MICROWAVELENGTHS

QST is proud to present the debut of a new bimonthly column: "Microwavelengths." The column editor is Tom Williams, WA1MBA. He has a graduate degree in Computer Science, and directs the development of imaging, software and millimeter-wave technologies as a consultant. Tom's radio amateur interests are primarily VHF, UHF and microwaves, and he is active on all bands from 144 MHz to 10 GHz from his home. He has done some pioneering work in the EHF bands of 120 and 145 GHz.—*Steve Ford, WB8IMY,* QST *Editor*

Welcome to the first "Microwavelengths" column.

Twenty years ago the number of amateurs operating above 1296 MHz may have been dozens, but now there are hundreds, perhaps even thousands. Hilltops are swarming with dish antennas during contest weekends, there are microwave topics at every major VHF conference, and there are kits available to get us on all bands up to 10 GHz. Hams are constantly experimenting with equipment, techniques and propagation. They are setting DX records on all bands. Recently, the 24 GHz band was added to the list of successful EME contacts.[1] Although contesting and DX records are great operating fun, most microwavers will tell you that the reason they come to and stay involved in these bands is the technical challenge and the rewards of successfully building and operating their own equipment.[2]

The ARRL has recognized this growing interest by providing multipliers in the VHF contests, creating a contest focused on 10 GHz and above, and by publishing DX records. *QEX*, the publication for ham experimenters, has always given significant space to microwave topics. The time has come to bring microwave techniques and information into the mainstream, and so this column is born.

"Microwavelengths" promises to be a technical forum, presented at a level that most amateurs will be able to understand. Hopefully, it will both stimulate and help our readers to move into this part of the spectrum. Each column will focus on one aspect of microwave techniques, and will answer some common questions about the topic. If you have a question, send it to ARRL, Microwavelengths, 225 Main St, Newington, CT 06111, or e-mail me at **wa1mba@arrl.org**. "The World Above 50 MHz" column will continue to deliver timely operating news and propagation reports for all the upper bands. Please send your operational reports and other news to Emil Pocock, W3EP. Although "Microwavelengths" explores the equipment and technology that make the microwave bands special, it will not describe details or news about operating or propagation.

I probably will not be able to answer every question, but will try to be informative and useful. Because no one person is an expert on all aspects of this field, I am getting help from well-respected amateurs as we cover each topic. In this issue, the topic is the general area of Amateur Radio microwaves, so I feel expert enough to continue on alone.

Q: What are microwaves?

A: How about a small motion of the hand. Or maybe that box in your kitchen that quickly heats up food? No, here we are discussing a range of wavelengths, and consequently, a range of frequencies. Unfortunately, the term "microwaves" is not well defined. During the Second World War, experimenters noticed the ease with which short wavelengths could be focused and the ability to get detailed range information by receiving echoes from transmitted pulses. This radar application was one of the reasons that engineers and others needed a word to distinguish this range of the spectrum as being different from the portion normally used for communication at the time. For our purposes, we will treat all frequencies about 1 GHz and higher (wavelengths about 30 cm and shorter) as "microwaves." See Table 1 for some better-defined terms for frequencies in this range.

Often, people will use the term "Millimeter Waves" to distinguish the EHF band from the others because of their wavelength and the especially difficult technical problems associated with their use.

Q: Is the 902 to 915 MHz band a microwave band?

A: Some would say yes; others no. For this column, we will include all bands, 902 MHz and above, recognizing that bands that most microwavers feel are "especially microwave" are 2.3 GHz and above. In this column the invented term "microwavers" is used to mean any amateur who is active on the microwave bands.

Q: How are microwaves useful to society?

A: There are many uses for microwave energy. The common ones are heating, radar and communications. Microwaves are particularly useful in a way distinct from lower frequencies because of beam-width and bandwidth. With such a small wavelength, it is possible to construct an antenna of convenient size that has quite narrow *beamwidth*. This allows for high gain and therefore less RF power than would otherwise be needed for communications. It also permits more communication activities on the same frequency in one geographic area because interference can be controlled with very directive antennas. And also, communications tend to be more secure on microwaves because of tighter beamwidths.

The added *bandwidth* available at these frequencies permits more information to be carried on one signal. Telephone companies have used this characteristic to carry hundreds of voice signals or dozens of video signals on one carrier. Advanced digital techniques can use microwaves to put many megabytes per second on one carrier. Other uses of microwaves include material heating, such as a microwave oven or industrial microwave heater, and radar which uses the narrow beamwidth to interrogate a narrow beam of the sky and the wide bandwidth to measure distance accurately.

[1]Notes appear on page 95.

Table 1
Frequencies and Wavelengths Associated with Microwaves

Abbreviation	*Designation*	*Frequency Range (GHz)*	*Approximate Wavelength Range*
UHF	Ultra High Frequency	0.300 to 3	1 meter to 10 centimeters
SHF	Super High Frequency	3 to 30	10 centimeters to 1 centimeter
EHF	Extremely High Frequency	30 to 300	1 centimeter to 1 millimeter

Tom Williams, WA1MBA ♦ wa1mba@arrl.org

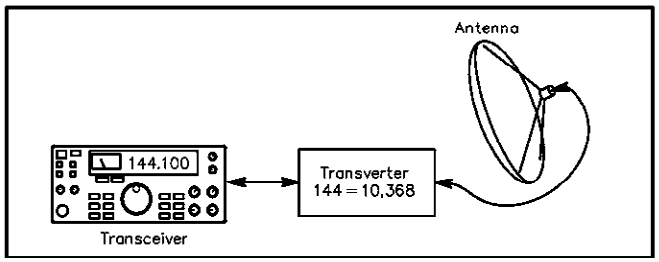

Figure 1—A typical microwave station consists of a transceiver with a transverter and antenna.

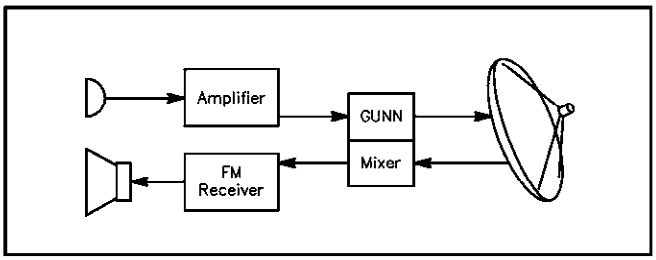

Figure 2—A Gunnplexer station setup. An FM receiver tuned to 30 MHz acts as the receiver.

Q: How do amateurs get on a microwave band?

A: This will be the primary interest of this column in general. Each issue will deal with a specific topic about techniques and equipment to get on the air. One common microwave radio consists of a transverter and a conventional transceiver (often running on 28 MHz or 144 MHz). The antenna is usually a Yagi or "looper," a dish with feed, or a horn. The transverter converts the conventional transceiver transmit signal up to the microwave band, and on receive converts the incoming microwave energy down to the transceiver frequency. By simply using the transceiver (and knowing the transverting frequency) one operates on the microwave band. In the example in Figure 1, 144.100 on the transceiver means 10,368.100 MHz on the air, which is the North America calling frequency for CW and SSB on 10 GHz.

It is necessary to interconnect the transceiver and the transverter so that proper transmit/receive switching is accomplished, and so that transmit and receive signal levels are appropriate and not damaging. Because most transmission lines are very lossy at microwave frequencies, the connection between the transverter and antenna must be kept short, or further amplification needs to be mounted close to the antenna feed.

Q: What is a "Gunnplexer"?

A: A Gunnplexer is a type of microwave radio that is much simpler than the transceiver and transverter type. The Gunnplexer consists of a microwave oscillator called a GUNN diode that can be frequency modulated by direct connection of an audio source. For reception, a simple diode type mixer is added. It creates an intermediate frequency equal to the difference of frequency between the two stations' transmitters, such as 30 MHz. As shown in Figure 2, an FM receiver tuned to 30 MHz will then act as the receiver.

This type of microwave radio has been most popular on 10 GHz, and to a lesser extent, on 24 GHz for a few decades. Although the system power and sensitivity are limited by modern standards, its sheer simplicity has brought many amateurs to the microwave bands. This mode is still used by many amateurs for successful and fun contacts. Because the modulation occupies a relatively wide bandwidth this mode is often referred to as WBFM or simply "wide band" to distinguish it from the narrow bandwidth modulation of SSB and CW used in higher performance systems. Wide-band FM can also be used for TV and data modulation.

Q: What modes of modulation are used?

A: As you may have guessed, all modes are used. Narrow and wide-band FM, SSB, CW, TV (AM and FM), spread spectrum, various data modes and even pulse are used. The greatest DX is provided by CW, and is probably used the most often during contests and attempts at DX records. The greatest information is communicated using TV, spread-spectrum and data modes. In all communication there is a tradeoff between bandwidth and noise, and therefore effectively between bandwidth and distance for a given pair of stations. This effect will be described more in future issues when we work out system performance details.

Q: Does everyone have to build his or her microwave rig?

A: There are ready-made transverters, preamplifiers, power amplifiers as well as kits. Some hams enjoy designing and building from scratch, others enjoy building kits, and others purchase ready-made systems. There are many publications that relate design and construction experiences, and those will be referenced in this column. About 15 years ago, there were not so many choices. Most hams had to build most of their equipment from components or surplus modules. Over the last decade there has been quite a bit of surplus showing up at flea markets and hamfests, and also there has been a significant increase in the availability of kits and pre-built systems from a few notable suppliers.[3] Most of the designs have come from a few of the leading amateur microwave circuit designers from around the world.

Q: Is microwave activity limited to line-of-sight communications?

A: No, there are over-the-horizon contacts being made every day. This is because there are several atmospheric phenomena that will scatter the transmitted energy and permit contacts around obstacles and across significant distances, much like with VHF and UHF signals. Certainly it is not every day that contacts of 1000 km are made on 2304 MHz, or 500 km on 10 GHz, but they happen frequently enough to have a lot of fun getting on and trying. Being on a high spot with a clear horizon does help, but setting up on a small hill overlooking a body of water, or even pointing at a nearby mountain can yield surprising results. There are many less-than-spectacular home station sites that operate successfully. Whether hilltopping, contesting, or operating from home, amateurs are getting on the microwave bands and having fun while learning to communicate beyond line-of-sight.

Next installment (March *QST*) we will look into the workings of the Gunnplexer and the transverter to get a good grounding on how these two most popular means of getting on the microwave bands function.

Notes

[1]"The World Above 50 MHz," *QST*, Nov 2001.
[2]Microwave Update, 2000, "A Survey of Microwave Radio Amateurs," ARRL.
[3]There are several suppliers of various useful microwave components and systems. The ones that cater to the needs of radio amateurs that the author knows of are:

(US)

Down East Microwave, 954 Rte 519, Frenchtown, NJ 08825; tel 908-996-3584; **www.downeastmicrowave.com/**.

SSB Electronic USA, 124 Cherrywood Dr, Mountaintop, PA 18707; tel 570-868-5643; **www.ssbusa.com/**.

DL2AM amplifiers are available from Tom Haddon, K5VH, 1005 Hidden Hills Dr, Dripping Springs, TX 78620; tel 512-894-4374; **k5vh@texas.net**.

Advanced Receiver Research, Box 1242, Burlington, CT 06013; tel 860-485-0310; **www.advancedreceiver.com/**.

SHF Microwave Parts Company, 7102 W 500 S, La Porte, IN 46350; **www.shfmicro.com/**.

(Overseas)

Kuhne Electronic, Birkenweg 15, D-95119 NAILA/Hoelle, Germany; tel +49-9288-8232; **www.db6nt.com/**.

Eisch-Kavka Electronic GmbH, Abt Ulrich Str 16, Ulm, Germany; tel +49-07305/23208; **www.eisch-electronic.com/**.