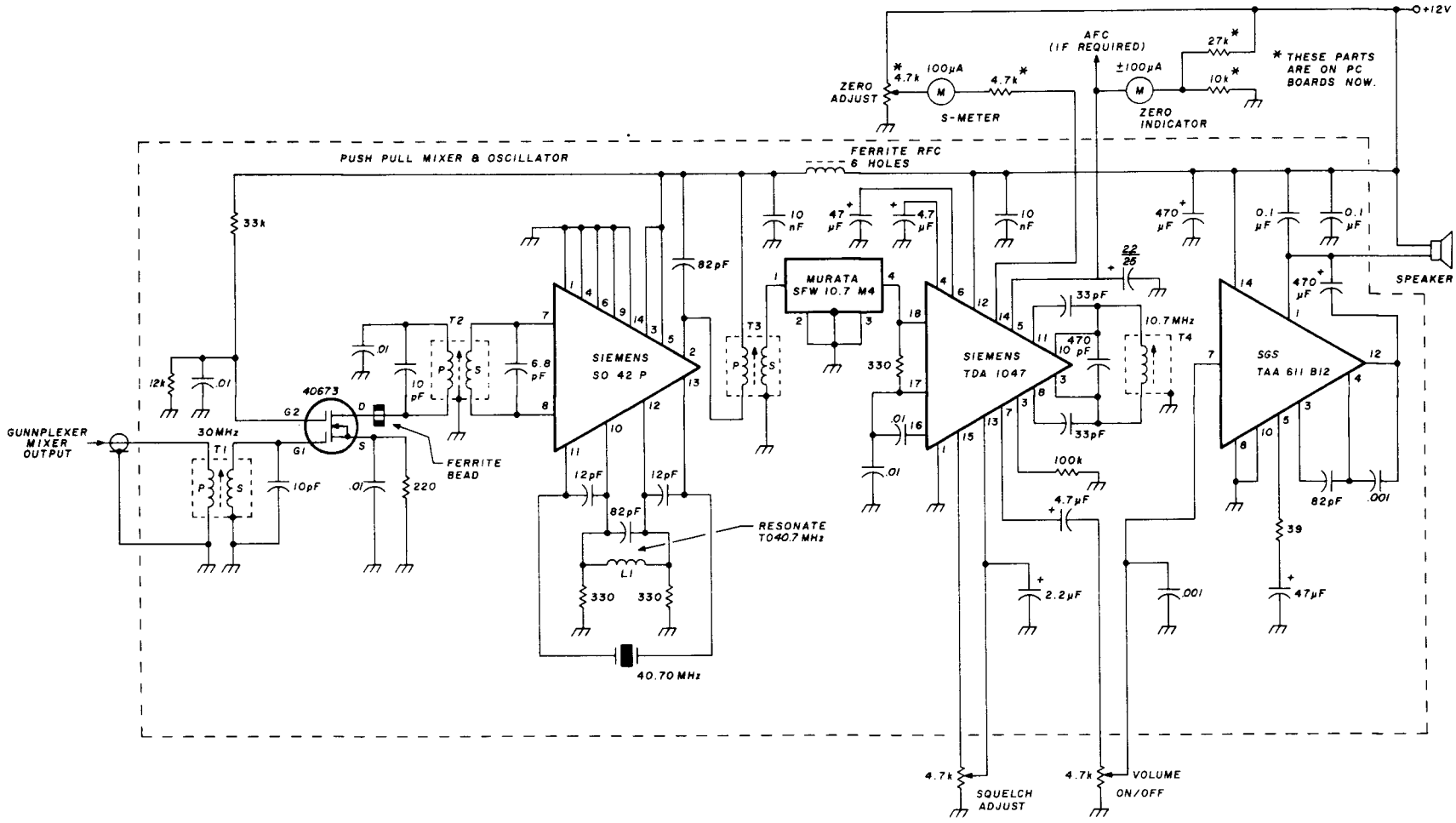


fig. 2. Block diagram of the complete 10-GHz Gunnplexer transceiver described by DJ7OO. In Germany these transceivers have been used to provide reliable communications up to 180 km (108 miles) or more. The 4:1 transformer consists of 18 turns slightly twisted no. 28 (0.3 mm) wire on an Amidon T50-6 toroid core; remove the protective diode installed across the mixer output before connecting the transformer.



L1 15 turns no. 28 AWG (0.3mm) unsupported, closewound on 4 mm (5/32 inch) diameter mandrel

T1 Primary, 3 turns; secondary, 18 turns

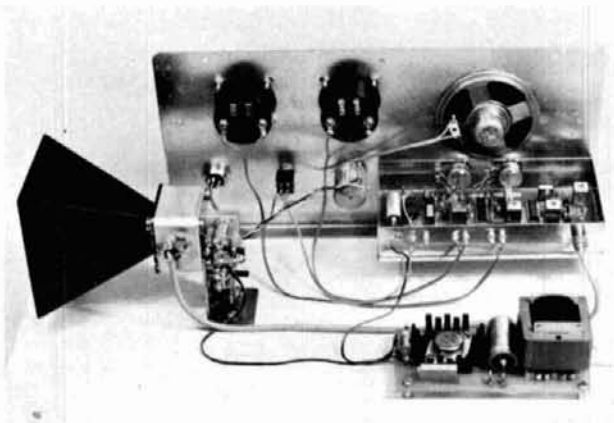
T2 Primary, 18 turns; secondary, 5 turns

T3 Primary, 18 turns; secondary, 5 turns

T4 8 turns

All transformers wound with no. 32 AWG (0.2mm) wire on Vogt D41-2520 forms.

fig. 4. Schematic diagram of a broadband 30-MHz i-f post-amplifier/receiver which features a MOSFET input stage, SO42P self-oscillating mixer, 10.7-MHz ceramic filter, TDA1047 amplifier/demodulator, and TAA611 audio power amplifier. The complete receiver is built into a package measuring 14.7 cm long, 7.4 cm deep, and 2.9 cm high (5.8 x 2.9 x 1.1 inches). A kit is available.



Layout of DJ3KM's 10-GHz Gunnplexer system, as set up for display at a German club meeting. The 30-MHz receiver is mounted on the front panel, under the speaker; the avc circuitry is built on a small board mounted next to the Gunnplexer. An ac power supply for the system is in the right foreground (photo by DB3PR).

amplifier/demodulator. This is a big help when aligning antennas for maximum received signal. The inherent noise of the TDA1047 produces a small current through the S-meter which can be nulled out by adjustment of the 4700-ohm ZERO ADJUST potentiometer. The output at pin 5 of the TDA1047 is a frequency-dependent dc voltage which can be connected to a carrier meter and/or an AFC circuit for the Gunnplexer (**fig. 5**). The Fairchild SGS TAA611B12 (or Texas Instruments 76001) serves as an audio power amplifier.

The frequency stability of the Gunnplexer is important for successful two-way communication; the manufacturer specifies a drift of −350 kHz per °C maximum. When the Gunnplexer is first turned on, the oscillator will drift a few MHz as the Gunn diode warms up, so the 220-kHz i-f bandwidth requires continuous tuning of the oscillator. The Gunnplexer also continues to drift slightly after the initial warm-up period. A simple solution to this problem is to compensate for the drift of the free-running oscillator by changing the operating frequency of the station at the other end of the link.

The AFC circuit shown in **fig. 5** uses the frequency-dependent voltage available from the i-f post-amplifier, as discussed previously. During two-way communications only one operator has his AFC circuit switched on; the Gunnplexer at the other end of the link is allowed to run free. A three-position switch is used because the frequency change might be up or down (center position is AFC OFF). The coupling between the AFC circuit and the Gunnplexer determines the system's holding range.

performance

The successful operation of various 10-GHz amateur stations in the Rhein-Main area, operating with the equipment described here, has proved the system's feasibility and reliability. The use of 17-dB horn antennas at both ends of the link allows communications up to 60 km (35 miles) or more. The 3-dB beamwidth of the horn antenna is approximately 30 degrees, so antenna alignment is not particularly critical.

Some stations are using home-built 23 dB horn antennas or 2 meter (6 foot) parabolic reflectors, so there have been many 10-GHz contacts in the range

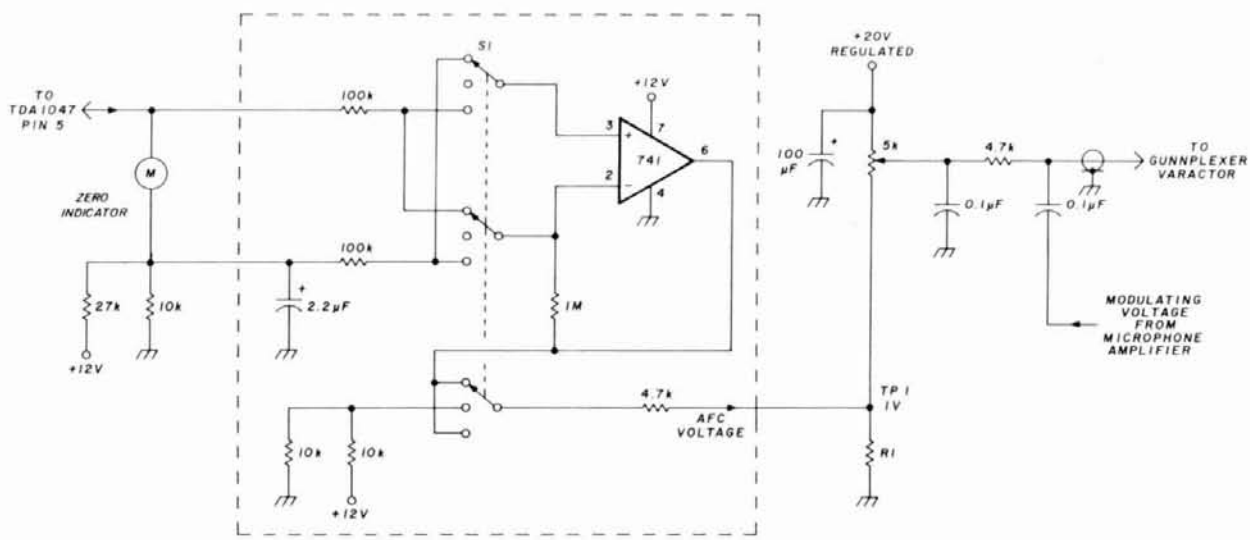
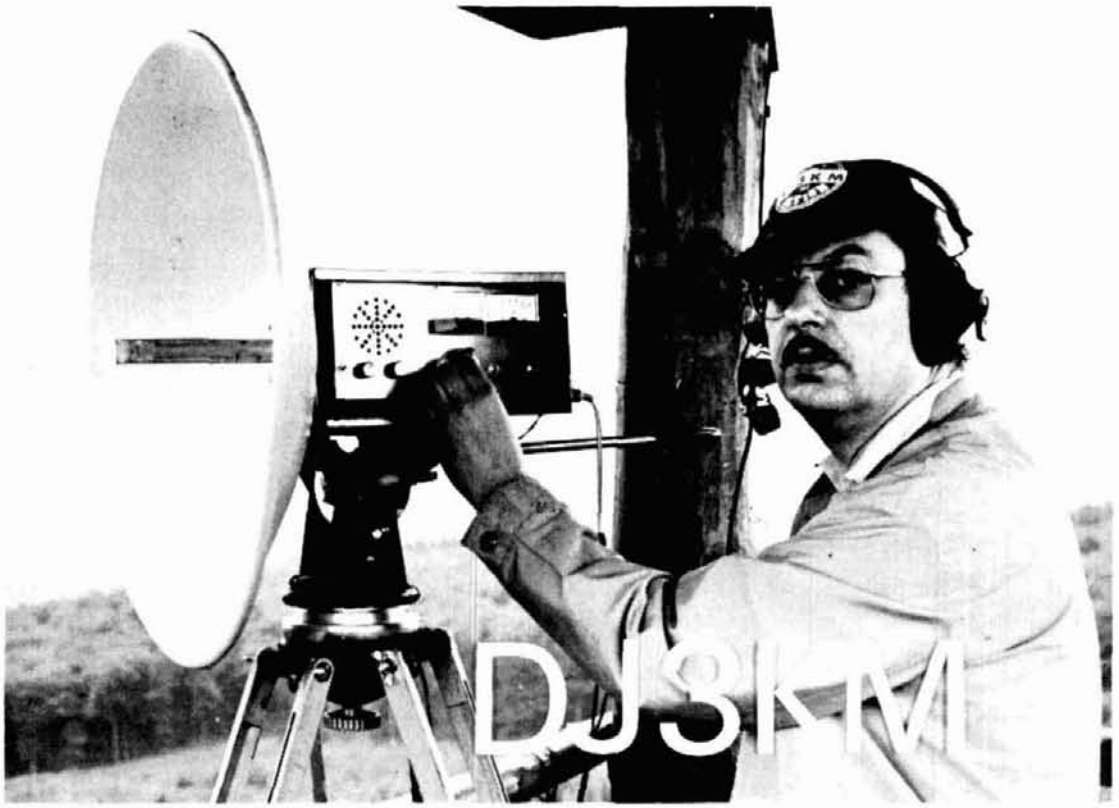


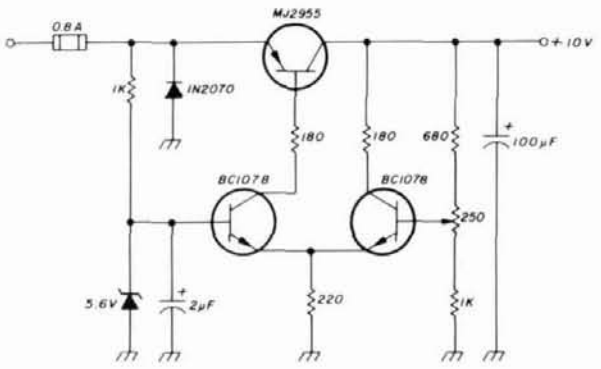
fig. 5. AFC voltage for the 10-GHz Gunnplexer transceiver is derived from the frequency-dependent voltage available from the 30-MHz receiver (fig. 4). The value of resistor R1 (approximately 330 ohms) must be determined experimentally so that 1 volt is measured at TP1.



QSL card used by DJ3KM showing his 10-GHz Gunnplexer and 30-MHz i-f receiver.

of 100 to 200 kilometers (60-120 miles). Since a pair of Gunnplexers with these high-gain antennas has a calculated systems range of at least 400 km (240 miles), we could work over distances greater than 200 kilometers (120 miles) if we could find a non-obstructed path that long.

When setting up the Gunnplexers it's helpful to have a secondary link on 144 or 432 MHz, but many contacts have been achieved without it. The operation of a microwave transceiver with the aid of a map and compass is a new challenge and hobby for many amateurs in Germany.



A +10 volt regulated power supply recommended for use with the 10 GHz Gunnplexer transceiver. The BC107B transistors may be replaced by any small-signal NPN silicon transistors such as the 2N4124. The MJ2955 may be replaced by a 2N3789 or similar 10 amp PNP device.

Activity on 10 GHz in Europe has now reached the point that a 10-GHz bandplan has been approved by amateur groups in Germany, Holland, and Switzerland. In addition to providing space for communications between individual amateurs, the bandplan accommodates beacons, repeaters, and narrowband modes (CW, RTTY, SSTV, and single sideband).

Trial runs with higher gain antennas, narrower i-f bandwidths, and phase-locked loop circuitry for frequency stability are presently going on (reference 3, which describes a phase-locked Gunnplexer system devised by WA6EXV, is available from Microwave Associates).

I would especially like to thank DJ6RW, DJ3KM, DK2DRX, DJ8QL, and DJ8CY for their help in the construction and planning of this equipment.

references

1. J. R. Fisk, W1HR, "Solid-State Microwave RF Generators," *ham radio*, April, 1977, page 10.
2. B. Heubush, DC5CS, Dr. Ing. A. Hock, DCØMT, and H. Knauf, DC5CY, "Ein Sende-Empfanger fur das 10-GHz Band," *UKW Berichte*, Autumn, 1976, page 184; Winter, 1976, page 245; and Spring, 1977, page 47.
3. C. Swedblom, WA6EXV, "ROCLOC Gunnplexer Stabilization System," available from Microwave Associates, Inc., South Avenue, Burlington, Massachusetts 01803.

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