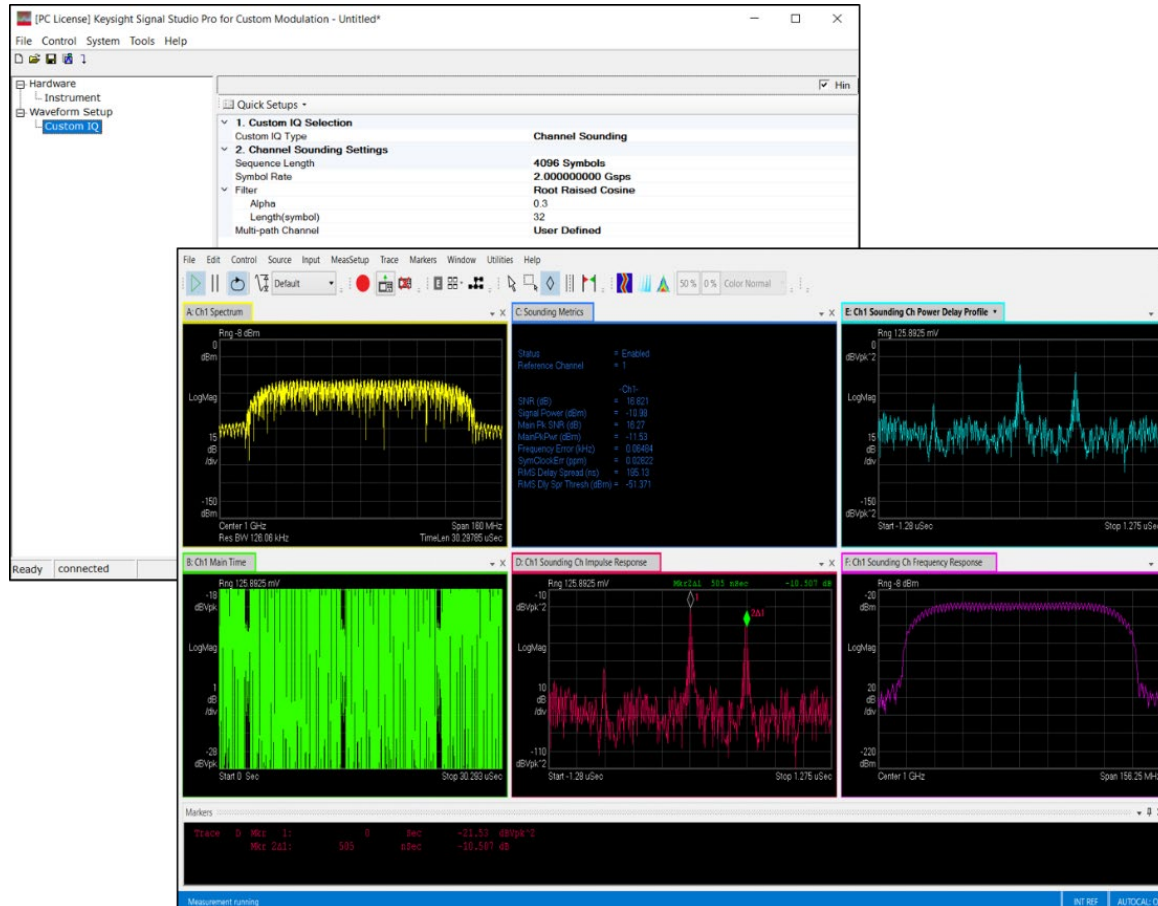


Channel Measurement Using

Signal Studio Pro for Custom Modulation and PathWave Signal Analysis (89600 VSA)



- Generate the complex (I+jQ) channel impulse response (CIR) and frequency response with a comprehensive set of tools for signal generation and vector signal analysis
- Create coded channel sounding waveforms with the simple setup of sample rate, shaping filter and sequence length
- Support latest Keysight signal sources and analyzer platforms up to mmWave frequency, including M9384B VXG, N9040B/N9041B/N9032 UXA, N9032B/N9030B PXA, N9021B MXA, Infiniium UXR-Series real-time oscilloscopes
- Download waveforms into the M8190A AWG with Vector PSG or external up-converter, M9384B VXG or N5182B MXG vector signal generators
- Acquire data with up to 8 channels including oscilloscopes or signal analyzers run channel sounding measurements including channel impulse response, channel frequency response, and sounding metrics

Introduction of Channel Sounding Measurements

The channel measurement solution consists of two major software components, signal generation with coded channel sounding waveform, and vector signal analysis with channel measurements. Combined with multiple hardware platforms, you can easily decide how you characterize the channel from RF to mmWave frequency bands, what channel bandwidth to use, and how many channels to utilize.

The N7608C Signal Studio Pro for Custom Modulation software generates the channel sounding stimulus signal and download the waveform into M8190A AWG, M8190A AWG + E8267D Vector PSG, M9384B/M9383B VXG and MXG/EXG vector signal generators. The PathWave Vector Signal Analysis (89600 VSA) software shows you spectrum and time traces of the channels under measurement. In addition, the channel impulse response, channel frequency response, and sounding metrics results from VSA software provide more insight on the channel characteristics. You can easily find the key parameters of channel sounding metrics such as signal-to-noise ratio (SNR), signal power, symbol clock error, and RMS delay spread in sounding metrics table.

The technique is based on transmitting a known waveform through the channel and comparing the received signal with the reference signal to calculate channel metrics. This does not rely on external synchronization or clocks so the time scale of the impulse response trace is relative to the largest peak. The image on the next page describes the basic block diagram.

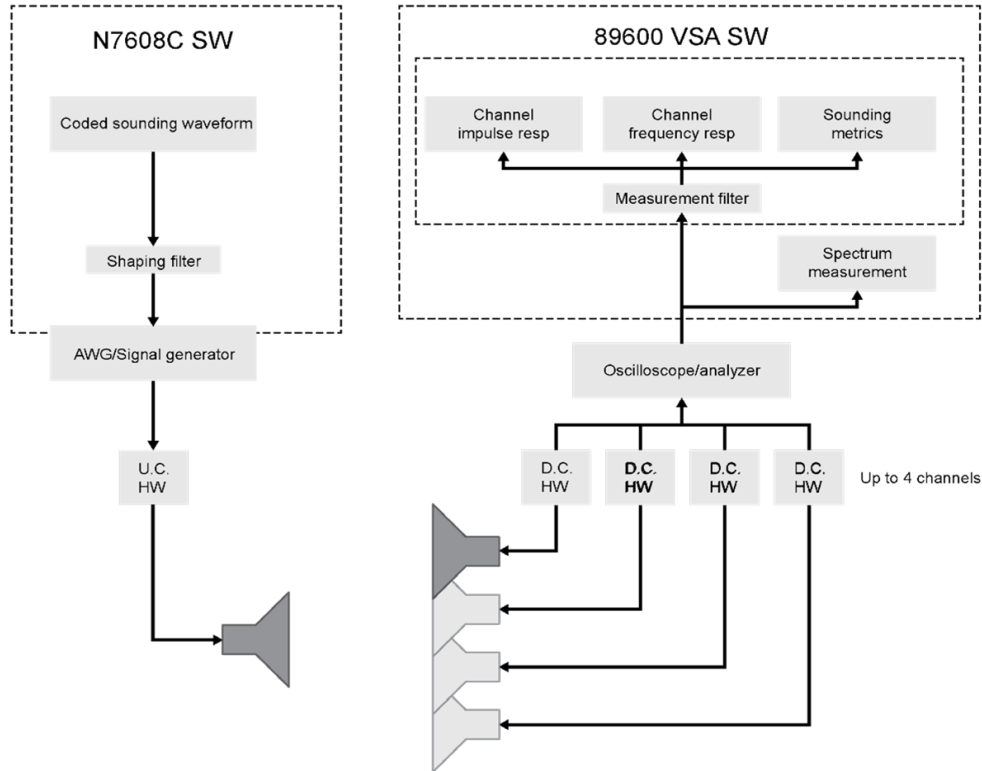


Figure 1. Basic block diagram of channel sounding solution with Keysight N7608C Signal Studio Pro for Custom Modulation software and PathWave Vector Signal Analysis (89600 VSA) software. Shaping filter is used to control bandwidth of transmitted signal. Up-converter (U.C.), Down-converter (D.C.) would be used for higher frequency range if needed.

Key Features

Versatile channel sounding setup and operations

System designer can start channel measurements quickly with this solution since the sounding signal can be generated at user-specified symbol rate and length. The symbol rate determines the bandwidth to be sounded, and the length of the coded signal determines the maximum time delay (distance) between the first and last reflections that can be resolved.

For simple setup, you will use the N7608C Signal Studio Pro for Custom Modulation software to generate a specially-coded waveform, by choosing the “Custom IQ” in the left tree-view window, and “Channel Sounding” as Custom IQ Type in the right window. The waveform then is then filtered and downloaded to the arbitrary waveform generator (AWG) or vector signal generator for playback. The generated signal can also be upconverted by external mixer to the desired RF or mmWave frequency and then transmitted through the wireless channel.

The signal can be received by one or more antennas and downconverted to the IF frequency. These signals are digitized by the supported measurement hardware platform (Infiniium Oscilloscope, X-Series Signal Analyzer, etc.). The channel sounding measurement extension of 89600 VSA software computes channel sounding metrics. The full set of PathWave Vector Signal Analysis (89600 VSA) vector measurement displays are also available as needed.

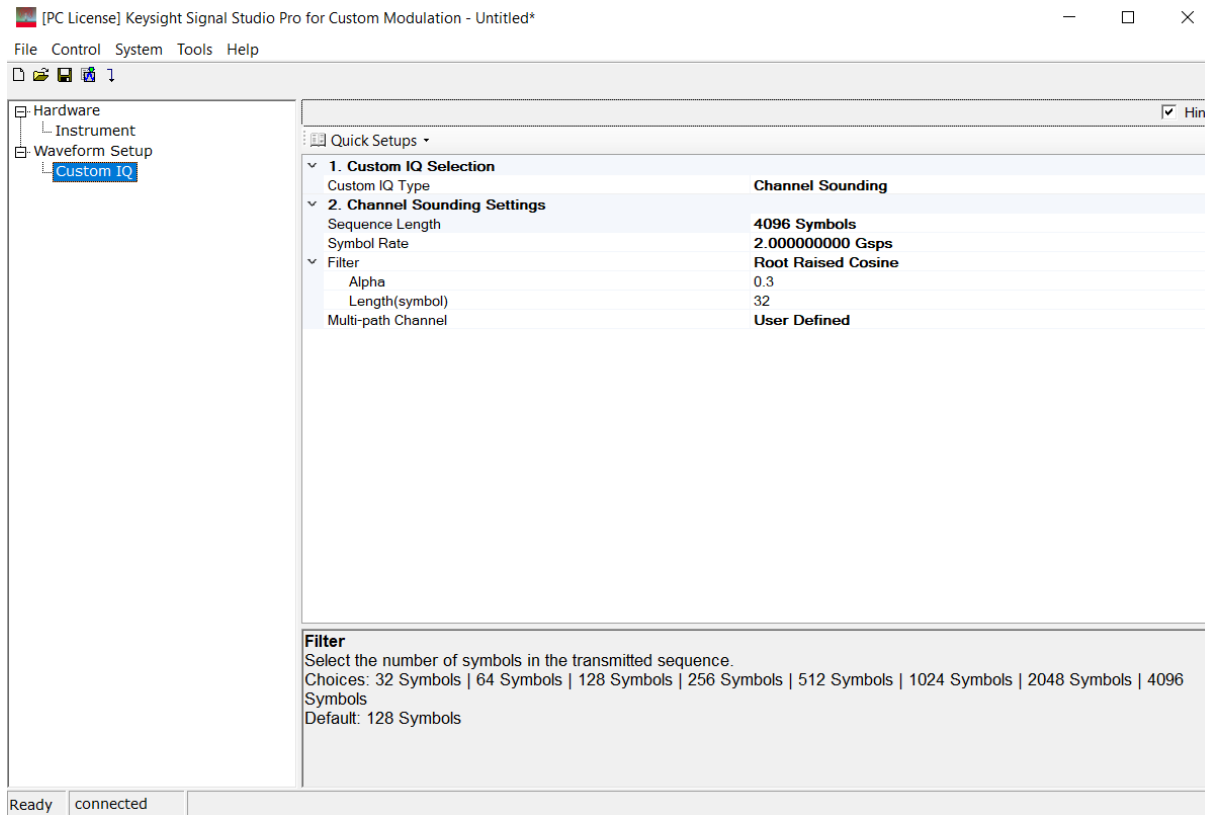


Figure 2. Using N7608C Signal Studio Pro for Custom Modulation to generate the specially-coded waveform IQ for channel sounding

Simple Channel Sounding Metrics and Results

Channel impulse response

The channel impulse response trace shows the time-domain effect of the reflections introduced by the channel. The impulse response consists of complex samples, so both magnitude and phase information which can be extracted for post processing are available. Any filtering applied during the generation and analysis is effectively included in this measurement.

Note: There is no absolute time reference in this system, and the x-axis is always relative to the largest peak (centered at 0 seconds).

The impulse response trace is twice as long as the sequence length, with the center half being valid. Any significant power falling outside this region will affect the accuracy of the measurement. The maximum excess delay (time between peak and last path) supported is determined by the length of the sequence and the symbol rate. The minimum resolvable path is the inverse of the symbol rate, but the actual resolvability of a path depends on the filtering applied at the transmitter and receiver.

When averaging is enabled, the noise in this trace is averaged towards zero (vector averaging).

Channel power delay profile

The power delay profile (PDP) is the magnitude of the channel impulse response. When averaging is enabled, the noise in this trace is averaged towards the noise power (RMS averaging). PDP is a popular trace for channel estimation to acquire the delay of each path.

Channel frequency response

The channel frequency response is the Discrete Fourier Transform (DFT) of the channel impulse response.

The frequency span of this trace is greater than the symbol rate, though only the frequency span corresponding to the symbol rate is valid for channel measurements. Any filtering applied during the generation and analysis will be included into the frequency response.

Sounding metrics

Sounding metrics are provided as below:

- **Signal to Noise Ratio (SNR)** - Ratio of signal power to noise power
- **Signal Power** - Estimate of the power of the received sounding signal
- **Main Peak SNR** - Ratio of the main peak power to noise power
- **Main Peak Power** - Power in the main path (centered at $t = 0$ sec)
- **Frequency Error** - Estimate of the frequency error between the transmitter and receiver (calculated from the main path)
- **Symbol Clock Error** - Estimate of error between sample clocks in the transmitter and receiver (calculated from the main path)
- **RMS Delay Spread** - Measure the spread of reflections considering their relative power
- **RMS Delay Spread Threshold** - Determine which samples contain paths (to be used in RMS Delay Spread calculation)

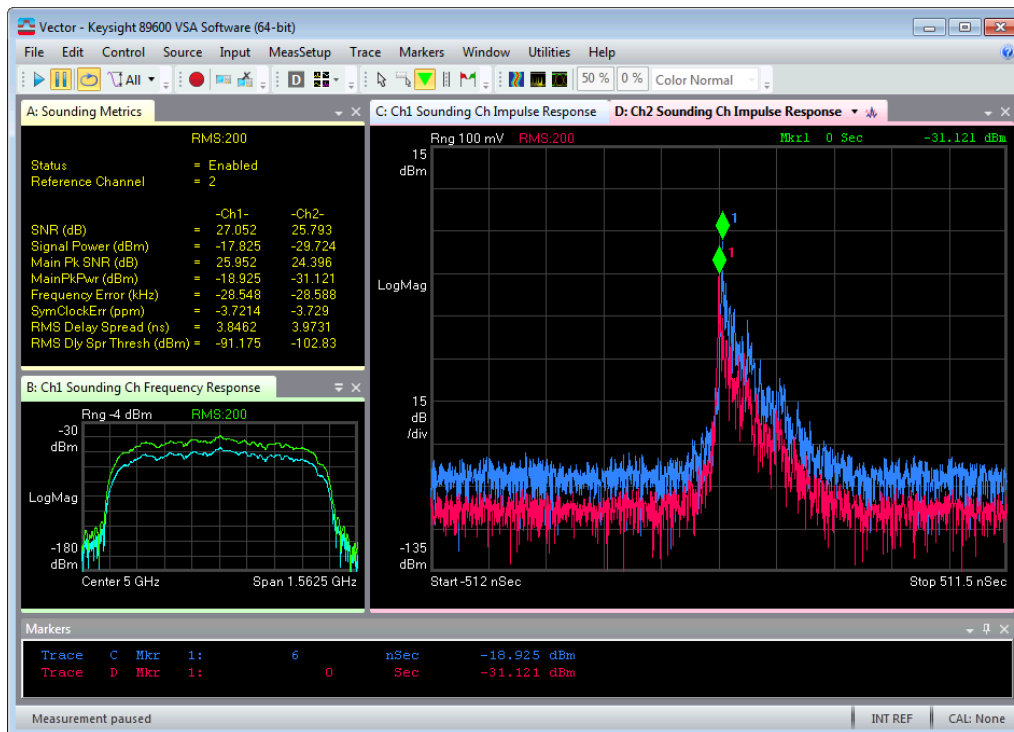


Figure 3. Showing sounding metrics, channel frequency response and channel impulse response of 2 channels (as overlaid) in PathWave Vector Signal Analysis (89600 VSA) software

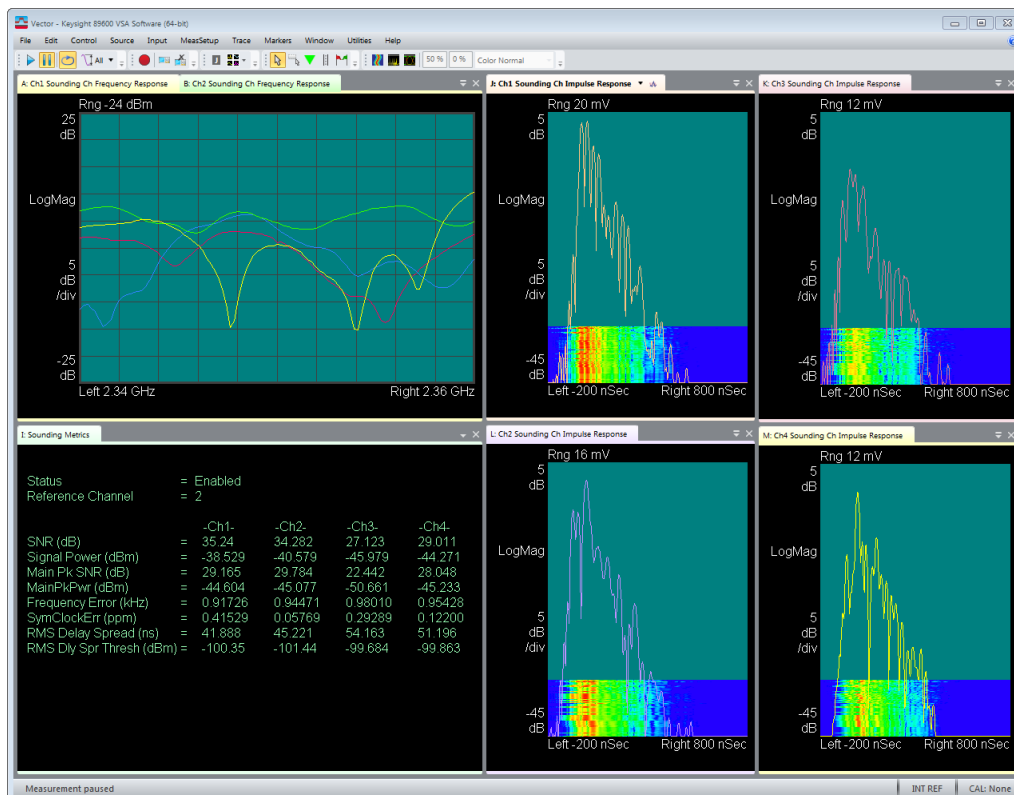


Figure 4. 4-channel measurements showing time variation of the channel impulse response

Flexible Hardware Choices

The flexibility of the N7608C and 89600 VSA software provides many hardware options covering a wide variety of bandwidths and frequencies as needed.

- UXA N9042B and V3050A freq extender up to 110 GHz and channel bandwidth up to 4 GHz
- UXA N9041B and N9040B signal analyzer up to 110/50 GHz and channel bandwidth up to 1 GHz
- PXA N9030B and MXA N9021B signal analyzer up to 50 GHz and channel bandwidth up to 510 MHz
- MXA N9021B signal analyzer up to 26.5 GHz with channel bandwidth up to 2 GHz
- Infiniium real-time oscilloscopes up to 4 channels, including the latest UXR-Series up to 110 GHz bandwidth
- VXG M9383B or M9384B microwave signal generator up to 44 GHz and bandwidth up to 2 GHz
- AWG M8190A and vector PSG signal generator up to 44 GHz and bandwidth up to 2 GHz
- mmWave up and down converter configuration for combining signal analyzers and generators, wideband digitizers or oscilloscopes

Key Specifications

Key specifications	Description
Maximum frequency ranges supported	Depends on hardware configurations: X-Series Signal analyzer up to 110 GHz without external mixer Up to 110 GHz with Keysight external mixer Up to 1.1 THz with third party external mixer Infiniium UXR-Series real-time oscilloscopes up to 110 GHz Up- and down-converter with oscilloscope or digitizer
Number of channels supported	Up to 8 channels with AXle M9703A digitizer or two oscilloscopes
	Up to 4 channels with Infiniium oscilloscope
	Single channel with X-Series signal analyzer
Channel bandwidth (symbol rate)	Depends on hardware configurations: X-Series signal analyzer up to 1 GHz Up to 2.5 GHz with Keysight M1971E external mixer Up to 1.3 GHz with Keysight N5152A/N1999A converters
Sequence length	32, 64, 128, 256, 512, 1024, 2048, 4096 symbols
Minimum SNR	Recommended 0 dB for consistent synchronization
Maximum delay spread	Center of impulse response +/- sequence length/2
Minimum resolvable path delay	1/symbol rate

Software Ordering Information

Key specifications	Description
89601200C	Basic vector signal analysis and hardware connectivity for 89600 VSA
89601CSDC (replace 89600CSP-H51)	Channel sounding measurement for 89600 VSA (requires 89601200C)
N7608APPC	Signal Studio Pro for Custom Modulation, PC Application

Additional Resources

Related literatures

- PathWave Vector Signal Analysis (89600 VSA), Brochure, literature number 5990-6553EN
- PathWave Vector Signal Analysis (89600 VSA), Configuration Guide, literature number 5990-6386EN
- PathWave Vector Signal Analysis (89600 VSA), 89601200C Basic Vector Signal Analysis & Hardware Connectivity, literature number 5992-4210EN
- PathWave Signal Generation, Brochure, literature number 5989-6448EN
- N7608C Signal Studio Pro for Custom Modulation, Technical Overview literature number 5992-2513EN

Webpages

- www.keysight.com/find/89600
- www.keysight.com/find/89600_software
- www.keysight.com/find/signal_studio
- www.keysight.com/find/n7608c