Table of Contents

INTRODUCTION

A few years back, several of us decided to start a new Ham Radio Club[1]. Such clubs are best forged around repeaters and so this was our first task. Actually, it became my task primarily because I had the QTH on a hill, and I had the means (at that time). My right hand man in this effort was NA5CC. The process included a number of errors on my part such as used equipment that did not work and new equipment that no one (here) was interested in[2]. The local hams were old school and were only interested in analog. These guys came through with donations which included tower sections, power supplies, coax, an air conditioner, and other goodies.

I still wanted to push their envelope and eventually provide a linked repeater. Internet linking repeaters is best done with Allstar (in my less than humble opinion), (and I've looked at a number of options).

So, what is Allstar?

AllStar is a digital **linking network** used to **link** standard analog repeaters, or nodes, over the **Internet** to other repeaters or nodes. It uses modified, open-source PABX, software that treats radio nodes like telephone numbers and allows users to 'dial-up' other nodes and/or make temporary or permanent 'conferences' of connected nodes. In its simplest form, you can interconnect two radios at different locations via the internet (or intranet on your own LAN).

This document is essentially a newbie guide to getting linked up into the Allstar network. It is actually quite easy. Most of what you need to know is well documented on websites that I will reference. What follows is not the only way, but it was my way, and it is an easy way, and it is a cost effective way[3].

This is a significant revision to my original document. Primarily, it adds a way to get onto Allstar with a plug-n-play simplex node. Also, I have learned some more lessons on what not to do and what works better.

If all you want is to get on the air with a simplex node, the next chapter is all you need - the remainder of this document will be for repeaters.

---

[1] Fayette Amateur Radio Transmitting Society, (F.A.R.T.S.) La Grange, Fayette County, Texas

[2] D-Star and Fusion

[3] Hams invented copper wire by pinching copper pennies.

AN EASY ALLSTAR SIMPLEX NODE

I keep seeing info on creating an easy Allstar node using a BaoFeng 888, modifying it, adding a Raspberry Pi computer, and a interface. Okay, but this is the hard way and you wind up with a toy.

Here is a summary of what is required and what I'm about to explain.

Find a real radio with good specs that does not require modification. Find either a Motorola CDM-750 or an Alinco DR-x35[4] mobile radio. It can be done with many other radios, but again, I'm documenting an easy way. These radios are available on Craigslist or eBay and at swap meets. With a little looking around, you can get the Motorola for as little as $50. The Alinco will cost a bit more but is much easier.

Go to repeater-builder.com and order a RIM-Maxtrac for the Motorola or the RIM-Alinco for the DR-x35.

Attach the RIM, plug in a Pi, install the software and your all set to configure.

No need to touch a soldering iron. Don't make a toy - in this case, the easy way is also the quality way.

First things first; register with https://web-tpa.allstarlink.org and get node numbers.[5] I recommend that you do not download the software from this site. See the next paragraph.

Download the software required for the Raspberry Pi computer. I strongly recommend the Ham-VOIP image. It is stable, well supported, has more features, and very well documented: https://hamvoip.org/#download. This version is fully menu driven making is much more user friendly.

Don't be intimidated by the Raspberry Pi computer and the software. It is easy to use and there are full instructions at https://hamvoip.org.

---

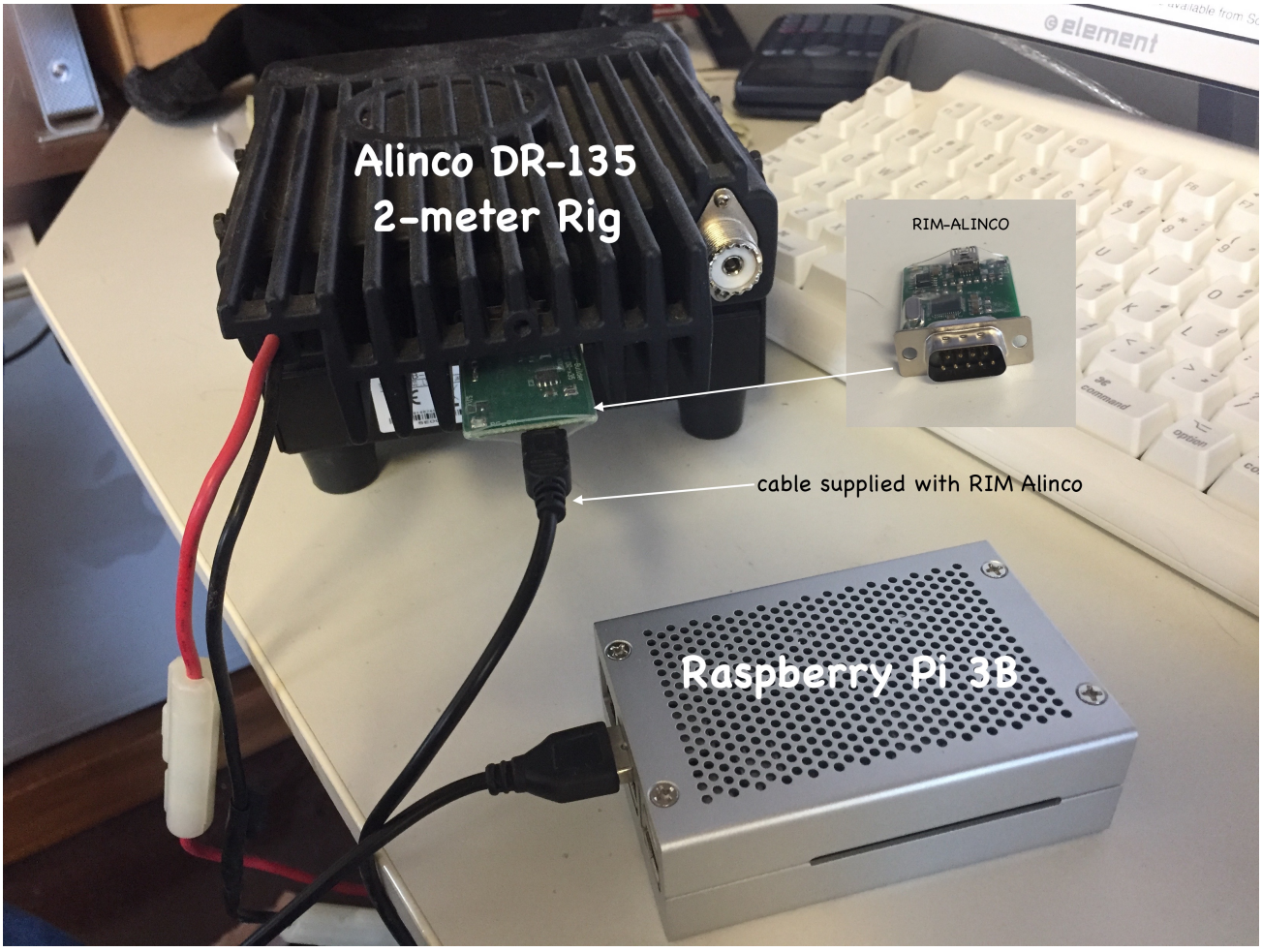
[4] Alinco DR-135 for 2 m, DR-235 for 1.25 m, or DR-435 for 70 cm. **The DR-635 dual-band won't work.**

[5] Get a block of numbers - maybe 5 as a minimum. Once hooked you will want more.

The Alinco Option

This is the easiest radio to use because you won't need programming software or a programming cable. If you go this route, here is all you need:

1. Alinco Model DR-135, DR-235, or DR-435: Choose the model based on the band you want to use.
2. RIM-Alinco: This is what is called a URI, USB-Radio-Interface. They are available from N3XCC for $50 on repeater-builder.com. Just Google "RIM-Alinco" and the first hit will take you straight to the page on repeater-builder.com.
3. Raspberry Pi Model 3b or 3b+: Readily available at Amazon, eBay, Fry's, etc. It is best to get a kit that has the power adapter, and enclosure, (cheaper to buy the package).
4. Micro SD card: 16GB is what I use as a minimum. They are available at Walmart for about $10.



What you see in this photo is all you need for the physical portion of the node. If you still want to take apart a BaoFeng 888 and start soldering, read no further.

The Motorola Option

Motorola is a great options but it is more complicated primarily due to the radio configuration software. You can do a lot with the Motorola, but it takes patience and learning. It is all well documented on repeater-builder.com. I use both Motorola and Alinco for my nodes.

I recommend the model CDM-750 but there are a other model options. The CDM-1250 and CDM-1550 are good but they have displays you don't need and just more to go wrong. Also, try to stay away from the -LS models. They are trunking radios and may or may not have conventional channels that you will need.

Here is a CDM model number decoder:

MOTOROLA CDM750, 1250, 1550 MODEL NUMBER DECODER

SERIES	BAND	POWER	DISPLAY	CH SPACING	PROTOCOL	FEATURE	REV
AA M 25	K 136-174	H 25 W	A none	9 Prog	AA Conv	1 4 ch	any
LA M 25	R 403-470	K 40 W	C no w/keypad		DU LTR	2 64 ch	
	S 450-512		D 1, w/keypad			5 128 ch	
	B 29.7-36		F 1, w/keypad			8 160 ch	
	C 36-42		N 4, w/keypad				
	D 42-50						

Clearly BAND 'K' or 'R' is your first choice. BAND # 'S' will work but you will need to modify the programming software with a hex editor. Instructions are on repeater-builder.com but modification causes other issues. Motorola software is hard to get and very featured making it harder for the beginner. So, for a beginner who chooses the Motorola option, look for a model AAM25K(K or R)A9AA1.

The VHF low band models 'B' and 'D' can be used on 10 meters and 6 meters respectively, but I have no experience with this. The 'C' model is reportedly unusable for Hams. I have successfully used the 'S' model for the UHF Ham Band with software modification.

So, it can readily be seen that Alinco is the simplest option. Motorola is 'doable' but just a bit more complicated. Here is what you need for the Motorola option:

1. Motorola per above criteria.
2. Motorola programming cable[6]: About $15 on eBay.
3. RIM-Maxtrac[7]: They are available from N3XCC for $50. Just Google "RIM-Maxtrac" and the first hit will take you straight to the page on repeater-builder.com.
4. Raspberry Pi 3b or 3b+: (same as above)
5. Micro SD card: (same as above)

[6] I've found that you don't need the interface box for the CDM-750. Get a DB-9 by RJ-45 cable.

[7] Don't get the RIM-Maxtrac-RM unless you are building a repeater. Repeater building is covered later in this document.

Simple Simplex Node Summary

It should be apparent that this route is at least as easy as using the BaoFeng 888 and the cost can be about the same. The URI used for the BaoFeng costs more than the URI required for the Alinco or the Motorola.

The plus with using this method to get onto Allstar is the fact that you don't have a toy when you are finished.

Add a modest antenna, connect your node to a another node or a hub node and you will be able to drive around connected to remote systems around the U.S.A. and around the world.

The remainder of this document is about building an Allstar repeater with some tips on how to link to a repeater that does not have internet access.

Stop here and build your first Allstar node or proceed on if you are interested in building a repeater.

REPEATER IMPLEMENTATION

One of the donations made to our fledgling club was a number of Motorola and Kenwood commercial mobile radios. Of special interest was the Motorola 20-pin[8] accessory port which was present on several CDM-750 radios. This accessory port makes it super simple to make a basic repeater using a Motorola RICK or other similar device such as the inexpensive RA-0 or RA-1 devices available on eBay. These controllers are okay but you really need more to be compliant because they do not ID and they do not give you the control required in Part 97.

A better use for these Motorola accessory ports when building a repeater is a computer based controller using the Raspberry Pi[9] and the RIM-Maxtrac-RM[10]. Please don't let this scare you off! What I am about to describe is almost plug-&-play.

I strongly recommend the CDM-750 mobile radio for building a repeater. Here is a model number guide. Obviously the BAND 'K' or 'R' would be most desirable.

MOTOROLA CDM750, 1250, 1550 MODEL NUMBER DECODER

SERIES	BAND	POWER	DISPLAY	CH SPACING	PROTOCOL	FEATURE	REV
AA M 25	K 136-174	H 25 W	A none	9 Prog	AA Conv	1 4 ch	any
LA M 25	R 403-470	K 40 W	C no w/keypad		DU LTR	2 64 ch	
	S 450-512		D 1, w/keypad			5 128 ch	
	B 29.7-36		F 1, w/keypad			8 160 ch	
	C 36-42		N 4, w/keypad				
	D 42-50						

The Controller Interface

RIM-Maxtrac-RM is a narrow definition. It will work with a number of Motorola radio models that have a 16 or 20-pin accessory port[11]. It certainly works with models including the CDM, Radius, and GM-300 series radios. The RIM circuit board was designed such that it can not be plugged in backwards on a Maxtrac, but care must be taken with other models.

See the image on the next page. The image on the left is a RIM plugged into a Maxtrac - note that the board design will not allow it to be plugged in upside down.

The image on the right is a RIM plugged into a CDM-750. Note that it could be reversed, but like the Maxtrac, the elongated side of the circuit board should face away from the heat sink.

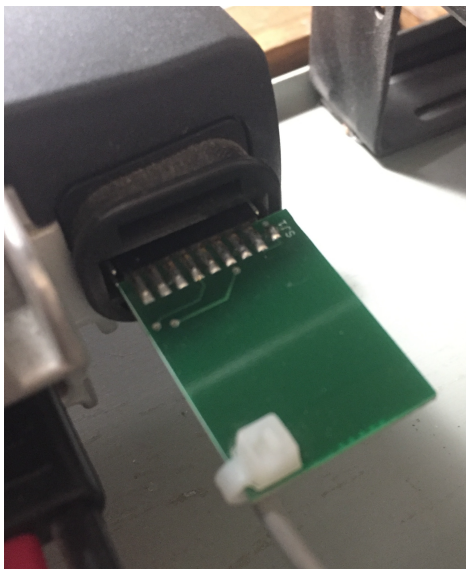
[8] Can be 16-pin on other radio models. Care must be taken to ensure compatibility. See RIM documentation. Also, the GTX radios use a different pin-out.

[9] https://www.raspberrypi.org

[10] http://www.repeater-builder.com/products/usb-rim-lite.html

[11] http://www.repeater-builder.com/motorola/maxtrac/maxtrac-option-plug.html

Another very important point is that the accessory port on the CDM model has 20 pins rather than 16 for the Maxtrac. The RIM is plugged into the center 16 pins. Once the radios are mounted and the RIMs are plugged in, the only other connection is a USB cable over to the Raspberry Pi computer.



Radio Programming

It is unfortunate that Motorola frowns upon the open use of their obsolete software by Hams. Much of this software is DOS based and no longer available and yet Motorola acts as if it has value. So, don't call Motorola for software. There are a number of ways to get these old radios programmed - I must leave this issue to the reader. In my case, I used the Motorola Windows based software, CPS_V6.12. This software can be found on the internet. Some of the Motorola gear will go straight onto the Ham Bands using the software without tricks or modification.

It is interesting to note that Motorola designed some of their software versions such that it can put some of their radios not designed to go into the Ham Bands, onto the Ham Bands simply by holding down the <Shift> key while entering the numbers for the frequencies. This is not a bug - it a feature. Example: <Shift>146 . <Shift>520

CDM series radios have soft-pots or e-pots. These are software configurable 'potentiometers' (not really) used to tune the radio. I thought this was going to be a problem but none of our radios, UHF or VHF, required the slightest bit of tuning. The UHF radios were moved down over 10 MHz (and out of their normal range) and yet the receiver front end remained quite hot. I fooled with the soft-pots a bit but was unable to improve the receiver sensitivity. My advice would be to check both radios for receive sensitivity and choose the best one for the receiver.

Configuration varies a bit from model to model but it should be fairly straightforward.

Allstar Node Numbers

You only need one node number but don't make the mistake of just getting one. I now have 8 and should have requested ten to start with. Get a block so you can have sequential numbers. If you choose to add Echolink, another node number may be required depending on how you configure.

Create an account https://web-tpa.allstarlink.org with and get your node numbers now. They ask questions about your intended implementation but don't worry - you can change node configurations anytime.

Raspberry Pi

The Raspberry Pi is a very powerful computer in a very small package. It runs on various flavors of Linux and uses a micro SD card as a 'hard-disk'. Buy a kit like the one shown below - the cost is well under $100. This small computer, coupled with the RIM-Maxtrac-RM serves as both your repeater controller, IDer. When connected to the internet, it becomes an Allstar Node and even an Echolink Node. For internet connectivity, there is a 1000BaseT Ethernet port and there is built in WiFi. This is a very 'featured' little computer.

As a minimum, you need the following:

- Raspberry Pi
- Power Supply
- Micro SD Card (at least 16GB and get a fast one)

Now you need the operating system.

Asterisk Allstar

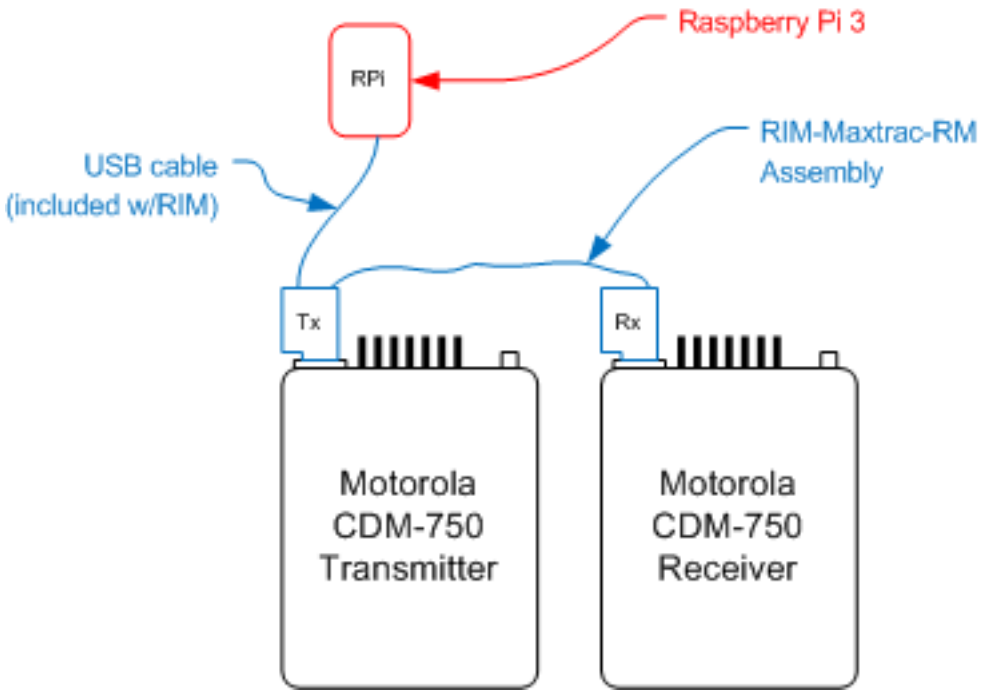
There are several ways to implement Allstar. Ham-VOIP or the official Allstar Link distro. Ham-VOIP is easier for beginners and I recommend it. It is more featured, easier to use, well supported and very well documented. It has all the tools and instructions you need to get up and running.

Once you have downloaded this file, you must 'image' it over to the micro SD card. This is not a simple copy job. Follow the instructions carefully. It can take some time - 20 minutes to an hour - it will let you know when its finished so be patient.

Put the imaged micro SD card into the Pi and you are ready to boot. There is no need to have the Pi connected to the RIM or the repeater at first. The Pi has a HDMI video port and four USB ports. VNC is resident but I found it easiest to just connect it up to a keyboard, mouse, and monitor the first time. It is not my purpose here to explain how to set this up. Everything is well documented.

Putting it all Together

If you have done this my way you have something that looks like this:



Add your duplexer, coax, antenna, and a power supply and this is all there is to it. You have a computer controlled repeater with voice ID and remote control that can link you anywhere in the world.

CONNECTING A REPEATER AT A SITE WITHOUT INTERNET

What if your repeater site does not have Internet or usable Internet? Our first Allstar repeater was up and running just as described above, but we had another repeater at another site without usable internet (we had no access to the router).

After a bumpy start with some misconceptions on my part, I implemented an Alinco DR-135 with a RIM-Alinco[12] connected to a Raspberry Pi making another Allstar node at our main repeater site with good internet. I used the Alinco as described at the beginning of this document. It is just like a simplex node except that is is programmed with the standard, other-repeater's offset.

This implementation falls under the FCC rules as an Auxiliary Station. Hams often call it a 'Remote Base'. The term 'Remote Base' is never mentioned in the FCC rules.

To be clear on how this works, I have an Allstar repeater and an Allstar 'remote base' at my main site. The 'remote base' is an Allstar simplex node configured to transmit with an offset to the remote repeater without internet access. Once the two nodes are linked via Allstar, the two repeaters are linked. The remote base is legally linking in-band to and from the other repeater under the FCC rules for an Auxiliary Station[13].

Rather than going into detail here, I have written a separate monograph on this subject. It is available in the Files section of our Club's Facebook Group, https://www.facebook.com/groups/n5frt.

OTHER OPTIONS

Micro Node

We had been talking about voting receivers for years and www.micro-node.com has a solution; the Allstar Radio Thin Client Module.

These provide the ability to bring in satellite receivers and vote based on signal thus reducing the need for linked repeaters.

This is an option worth looking in to for more advanced repeater builders, (and especially those with lots of disposable income).

Motorola R1225

This is a small packaged repeater with integral controller. You can turn off the integral controller, add a RIM-Maxtrac with Raspberry Pi, and make it into an Allstar Repeater.

[12] http://www.repeater-builder.com/products/usb-rim-lite.html

[13] http://www.arrl.org/auxiliary-station-faq

CONFIGURATION NOTES

When it comes down to final configuration and testing, it is best to have an Allstar Elmer. Join an Allstar Group on Facebook or Yahoo. There will always be someone there who will go offline and help you.

The Radio

If the radio model allows for a TX or RX only personality, or a repeater programming mode, use it.

Motorola Accessory Pins Assignments: For the transmitter, pin 3 is PTT input. For the receiver, pin 8 is PL and CSQ detect.

Stay away from Motorola mobiles that have trunking features (the LS models). Keep it simple - use the CDM-750 - it uses windows based software and has better specs than the older radios.

Another important issue is cooling for the transmitter. Mobile radios do not normally have the duty cycle required for a repeater, so, lower the transmit power to about half of the transmitter's capability and put a fan on the heat sink. Allstar nodes can have intermittently very high usage and cooling is an absolute necessity. I use a good fan and have zero overheating issues even running close to maximum power.

De-Emphasis and Pre-Emphasis

Don't use De-emphasis or Pre-emphasis on a repeater! In my original version of this document I had some notes on implementing it in the software rather than radios. No need - you will have much better audio without it. I found a document on 'flat audio' by K6JSI. Up front he states this and he is right:

"When repeaters came along, hooking up the audio between the repeater RX and TX became a hotly contested topic, with many variations on how to do it. Some repeater builders took the user's pre-emphasized audio and de-emphasized it in the repeater RX, then pre- emphasized it again in the repeater TX for delivery to the end user. Then the end user's receiver de-emphasized it again, thus returning the audio to normal. Whew! This could probably work out if all of the emphasis curves in the repeater are matched (a difficult task). Also, all the processing in the TX's speech amplifier affects the audio quality too."

The Raspberry Pi Computer

Security is CRITICAL. Be sure and change your passwords away from default. Use strong passwords. After installation, update, upgrade, and update again. I recommend adding fail2ban. Don't use WiFi unless you can't get to your network with an ethernet cable.

The URI

The **RIM** is configured with the "simple-usb-tune" menu item #12. Some of the info for RIM configuration is on the schematic supplied with the RIM. Use these settings.

Router Ports

Allstar requires a single UDP port open to the node's IP address on your network. If you have more than one node, you need to open a different port to each node. I tried to be logical with my setup:

Node 56581 to 192.168.2.81 using port 4681

Node 56582 to 192.168.2.82 using port 4682

(see why getting a block of node numbers up front is wise)

These port numbers are also set up on https://web-tpa.allstarlink.org - you have a bit of configuration there but it is well documented and menu driven.

SUMMARY and END NOTES

Well, I told you how we implemented our first Allstar repeater and then I told you how you can tie in an existing repeater. You have a lot of capability and choices with Allstar.

Simplex Node from Scratch, Summary

1. Scrounge up an Alinco DR-x35 or a Motorola CDM-750
2. Buy the RIM-Alinco or the RIM-Maxtrac (for the radio selected)
3. Buy a Raspberry Pi Model 3b
4. Get at least one node number and set up on https://web-tpa.allstarlink.org
5. Download the Ham-VOIP version of the operating system, https://hamvoip.org/#download
6. Configure and you're good to go.

Repeater from Scratch, Summary

1. Scrounge up two Motorola CDM-750 mobiles
2. Configure the radios or have some one do it for you
3. Buy the RIM-Maxtrac-RM (the "-RM" means "Repeater Maker")
4. Buy a Raspberry Pi Model 3b
5. Get node numbers and set up on https://web-tpa.allstarlink.org
6. Download the Ham-VOIP version of the operating system, https://hamvoip.org/#download
7. Configure and you have an Allstar Node repeater.

The Duplexer

Buying a used duplexer is risky. By the time the price gets down to Amateur Radio budgets, many are corroded or have lightning damage. You can't see this at a swap meet.

All cabling around a duplexer must be double shielded. Use RG-214 as a minimum - mil-spec RG-214 with silver plated braid is best.

If you are diplexing a VHF and UHF system into the same antenna, use a good quality diplexer with no pigtail leads. Connect your double shielded coax directly to the diplexer. Also, avoid the use of adapters - just buy or make up cable jumpers with the right connectors on them. It is critical to avoid connectors and adapters made in China. Use good quality connectors and adapters that are silver plated.

Echolink

Previously we had Echolink set up as a 'simplex user' using a PC and a Kenwood V71. This was decommissioned because Echolink can be easily implemented into the Allstar node. Echolink works better on the Pi under Allstar than it did on the PC running the Echolink sysop node. Bottom line, I eliminated hardware and complexity to get a better Echolink implementation.

OUR ALLSTAR PROJECT CONTRIBUTORS

- KB5ASW, my son, was (and will be) invaluable in working through config issues and implementing new features.
- NA5CC is my right hand man in getting our club started and providing insight based on his years of repeater building experience.
- K5TRA is the consummate professional who tuned our duplexers, helped with Allstar questions, and doesn't like the Ham-VOIP image.
- K5IHK (SK) was my old friend who helped me get my first mobile radio (a Motorola T-Power) on the air 45 years ago. Jerry donated antennas, duplexers, and radios to our cause.
- N5MBM and W0FCM (SK) provided invaluable help in our initial Allstar setup.