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## INTRODUCTION

A few years back, several of us decided to start a new ham radio club<sup>1</sup>. 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<sup>2</sup>. 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).

This document is essentially a newbie guide to building a linked repeater using Allstar. It was actually quite easy. Most of what you need to know is well documented on websites referenced herein. What follows is not the only way, but it was my way, and it is an easy way, and it was cost effective.

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<sup>1</sup> Fayette Amateur Radio Transmitting Society, La Grange, Fayette County, Texas

<sup>2</sup> D-Star and Fusion

### FIRST REPEATER IMPLEMENTATION

One of the donations made to our fledgling club was a number of Motorola and Kenwood commercial radios. Of special interest was the Motorola 20-pin<sup>3</sup> accessory port which was present on several CDM-750 UHF 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<sup>4</sup> and the RIM-Maxtrac-RM<sup>5</sup>. Please don't let this scare you off! What I am about to describe is almost plug-&-play.

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#### The Controller Interface

RIM-Maxtrac-RM is a narrow definition. It should work on any Motorola radio with a 16 or 20-pin accessory port<sup>6</sup>. It certainly works with other models including the CDM, Radius, and GM-300 series radios. In my case, I used the CDM-750. 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 Figure 1 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, it has the elongated side of the circuit board facing away from the heat sink.

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

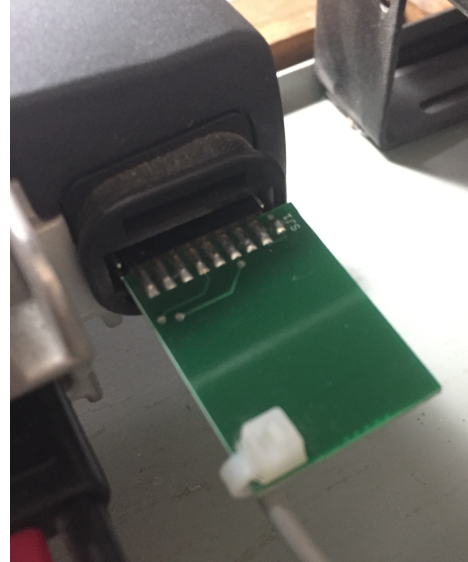
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<sup>3</sup> Can be 16-pin on other radio models. Care must be taken to ensure compatibility. See RIM documentation

<sup>4</sup> <https://www.raspberrypi.org>

<sup>5</sup> <http://www.repeater-builder.com/products/usb-rim-lite.html>

<sup>6</sup> <http://www.repeater-builder.com/motorola/maxtrac/maxtrac-option-plug.html>



**FIGURE 1**

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### 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 will leave this issue to the reader. In my case, I modified the Motorola Windows based software for the CDM series per the article on Repeater-Builder and therefore was able to put our UHF radios onto the Ham band. Note that this may not be necessary if the model range covers the Ham Band. It was easy enough. Depending upon the radio model, software mods are probably not required. Much of the Motorola gear will go straight onto the Ham Bands.

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. This is not an article on configuration - if you intend to program the radios yourself and have questions, contact me via email; na5rc @ na5rc dot net.

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### Allstar Node Numbers

You only need one node number for a repeater but don't make the mistake of just getting one. I now have three and should have requested five to start with. If I had requested five, my systems would have sequential numbers, and it would have been much easier to remember. If you choose to add Echolink, it requires a node number. Just get 5 - trust me.

Create an account with [allstarlink.org](http://allstarlink.org) and get your node numbers now. They ask questions about your intended implementation but don't worry you can change node configurations later so don't worry about it.

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### 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'. If you are not familiar with this computer, just buy a kit - the cost is well under \$100. This small computer, coupled with the RIM-Maxtrac-RM serves as both your repeater controller and 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)

**FIGURE 2**

Now you need the operating system.

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### Asterisk Allstar

There are several ways to implement Allstar - I chose the easy way. Go to <https://hamvoip.org> and download their latest software. This is an Asterisk Allstar implementation on Linux. It has all the tools and instructions you need to get up and running. Asterisk is PBX software that has been adapted to radio by using node numbers in lieu of telephone numbers. Yes, you will be able to dial up other nodes from your radio.

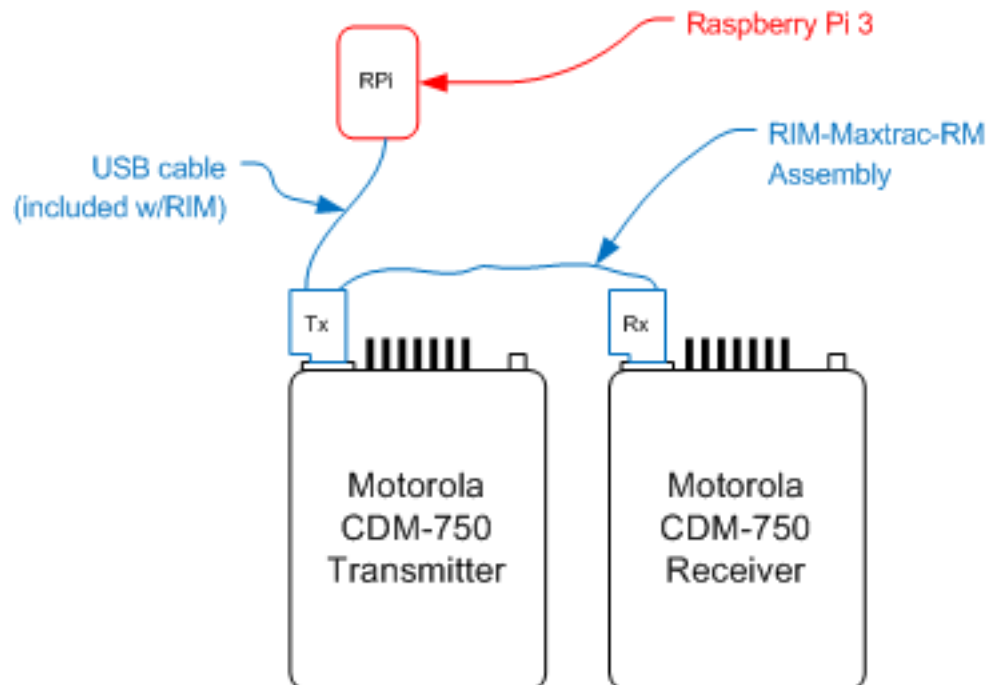
Once you have downloaded this file, you must 'image' it over to the micro SD card. This is not a simple copy job. Follow the instructions carefully. It can take some time - 20 minutes to an hour - it will let you know when its finished so be patient.

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.

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### Putting it all Together

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

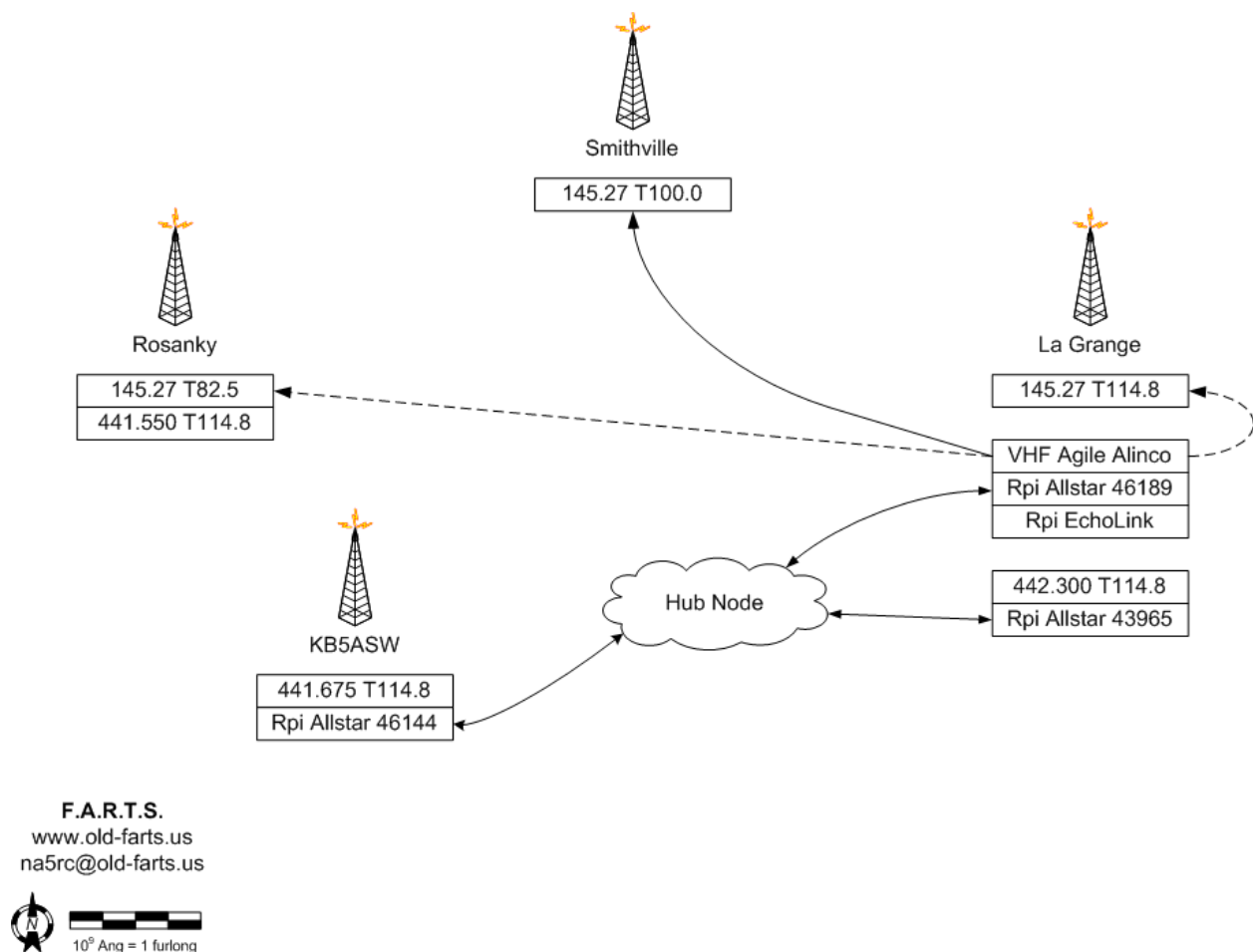


**FIGURE 3**

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.

### **COROLLARY TO YOUR FIRST ALLSTAR REPEATER**

Okay, our first Allstar repeater was up and running just as described above. Our members did not want to listen to a people they didn't know all day on our primary VHF system. This is why the above described system was on our lesser used UHF repeater. However, I wanted the capabilities of Allstar on VHF, but we had three existing systems all on 145.27, and all with different hardware, and two of the sites do not have internet. A bit of explanation is required. We have three 145.27 repeaters with overlapping coverage of a multi-county area. Each repeater is accessed with a different tone but all three transmit the same tone. It works really well and is quite seamless in most cases.



**FIGURE 4**

It would be easy enough to build a new repeater for a site with internet but why not make an independent simplex node that could be pointed to any of the three? This is the method I chose.

After a bumpy start with some misconceptions on my part, I implemented an Alinco DR-135 with a RIM-Alinco<sup>7</sup> connected to a Raspberry Pi making another Allstar node. This radio can hear all three repeaters full quieting and each of the three repeater input tones is programmed into a channel. Simply stated, this is an “Allstar User” that can access any of our three VHF repeaters (or any area VHF repeater during an emergency). So now we have this awesome capability with gravy. The gravy includes keeping our VHF system connected to my son’s UHF system. Hold on, there is more gravy!

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. I don’t think it is my imagination, but Echolink seems to work 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.

There is one issue worthy of note here regarding this simplex node, (not applicable when implementing a repeater). When “duplex=0” is set in rpt.conf, there is no voice ID capability. Changing to duplex=1 enables the voice ID but the default courtesy beep plays ping-pong with the repeater. I tried everything on timing and followed some advice found on forums to no avail. Solution? Simply turn off the courtesy tone from Allstar: set nounkeyct=1 in the rpt.conf file.

Another important issue is cooling for the transmitter. Mobile radios do not 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.

## **ANOTHER OPTION**

Hindsight is 20-20. We have been talking about voting receivers for years and Allstar has a solution; the Allstar Radio Thin Client Module, [www.micro-node.com](http://www.micro-node.com).

Rather than the Raspberry Pi for my simplex node, I could have used the RTCM. We would then have the ability to bring in satellite receivers or even replace the other repeaters with receivers and just vote.

This is an option worth looking in to for more advanced repeater builders.

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<sup>7</sup> <http://www.repeater-builder.com/products/usb-rim-lite.html>

### CONFIGURATION NOTES

There are three configurations required; **Radio**, **Computer**, and **RIM**.

For the **Radio**, there are several factors to consider:

1. If the radio model allows for a TX or RX personality or a repeater programming mode, use it.
2. Accessory Pins
  - A. For the transmitter, pin 3 is PTT input.
  - B. For the receiver, pin 8 is PL and CSQ detect.
3. De-Emphasis and Pre-Emphasis: it is best to do this in the controller (Raspberry Pi) and not in the radio. So, in the radio configuration disable de-emphasis and pre-emphasis or select "Flat Audio" in the case of the CDM series. On the Maxtrac this is an internal jumper rather than a software configuration.

We have already discussed the **Computer** - this is well documented. Again, if this is your first time, use the pre-configured package from <https://hamvoip.org> and follow their instructions. They give you a configuration menu which includes a submenu for configuring the RIM.

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. Here are some of the key settings:

- 2) RX voice level: Very important so set it per instructions
- 3) TX A level? Also important (note that TX B level is not used)
- B) Toggle RX boost: May be required (use with RX voice level setting above)
- F) Toggle PRE-emphasis: Enable this
- G) Toggle DE-emphasis: Enable this



### 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.

Repeater from Scratch:

1. Scrounge up two Motorola mobiles
2. Configure the radios or have some one do it for you
3. Buy the RIM-Maxtrac-RM
4. Buy a Raspberry Pi
5. Get node numbers
6. Download the operating system
7. Configure it, plug it in, and boom - you have an Allstar node

Simplex Node to Existing Repeater:

1. Buy a **single band Alinco** DR-x35 (with DB-9 connector on back) (don't get the internal TNC)
2. Buy a RIM-Alinco
3. goto #4 above

In Figure 4 you see that I connected our repeaters together with a hub node. This is not required for a one-to-one connection. Nodes can be connected directly together but 'chaining' nodes can become a problem. At some point of growth, a hub node becomes advantageous. I chose to make a hub node early with a spare Dell running a Linux distribution called DIAL. Ignore the hub node for now - it is not a subject for this document.

I have not mentioned a duplexer. We already had duplexers in service for our frequencies. Buying a used duplexer is risky. Many are corroded or have lightning damage that you can't see at a swap meet. If you need a duplexer, I strongly recommend JAG-RF. Their refurbished duplexers are cheap and like new. All cabling around a duplexer must be double shielded. Use RG-214 as a minimum. 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.

### **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.
- K5IHK is my old friend who helped me get my first mobile radio on the air 45 years ago. Jerry donated antennas, duplexers, and radios to our cause.
- N5MBM and W0FCM of [thetexasconnection.net](http://thetexasconnection.net) provided invaluable help in our initial Allstar setup.