Spectrum Analysis
Back to Basics

Agilent Technologies
Agenda

Introduction

Overview:

– What is Spectrum and Signal Analysis?
– What Measurements are available?

Theory of Operation

Specifications

Modern spectrum analyzer designs & capabilities

Applications

Automation Tools

Wrap-up
Overview

Frequency versus Time Domain

Amplitude (power)

Time domain Measurements (Oscilloscope)

Frequency Domain Measurements (Spectrum Analyzer)
Overview

Types of Measurements Available

Frequency, power, modulation, distortion & noise

– Spectrum monitoring
– Spurious emissions
– Scalar network analysis
– Noise figure & phase noise
– Harmonic & intermodulation distortion
– Analog, digital, burst & pulsed RF Modulation
– Wide bandwidth vector analysis
– Electromagnetic interference

– Measurement range (-172 dBm to +30 dBm)
– Frequency range (3 Hz to 325 GHz)
Overview
Different Types of Analyzers

**Swept Analyzer**

Filter 'sweeps' over range of interest

LCD shows full spectral display

A

\[ f_1 \rightarrow f_2 \rightarrow f \]
Overview
Different Types of Analyzers

FFT Analyzer

Parallel filters measured simultaneously

LCD shows full spectral display

A

f_1 f_2 f
Agenda

Introduction
Overview

Theory of Operation:
  – Swept Spectrum Analyzer Hardware

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Modern spectrum analyzer designs & capabilities
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Theory of Operation
Swept Spectrum Analyzer Block Diagram

RF input attenuator

Input signal

Pre-Selector
Or Low Pass Input Filter

local oscillator

Crystal Reference Oscillator

mixer

IF gain

IF filter (RBW)

envelope detector

Log Amp

video filter

ADC, Display & Video Processing

Back to Basics Seminar
Theory of Operation
Display terminology

Reference Level

Amplitude

Start Freq.

Stop Freq.

Freq. Span

Center Freq.
Theory of Operation
Mixer

MIXER

f_{\text{LO}}

f_{\text{sig}}

\text{LO}

\text{RF}

\text{IF}

1.5 \text{ GHz}

3.6 \text{ GHz}

6.5 \text{ GHz}

f_{\text{LO}} - f_{\text{sig}}

f_{\text{LO}} + f_{\text{sig}}

f_{\text{sig}}

f_{\text{LO}}

Back to Basics Seminar
Theory of Operation

IF Filter (Resolution Bandwidth – RBW)

Input Spectrum

IF Bandwidth (RBW)

Display

A B C
Theory of Operation

Envelope Detector

Before detector

After detector

Envelope Detector
Theory of Operation

Envelope Detector and Detection Types

Positive detection: largest value in bin displayed

Negative detection: smallest value in bin displayed

Sample detection: middle value in bin displayed

Other Detectors: Normal (Rosenfell), Average (RMS Power)

*Sweep points

bins/buckets*
Power Average Detection (rms) = Square root of the sum of the squares of ALL of the voltage data values in the bin / 50Ω
Theory of Operation

Video Filter (Video Bandwidth – VBW)

[Diagram of a video filter system]

Video Filter

[Graphs showing waveforms before and after filtering]
Theory of Operation

Video Filter vs. Trace/Video averaging

- **Video Filter** operates as the sweep progresses, sweep time may be required to slow down by the transient response of the VBW filter.

- **Trace/Video Average** takes multiple sweeps, sweep time for each sweep is not affected.

- Many signals give the same results with either video filtering or trace averaging.

Trace averaging for 1, 5, 20, and 100 sweeps, top to bottom (trace position offset for each set of sweeps).
Theory of Operation
Other Components

![Diagram of RF input, attenuator, and IF gain](image-url)
Theory of Operation
How it All Works Together - 3 GHz spectrum analyzer

0 1 2 3 (GHz)

f_s

mixer

Signal Range

f_s

f_s - f_s

LO Range

f_lo

f_lo + f_s

sweep generator

IF filter

3.6 GHz

f_IF

detector

LCD display

A

0 1 2 3 (GHz)
Agenda

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Theory of Operation
Specifications:
  – Which are important and why?
Modern spectrum analyzer designs & capabilities
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Key Specifications

- Frequency Range
- Accuracy: Frequency & Amplitude
- Resolution
- Sensitivity
- Distortion
- Dynamic Range
Specifications

Accuracy: Frequency & amplitude

Components which contribute to uncertainty are:

- Input mismatch (VSWR)
- RF Input attenuator (Atten. switching uncertainty)
- Mixer and input filter (frequency response)
- IF gain/attenuation (reference level accuracy)
- RBW filters (RBW switching uncertainty)
- Log amp (display scale fidelity)
- Reference oscillator (frequency accuracy)
- Calibrator (amplitude accuracy)
Specifications

Absolute and Relative Accuracy: Frequency & Amplitude

Note: Absolute accuracy is also “relative” to the calibrator reference point.
Specifications
Accuracy: Frequency Readout Accuracy

From the PXA Data Sheet:

\[ \pm (\text{marker frequency} \times \text{freq reference accuracy} + \ 0.1\% \times \text{span} + 5\% \times \text{RBW} + 2\text{Hz} + 0.5 \times \text{Horiz. Res.} \) \]

*Horizontal resolution is \( \frac{\text{span}}{\text{sweep points} - 1} \)
Specifications

Accuracy: Frequency Readout Accuracy Example

**Frequency:** 1 GHz  
**Span:** 400 kHz  
**RBW:** 3 kHz  
**Sweep points:** 1000

**Calculation:**

\[
(1 \times 10^9 \text{Hz}) \times (\pm 1.55 \times 10^{-7} / \text{Year ref. Error}) = 155 \text{Hz}
\]

\[
400 \text{kHz Span} \times 0.1\% = 400 \text{Hz}
\]

\[
3 \text{kHz RBW} \times 5\% = 150 \text{Hz}
\]

\[
2 \text{Hz} + 0.5 \times 400 \text{kHz}/(1000-1) = 202 \text{Hz}
\]

**Total uncertainty** = ±907 Hz

Utilizing internal frequency counter improves accuracy to ±155Hz
Specifications

Accuracy: Frequency Response

Signals in the Same Harmonic Band

Absolute amplitude accuracy – Specification: ± 1 dB
Relative amplitude accuracy – Specification: ± 2 dB
Specifications

Accuracy: Display Fidelity

Display Fidelity includes:

- Log Amp Fidelity
- Envelope Detector Linearity
- Digitizing Circuit Linearity

Display fidelity error applies when signals are not at the same reference level amplitude when measured.

In the past, technique for best accuracy was to move each measured signal to the reference line, eliminating display fidelity error.
Specifications

Amplitude Accuracy: Reference Level Switching

Uncertainty applies when changing the Ref. Level

Also called IF Gain Uncertainty

Decision: Do I change the reference level or live with the display fidelity uncertainty in my measurements?
# Specifications

## Accuracy: Key Amplitude Uncertainty Contributions

<table>
<thead>
<tr>
<th>Relative and absolute:</th>
<th>PXA Uncertainties</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Input impedance mismatch</td>
<td>±0.13 dB</td>
</tr>
<tr>
<td>• Input attenuator switching uncertainty</td>
<td>±0.14 dB</td>
</tr>
<tr>
<td>• Frequency response</td>
<td>±0.35 dB</td>
</tr>
<tr>
<td>• Reference level accuracy</td>
<td>0 dB</td>
</tr>
<tr>
<td>• RBW switching uncertainty</td>
<td>±0.03 dB</td>
</tr>
<tr>
<td>• Display scale fidelity</td>
<td>±0.07 dB</td>
</tr>
</tbody>
</table>

### Absolute only:

<table>
<thead>
<tr>
<th>Absolute only:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>• Calibrator accuracy</td>
<td>±0.24 dB</td>
</tr>
</tbody>
</table>
Specifications

Amplitude Accuracy - Summary

Optimize measurement setup & techniques for best accuracy

- Minimize changes to uncertainty contributors
  - Or change contributor with least error impact
  - Or stay within the optimum accuracy envelope parameters that modern auto-alignment calibration techniques provide

- Traditionally, one technique for best accuracy was to move each measured signal to the reference line, eliminating display fidelity error. However, in today’s designs, display fidelity has improved to the point where there is generally less error just to leave the signals where they occur on the display.

- Except for frequency response, uncertainty contributors that impact both signals equally in a relative measurement can be ignored.

- In the absence of specified relative frequency response, the relative response uncertainty is assumed to be 2x specified absolute error.
Specifications

Resolution: Resolution Bandwidth

Input Spectrum

Mixer

LO

3 dB BW

IF Filter/
Resolution Bandwidth Filter (RBW)

Sweep

Envelope Detector

RBW

Display
Selectivity $= \frac{60 \text{ dB BW}}{3 \text{ dB BW}}$

Determines resolvability of unequal amplitude signals
Specifications
Resolution BW Selectivity or Shape Factor

RBW = 1 kHz
Selectivity 15:1

RBW = 10 kHz

3 dB
60 dB

60 dB BW = 15 kHz
10 kHz

7.5 kHz
distortion products
Specifications
Resolution: RBW Type and Selectivity

Typical Selectivity
Analog  15:1
Digital  \leq 5:1
Specifications

Resolution: Noise Sidebands

Noise Sidebands can prevent resolution of unequal signals

Phase Noise
Specifications
Resolution: RBW Determines Sweep Time

Penalty For Sweeping Too Fast
Is An Uncalibrated Display
A Spectrum Analyzer Generates and Amplifies Noise Just Like Any Active Circuit
Sensitivity is the Smallest Signal That Can Be Measured

Signal Equals Noise

\[ \sim 2.2 \text{ dB} \]
Effective Level of Displayed Noise is a Function of RF Input Attenuation

Signal To Noise Ratio Decreases as RF Input Attenuation is Increased
Specifications

Sensitivity/DANL: IF Filter (RBW)

Displayed Noise is a Function of IF Filter Bandwidth

Decreased BW = Decreased Noise
Specifications
Sensitivity/DANL: Video BW filter (or Trace Averaging)

Video BW or Trace Averaging Smoothes Noise for Easier Identification of Low Level Signals
Specifications

Sensitivity/DANL:

Signal-to-Noise Ratio Can Be Graphed

POWER AT MIXER = INPUT - ATTENUATOR SETTING dBm

Displayed Noise in a 100 Hz RBW

Displayed Noise in a 1 kHz RBW
For Best Sensitivity Use:

- Narrowest Resolution BW
- Minimum RF Input Attenuation
- Sufficient Averaging (video or trace)
Specifications
Distortion

Mixers Generate Distortion

Signal To Be Measured

Frequency Translated Signals

Mixer Generated Distortion

Resultant
Most Influential Distortion is the Second and Third Order

Two-Tone Intermod

Harmonic Distortion
Specifications
Distortion

Distortion Products Increase as a Function of Fundamental's Power

Two-Tone Intermod

Second Order: Δ 2 dB/dB of Fundamental
Third Order: Δ 3 dB/dB of Fundamental

Harmonic Distortion

Second-order distortion
Third-order distortion

Power in dB

3Δ

f 1

2f 2

f 2

2f 1

3Δ

Power in dB

3Δ

f

2f

3f
Specifications
Distortion

Distortion is a Function of Mixer Level

Second Order

Third Order

POWER AT MIXER = INPUT - ATTENUATOR SETTING dBm
Specifications

Distortion – Internal or External?

**Attenuator Test:**

**Change power to the mixer**

1. Change input attenuator by 10 dB
2. Watch distortion amplitude on screen

*No change in amplitude:* distortion is part of input signal (external)

*Change in amplitude:* at least some of the distortion is being generated inside the analyzer (internal)
Specifications

Spectrum Analyzer Dynamic Range

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.
Specifications
Dynamic Range

Dynamic Range Can Be Presented Graphically

- Maximum 2nd Order Dynamic Range
- Maximum 3rd Order Dynamic Range
- Optimum Mixer Levels

POWER AT MIXER = INPUT - ATTENUATOR SETTING dBm

SIGNAL-TO-NOISE RATIO, dBC

-20 -40 -60 -80 -100

-60 -30 0 +30 TOI SOI

DISPLAYED NOISE (1 kHz RBW)
SECOND ORDER
THIRD ORDER
Specifications
Dynamic Range

Dynamic Range for Spur Search Depends on Closeness to Carrier

- Dynamic Range Limited By Noise Sidebands dBc/Hz
- Noise Sidebands
- Dynamic Range Limited By Compression/Noise
- Displayed Average Noise Level
- 100 kHz to 1 MHz
Specifications

Dynamic Range vs. Measurement Range

- **MAXIMUM POWER LEVEL**: +30 dBm
- **MIXER COMPRESSION**: +3 dBm
- **THIRD-ORDER DISTORTION**: -40 dBm
- **SECOND-ORDER DISTORTION**: -50 dBm
- **SIGNAL/NOISE RANGEx (Dynamic Range)**: 195 dB
- **DISPLAY RANGE**: 100 dB @ 10 dB/Div (200 dB @ 20 dB/Div)
- **Minimum Noise Floor (DANL)**: 0 dBc
- **Noise Sidebands (Dynamic Range)**: -129 dBc @ 10 kHz Offset

**Increasing RBW or Attenuation**
- -155 dBm (1 Hz BW & 0 dB ATTENUATION)
- -165 dBm with preamp

**Signal/Noise Range**
- 158 dB

- **Signal/3rd Order Distortion (Dynamic Range)**: 115 dB range
- **Signal/2nd Order Distortion (Dynamic Range)**: 105 dB range

**Measurement Range**
- 158 dB
Specifications
Summary: Optimizing Dynamic Range

• What settings provide the best sensitivity?
  • Narrowest resolution bandwidth
  • Minimal input attenuation
  • Sufficient averaging

• How do you test for analyzer distortion?
  • Increase the input attenuation and look for signal amplitude changes
  • Then set the attenuator at the lowest setting without amplitude change

• What determines dynamic range?
  • Analyzer distortion, noise level, and sideband/phase noise
Agenda

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Modern spectrum analyzer designs & capabilities
  – Wide Analysis Bandwidth Measurements
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Automation Tools
Wrap-up
Modern Spectrum Analyzer Block Diagram
Modern Spectrum Analyzer Block Diagram

- **Auto Alignment**
  - Temp & time calibration

- **3 to 26.5 GHz Pre-amp**
  - Improve 1 GHz
  - DANL -155dBm to -165dBm

- **Analog Pre-Filter**
  - (Single Pole)

- **Attenuation**
  - 2 dB step to 26.5 GHz

- **Digitally Synthesized LO**
  - Fast tuning
  - Close-in phase noise
  - Far-out phase noise

- **16 bit ADC**
  - Wider dynamic range with autoranging
  - Dither on/off

- **Digital IF Filters**
  - 160 RBW filters
  - 1 Hz to 8 MHz
  - ±0.03 dB switching error
  - 4.1:1 Shape factor
  - Fast sweep
  - EMI RBW’s (Opt. EMC)

- **Digital Detectors**
  - Normal
  - Peak
  - Min
  - Sample
  - RMS
  - Avg
  - QPD (Opt. EMC)

- **FFT vs Swept RBW**
  - Faster Sweep w/Max DR

- **Digital Log Amp**
  - ±0.07 dB Scale Fidelity
  - >100 dB Dynamic range
  - ±0.0 dB reference level error

- **Digital Video Filters**
  - Power, voltage, log filtering

- **Frequency Counter**
  - Fast (0.1s)
  - High resolution (mHz)

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Modern Spectrum Analyzer - Specifications
Digital IF provides improved accuracy

<table>
<thead>
<tr>
<th>Specification</th>
<th>PXA</th>
<th>Traditional</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input impedance mismatch</td>
<td>±0.13</td>
<td>±0.29 dB</td>
</tr>
<tr>
<td>Input attenuator switching uncertainty</td>
<td>±0.14</td>
<td>±0.6 dB</td>
</tr>
<tr>
<td>Frequency response</td>
<td>±0.35</td>
<td>±1.8 dB</td>
</tr>
<tr>
<td>Reference level accuracy</td>
<td>±0.0</td>
<td>±1.0 dB</td>
</tr>
<tr>
<td>RBW switching uncertainty</td>
<td>±0.03</td>
<td>±0.5 dB</td>
</tr>
<tr>
<td>Display scale fidelity</td>
<td>±0.07</td>
<td>±0.95 dB</td>
</tr>
<tr>
<td>Calibrator accuracy</td>
<td>±0.24</td>
<td>±0.34 dB</td>
</tr>
</tbody>
</table>

**Total accuracy (up to 3 GHz)**
- 95% Confidence
- PXA: ±0.59 dB vs. ±1.8 dB
- ±0.19 dB
Wide band analysis

PXA Simplified Block Diagram (140 MHz BW)

140 MHz Path
- ADC Nominal bits: 14
- ADC Effective bits: 11.2
- SFDR: up to 75 dBc

140 MHz BW (option B1X)
- 140 MHz
- 2Gbyte SDRAM
- FPGA
- ASIC

40 MHz BW (option B40)
- 40 MHz
- 2Gbyte SDRAM
- FPGA
- ASIC

Electronic Preamp, e-attenuator and calibrator switches

Front End
- 3.5-26.5 GHz high band
- 3 Hz-26.5 GHz Input
- 2.2-8.102030
- 8.3-14 GHz LO
- FPGA ADC
- 3.5-26.5 GHz high band
- 140 MHz

RF converter
- 4.8 GHz LO
- 140 MHz
- Linearity Corrections
- 2nd converter

0-3.6 GHz low band
- 4 GHz
- 1 dB-step electronic atten
- RF preamp

300 MHz LO
- Swept IF, 10 MHz & 25 MHz BW (option B25)
- 966K
- 303K
- 79K
- 9K

Switched filters, F0=22.5 MHz

300 MHz LO
- Back to Basics Seminar

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The combination of real-time measurement processing with an unprecedented characterization of the analyzer’s own noise to allow that noise to be accurately removed from measurements.

The improvement from *noise floor extension* varies from about 3.5 dB for CW and pulsed signals to approximately 8 dB for noise-like signals, and up to 12 dB or more in some applications.

DANL at 2 GHz is –161 dBm without a preamp and –172 dBm with the preamp.
Agenda

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Modern spectrum analyzer designs & capabilities

Applications
  – Digital Modulation
  – Phase Noise
  – Noise Figure

Automation Tools
Wrap-up
### Application Focused Internal Software

#### General purpose applications
- Phase noise
- Ext. source control
- Noise figure
- Code compatibility suite
- EMI pre-compliance
- Analog demod

#### Flexible digital modulation analysis
- Flexible demod
- LTE FDD, TDD
- W-CDMA/HSPA/HSPA+
- GSM/EDGE/EDGE Evo
- cdma2000 & 1xEV-DO
- cdmaOne
- DVB-T/H/C/T2
- TD-SCDMA/HSPA
- WLAN (802.11a/b/g/p/j)
- 802.16 OFDMA
- Bluetooth

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![Image of graphs and charts related to digital modulation analysis.](image-url)
change pictures for PXA
shanscon, 12/2/2010
Built-in One-Button Power Measurements

- Occupied Bandwidth
- Channel Power
- ACP
- Multi-carrier ACP
- CCDF
- Harmonic Distortion
- Burst Power
- TOI
- Spurious Emissions
- Spectral Emissions Mask
Why Use Digital Modulation?

- More information capacity & more spectrally efficient than analog modulation
- Compatibility with digital data services
- Higher data security
- Better quality communication
What is Digital Modulation?

- Restricts modulating baseband signal to discrete states (Digital)

Amplitude (ASK)
Frequency (FSK)
Phase (PSK)
Both Amplitude and Phase (QAM)

- Project Signals to “I” and “Q” Axes
- Polar to Rectangular Conversion
- IQ Plan Shows 2 Things
  - What the modulated carrier is doing relative to the unmodulated carrier
  - What baseband I and Q inputs are required to produce the modulated carrier
Some Simple Examples of Digital Modulation

<table>
<thead>
<tr>
<th>Modulation format</th>
<th>Number of bits per symbol</th>
<th>Constellation</th>
<th>Transmission bandwidth</th>
</tr>
</thead>
<tbody>
<tr>
<td>BPSK</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>QPSK</td>
<td>2</td>
<td></td>
<td>F/2</td>
</tr>
<tr>
<td>16 QAM</td>
<td>4</td>
<td></td>
<td>F/4</td>
</tr>
</tbody>
</table>

Symbol Rate = #symbols/sec. (Hz)
Digital Format Access Schemes

**FDMA**
- One User
- Different channel - different Users

**TDMA**
- Different time - different Users

**CDMA**
- Same channel – many users

**OFDM**
- Different time - different Users
How to Digitally Modulate/Demodulate?

Modulate

Demodulate

Q:

I:
Measurements of Quality for Digital Modulation

Demodulated signal I/Q values are compared with ideal expected constellation location. The difference is the Error Vector Magnitude (EVM).

Overall measurement of signal quality is rms EVM given in percent of dB.

EVM can also be displayed versus time and versus frequency.
Tools for Digital Modulation Analysis

Embedded Software Applications:
• Over 30 modulation format specific measurement applications which run inside the X-series analyzers.
• Best solution for manufacturing where speed is required.

Software: 89601B VSA Software
• Supports over 70 modulation formats.
• Runs on an external PC, or inside hardware.
• Best solution for R&D where flexibility and troubleshooting tools are required
Phase Noise Overview

What is “Phase Noise”?  
- A random, side band noise 
- Caused by phase fluctuations of an oscillator

In the time domain, PN shows as jitters. 
In freq. domain, PN appears as noise sidebands.

In the time domain, PN shows as jitters. 
In freq. domain, PN appears as noise sidebands.
Phase Noise Overview

How to define “Phase Noise”?

3 elements:
- Offset freq. from carrier freq.
- Power spectral density (in 1 Hz BW)
- Relative to carrier power in dBc

\[ \text{dBc/Hz} \ @ \ offset \ freq. \ fm \]
Why is phase noise important?

- Better PN of the LO improves sub-channel resolution
Direct Spectrum Measurement Method

- Easy to configure and use
- Quick phase noise check
- Log pot
- Spot frequency (PN change vs. time)
- rms PN, rms Jitter, residual FM
- X-Series phase noise application automates the PN measurements
- Limited by SA internal PN floor
- Caution: Direct Spectrum method requires AM << PM
What is Noise Figure?

\[ F = \frac{S_i}{N_i} \frac{S_o}{N_o} = \frac{S_i}{N_i} \frac{G S_i}{(N_a + GN_i)} = \frac{N_a + GN_i}{GN_i} \]  

Signal/Noise Degradation

CF = 850 MHz  Span = 100 MHz

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Noise in Cascaded Two Port Networks

\[ F_{sys} = F_1 + \frac{F_2 - 1}{G_1} \]
How to Measure Noise Figure:

\[ (kT_B G_a + N_a) \cdot k T \cdot B \cdot G_{fa} \cdot N_a + \]

\[ k T_0 B \]
Corrected Noise Figure

\[ F_{sys} = F_1 + \frac{F_2 - 1}{G_1} \]

\[ F_1 = F_{sys} - \frac{F_2 - 1}{G_1} \quad (13) \]

\[ G_1 = \frac{N'_2 - N'_1}{N_2 - N_1} \quad (14) \]

\( N_2 \rightarrow \text{noise source on} \)

\( N_1 \rightarrow \text{noise source off} \)
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LAN eXtension for Instrumentation

LXI devices serve a web page

- Manufacturer
- Model #
- Serial #
- Firmware rev.
- IP Address
- Domain name
- etc.

Ability to change the IP address

Using standard web browser
X-Series LXI Web control example

Display

Keypad
LXI Possibilities

- Long distance operations
- Expert Troubleshooting
- Parallel operations
- Reduce programming
- Smart instruments
- Higher throughput
- No trigger wires
- Flexible triggering
- Eliminate latency
- Timestamp all data
- Internal network
- Asset Management
SystemVue

*Overcome early R&D measurement holes using simulation*

If any of these pieces is missing….

- TX but no RX!!
- Test Equipment personality doesn’t exist yet 😞
- Fading & Interference
- The standard just changed!
- Vendor is LATE getting you hardware
- Multiple H/W for MIMO?
- Will this still work when I add the RF front end?
- Modulated RF in vs. Bits out …how to measure Throughput?

….Use SystemVue to complete a working PHY

- Finish create superior algorithms
- Make new or challenging link-level measurements, such as BER, Throughput
- Verify critical system-level performance, despite missing IP, Equip, or H/W
SystemVue Example

Simulated EVM = -47 dB

Measured EVM = -39 dB

Signal Generator

Signal Analyzer
MATLAB Software Control

- MATLAB software can now be installed directly on the signal analyzers.
- **Key uses:**
  1. Create, modify, and execute your own applications
  2. Analyze, filter, and visualize data
  3. Execute and test custom modulation schemes
  4. Generate arbitrary waveforms
  5. Automate measurements
  6. Configuration and control instruments

www.agilent.com/find/n6171a

```matlab
% Example: MATLAB/MXA program
% TCPIP parameters of the MXA box
mx_a_ip = '141.121.92.157';
mx_a_port = 5025;
% MXA connection opening
mx_a = tcpip(mx_a_ip,mx_a_port);
fopen(mx_a);
% Instrument identification
idn = query(mx_a,'*IDN?');
fprintf('Hello from %s', idn);
% Set the center frequency to 1 GHz
fprintf(mx_a,':FREQ:CENT 1 GHz');
% Set the span to 20 MHz
fprintf(mx_a,':FREQ:SPAN 20 MHz');
```
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Agilent X-Series Signal Analysis
An evolutionary approach to signal analysis that spans instrumentation, measurements and software

X-Series Signal Analysis
Just got better.....

Price

Performance

856xEC
Mid-performance

PSA
Market leading performance
3 Hz to 50 GHz

PXA
X-Series
High-performance
3 Hz to 26.5 GHz

MXA
X-Series
Mid-performance
20 Hz to 26.5 GHz

ESA
World’s most popular
100 Hz to 26.5 GHz

EXA
X-Series
Economy-class
9 kHz to 26.5 GHz

CXA
X-Series
Low-cost
9 kHz to 7.5 GHz

Expanded backward code compatibility with 856xE/EC, 66/68 on PXA/MXA/EXA

Back to Basics Seminar

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Agilent Spectrum Analyzer Families (Handhelds)

**N9342C Handheld Spectrum Analyzer**
- **Handheld SA** -- 100kHz to 7.0 GHz
- Fastest sweep – minimum sweep time < 2ms
- $-164$ dBm displayed average noise level (DANL) typical
- $+10$ dBm third order intercept (TOI)
- Light weight, rugged and portable
- four hours battery life

**N9340B Handheld Spectrum Analyzer**
- **Handheld SA** -- 100kHz to 3.0 GHz
- 10 ms non-zero span sweep time
- $-144$ dBm displayed average noise level (DANL) with pre-amplifier
- $+10$ dBm third order intercept (TOI)
- Light weight, rugged and portable
- four hours battery life
Agilent Vector Signal Analysis Software

89600B VSA Software

- FFT-based spectrum, time-domain & bit-level modulation analysis
- Support for more than 70 signal standards and modulation types
- 20:20 trace/marker capability and arbitrary window arrangement
- Digital persistence and cumulative history displays

- Wireless networking: 802.11a/b/g/n, 802.16 OFDMA, WiMAX...
- Cellular: LTE (FDD/TDD), W-CDMA HSPA+, GSM/EDGE Evolution
- Custom OFDM modulation analysis for proprietary signals

- Links to over 30 hardware platforms including: X-series signal analyzers, 16800 logic analyzers, 90000 X-series scopes, Infinium scopes, VXI
- Runs on external PC linked to hardware or embedded operation on instruments with Windows OS
Basic Spectrum Analyzer Application & Product Notes

A.N. 150 – Spectrum Analysis Basics: #5952-0292EN
A.N. 150-15 - Vector Signal Analysis Basics: #5989-1121EN

Spectrum Analyzer & Signal Analyzer Selection Guide: #5968-3413E

PXA Brochure: 5990-3951EN
MXA Brochure: 5989-5047EN
EXA Brochure: 5989-6527EN
CXA Brochure: 5990-3927EN
N9342B Brochure: 5990-5586EN
89600B Brochure: 5990-6553EN

www.agilent.com/find/sa
The End

THANK YOU!