Horizontal Scan – Theory and Practice

Radio direction finding on a FM transmitter using horizontal scan and triangulation

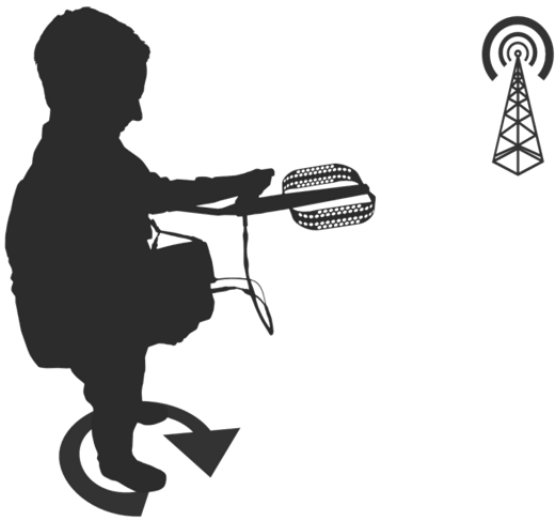

Figure 1: Procedure for a horizontal scan. The signal level is recorded over a 360° angle using the appropriate directional antenna.

The main tasks of the IDA-3106 lie in the detection, classification and localization of RF signals. These tasks are made easier by the directional antenna set with its built in electronic compass. Functions such as Horizontal Scan with automatic determination of azimuth, and smartDF® for automatically calculating the transmitter positions are outstanding features.

Horizontal Scan allows precise automatic determination of the azimuth angle of a transmitter being looked for. The scan is started and stopped by pressing the button on the antenna handle, while the antenna is evenly panned horizontally during the scan. The IDA-3106 presents the measurement results of a horizontal scan in the form of a polar diagram. It calculates the most likely direction of a transmitter from this information. The Max Hold function allows the localization of signals even if they are only transmitted intermittently. As soon as the scan result has been saved, smartDF takes over further processing of the data. These functions conveniently solve the problem of manual direction finding.

Horizontal Scan: What does the diagram reveal?

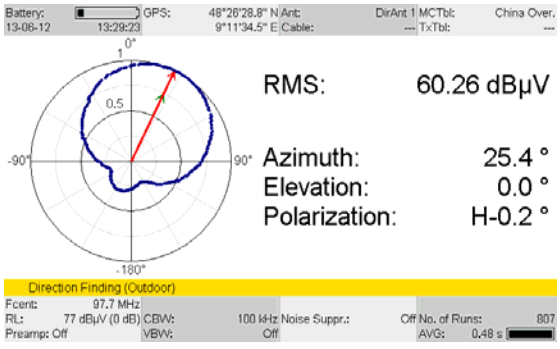

Figure 2 – Bearing 1: Ideal situation for a horizontal scan. The polar diagram shows the directional characteristic of the direction finding antenna because the field is undistorted (compare Figure 9). Interpretation is simple, the bearing of the source is easily found.

Performing a horizontal scan results in a polar diagram, which shows the measured signal level over an angle of 360°. The diagram is arranged on the instrument display. In the ideal situation – a transmitter with constant power and without any distortions caused by the surroundings – the polar diagram shows the far field directional characteristic of the direction finding antenna. In this case it is very easy to determine the direction simply from the signal maximum. A comparison with the expected antenna characteristic is a useful reference here. All the antennas used have a relatively monotonically decreasing major lobe and almost no minor lobes. If the diagram is significantly different from this, it is likely that reflections from the surroundings or co-frequency transmitters have also been recorded.

FM transmitter

Figure 3: Recording a horizontal scan in an open space. The conditions for taking bearings on the FM transmitter are ideal. Vertical polarization was selected here as an experiment. Normally, DAB transmitters are vertically polarized and analog FM transmitters horizontally polarized.

Advantages of graphical display

In the ideal situation already described, the recorded scan shows the directional characteristic of the receiving antenna. The measured signals are normalized linearly to the maximum value (1 = 100 % signal strength) during the measurement. The graphical display makes it easier to distinguish between directly received signals and reflections. Based on these horizontally measured values, the IDA-3106 automatically estimates the direction of the signal source using several parameters.
If the direction calculated on the basis of the measured values does not seem plausible, this can be seen in the diagram and corrected manually. In practice, reflections often occur. These are superimposed on the ideal diagram and make direction finding more difficult. The reflected signal can be stronger than the directly received signal if the latter is shadowed by some obstacle at a particular location. Expert assessment of the polar diagram will allow users to recognize these reflections and correct an erroneous bearing if necessary. The next section illustrates this by way of example.

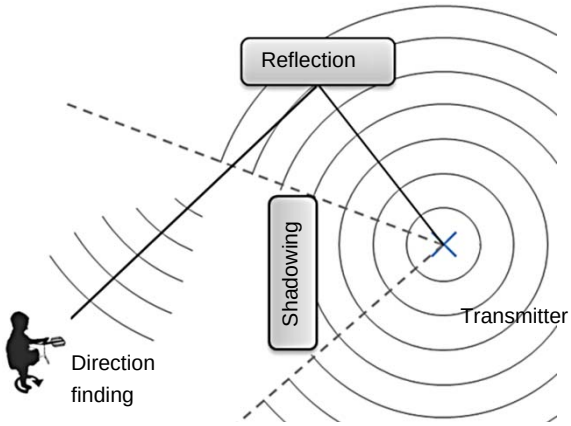

Figure 4: Shadowing and reflection during direction finding.

A practical example

Direction finding of a 97.7 MHz FM transmitter was carried out in order to demonstrate the capabilities of the Horizontal Scan function in a practical application. Four horizontal scans were recorded. The first bearing was taken under ideal conditions from an open space. The diagram (Figure 2) shows the directional characteristic of the direction finding antenna (Figure 9), as expected. Users should always be aware that the antenna characteristics change, depending on the frequency

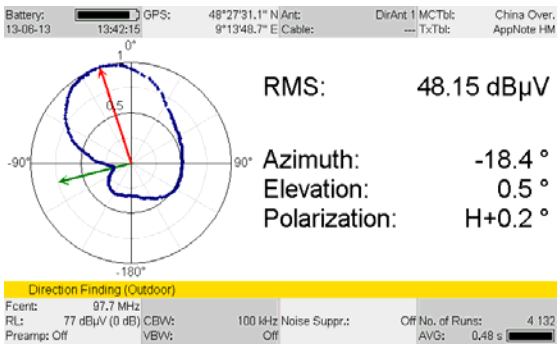

Figure 5 – Bearing 2: Reflection effects. The red arrow indicates the calculated direction. The green arrow indicates the direction in which the antenna is currently pointing. From this direction, the reflections almost obliterate the signal.

and the orientation relative to the polarization of the field. The bearing result is saved in the instrument using the “Localization” softkey.
A second bearing was taken in an industrial area. Obvious shadowing and reflections can be seen here (Figure 5). The diagram is distorted by shadowing due to buildings, and the direction determined is incorrect. Reflections from buildings, vehicles and even a lamppost also falsify the characteristic. Expert assessment is called for here; the incorrect bearing is apparent from the diagram. The scan was rejected.
An open space behind a hill was chosen as a further measurement location. The hill was directly between the measurement location and the transmitter for bearing 3. The transmitter is therefore strongly shadowed by the hill. The shadowing can be clearly seen in the polar diagram (Figure 6). Reflections cause the highest signal level to be measured in the wrong direction.
A final bearing 4 (Figure 7) was taken under largely ideal conditions in an open space with a line of sight to the FM transmitter.
All the horizontal scans were saved in the instrument and shown on the map. By this point at the latest, the incorrect bearings become apparent. However, the graphical display as a polar diagram makes it possible to recognize false bearings immediately.
Only bearings 1 and 4 were used for the evaluation.

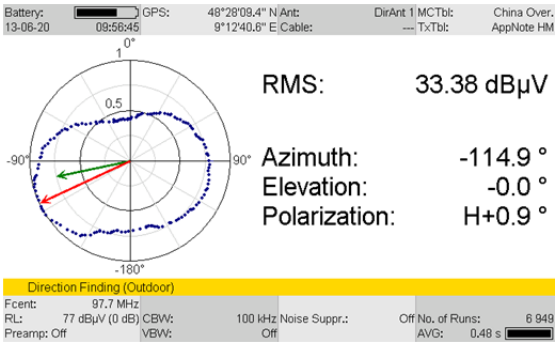

Figure 6 – Bearing 3: Horizontal scan from an unfavorable location behind a hill. Shadowing and reflections cause the direction to be determined incorrectly. An expert can see from the shape of the measured characteristic that the measurement is incorrect.

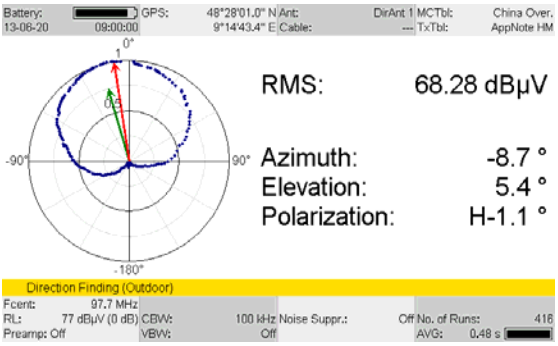

Figure 7 – Bearing 4: Ideal conditions just like Bearing 1 (Figure 2).

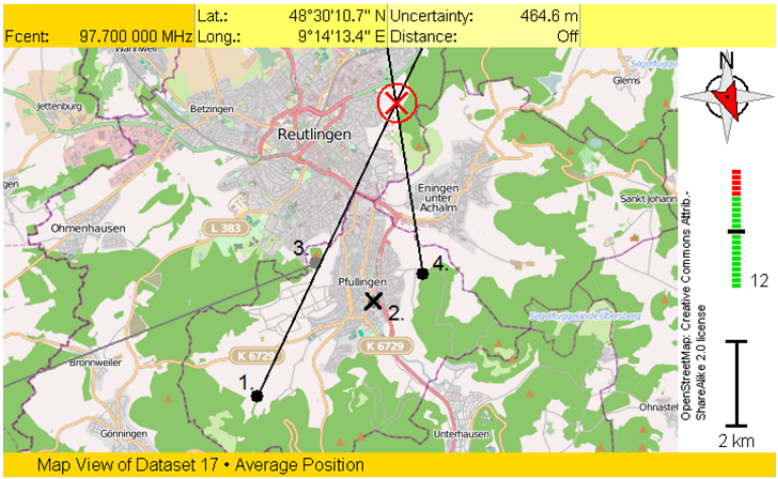

Figure 8: The instrument displays the bearing result of the saved horizontal scan on the map directly on site. False bearing 2 was rejected, and false bearing 3 points in the wrong direction because of shadowing by the hill. The two successful bearings 1 and 4 are enough to pinpoint the location of the transmitter.

There are four directional antennas covering different frequency ranges for direction finding with the IDA-3106. The antenna used in the example described is Directional Antenna 1, a frame antenna, which covers the frequency range from 20 MHz to 250 MHz.

For more information on the IDA-3106 and its antennas, go to:
www.narda-ida.com

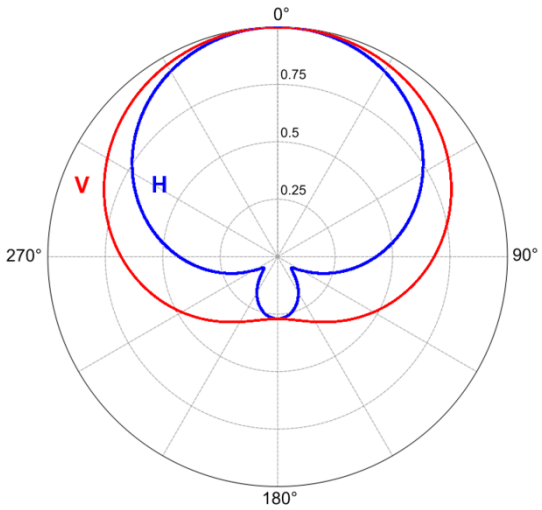

Figure 9: The typical directional characteristic of Directional Antenna 1 at 150 MHz for vertical (V) and horizontal polarization (H).

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