SAN BERNARDINO MICROWAVE SOCIETY, Incorporated

FOUNDED IN 1955

A NON-PROFIT AMATEUR TECHNICAL ORGANIZATION DEDICATED TO THE ADVANCEMENT OF COMMUNICATIONS ABOVE 1000 MC.

W6IFE Newsletter

May 2010 Edition

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At the **May 6, 2010** SBMS meeting the "Tech Talk" will be Frank, WB6CWN on the topic of 24 GHz hardware. The SBMS meets at the American Legion Hall 1024 Main Street (south of the 91 freeway) in Corona, CA at 1900 hours local time on the first Thursday of each month. Check out the SBMS web site at http://www.ham-radio.com/sbms/.

Election of new SBMS officers will take place at the 6 May meeting!!!!

And the anomalies are: President John Oppen KJ6HZ; Vice President Doug Millar, K6JEY or Dick, WB6DNX; Recording Sec Larry Johnston K6HLH; Corresponding Sec open; Treasurer Dick Kolbly, K6HIJ; and Editor Bill Burns, WA6QYR

REMINDER- NO PARKING IN THE CHURCH LOT

Last meeting.. Ed, WX6DX gave a well pictured talk on his trip to Cape Canaveral, FL to see the launch of a weather satellite. This was the 50th anniversary of the first weather satellite TIROS. Well done Ed. Larry, K6HLH ran the meeting. The Annual Tune UP Party for end of July is awaiting news from San Diego group on which day they can come to run the equipment 24 or 31 July. Seed money from MUD 2009 came in for MUD 2010. Peter, K6PTL arranged a tour of JPL Labs on Oct 21 930-1400. Dick, WB6DNX is working the vendor list for MUD. SBMS elections according to the by laws have to have nominations first so the actual election will be held in May this year.

Activity reported at the April SBMS meeting: Pat, N6RMJ sold gear to purchase new 1296 MHz hardware; Dick, K6HIJ made a 1296 antenna for KN6VR; Chris, N9RIN built some 2 and 3 GHz radios; Steve, WA7LKP is a new SBMS member; Don, KE6BXT did some ATV work; Tom, KF6Q has a C-band dish; Juno built a 432 circular polarized antenna; Walt demonstrated how by biasing a 1N21 into its conduction region, it modulates RF better and had some breadboard PCB to show different ways to build projects (www.busboard.net); Bill, WA6QYR did some work on his EMER dish; Chuck, WA6EXV went to Hawaii for a week to checkout microwave beacons, radio telescopes, visual telescopes, and designed a new low noise PLL and did some HF high power amplifier work for a friend; Dick,

WB6DNX did some work on city emergency radio, Powerwerks.com has a new switching power supply SS-30 30 amp 12v ; Larry, K6HLH has the tower back up with a working 10 GHz rig on top; ATV had K6BNN, AF6HP and AC6RB checked in.

Scheduling.
1, 2 May SBMS 2 GHZ and Up Club Contest
May 23-28 week IEEE conference in Anaheim Conference Center- Demos by Pat, Dennis, Brian and Walt.

SBMS sponsored MUD 2010 October 21 to 24 Cerritos Sheraton Hotel. Website is microwaveupdate.org. Preregistration on line $35. Hotel info on the web site. Thursday Tours. Friday talks and swap meet. Saturday talks, noise figure measurements, banquet and speaker. Sunday antenna measurements. Papers due 1 September for proceedings.

ARRL 2010 Contest Calendar
June 12-14 VHF QSO Party
June 26 Field Day
August 7-8 UHF Contest
August 21-22 10 GHz and UP contest 1st weekend
September 11-13 September VHF QSO Party
September 18-19 10 GHZ and UP second half

European EME Contest Calendar 2010
May 22/23 1.2 GHz

Welcome to ***Microwave Journal***'s MTT-S International Microwave Symposium 2010 Pre-show Coverage **May** 23-28, Anaheim, California**. Welcome to this year's IMS INSIDER, *Microwave Journal*'s coverage of the IEEE MTT-S International Microwave Symposium taking place May 23-28th in Anaheim, CA. The IMS INSIDER is your source for industry activity related to the conference and exhibition - before, during and after the event. Join us for exclusive conference information, exhibitor profiles, social networking, photos, videos, and more. If you are not attending the show, stay informed with the IMS INSIDER and our online show coverage on the *Microwave Journal* home page.**

You are cordially invited to attend the Ham Radio Social event of the IEEE International Microwave Symposium. This will be held at the Anaheim Hilton which is on Convention Way off of Harbor Blvd.
Day: Tuesday, May 25
Time: arrive 6pm sharp, or earlier if you are setting up equipment. This event will go to 9pm.
Room: California-A This is on the 2nd floor and accessible by escalators and also 4 elevators from the lobby. When you get off on the 2nd floor, go to the left and there will be a large sign at the door.
Guest badges with flashing LEDs will be provided by Chuck Swift.
Display tables and easels will be provided for your displays. You must use those as it is not permitted to tape to the walls. Please bring your transceivers, projects, and photos of your equipment and events. There will be hundreds of microwave engineers attending this and we want to show them what we are doing with our valuable spectrum and also show our ingenuity with extremely limited budgets. You do not have to have your equipment working, but if you want, then bring your own extension cords, outlet strips, or batteries. We will likely encourage many of the engineers to obtain ham licenses. We have been quite successful in the recent past. We would like as many bands represented as possible from UHF to 243GHz. Laser communications are also welcome. I suggest making up leaflets about your group which can be placed on the tables so local engineers may take them to come to your meetings.
A buffet dinner and open bar will be provided free.
Details on unloading equipment and parking: Drive into the main check-in driveway (you will see the line of cabs) and tell the bellman you are attending

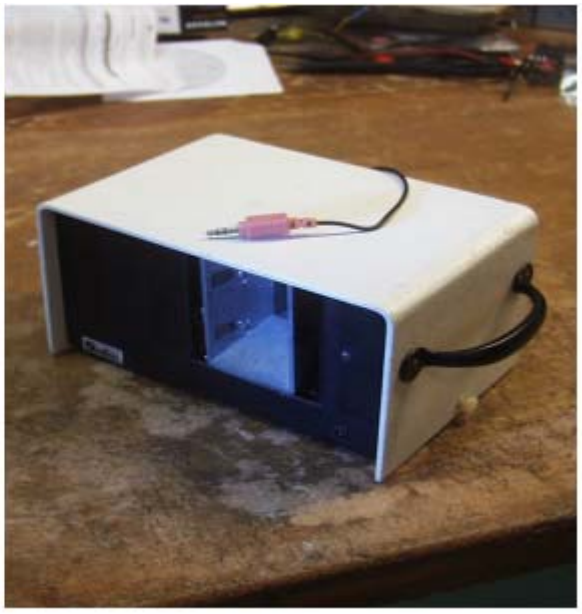
an IEEE event. Either carry your equipment and posters or ask for a luggage cart. I suggest using the valet parking for the event so your car can be brought back there to load your equipment when you leave.
Parking is at your expense.
73, Jeffrey Pawlan WA6KBL

Wants and Gots for sale.
For Sale- 220MHz heavy duty 7 el beam $15; Bill WA6QYR 760-375-8566 bburns@ridgenet.net.
For Sale: 10 ft prime focus dish mesh/fiberglass $100 Brian AF6NAbytcorona@yahoo.com 909-226-2015
For Sale 30w 1296 MHz kit $50 + $5 for shipping Chris Shoaff cshoff@yahoo.com

Simplest Possible X-Band Radio

Microwave ham radio is unique in that you have to make your own gear. For that reason, microwave is the most respected end of the ham radio spectrum. Go any higher, that is, into the optical wavelengths and it gets easy again. It's easier not because you can buy a rig up there but because to modulate a light beam and directly detect it is breathlessly easy. There's no need for atomic clock frequency reference standards, surface mounted devices or exotic sounding things like YIGs and diplexers. This article describes an X-band radio that is very much like a light beam modulator. It is a way into the microwave band in the simplest way possible. It is far simpler than a Gunnplexer; the traditional starting point for microwave communications. The range is less than a Gunnplexer but long enough to enjoy how precisely you have to point the horns at each other. You will also enjoy extending the range with a dish. In that single step, the range increase is so much, the logistics of the link becomes delightfully significant. The range can be a good portion of a block with a surplus satellite dish on either end; as much as a mile, with dishes on both ends. With only that which comes with the surplus equipment you will be using, the range is enough certainly to impress judges at a science fair.

On the left is the Fuzzbuster horn and underneath it a thrift-store HiFi amplifier. The Pomona Box on the side of the horn has nothing in it. It is just a way to mount a BNC chassis mount connector. The unit on the right is the transmitter assembly. It is a motion sensor modified with the mini-phone cable and two small resistors attached to the Gunn diode.



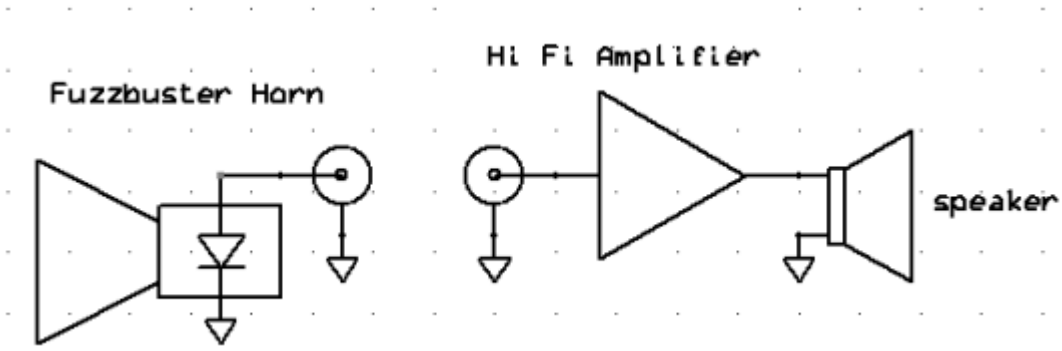
My own microwave interests are primarily with the physics of radiation; polarization, diffraction and interference. In one experiment where I was playing with different diameter wires going in the E-direction across a waveguide I discovered something interesting with a diode stretched across in that direction. You would expect that a diode across a waveguide would reflect the radiation when a current is made to go through it. And that is

the case for microwave diodes. But with an ordinary germanium 1N34, I found the exact opposite going on. The more forward current the less it blocked the radiation. In the process of playing with this phenomenon I couldn't resist using it as a modulator. Detection consisted of one of my field strength meters connected to a speaker. I had an instant radio; a motion sensor, a 1N34 and a field strength meter. This simplicity was inspiration to write an article for a beginner microwave radio. This method of modulation however requires a very rare diode mount. The connection to the diode must have a very low inductance yet a very significant capacitance. This is difficult to build and not suitable for a beginner project. I had already started this article before I realized how special the diode holder was. (I bought it on eBay several years ago and I have never seen one like it since.) It won't work with the diode simply stretched across the broad walls of a piece of waveguide. The backup method of modulation is to modulate the Gunn diode source directly as you would a laser diode in an optical communicator. This method runs a risk of damaging a very hard to replace part. But it works without any exotic components. The best reason to risk it however is that this method of modulation is exactly what must be done to make a Gunnplexer.

A Gunnplexer is a serious means of microwave communications; one that definitely puts you in the ham category. A Gunnplexer receiver involves an RF preamplifier and an FM radio. It has much more range than the AM receiver described here, but is more complicated. It is also difficult to tune. The output of the microwave components of a Gunnplexer receiver is essentially an IF signal. The IF frequency is adjusted to be somewhere in the FM broadcast band so that after some VHF amplification an ordinary FM radio can be used for demodulation. There are many plans describing Gunnplexers made from motion sensors on the net. You can find details on a polarplexers; a kind of Gunnplexer, on the SBMS website: http://www.ham-radio.com/sbms/sd/ppxrdsgn.htm
The polarplexers uses polarization to allow a more powerful microwave source such as a klystron. This is definitely a project for after you get your ham license. What a Gunnplexer and the radio described here have in common is the transmitter. The Gunn diode changes both in amplitude and in frequency with a change in source voltage. It should be noted that the 10 fold increase in range when stepping up to the Gunnplexer receiver is not because it is FM. It is because amplification is done while the signal is a very narrow intermediate frequency. (More on noise later.)

The AM Receiver Circuit

You will need the horn and just one of the two detectors inside an old Fuzzbuster. It doesn't matter which one remains. (To do Fuzz-busting, one of the diodes is sent a square wave to allow it to switch the cavity on and off. That way, the other diode can measure CW sources of microwave



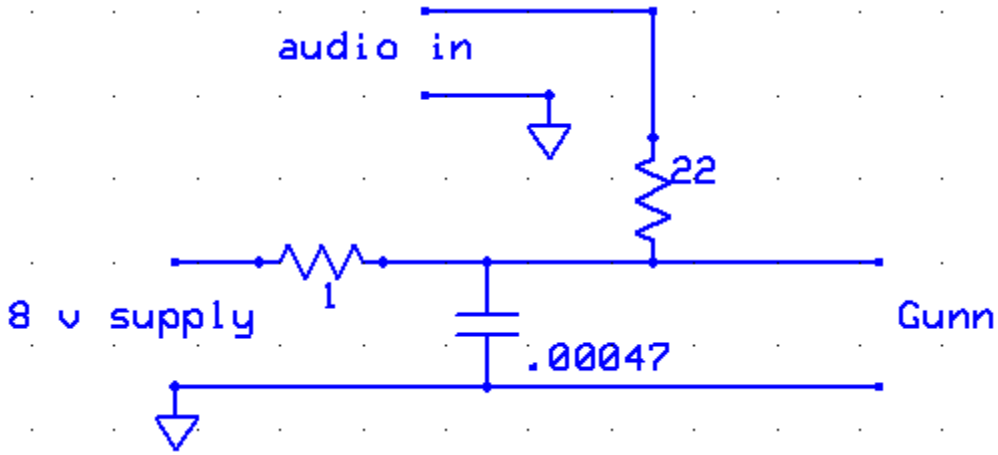
radiation very close to zero without any adjustment by the user. Because of that chopping circuit however, the amplifier used in the Fuzzbuster won't work for our application.)

It turns out the post detection amplifier is the limiting thing in this project. Any thrift shop HiFi amplifier will have a “mag-phono” input. That’s the most sensitive input. But if you can find or make a preamp to go in front of the amplifier with another 10X gain, you will improve the range 10X too. That much more gain will introduce that much more noise in the form of hiss, but it is an amount of hiss that is very familiar to shortwave listeners. So much audio frequency gain is unusual in the design of radios. Normally the audio gain is unity; that is, just a change in impedance, or maybe as much as a factor of 10; nothing like the factor of a thousand you may be using. Since that much gain is the dominant source of noise you can bring the transmitter closer (or use a dish or horn at the same range) and eliminate that extra gain stage which is the cause of so much noise. The result is a very clean signal; very impressive to the science fair judges.

Although you are NOT using the detector inside the motion sensor, the detector in your receiver will be also doing motion sensing. It can hear the Doppler caused by anything moving in the field that is in a direct line of sight between transmitter and receiver. A typical Doppler frequency of arms moving around is about 100 Hz. And very loud too. You will grow tired of the constant woomp, woomp as you move your arms around. (This is another reason to look forward to upgrading to an FM Gunnplexer.) If you find motion sensing interesting, connect the amplifier to the detector in the motion sensor instead of the one in the Fuzzbuster. If you have a spectrum analyzer connect that to the output of the amplifier, then point the motion sensor at the street to pick up cars driving by.

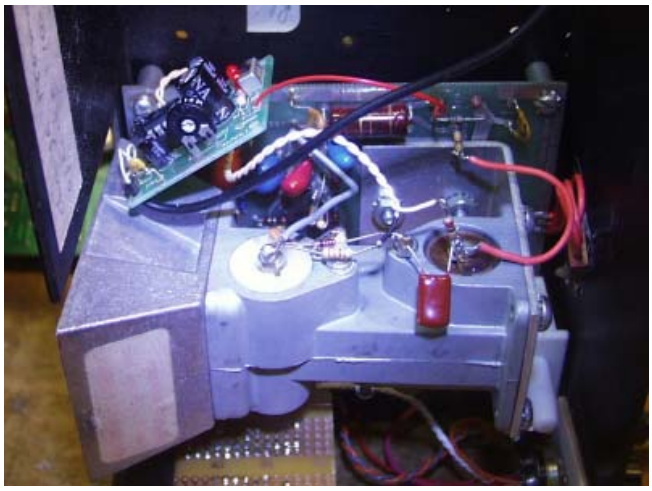
Transmitter Circuit

Part of the appeal of this project is that the circuit is mostly making or buying the correct cables and adapters. The only soldering is the circuit that adds about a half a volt of modulation to the existing power supply in a surplus motion sensor. You will need an audio amplifier because a half a volt on 22 ohms is more than a microphone or even a CD player can deliver. It doesn’t take much of



amplifier though; 2 watts is way more than you need. Actually, all you are doing with the amplifier is lowering the impedance of the line level out of the CD player; assuming that’s your source. If your source is a microphone you will also need some gain. The “mag” input setting of the “phono” input is fine. The two channels of a stereo amplifier works for both receive and transmit, but it is important to note that you don’t need very much audio gain on the transmit side. The receive side is where you need gain.

The amplifier doesn't have to be a stereo from a thrift store. It can be an electronics store audio amplifier kit (about $18) and if you choose to go that route you may want to put the transmitter's amplifier in the same box with the motion sensor. In the photo to the right, is a mono amplifier. The amplifier is the tilted green circuit board. Notice that there's plenty of room in surplus motion sensor housings. If you put the receiver amplifier in here as well, it will make system smaller but less modular. There may also be a problem with feedback since the receiver circuit needs to be so sensitive.



Noise: The Most Important Concept in Radio

The microwave spectrum is different from HF and visible in that the world is profoundly black. With even the oldest broadcast band radio you can hear environmental noise over the noise of the amplifier no matter how narrow the band. On the other hand, in the microwave, to hear anything at all of the environment takes a very good receiver, some high gain, pointed in just the right direction and using as wide a band as you can. The microwave radio receiver described here is essentially a crystal set on a band without any noise. So how does that compare to a receiver that could be tuned to a narrow band around whatever the Gunn was working at? The quick answer is: the quiet background doesn't help much since amplification is always subject to its own noise. The noise of an amplifier is not just a practical limitation. It is a fundamental limitation no matter how much money you spend on it. (It has to do with random motion of electrons at the temperature of the amplifier's load resistor.)

It is amplifying that weak audio signal where we introduce the noise. The Fuzzbuster has a 1N23 in a WR90 cavity; essentially looking at the entire X-band. It is easy to see there was absolutely no environmental noise. (Just put your hand over the receiving horn and notice that there is no change in the hiss you hear.) There's no detector noise either. (Replace the detector with the same value resistor; again, the same noise level.) All the noise is from the front end of the audio amplifier. All radio engineers know that the next step is to use some narrow band RF gain so the audio amplifier can be reduced in gain and therefore in noise too. Narrow band RF amplification is gain without noise; well less noise than the audio working at such high gain. That in a nutshell is how a radio works. All of those parts that make up "heterodyning" are just the best way to make the RF gain narrow in bandwidth.

Buying the Hardware

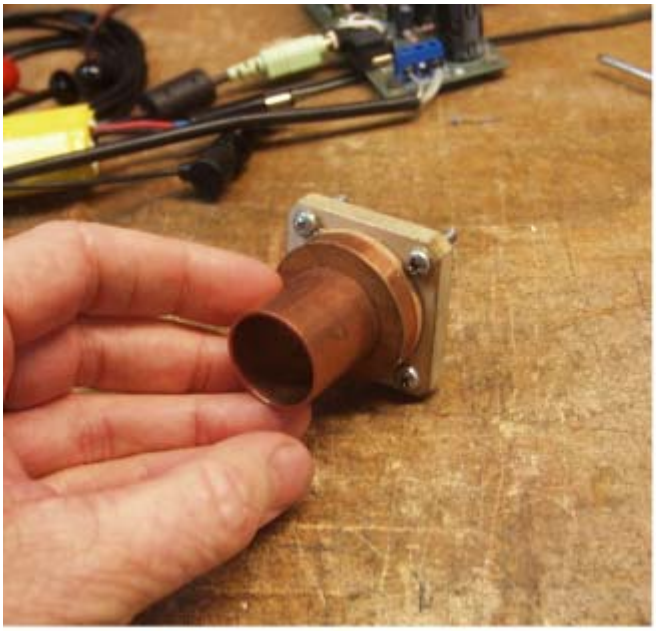
The cables and adapters can be purchased from an electronics store. The amplifiers are cheaper if purchased at a thrift store but audio amplifier kits such as this one:
http://www.canakit.com/mini-walkman-stereo-amplifier-kit-ck122-uk122.html
are better because they are small and battery powered. (There are many kits available on line. The above link is one of many.) The places that sell audio amplifiers may also have the preamp you will need for the receiver side. Remember you will need two amplifiers for each end of your communications link; three, counting the preamp. The only thing hard to find for the receiver is the detector and horn. The easiest place to get those is an old Fuzzbuster from eBay. (If you are patient

you can get one for a few bucks more than the cost of shipping.) All you need is the horn, and one of the detectors that is mounted inside. (The front detector is usually more sensitive.)
The motion sensor is also something you may need to buy through eBay. They are not offered nearly as often as Fuzzbusters so you may have to wait several weeks for one to show up. Many microwave hams will have one tucked away in some box. If you are being helped by a microwave ham, it is very likely he will know someone who would like to sell one to you. A good price is $20. $40 is a bit high. You can use the electronics that is in the motion sensor to drive your source. (Note that the circuit above assumes the drive current is from an 8 volt source. If it is other than that, the resistor values will be the same.) If the one you have is without electronics you can provide a voltage limited supply for just a few bucks by buying a regulator and a wall wart capable of 12volts and at least 100 ma. The Gunn source almost always has a label that says what voltage to use. Don't go above that and make sure you have filtered the supply and there's a small cap across the Gunn as close as possible to the Gunn diode.
You can demonstrate table top communications without dishes. Across the room gets a bit noisy with only the horns that came with the motion sensor and Fuzzbuster. Cupping your hands around the output can noticeably increase the signal. You can make your own horn with sheets of metal. Let the loudness at the other end be your guide for what angles are best. A funnel makes a pretty good horn if you are using round waveguide. (More on copper pipe waveguide below.) If you can find surplus satellite dishes and go to the trouble of positioning your gear on them, your range will improve tenfold; a hundred fold if there's a dish on both receive and transmit. If you can only find two dishes, you can experiment with whether it is better to have one on each transmitter, one on each receiver or both dishes, on transmitter and receiver of just one side.

If you found a Gunn source in a cavity without a label a good guess is 8 volts. But here's how to be sure:
Put your Gunn source a foot or so from the input to the Fuzzbuster horn with a voltmeter on its detector. Put about 5 volts on the Gunn and note the output on the detector. It should be 10 to maybe a few hundred millivolts. Increase the voltage a bit at time and note the increase in detector voltage. When the detector output stops going up even though you've increased the power to the Gunn, you've found the maximum power. Back off about 100 mV to be safe. (Don't forget to make sure the orientation of the throat of the horns are the same; microwave like all electro-magnetic waves are sensitive to polarization.)

Round Waveguide

All motion sensors and Fuzzbusters use rectangular microwave waveguide. Most microwave amateurs have used pieces of WR-90 tucked away in boxes throughout the garage. But if you don't have access to these, copper pipe works just fine. For X-band, standard 7/8" diameter copper is perfect and available in convenient lengths at the hardware store. (The diameter of round waveguide should be about twice the width between broad walls of the rectangular waveguide.)



The picture above shows a wooden flange where the pipe is butted to the rectangular end of the motion sensor. There is very little loss doing it this way. And no it isn't real important that the round and rectangular waveguides touch each other. Once you have the microwaves in a standard pipe, you can use any plumbing fitting available and it will work just fine for microwave; unions, tees, elbows. The only thing you have to watch out for is the polarization. It can end up coming out at a slight angle. (The reason microwave engineers are concerned about tapered transitions, casketed unions and choked flanges isn't for efficiency but for preventing the powerful transmitting signal from leaking out into the receiving circuit. This microwave radio demonstrator doesn't have the receiver in the same box with the transmitter. They don't even share the same dish.)

Polarization is fun to play with. If you are using round waveguide, you can coax the polarization a full 90 degrees by making an internal spiral ladder of heavy gauge wires about ½" apart. You can do it with as few as 5 steps. With a single wire through a coupling you can rotate the axis of polarization. It will go about 10° without loss.

Funnel Horn

Here's a trick using a funnel and round waveguide. Use a plastic funnel because they can be cut to fit tightly over the pipe. You will have to use metalized tape (available at an automotive supply store) on the outside of the horn to make it reflective but you don't have to electrically connect the metal foil to the waveguide. The reason you want it to fit snuggly is that it will allow the waveguide to stick into the horn by an adjustable amount (a few millimeters). That simple expedient changes the reactance characteristics of the connection so you can get an impedance match. The

improvement can be as much as a two to one if you get that distance just right. You can use the voltmeter trick describe in the text box above to tune for maximum good.

Areas to Investigate

- There are a lot more sensitive police radar detectors out there that are as cheap as a Fuzzbuster. Could they be modified for more sensitivity? Receiver sensitivity is what's really holding us back here.
- Even more sensitive is a surplus LNB; the thing at the focus of a satellite dish. You can find them for bands that cover the frequency of any motion sensor. They work as down-converters (900MHz) so you will have to go to some trouble to amplify their output and detect that. (What makes satellite reception complicated comes after that. You are only interested in the RF.)
- The Gunn diode changes its output power with voltage. It is non-linear so the modulation has to be limited. But how much? Extending it by more than what is shown above in the transmitter circuit is not recommended to anyone who is without a ready source of replacement Gunn diodes and nerves of steel. Gunn diodes are very instable oscillators. They are instable at all frequencies including DC. I have burned out many of them.
- For voice, this radio sounds as good as any ham rig. But since you are experimenting at power levels that don't need a ham license, you can do something that hams aren't allowed to do. You can send music. The quality of the music could be improved. Perhaps one of you will discover a way of filtering the signal going to the modulating resistors to bring out the highs. The present circuit also seems to exaggerate the loudness. I find it necessary to turn the volume up and down as the music changes.
- Maybe you can figure out a way to use the detector in the motion sensor so you can use the same horn for transmit and receive.
- It was mentioned above that the reason the Gunnplexer is more sensitive was unrelated to the fact that this radio is AM and the Gunnplexer is FM. It might be very interesting to make an AM Gunnplexer; where the detector inside the motion sensor is connected to the antenna of an AM radio.
- One difference between a detector and a mixer is that a mixer has so much LO energy on it that it is carrying a DC bias. That bias puts the signal in the non-linear part of the i-e curve. A bad detector can become a sensitive detector if you bias it a few hundred millivolts. You can experiment with biasing your detector to make it more sensitive.

If anyone does answer these, or answers any other interesting question, or learns of ways to get more range (without much more expense), please post your suggestion to the SBMS website.
Walter Clark

Ed, WX6DX pointing his dish for an On-The-Air demo at the April SBMS meeting. . The San Bernardino Microwave Society is a technical amateur radio club affiliated with the ARRL having a membership of over 90 amateurs from Hawaii and Alaska to the east coast and beyond. Dues are $15 per year, which includes a badge and monthly newsletter. Your mail label indicates your call followed by when your dues are due. Dues can be sent to the treasurer as listed under the banner on the front page. If you have material you would like in the newsletter please send it to Bill WA6QYR at 247 Rebel Road Ridgecrest, CA 93555, bburns@ridgecrest.ca.us, or phone 760-375-8566. The newsletter is generated about the 15th of the month and put into the mail at least the week prior to the meeting. This is your newsletter. SBMS Newsletter material can be copied as long as SBMS is identified as source.

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