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Crystal Microwave

"Easedropping" on this part of the spectrum is up to you. Here's a simple way to start.

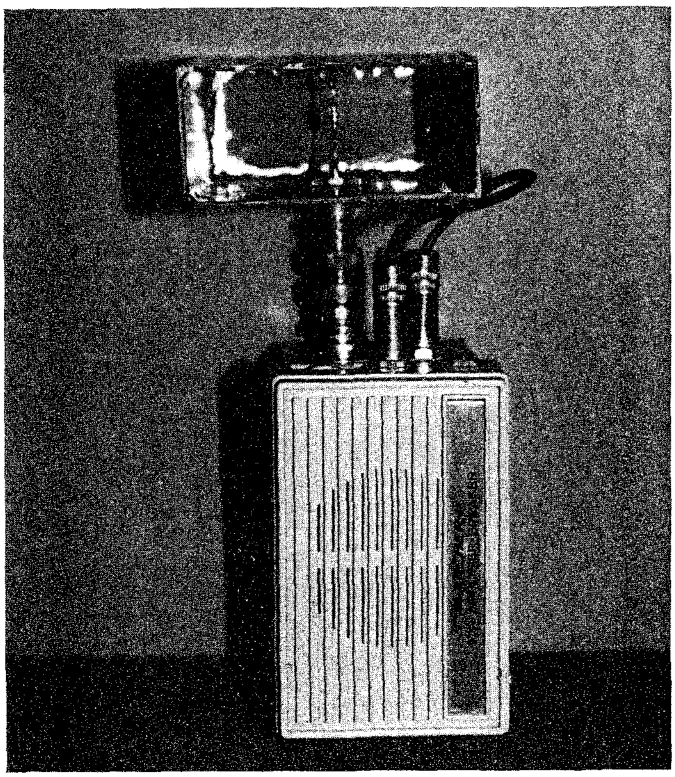
Interest in the microwave spectrum has increased rapidly since the introduction of the "Gunnplexer" by Microwave Associates. Many amateurs, though, have expressed interest in finding a more economical way to get started. What I hope to accomplish with this article is to show how to get involved in microwaves with a minimum investment of time and money.

The microwave spectrum is populated with myriads of signals, ranging from telephone relays to television-studio links to radar to satellite signals. How can we detect and monitor these signals? The simplest way is with a crystal receiver. Don't scoff. I know of several production microwave systems that use crystal detectors or crystal video receivers as they are called. The common police radar detector is a special type of crystal video receiver.

A crystal receiver can be broken down into four basic parts: an antenna, a tuned circuit, the detector, and an amplifier (see Fig. 1). The most common tuned circuit is not really a tuned circuit but a high-pass filter, a waveguide. In this mode, the antenna and tuned circuit can be combined. If the detector is mounted in the waveguide, then the only external component is the amplifier.

Rectangular waveguide will pass all frequencies above a cutoff frequency (f_c). The cutoff frequency is determined by the internal width dimension of the waveguide. The cutoff frequency occurs when the internal width is exactly one-half wavelength. A simple formula for calculating this is $f_c = 15/b$, where b = internal width in centimeters and f_c = cutoff frequency in GHz. For example, the most common waveguide for the 3-cm amateur band (10 GHz) has an internal width of 0.9 inches or 2.29 cm. Hence, $f_c = 6.55$ GHz.

If the frequency is raised such that the width is now one wavelength, the guide can support another mode. This occurs at $f = 2f_c$. So, the maximum stable frequency range is from f_c to $2f_c$. Well, if you consider skin losses and other factors, the practical frequency range is



Front view of S-band unit showing diode placement.

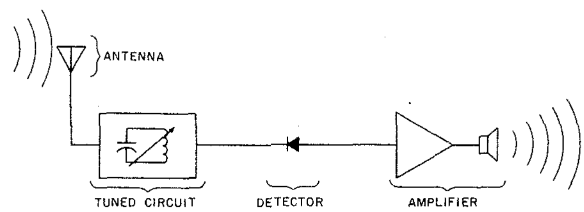


Fig. 1. Basic elements of a crystal video receiver.

from 1.25 f_c to 1.9 f_c. For the previous example, the practical or useful frequency range is 8.19 GHz to 12.44 GHz. This is in good agreement with the published range of 8.2 GHz to 12.4 GHz. Fig. 2 is a graph of the upper and lower practical frequency range of rectangular waveguides having internal widths from 2 cm to 18 cm.

The graph is not meant just to enable you to determine the frequency range of a piece of surplus waveguide. It will also enable you to decide how wide to make a piece to use. Yes, you can make your own waveguide and do it without a machine shop. Waveguide can be made from flashing copper, brass shim stock, or, my favorite, printed circuit board. To illustrate, I made a crystal video receiver to monitor several radars located near my home.

There are three S-band search radars within 20 miles of my home. The term S-band refers roughly to any frequency between 1.5 GHz and 5 GHz. Table 1 is a listing of these informal designations. Table 2 is a listing of some microwave frequency ranges of interest. The local search radars are grouped from 2.7 GHz to 2.9 GHz.

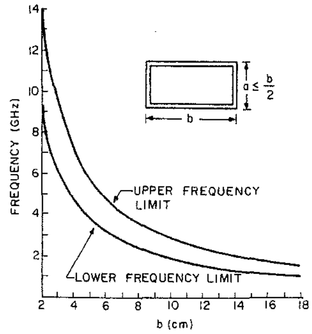


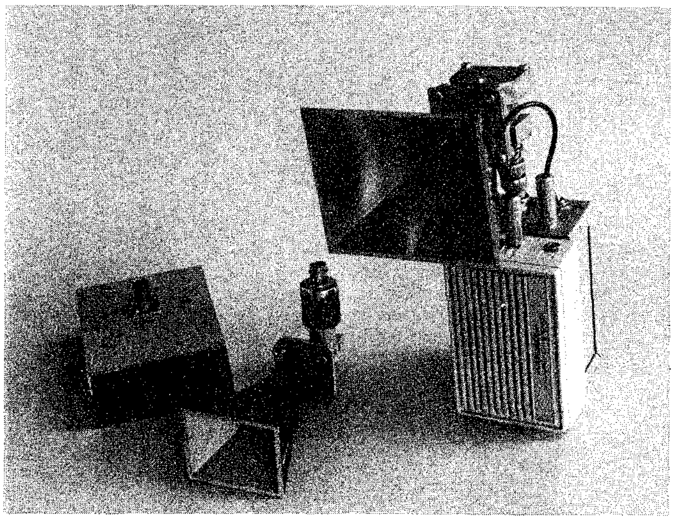
Fig. 2. Upper and lower frequencies shown for rectangular waveguides.

Hence, from Fig. 2, the waveguide should have an internal width between 6.9 cm and 9.5 cm. I chose 8 cm as a compromise. The internal height should be one half or less than the internal width. The guide height determines the impedance and power-handling capability of the guide. The useful frequency range of the 8-cm guide is approximately 2.4 GHz to 3.6 GHz. This range just happens to include the amateur 2400-MHz and 3300-MHz bands. Higher frequencies can travel or propagate down the guide, but the mode structure would be uncertain. I mention this because the guide will pass X-band signals and you should not be surprised to hear them.

For a crystal receiver, I prefer to make the guide 1 to 2 widths long. For the example, the guide is 9.5 cm or 1.125 widths long. This length was chosen on the basis of available pieces of circuit board. Since the receiver will not be used for a specific frequency but rather for a band, I mounted the BNC connector and detector one-half guidewidth from the shorted end.

Construction is simple. The circuit board material is easily sawed or sheared to size. The BNC mounting holes and the opposing diode hole are drilled next. The guide is taped together and the seams are soldered with a 100-/150-W iron. After assembly, the diode is placed inside and soldered. No bypass capacitor is used. I find that normal construction techniques are adequate to block the microwave energy and pass only the modulation. Surplus mixers have a very efficient bypass scheme and function well as crystal receivers. I use an X-band mixer to monitor small marine radars in the harbor.

The weak detected signal is boosted by the amplifier shown in Fig. 3. An LM301 is used instead of the more common 741 because of the lower noise output of the LM301. The output of the amplifier is further boosted by Radio Shack's "Mini Amplifier-Speaker." The low current drain of the amplifier makes it inviting to obtain its power from the mini amplifier, but problems with



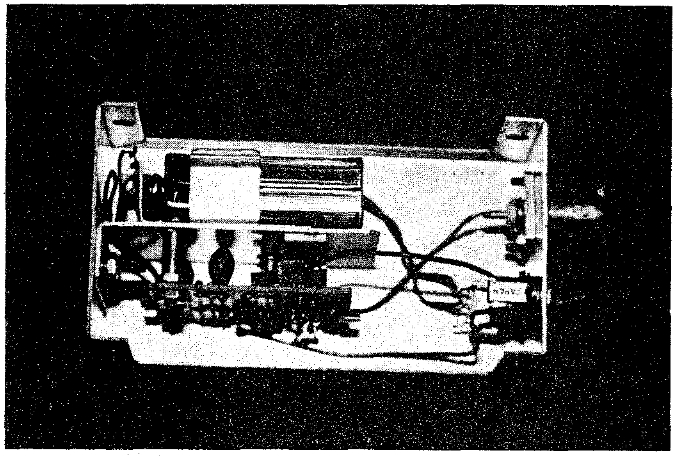
Detector/amplifier with X-band head and nearby S- and K-band heads.

Band Designation	Freq. Range (GHz)
P	.2- .4
L	.4- 1.5
S	1.5- 5.0
C	4.0- 6.5
X	5.0-12.0
K	12.0-36.0
Q	36.0-45.0
V	45.0-60.0

Table 1. Microwave band designations.

Source/Emitter	Freq. Range (GHz)
ILS Glideslope	.3286-.3354
TACAN-DME	.96-1.215
Radar Beacons (IFF)	1.03, 1.09
Air Route Radar	1.3-1.35
Airport Radar	2.7-2.9
Aircraft Doppler Radar	8.8
Precision Approach Radar	9.0-9.2
Marine Radar	9.3-9.5

Table 2. Selected emitter frequencies.



Internal view of preamplifier showing circuit card and battery.

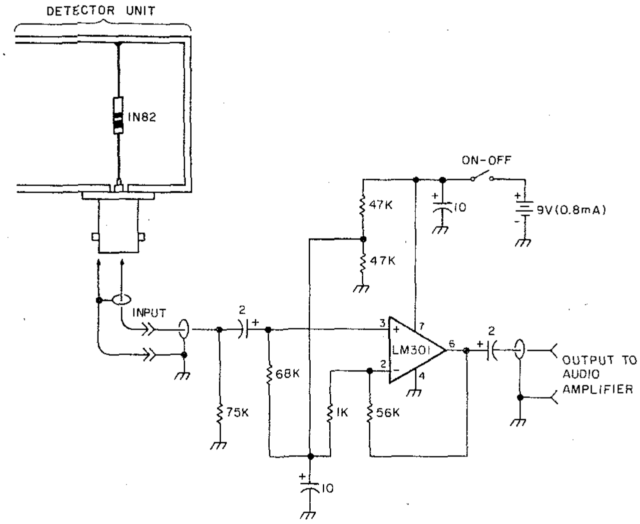


Fig. 3. Schematic of a 50× audio preamplifier.

motorboating forced me to use an independent battery. The compact assembly is quite portable and accompanies me on short outings.

Waveguides are not the only usable form of crystal receivers. For narrowband signals, a separate antenna, tuned circuit or cavity, and detector might be better. Preamplifiers, if available, greatly enhance the overall sensitivity.

Try something simple and build one of these. This might be the easiest microwave construction article yet. Let me know what you build and how it worked, and please remember to enclose an SASE! ■