Analysis of frequency agile radar systems and ultrashort pulses

Advanced radar systems are able to change the signal frequency and modulation from one pulse to the next. In order to test these frequency agile systems, the test instruments must have a large analysis bandwidth.

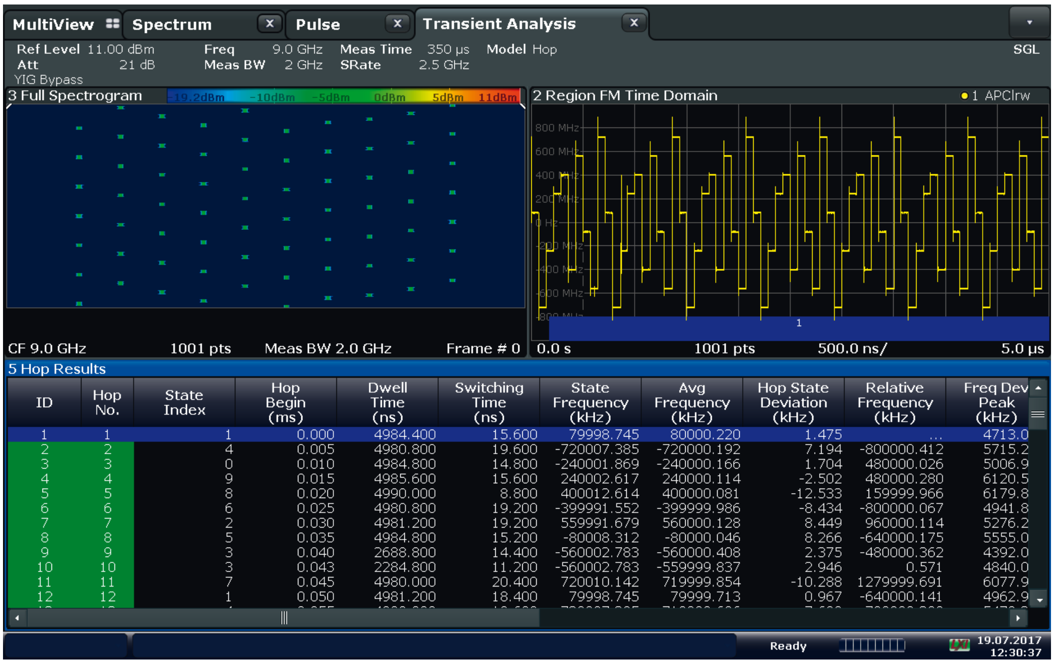

Fig. 1: The 2 GHz spectrogram of a frequency agile signal is shown in the top left window, with a plot of the frequency hops in the time domain to its right and a list of all significant parameters beneath

Frequency agile radars and jamming systems

Rapid frequency hopping makes radar systems more resistant to atmospheric disturbances, targeted attacks (jamming) and unwanted signals (interference). To increase resolution, these systems additionally alter the modulation, pulse width and pulse sequence depending on the target. Pulses in the nanosecond range are not uncommon. Analysis of such systems typically involves measuring the frequency hops or the modulation quality of pulse compression. That requires a large bandwidth for acquiring the emitted signal.

Jamming systems use targeted interference signals to try to impair the sensitivity of the enemy radar or even make it totally blind. Wideband noise-like signals or frequency agile signals are used for this purpose. These systems may change frequency very often, simply send back the received radar signal or sweep rapidly through a frequency range. That can disrupt even frequency agile radar systems. Wideband signal acquisition during development and verification of radar systems or sophisticated jamming systems enables a detailed analysis of the frequency hops and the effectiveness of various algorithms.

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Large internal analysis bandwidth

The R&S®FSW signal and spectrum analyzer with the R&S®FSW-B2001 option provides an internal analysis bandwidth of 2 GHz. That allows the instrument to resolve rise times in the nanosecond range. The A/D converter is integrated into the analyzer, eliminating the need for a wideband oscilloscope for data acquisition. The R&S®FSW-B2001 option features low distortion of input signals with a large dynamic range. The spurious-free dynamic range (SFDR) is an outstanding 60 dBc. These characteristics are important not only for precise determination of signal modulation quality, but also to avoid interpreting internally generated spurious signals as true reflections ("phantom targets"). In addition, the R&S®FSW signal and spectrum analyzer can be equipped with the R&S®FSW-K60?/?K60H option to enable automatic analysis of frequency hops. This option detects the initial and target frequencies of a hop, determines the offset, and measures how long a frequency is occupied or how long the system takes to change to the next frequency. The analyzer produces a table listing all frequency hops and time parameters (Fig. 1) Users can display deviations with respect to a predefined list or specify a tolerance range for frequency hop detection.

Analysis of ultrashort pulses

A large measurement bandwidth is not only useful for characterization of frequency agile systems over a broad frequency range. It is also advantageous for measuring ultrashort pulses or wideband modulation of the pulses.

The R&S®FSW-K6 option supports such measurements. It performs detailed pulse analysis, especially for radar applications. The option measures the amplitude, frequency and phase of the pulses and displays them versus time. Pulse rise and fall times, pulse repetition rates and many other parameters are automatically detected and listed in a table (Fig. 2). The option can display trends of parameters, such as the pulse repetition rate, over an extended time period. This can be very useful, for example in scenarios where the aim is to deceive the enemy radar. For this purpose, the targeted aircraft transmits a similar signal in modified form to give the impression that the aircraft is closer to the radar antenna than it actually is. In response, the enemy radar reduces its sensi-

Fig. 2: Time domain analysis of ultrashort pulses (< 20 ns). An enlarged portion of the total acquired signal is shown at the top left, with a list of key parameters to the right (rise time, pulse width, etc.). The amplitude of a selected pulse is shown at the bottom right, with the phase trend to its left

tivity and loses the target. Examination of this type of scenario, which is called range gate pull-off (RGPO), requires trend analysis of several parameters over an extended time period. Segmented acquisition, in which only the pulses are acquired and time-stamped, is useful for this purpose. The intervals between pulses are ignored, greatly increasing the number of pulses that can be acquired and used for analysis. The R&S®FSW-K70 vector signal analysis option is intended for pulses with complex modulation, such as binary phase shift keying (BPSK). It can also be used with an analysis bandwidth of 2 GHz. It does not provide a detailed pulse analysis, but it can analyze the modulation quality of a wide variety of digitally modulated signals.

Ultrawideband radar

UWB radar systems use a significantly broader spectrum than conventional systems. They operate with pulses having widths of only a few nanoseconds and low power. The spectrum is very broad and resembles white noise. That makes unwanted interference to other applications unlikely. The spectrum width of a UWB radar is at least 25 % of the transmit frequency, which means 2 GHz with a transmit frequency of 8 GHz. An analysis bandwidth of at least 2 GHz is therefore required for analysis of these systems in the UWB band up to 10.6 GHz. Similar technology is currently used for keyless entry systems in the automotive industry to determine the distance between the key and the vehicle. ◄