D-STAR Repeater Fault Diagnosis: Mt. Climie 145.425 MHz and 438.600 MHz.

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Mt. Climie is a high elevation site north of the capital city of Wellington, New Zealand. The altitude above sea level is 867 meters or 2845 feet.

The amateur club, Branch 63 (NZART), maintaining the Mt. Climie site has two DSTAR repeaters. Both ICOM supplied RP-2000 and RP-4000 commonly connected to the RP-2C controller. This controller is connected via a 5 GHz WiFi link to the internet 6.3 kms away. (ZL2VH (Module B) 438.600 MHz and (Module C) 145.425 MHz)

The club technicians discovered early on after equipment installation that the traditional methods of fault diagnosing were quite different to that used on analogue FM repeaters. The Bit Error Rate (BER) that determines the quality of the digital signal could not be monitored easily, because Mt. Climie is a remote site. It is not an easy task to get this BER information when you are either sighted some distance away or on the valley floor where most users reside. Some repeater trustees have access to the ICOM receiver internals and have extracted useful information that way. Our ICOM repeaters were still under warranty which limited what we could do so as not to void this warranty.

What is the BER?

The Bit Error Rate or Bit Error Ratio is the number of bit errors divided by the total number of transferred bits during a studied time interval. BER is a unit less performance measure, often expressed as a percentage.

What causes poor BER?

In a communication system, the receiver side BER may be affected by duplexer, antenna transmission channel noise, interference QRM, distortion, bit synchronization problems, attenuation, multi-pathing, fading, etc.

The following preamble is covered band by band firstly with UHF.

UHF 438.600 MHz:

In most countries the 70cm amateur band is occupied by small signal remote control devices in the frequency range of 433 to 434 MHz. In New Zealand these devices often enter set to illegal power levels or have power boosters added to them to increase their range or performance. These signals interfere with amateur signals on the input of the DSTAR RP-4000 repeater on the 433.600 MHz input frequency. Previously the analogue FM repeater, using the same frequencies, needed a CTCSS decoder fitted to avoid false triggering.

While weaker amateur stations were communicating via the FM repeater the heterodyne from small signal devices could be heard in the back ground. (A nuisance if nothing else to normal communication.)

Weak signal users of FM who have switched to DV mode are now clear and free of any noise. This is the benefit of DV radio over FM analogue radio.

Weak signals clashing with bona fide weak DV signals result in a high BER and the

resulting R2D2 sound of a corrupted DV signal. This only lasts a short time but has often put a question mark on the RP-4000 repeater as having a fault.

Operators have in a very short space of time forgotten about QRM from other band users and blame D-STAR instead.

The other sources of high BER is from out of band high power commercial transmitters in close range of the D-STAR repeaters. Those along with faulty antenna and coax feeders all add up to provide QRM and diagnoses is therefore difficult when try to isolate the exact issue.

Using a correctly tuned multi pole duplexer with sharp skirts will illuminate overload to the RP-4000 from out of band transmitters. What is not that easy to determine is crackle and noise from faulty antenna dipoles, connectors or corroded feeder cable.

VHF 145.425 MHz

At Mt. Climie two VHF repeaters also share the site – one on FM 147.300 MHz (45W output) and other on D-STAR145.425 MHz (25W output).

Both are, at the time of writing, using Wacom WP-639 four cavity duplexer and traditional four dipole stacked array, with a phasing harness type design for the antennas. The phasing harness and dipoles use many connectors that work loose in time causing water ingress.

The Mt. Climie site is subject to freezing snow and ice during the winter and higher temperatures during the summer. Expansion and contraction has caused some connectors to fail or simply break apart.

Club Technicians keep an analogue VHF and UHF repeater in original working condition for the purpose of diagnosing QRM, crackle and noise de-sense problems.

The analogue repeaters are installed for a period of days and users asked to communicate both mobile and from home base stations. This has to be done during a period of fine and adverse weather conditions. Mt. Climie can have high velocity winds up to 170 km/hr at times that will reveal loose connections causing crackle and noise. If any degradation to the signal is heard the FM repeater can be left in service while the faults are corrected. Once the system is known to be good DV is then returned to service.

With the FM repeater in service (VHF or UHF) a weak signal source is connected to the antenna feeder via an “Iso T”. The FM repeater TX can then be enabled or disabled to check for de-sense or degradation. The repeater duplexer can be illuminated with a 50 ohm load connected to the antenna port.

If de-sense and noise bursts are heard whenever the TX is enabled, i.e. Repeater is in repeat mode, then the problem is the duplexer.

If the problem only occurs with the antenna connected then it is a combination of the feeder and antenna.
The feeder then needs to be disconnected at the antenna and signal injected there. If still good then the antenna has a fault.

A Time Domain Reflectometer (TDR) or network analyzer might be used to determine where a bad connection is but RF wideband noise generated by corroded joints is more difficult. RF heating in bad joints or across corroded surfaces will produce noise on the RX frequency. This noise on the RX frequency degrades the real signal that should pass through the repeater. A regular culprit is LMR400, Beldon 9913 and RG-214 coax. Any movement of the braid and foil will cause noise. This is worse with the ingress of moisture causing corrosion to start.

The point I am emphasising here is, that the repeater must function without any noise or de-sense evident in analogue FM mode before a D-STAR repeater is connected to the duplexer and antenna. If this is followed the data errors will only be evident and expected with marginal DV signals and not caused by a poor repeater installation.

Communication must be two way and simply triggering (or kerchucking) the repeater does not constitute a valid check that the repeater is working correctly.

The following explanation details the current methods used to determine the BER and the reasons why this is so important in maintaining a D-STAR system.

I recently purchased a DV Dongle device and was pleasantly surprised that a BER readout was available on my PC screen. This feature is available with DVtools2.0beta5 software release. With a good 128kbps, ADSL or Cable internet connection I could connect to the ZL2VH Gateway Module C VHF or Module B UHF repeaters. The BER could then be checked on RF signals passing though each repeater.

The RF radio I use is the ICOM IC-2820H. Reading the service manual I was able to build a service RJ-45 plug and cable to access the engineering menu. Once inside the menu the TX power on the “LOW” position could be adjusted from the standard 5 watts output. I have been able to adjust the power on VHF and UHF down to a level where the BER is just lifting off Zero reading 1-4 via the DV dongle. 150 mW on VHF and 200 mW on UHF feeding my roof top mounted newly installed Diamond Super Gainer antenna. A BER of more than 50-100 will show signs of R2D2 and warble in the speech. When the BER increases over 100 communication is very difficult and often lost. Club technicians are now able to examine the D-STAR systems on a monthly schedule to determine if an increase in BER is caused by poor RF transmission or Wi-Fi link degradation.

Recently an RX attenuation fault was found on the RP-4000 repeater using this method. At the repeater site the same “Iso T” injection method is used with the IC-2820H and a stepped attenuator to find the correct levels. The repeaters are then keyed on and off using the ICOM service software connected via USB front panel service ports.

The analogue FM method described previously has always proved to be the more effective way of determining faults on site and the DV dongle BER method from home station.

I hope this article gives an insight and ideas to any repeater groups who maintain DSTAR systems and have difficulties knowing how to go about diagnosing a problem.

73 and good DV, John ZL2TWS