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RF Test & Measurement

Part 2: HP 8563E Spectrum Analyzer & HP 85640A Tracking Gen.

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Scope of Presentation

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- Use of the HP 8563E Spectrum Analyzer (examples):
  - Transmitter IMD measurement
  - Measurement of harmonics, spurious and THD
  - Phase noise measurement on signal sources and transmitters
  - Scalar network analysis (with HP 85640A tracking generator)
    - Characterization of 2-port networks
      - Transmission lines (e.g. coax jumpers)
      - Crystals for oscillators and filters
      - Filters (LC and crystal)
    - Characterization of 1-port networks with directional coupler
      - Terminations (short, open, 50Ω load)
      - Terminated transmission lines & filters
      - Antennas

HP 8563E Spectrum Analyzer

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- 9 kHz - 26 GHz freq. range
- 140 dB dynamic range
- Noise floor ≤ -120 dBm at 10 kHz offset
- Min. resolution bandwidth 1 Hz
- Accepts software utilities for various test suites
- Works with HP 85640A tracking gen.

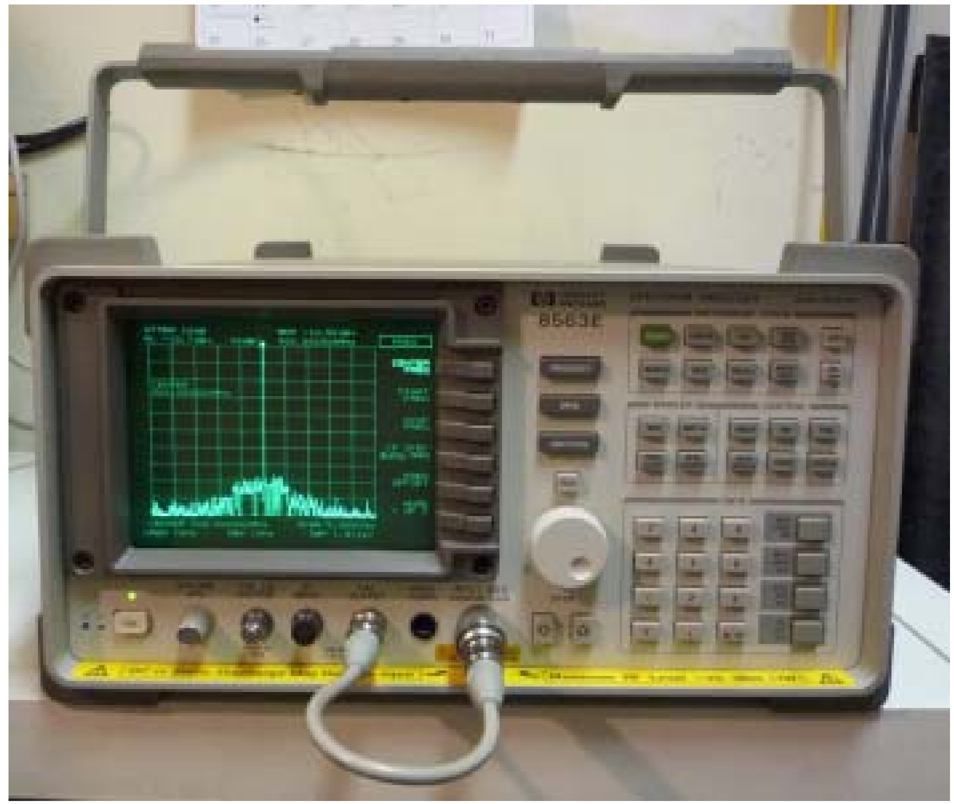
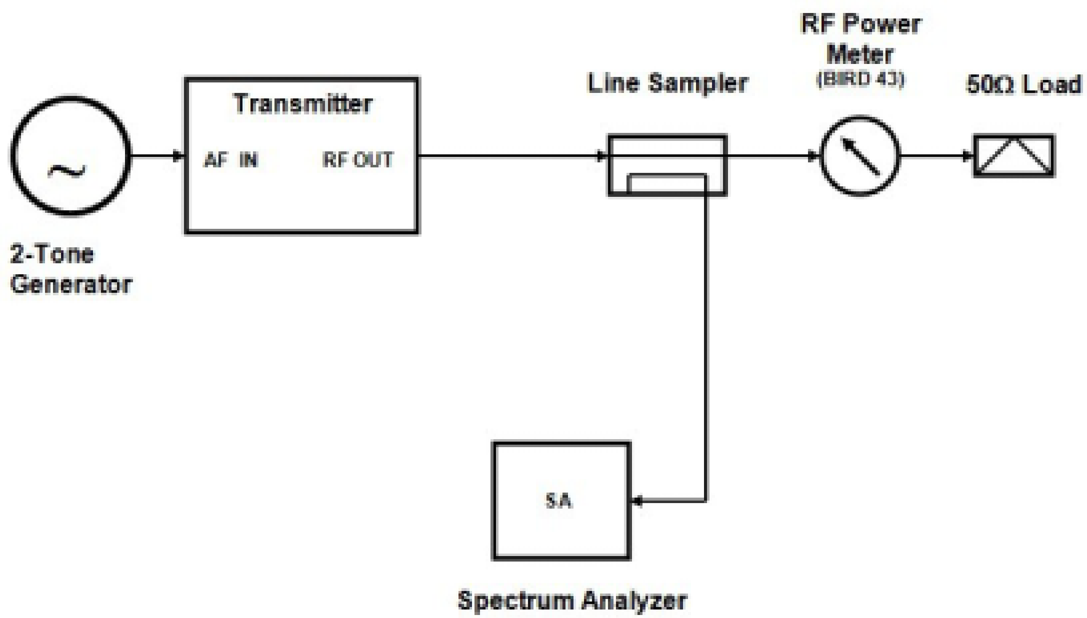


Fig.1: HP 8563E Spectrum Analyzer with HP 85620A Mass Memory Module.

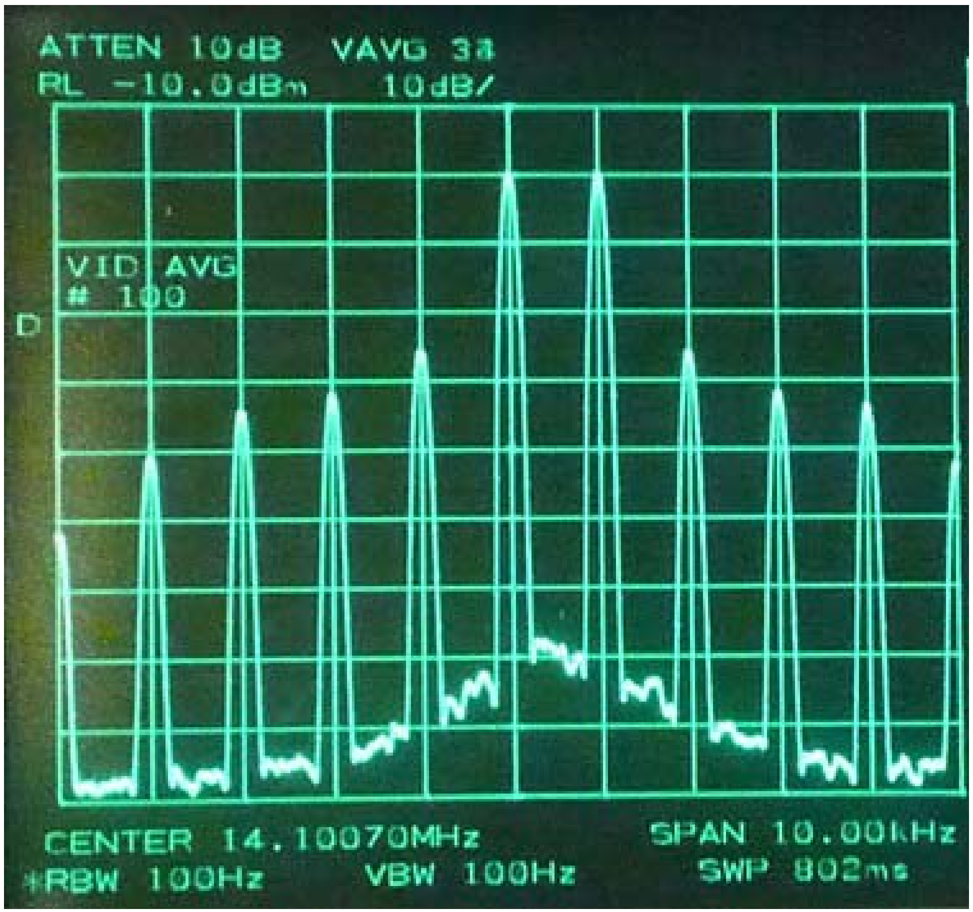
Transmitter Testing

IMD, harmonics, spurs, phase noise



- **Fig. 2: Test setup for transmitter testing**
  - **The line sampler is adjusted for a 0 dBc reference on spectrum analyzer at rated output in RTTY mode. Harmonics, spurs and phase noise are tested in RTTY.**
  - **The 2-tone generator is adjusted for 2 equal tones at -6 dBc in SSB mode.**
  - **SSB test tone frequencies 700 and 1700 Hz.**
  - **AM percentage modulation and harmonics are measured with a single 1 kHz tone.**

IMD Test Results
(Icom IC-7600)



2-tone IMD Products at 100W PEP	
IMD Prod.	***Relative level (0 dBc = 2-tone PEP)***
	14.1 MHz
IMD3	-31 dBc
IMD5	-38 dBc
IMD7	-40 dBc
IMD9	-47 dBc

Fig.3: IMD test results.

Harmonics/Spurs Test Results (Icom IC-7600)

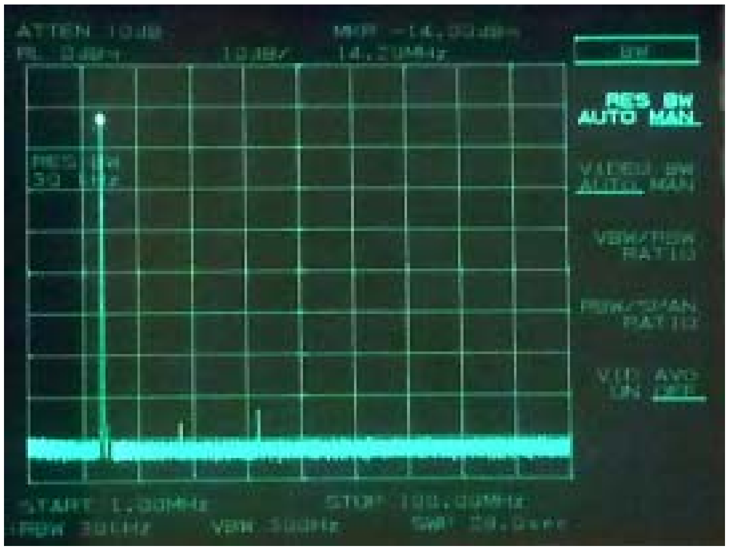


Fig.4: Harmonics/spurs display.

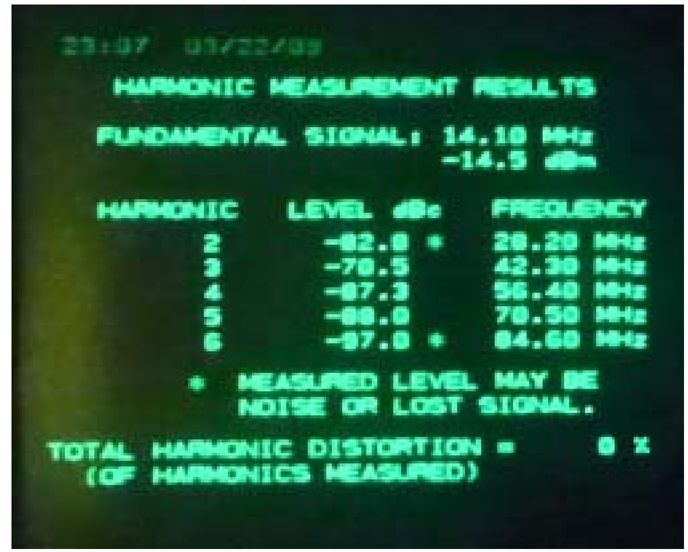


Fig.5: HP 85672A utility result.

- **Harmonics and spurs are displayed , then harmonics are captured and recorded with the HP 85672A spurious response utility.**

Phase Noise Test Results (Icom IC-7600)

- **Phase noise is the frequency-domain representation of rapid, short-term, random fluctuations in the phase of a wave, caused by time-domain instabilities (jitter). RF engineers speak of the phase noise of an oscillator, whereas digital system engineers discuss the jitter of a clock.**

- **The amplitude of phase noise increases with decreasing frequency offset from the carrier.**

- **Excessive local-oscillator (LO) phase noise degrades receiver performance due to *reciprocal mixing.* Strong unwanted RF signals mix with LO phase noise, degrading S/N in the IF.**

- **Phase noise in the transmitted signal increases its occupied bandwidth.**

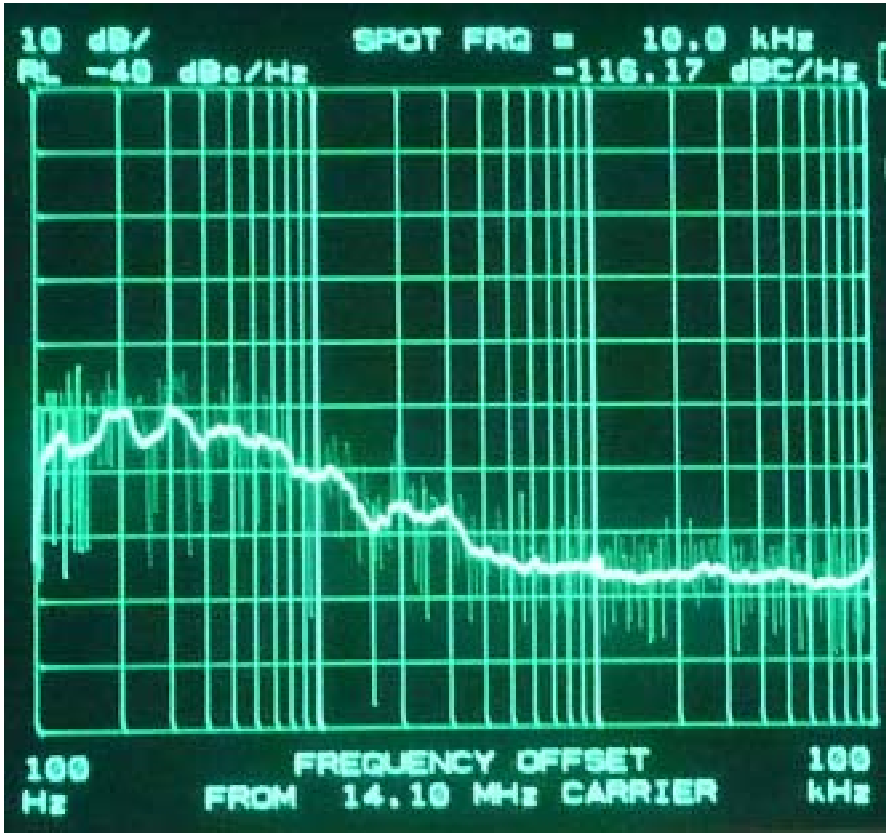


Fig.6: Phase noise test results (HP 85671A phase-noise utility).

Phase Noise of Signal Sources

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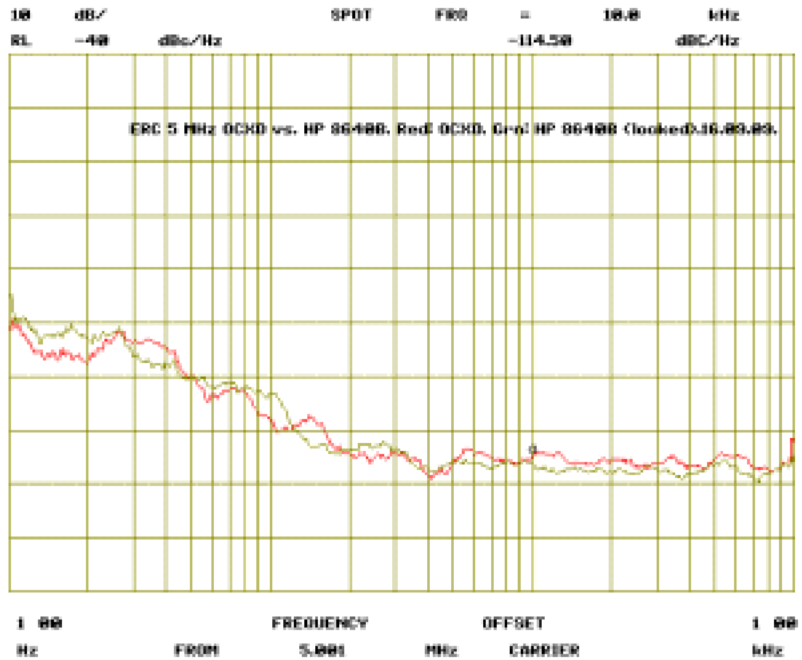

Fig.7: Phase noise of precision 5 MHz OCXO vs. HP 8640B sig. gen.

- **Using the HP 85671A utility and the KE5FX plotter emulation program (via a ProLogix GPIB/USB adapter), the OCXO and generator were tested and the plots overlaid.**

Scalar 2-port Test Setup

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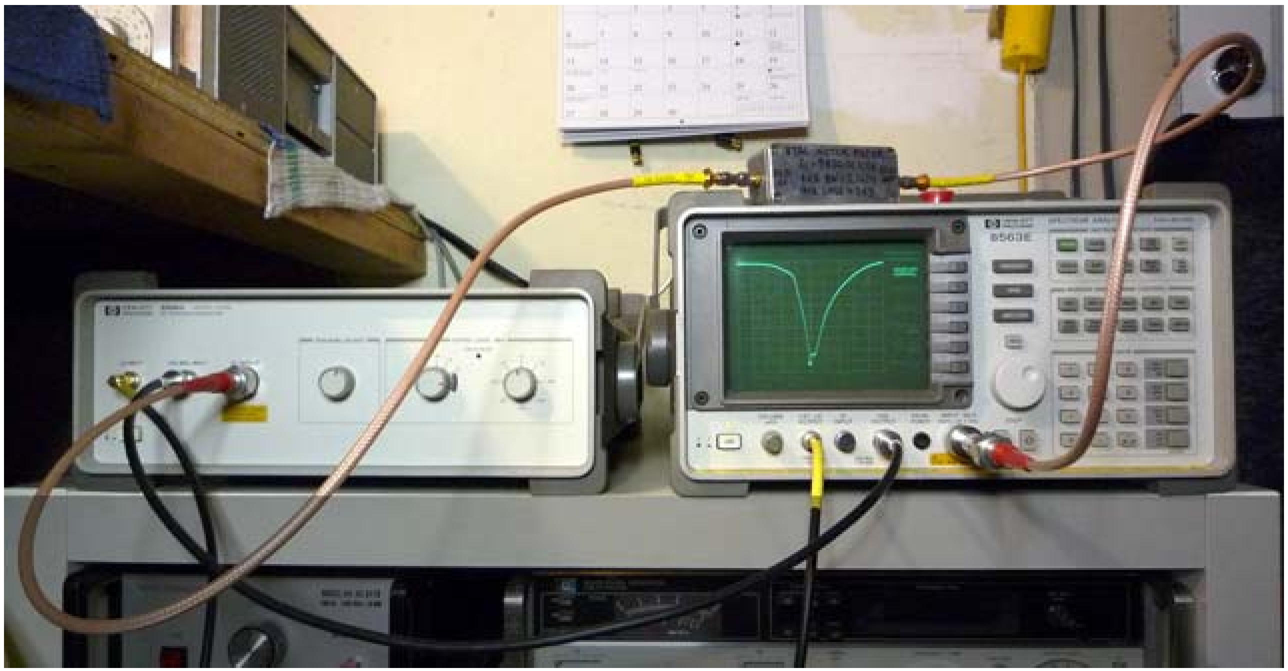

- **Fig.8:The DUT (device under test) is a 9.830 MHz, 4-pole crystal notch filter, connected between the tracking generator output (left) and the spectrum analyzer input (right). The analyzer's sweep controls the test signal frequency.**

Block Diagram of 2-Port Test Setup

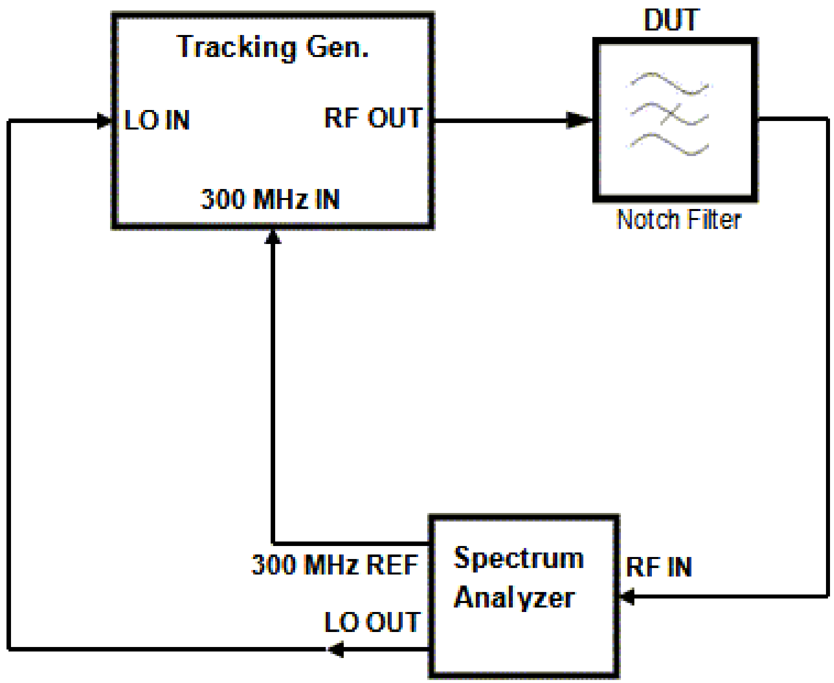

Fig.9: Block diagram of 2-port scalar network analysis setup.

Crystal Filter Test Result

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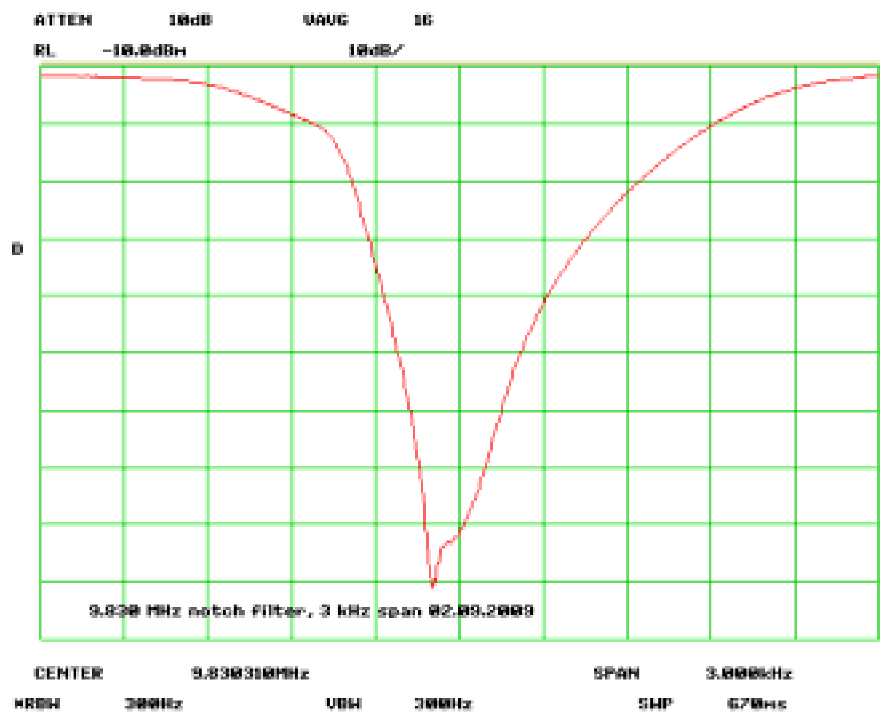

- **Fig.10: Attenuation/frequency response of crystal notch filter, captured from spectrum analyzer via KE5FX plotter emulation program.**

Scalar 1-port Test Setup
(with directional coupler)

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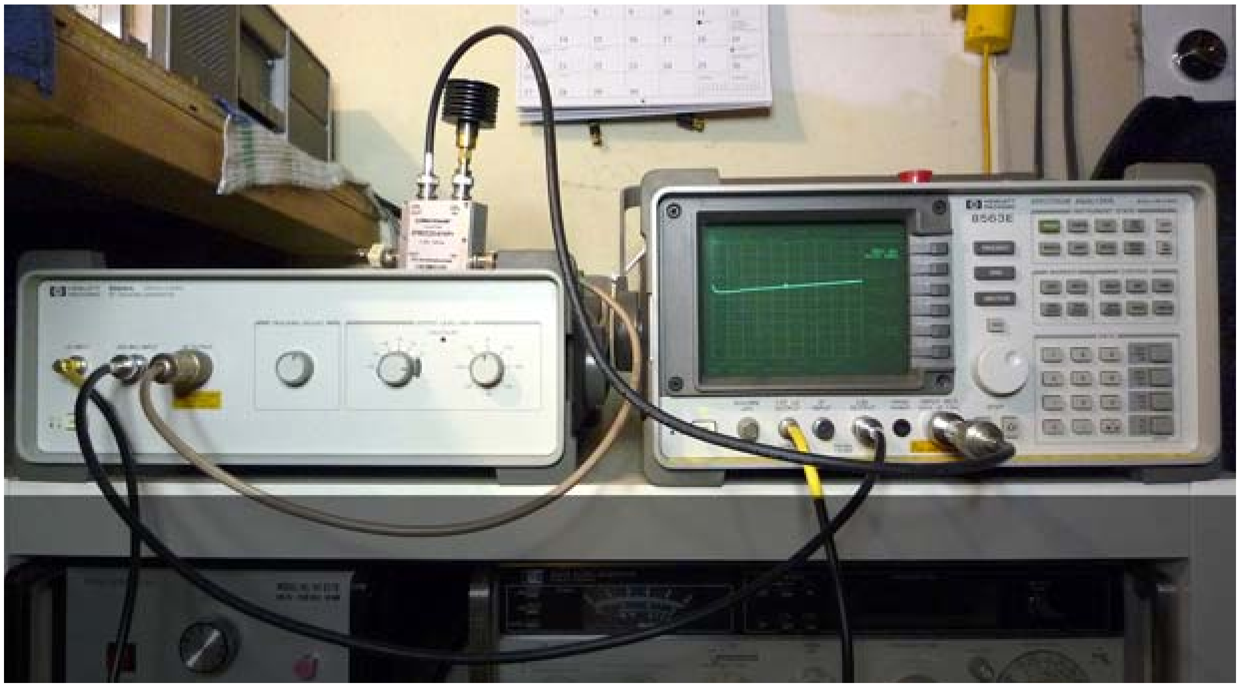
$$R.L. = -20 * \log\left(\frac{VSWR-1}{VSWR+1}\right) \; dB$$



- **Fig.11: The tracking generator output is connected to the input of a 30 dB directional coupler. The DUT is connected to the coupler output. The coupled port is terminated in 50Ω, and the isolated port is connected to the spectrum analyzer input.**
- **The spectrum analyzer displays return loss (RL) vs. frequency.**

Block Diagram of 1-Port Test Setup

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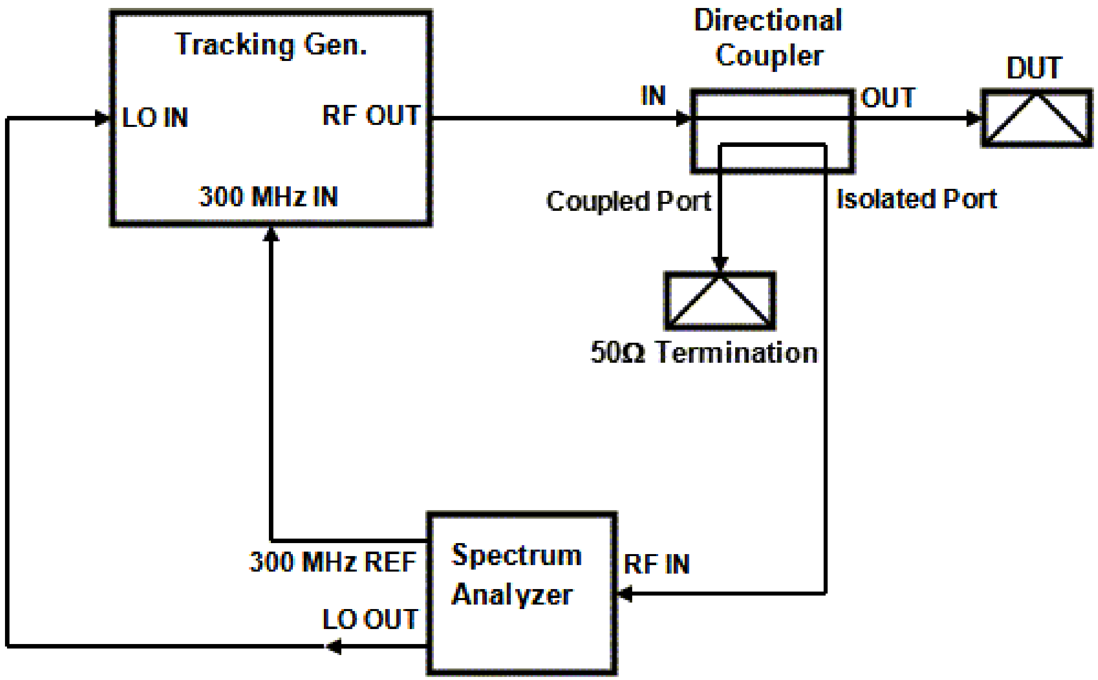
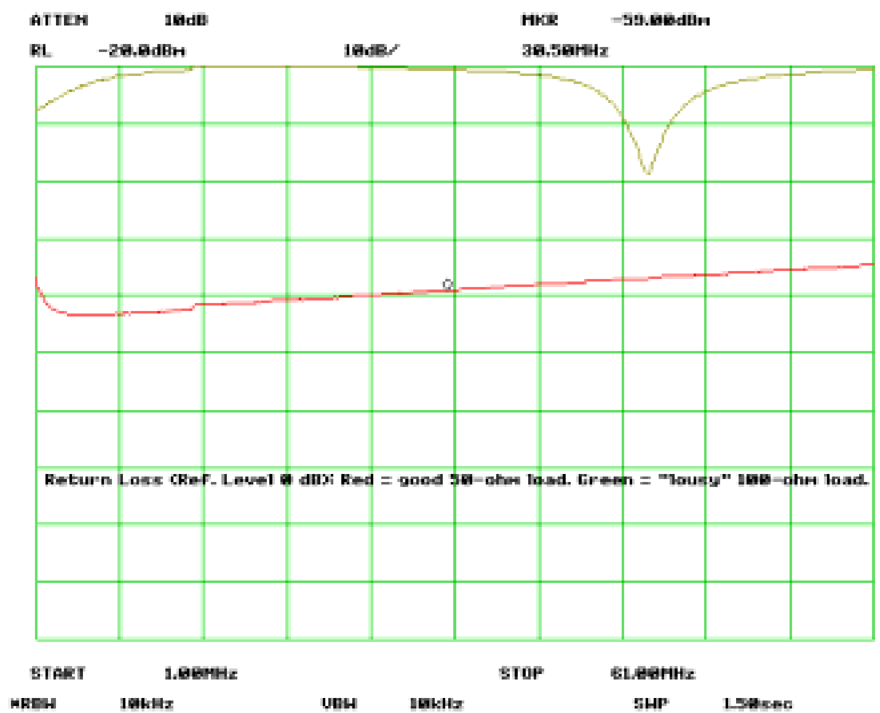


Fig.12: Block diagram of 1-port scalar network analysis setup.

Scalar 1-port Test Result
(1 – 61 MHz)

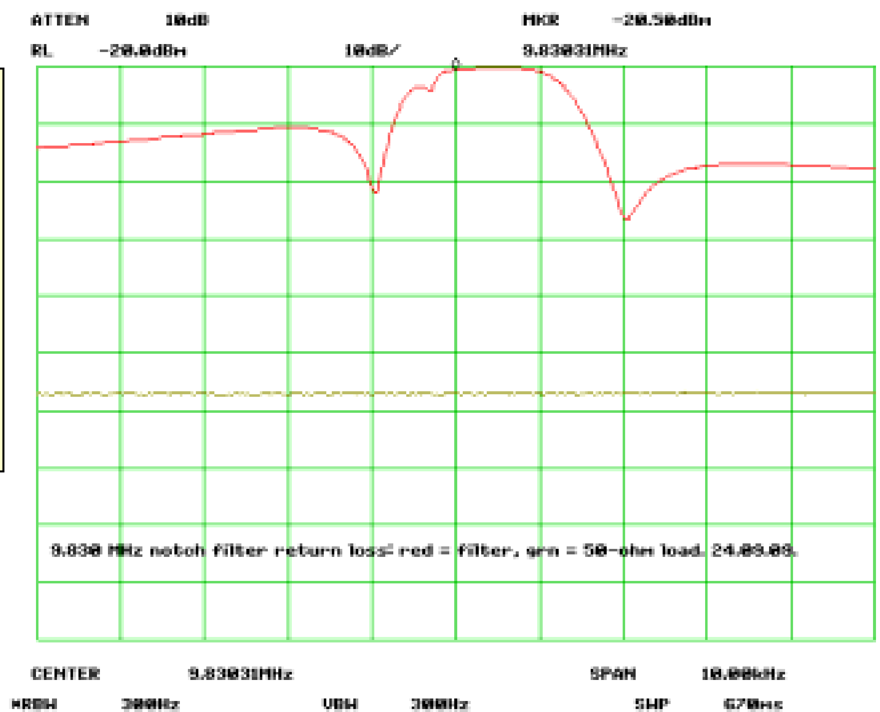


RL dB	VSWR
5	3.57
10	1.92
20	1.22
30	1.07
40	1.02

- **Fig. 13: 1-61 MHz return loss sweep of a “known good” 50Ω load and a suspect 100Ω load , captured from spectrum analyzer via KE5FX plotter emulation program.**

Scalar 1-port Test on Filter
(1 – 61 MHz)

Note: A crystal filter attenuates by reflecting power (***not*** by absorbing it). At the 3 dB points, half of the incident power is reflected; thus, the return loss is 3dB. At the bottom of the notch, virtually all the incident power is reflected; return loss is 0 dB.



RL dB	VSWR
5	3.57
10	1.92
20	1.22
30	1.07
40	1.02
50	1.006

- **Fig. 14: Return loss sweep of crystal notch filter, captured from spectrum analyzer via KE5FX plotter emulation program.**

References

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1. **HP/Agilent Spectrum Analyzer Application Notes**
2. **Spectrum Analyzer Tutorials**
3. **Spectrum Analyzer Fundamentals**
4. **Scalar Network Analysis (Example)**
5. **Agilent Spectrum Analyzer Measurements and Noise**
6. **The KE5FX GPIB Toolkit** **(controls GPIB test instruments from a PC)**