Number 21 on your Feedback card

ABOVE AND BEYOND

VHF and Above Operation

C.L. Houghton WB6IGP
San Diego Microwave Group
6345 Badger Lake Ave.
San Diego CA 92119

5670 MHz LO & Converter

Browsing through back issues of *Feedpoint*, the North Texas Microwave Society newsletter, I found a design for a 5.6 GHz microwave building block PC board in the July 1988 issue. The original article was published in Germany and is used in this column courtesy of *CQ-DL* magazine, 12/87. Credit for this converter design goes to Roman Wesolowski DJ6EP and Jurgen Dahms DC0DA.

This project was just what the doctor ordered, even in time for Christmas. I could not believe the simplicity of the design and the methods for constructing such a truly fine converter for 5.670 GHz. This discovery completed the search for a working design that I thought was not available. Prior to this I was assembling components to put a system together, and I had not completed the gathering phase. This PC board made the job a lot easier. I have to praise our German amateur counterparts for their workmanship. See Figure 1 for the schematic.

Circuit Description

The circuit uses two GaAsFET amplifiers, one for the receive pre-amplifier stage, and the other for a transmit amplifier stage. The transmit amplifier provides about 5 mW power output and helps balance out the filter loss. The 5.6 GHz filters, interestingly designed, use two ¾-inch copper pipe caps with ¼-inch stubs for coupling into the filters. The depth of the stub determines the bandpass and filter loss. One-fourth of an inch is a good compromise. Each filter is fed from independent transmit and receive mixers, further simplifying the circuitry. See Figure 4 for details.

The mixers use any good mixer device, such as the economical HP 5082-2711 to the high performance stripline HP 5082-2794. Alpha 6-5827-00 stripline types are also suitable. The RFC for the 144 MHz coupling mixer input/output is an air-wound coil. I used 5 turns of #32 wire. If you want a form, use a 1 meg ¼W resistor.

Other parts for the PC board, such as the transmit attenuator, are common. Use carbon resistors, not wirewound types. The variable inductor L in the preamp stage is a NEOSID 5061. A suitable replacement can be made by winding 4 turns of #26 magnet wire over a ⅛-inch slug tuned form. The stripline PC board is etched from double-sided 0.031-inch Teflon™ stock. Leave the side opposite of the stripline unetched to act as a ground plane. After drilling the board, I used a ¼-inch sharp drill bit to ream out the holes on the ground plane to allow the components' leads to pass through without shorting out. Please note that those connections indicated with a ground symbol on the schematic should be jumpered from the stripline side of the board directly to the ground plane side. Most of the components including the pipe cap filters are mounted on the ground plane side. The chip capacitors, RF chokes, the mixer diodes and a few of the resistors are mounted on the stripline side. See Figure 2 for parts placement and the foil diagram.

Modifications

The IF system for this converter works at 2 meters and has an on-board U-310 receive 2 meter preamp. If you desire, you can replace this preamp with other preamps by coupling directly out of the U-310 input circuit.

I have made several modifications to the original PC board to suit my requirements. For example, I removed the crystal multiplier that was part of the local oscillator drive circuit. The system as originally designed used a crystal oscillator running at 117 MHz, and one tripler and five doublers multiplying the crystal frequency to 5616 MHz. The final doubler circuit, located on the main PC board, is driven by 2808 MHz from the oscillator PC board.

I modified the circuit by eliminating the crystal oscillator PC board and removing the multiplier (doubler) on the main converter PC board. I replaced this entire circuit with a 5.6 GHz, phase-locked "brick" local oscillator (see Figure 3). The brick provides a local oscillator output directly at 5.615 GHz. (5760 operating frequency - 145 MHz IF frequency = 5.615 GHz local oscillator.) This greatly improves stability and simplifies construction. There's nothing wrong with the multiplier string, but if a high quality oscillator is available from surplus, why not use it?

Phase-Locked Brick Oscillators

The phase-locked brick oscillator can be described as a compact, self–

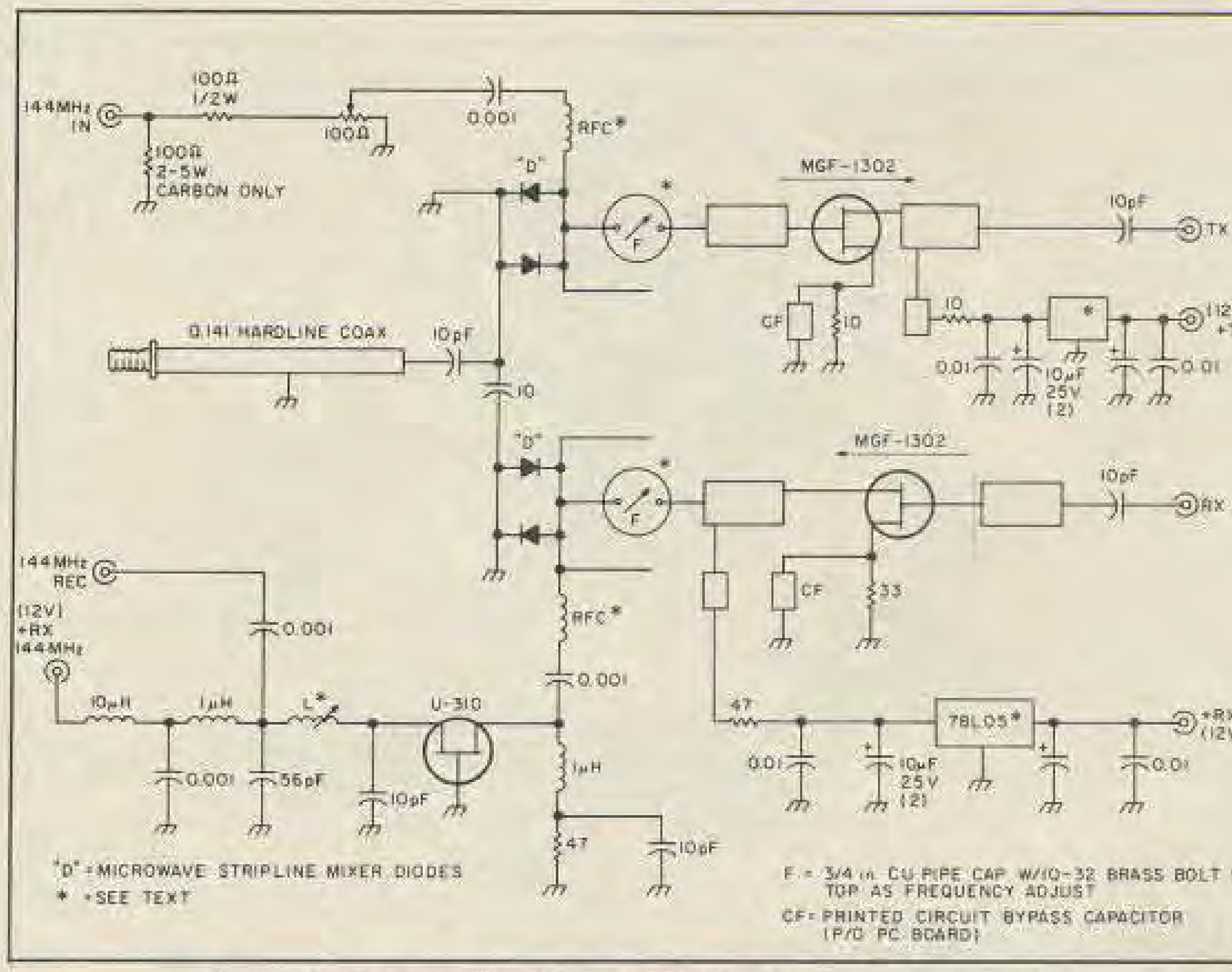

Figure 1. Schematic of the 5.6 GHz microwave converter.

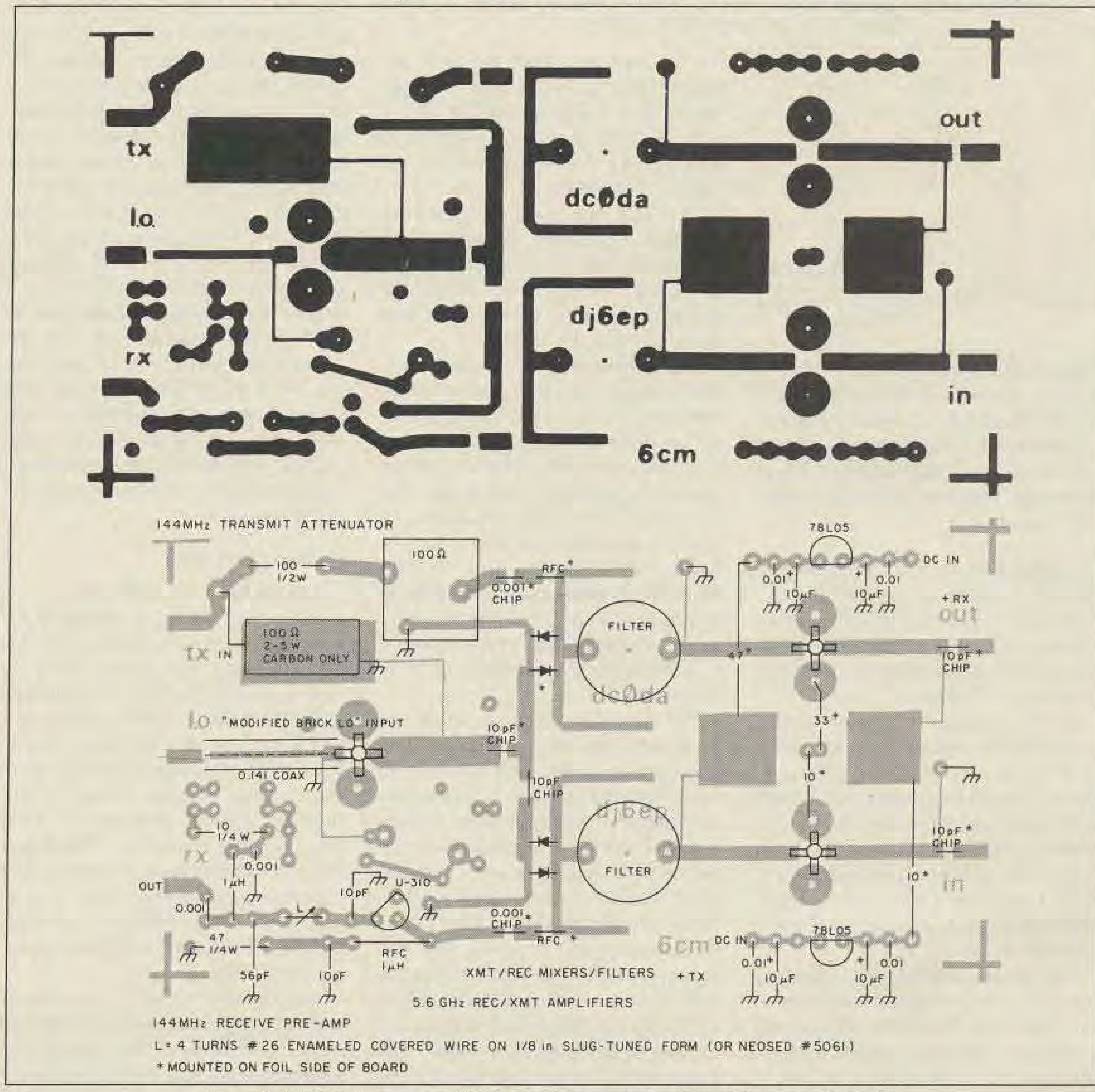

Figure 2. (a) Foil diagram and (b) parts placement (as viewed from stripline side).

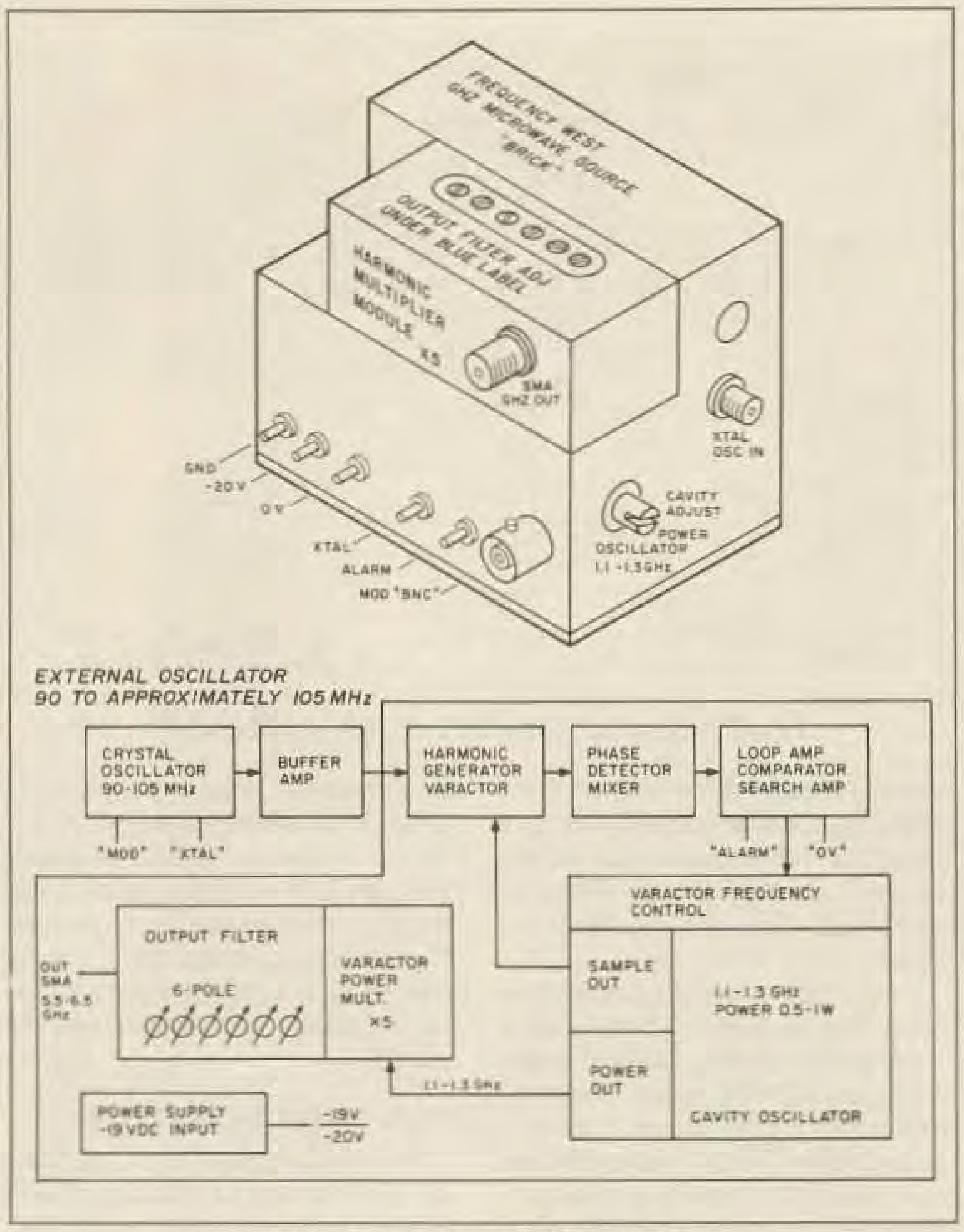

Figure 3. The microwave brick oscillator.

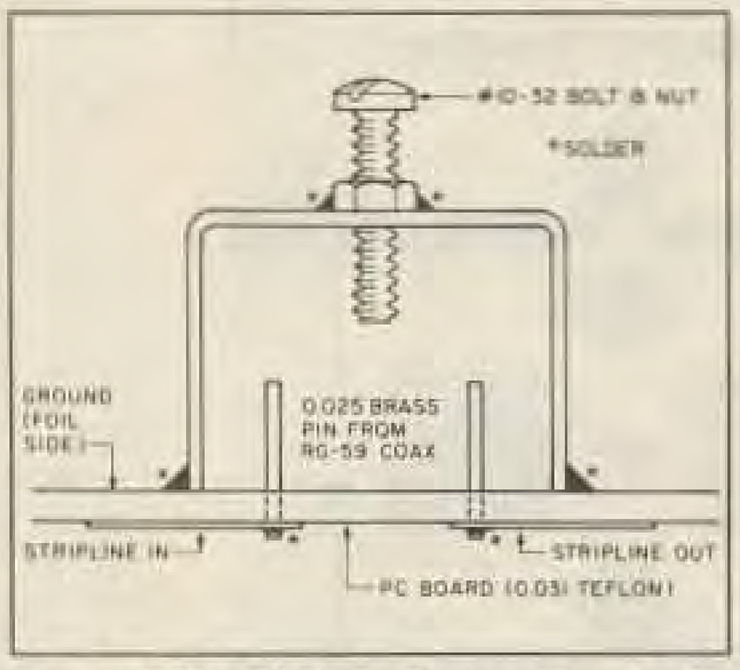

Figure 4. The ¾-inch pipe cap filter for the 5.6 GHz converter. Adjust the pin length for filter shape and loss (approximately ¼ inch long). Use RG-59/U center conductor leaving the foam insulation intact. Adjust the bolt for resonance at 5670 MHz or desired frequency.

contained system for local oscillator injection, hence the name "brick." Availability depends on the drifting winds of surplus. The circuitry internal to a brick is quite extensive; new, they cost about $1700 each.

Working surplus bricks were priced at $25 to $35 when they first started to show up, but prices on all microwave related components have been steadily rising. I have seen tested, certifiable bricks sell for a low of $50 and a high of about $75, depending on their condition. I've picked up bargain bricks at $5 each, only to find them in serious trouble.

The crystal oscillator for controlling the brick can be internal or external to the basic brick. The bricks with internal oscillators make the system simpler, but they are getting hard to find in surplus.

If the brick you obtain needs an external oscillator circuit, see the September and October issues of *73* this year, in which I describe a crystal oscillator circuit and a temperature control circuit in this column.

The brick I am using does not have an internal oscillator, so I've put the external oscillator and temperature circuit to use. It is a lot easier to build the crystal oscillator and buffer stage than the entire multiplier string.

Two transistors for a 100 MHz oscillator and a single op amp for temperature control are not difficult to put together. The external oscillator supplies the brick's harmonic generator, whose overall multiplication ratio is 60. That means that the crystal is multiplied 12 times, and controls the high power oscillator, phase-locking it at the 12th harmonic. A diode multiplier multiplies this phase-locked signal five times to the 6 GHz range. The crystal multiplier (12), times the harmonic multiplier (5), equals 60.

The oscillators showing up on the surplus market are coming from telephone companies, who are shifting from microwave to fiber optics for communications systems. Most equipment is junked out to scrap metal dealers at ten cents a pound. Now this sounds great, but don't forget that the bricks come with about 300 pounds of relay rack and support equipment. After this is removed, the junkyard still has the bulk of iron and unusable equipment left over. You have to find the brick oscillators before they're turned into scrap metal. People are catching on and demanding higher prices for them.

All is not a bed of roses, as you must purchase this equipment without any form of guarantee. My local scrap dealer has told me several times in price negotiations that: "You can't romance a junk man." Their price is firm! Looking for treasure in a scrapyard can be lots of fun, but it takes time and is wrought with dead ends.

Crystal Multipliers

Here are a few hints on how to properly tune a crystal multiplier for comparison. Some of the details are applicable to general building at higher frequencies. Component parts and construction techniques are very important, and not paying attention to detail will give poor results.

First, let's assume a multiple stage circuit like the original one used for the 5.6 GHz converter. Adjust each multiplier stage for a clean stable output, making sure the output is on the intended harmonic. Don't tune the circuit for maximum, as a system, by the tweak and peak method. Sure, it puts out power, but on what frequency? And what about oscillator garbage? I bet it'd have lots of false outputs and be somewhat unstable. It's better to tune each stage as a separate output before proceeding on to the next stage, making sure it's on frequency and not self-oscillating. (Pull the crystal; the system should be stable and not oscillate).

As I stated earlier, circuit construction techniques are very critical because at microwave frequencies, the size of the components becomes a larger and larger fraction of a wavelength. A short wire connection at low frequency can be a very large impedance, or RF choke, at microwave frequencies. Poor construction techniques and solder blobs can render a microwave circuit useless. Don't leave solder rosin on the PC board. Clean it with alcohol or other thinners. Just as you tune one stage at a time, do the same when building. Do not populate the entire PC board with component parts at one time. You could place most of the "nonvolatile" parts, transistors, and diodes only as needed while testing. This should minimize any circuit problems.

Mailbox Comments

Junji Tamara JH1MOY of Tokyo inquires about the brick oscillators for both 10 and 6 GHz bands. We are sending him details on the bricks. He reports that a 2.4 GHz repeater was settled in Tokyo recently, and activity has increased on that band. He believes that soon this wave of interest will cover all of Japan. Well, Junji, I hope the interest spreads and many other amateurs enter the fascinating world of microwave communications. I started in amateur microwave several years ago, being interested in building simple and practical circuits for our microwave bands.

Ray Kajma of Farrell, Pennsylvania, writes that he is looking for an APQ-110 radar manual. He's also looking into small antennas, and has researched a spiral antenna capable of operation over many GHz. A spiral antenna, like a log array, starts small in the center and spirals out, the dual elements getting broader as they circle out. Contact Ron at 317 Florida St., Farrell PA 16121.

Terry N8BIF questions the polaplexer. Does it function as a circulator and detector? Also, he wants me to describe my TWT and power supply. Well, Terry, the polaplexer is not a circulator, in that no magnetics isolate the detector from the transmit source. The polaplexer was first used over 40 years ago with tin cans of resonant size. The polaplexer derives its isolation from the fact that transmit is 180 degrees offset from the receive, one horizontal and one vertical in the waveguide or tube. Local oscillator injection is controlled by upsetting the inherent balance by a 8/32 brass bolt. This bolt is positioned at 45 degrees, and its depth of penetration controls transmit injection of current into the detector diode for bias.

The TWT or traveling wave tube that I use is a surplus item from telephone equipment for analog microwave transmitters that became obsolete. The TWT is a helix tube 6 to 8 inches long, its plate structure a spring-like, spiral-wound coil. It is surrounded by special magnets to contain an electron beam tightly focused in the coil. The power supply requires several high voltages—600, 1200, 3000 volts—which are adjusted to each tube type. Currents are quite low, in the 3 to 25 mA range for 10W types.

My TWT runs off 24 volts DC at 3 amps on transmit and has an output of 10 watts. My Field Day station has two options. One is the lower, more convenient solid state amplifier with 200 mW output for 12 volts at 1.3 amps on transmit. The other is the TWT with its power supply. The power supply is as wide as a relay rack (19 inches). It's 8 inches high and weighs about 10 pounds. The tube is 10 inches long in its protective case.

The large battery supplies that the TWT needs for a full day's operation (two 12V, 26 Ah) pose a problem for Field Day microwave contests. The battery might be overkill, but it can last a full weekend without recharging.

Bricks Available

By the way, I have obtained several extra 6 GHz brick oscillators similar to the ones described in this column. The bricks are as good as new, and I'll make them available for $50 each, postpaid U.S. They require an external oscillator (100 MHz crystal, approximately). All have been tested and are in good condition, phase-locking at 6 GHz, with the typical 6 GHz output 50 to 100 mW (+20 dBm maximum).

The last weekend of the ARRL 10 GHz Contest is about to start, and I hope to get some pictures to let you know what's happening. As always, I will be glad to answer any questions concerning this and other VHF/UHF microwave-related items. Please include an SASE for a prompt reply. 73 Chuck WB6IGP