Operating principle

Frontend

Starting from the antenna socket, the frequency in the signal path is limited to 8 GHz. Signal processing then takes place in three paths for three different frequency ranges.

Signals from 9 kHz to 30 MHz are routed via a preamplifier directly to the A/D converter. Signals from 20 MHz to 3.5 GHz are taken to the IF section via a preselection and a preamplifier, or via an attenuator in the case of high signal levels. The preselection as well as the attenuator effectively protect the IF section against overloading. This is particularly important in this frequency range, where the maximum signal sum levels occur. Signals from 3.5 GHz to 8 GHz are taken to the IF section via a preamplifier.

The three-stage IF section processes the signals from 20 MHz to 8 GHz for the subsequent A/D converter. To provide optimum instrument performance, only signals up to 7.5 GHz are processed in the subsequent stages. The uncontrolled 21.4 MHz IF can also be tapped ahead of the A/D converter via a BNC socket of the R&S®PR100 for further external processing.

Digital signal processing

After A/D conversion of the signal, the signal path is split up:

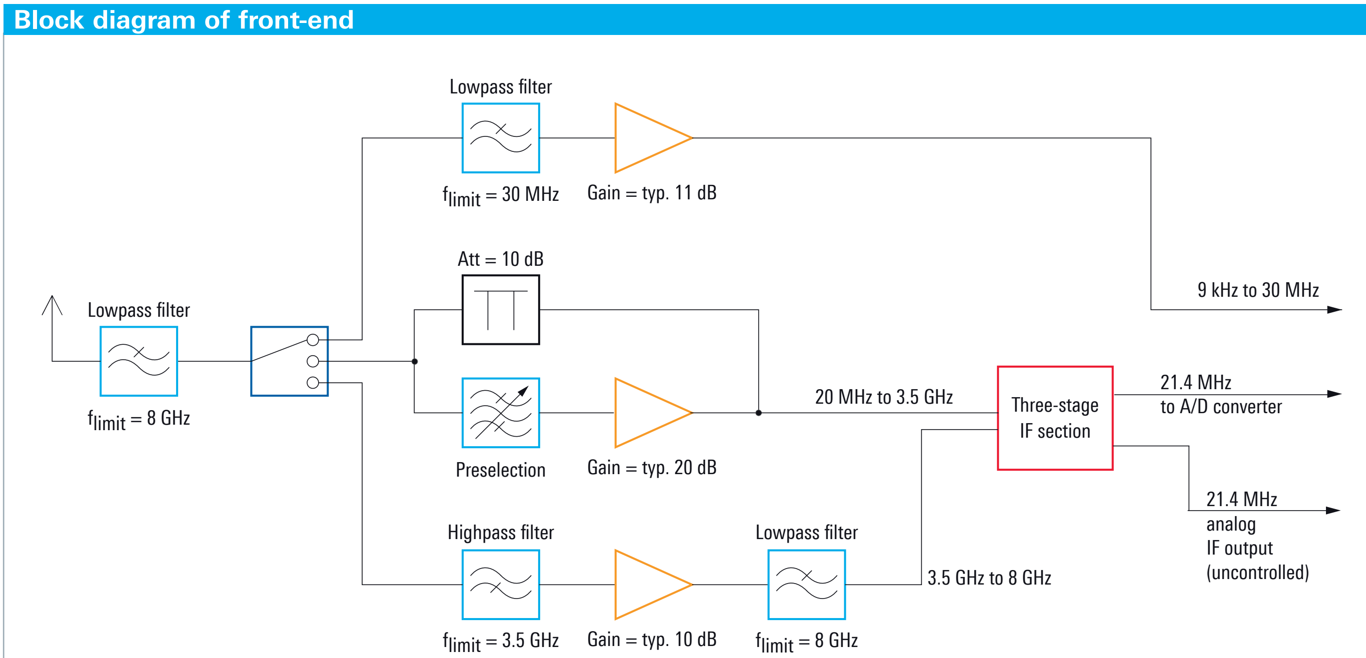
In the first path, the IF spectrum is calculated by means of a digital downconverter (DDC), a digital bandpass filter and an FFT stage. The bandwidth of the bandpass filter can be selected between 10 kHz and 10 MHz. Before the IF spectrum is output on the display or via the LAN interface, results are postprocessed by means of the AVERAGE, MIN HOLD or MAX HOLD function as selected by the user.

In the second path, the signal is processed for level measurement or demodulation. Here, too, the signal is taken via a DDC and a bandpass filter. To process the different signals with optimum signal-to-noise ratio, the receiver contains IF filters with demodulation bandwidths from 150 Hz to 500 kHz, which can be selected independently of the IF bandwidth.

Prior to the level measurement, the absolute value of the level is determined and weighted by means of the AVERAGE, MAX PEAK, RMS or SAMPLE function, as selected by the user. The measured level is then output on the display or via the LAN interface.

For the demodulation of analog signals, the complex baseband data is subjected to automatic gain control (AGC) or manual gain control (MGC) after the bandpass filter. It is then applied to the AM, FM, USB, LSB, ISB, PULSE or CW demodulation stage. The complex baseband data (I/Q data) of digital signals is directly output for further processing after the AGC/MGC stage.

Block diagram of front-end



The results obtained are available as digital data and can be output via the LAN interface as required for the particular task. Digital audio data are reconverted to analog signals for output via the loudspeaker.

High receiver sensitivity, high signal resolution

The R&S® PR100 features an IF bandwidth of up to 10 MHz. This allows even very short signal pulses to be captured since the receiver displays the large bandwidth of 10 MHz in a single spectrum about the set center frequency without any scanning being required.

The widest IF bandwidth of 10 MHz yields the widest spectral display; the narrowest IF bandwidth of 10 kHz yields maximum sensitivity.

The IF spectrum is digitally calculated by means of a Fast Fourier Transform (FFT). The use of FFT computation at the IF offers a major advantage: The receiver sensitivity and signal resolution are clearly superior to those of a conventional analog receiver at the same spectral display width.

IF spectrum

FFT calculation of the IF spectrum is performed in a number of steps. These are described below in simplified form for an IF bandwidth of 10 kHz ($BW_{IF\ spectrum}$ = 10 kHz), which yields maximum sensitivity.

Due to the finite edge steepness of the IF filter, the sampling rate f_s must be larger than the selected IF bandwidth $BW_{IF\ spectrum}$. The quotient of the sampling rate and the IF bandwidth is thus a value >1 and is a measure of the edge steepness of the IF filter. This relationship is expressed by the following two formulas:

$$\frac{f_s}{B_{IF\ spectrum}} = const$$

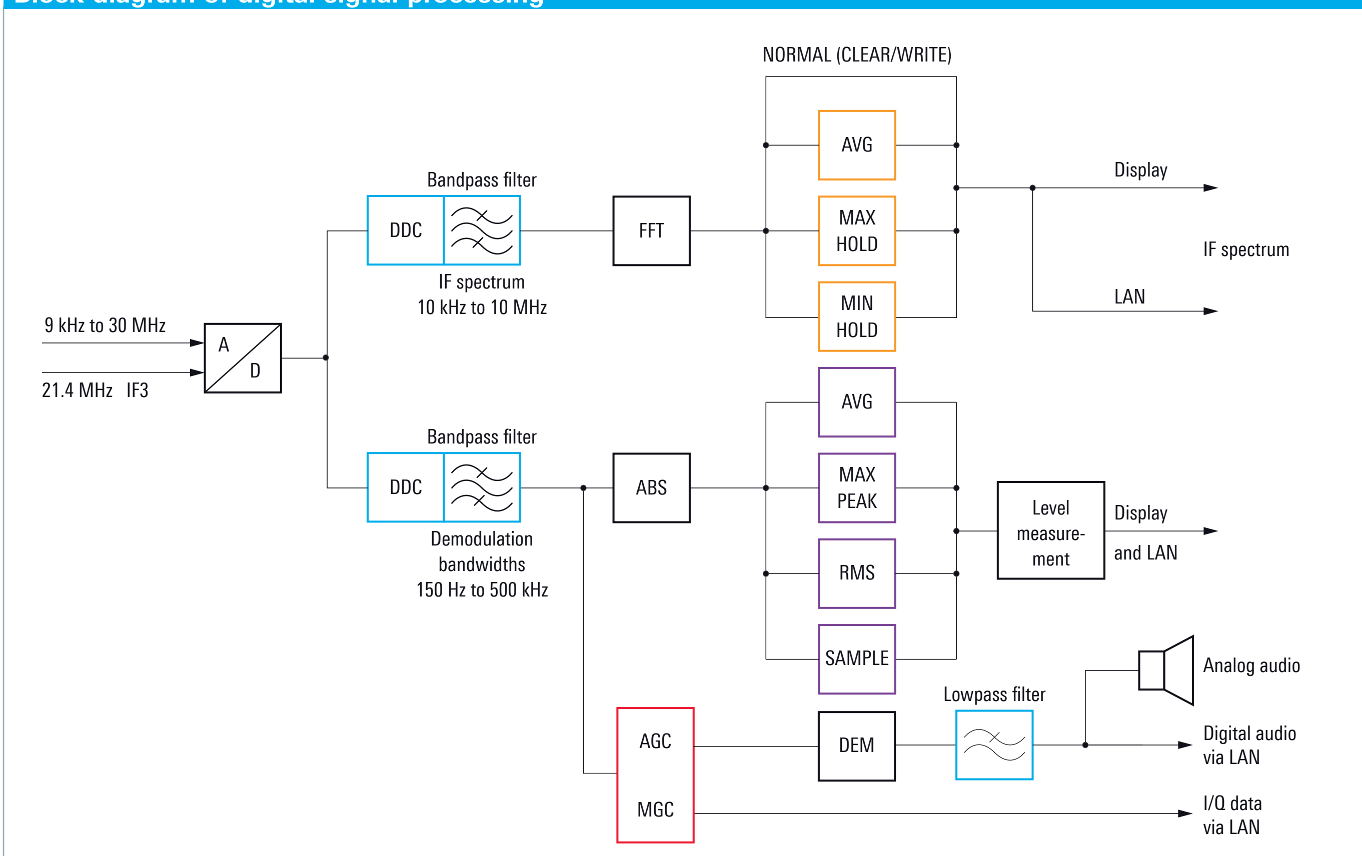
or

$$f_s = BW_{IF\ spectrum} \cdot const$$

The value of the constant is dependent on the selected IF bandwidth, i.e. it may vary as a function of the IF bandwidth.

For an IF bandwidth of $BW_{IF\ spectrum}$ = 10 kHz, the constant has a value of 1.28. To display a 10 kHz IF spectrum, therefore, a sampling rate of f_s = 12.8 kHz is required.

Block diagram of digital signal processing



The R&S®PR100 uses an FFT length N of 2048 points to generate the IF spectrum. To calculate these points, the 12.8 kHz sampling band in the above example is divided into 2048 equidistant frequency slices, which are also referred to as “bins” (see figure "Signal processing for IF spectrum").

The bandwidth BW_{bin} of the frequency slices is obtained as follows:

$$BW_{bin} = \frac{f_S}{2048} = \frac{12.8\ \text{kHz}}{2048} = 6.25\ \text{Hz}$$

This means that in the above example only the calculated bandwidth of 6.25 Hz for each bin has to be taken into account as the noise bandwidth in the calculation of the displayed average noise level (DANL) in accordance with the formula below (the effect of the window function (Blackman window) of the FFT is not considered here for simplicity's sake):

$$DANL = -174\ \text{dBm} + NF + 10 \cdot \log(BW_{bin}/\text{Hz})$$

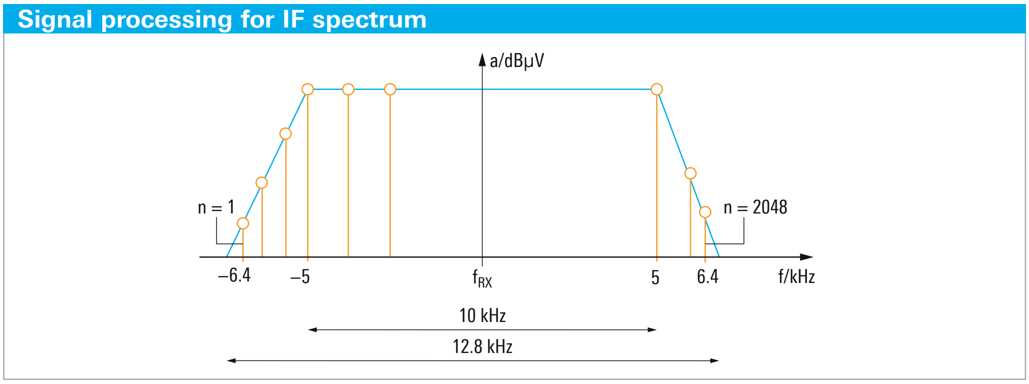
The quantity NF represents the overall noise figure of the receiver.

The above example shows that, due to the use of the FFT, the actual resolution bandwidth (RBW) to be taken into account in DANL calculation is clearly smaller (i.e. BW_{bin}) than would be expected for the wide display range of 10 kHz.

Another advantage of the high spectral resolution used in the FFT calculation is that signals located close together (e.g. f_1, f_2, f_3) can be captured and represented in the IF spectrum as discrete signals (see figure "Signal display in IF spectrum").

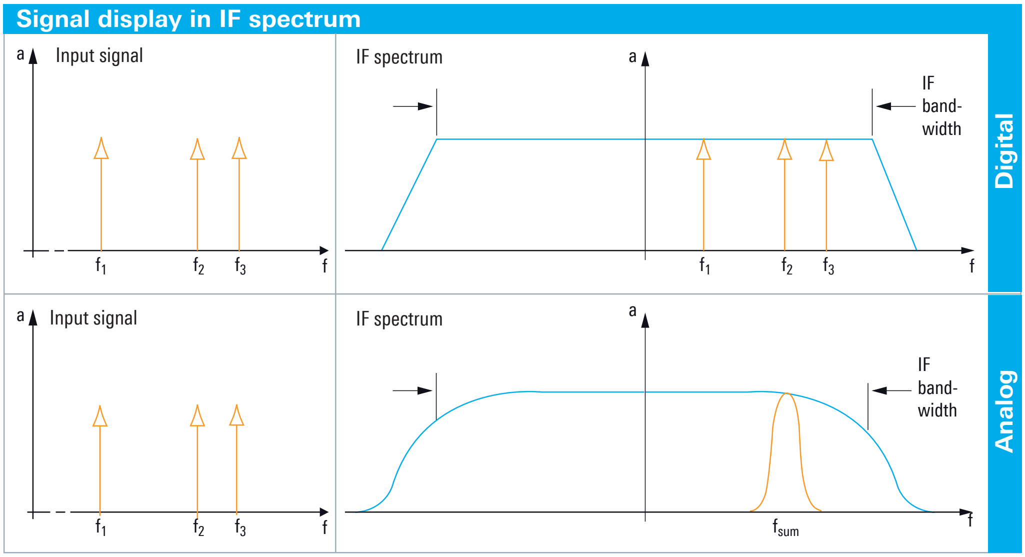
If, on an analog receiver, a resolution bandwidth equal to the set IF bandwidth were selected ($RBW = BW_{IF\ spectrum}$), a sum signal f_{sum} would be displayed instead of the three discrete signals f_1, f_2 and f_3.

Signal processing for IF spectrum



Actual sampling bandwidth compared with selected IF bandwidth

Signal display in IF spectrum



Signal resolution in IF spectrum with digital and analog receiver concept