Spectrum Analyzers R3172 / R3182 from Advantest

Analyzing broadband FMCW signals at a keystroke

FIG 1 Spectrum Analyzer R3182 from Advantest (9 kHz to 40 GHz)

FMCW signals have become popular for distance measurements in recent years in addition to classic pulsed radar signals. For this special and new measurement application, Advantest has developed an FM demodulation option for its Spectrum Analyzers R3172 and R3182 (FIG 1), allowing demodulation of FMCW signals and examination of deviation and linearity.

A new measuring application – FMCW signals

Classic distance measurement is based on time-delayed reception of pulsed signals. The distance is determined from the time it takes the pulse to travel between the transmitter and receiver via a reflecting object.

In contrast to this, FMCW (frequency-modulated continuous wave) signals are applied continuously, but the carrier frequency is broadband modulated in linear ramps. The distance to the reflecting object can be determined from the different frequencies of the transmit and receive signal (see box on page 30). This method of measuring distance and speed is often used in the far radar range with a carrier frequency between 76 GHz and 77 GHz, for instance by the automobile industry for ACC (adaptive cruise control) or in the military sector.

With this new method, the distance resolution depends on the frequency deviation of the radar signal, analogous to pulsed radar signals where it is a function of bandwidth. The carrier is therefore broadband modulated, the typical modulation deviation being maximally 250 MHz.

The two microwave Analyzers R3172 and R3182 from Advantest are able to demodulate signals with a peak-to-peak frequency deviation of up to 500 MHz

and display them as frequency versus time. The ramp structure and deviation can be analyzed at a keystroke. This attractive new solution means that all major signal parameters can be characterized conveniently and within a minimum of time.

A high-speed IEC/IEEE bus further enhances the time to measure, which is of particular advantage in a production environment.

External mixers up to 110 GHz

External mixers are required for measurements between 76 GHz and 77 GHz to extend the analyzer frequency ranges. Advantest has developed two-diode mixers with low conversion loss especially for the R3172 / R3182 analyzers. These mean a considerable improvement in measurement sensitivity compared to conventional single-diode mixers. To simplify entering frequency-dependent conversion loss parameters on the analyzer, the values are supplied on a diskette ready to read in. The analyzers also come with a software preselector to suppress image frequencies. This allows unambiguous identification of the input signal.

Measuring linearity and deviation

Deviation and linearity are key parameters for defining ramp characteristics. Immediately after signal demodulation, the analyzer shows a menu for deviation and linearity measurement. For deviation, the software automatically sets two markers. They show the spacing between the positive/negative peak and the carrier frequency, the mean deviation and the repetition frequency (FIG 2).

The linearity of the frequency ramp is decisive for measurement accuracy and

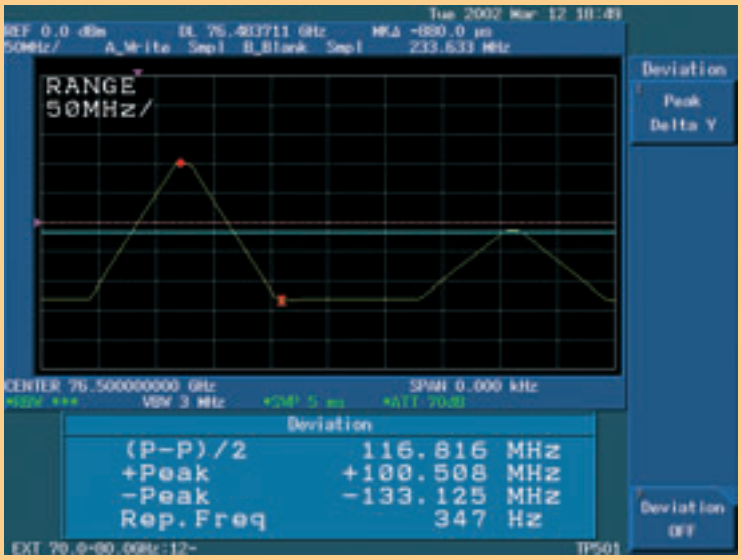

FIG 2
Measuring deviation of FMCW radar signal

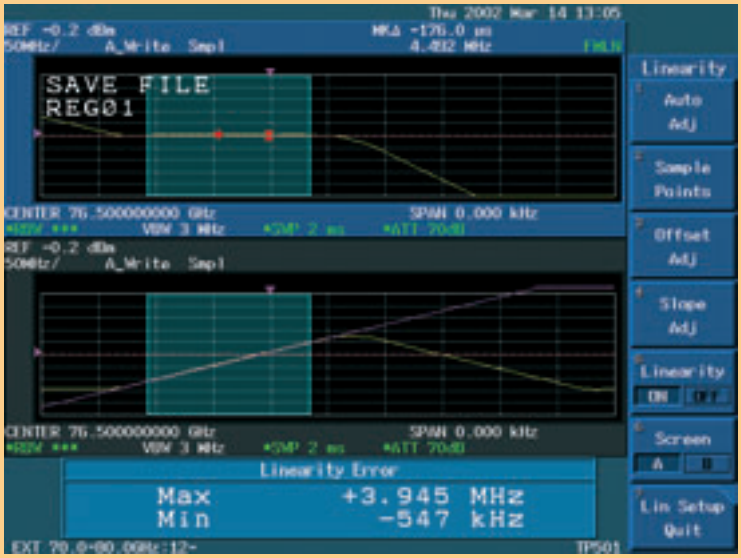

FIG 3
Linearity measurement with window and reference line on vertical scale of 50 MHz/div

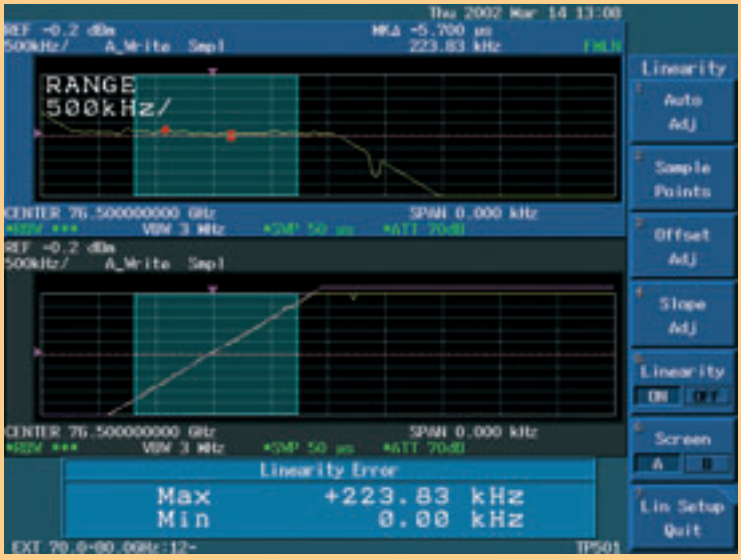

FIG 4
Higher resolution of linearity error display by reducing vertical scale to 500 kHz/div

FMCW in detail

The carrier signal of the radar sensor is frequency-modulated in linear ramps (FIG 5). The sensor receives and transmits simultaneously. The difference frequency Δf between the transmitted and received signal (e.g. between two vehicles) is proportional to the time difference of the two signals and is generated in the sensor by mixing. The time difference of the two signals is in turn proportional to the distance between the transmitter and the reflecting object. The distance between two objects can thus be determined with high accuracy from the difference frequency Δf, the resolution depending on the bandwidth (deviation) of the ramp signal [*].

The Doppler shift – a frequency shift between two objects moving in relation to each other – is used in addition to determine the relative speed of the reflecting object, e.g. the vehicle ahead. So the FMCW radar determines distance and speed independently of each other.

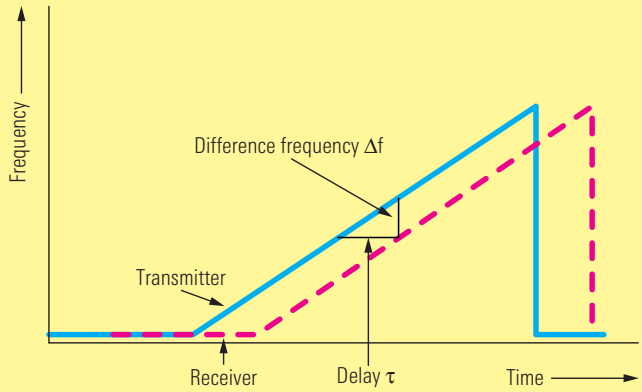

FIG 5 Signal pattern in FMCW radar

therefore is a major parameter of FMCW radar signals. For linearity measurements, a window and a straight reference line can be displayed on the particular segment. The maximum and minimum difference frequency between the signal section and the reference line is then measured with the aid of two markers (FIG 3). This is a convenient way for the user to determine the linearity error of the ramp signal. Reducing the vertical scaling increases the accuracy of the linearity display (FIG 4). The typical linearity error of the analyzers for FM demodulation is as low as 0.2 % of the scaling, which ensures accurate measurement results.

With option .29 (50 µs sweep time in time domain) even FMCW signals with a short ramp period can be displayed.

Summary

The integrated FM demodulator of the Advantest Spectrum Analyzers R 3172 / R 3182 allows you to analyze the deviation and linearity characteristics of broadband FMCW radar signals at a simple keystroke. This saves a lot of time, particularly in production, because to date measuring the linearity required time-consuming evaluation of discrete frequencies.

The new external mixers ensure high sensitivity in the frequency bands up to 110 GHz, where you find the radar frequencies used for ACC in the automobile industry and for military applications. Advantest is thus able to offer an attractively priced and all-in-one solution for analyzing FMCW radar signals.

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More information and data sheet at www.rohde-schwarz.com (search term: R 3172 or R 3182)

Data sheet for Spectrum Analyzers R 3172 and R 3182

REFERENCE

[*] Olbrich, H., Winter, K., Lucas, B., Beez, T., Mayer, H.: Design and Development Process of Present ACC Systems. Robert Bosch GmbH