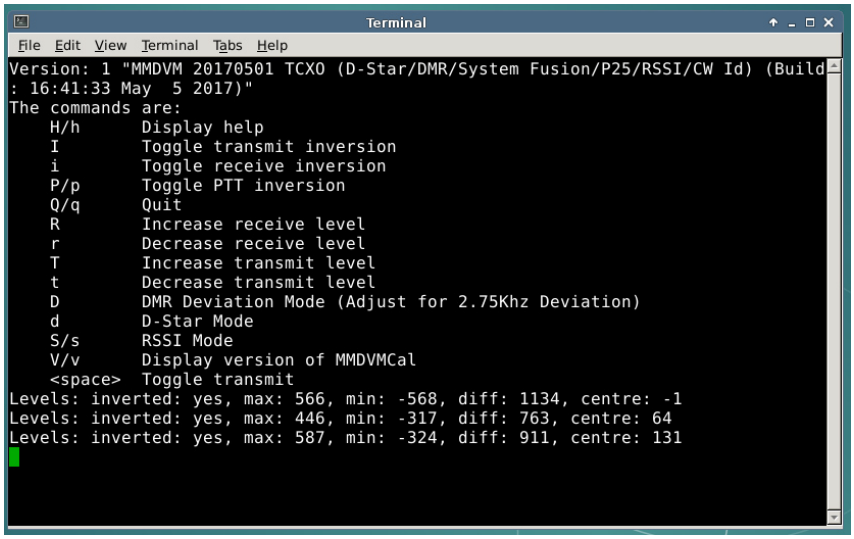
Alignment of repeaters with MMDVM modem

Recently, questions have arisen again and again about how to properly synchronize your repeater with the MMDVM modem. Since the documentation is quite sparse, but development continues to progress, I decided to create this small guide so that you have a guide on how to properly tune your repeater.

1. Alignment of the transmission branch (TX)

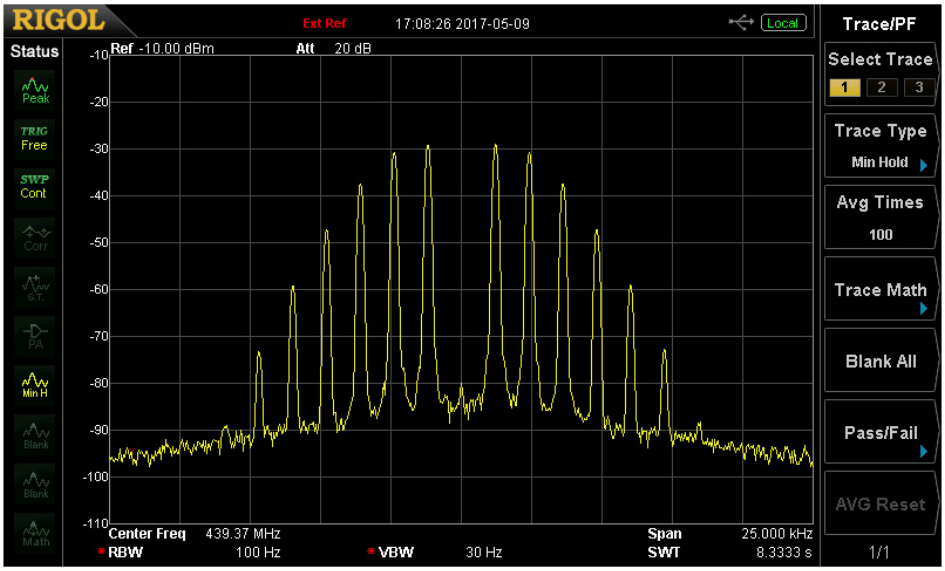
Why the send branch first? In contrast to analogue transmissions (FM), the radio communicates with the repeater. So it makes no sense to start with the receiver if the radio doesn't understand the transmitter afterwards. A correctly aligned transmitter is a prerequisite for aligning the reception branch.

For this we are provided with a very helpful tool, MMDVMCal. We will use this several more times.



To calibrate, we press “D” to enter DMR Deviation Mode. A simple sine wave tone at 1200Hz is sent here. Either you are now the happy owner of a measuring station, or you simply have an RTL-SDR stick.

To make our work a little easier, we now press “T” until we have set a TX level of 84%. Now control the PTT with the space bar and set Bessel-zero using the TX potentiometer on the modem board.



Once that's done, press the spacebar again to release the PTT and close the program. Now we enter a value of 80 for TX level in MMDVM.ini. But why 80?

At Bessel zero the carrier disappears, as you can see. Then the modulation index is exactly 2.40.

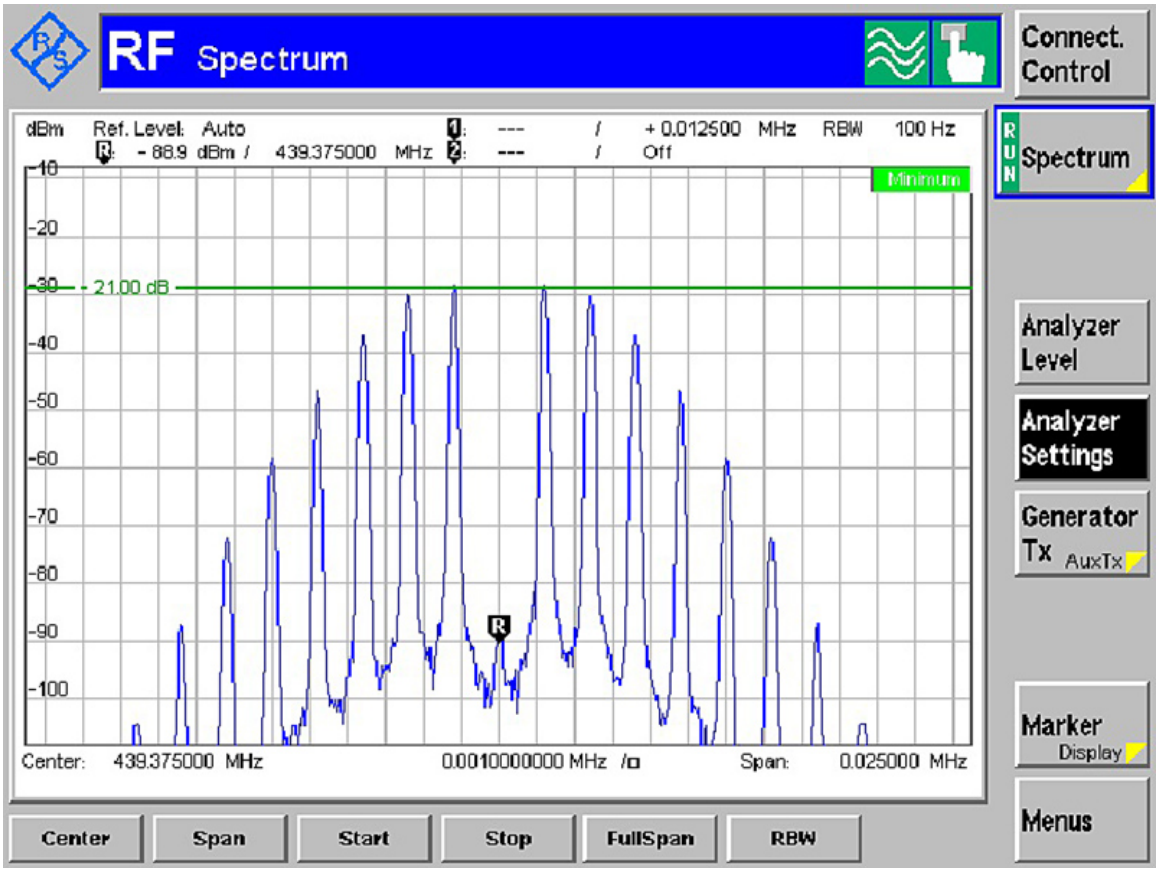
1.2kHz modulation * 2.40 = 2.88 kHz excursion

But if I enter a value of 80 instead of 84 (approx. 5% less), then my stroke is almost exactly 2.75kHz. My error is less than 0.02% with this method and these values.

That's it. The HF side of the transmitter is balanced.

Another method for channel matching:

Amateur radio is a hobby and not everyone is willing to spend thousands of euros on measuring equipment. Even the Rigol DSA815TG reaches its limits here. My R&S CMU200 shows me that even with this adjustment there is still a remaining carrier.



67.9 dBm suppression, where Rigol speaks of nothing.

You can get an RTL-SDR stick from a well-known auction house for 10-20 euros. This not only opens up many more possibilities in amateur radio, it also enables spectrum analysis with free software such as RTL-SDR, albeit to a limited extent.

Unfortunately, such sticks have very low dynamics, which makes the game a little more difficult for us.

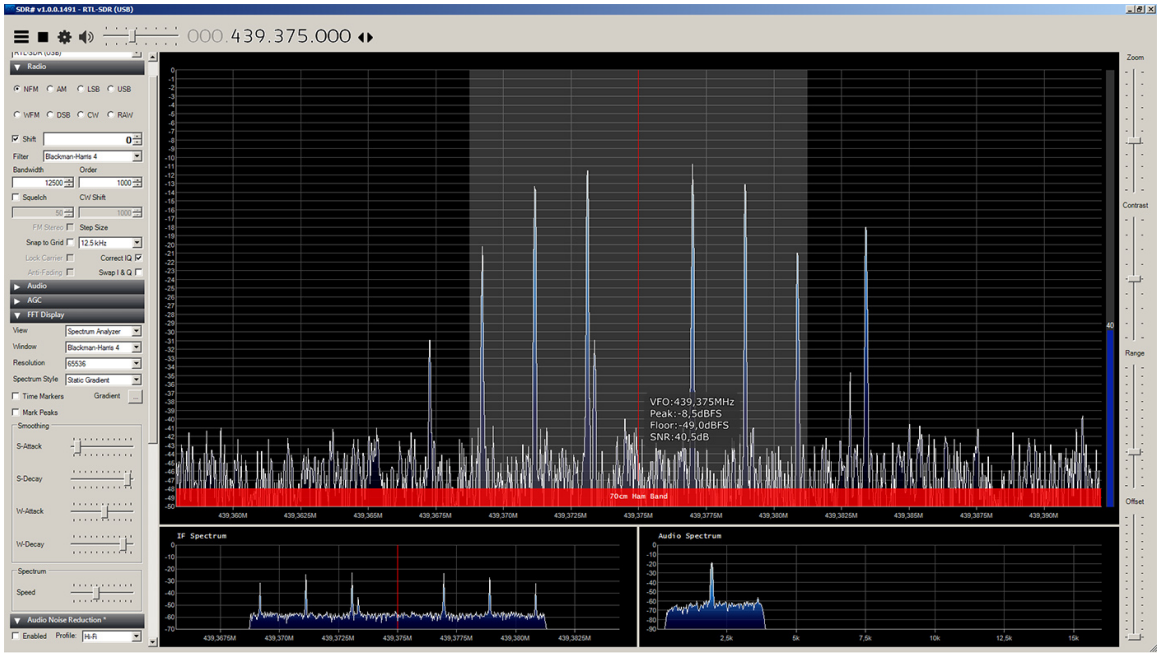
We set a TX value of 80 in the MMDVMCal and try to set the carrier to “invisible” with the potentiometer. Once we have achieved this, the small but nice trick starts:

We increase the Tx level until we see the carrier again. Let's say I see him at 94 again.

Now we lower the Tx level until we see the carrier again. Let's say it appears at 78.

The average between 94 and 78 is 86. We subtract 5% from this value. So we enter a value of 82 in the MMDVM.ini.

This isn't super accurate, but later you can refine it further with +-1 to bring the BER towards 0%.



2. Alignment of the reception branch (RX)

To start matching, we first need to adjust a few values in MMDVM.ini.

Under

[Log]we provide
DisplayLevel=2a.

Under

[Modem]we provide
RXLevel=80and
Debug=1a.

DisplayLevel=2 then gives us a clear overview of all the data we need in the console.
RXLevel=80 prevents us from getting an ADC overflow when receiving no signal.
Noise has the largest sum signal.

Now we start MMDVM and send with our radio at low power**TG9**.

```
M: 2017-05-09 16:52:28.455 Debug: DMRSlotRX: voice header found slot/pos/centre/threshold 2 432 140 742
M: 2017-05-09 16:52:28.464 DMR Slot 2, received RF voice header from DL4OCH to TG 9
M: 2017-05-09 16:52:28.516 Debug: DMRSlotRX: voice header found slot/pos/centre/threshold 2 432 124 744
M: 2017-05-09 16:52:28.573 Debug: DMRSlotRX: voice header found slot/pos/centre/threshold 2 432 100 748
M: 2017-05-09 16:52:28.635 Debug: DMRSlotRX: voice sync found slot/pos/centre/threshold 2 432 78 751
M: 2017-05-09 16:52:28.995 Debug: DMRSlotRX: voice sync found slot/pos/centre/threshold 2 432 54 754
M: 2017-05-09 16:52:29.355 Debug: DMRSlotRX: voice sync found slot/pos/centre/threshold 2 432 46 751
M: 2017-05-09 16:52:29.716 Debug: DMRSlotRX: voice sync found slot/pos/centre/threshold 2 432 50 748
M: 2017-05-09 16:52:30.072 Debug: DMRSlotRX: voice sync found slot/pos/centre/threshold 2 432 45 745
M: 2017-05-09 16:52:30.433 Debug: DMRSlotRX: voice sync found slot/pos/centre/threshold 2 432 49 743
M: 2017-05-09 16:52:30.794 Debug: DMRSlotRX: voice sync found slot/pos/centre/threshold 2 432 38 743
M: 2017-05-09 16:52:31.154 Debug: DMRSlotRX: voice sync found slot/pos/centre/threshold 2 432 41 745
M: 2017-05-09 16:52:31.514 Debug: DMRSlotRX: voice sync found slot/pos/centre/threshold 2 432 37 745
M: 2017-05-09 16:52:31.875 Debug: DMRSlotRX: voice sync found slot/pos/centre/threshold 2 432 45 747
M: 2017-05-09 16:52:32.235 Debug: DMRSlotRX: voice sync found slot/pos/centre/threshold 2 432 57 749
M: 2017-05-09 16:52:32.596 Debug: DMRSlotRX: voice sync found slot/pos/centre/threshold 2 432 58 747
M: 2017-05-09 16:52:32.957 Debug: DMRSlotRX: voice sync found slot/pos/centre/threshold 2 432 55 748
M: 2017-05-09 16:52:33.313 Debug: DMRSlotRX: voice sync found slot/pos/centre/threshold 2 432 40 746
M: 2017-05-09 16:52:33.673 Debug: DMRSlotRX: voice terminator found slot/pos/centre/threshold 2 432 45 751
M: 2017-05-09 16:52:33.679 DMR Slot 2, received RF end of voice transmission, 5.0 seconds, BER: 0.0%, RSSI: -65/-63/-63 dBm
```

Ideally, my values would look like this.

slot — indicates in which time slot I send. So here is time slot 2

pos — enters the synchronization point. If this value changes during a longer transmission, then the clock of the other station's radio is most likely inaccurate. Hopefully we all have a TCXO installed.

center — This value indicates the skew of the I/Q demodulator and is an indicator of how far the frequency offset is between the other station's transmitter and its own receiver. Errors of more than +500Hz result in values of around 200, negative values appear when the offset goes downwards. Ideal values here are theoretically around zero, values between -100 and 100 are harmless.

Thereshold	This is where our sensitivity comes into play. Here we should get a value as close to 750 as possible. This means that the input sensitivity is greatest and even weak signals are decoded more reliably. My first settings were between 1200 and 1300, which gave my relay a range of 10km. With the right adjustment I was able to more than double this radius.

What to do if it still doesn't work?

For the most commonly used GM3x0 devices from Motorola, TXInvert=0 and RXInvert=0 must be set. These values must be changed because RXInvert is set to 1 after downloading. You have to experiment with other device pairings. The reception of the TG262 should work straight away. If you don't hear anything here, change TXInvert.

3. Determine values for RSSI.dat

Here we encounter two problems: We absolutely need a measuring transmitter and the output voltage of the RSSI line of Motorola radios is too high.

Here it has proven useful to build a simple 50% voltage divider, for example from 2k7/2k7 resistors. In this way we lower the maximum voltage to below 3.3V.

RSSI.dat files with such a voltage divider value are also available.

But what to do if you don't have a measuring transmitter and no one has used these devices yet? There is a small workaround to get at least halfway values.

Almost all commercial radios output the maximum voltage with an input signal of S9+30. This corresponds to a value of -63 dBm. We use the MMDVMCal tool again and determine the maximum value here and enter it into the RSSI.dat.

Now let's look at the signal in pure noise. This value corresponds approximately to S0 and is -144 dBm.
This workaround works until you get to a measuring transmitter.

Example values for a Motorola GM340

```
# This file maps the raw RSSI values to dB
# points should be entered and the softwar
#
# The format of the file is:
# Raw RSSI Value                dBm Value
#
# For example
# 1134          -90
# 1123          -100
# 1000          -109
#



448             -63     # S9+30
441             -68     # S9+25
422             -73     # S9+20
397             -78     # S9+15
375             -83     # S9+10
356             -88     # S9+ 5
332             -93     # S9
307             -99     # S8
285             -105    # S7
257             -111    # S6
232             -117    # S5
206             -123    # S4
181             -129    # S3
165             -135    # S2
160             -141    # S1
```

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DL4OCH