Low Cost Receiver For 10 GHz

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If you are thinking about getting into the microwave bands, 10 GHz might be a good place to start. There is a reasonable amount of activity on this band, there are sufficient propagation mechanisms that in most areas you should be able to hear signals and make contacts even if your location is not ideal, and perhaps best of all you can get started with a low cost receiving setup that doesn't require specialized knowledge or skill to put together.

Even if you are not thinking of getting on the microwave bands, listening on 10 GHz might be interesting. Even on local signals there are fascinating propagation effects that you won't experience on HF, VHF or UHF. You may find it interesting to observe what happens to a signal when precipitation passes between you and the source of the signal. If there are trees in the path, you will see and hear the effect of them moving in a breeze. If you are fortunate enough to have a powerful beacon in your area and you are using an SDR or conventional receiver with a panadapter, you might see aircraft activity. If so, you have your own radar station. 10 GHz is a different world.

Satellite TV Hardware for 10 GHz Receiving

Satellite TV systems use a low-noise block downconverter (LNB) mounted on the dish. The LNB collects signals from the dish and converts them to a lower frequency which is sent down a coaxial cable to the receiver inside the building. The LNB is a dish feed horn, low-noise amplifier (LNA), oscillator, frequency mixer and intermediate frequency (IF) amplifier. LNBs convert frequencies in the 10.7 to 12.75 GHz range to 950 to 2150 MHz.

Results of using a LNB at slightly lower frequencies vary but some will do a good job of converting 10.368 GHz (the portion of our 3cm band used for weak signal "DX" operating) down to 618 MHz. That IF is well within the range of inexpensive USB SDR receiver "sticks" such as the RTL-SDR. Perhaps best of all, LNBs and RTL-SDR devices are are very inexpensive and easy to use.

The availability of this simple and inexpensive hardware is one thing that makes the 10 GHz band an attractive place to get started on microwaves. There is something to be said for starting out with a receiver first to see if you like microwaves, just as hams of old often started out as shortwave listeners.

What you need

To build this simple low cost receiving system you will need the following items:

Ku band LNB
Power inserter (bias tee)
12V and/or 17V power supply
SDR or other receiver capable of working at 618 MHz
Computer or other device running SDR software (if using SDR receiver)
(optional) small satellite dish

Let’s start by taking a look at each of these items individually.

LNB

There are many different models of LNB available. You want a Ku band unit. Some can be had for less than $5 but spending a little more may be worth it. The really cheap LNBs, while adequate for the intended purpose of satellite TV reception, may have poor frequency accuracy and enough frequency drift to make using them for weak signal 10 GHz reception rather challenging. Fortunately there are some that do better. Likewise, not all LNBs are created equal when it comes to working somewhat outside their intended frequency range.

I am partial to the “Bullseye 10 kHz” LNB. Claimed frequency stability is within 10 kHz and it works well at 10,368 – 618 MHz. While 10 kHz drift might sound terrible it is actually quite usable and is far better than some cheaper LNBs. The Bullseye 10 kHz LNB, model BE01 is available from several sources on eBay, Amazon and elsewhere. Othernet[1] has them at the lowest price I have seen in the U.S. As of July 2023 they are $19 plus $5 shipping.

Figure 1: Bullseye LNB, "top" and "bottom" views

1 http://othernet.is/

There are LNB offerings with special features and claims for amateur radio use. Some place the IF at 432 MHz when receiving 10,368 MHz. This may be attractive if you have a transceiver or transverter covering 432 MHz. Others include modifications which allow use of an external high stability frequency reference to reduce or eliminate drift. You might want to explore these. I don't have personal experience with them and cannot speak to their performance.

DX Patrol[2] offers LNBs marketed for QO-100 satellite reception in the 10,489 to 10,499 MHz range.

Ham parts[3] offers LNBs with various options including 10,368 to 432 MHz conversion.

Power inserter

What we would typically call a bias tee is known as a power inserter in the satellite TV world. Its purpose is to send DC power to the LNB over the coax that brings the IF signal from the LNB to your receiver. If you have one of the specialty LNB systems marketed for amateur radio use, it may already come with power inserter functionality. If not, or if you are using a Bullseye or other standard LNB, you will need a power inserter. Perhaps you are comfortable building a bias tee. If not, they are readily available and inexpensive. I have been using the HRF-PI from Holland Electronics. They are available on eBay and elsewhere. Recently I found the best price at Newark[4].

Figure 2: Holland HRF PI power inserter

2 https://dxpatrol.pt/
3 https://hamparts.shop/
4 https://www.newark.com/

Power supply

You will need to provide DC power to your LNB. Most, if not all LNBs can switch between horizontal and vertical polarization. The Bullseye and other LNBs that I have used select vertical polarization when the operating voltage is 11 to 14 volts and horizontal polarization when the voltage is 16 to 18 volts or thereabout. Check the specifications for your LNB. I have been told some LNBs are the reverse of this with horizontal polarization at the lower voltage. The current required by most LNBs is fairly low. The Bullseye runs at approximately 75 milliamps. We will get back to the subject of polarization later.

SDR or other receiver

Any receiver that works at 618 MHz can be used, whether conventional or SDR. The lowest cost route is probably the RTL-SDR stick. These are available in several versions. Sources include RTL-SDR.com[5] and Amazon, among others. I had success using an older one that does not have a TCXO and therefore has fairly poor frequency accuracy and more drift than newer versions which employ 1 ppm or 0.5 ppm TCXOs. Nevertheless it worked well enough for receiving terrestrial 10 GHz signals and even EME (moonbounce) signals when my luck was just right.

Figure 3: One example of a RTL-SDR receiver stick. They are many varieties and styles on the market.

5 https://www.rtl-sdr.com/

Computer or other device and SDR software

If you are using one of the RTL-SDR sticks or other SDR, you will need a computer of some type running SDR software. The choice here is up to you. There are SDR applications available for various hardware platforms and operating systems. While I use linux for most daily computing needs I have been disappointed in the available amateur radio software for it so I use Windows 10 on my ham shack computer. My personal choice in a SDR application for Windows is HDSDR[6].

For portable operations or if using a computer isn't convenient, you may want to try using an Android phone or tablet running the SDR Touch app. You will need the correct USB OTG adapter cable to connect your RTL-SDR or other SDR hardware device to your phone or tablet.

Small parabolic dish (optional)

It is possible to receive strong local signals with just the LNB. If you have a 10 GHz beacon or active 10 GHz stations nearby that might be the way to start out due to its simplicity. It is even possible to receive strong rain scatter signals with a LNB alone, as demonstrated in a video of WQ0P receiving N0OY.[7] But you won't be getting weaker signals from longer distances this way.

The range can be greatly extended by placing the LNB on a small satellite TV dish in the 18 to 30 inch size range. These are often available for free, but if you use a dish from any of the major satellite TV subscription services such as Dish Network or DIRECTV, you will need to determine the optimum position of the LNB and likely build some sort of holder or LNB support extender. I suggest reading relevant portions of The W1GHZ Online Microwave Antenna Book[8].

If you decide to use a dish, there is another option which may simplify the setup. You can buy a "free to air" dish that is already set up to accept standard LNBs with 40mm neck such as the Bullseye. This will make getting the LNB correctly positioned relative to the dish surface easier but you probably won't find one of those dishes for free. Buying one will be the most expensive part of your system if you go that route. I bought a Winegard DS-2076 dish which has served me well for EME (moonbounce) reception experiments and listening to terrestrial 10 GHz signals via line of sight, tropo, and rain scatter.

With any dish you will get best results by optimizing the position of the LNB but my experiments with the DS-2076 and Bullseye LNB seemed to indicate it isn't too critical unless you are going for EME signals. I tried the LNB in various positions from the closest to farthest point the LNB holder adjustment would allow and found only relatively small differences in performance based on measuring sun noise, ground noise and sky noise.

One thing to keep in mind when using a dish is that you will have to aim it much more precisely than a bare LNB.

6 http://hdsdr.de/
7 https://www.youtube.com/shorts/19w9GEUdRZ0
8 http://www.w1ghz.org/antbook/preface.htm

Connecting the hardware

OK so you've acquired these items. Now what? If you have a Bullseye or other standard LNB it couldn't be simpler. Connect your power supply to the DC connection on the power inserter or bias tee. Run a length of coax from the power inserter common port to the LNB IF and DC port. On a Bullseye this is the *green* color coded connector. Connect coax from the power inserter RF port to your receiver's antenna input. If using an SDR receiver, connect it to your computer, phone or tablet via USB. That's it!

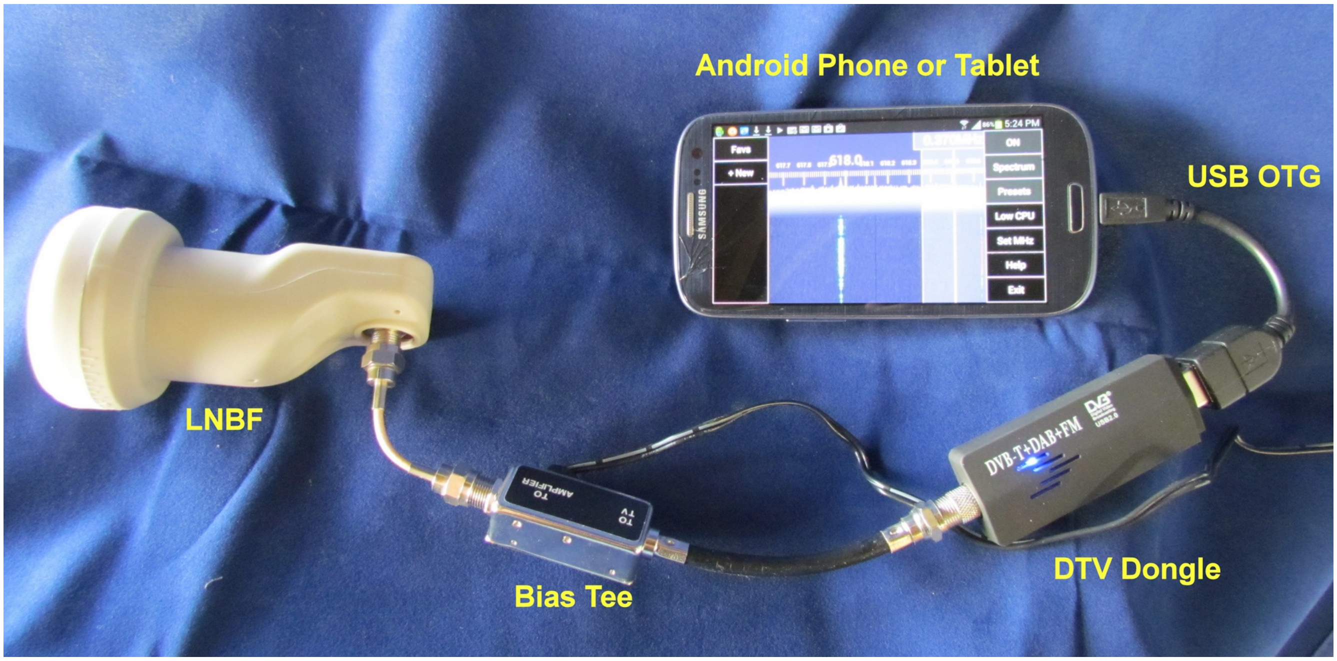

Figure 4: Cheap 10 GHz receiving setup using an Android phone. Photo courtesy of W1GHZ.

For my home station I found an unregulated "wall wart" power supply that is rated 12VDC at 500mA. With a 75mA load the voltage measures 16.5V. I built up a small box that the wall wart output cable plugs into. Inside the box I have a 7812 regulator and a switch that routes the 16.5V directly to the LNB for horizontal polarization or 12V from the 7812 to the LNB for vertical polarization. The box also has a switch to cut power completely by disconnecting the 16.5V where it comes into the box.

Drivers and software configuration

If you are using a SDR, you will need to install the appropriate driver for it and your computer operating system. You will also need to install and configure one of the various SDR applications. Since the options vary widely I will not attempt to cover them in detail here. If you are using one of the cheap RTL-SDR USB sticks, there is a lot of helpful information and quick start guides at RTL-

SDR.com[9]. HDSDR doesn't have much documentation but there are helpful websites including G4ZFQ Radio[10].

Polarization

Horizontal polarization is the standard for terrestrial weak signal operation on 10 GHz. You can get horizontal polarization by applying the appropriate voltage to your LNB. Some LNBs, including the Bullseye may have lower noise figure (able to hear weaker siganls) on vertical polarization due to the way they are constructed internally. I have found the Bullseye on horizontal polarization is doing well for me on terrestrial signals but for EME, vertical was clearly better. You can use the vertical probe in the LNB for horizontal polarization by physically rotating the LNB 90 degrees. This will place the connector(s) on the side of the LNB rather than the bottom. In that orientation it will probably not be weather resistant. Keeping water out of it will be up to you.

If you are trying to receive EME signals, polarization is a little more complicated. The geometry of Earth and moon makes it such that the polarization of signals received will vary widely. For this you will want to use whichever probe in the LNB has the lowest noise figure (vertical for the Bullseye) and physically rotate the LNB to optimize polarization for each station you want to receive. Details are beyond the scope of this article but the correct polarization is easily calculated by various EME software and digital mode communication software.

Location

Microwave signals are greatly attenuated by trees and other obstructions. For long range work it is important to locate your dish or LNB in a spot where it has unobstructed view of the horizon. If this isn't possible at home, consider a portable location. A great deal of microwave operation is done with portable stations.

For short range work, all is not lost if you cannot achieve the perfect location. I have a temporary beacon 5.6 miles away that is running 5 milliwatts into a tiny antenna inside a building and looking through many trees in my direction. With the 76cm dish and Bullseye LNB on my tower I can always hear it. Most of the time is is between 20 and 30 dB above the noise.

I have found it interesting to observe the signal changes in calm weather vs. windy days when the trees are moving and to hear what happens when a rain shower passes between me and the beacon.

9 https://www.rtl-sdr.com/
10 https://sites.google.com/site/g4zfqradio/home

Advanced versions

There is much more that you can do depending on your abilities and how far you want to take this. I am a self-professed perfectionist and I had a unique challenge in that the only tower where I could put such a system at home requires 350 feet of cable to reach. I only had one unused coax cable running to it. I modified a Bullseye LNB to accept an external 25 MHz reference from a GPSDO to get rid of frequency drift. Normally that would require a second run of coax to carry the 25 MHz but I only had one spare run of coax to the tower. I used triplexers to send DC, 25 MHz and 618 MHz over the single coax. This system has near zero frequency drift (in theory less than 5 Hertz, which seems to hold true in practice). It works great but it is no longer an inexpensive system and quite a bit of work was involved. If you are an experimenter and want to know more about what I did, there is information on my web site[11] and Youtube channel[12].

11 http://www.n1bug.com/10ghz/
12 https://www.youtube.com/@n1bug