



Agilent Technologies

RF Source Basics

January 30, 2002

presented by:

**Al Lorona
Tom Holmes
Terri Hightower**

Welcome

- **Types of sources**
 - CW
 - Swept
 - Signal generator (modulation)
 - Analog
 - Digital modulation concepts
- **Important specifications**
 - Frequency and spectral purity
 - Amplitude



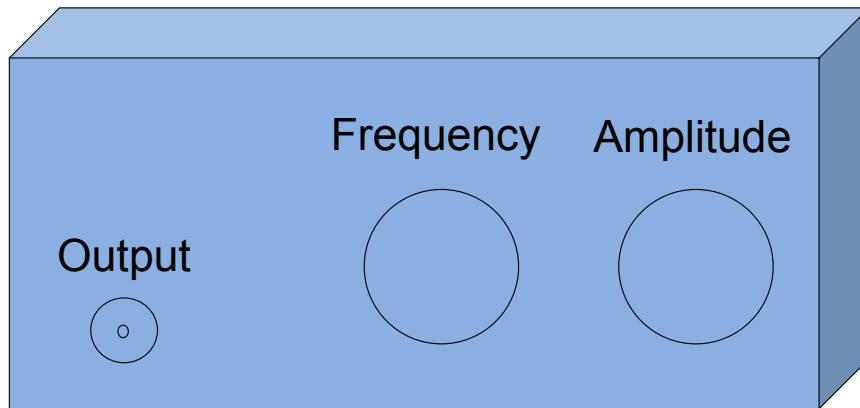
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The Ideal Source



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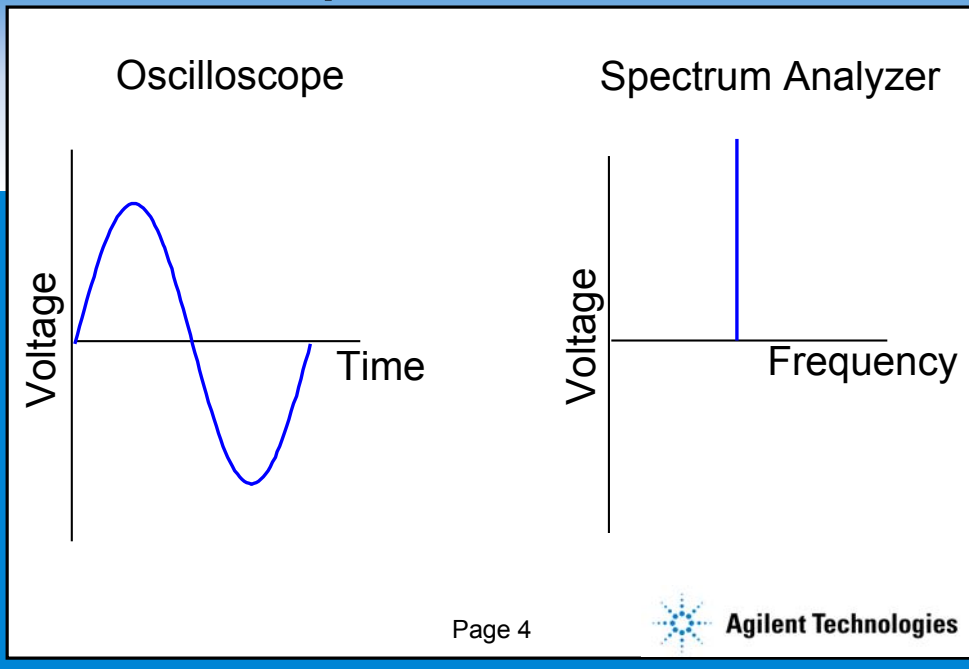
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What the Output Looks Like



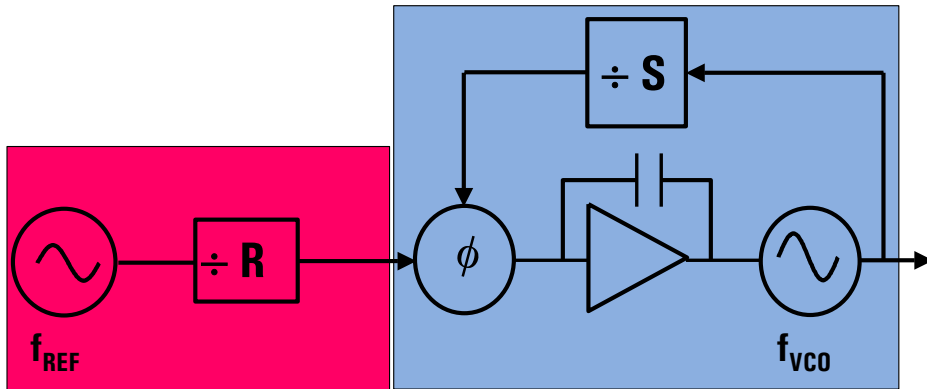
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Block Diagram



$$f_{VCO} = S/R * f_{REF}$$



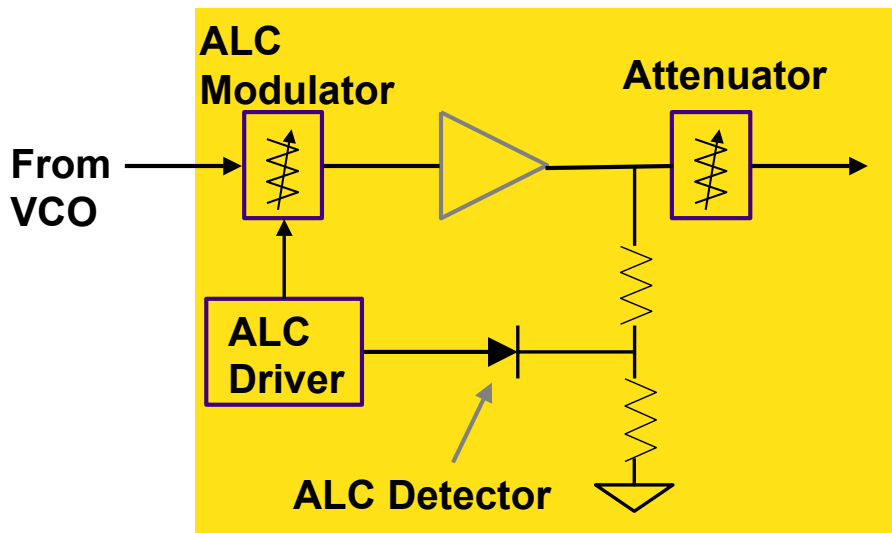
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Output Section



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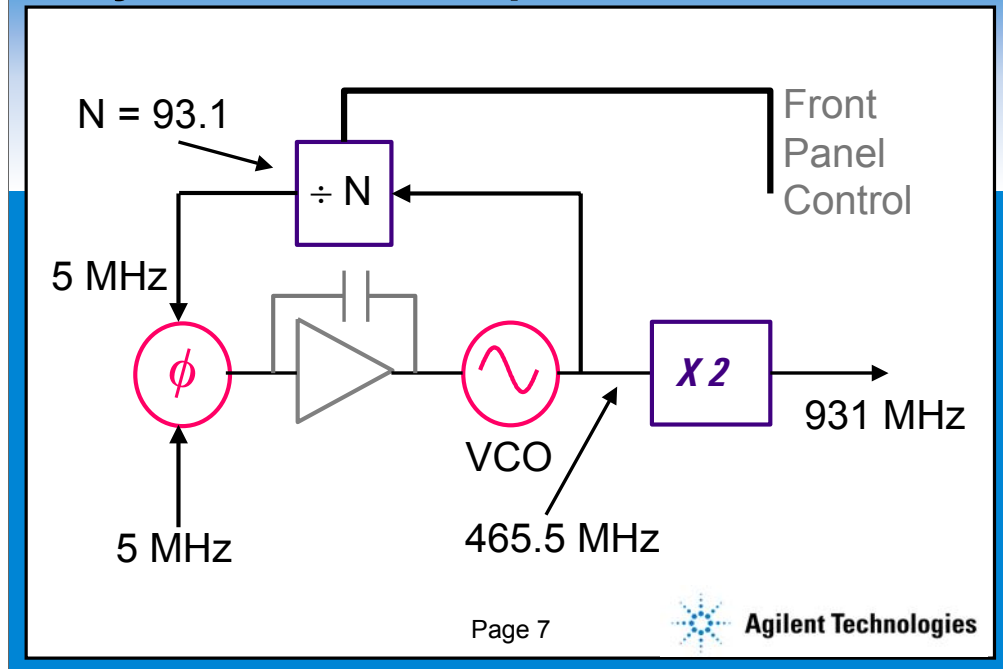
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A Synthesizer Example



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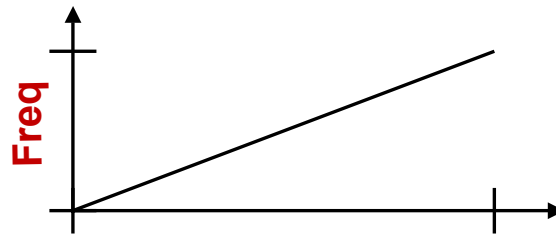
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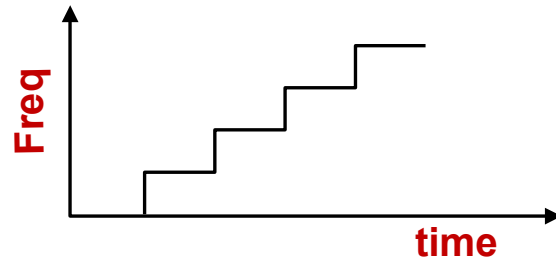
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Swept Sources

Ramp Sweep



Step Sweep



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Signal Generators Add Modulation

- **Calibrated modulation**
 - **Analog (AM, FM, PM, pulse)**
 - **Digital (I-Q)**
 - **Format specific (for example, TDMA and CDMA)**

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Modulation... Where the Info Is

$$V = A(t) \sin [2 \pi f(t) + \phi(t)]$$

AM, Pulse

FM

PM



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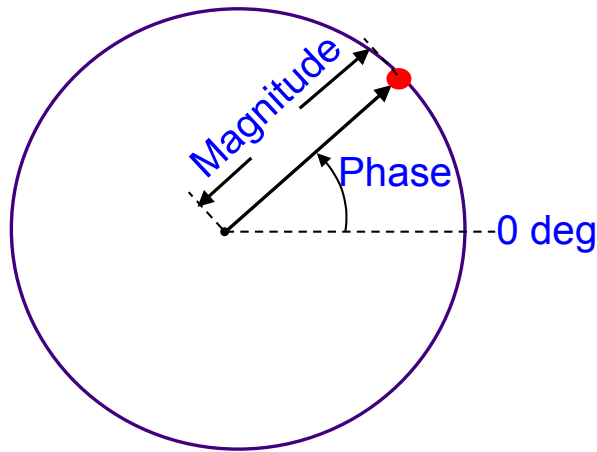
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Polar Display

Magnitude and Phase Represented Together



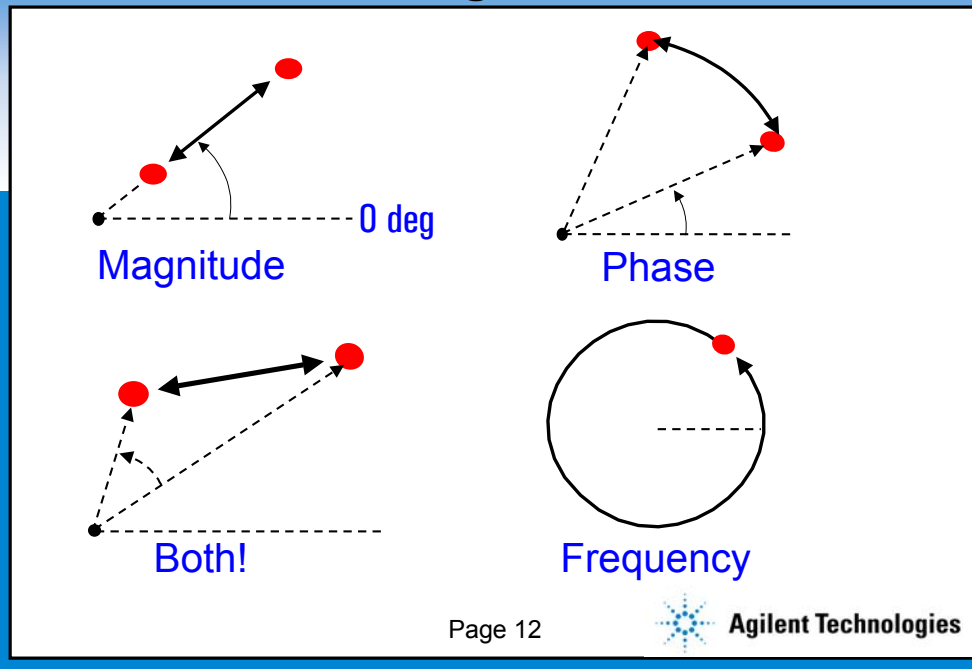
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What Can Be Changed ?



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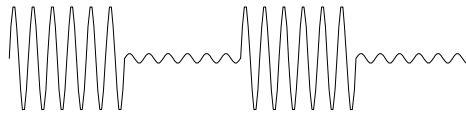
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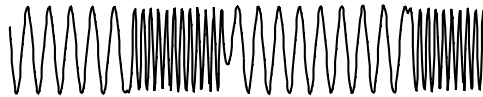
Digital Modulation

Signal Characteristics to Modify

Amplitude



Frequency



Phase



Both Amplitude
and Phase



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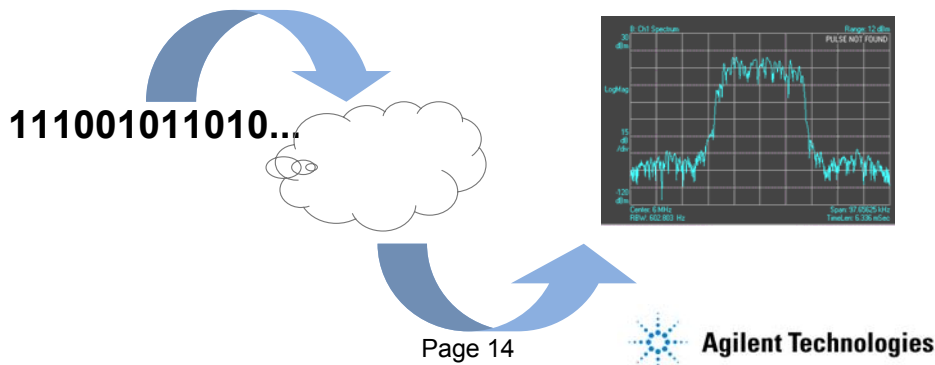
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From Bits to Modulated Signal

Now we are going to show how information is transmitted by digital modulation.

Our example is a QPSK transmitter.



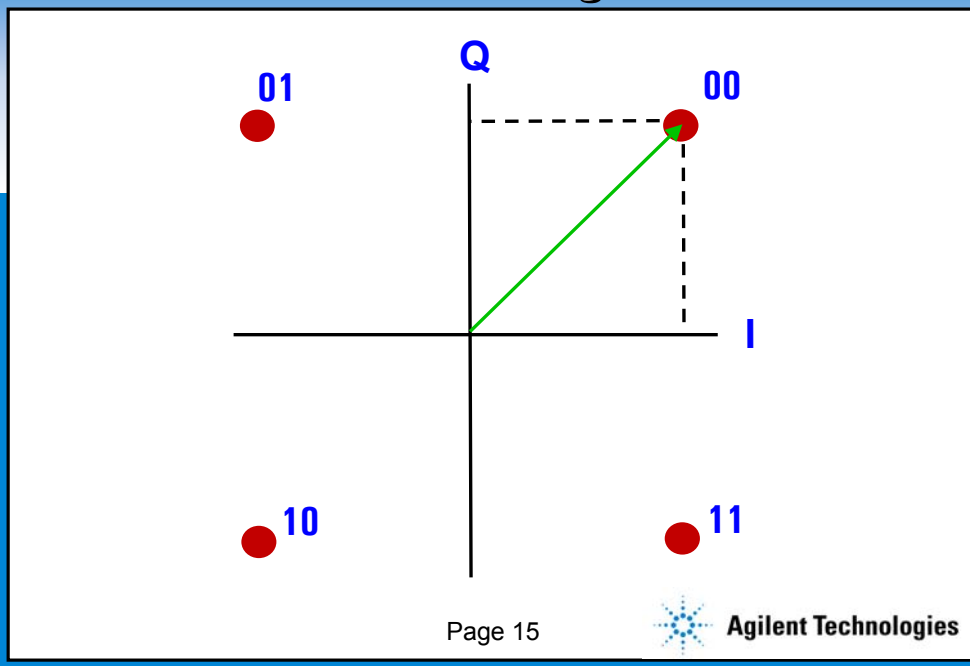
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QPSK Constellation Diagram



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Serial Bit Stream

Suppose these are the bits we want to send:

0110110001...

We group them into 2-bit symbols:

01 10 11 00 01...

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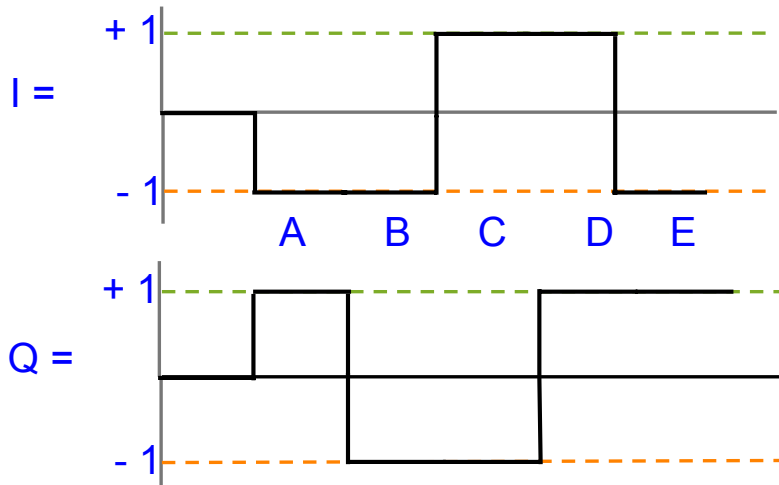
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Two Waveforms

I and Q Voltages Represent 01 10 11 00 01 . . .



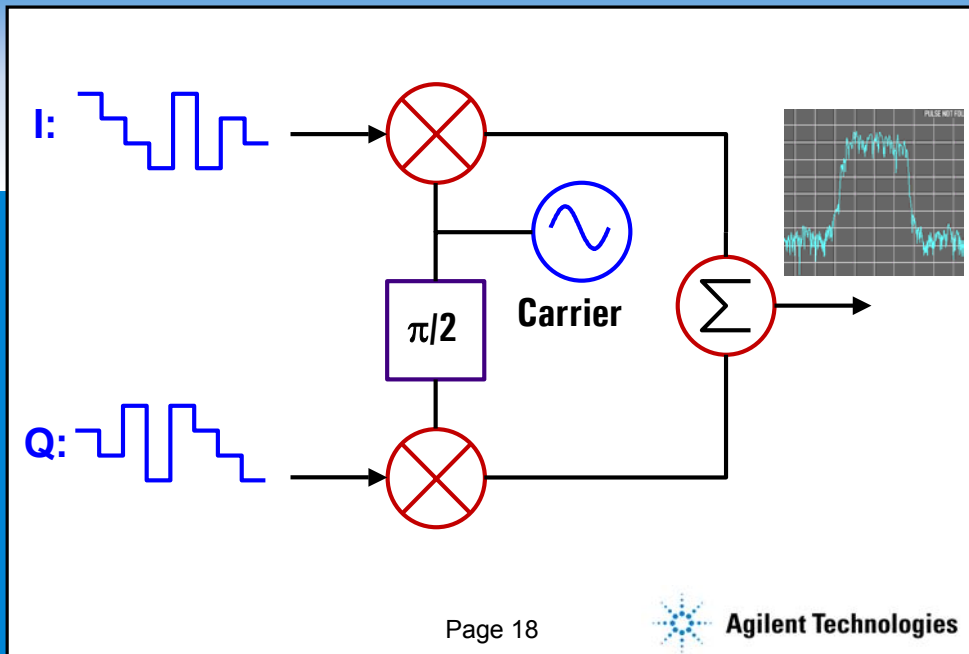
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I-Q Modulator



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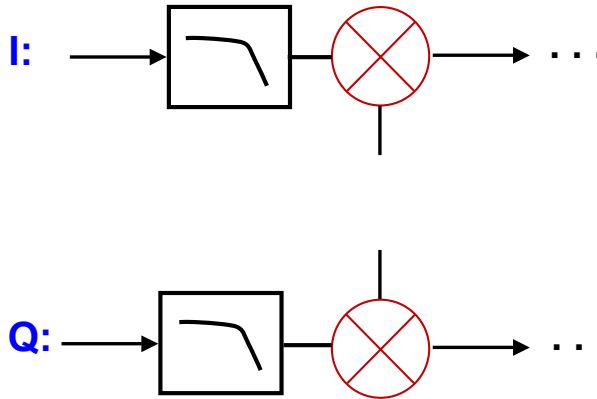
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Limiting Bandwidth

Low-Pass Filters Are Added at Inputs



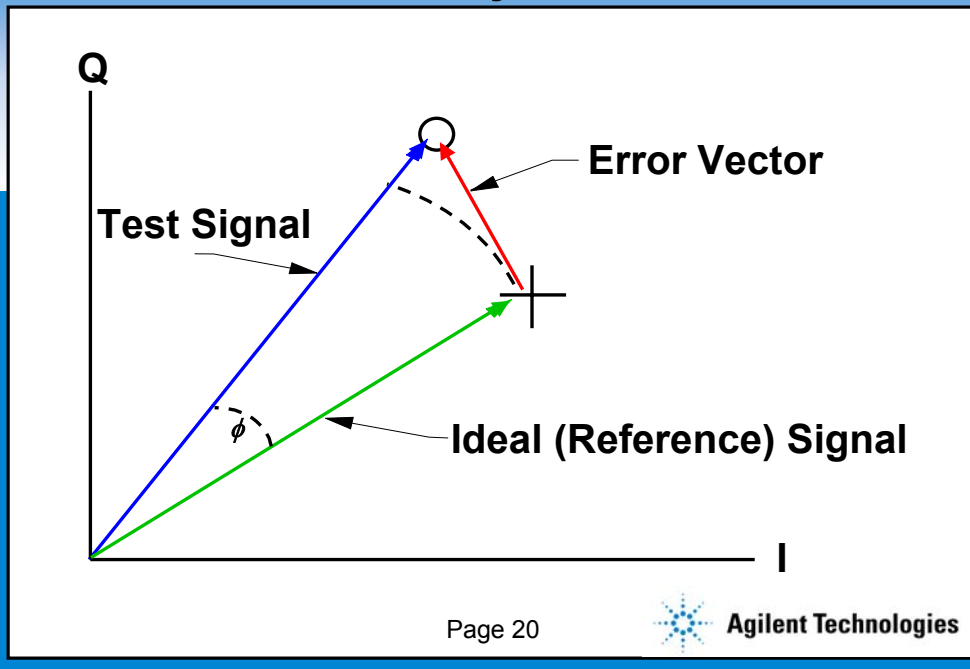
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Modulation Accuracy — EVM



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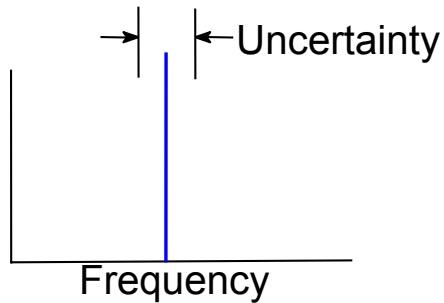
Critical Specifications

$$\text{Frequency accuracy} = \pm f_{\text{cw}} * t_{\text{aging}} * t_{\text{cal}}$$

CW frequency = 1.000000000 GHz

Aging rate = 0.152 ppm / year

Time since last calibrated = 1 year



Accuracy = ± 152 Hz



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Reference Oscillator Stability

	Temperature-compensated crystal oscillator (TCXO)	Oven-controlled crystal oscillator (OCXO)
Aging rate (ppm/yr.)	± 2	± 0.1
Temperature (ppm)	± 1	± 0.01



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Amplitude

- Range (-136 dBm to +13 dBm)
- Accuracy (± 0.5 dB)
- Resolution (0.02 dB)



DUT



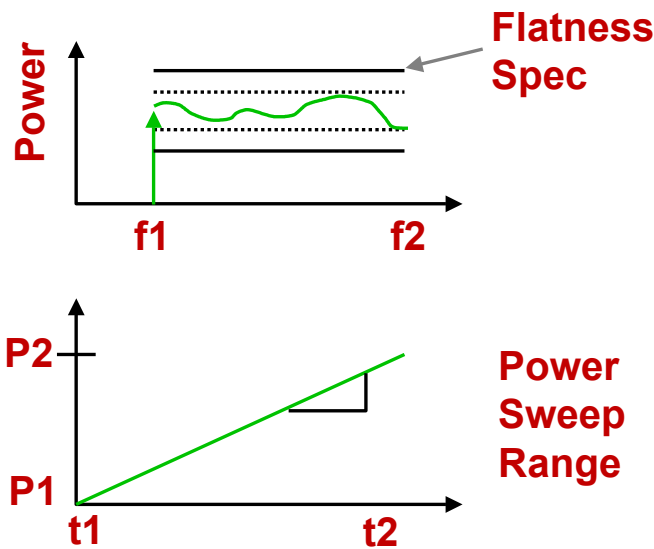
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Amplitude Accuracy



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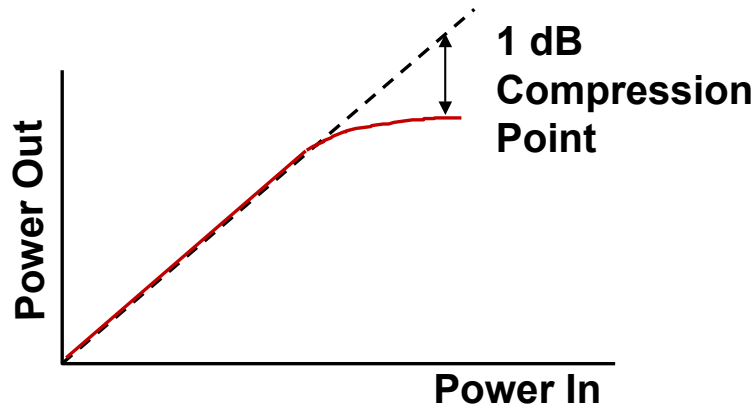
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Power Sweep

Important for Measuring 1 dB Compression



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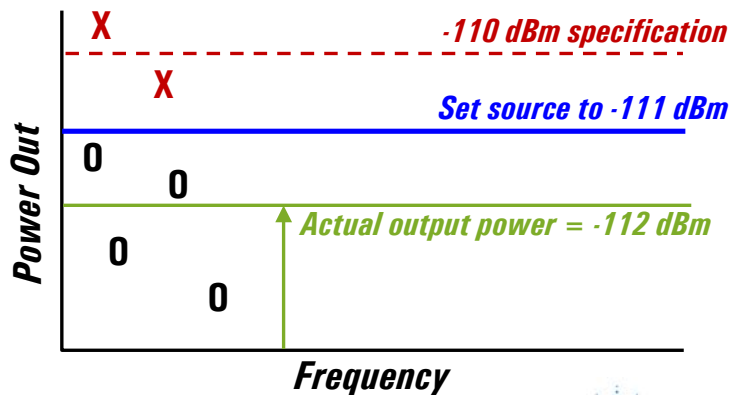
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Receiver Sensitivity Testing

Testing a Pager with Sensitivity Spec. of -110 dBm

X = Failed Unit

0 = Passed Unit



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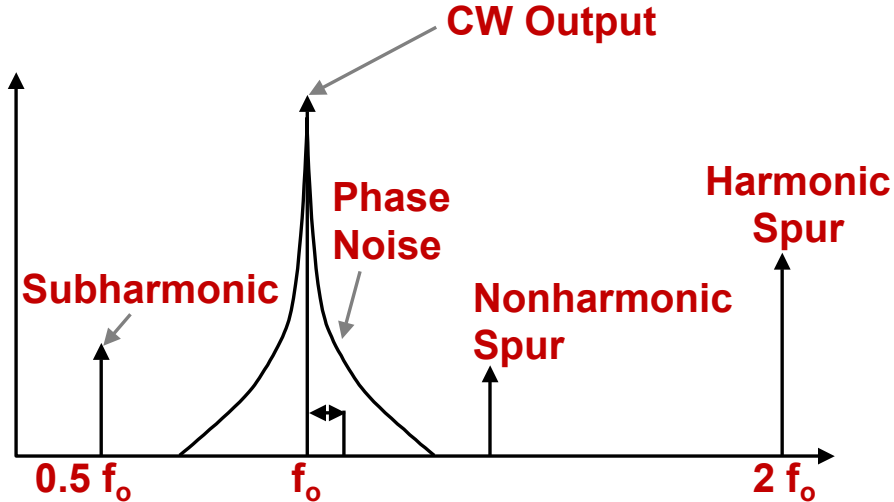
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Spectral Purity



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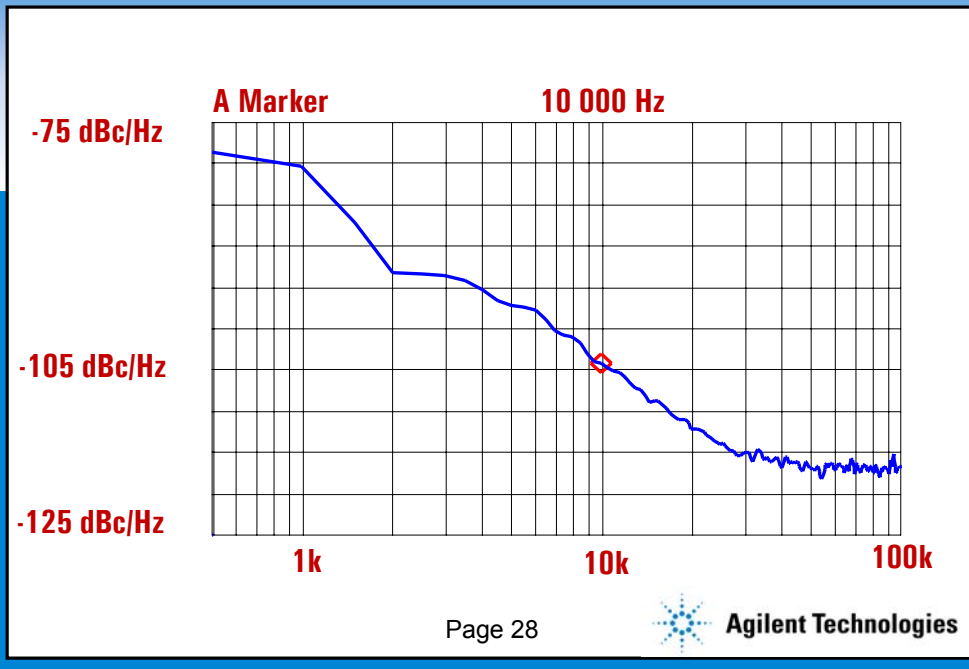
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Phase Noise



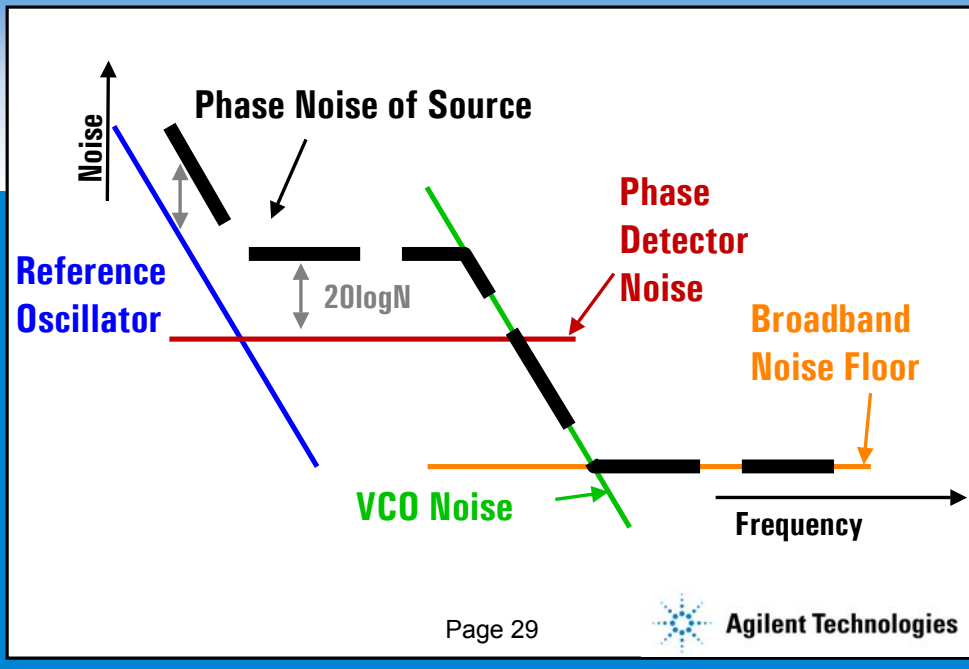
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Contributors to Phase Noise



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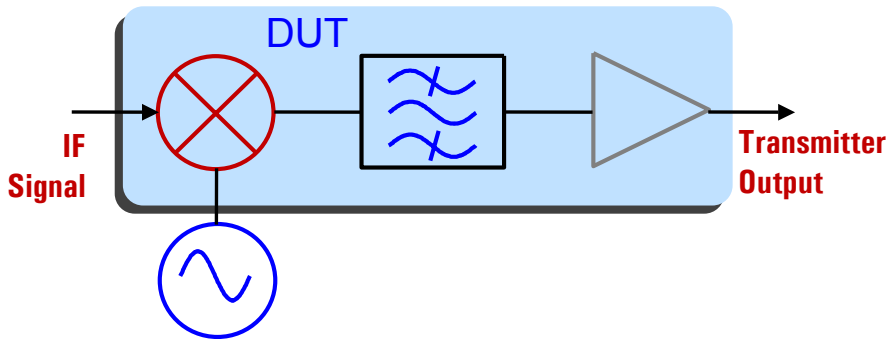
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Critical Specifications

When Used As a Local Oscillator



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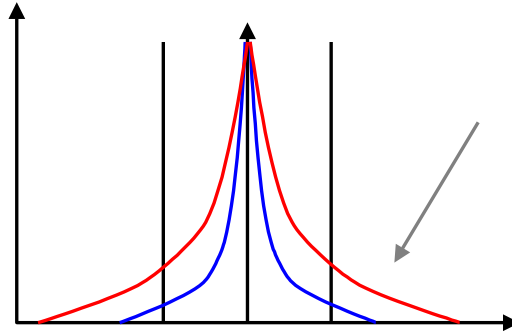
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Critical Specs As a Local Oscillator

Poor frequency accuracy will cause transmitter to be at the wrong frequency

Poor phase noise spreads energy into adjacent channels



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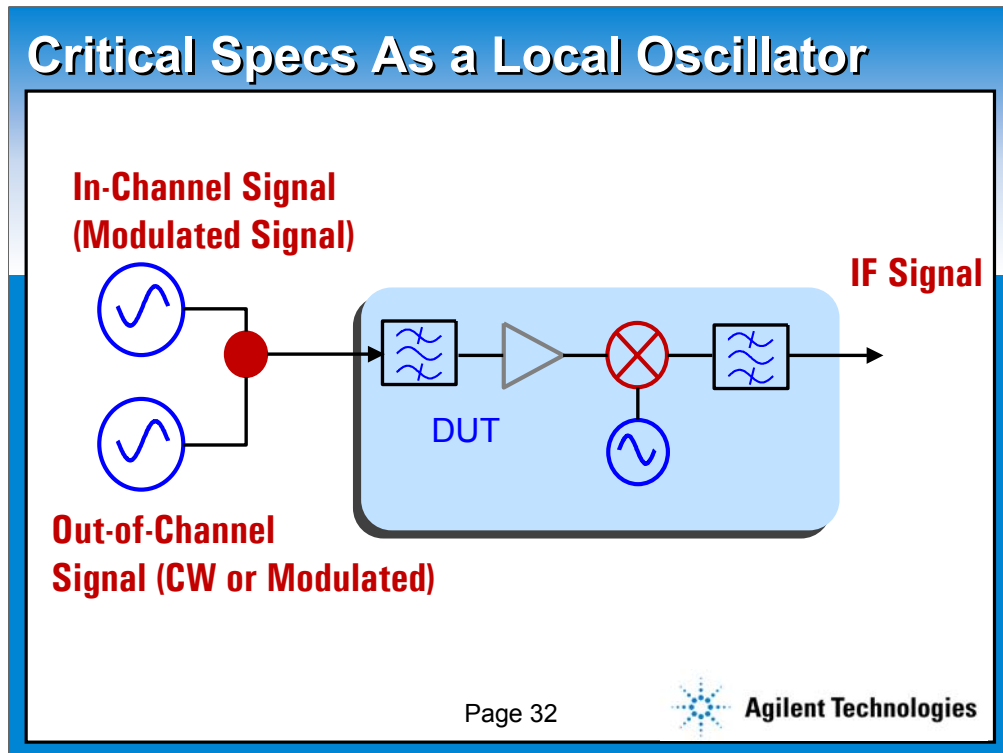
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A



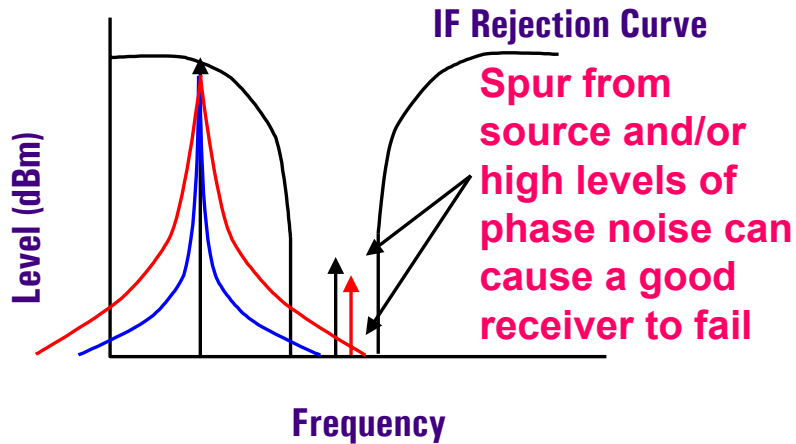
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Receiver Selectivity Testing



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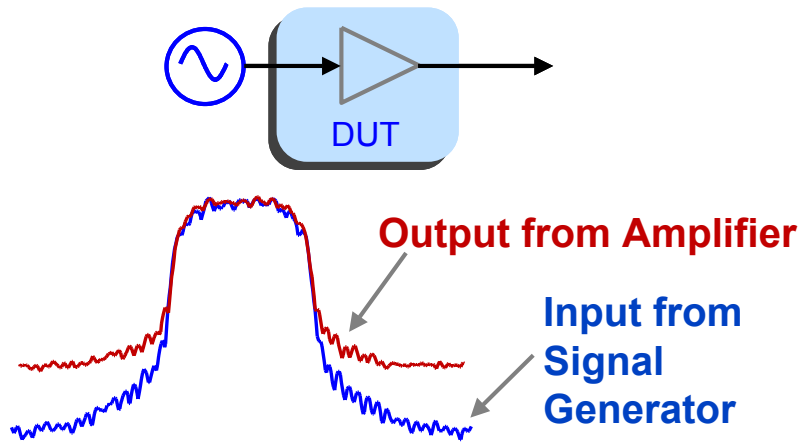
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Spectral Regrowth Testing

Requires Low Adjacent Channel Power (ACP)



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Summary of Critical Specs

- **Receiver sensitivity**
 - Frequency accuracy
 - Level accuracy
 - Error vector magnitude
- **Receiver selectivity**
 - Phase noise
 - Spurious
 - Spectral accuracy
- **Spectral regrowth**
 - ACP performance



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