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SWISS C-BAND RADAR NETWORK MONITORING

Long and Short Term Monitoring: Magnetron and TR-Limiter as examples

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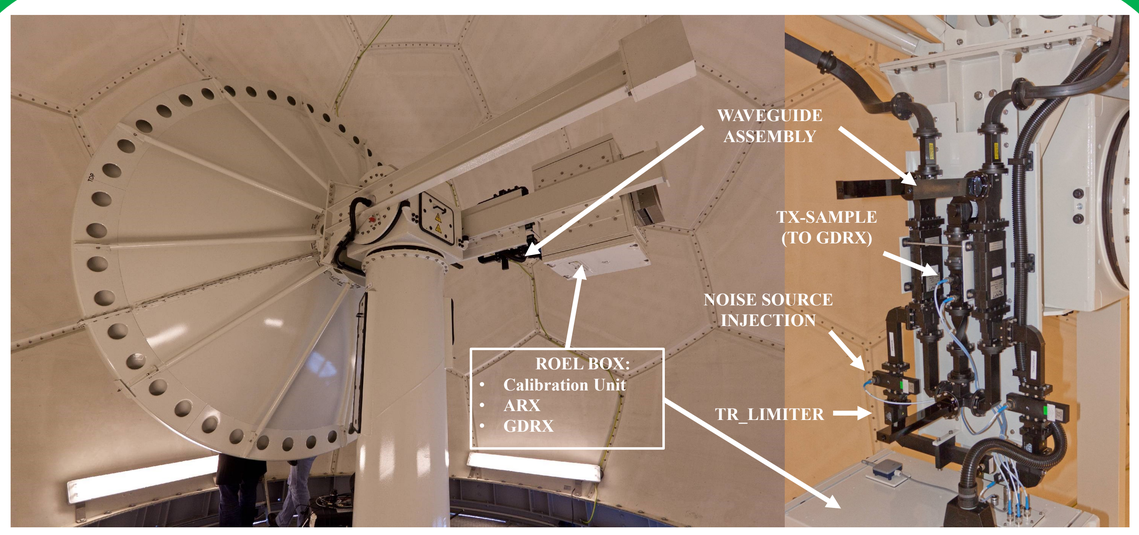
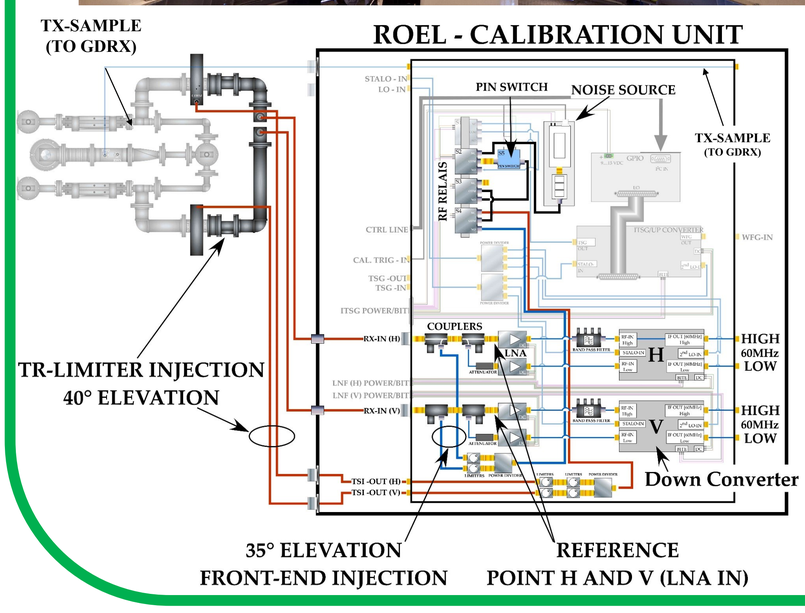
System Setup





TX SAMPLE
In the ROEL System, the Tx-Sample is measured just before the Magic-T (waveguide to coaxial coupler). Down-conversion and Digitization is performed in the ROEL Box (Analogue receiver ARX and digital Receiver GDRX, respectively)

TR-LIMITER
A noise source signal is injected via coupler in front of the TR-Limiter, in order to monitor it's behavior.

In this particular case, the noise source is used to monitor the TR-Limiter (injection at elevation/sweep 40°). The noise source is also used for calibration, in this case it is injected via directional coupler just in front of the LNA (Reference Point H and V) at elevation/sweep 35°.

Magnetron Degradation Monte Lema

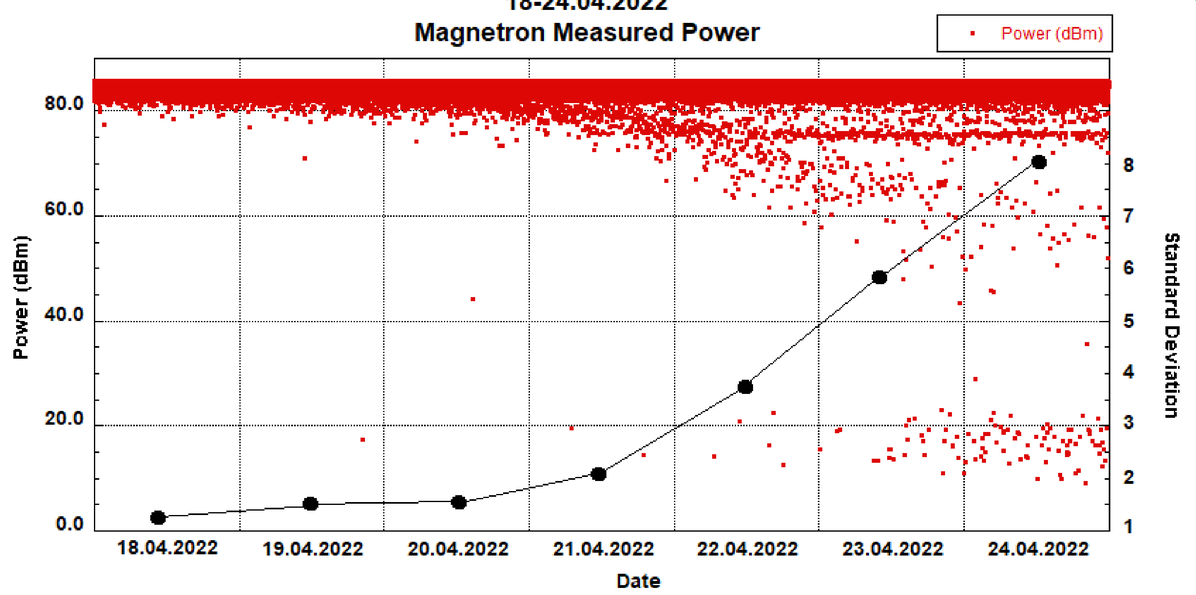


Figure 1:
Each red point represent an averaged power value from a few transmitted pulses (3-4). The Tx-sample is collected at the TX-Coupler (see System Setup) and measured in the Digital receiver (GDRX in the ROEL Box). At the end of each sweep (20 in total for each volume) the last measured value is stored, resulting in 20 values every 5'. Standard Deviation daily trend (black dots) was calculated using 5760 samples per day.
The magnetron on Monte Lema was running since summer 2010 (commissioning), operational at radar site since Mai 2011. We observed a steady degradation (increase in the dispersion) since winter 2021. The dispersion increased to alarming proportions in April 2022, as you can see above. On April 25, 2022, the magnetron was replaced.
In the week following the replacement, the Standard Deviation over ca. 7 days with the new magnetron:
Standard Deviation after replacement : 0.0685 (40293 samples).

Magnetron Degradation Plaine Morte

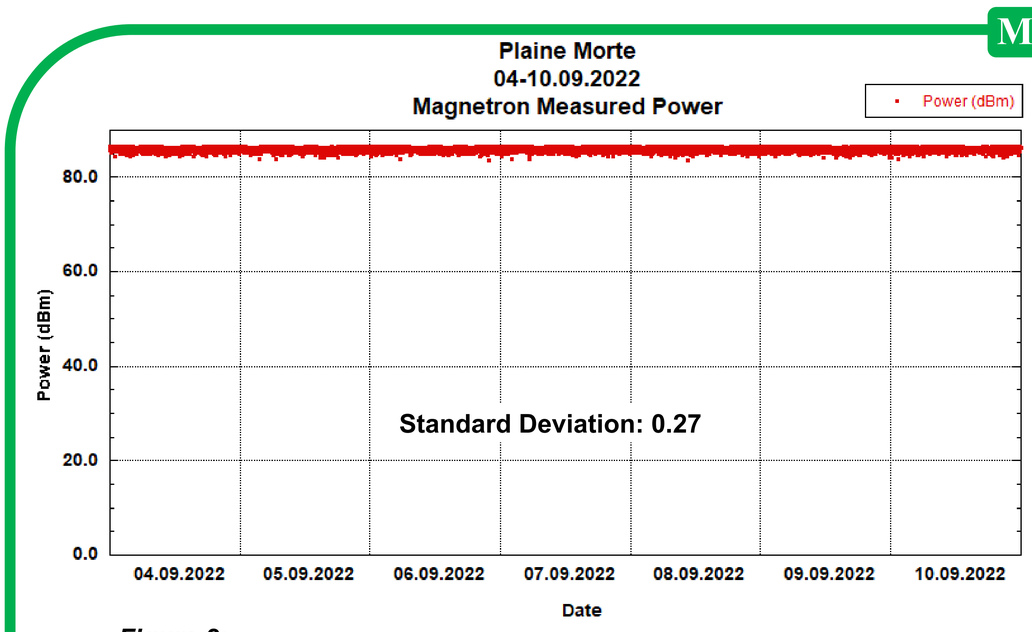
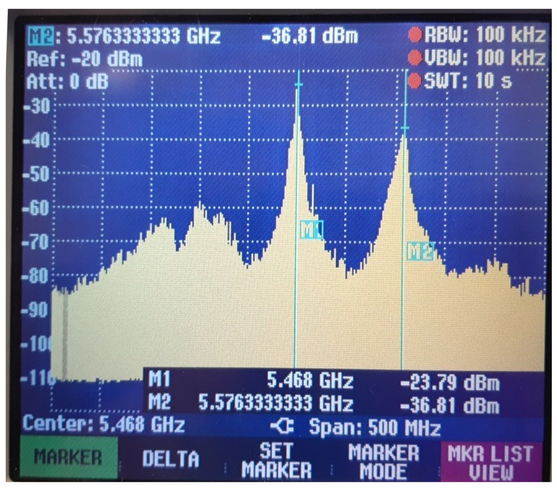
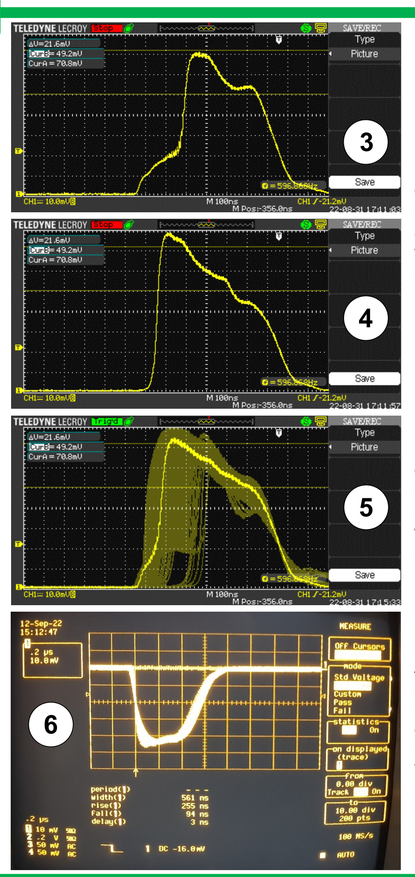


Figure 2:
Tx-power measurements have been collected for one week, in the same manner as described in Figure 1. For comparison purposes, the y-scale is the same as in Figure 1. Despite the striking difference, the dispersion observed at Plaine Morte was already an indication of aging. Standard Deviation over the entire week (40319 samples) was 0.27, lower that the lowest value in Figure 1. In Picture 2 to 5, additional measurements showed anomalous behaviors on the spectrum and on the pulse.
This magnetron, a modified version for high altitude operation (3000m), was installed on June 24, 2015. On September 12, 2022, the magnetron was replaced.
Standard Deviation after replacement: 0.094 (5760 samples).



Picture 2
31.08.22: The spectrum measured at magnetron output shows the operational frequency at 5.468 GHz, and a very strong spurious signal at +108 MHz from the carrier.



Picture 3 and Picture 4
31.08.22: The signal was measured with an oscilloscope (+ detector diode) at the output of the TX-coupler used to measure the TX-sample at Plaine Morte. The subdivisions are 100us, 10mV. In both cases, single-shot images were taken, showing a high variability in pulse shape (PW nominal : 500ns).

Picture 5
31.08.22: The oscilloscope was set to Persistence Mode over a period of 5 minutes (same configuration as in pictures 3 and 4). The subdivisions are 100us, 10mV. The measured pulse width at Plaine Morte is highly unstable, with variations in pulse length length exceeding 200ns (PW nominal: 500ns).

Picture 6
As a comparison: example of an oscilloscope measurement performed at La Dôle on September 2022 (magnetron running since 2011), using persistence Mode over a period of 5'. Note that the subdivision is 200ns, 10mV (PW nominal: 500ns).
The observed jitter is of the order of ca. 100ns

TR-Limiter Degradation Albis

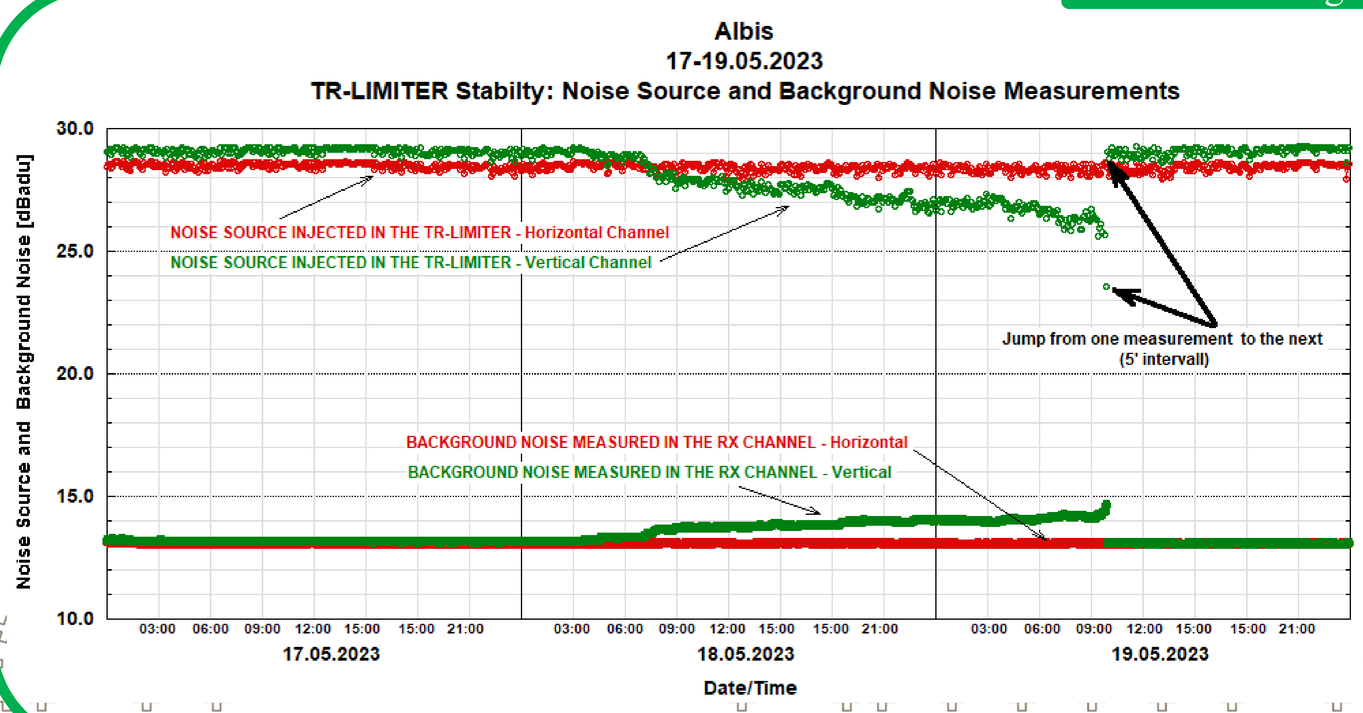


Figure 3:
For monitoring purposes, every 5' minutes the noise source signal in injected into the receiving path, just in front of the TR-Limiter (see system setup). The signal in injected and measured at a range of 40km up to 50km, for the entire sweep, i.e. 360°. At the same time, the measurement without noise source signal is repeated at a distance of 60km up to 70km. At this distances, only background noise from the antenna is measured.
For both procedures, an average value is computed every 10° from a set of ca. 50'000 measurements. This results in 36 average values, from which a "median" is calculated. These median values are the ones plotted in figure 3, with a resolution of 5'. We have thus two noise source measurements in the horizontal and vertical channel (nominal values around 28-29 dBadu), and two background measurements in the horizontal and vertical channel (nominal values around 13 dBadu). The value 13dBadu (digital units) represents the noise floor of our system (ca. -112dBm).

On Mai 18, 2023, the measured noise source signal in the vertical channel starts decreasing steadily in power, with a total loss of ca. 3dB on Mai 19 at ca 10:00. At the same, the background noise in the vertical channel increases, also steadily, from ca. 13dBadu up to values close to 15dBadu.
Then a very unusual (unique, as far as our experiences teaches us) behavior was observed: Around 10:00 on Mai 19.05.23, the noise source was measured at 23.6dB, five minutes later it was measured at 30dBadu, the expected nominal value. At the same time, the background noise went back to its nominal value. One may wonder, why it is the magic-T that is called "magic", and not the TR-Limiter…
On Mai 24, 2023, the TR-Limiter in the vertical channel was replaced

Final Note: This was a TR-Limiter with tritium as primer. We already started the migration to TR-Limiters with no radioactive primer (migration completed in four out of five radars).