Interfacing the MMDVM to a pair of CDM 1250 Uhf Radios
By: Mark K Ward N6IB

The Shopping List for your Home-Brew MMDVM Repeater Project using Motorola CDM 1250 Uhf radios

Before we attempt getting started on this project, you will first need go shopping for a few essentials before beginning:

1. Raspberry Pi 3 (Amazon) $39-45ea
2. Raspberry Pi Case (Amazon)$6.00 - $20ea
3. Power supply for Raspberry Pi (Amazon) $8.00-$10.00
4. Ardueino Due or Due Clone gets power from the pi USB. (Amazon) $18.50-$25.00ea
5. Ardueino Due Case Geaux Robot (Amazon) $12.00
6. Scan-Disk Ultra Class 10 Micro SD Card with adaptor 32GB (Amazon) $15.00ea
7. MMDVM rev 1.0.1 with pig tail(Bruce Given VE2GZI) Bruce.Given@Gmail.com $60.00 + $10.00 Shipping
8. HLN9457A quantity 2 (E-Bay) $8.00-15.00 ea
9. Pin crimper Kinee Dupont (Amazon) $20.00
10. Solder (Amazon) $6.00-$10.00
11. Soldering Iron Weller WES51 Recommended for the HAM and his or her projects worth the money (Amazon) $99.95
12. Heat Gun (Amazon) $20.00-$40.00
13. Heat shrink multiple sizes I recommend a heat shrink kit(Amazon) $10.00
14. 47k Ohm resistor together with a 250K 10 turn trimmer Pot both to be connected in series together and to PIN 11 RX audio on the CDM. Both parts can be sourced on Amazon for less than ($10.00 ea) this will allow for the fine tuning of the flat RX audio to achieve .9 – 1v pk:pk of the receivers IF. The reason for the trimmer is we have found multiple CDM radios require different amounts of padding ranging from 50K – 300K none are alike and none perform the same this is because the radios were never designed with such tight tolerances in mind.
15. Cat 5e stranded used for interfacing the CDM radios to the MMDVM board your local hardware store
16. CDM 1250 Radios Model: AAM25RKD9AA2AN. 403-470MHZ 45W Qty 2 (E-Bay) $75-$150
17. Motorola Power Cables HKN4137A Qty 2 (E-Bay) $10.00
18. Jumpers Mini-UHFMale :NMale for radios LMR 240 three Ft Qty 2 (E-Bay) $14.00 ea
19. Duplexer BPBR preferred if going to comm site if at home or low level Notch Duplexer will work. Hill top duplexers go for ($250.00 - $500) Notch duplexers ($50-100) *Essentials source on your own or borrow from a friend*
20. 25amp 12VDC Switching power supply
21. Service monitor
22. OScope with probe
23. Programming cable for CDM radios
24. Mototola CPS rev 06.12.09 or earlier

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A home brew repeater complete for under $700 as opposed to $5000 industrial not to bad and they work well

Download your image and set up the Pi and Ardueino interfacing to the Brandmeister DMR Network

There are many images available, however the one I have used has all the essentials and works very well. I use the DMR-UTAH mmdvm_Pixel_DMR-UTAH :

https://drive.google.com/uc?export=download&id=0BxeyR6_rxGV1Mk12X2owVUpBSVE

This image has the tool to upload the firmware to the Arduino and all the essentials pre-loaded into the image so my references to getting things going in this text will pertain to this image

1) Now that you have your Pi assembled the image loaded on to your SD card and your Arduino assembled and interfaced to the pi, you will need to set the MMDVM board on the Ardueino. It will sit very close and snug against the Ardueino board this is normal. If you must remove the board from the Ardueino exercise caution and go slow.
2) The next step is interfacing the Ardueino DUE with the Raspberry Pi 3.
3) Plug the USB cable that is designed to connect to the Ardueino DUE into one of the 4 USB plugs on the Front of the Raspberry Pi.
4) The Next step is to connect to the proper micro USB port on the Ardueino. The Ardueino has two of them this is the most important step and the one to not overlook as one port works and the other does not. **Connect the micro USB to the port closest to the barrel on the Arduino also known as the Programming Port**. This port servers two purposes it is the port the Ardueino gets its power from as well as the port that interfaces with the pi for communication back and forth for the services such as MMDVMHost, MMDVMCal and the Ardueino IDE firmware program.
5) Power up your pi. The User name is : pi the password is: raspberry
6) Go to the start menu then to the folder Ham Radio select towards the bottom Update all. This will download the latest firmware, MMDVMHost, and MMDVMCal repository directly from the GitHub and install it on your Pi and place them in the appropriate folders for you.
7) Go to start menu then to the folder Ham Radio select Stop MMDVMHost background services follow the same step once more and Select Stop MMDVMHost.
8) Go to the Ham Radio folder and select the top icon titled ArdueinoIDE. This program queues up the software and firmware to be loaded on your Ardueino DUE board.
9) Once the application is running, you will see a button that looks like an arrow going to the right it is called update configuration hit that and you will burn the firmware to your DUE and MMDVM.
10) You will need to access a file named: MMDVM.ini. The MMDVM.ini file is the config file that tells the MMDVMHost software your settinngs and contains information such as: repeater callsign, etc. This file is located in the following directory: /home/pi/MMDVM.ini

11) Double click on file manager and go to the Home directory then to the sub directory Pi you will see the file: MMDVM.ini double click it and begin editing it.

```
[General]
Callsign=your call sign
Timeout=180
Duplex=1
# ModeHang=10
RFModeHang=10
NetModeHang=3
Display=None
Daemon=0

[Info]
RXFrequency=446000000
TXFrequency=441000000
Power=45
Latitude=your latitude in decimal
Longitude=your longitude in decimal
Height=your antenna height in meters
Location=city and state
Description=description of your repeater
URL=your web site URL

[Log]
# Logging levels, 0=No logging
DisplayLevel=1
FileLevel=1
FilePath=/mnt/ramdisk
FileRoot=MMDVM

[CW Id]
Enable=1
Time=10

[DMR Id Lookup]
File=DMRIds.dat
Time=24

[Modem]
Port=/dev/ttyACM0
# Port=\\.\COM3
TXInvert=0
```

```
RXInvert=0
PTTInvert=0
TXDelay=100
DMRDelay=0
RXLevel=16
TXLevel=50
# CWIdTXLevel=50
# D-StarTXLevel=50
# DMRTXLevel=50
# YSFTXLevel=50
# P25TXLevel=50
OscOffset=0
# RSSIMultiplier=1
# RSSIOffset=10
Debug=0

[D-Star]
Enable=0
Module=C
SelfOnly=0

[DMR]
Enable=1
Beacons=1
Id=your repeater id
ColorCode=1
SelfOnly=0
# Prefixes=234,235
CallHang=3
TXHang=4
#Blacklist=
#DstIdBlackListSlot1RF=
#DstIdBlackListSlot2RF=
#DstIdWhiteListSlot1RF=
#DstIdWhiteListSlot2RF=
#DstIdBlackListSlot1NET=
#DstIdBlackListSlot2NET=
#DstIdWhiteListSlot1NET=
#DstIdWhiteListSlot2NET=
TGRewriteSlot1=0
TGRewriteSlot2=0
BMAutoRewrite=0
BMRewriteReflectorVoicePrompts=0
```

```
DirectDial=0
TargetTG=9
#RewriteMapSlot1=
#RewritemapSlot2=

[System Fusion]
Enable=0
RemoteGateway=0

[P25]
Enable=0
NAC=293

[D-Star Network]
Enable=0
GatewayAddress=127.0.0.1
GatewayPort=20010
LocalPort=20011
Debug=0

[DMR Network]
Enable=1
Address=74.91.118.251
Port=62031
Jitter=300
# Local=3350
Password=passw0rd
RSSI=0
Slot1=1
Slot2=1
Debug=0

[System Fusion Network]
Enable=0
LocalAddress=127.0.0.1
LocalPort=3200
GwyAddress=127.0.0.1
GwyPort=4200
Debug=0

[P25 Network]
Enable=0
GatewayAddress=127.0.0.1
```

```
GatewayPort=42020
LocalPort=32010
Debug=0

[TFT Serial]
# Port=modem
Port=/dev/ttyAMA0
Brightness=50

[HD44780]
Rows=2
Columns=16

# For basic HD44780 displays (4-bit connection)
# rs, strb, d0, d1, d2, d3
Pins=11,10,0,1,2,3

# Device address for I2C
I2CAddress=0x20

# PWM backlight
PWM=0
PWMPin=21
PWMBright=100
PWMDim=16

DisplayClock=1
UTC=0

[Nextion]
# Port=modem
Port=/dev/ttyAMA0
Brightness=50
DisplayClock=1
UTC=0
IdleBrightness=20

[OLED]
Type=3
Brightness=0
Invert=0
```

file:///usr/share/applications/mmdvm-mmdvmhost_service_restart.desktop

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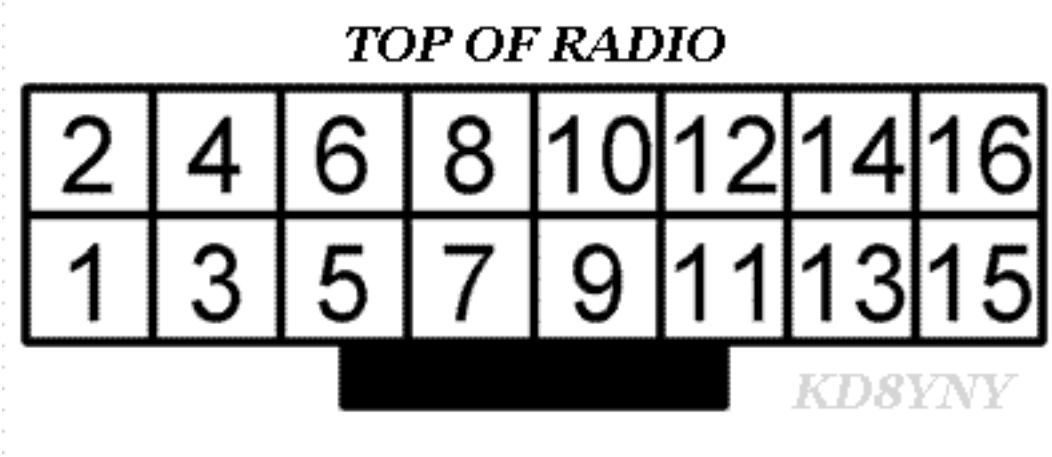
12) Go to Start than Ham Radio then to Start MMDVMHost this will get your initial interface on the network
13) Go to: brandmeister.network
14) Select repeaters
15) Search for your repeater ID after a few minutes you should see your node on the Master server if you see this you have been successful in connecting to the network

Interfacing the CDM 1250 Radios with the MMDVM Modem this is the wiring harness process

The CDM radio has a 20 pin accessory connector on the back of the radio. However, we can use the 16 pin accessory connector a used with the GM300 radius radios and Maxtrac radios. When we plug this in, the last two pins to the right and left are not used only the inner 16 with the locking tab being in center. The pins I will be referring to are the numbers on the 16 pin connector and not the 20 pins as the CDM uses the same program numbering for the inner 16 pins.



Pin 5 = Transmit Audio	Configure in CPS to FLAT TX audio
Pin 3 = PTT	Configure pin in CPS to (Data PTT) Active Low
Pin 10 = +12vdc for ignition sense	Configure pin CPS to follow ignition and connect to + 12vdc
Pin 11 = Receive Audio	Configure in CPS to FLAT Receive AUDIO
Pin 7 = Ground	
Pin 8 = Carrier Detect	

Wiring for the 8 pin plug is labeled as follows).

Pin (1) CTRL not used in this case
Pin (2) COS/STAT_1 cos carrier from the RX radio
pin (3) RX Audio connect your variable 47k-300k trimmer Ohm in series with the RX audio from

the discriminator. The audio that comes from the CDM is too hot and needs padding for it to work with the CDM **don't skip this step you will pull your hair out if you do and it won't work!!**
pin (4) RX GND
pin (5) TX GND
pin (6) TX Audio
pin (7) PTT
pin (8) STAT_2 not used in this case

Configuration of the Motorola CDM in Motorola CPS these steps are very important

Radio personality configuration

Within the conventional personality, we can set the bandwidth of the station(s) to get the best and easiest tuning results of audio levels, we recommend that you program both the receive and transmit radios for wide band or 25KHz. This is not a problem with the emission mask of the mode because when we look at it on a spectrum analyzer we are only utilizing 12.5KHz bandwidth based upon the TX tuning levels of the MMDVM. We have found that when you narrow the radios you enable the filters which make the tuning and adjustments very difficult to achieve satisfactory results.

Interfacing the MMDVM to a pair of CDM 1250 Uhf Radios
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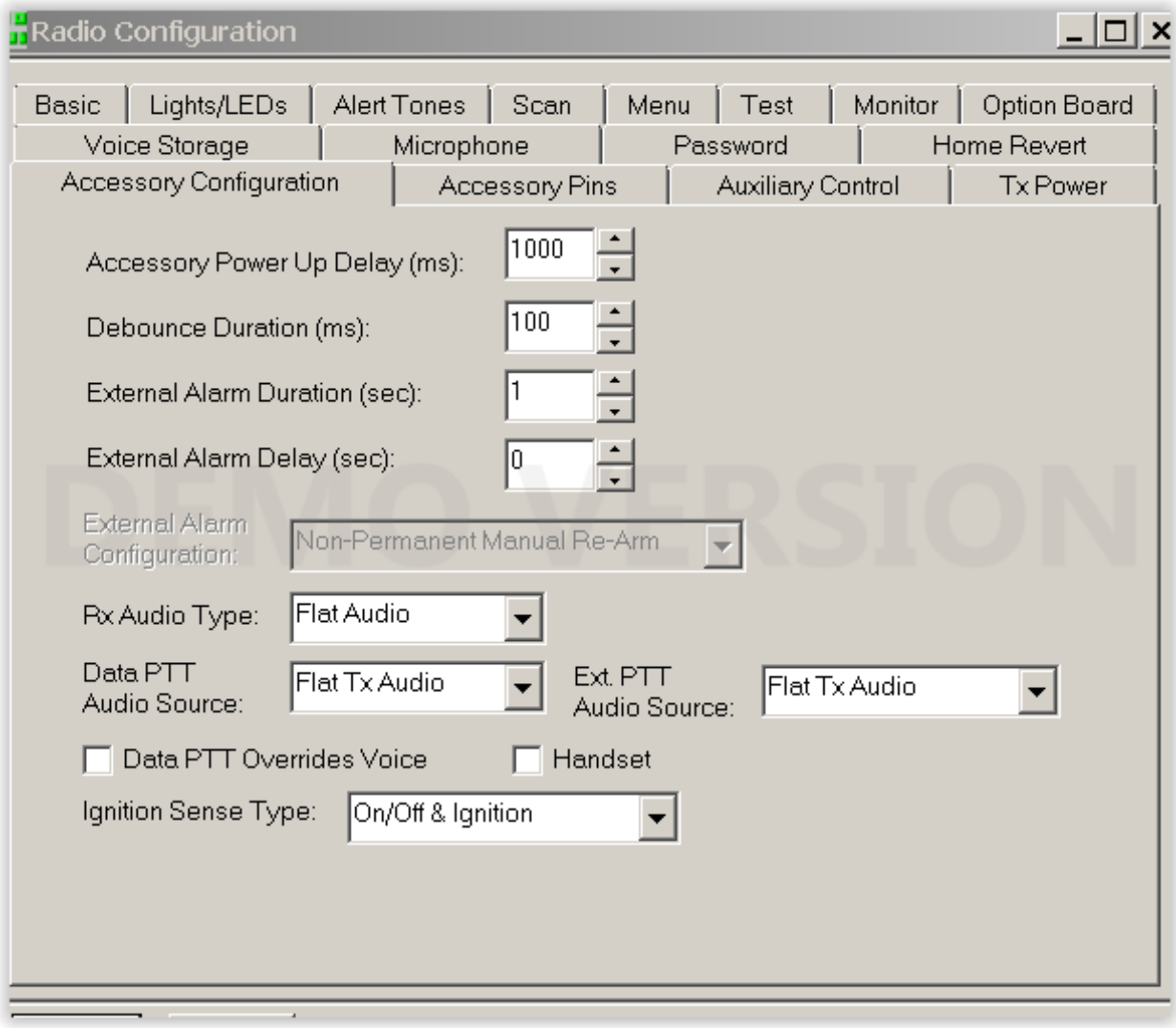
Radio Configuration



This is the section under radio configuration after the radio was read where we set the Receive Audio and Transmit Audio to Flatt all the way across the board. This is an essential step as the digital wave form requires audio to be as flat as possible to minimize errors and bit errors which is commonly referred to as packet loss.

Configuration of the Conventional Personality Advanced Tab

Make sure under Emphasis Selection, you select none as indicated in the below picture. Because we want receive and TX audio to be as flat as we possibly can have it adding emphasis makes the tuning of the receive and transmit almost an impossibility.

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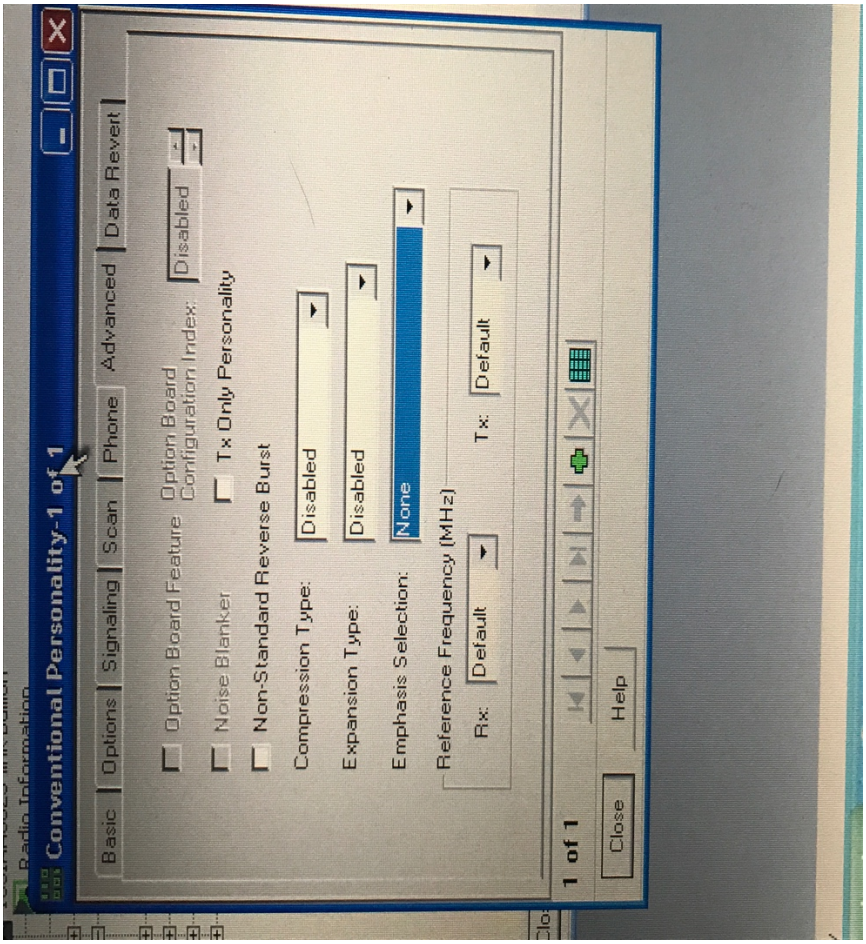

Pin Assignments in CPS

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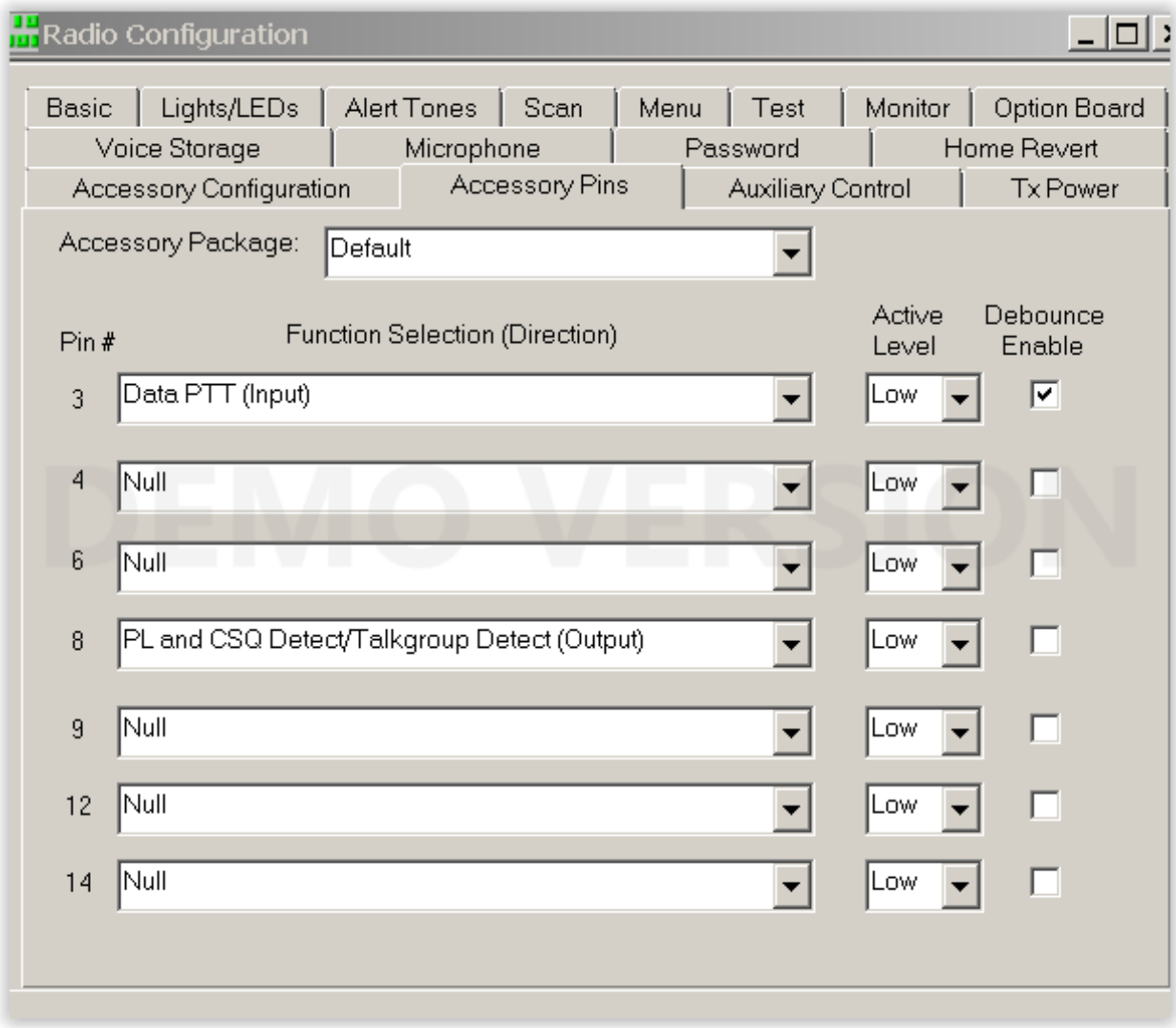

This step tells the radio which port to utilize when communicating to the MMDVM modem also another important step to not over look

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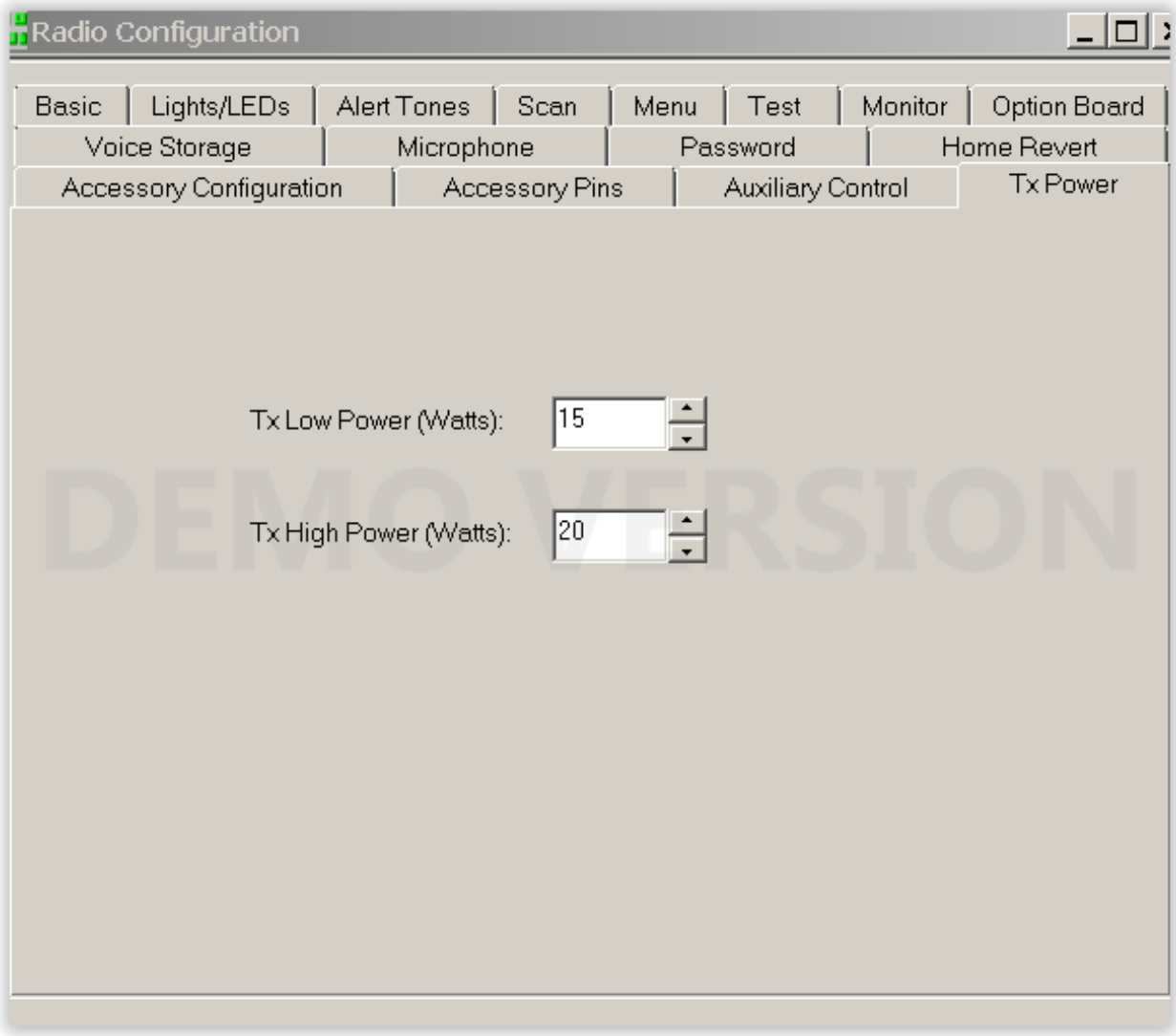
Power Setting of Radio This example is for a 25 W Radio



Because these radios are mobile they were never designed to run at 100% duty cycle I recommend setting the High power level to between 50-60% of full power and Lo power to 25-30% this will ensure that the PA doesn't fail before you are ready. I also recommend getting a fan to place on the PA unit to keep it cool.

Setting the Transmit audio levels

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Go to Start then access Ham radio click on MMDVMCal select DMR audio setting grab your service monitor set up to monitor over the air your frequency and have it set up where you can see deviation levels in KHz mode

Version: 1 "MMDVM 20161230 (D-Star/DMR/System Fusion/P25/RSSI/CW Id)"
The commands are:

- H/h Display help
- I Toggle transmit inversion
- i Toggle receive inversion
- P/p Toggle PTT inversion
- Q/q Quit
- R Increase receive level
- r Decrease receive level
- T Increase transmit level
- t Decrease transmit level
- D DMR Deviation Mode (Adjust for 2.75Khz Deviation)
- d D-Star Mode
- S/s RSSI Mode
- V/v Display version of MMDVMCal
- <space> Toggle transmit

Once that is done hit the space bar to key the radio you will see a note to adjust deviation to 2.75Khz you will also hear a 1000Khz tone being generated adjust the TX pot till you attain 2.75KHz deviation and the TX audio is set. This effectively sets up the transmit stage of the radio for what is know as 1st carrier drop-out and places all the power into the sidebands of the DMR carrier. On a service monitor set to the frequency set dispersion to 15Khz and you should see this while the radio is the DMR Calibration mode while transmitting. You should see the main carrier is completely dropped out or nulled this is referred to as first carrier drop out.

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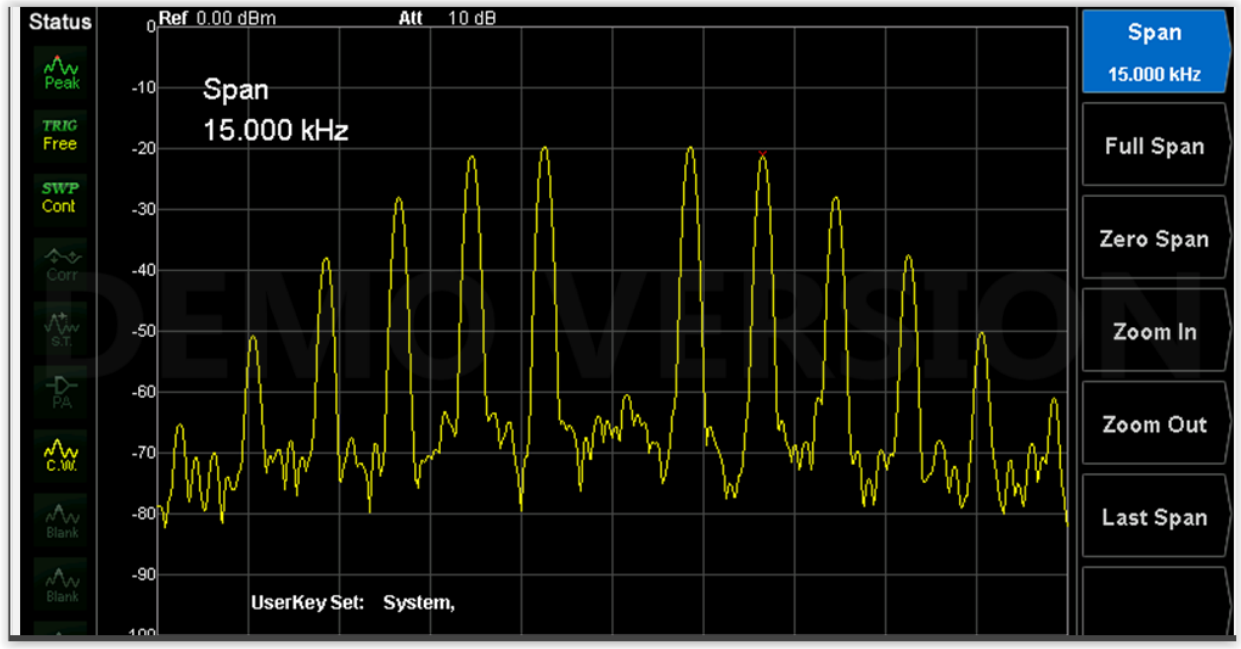
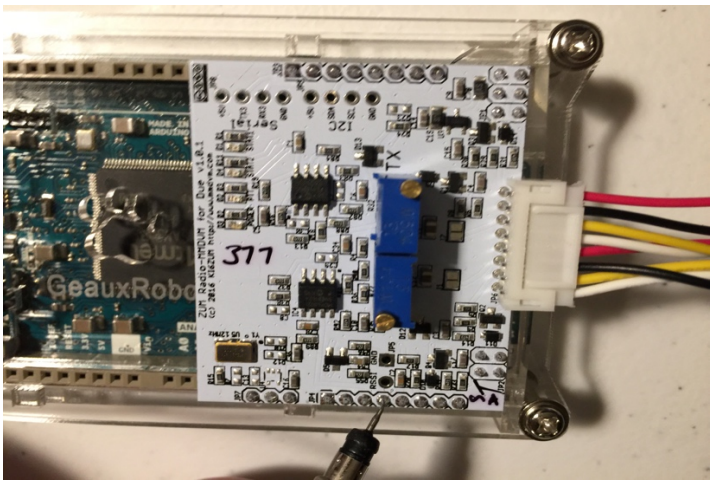


Setting the Receive Levels

When hooking up your O-Scope, make sure it is calibrated. When measuring audio voltage, connect the probe to pin A11 on the Ardueino and adjust the RX POT to the point where you see 1v ac pk:pk from the receivers IF.



Pin A11 where the probe is touching

If you cannot get the 1v pk to pk due to the fact that the receive audio out is too high coming from the receiver, it will become necessary for you to increase the in series resistor on RX audio until you can get the receivers IF level to the 1v pk to pk or slightly less so that the DMR wave

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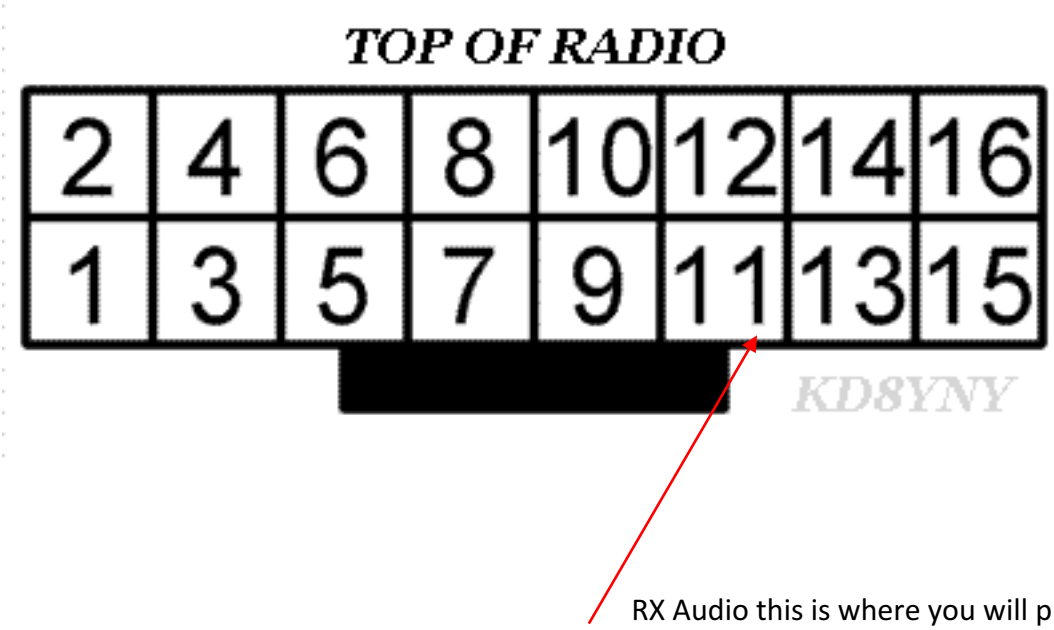
for can evolve to the level required to be within specification. We have found that depending upon your radio we have seen in series resistors required in range of: 47k:300k, It becomes ever more clear the need for this due to the fact these radios were never designed to do what we are requiring them to do and their tolerances were not built to such a tight specification.

Therefore, because of this disparity, it is best to use a trimmer pot rated at 250k in series with a 47k ohm resistor to give you the min and max range as found with Motorola CDM series radios. Once you achieve your desired result, measure the impedance and you can replace the pot with a fixed resistor or simply leave it alone in place.



RX Audio this is where you will put your resistance in series with the MMDVM RX Audio Connection on Pin 3 of the pigtail
I recommend using a 47K ohm resistor in series with a 250k trimmer Pot to achieve the range of 50k-300k ohms to achieve the desired results per your radio.

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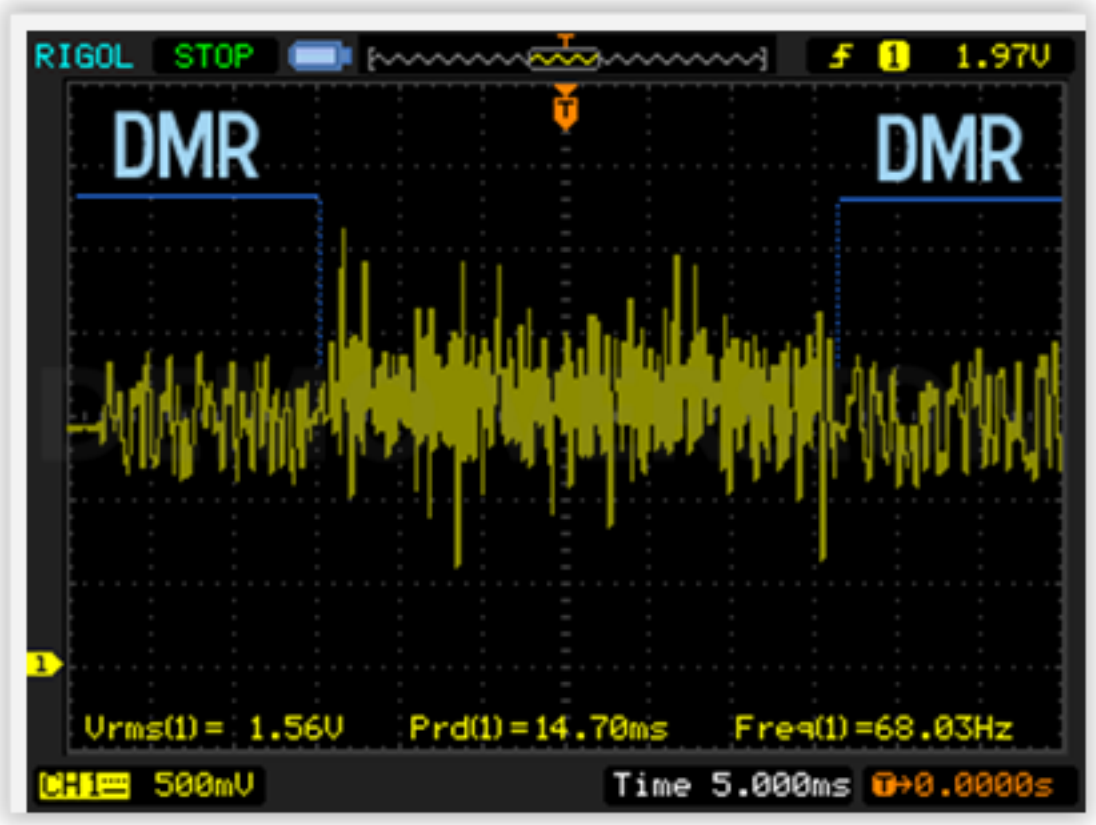

When you generate a DMR signal, you will begin to see the signal it is important to note that the DMR wave for or digital signal tends to evolve around 300mv-440mv peak to peak. As seen below in the picture of the O-Scope showing analog receiver IF relative to that of the DMR wave form. If you have successfully achieved this, you are good to go.

We have found setting the RXLevel located in the modem section of the MMDVM.ini file to be between 15-50 depending upon the amount of resistance you require to achieve your desired results.

Wrapping things up

Go to Start Menu, Ham radio , Start MMDVMHost back ground service
Go to Start Menu, Ham radio, MMDVMHost Background Console

You should see your pi Ardueino log into the network once connected key your radio. You should see the headers and packets going across the screen when you are done it should say call duration and BER rate if your BER is < 0.9% you are good if its above 1% slowly adjust the RX level up and down in the MMDVM.ini save and restart service.

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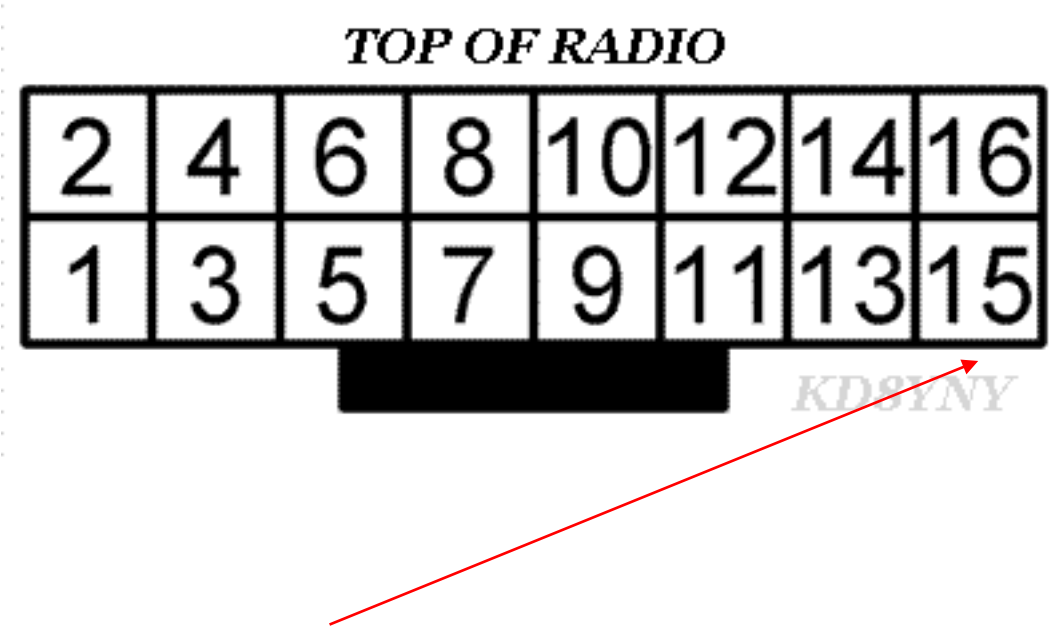
[Modem]
Port=/dev/ttyACM0
# Port=\\.\COM3
TXInvert=0
RXInvert=0
PTTInvert=0
TXDelay=100
DMRDelay=0
RXLevel=16 **Adjust this**
TXLevel=50 **Adjust this**

Hooking up RSSI Data Tap point from the Motorola CDM to the MMDVM board for reporting value to the Brandmeister network

On the CDM you will need to connect a jumper from Pin 15 on the CDM



To this pin on the MMDVM board

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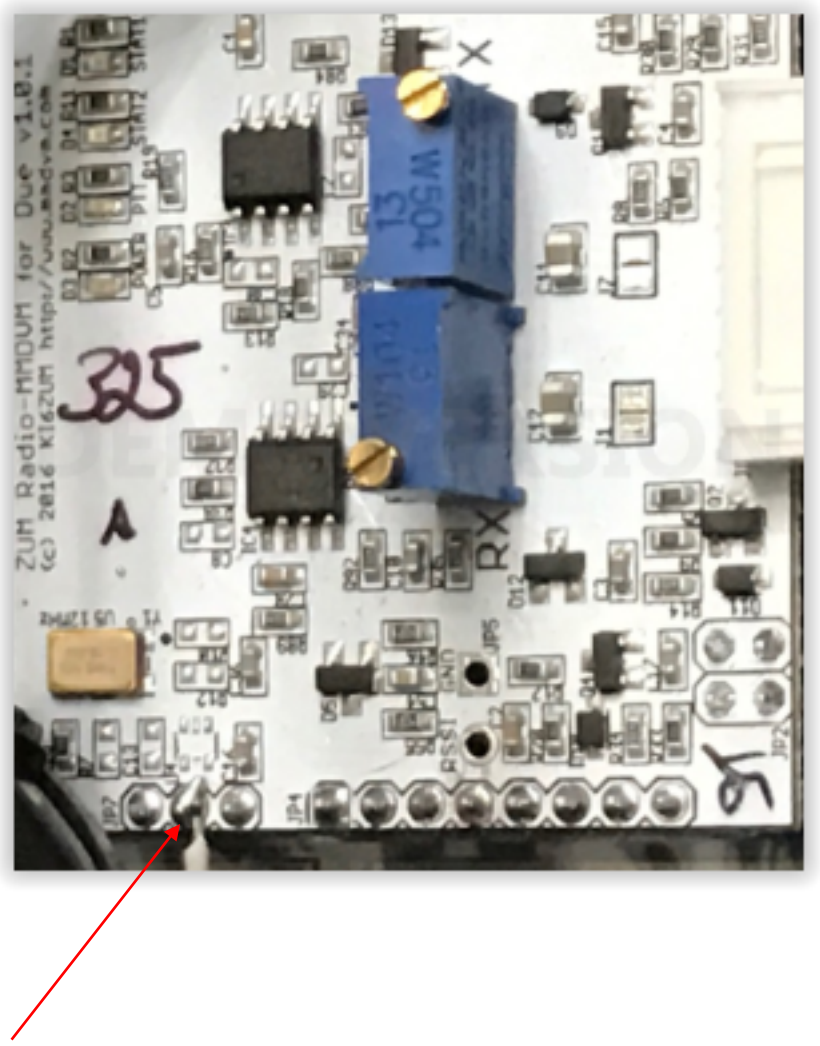

attach the other end of the jumper to this test point on the MMDVM

The next step is to modify the config.h file located in: /home/pi/MMDVM/config.h
The configuration file should look like this:

Interfacing the MMDVM to a pair of CDM 1250 Uhf Radios
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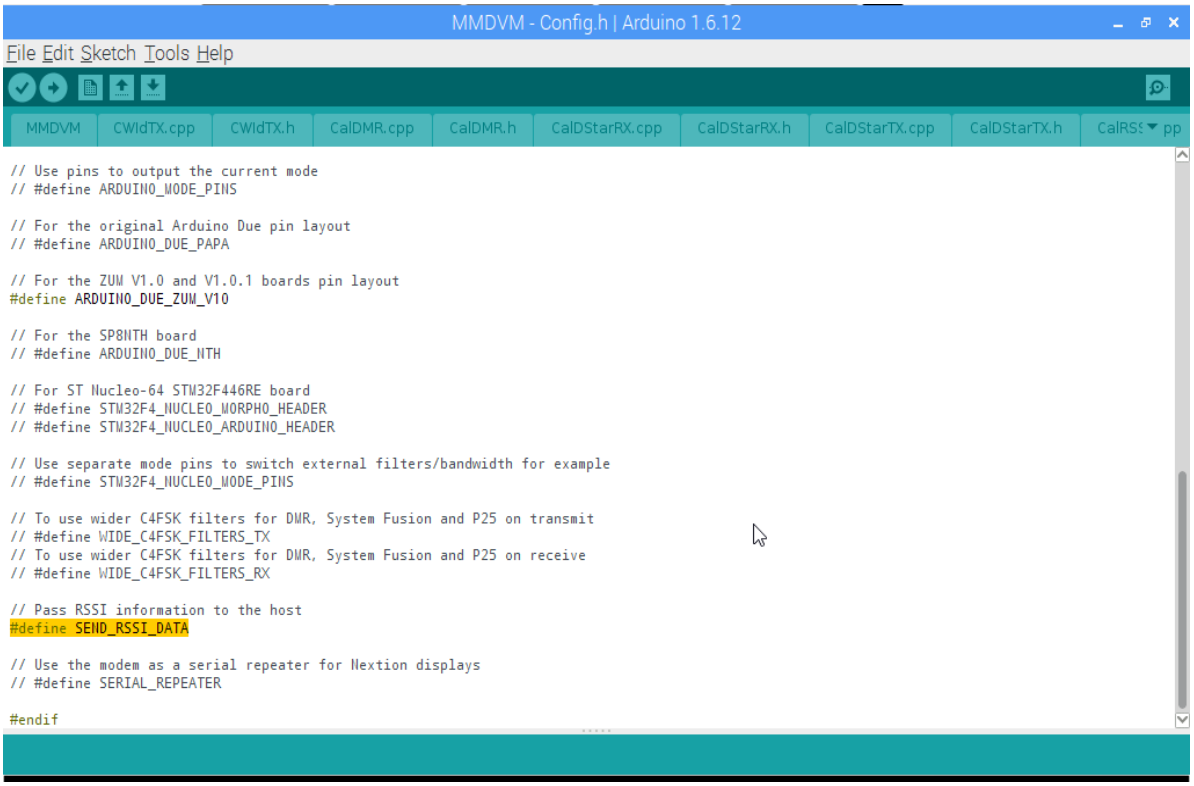

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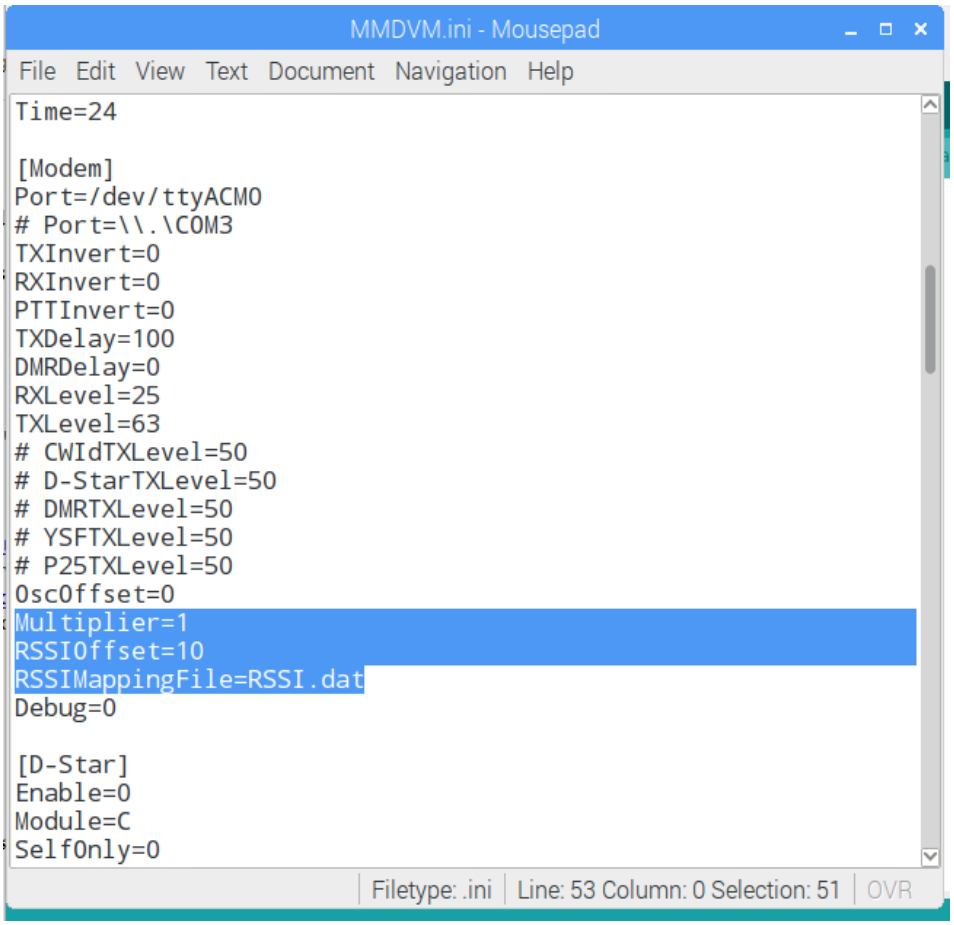
The next step is to modify the MMDVM.ini file located: /home/pi/Applications
The file should look like this:



Now you will need to put the calibrated RSSI values for the CDM radio into the RSSI.dat file. The file is located: /home/pi/Applications/MMDVMHost/RSSI.dat
The file should look like this:

```
# This file maps the raw RSSI values to dBm values to send to the DMR network. A number of data
# points should be entered and the software will use those to work out the in-between values.
#
# The format of the file is:
# Raw RSSI Value                dBm Value
#
# For example
# 1134          -90
# 1123          -100
# 1000          -109
346     -137
381     -124
443     -115
485     -110
560     -100
629     -90
698     -80
740     -75
787     -70
819     -65
830     -60
832     -55
```

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Inside look of Completed Concept