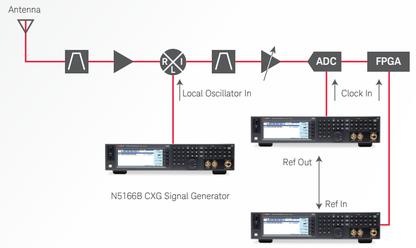
SIGNAL GENERATION AND SIGNAL ANALYSIS **FUNDAMENTALS**

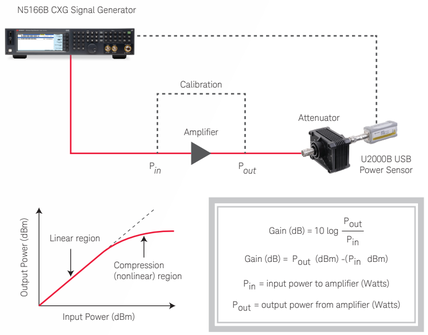
See the real performance of your device with industry-leading analysis tools. Design, test and deliver your next breakthrough with our most advanced signal generation and signal analysis.

Common measurements that require a signal generator

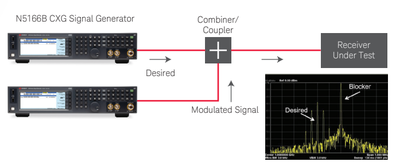
Local oscillator/clock substitution
A signal generator can be used as a substitute for a system's local oscillator (LO) and clocking subsystems during the development of transmitter and receiver products. By selecting a signal generator with low phase noise and low spurious signals, designers can confirm the operation of the system before the subsystems are added in.



Amplifier gain testing
Gain is a fundamental characteristic of amplifiers, and designers often like to observe and verify this parameter before using an amplifier in their designs. This type of measurement is typically done using a signal generator and a power sensor. The input to the amplifier (the signal generator output) is varied, and the output is measured with a power sensor, with results displayed directly on the signal generator.

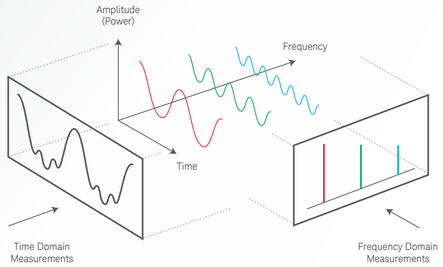


Receiver sensitivity testing with RF interference
In many cases during actual use of a device, a interfering signal can be present in the spectrum and may interfere with a receiver's ability to properly receive a signal. To verify a devices performance in the presence of a interfering signal, the output from two signal generators can be combined and applied to the device.



Common measurements that require a spectrum analyzer

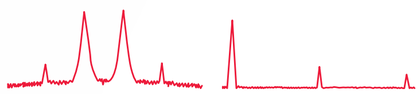
Frequency and power measurements of RF transmitters
Spectrum analyzers are used to test RF or modulated signals, while scopes are for testing base band signals. Though spectrum analyzers are relatively a narrow band analyzer, they are able to tune in order to meet your testing needs. Frequency and power measurements are primary parameters for characterizing RF devices.



Distortion and interference measurements
Designers involved into wireless communications are extremely interested in spurious emissions, such as 2nd, 3rd harmonics, TOI, (3rd order intermodulation), or other types of unwanted emissions. As those distortion components may fall within the band of interest, thus downgrading other components' performance.

EMI is unwanted conducted or radiated emissions from both intentional and unintentional radiators. Almost every electronic device in the marketplace today must be tested for emission levels versus frequency according to CISPR standards.

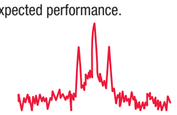
Spectrum monitoring is another important measurement activity. Government regulatory agencies allocate spectrum resources for various radio services. It is critical that each service operates at the assigned frequency and stays within their designated channel bandwidth.


Distortion

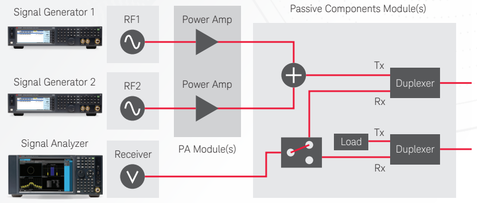
Noise
In many cases, your target signal is a low-level signal. Any active circuit or device will generate excess noise. Tests such as noise figure and signal-to-noise ratio (SNR) are important for characterizing the performance of a device, and their contribution to the overall system.


Noise

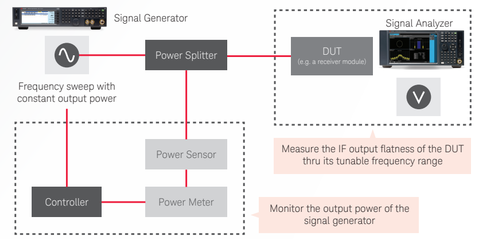
Modulation
Baseband signal modulated onto a carrier can be transmitted over longer distances via radiation. In some cases, you may need to demodulate the signals to get the metrics needed in order to verify that your RF transceiver delivers an expected performance.


Modulation

Signal generator and spectrum analyzer where used or application



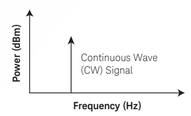
Reference solution for PIM measurement



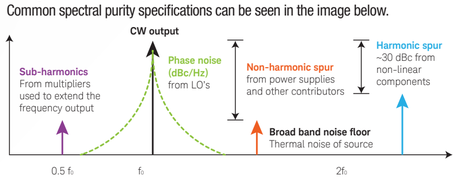
Reference solution for frequency response measurement

Key signal generator specifications and why they matter

Frequency and amplitude
There are a number of signal generator specifications that relate to the frequency and amplitude of the instrument. Frequency range, for example, will determine what range of frequencies can be generated by the signal source and is specified in Hertz (Hz). There are similar specifications for maximum and minimum output power, which are specified in dBm. Frequency and amplitude accuracy are also common signal generator specifications that describe how close to the set value the actual output will be. And finally, the frequency and amplitude switching speed defines how quickly the signal generator can switch from one value to the next. These specifications can all be key in determining which signal generator a user needs.

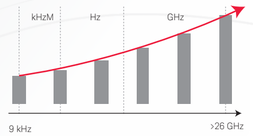


Spectral purity
Spectral purity is the inherent stability of a signal. Stabilities can be either short or long term, but the greater concern is for short-term stability or changes in frequency in less than one second. Spectral purity is important for mobile radio testing, receiver selectivity test, and local oscillator substitution applications. Common spectral purity specifications can be seen in the image below.



Key spectrum analyzer specifications and why they matter

Frequency range
Spectrum analyzers are narrow band analyzers, but they can tune. Therefore, they can cover a wider frequency range than scopes.

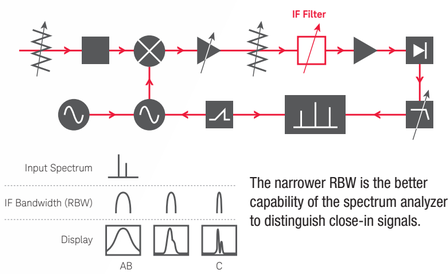


Measurement uncertainty: frequency and amplitude
How accurate is your measurement result?
Frequency accuracy
Contribution factors include:
- Frequency reference accuracy, Span, RBW and Horizontal resolution

± [(Marker Frequency x Frequency Reference Accuracy) + (0.1% x Span) + (5% x RBW) + 2 Hz + (0.5 x Horizontal Resolution)] = span / (sweep points – 1)

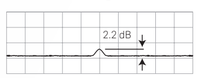
Amplitude accuracy
Contribution factors include:
- Input connector (mismatch), RF input attenuator, mixer and input filter (flatness), IF gain/attenuation (reference level), RBW filters, display scale fidelity and calibrator accuracy (absolute accuracy)

Resolution BW
Resolution bandwidth (RBW)
IF Filter: By giving you a broad range of variable resolution bandwidth settings, the instrument can be optimized for the sweep and signal conditions, letting you trade off frequency selectivity (the ability to resolve signals), signal noise ratio (SNR), and measurement speed

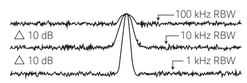


The narrower RBW is the better capability of the spectrum analyzer to distinguish close-in signals.

Sensitivity
Displayed average noise level (DANL) is an indication of how well it can measure small signals.

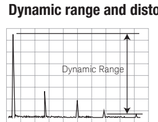


Sensitivity is the smallest signal that can be measured.

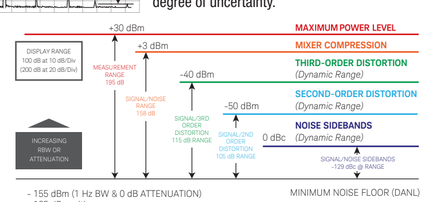


Displayed noise is a function of IF filter bandwidth: noise decreases as bandwidth decreases

Dynamic range and distortion



The ratio, expressed in dB, of the largest to the smallest signals simultaneously present at the input of the spectrum analyzer that allows measurement of the smaller signal to a given degree of uncertainty.



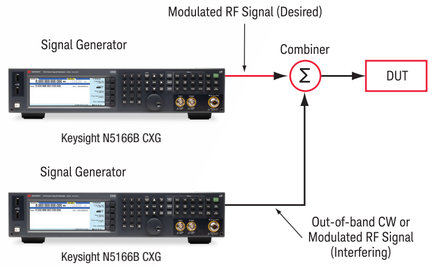
Testing and troubleshooting digital RF communications receiver designs

In-Channel Testing
The most significant in-channel test measures the sensitivity of the receiver. Sensitivity specifies the minimum signal level for a specified percentage of errors in the demodulated information.

Co-Channel Immunity Testing
Co-channel immunity testing is similar to sensitivity testing. The level of signal distortion is monitored with an interfering signal present in the same RF channel. Co-channel immunity testing, which is similar to sensitivity testing, is the measure of the ability of the receiver to remain sensitive to the desired signal while subjected to the interfering signal.

Sensitivity Measurement Setup

Out-of-Channel Testing
Out-of-channel, or blocking, tests verify correct receivers operation in the presence of out-of-channel signals and monitor the receiver's susceptibility to internally generated spurious responses. Three prominent out-of-channel tests verify receiver performance: spurious immunity, intermodulation immunity, and adjacent/alternate channel selectivity.



Spurious Immunity Measurement Setup

Reach higher in RF—with confidence

"Good enough" can get you only so far. When you're ready to take your product to new levels of performance, you'll need measurement tools that go farther than your target specs. Keysight is ready to help you test your devices within and beyond their limits. We offer a range of RF instruments that deliver tremendous value, balancing excellent performance with affordable pricing. Raise the bar with Keysight and be equipped to reach higher in RF—with confidence.
To find out more information, visit www.keysight.com/find/rf

KEYSIGHT TECHNOLOGIES

N5181B MXG Analog Signal Generator | N5166B CXG Vector Signal Generator | N9310A RF Signal Generator | N9322C BSA Spectrum Analyzer | N9000B CXA Spectrum Analyzer | Fieldfox Handheld RF and Microwave Analyzers | HSA Handheld Spectrum Analyzer