Spectrum Analyzers
And
Network Analyzers

The Whats, Whys and Hows...

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Today's Program

- Definitions of Spectrum and Network Analyzers,
- Differences between SNA and VNA,
- Inner guts of both types of Analyzers,
- What you get with them,
- Calibration Kits,
- Buying one?
- Example measurements,
- Measurement of your devices?

Spectrum and Network Analyzers

- Look somewhat similar
  - CRT, Knobs, buttons, span, filters, RF input...
- Both work in the Frequency Domain
  - Sweep narrow to wide parts of frequency spectrum
  - Detect amplitudes and/or phase
  - Have similar displaying capabilities

HP 8560A SA

HP 8755A SNA

RF Spectrum Analyzer – Definition

- An RF spectrum analyzer is a device used to examine the spectral composition of some electrical waveform. It may also measure the power spectrum.

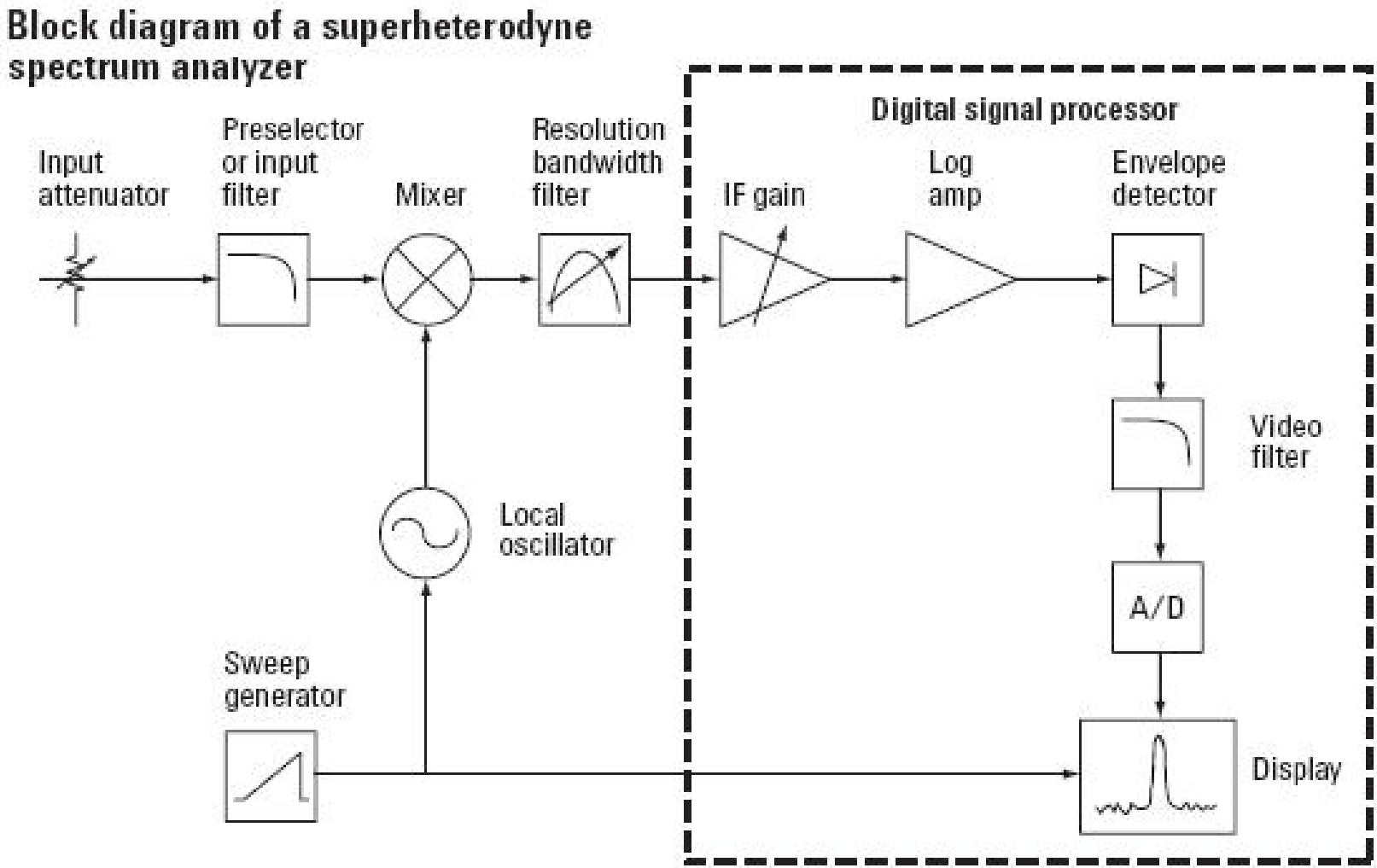
  Wikipedia

- Translation: It is a fast-sweeping tuned radio receiver that displays signal amplitudes at various frequencies.

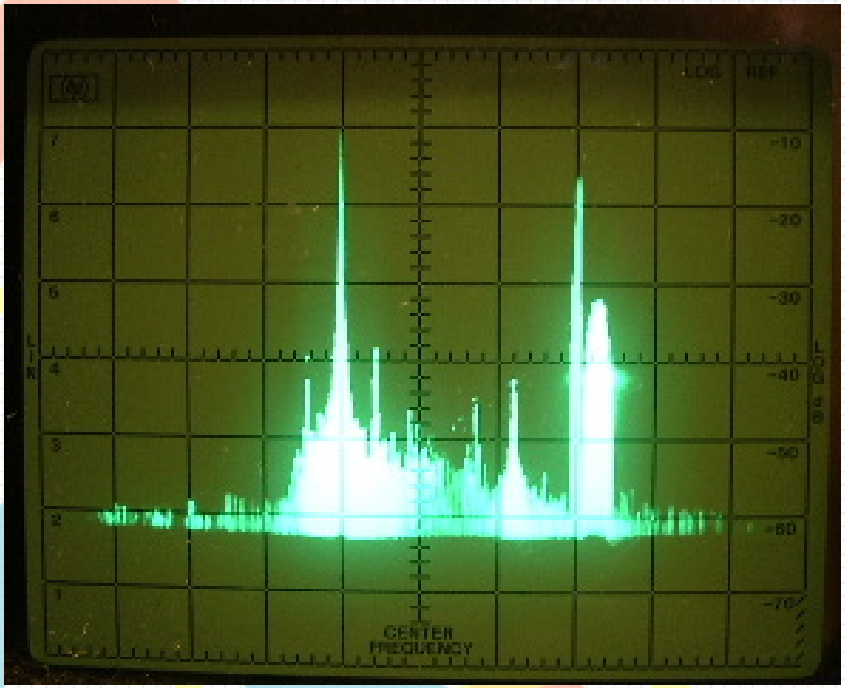
HP 494AP SA

HP 141T SA

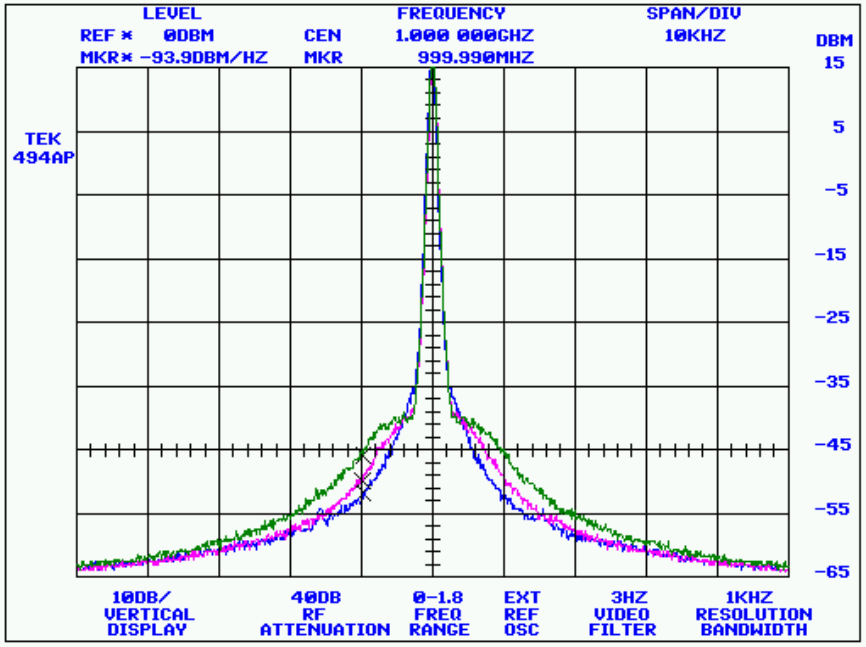
Spectrum Analyzer – Block Diagram



Spectrum Analyzer – What you get



Analog / Storage CRT



Synthesized with u-processor

Network Analyzer - Definition

- An instrument used to analyze the properties of electrical networks, especially those properties associated with the reflection and transmission of electrical signals known as scattering parameters (S-parameters). Wikipedia
- Translation: It is a fast-sweeping tuned or wideband radio receiver that displays relative signal amplitudes (and optionally phases) when compared to a reference at various frequencies.

HP 8505A VNA

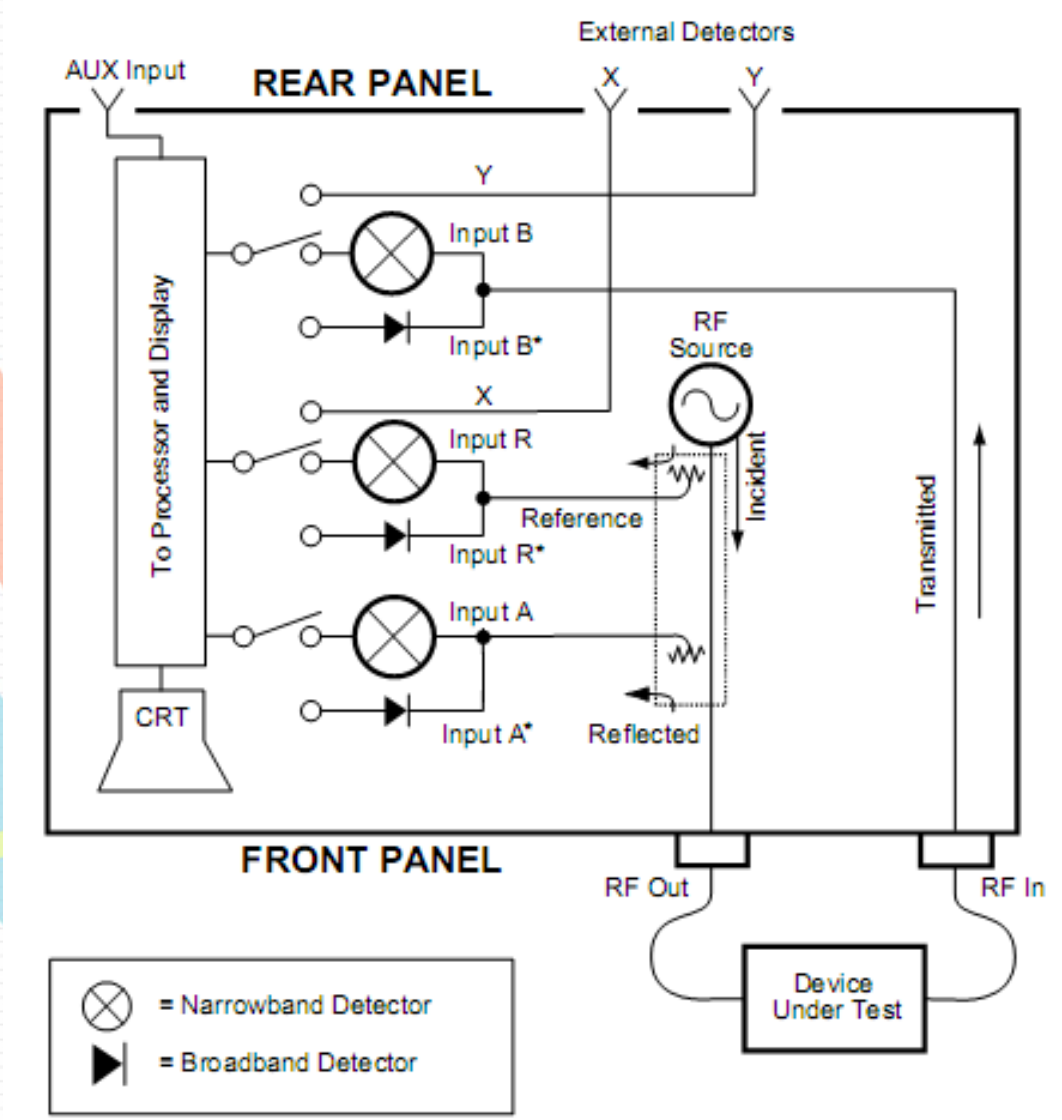
Network Analyzer – Two Types

- Scalar Network Analyzer (SNA)
  - Measures amplitude properties only. Simpler design ($)
  - Usually requires an external sweeping RF source
  - May have external RF detectors
- Vector Network Analyzer (VNA)
  - Measures both amplitude and phase properties with greater dynamic range and accuracy. Complex unit ($$$)
  - Has built-in sweeping RF source (generally)
  - Has built-in Tuned RF receiver

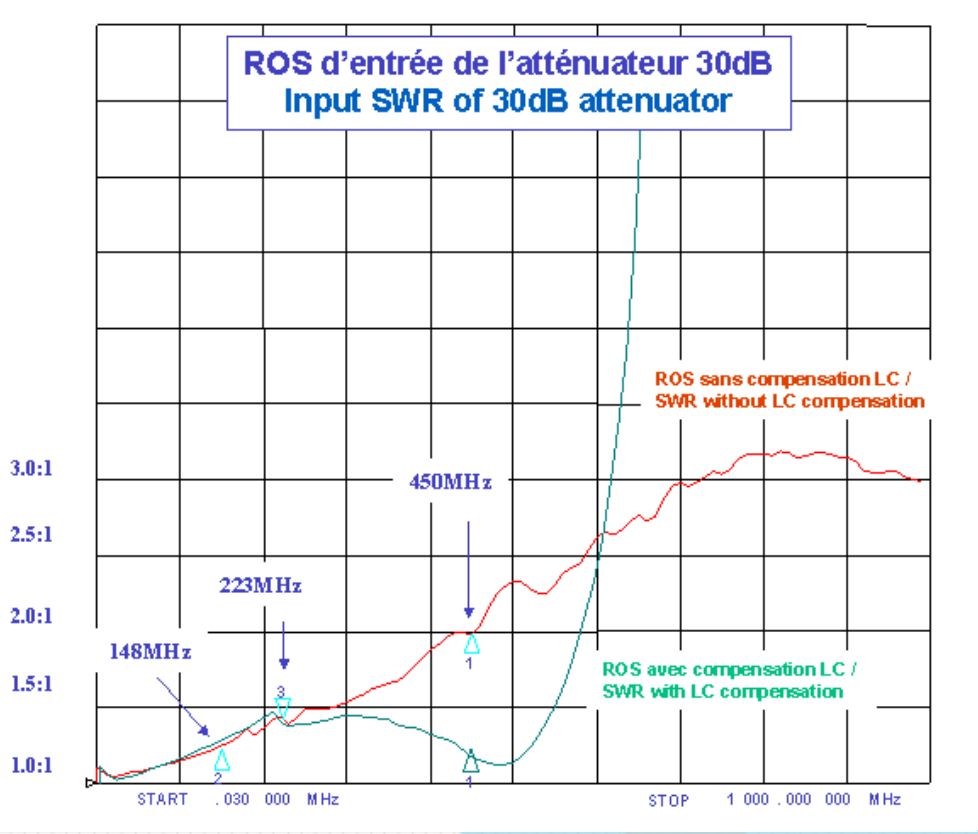
Wiltron 560 SNA

HP 8753C VNA

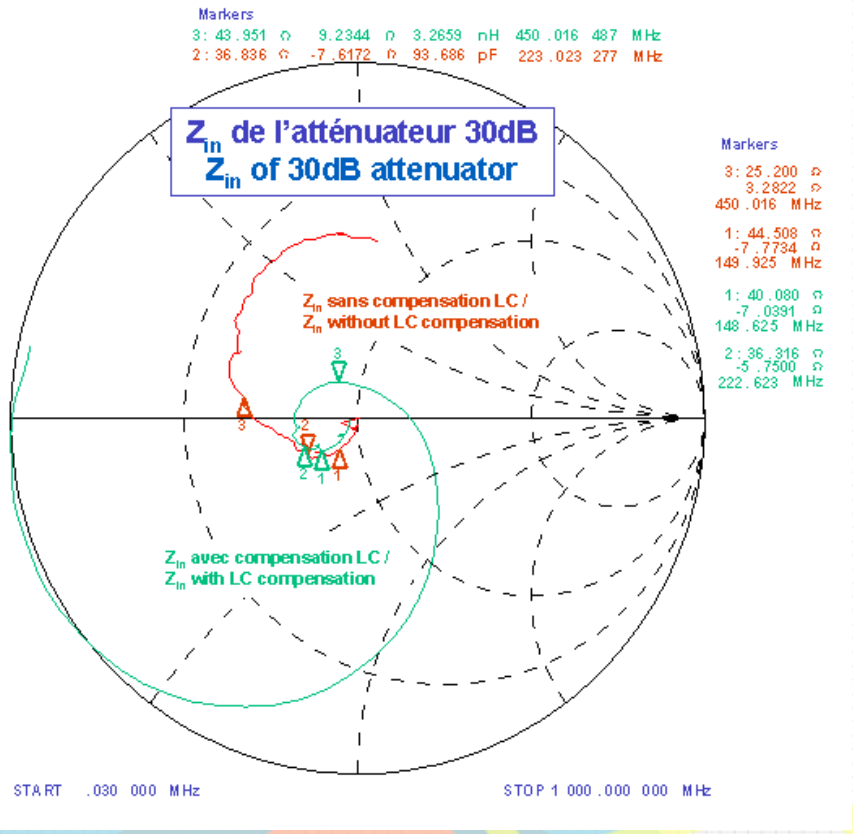
Network Analyzer – Block Diagram



Network Analyzer – What you get



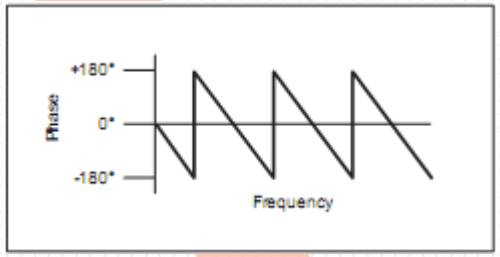
SNA or VNA



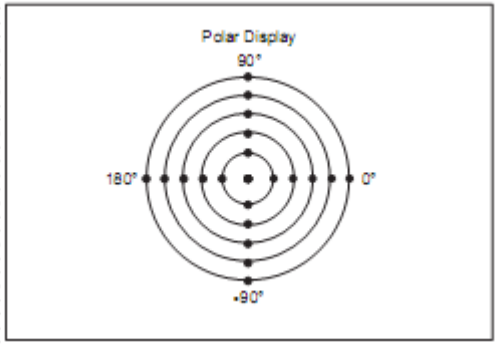
VNA

Vector Network Analyzers

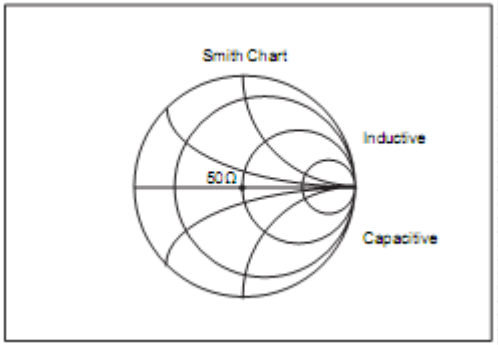
- Can display data in various forms



Linear Phase with Frequency

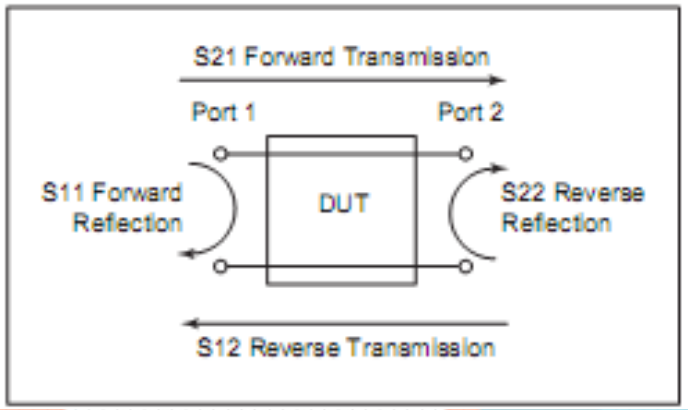


Polar Plot

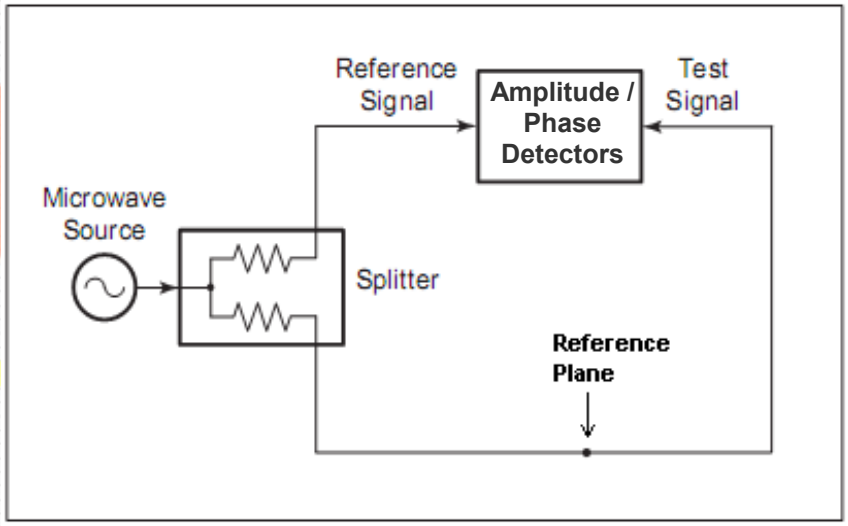


Smith Chart

- Can usually express results in the form of S-parameters directly.
  - Completely characterize a one-port or two-port linear or passive device



VNA Calibration before measurement



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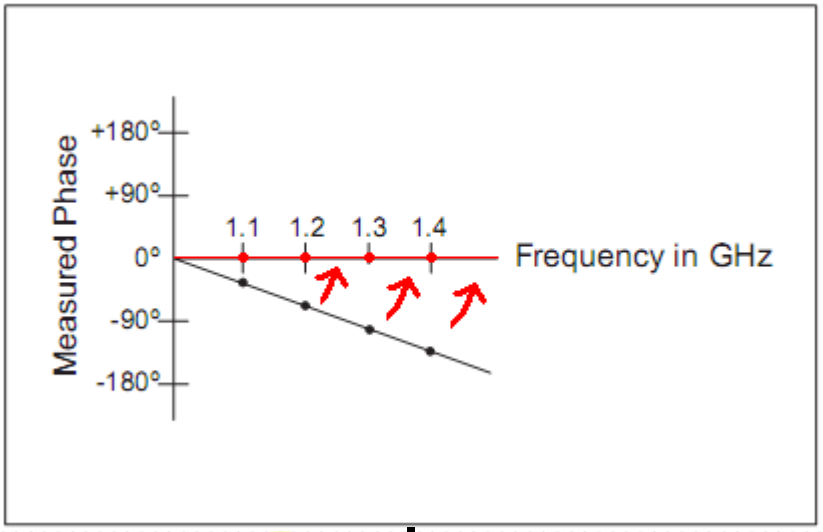

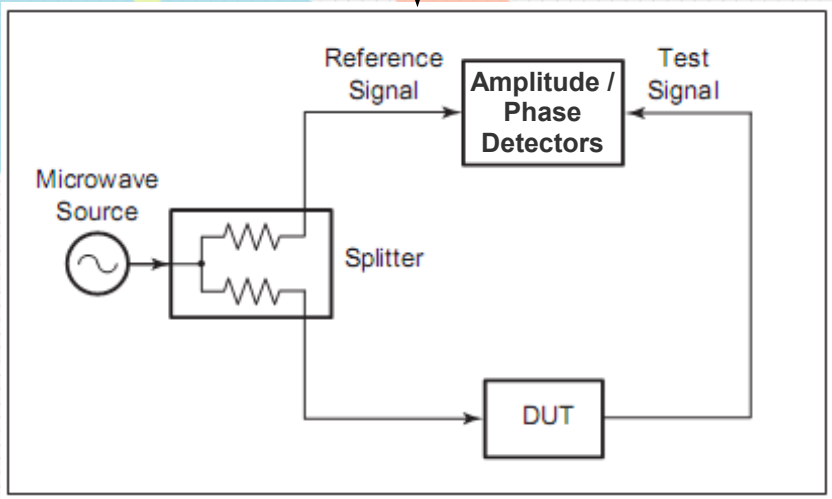

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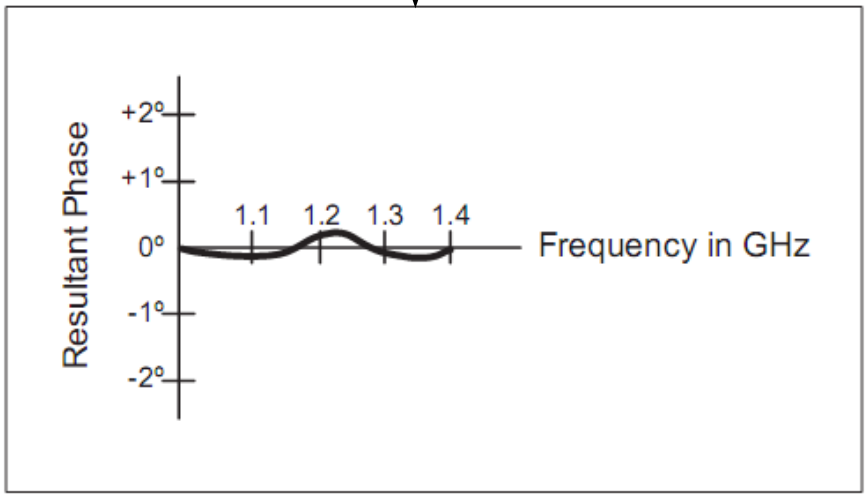
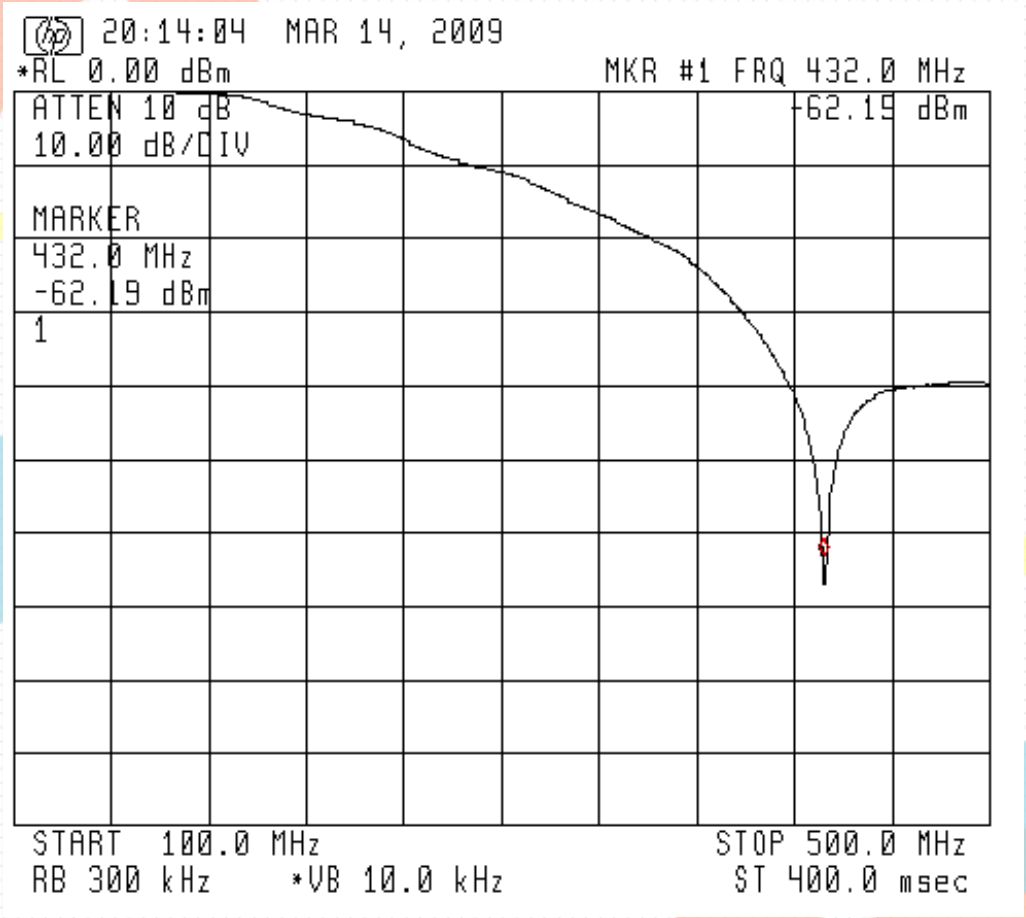


Some Calibration Required...

- VNAs require performing a “zero” to bring the reference plane at the Device-Under-Test point.
- Cal Kits
  - Short, Open, Termination and Thru.
  - Expensive!!!
- Make your own using good quality connectors, a termination and a bit of imagination...

SA can make a good SNA

- With addition of Tracking Generator



HP 8594A SA

HP 70000 SA

Buying a Spectrum Analyzer?

- Prices vary from ~ hundreds$ to thousands$.
- Good for general purpose experimenting and test. For example, required for cavity duplexer adjustment.
- CRT Trace Storage capability is a must.
- Addition of Tracking generator is a wise move.
- It is nice to be able to capture the plots. Need 1980's grade (GP-IB bus). Otherwise take screen pictures.
- The HP-141T mainframe SA is good entry point.
- Lab-Grade units keep their value.

Buying a Network Analyzer?

- Classic VNAs are expensive (min. 1000$). Keep their value.
- SNA....Better off with SA and Tracking Generator.
- Cheaper newer models available (use the computer for display/control). Not as broadband, not as accurate as classic lab-grade VNAs. Require a PC.
  - MiniVNA, max. 180MHz
  - N2PK Vector Network Analyzer, max. 60MHz, a kit.
  - VNA 2180, max. 180MHz
- Antenna Analyzers, a possibility...Limited in frequency and measurement range, accuracy, but are small and can be connected up at the antenna feedpoint.
  - MFJ-269, HF, VHF, UHF
  - AEA CIA-HF, HF
  - Autek RF-1, HF only

Want more?

- Spectrum Analyzer tutorial
  - http://www.radio-electronics.com/info/t_and_m/spectrum_analyser/rf-analyzer-basics-tutorial.php
  - http:///www.home.agilent.com .
    - Spectrum Analyzer Basics (AN 150)
    - Spectrum Analysis Basics: From 1997 Back to Basics Seminar
- Network Analyzer tutorial
  - http://www.radio-electronics.com/info/t_and_m/rf-network-analyzer/analyser-basics-tutorial.php
  - http:///www.home.agilent.com .
    - Network Analyzer Basics
    - Network Analysis Basics - Architecture Of Network Analyzers (AN 1287-2)
- Smith Chart Tools (Online Java Applets)
  - http://www.amanogawa.com/archive/transmissionB.html
  - http://www.bessernet.com/jobAids/jSmith/jSmith.html

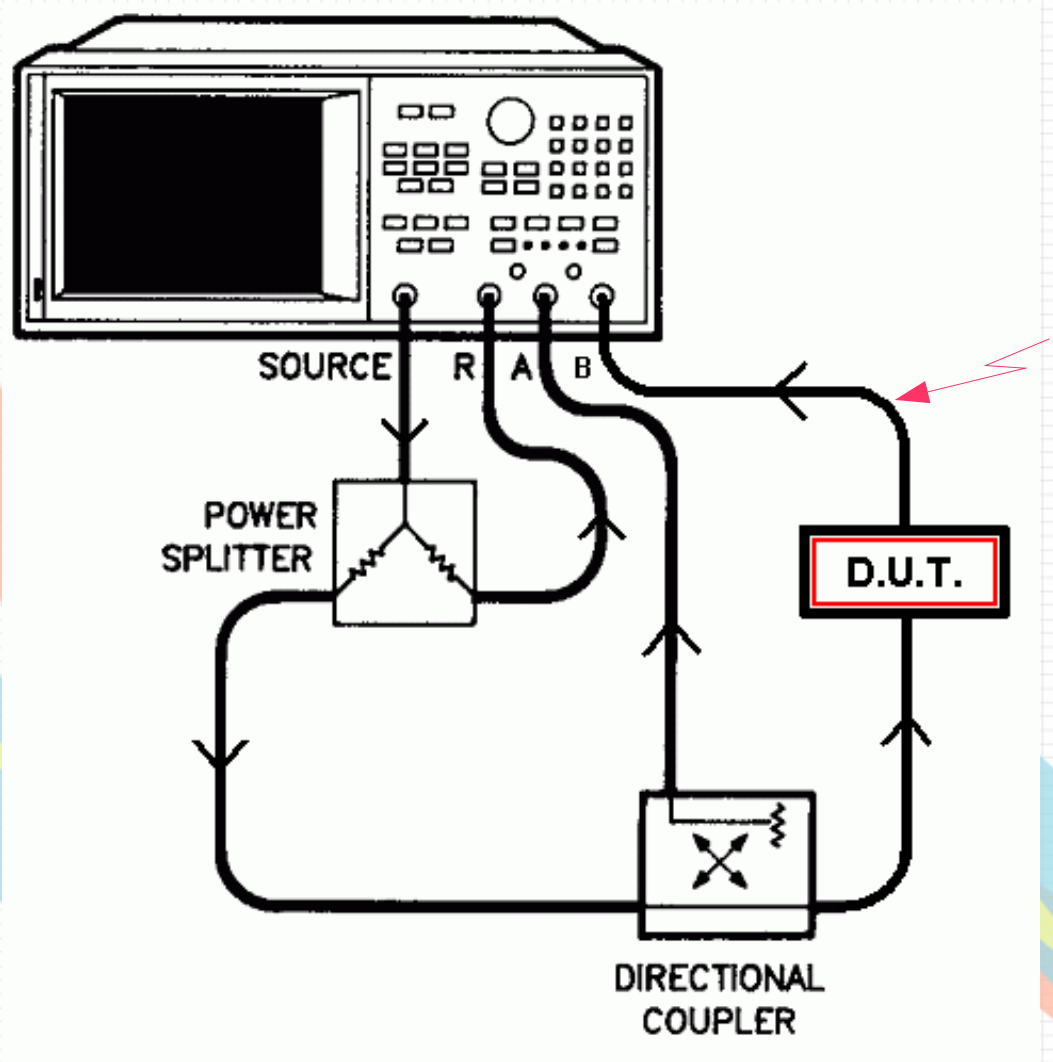
Today's Measurements on the VNA

- Crystal Resonance
- 1.56GHz Low-Pass Filter
- HF Lowpass Filter
- 2.4GHz Helix antenna
- Tektronix termination
- Your Device?

Today's Measurements on the VNA

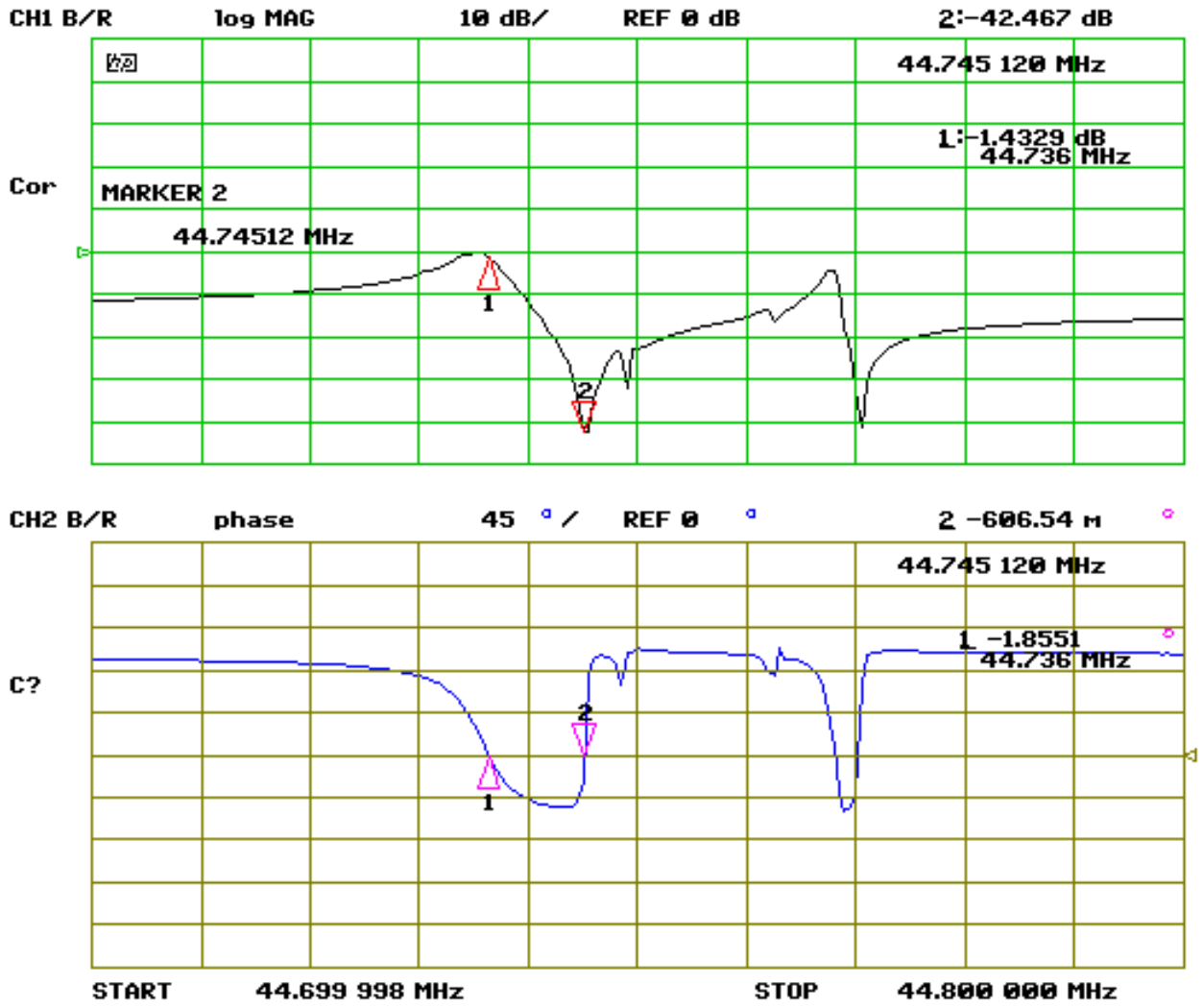
Using the HP 8753C VNA (0.5MHz to 3000MHz)

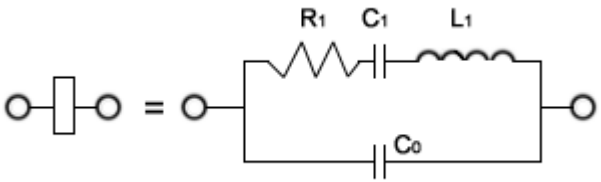
The Setup



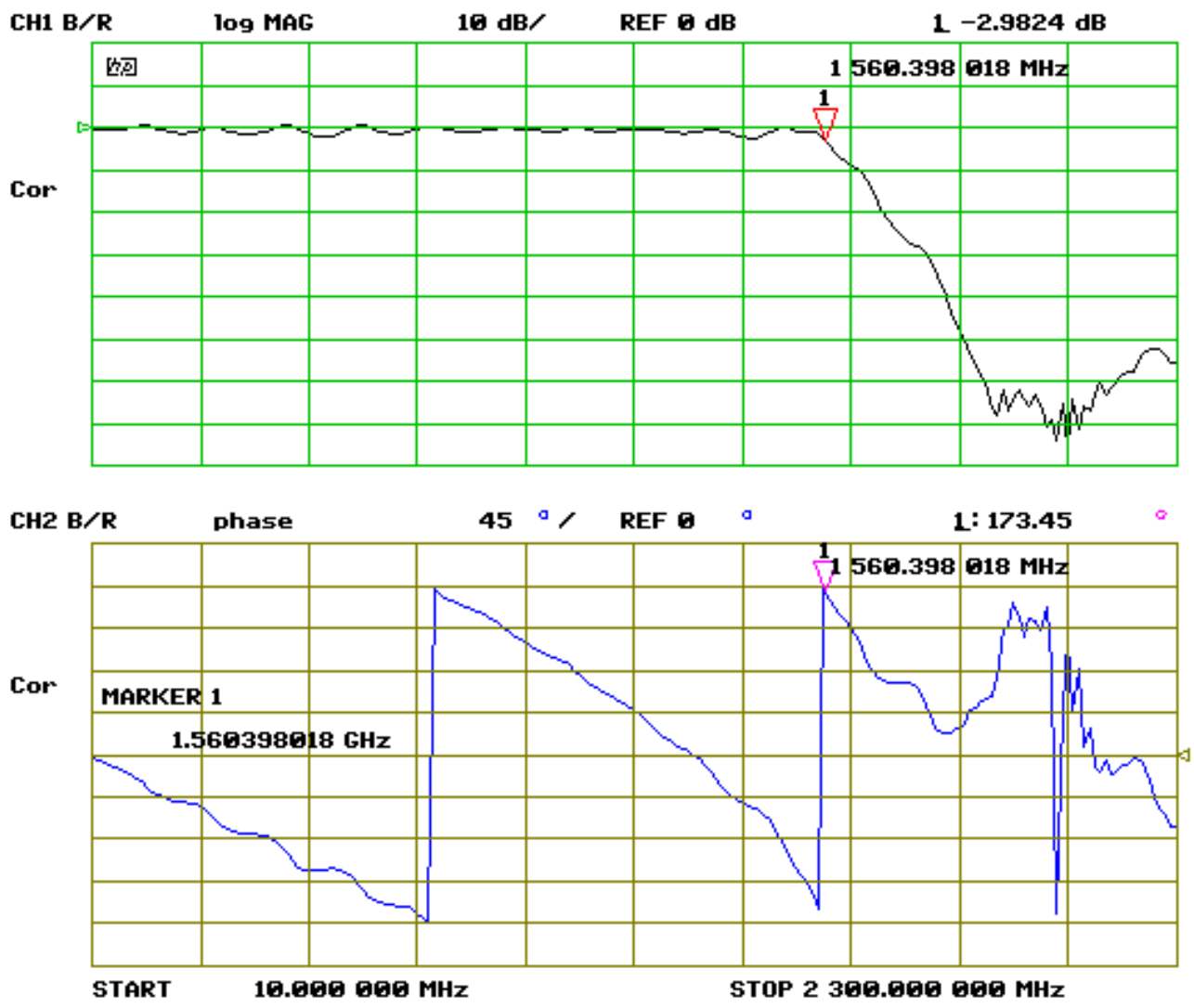
Backup Slides

Crystal Resonance

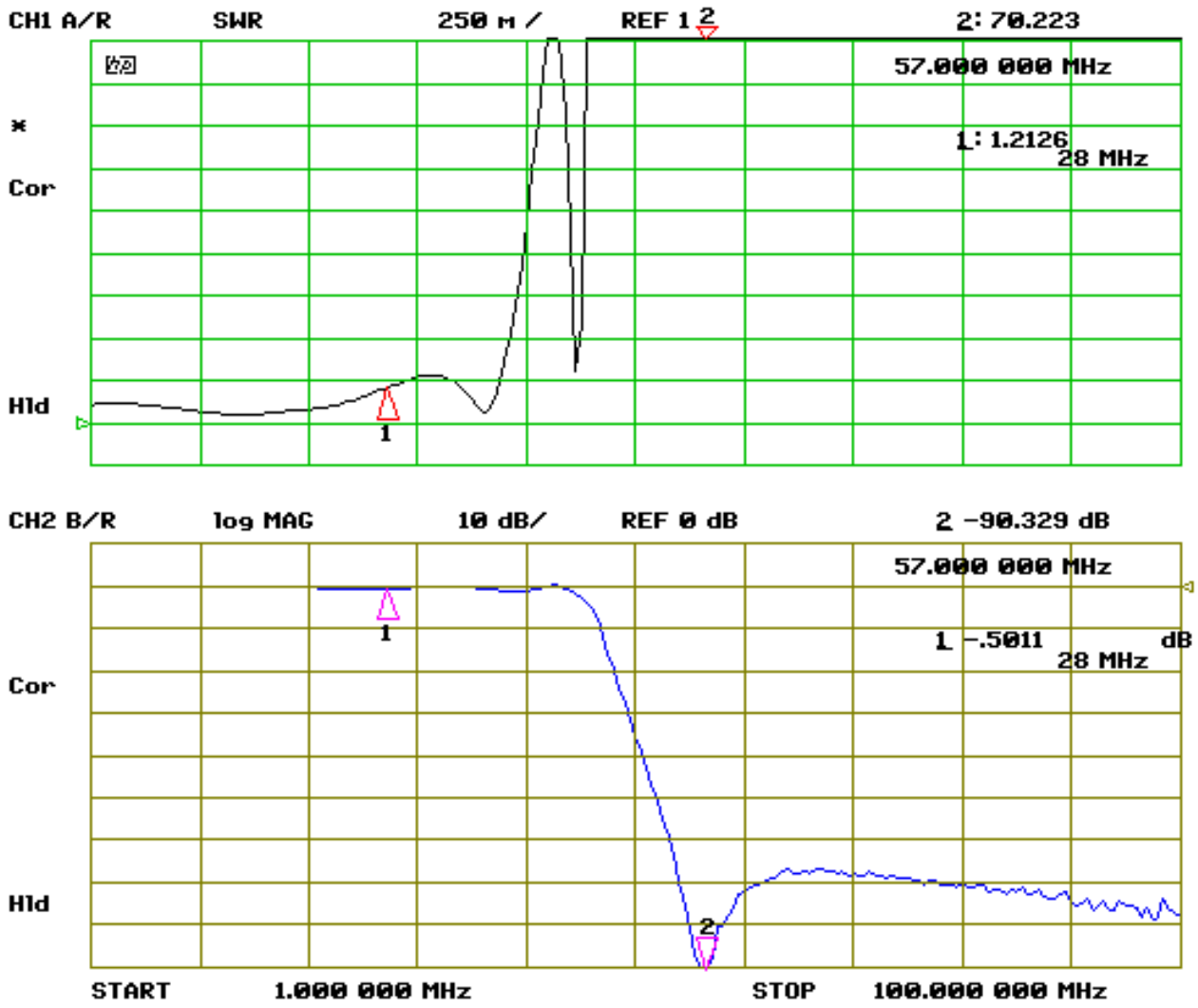




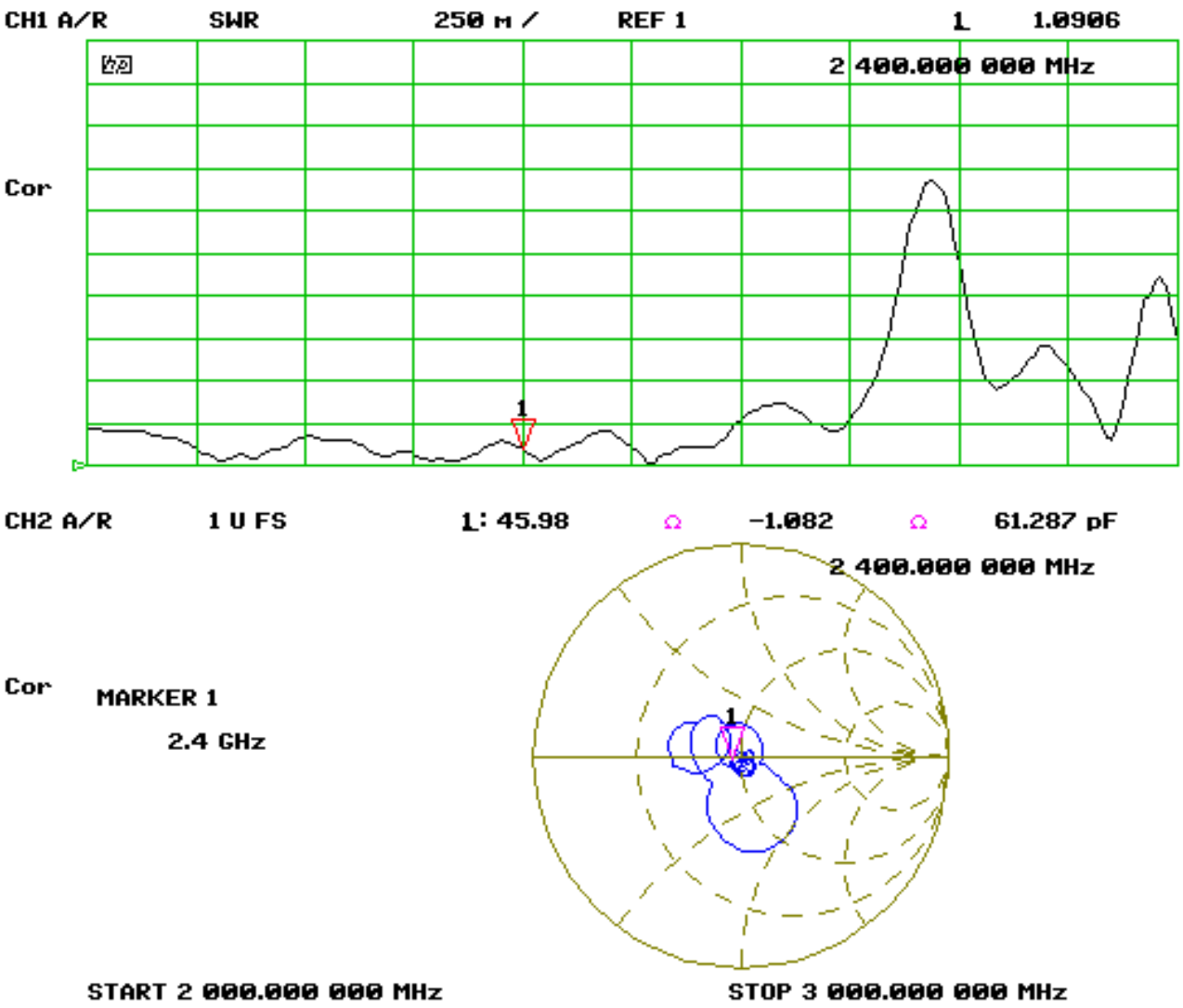
1.56GHz Low-Pass Filter



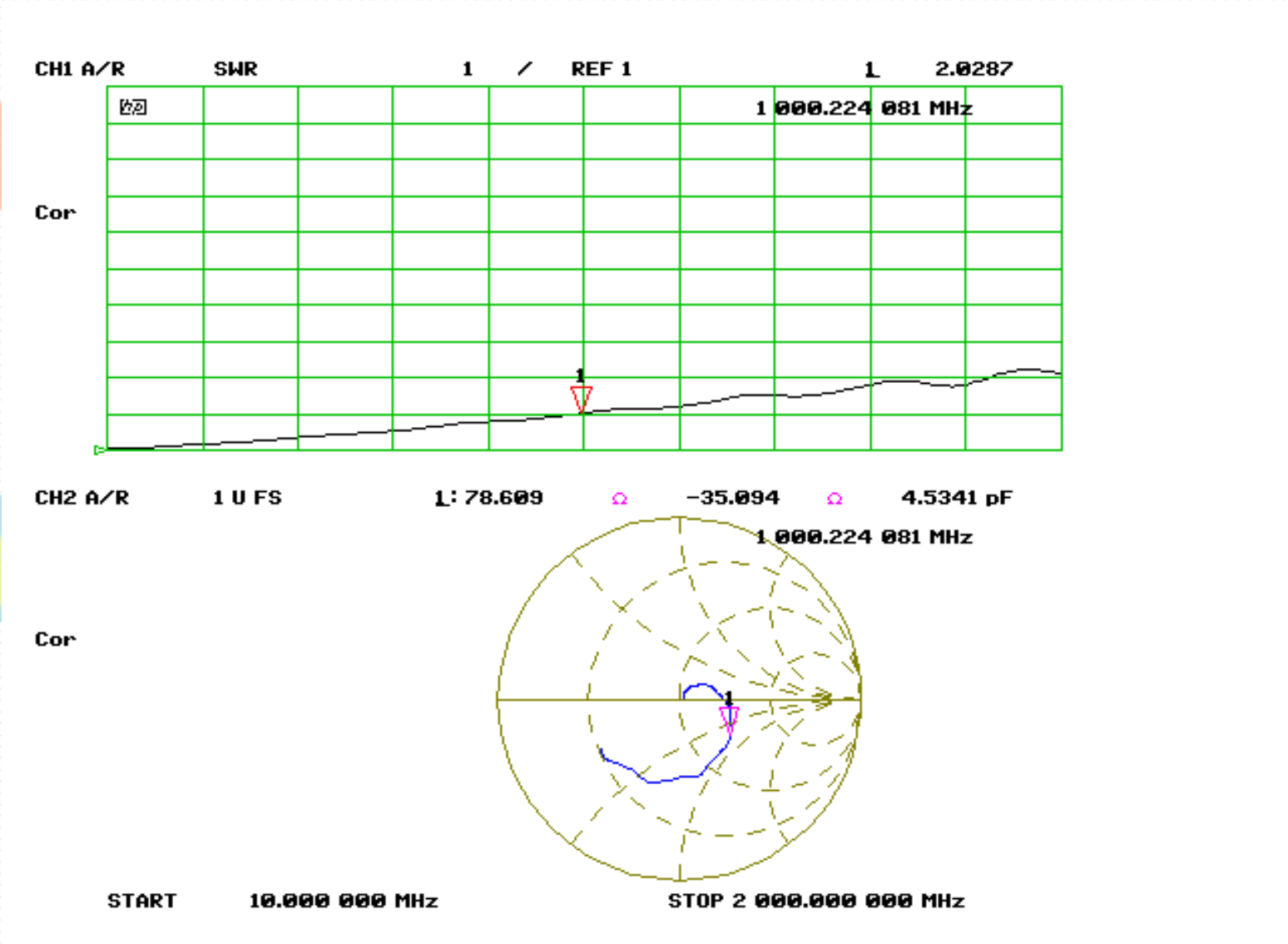
HF Low-Pass Filter



2.4GHz Helix Antenna



Tektronix 50-Ohm BNC Termination



Two Types of Spectrum Analyzers

- Swept
  - Traditional Heterodyne design.
  - The most popular and least costly
  - Has wider frequency coverage (GHz...)
  - Has limitations in capturing bursty or complex events
  - Provides only amplitude information
- Real-Time (Fourier Transform)
  - RF samples are taken by ADC in the time domain
  - Fourier Transform and other post-processing (math) is applied to the samples at various frequency bins.
  - Is much better in capturing complex or fast changing signals
  - Provides both amplitude and phase info, thanks to FFT
  - Has frequency range limited by ADC.
  - More costly

The Smith Chart