**Deutscher Wetterdienst**
**Wetter und Klima aus einer Hand**

# Upgrading the DWD weather radar with a new STALO and an internal test signal generator

**Jan Petersen, Bertram Lange, Michael Frech, Maximilian Schaper, Benjamin Rohrdantz**

*A replacement of Stable Local Oscillator (STALO) and internal Test Signal Generator (iTSG) was necessary due to a shortage of spare parts and the fact that the components reached the end of their lifetime. Therefore, starting in November 2022, both components were replaced in the 17 weather radars by commercially available signal generators. Prior to introduction into the radar network, comprehensive tests were carried out. The setup with the two new devices was then incorporated into the research radar Hohenpeißenberg in order to demonstrate the full functionality. Since the STALO and the iTSG differ only in their technical specifications regarding the usable power level range, the components can be mutually replaced in the event of failure, thus increasing operational reliability.*

## Integration

In order to improve the spare parts situation, a public tender for the signal generators was prepared. For the STALO, emphasis was placed on phase noise, while the iTSG had to have a higher power level range. Since the same model "AnaPico APSIN6G" was procured for both components and they only differ in an extended level range, the STALO can be easily replaced by the iTSG in case of failure. To swap them, it is only necessary to reconnect the RF signal (see Fig. 1) and change the network address.

To obtain regular calibration data, an additional signal path was created for the iTSG. For this purpose, the input of the iTSG signal must be mechanically connected to the cross-guide coupler (CGC) instead of the low noise amplifier.


*Fig. 1: Radar receiver box with two integrated AnaPico APSIN6G (STALO left, iTSG right). The path to the CGC is not visible.*

## Power output and phase noise measurement

In order to verify the specifications of the signal generators, automatic test procedures for measuring power level accuracy and phase noise have been developed. Before execution of the automatic measurements, the devices were active for 15 minutes to reach the operating temperature. It was measured at a frequency of 5.6 GHz for the supported level range.

Figure 2 shows the combined results of all the iTSGs tested, with each color representing a separate unit. The Y-axis represents the difference between the set level and the measured level. Values above 0 dB indicate that the output power was higher than set. Except for one device, the deviation is below 0.75 dB in the range of -85 dBm to +20 dBm. Below a level of -90 dB it can be seen how the variance increases with decreasing level. A later long time measurement showed that after 60 minutes warm-up time the level accuracy improves up to 0.25 dB and that the frequency offset at peak power became smaller.

Fig. 3 shows the combined results of the phase noise measurement for the local oscillators, with each color representing a separate unit. For recording the data the Rohde & Schwarz FSPN-8 was used. The specified criteria of the tender were -80 dB for a frequency offset of 100 Hz and -105 dB for an offset of 10 kHz. The results of all devices show a low variance and a 5 dB better phase noise at both defined points than specified.

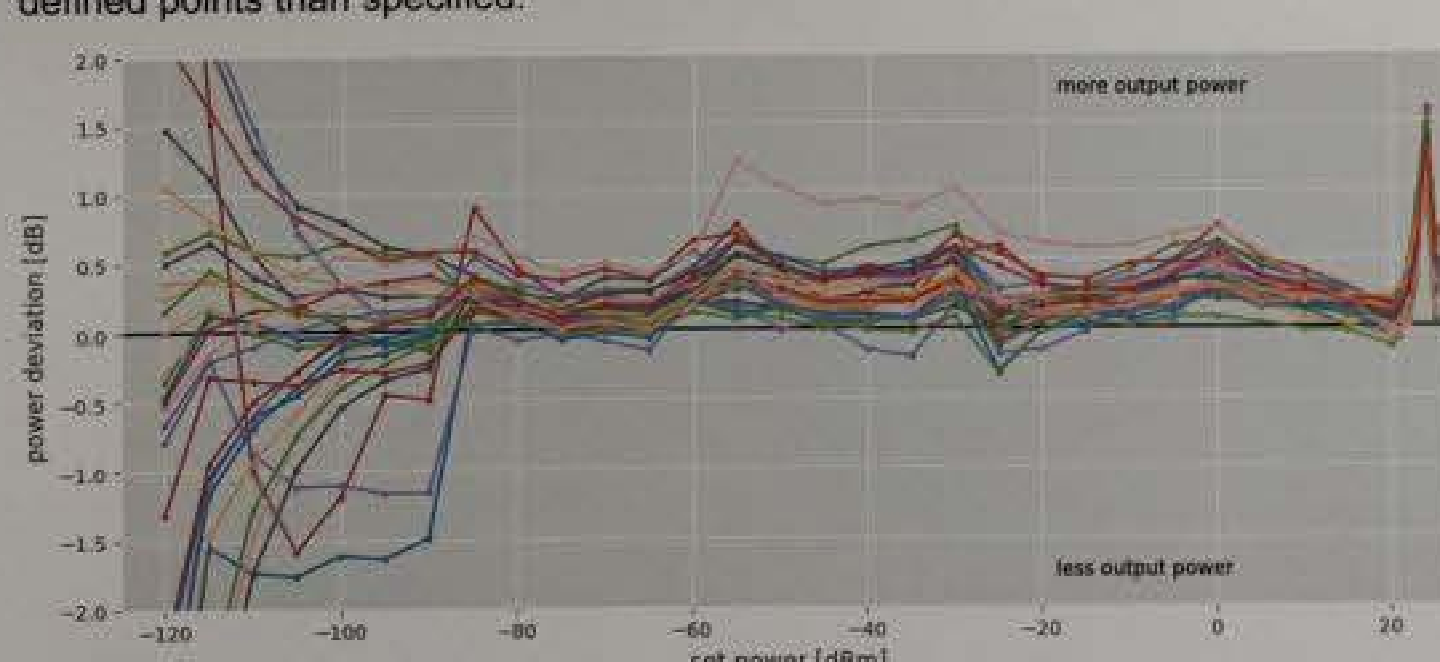


*Fig. 2: Deviations between set and measured power levels of -120 dBm to 25 dBm for the test signal generators used. Each color represents one of the 30 iTSGs tested. There is no metrological explanation for the systematic deviation of +1.5 dB at 22 dBm.*


*Fig. 3: Phase noise (PN) of the procured stable local oscillators at 5.6 GHz. The markings in red at 100 Hz and 10 kHz indicate the required specifications. In addition to the phase noise, the amplitude noise (AN) and the total noise (PN+AN) were also recorded (not shown here).*

In order to test the level stability during temperature fluctuations, an experimental setup was created in which the Anapico device was located inside a climatic chamber and the measuring device at room temperature. Starting at -15 °C, the temperature was gradually increased to +40 °C. Figure 4 shows the measured power deviation against the set power. Each temperature state was held for 60 minutes (marked in different colors) to allow the temperatures to settle. It can be clearly seen that the output power increases with rising temperature with a maximum level deviation of approx. 0.21 dB within a temperature range of 55 K.

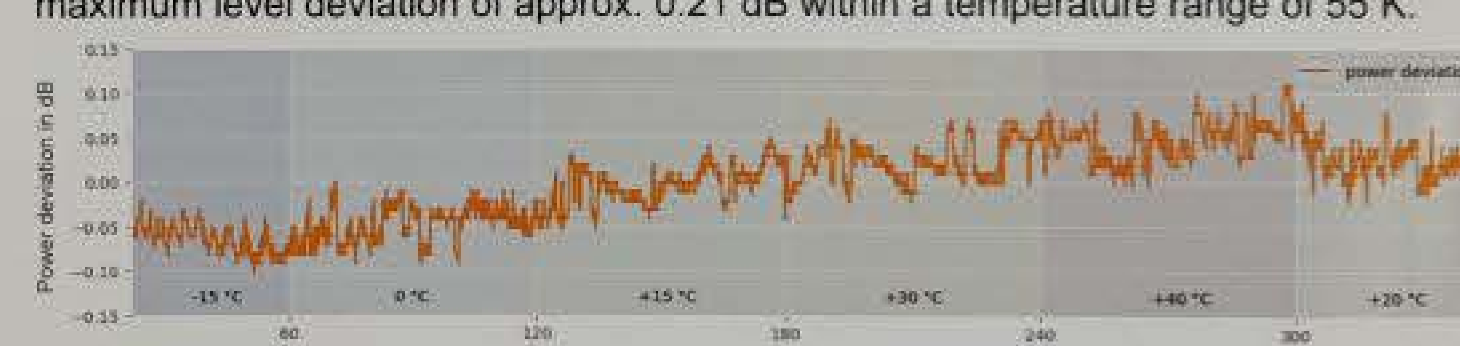


*Fig. 4: Power deviations at 20 dBm in the temperature range from -15 °C to +40 °C. Jumps in the measurement are due to short-term level changes to obtain a data set at a lower power level (-60 dBm).*

## Clutter target scan

The setup with new signal generators was incorporated into the research radar Hohenpeißenberg in order to demonstrate the full functionality by checking the radar coherence using clutter target scans. In addition to the APSIN, other models were also tested (see Fig. 5). In the horizontal polarization there are no significant differences in clutter correction, in the V channel there is a deviation of up to 3 dB.

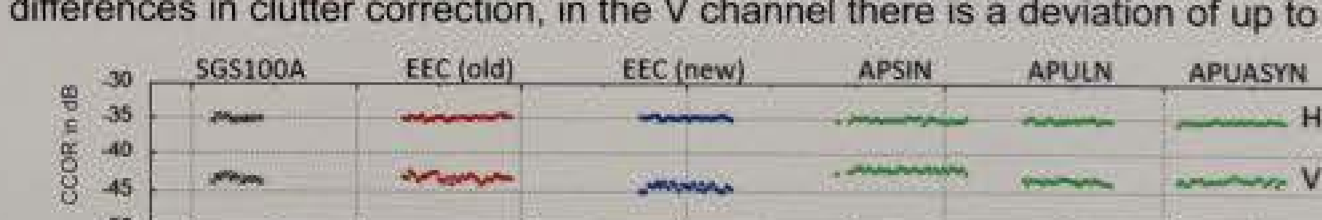


*Fig. 5: Measurement of CCOR at target scan in H (top) and V (bottom). Several AnaPico models were tested (green). A TV tower at a distance of 1.14 km was used as a fixed target.*

## Calibration scan

Feeding the iTSG signal to the CGC enables monitoring of the receiver path. Every two hours at the end of the scan routine a test signal with 20 dBm is fed in. In addition to the power samples (SNR at IFD), the sensitivity in form of dBZ0 is recorded for each channel and stored in the database with additional metadata.

Fig. 6 shows the correlation between the temperature in the receiver box and the measured SNR. With an increase of 10 K, the SNR decreases by about 0.7 dB. Furthermore, the scan offers the possibility to monitor the degradation of the TR limiters as soon as long-term data are available.


*Fig. 6: Correlation of power samples (left axis) temperature of the receiver box (right axis).*

**Deutscher Wetterdienst**
**Jan Petersen, jan.petersen@dwd.de**