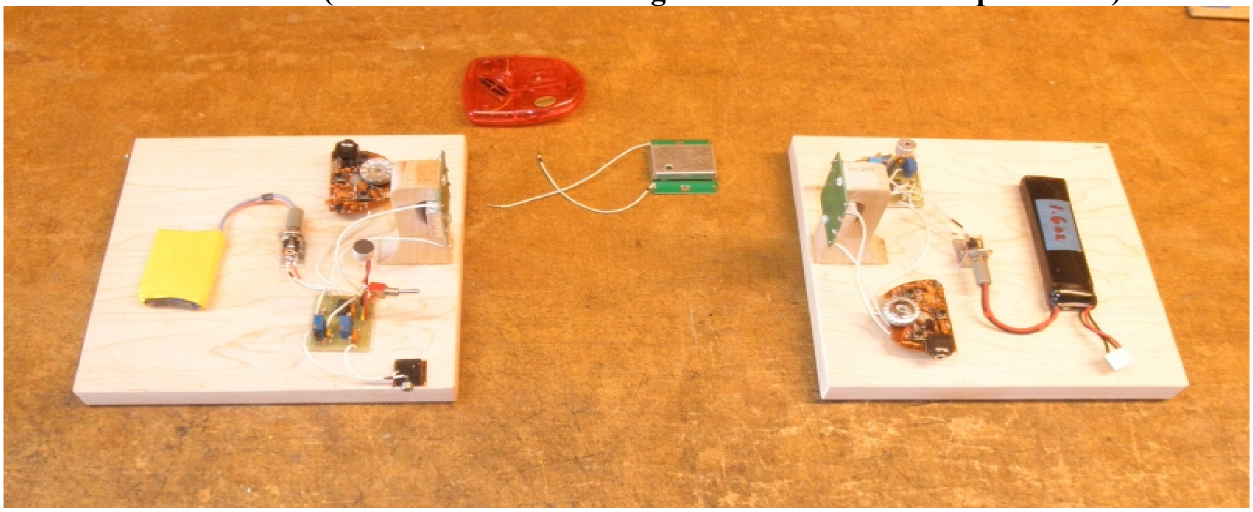
Inexpensive, Easy to Build Microwave Transceiver
—The DROplexer—

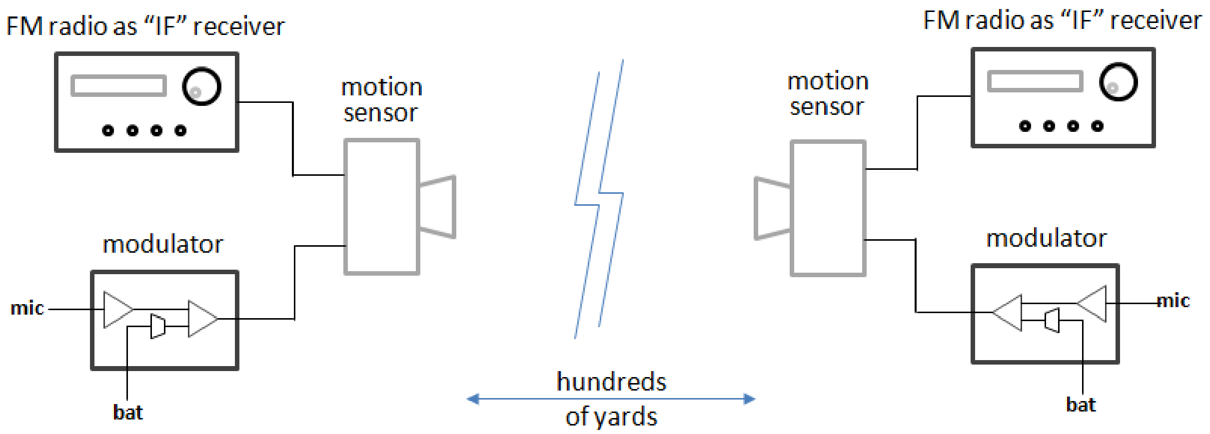
Walter Clark (based on the work and guidance of Eddie Phillips W6IZJ)



This project is a modern day Gunnplexer. It is a "hack" (to use the modern vernacular) of a $6 motion sensor module and a 99¢ store FM radio. The motion sensors are sold to companies that make intruder sensors, or door openers and are available on eBay to the experimenter. They are replacements for the Gunn diode motion sensor module which has been used since the 60s. The new module is far cheaper, much smaller, and consumes 30 times less power than a Gunn. It is also more stable; the biggest complaint about the use of Gunn's in ham equipment. In the above photo the $6 DRO motion sensor module is in the middle next to the red 99¢ Store FM receiver. There is a 99¢ Store receiver and the $6 DRO motion sensor on each breadboard. The circuit boards have been removed from the red enclosure but the volume control was put back on the pot. There is a modulator which is the only circuit you have to build yourself. The modulator has only 10 parts and can be assembled in just a few hours. In the picture above you can see a microphone sticking out from modulator. Any headphones will work and they plug into the headphone jack that comes with the 99¢ FM radio. The range on this under $10 radio can be several blocks easily.

The picture to the right, is what the older Gunnplexers looked like. Actually this is a motion sensor version of a Gunnplexer. The real Gunnplexer was a commercial product made by Microwave Associates in the 1970s. It used a varactor diode and circulator that this simpler version doesn't have. There is another variation of the Gunnplexer made popular among amateurs by the early members of the SBMS. It was called a Polaplexer. An article about the Polaplexer can be found under projects in the SBMS website. The cable in the above picture goes off to a car radio which serves as the I-F receiver and a source of 12 volts. That's 12V at 1 amp, as opposed to 5 V at 30 mA for the DRO motion sensor. For more information on the real Gunnplexer go to the AR^2 website.

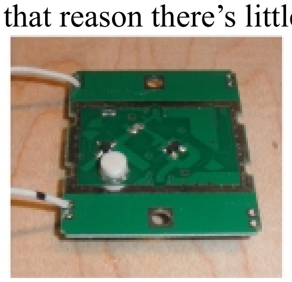
While the introduction of the Gunnplexer permitted hams to have a relatively cheap wide-band FM communication transceiver the real state of the art at the time was almost as advanced as it is now, except that synthesizers and 'atomic clock' frequency references weren't available at affordable prices. Ham microwave technology has always been equivalent to 'best commercial practice' since the guys developing the commercial gear were mostly the same hams playing with microwaves as hams. The reason it was so popular for the beginner was the utter simplicity: the Gunn diode inside a mechanical cavity was all you need to have 10 GHz. The reason the Gunnplexer no longer dominates the ham community in that band is that commercial microwave communications gear –even atomic clocks-- have become available in the surplus market and can be modified for the ham bands. Modified communications gear with their higher power and atomic clocks as frequency references have made the Gunnplexer obsolete.



Here's a block diagram for the Gunn motion sensor based communicator. For those of you hams who are familiar with UHF transverters, the motion sensor module is the transverter. It "transverts" the 10 GHz to a frequency within the FM band allowing an FM radio to serve as the "I-F" receiver. It's not a complete transverter in that the I-F transceiver is receiver only.

DRO

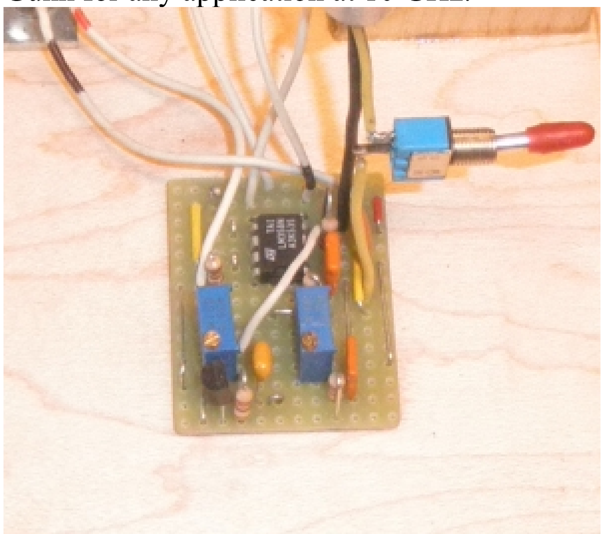
The DRO is the modern version of the Gunn diode. It stands for dielectric resonant oscillator. Both the DRO and the Gunn diode act as the local oscillator as well as the transmitter in their normal use as a motion sensor and as a communicator. There is no special name for this configuration other than superheterodyne. But the tuning of the transmitting frequency affects the receiving frequency, which is normally not the case for superhet. Changing the transmitting frequency turns out to be difficult to do with both DRO as well as Gunns, so this is a one frequency radio and for that reason there's little temptation to make this a normal ham radio.



This DROplexer project has the same block diagram (see above) as the Gunn based motion sensor. The DRO (dielectric resonant oscillator) takes a few more parts than the Gunn but you buy it as a small module and can be thought of in the same simple way:

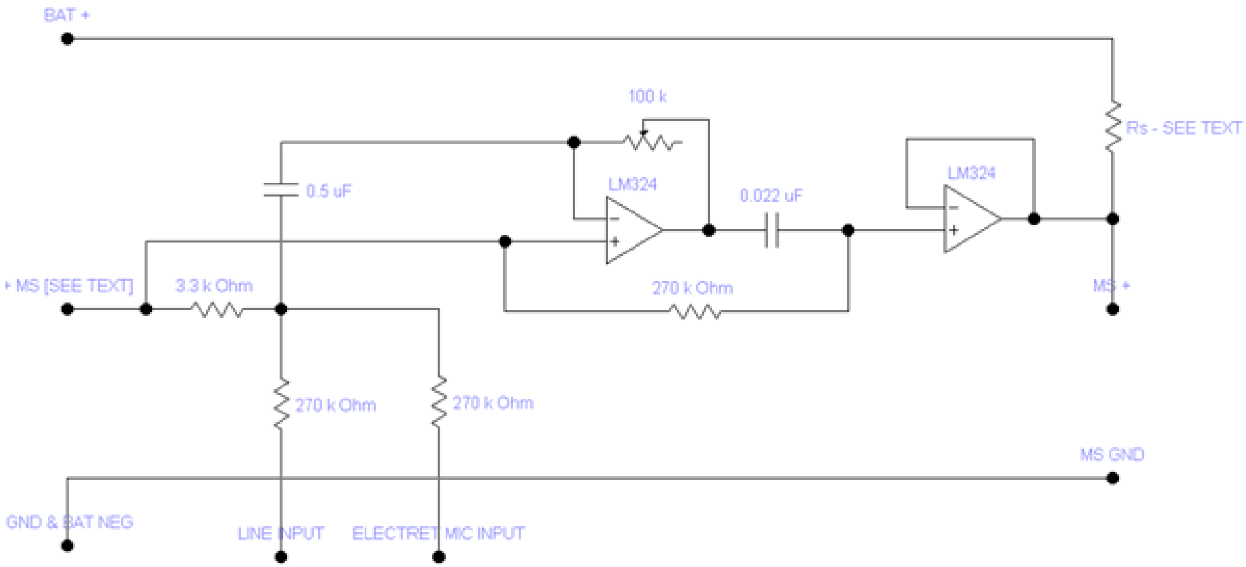
- you frequency modulate the carrier by changing the supply voltage (millivolts)
- you change the position of the carrier within the 10 GHz band by adjusting a screw ***(This is the first mention of frequency change in the article. It is important to note that because a frequency change is made, it moves this project out of the realm of Part 15 (license free). It is a ham radio project to be tested by a ham or under the supervision of a ham.)***

The DRO element is the white pellet in the photo on the right. Dielectric resonance has been known since before WW2 and even used commercially (in VHF) since the 60s. For more on the DRO see the [Wikipedia article on it](). The DRO is better in all ways than the Gunn diode but was held back in use because microwave transistors are a comparatively recent development and mass-produced dielectric resonators were only seen as useful within the last 10 or 20 years. Because the 10 GHz transistors are available and affordable, there is no reason to consider the Gunn for any application at 10 GHz.



The Modulator

The commercial Gunnplexer was modulated by a change in voltage across a varactor that was in the cavity with the Gunn diode. The more common variety of Gunnplexer, the motion sensor communicator, modulated the Gunn diode itself by modulating the DC current that drives it. Although not its intention, the newer DRO motion sensor also changes frequency with voltage. It's about 3 kHz per millivolt. Normally that would require the designer to put in a voltage regulator, but such stability is not necessary for motion sensing. This frequency sensitivity to power supply voltage makes it very convenient for us because it can be treated just like the common variety of Gunnplexer. The output of the modulator has a DC value of 5 volts which you will confirm before you connect your DRO. (The DRO is easily burned out with excess drive voltage. Five volts is perfectly safe and works down below 4 volts if desired.) This regulated voltage enters the circuit (see below) at the non-inverting input of the first opamp. The 5 volts can be provided by an LM28L05 fixed-voltage regulator or better yet an LM317 adjusted to 5 volts. (Adjustment can be used for fine tuning.) The modulation on the 5 V will be on the order of 20 mV. (100 mV is too much.) This is mixed with the 5 V at the second opamp. The amount of modulation is determined by the pot in the feedback of the first opamp and optimized by listening. If the modulation is very low, the volume control on the receiver (of the other radio) will make up for it, but you will of course, hear more noise. You will then down the volume on the receiving radio while turning up the modulation (of the first radio) until you begin to hear distortion. You are to find an optimum between distortion and noise. That optimum adjustment will be done after the receive mode is working on both radios. At first, use a scope to confirm 20 mV of modulation on 5 volts of DC. The modulation (into "LINE INPUT" below) can come from a signal generator, CD player or an mp3 player.



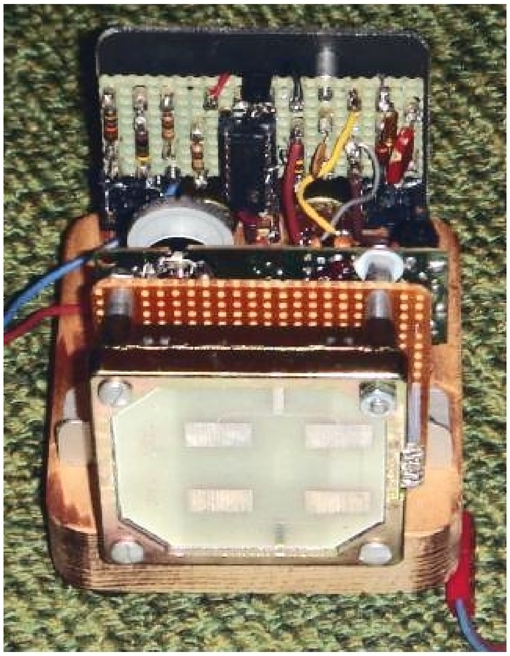
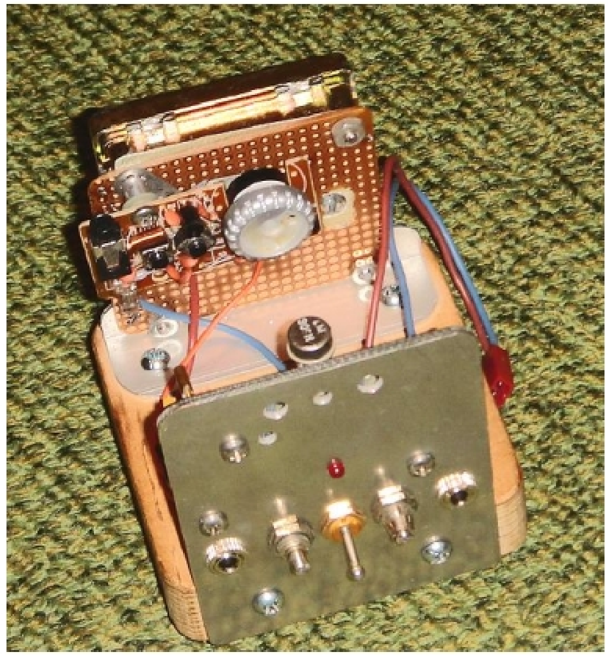
It's a good idea to put a switch on the microphone. The reason is that this particular design is full duplex and you can hear yourself and if a speaker is involved there will be feedback. Even with headphones which would eliminate the feedback, open mics just add to the noise.

The resistor Rs above is kind of interesting. The current through it supplements the modulated 5 V source so the opamp doesn't have to work as hard. For a two cell lithium-polymer battery, (7 volts) the value should be 120 ohms. If you want to optimize it for a different supply voltage, disconnect the opamp, then use a 100 ohm dummy load where the DRO would go, and adjust the value of Rs until the voltage across the dummy load is 5 volts. If it is exactly ballanced when you re-attach the opamp the opamp will only be providing the modulation current. For a 12 V supply, you will find Rs to be about 270 ohms.

The I-F Receiver

The hard part about making your own frequency modulation radio is the discriminator circuit (analogous to the detector in an AM radio) and of course that is done for us within the 99¢ Store FM radio that we will hack. In this project what is hacked is a 99¢ Store FM radio just for the challenge of making something as cheap as possible. Any FM broadcast band radio will work, however. The best in fidelity is the car radio. They are also the best for shielding which is very important for this particular project as will be discussed later. In the picture of the breadboard version above, there is no shielding around the receiver. This is allowed by a very clever trick (described in detail later) where the entire band of the receiver is moved to a quiet place in the radio spectrum.

A Ramsey Kit 30 MHz FM ham receiver has been used as an I-F in the past with Gunn motion sensor Gunnplexers. http://www.ka7oei.com/10gig/fr1c_mods.html Theoretically, a 2 meter ham receiver could serve as the I-F receiver. The cheaper radios have a great advantage over all of these "better" quality receivers. They use automatic frequency control (AFC) to make up for their own lack of stability. This is important for a motion sensor based radio because they aren't as stable as commercial ham gear. The cheapest of FM receivers even have a scanning ability which will locate your signal if it breaks away from the AFC. This feature you will use a lot. In contrast the other radios will need constant adjustment as the oscillators on both sides wander about.

Putting It Together

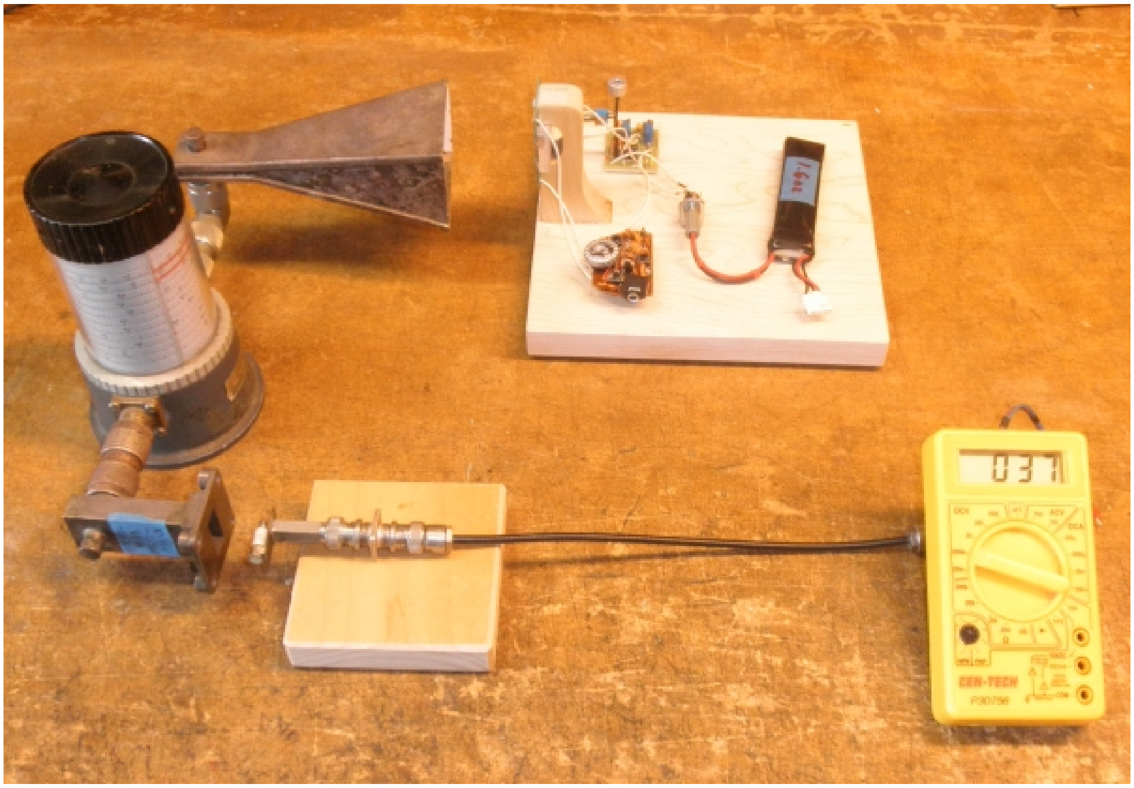
The photos on the first page shows DROplexer laid out on a breadboard as a teaching aid. That was made by the author; Walter Clark. Here is a better form factor version made by Eddie Phillips who is the real designer of this DROplexer.

The antennas involved with the DRO motion sensors are called patch antennas (the left photo). The two patches on the top are for receive and the two on the bottom for transmit. The separation of the patches means the angular sensitivity is narrower horizontally than vertically. It is a beam of about 45 degrees by 90 degrees. The Gunn diode motion sensor has the advantage over the DRO motion sensor in that both receive and transmit signals are in the same waveguide which means that a horn or even a dish can be used to extend the range clear to the horizon. This is the only disadvantage of the DRO-plexer and perhaps a clever reader can figure out a way to pull the signals off the antenna board into a circulator and then to a horn or dish.

What makes this radio so simple is that the transmitter is also the local oscillator. That means that when two Gunnplexers, two DROplexers (or one of each) find each other, they will be occupying two channels in the band and be a full duplex type communications. What you hear in your earphones is both sides of the communication. And as is typical of any FM communications, the sound level is exactly the same whether they are inches apart or several blocks apart. And your voice will have the exact same sound quality as the other person's; no louder and no less noisy.

Although usually made in pairs, they are not stuck with each other and in fact you can communicate with another more modern X-band ham. Except that who you are talking to will have to listen and speak on two different frequencies; something they are not accustomed to. (The separation is the same frequency as the I-F going to your FM radio.)

The most critical step in putting this motion sensor radio together is getting the DRO transmitters to be the correct difference apart in frequency. The FM broadcast band radio spans from 88 to 107 MHz. The correct difference you must achieve is anywhere between 88 and 107 MHz. That seems like a big target, but DROs don't tune very precisely and it will seem like a matter of luck to get it where you want.



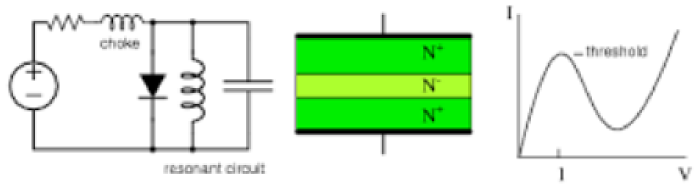
Exact Tuning of The Pair of Radios

The adjustment range available on the DROs is more than enough so the difference between the two can be within the FM band but unfortunately the slug on the back of the DRO motion sensor is so coarse, where on the dial it ends up is a matter of luck. You can leave one DRO motion sensor the way it came and adjust the other one in front of a spectrum analyzer, a GHz counter or a wave meter. To do this you will find very useful, the help of a ham with experience and instrumentation in the microwave. Spectrum analyzers are thousands of dollars; used. A counter that goes up to 10 GHz is much more affordable but still something only a microwave ham would own. If you want to do it yourself the most affordable microwave instrument is a used wave meter. These are available on eBay for a bit more than the cost of shipping. Although they are very coarse (finest division is 10 MHz) and never calibrated, they can do the job. What you are after is only an accurate ***difference*** frequency and that doesn't requre calibration. Here is a test setup using a wave meter . . .

The detector, in the above photo, is a 1N23 which is available from eBay for about $4. The meter on the right is showing 37 mV corresponding to the "dip". Turning the meter a fraction of a division (a few MHz) on either side of the dip will read 40 or 50. Your numbers would be different of course, but this shows what kind of values to expect and how shallow the dip really is. An ordinary swinging needle meter would be better for finding the dip.

What you will do is tweak the setscrew under the label of the motion sensor.

Adjust one or the other to a frequency which is either above or below the other one by the number of MHz that is the middle of the dial in whatever FM radio you chose as your I-F receiver. (Both must be less than 10.500 GHz.) For an FM car radio, the middle is about 100 MHz. That is 10 divisions for a typical 10 GHz wave meter. The setscrew is so coarse that you are pretty much obligated to move it a tiny bit, and then see where the fequency went with the wave meter. There will be a lot of trial and error; cut and try. If you are fortunate enough to have a microwave ham friend to help you with a counter or better yet a spectrum analyzer, tuning will be a piece of cake compared to the use of a wave meter.

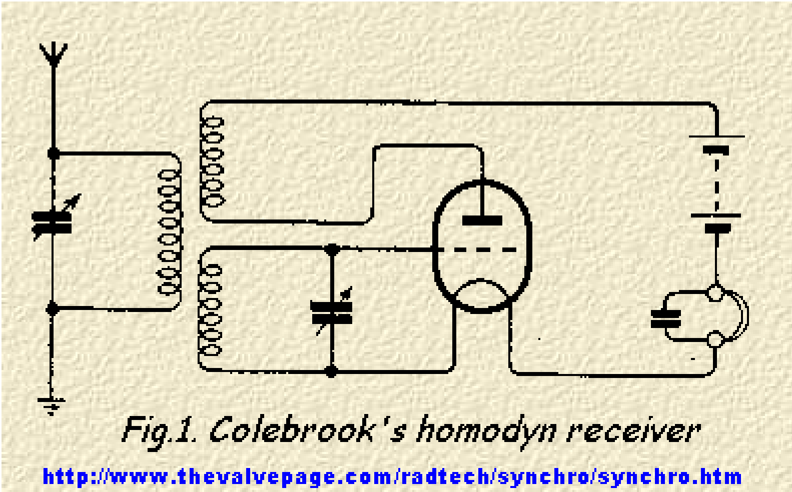


For an excellent article on Gunn diodes: http://electronicslovers.blogspot.com/2011/07/gunn-diode.html

Theory

The trick that makes this hack doable is the use of a motion sensor's ability to be both transmitter and receiver; where the transmitter is also the local oscillator for the receiver mode. This doesn't have a name like auto-dyne or dual-dyne. The consequence of the transmitter being part of the receiver means that both transmit and receive frequencies are fixed. (Or changed with great difficulty.) The output of the DRO motion sensor is an "I-F". The I-F frequency is the difference in carrier frequency between the distant transmitter and the local transmitter acting as an L. O. The transmit frequency is set by a screw adjustment. In the case of the Gunn, the screw changes the capacitance of the cavity. In the case of the DRO it is a threaded slug of steel that influences the resonance of a dielectric puck. Moving closer to the puck raises the frequency.

This project, using the DRO motion sensor and the much older Gunn motion sensor based radio take advantage of the larger market of motion sensors used in security and door openers. The technology that makes it work as a motion sensor is slightly different from working as a radio, but just as interesting. Instead of another radio, the motion sensor receives weak reflections of its own signal. The reflected signal on the mixer is much weaker of course, than the signal directly from the transmitter, but it still produces within the mixer a difference frequency. That difference is due to the Doppler shift of any moving object. For a motion sensor, the word homodyne or "zero I-F" is appropriate because the two signals being mixed are exactly the same. Exactly the same… except for a difference due to Doppler. That is, the slight shift in frequency due to the velocity of whatever is doing the reflection out there. Our radio project shifts the weak signal going into the mixer by 100 MHz or so. That's so the mixer can create a 100 MHz signal that a broadcast receiver can work with. That shift in frequency is shifted further by the modulation (tens of millivolts) added to the 5 V DC. In this case only tens of kilohertz, which the FM receiver's discrimination circuit turns into voltage changes. These are then amplified by an audio amplifier also in the receiver.



Notice something interesting. If instead of shifting it by 100 MHz we made both transmitters exactly the same frequency, and continued exposing the mixer to the local transmitter, there would be nothing for the FM receiver to work with. But if we moved the discriminator out of the FM receiver and connected it to the mixer directly, we could hear the other radio. Now the radio is working in the homodyne mode. This is also known as synchrodyne, zero-IF or direct-conversion. This form of communication is historical in that it came before super-heterodyne and is being looked at today for low cost high data rate transmission.

Go to the link in the picture to the right, for more on homodyne and for more on ***Gunnplexers***, there are dozens of great articles and they can be found with that one word in Google or Bing.

What the DROplexer (and Motion Sensor Gunnplexer) Can't Do Well

- Although about a hundred channels are available (same number as the number of stations on an FM radio) it is difficult to change frequency with this particular arrangement of parts. All you know is that the other fellow will be somewhere on your receiver's dial. Fortunately while trying to find each other, one of you will find the other first. The frequency on the FM receiver will be the same for the other person and a cell phone call can communicate that.
- The lack of frequency stability of the DRO (worse for the Gunn) means finding each other is a lot of work.
- One of the many causes of frequency instability (perhaps the biggest problem) is reflections from objects (that change position) in the vicinity of the transmitter. Like your hand when you adjust things. The structure of your radio is that of a motion sensor which means that reflecting the transmitting signal back into itself will cause a cancelling that can make the signal from the other radio completely go away causing a loss of lock.
- There is also microphonics (you can't bump anything without that vibration getting to the motion sensor.) You can "play" the radio like a very loud drum, just by tapping the breadboard.

Notes on The Use of a 99¢ Store Radio

If you are using a car radio, it is as simple as running a coax from the output of the DRO motion sensor (where it says "IF") to the radio's antenna coax input. It is simple because they are so well shielded. But for the challenge of using a 99¢ Store radio, you need to move the entire tuning range of the radio to a quiet band in the radio spectrum. (More on that later.) To power the little receiver, you must find where the battery leads go past the switch. (You can confirm your decision by measuring the voltage with the battery in place and switched on.) You will connect the 99¢ Radio power ground to the ground side of DRO motion sensor. The power for the 99¢

radio is the 5 DC output of the regulator from the modulator. That is more than the two AAA cells the radio comes with, but it works fine. The ground side of the motion sensor is the same as power ground. The RF from the motion sensor is easy to find; it says “IF”. The signal into the 99¢ radio is much harder to find. It is pin 11 on the IC that is the heart and soul of the radio. To confirm you found the right place, there will be a tiny 82 µµF on it. This 82 µµF cap goes to the headphone circuit. Yes, in normal operation, the headphones are the antenna for this clever little radio. Remove this capacitor and replace it with your own 82 µµF capacitor.(It doesn’t have to be 82 µµF. 100, a more common size, is just fine.) It will look like heck, but all that counts is that you solder one lead of the cap to the IC side of where the other cap was without creating a solder bridge. There’s no place to solder the other lead of your cap; it will just dangle and you will solder to that a flexible wire over to the I-F output of the motion sensor. (That wire need not be shielded.)

This Elenco instructional radio kit (to the right) uses the same chip as the 99¢ Store radio but is much easier to modify. In this case the headphones are not part of the antenna circuit and you will go in, in place of their antenna. That chip is quite a wondrous thing and you can read about it in alldatashhet with the part number SC1088. But instead, check out this much more interesting website about that chip: http://www.petervis.com/electronics%20guides/SC1088/SC1088.html

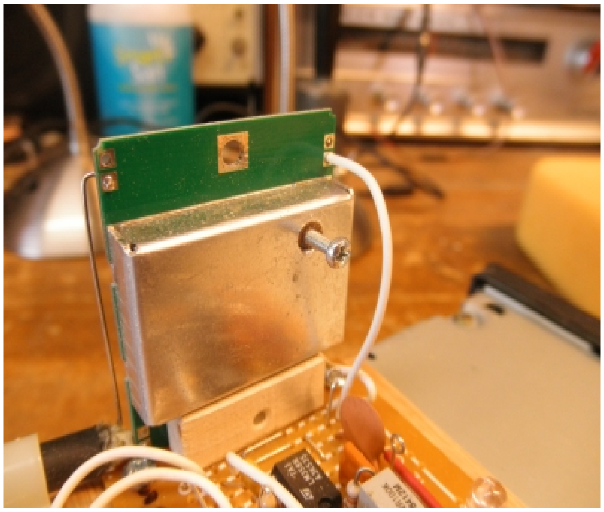
Shielding

The 99¢ Store radio has a button to scan the channels from lowest frequency to highest and the other one resets the frequency back to the beginning. The frequency difference you created between the DRO motion sensors will be what the radio will find when you click the scan button. It will find this I-F signal if it is somewhere within the band and there are no broadcast radio stations present. The trick is to move the radio band to a quiet place in the spectrum. If you don’t do that, keeping out the broadcast band stations is difficult. Using shielded wire between the motion sensor output and the radio is easy, but shielding the 99¢ radio itself is a lot of work. The power leads have to use feed-through capacitors; and then there’s the problem of holes to get at the switches and volume control. Complete shielding is most easily done (use coax) with the car radio because they are so well shielded to start with.

This frequency shifting trick in place of shielding the 99¢ radio was thought up by Eddie Phillips. He found that with a 22 pF cap across the coil in the local oscillator circuit (of the 99¢ Store radio) you can shift the receiver out of the FM radio broadcast band and into the old analog TV band; which to this date has not been re-assigned. That means when you are tuning the DRO, instead of aiming for 100 MHz (the middle of the FM band) you will aim for 75 MHz; the center of the new band; the old analog TV band. Nowhere in this new band will there be found any radio stations to interfere with the scanning.

Procedure for Shifting The Receiver to A Quiet Spot in the Spectrum
The coil and capacitor that sets the local oscillator frequency are attached to pins 4 and 5 of the IC in the 99¢ Store radio. You will add capacitance to lower the L.O. frequency. That will in turn lower the frequency it tunes for. The coil is easy to spot, it is 4 turns, air core. Solder the cap across that coil (or anywhere, where you will be across pins 4 and 5). Keep the leads on it less than 3/16" long. You have to make very sure you don't make any solder bridges. To confirm you have the correct pads to solder to, you will note that the coil is zero resistance to a VOM. 24 pF is perfect and some 22 pF caps read that high. Much more than 27 and the tuning range would be too different; and into an unknown performance area for the chip. But less than 22, and you'd be nibbling the bottom of the FM band. You may hear a station when you scan high enough. Make sure you have lots of 99¢ Store radios on hand to make this modification less traumatic.

Output of the 99¢ Store Receiver
The cheap radios usually put the signal on the tip and sleeve part of the miniphone connector, in which case the ground of the headphone cable is unused. That way both ear pieces get the same monophonic audio. Another complication is that the headphones are connected between the collector of a transistor and +V usually, but sometime to ground . That means that current has to flow for there to be an audio output and putting a preamp (because it draws no current) will see no voltage change to amplify. You can insert a 100 ohm resistor as a load or better yet put the preamp on the volume control where there will be a signal even without adding a load. The fidelity will be better there and by not adding a 100 ohm resistor, you'll save between 20 mA and 50 mA. That is almost half the total current of this very efficient radio. Expect an audio level of about 100 mV.



DRO Modification
This is perhaps the only fun part of the hack in that it is mechanical and straightforward. The setscrew that comes with the DRO motion sensor is extremely coarse. So coarse, that its movement with temperature may be the biggest cause of frequency instability. You can easily move it out of the band entirely with a single turn. It's in wax and the threads are very loose which means that it will move just letting go of the Allen wrench. To improve on that course thread, replace that setscrew with an ordinary screw that is much smaller and with finer threads.

- The metal box that holds the setscrew is easily removed by folding back the tabs.
- Clean out the wax by reaming the hole or re-threading it with a slightly larger tap. The hole is not just a hole in sheet metal. There's about 3 mm of depth to it on the inside.
- Put tape over one side of the hole to make it a blind hole and back fill that blind hole with an epoxy that can take threads. Filled epoxies (powdered anything) are less strong, but more rigid; ideal for threads.
- Drill and tap that blob of epoxy for a 2-56 or if you have it, something smaller. With a 2-56 screw, you will have about four, maybe six useful turns of frequency change (about 100 MHz).

It’s unknown how fragile the barium titanate puck is. But with finger adjustment you can tell when the end of the screw contacts it. Nothing seems to happen when you do touch; there’s no difference in behavior from contacting, or the tiniest turn away from contacting. Exact counting of turns should begin with contact then moving away. From contact to full removal is more than enough range to put the difference within the capture band of any receiver.

If the above procedure seems scary, perhaps you can think of a way to merely remove the set screw and use an external nut glued to the outside passing through the center of the set screw hole. However you choose to do it, buy an extra DRO motion sensor; just in case. They are only $6 a piece.

Locking onto the Difference-Frequency without the Wave Meter

If you go to the trouble of putting in a finer DRO adjuster, you can use another method of locking the two radios to each other. That is, use fine adjustment, your ears and trial and error. Here's the steps involved.

- Modulate the transmitting radio with a 100 mV tone that is of an easy to recognize frequency; a thousand Hz for example. Or modulate it with music. If you use a CD or mp3 player, use the headphone output with the volume a bit on the high side. It will be distorted of course, but it won't hurt anything and will be very loud. Loud in FM means that it will occupy more than the width of a normal station. Normally this is bad, but it is important in this case because even with the modification for the finer screw adjustment, you will slide through the dial extremely quickly. With the station occupying twice or three times the normal space, you have a good chance of hearing it.
- Start with both DRO adjusting screws touching the puck. Rotate one of them counterclockwise until you hear your station go by. It will go by fast; too fast with the coarse setscrew the DRO comes with. If you are using a car radio the automatic frequency control (AFC) is either absent or so limited, it will fail to capture it. But you will hear it briefly. With the car radio, you will have to hunt around for it after you hear it go by. It won't be far from where you heard it. The 99¢ Store radio may latch on to it and keep it. If it didn't, you will have to hit the "scan" button or the "reset" button to find it.
- After finding it, turn the modulation down and the receiver volume control up to get the best compromise between distortion and noise. Note that with the proper amount of modulation, you may fall between station positions. (Most radios built in the last 30 years jump 200 KHz at a step.) It is for that reason that you want it loud (lots of excursion) so that you can hear it even if it is not on the step.
- If you keep turning the screw you will find several places where you will hear the other radio. They may be as much as a whole turn apart (for the finer adjusting version). If you use your wave meter for each locking, you will find they are not separated by harmonics. That's because of the tendency of the 99¢ Store radio to capture anything at will. Which one to use? Clearly it is the closest one to the same frequency as the other radio, but it isn't necessarily the first one you come to even if you start both screws bottomed out on the puck. This is where the wave meter would be handy. Even if not calibrated it can tell you which captured frequencies have the least separation. You may notice if you do encounter more than one, that they are all the same loudness or lack of noise. This is a characteristic of FM, so you can't use sound quality to determine which frequency capture to use. That's the case if both radios are close to each other. Range or a great deal of fixed attenuation might allow sound quality to determine the best frequency to use.

Tuning Is the Biggest Problem

The limited range of Part 15 power levels is the most well known problem with Gunnplexers, but the characteristic that is most off-putting is the constant need to follow their drift in frequency. The advantage the cheap scan type radios have is that they can lock onto the signal precisely and follow it as it drifts. Unfortunately, you never know where you are. The car radio can't follow frequency but is more educational (and more fun) because you can see what frequency difference you have going. The lack of AFC would not be so bad if the radio was analog tuning. If that was the case, you just constantly adjust the dial for best quality sound. But they tune in 200 MHz steps so your communications is highly likely not be centered on whatever frequency the radio allows you to tune to.

However…. You can position your DROplexer exactly on one of these frequency detents. You do that with the finest adjustment in frequency available to you; the power supply voltage. Use the trim pot of the LM317 variable regulator of the modulator. This is the finest tool you have but you must monitor the voltage to make sure you don't go above 5 volts. The amount of change needed to center the signal on the frequency of the receiver's detent is just millivolts. As you adjust voltage and note that you are approaching 5.0 V, you can always drop down was station step and then fine tune the voltage downward to find the new place.

Sources For DROplexer Components

The DRO Motion Sensor

These seem to be all over eBay. Use the key words "motion sensor microwave."

The 99¢ Store Radio

These seem to be no longer available at the 99¢ Stores although you can buy them online with the key words "FM scan radio" for about $4. The red radio pictured above is highly recommended. It looks great and easy to get at the traces for modification. It is an instructional kit version of 99¢ Store radio and is available through Amazon: http://www.amazon.com/Elenco-FM-88K-FM-Radio-Kit/dp/B004YHZE0G

A data sheet is available at: http://www.elenco.com/admin_data/pdffiles/FM88K.pdf

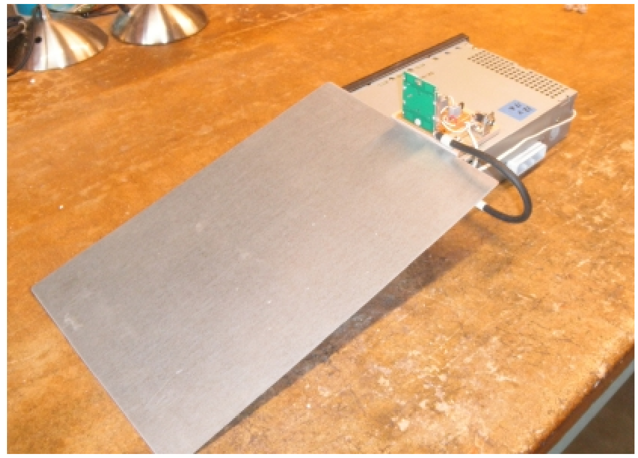
Car radios are available at Goodwill type stores. They are well shielded, have high fidelity but they don't have AFC so you will have to find adjust the frequency with the modulator's voltage regulator. And that means a dedicated voltmeter so you won't burn out the DRO. Try this: http://www.mpja.com/07-09-13.asp?r=254149&s=15 for a voltmeter.

The Modulator

You have to build the modulator. I'm addicted to the solderless protoboards and the solder PCBs that have the identical pattern. Here's an excellent vendor for prototyping: http://www.busboard.us/ One trick for using protoboards. Always buy enough parts for at least two circuits and then copy from the working protoboard to the soldered version. Never "move" the components. The microphone if you have to buy one can be purchased from Sparkfun for example.

Extending the Range

The DRO motion sensors have distinctly different places for the antenna elements that do the transmitting and receiving. It's not clear if a horn or dish will be of any gain for you at all, because of that separation. But experimentation has shown that a half of horn can improve the gain quite noticeably. In the picture above, you can see that making a half of a horn is so much easier than making a proper horn. The optimum height and flare angle are easily arrived at by experiment using the 1N23 and sensitive voltmeter as shown above for tuning, but as far away as



you can. Note that for this simple trick to work, the E-component of the wave must be vertical. (The e-component is same direction as the long dimension of the 1N23 detector.) A field strength meter at ten feet shows a factor of four times in gain. With that kind of gain, even though it's only 5 mW, you could easily go over a mile in range. That is, if you take outside.

Unlike HF and VHF ham bands, microwaves don't go through walls. (They will bounce around and go out through glass, however.) To get the motion sensors to work as communications devices, requires a change in frequency into the ham bands. Although you would never bother anyone and hence the FCC wouldn't care, working indoors without a license is still illegal. Part 15 of the FCC regulations (license free) under which the motion sensors were built, does not extend to their use in communications even if you could keep it at the Part 15 frequency. It should be clear that you need to be a ham or be under the direction of a ham when you are testing your radios. Your ham friend need not be an expert on microwaves but if he has a call sign, he will know how to sign on, and make entries in a log and that's all that's necessary.

Microwave hams tend to do all their communicating on field days. The reason is because you have to be in a high place and the logistics are best when you all do it the same day. You don't have to find another ham with a DROplexer or Gunnplexer to get in on the fun. They would have to find you on two different frequencies; one to talk on and the other to listen to you on. They aren't used to that. Again assuming you are a ham, you could loan one of your DROplexer rigs to any ham friend and you could have fun testing range any time. No need to wait for a field day. Your QSOs on this band will count and you may inspire some of the older microwave hams to bring out their Gunnplexers. You should be able to communicate with them even though they used a Gunn diode. (You only need to be compatible on the band chosen for the I-F out of the DRO.) You definitely will have to hunt for them on the FM dial, and you may have to tweak your DRO adjusting screw. But if you have practiced the above steps many times, you should be able to impress the old timer by locking onto his rig in just a few seconds. I guarantee you, he won't remember how to do it, and probably be unable to at all without instrumentation.

The group shot is from the San Quentin volcanos DM10xd
Left to right: Miguel XE2/W6YLZ, Jerry XE2/K6DYD,
Ken XE2/WB6DTA and Dave, XE2/WB6TFC