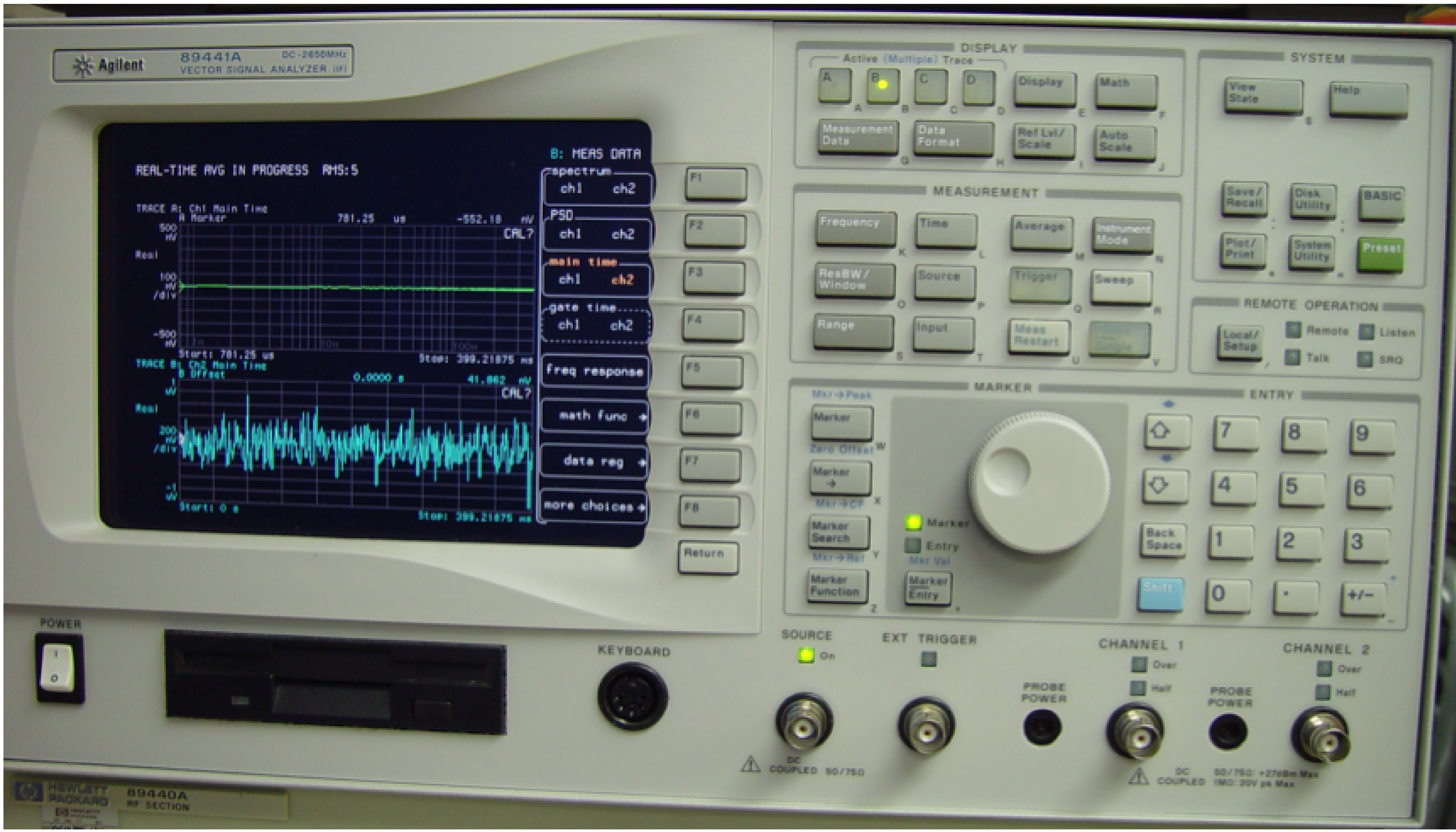
Fermilab

Vector Signal Analyzer
VSA

Ralph J. Pasquinelli

Fermilab VSA



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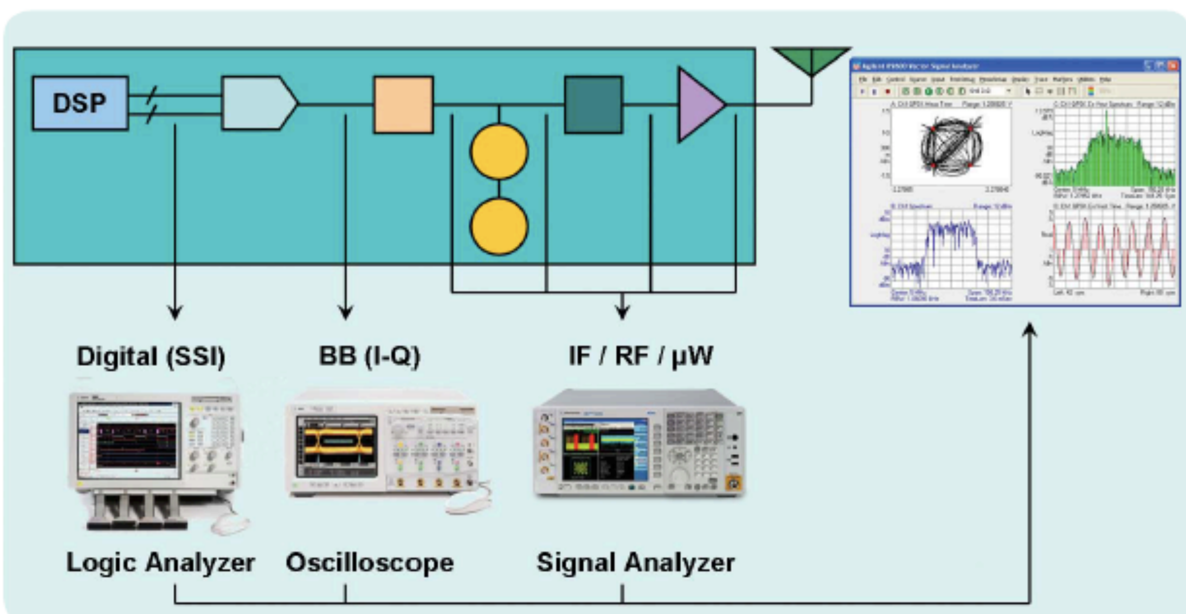
Agilent 89600 Series Vector Signal Analysis Software

89601A/89601AN/89601N12

Technical Overview



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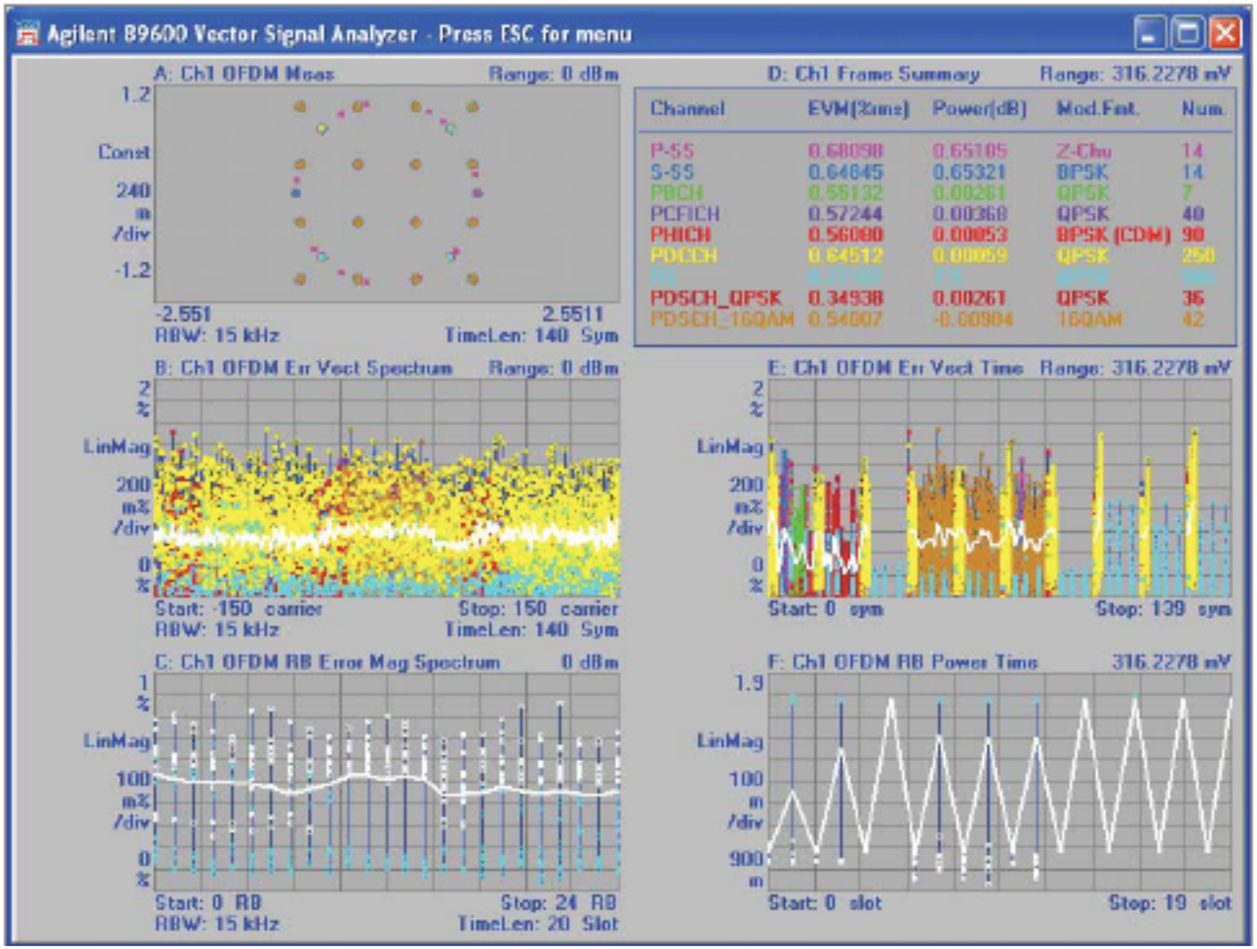

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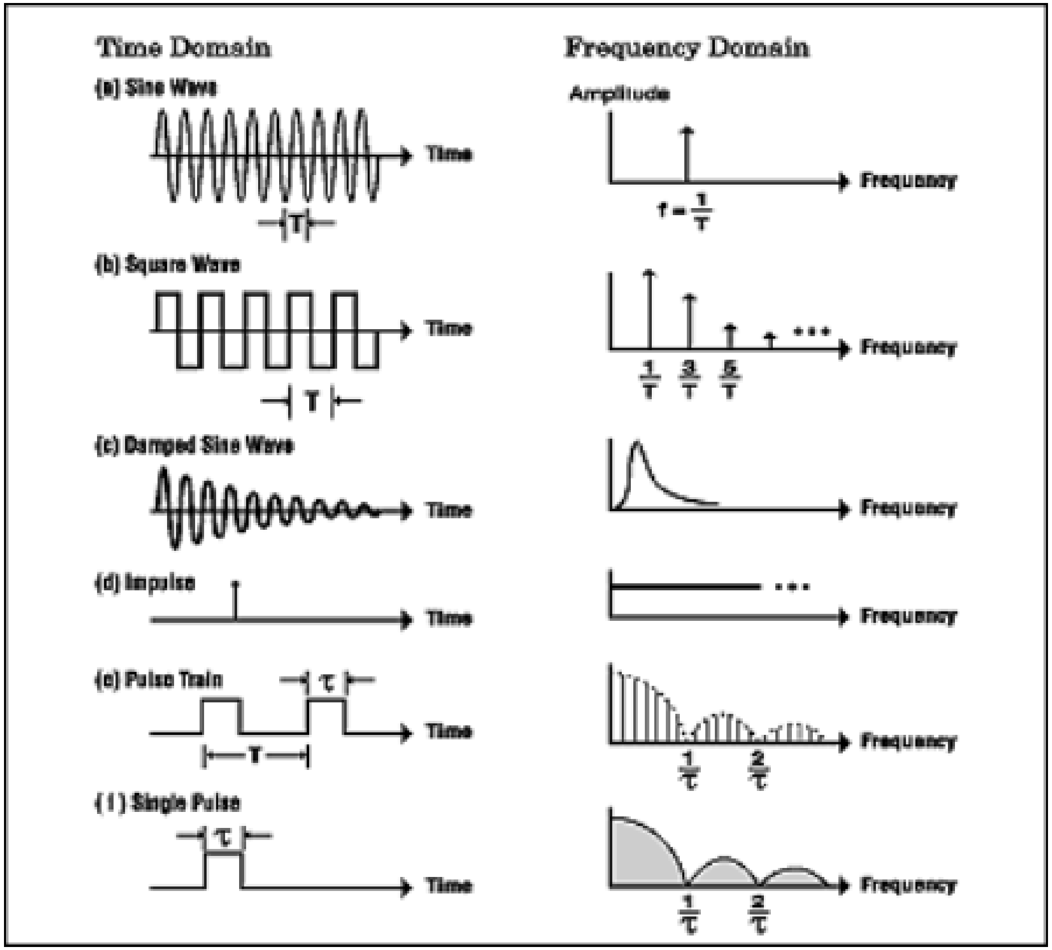
Fourier Transform

$$V(f) = \int_{-\infty}^{\infty} v(t)\, e^{-j2\pi ft}\, dt$$



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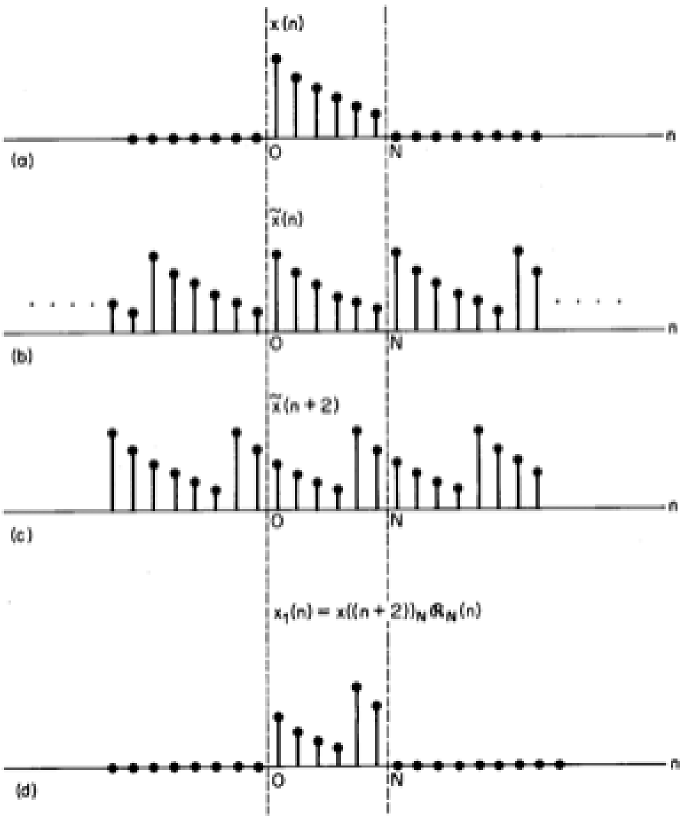
Discrete Fourier Transform DFT

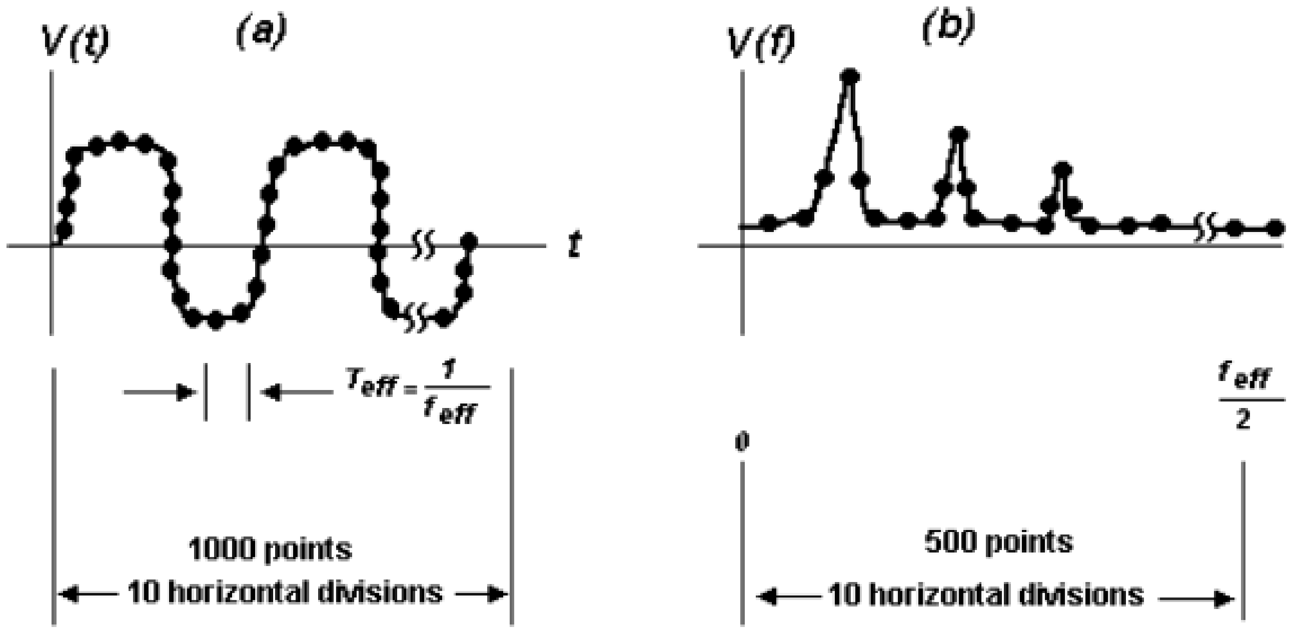
$$X(k) = \begin{cases} \sum_{n=0}^{N-1} x(n) W_N^{kn}, & 0 \le k \le N-1 \\ 0, & \text{otherwise} \end{cases}$$

where $W_N = e^{-j(2\pi/N)}$

The Discrete Fourier Transform



Fast Fourier Transform FFT



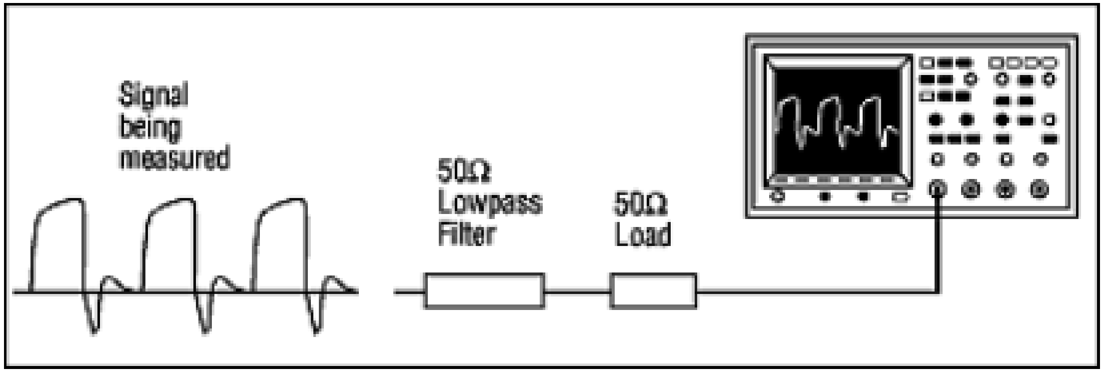
3a).

Figure 3

(a) The sampled time domain waveform.
(b) The resulting frequency domain plot using the FFT.

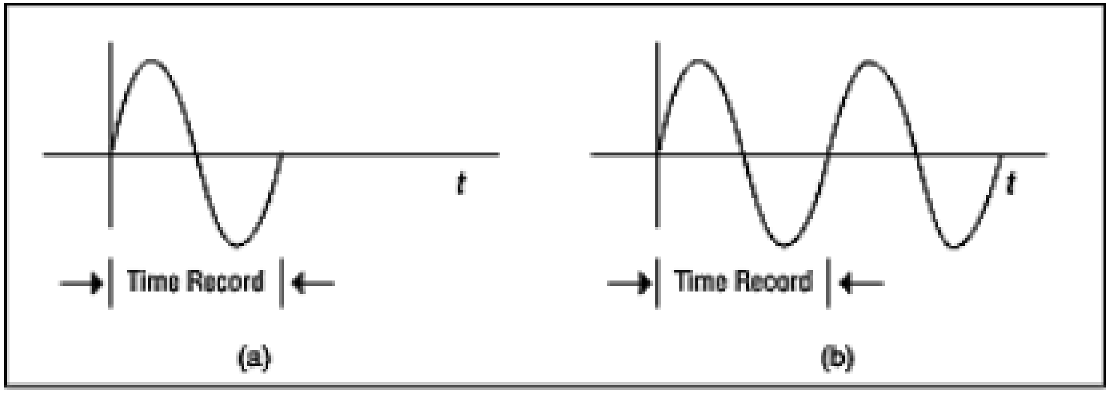
Aliasing

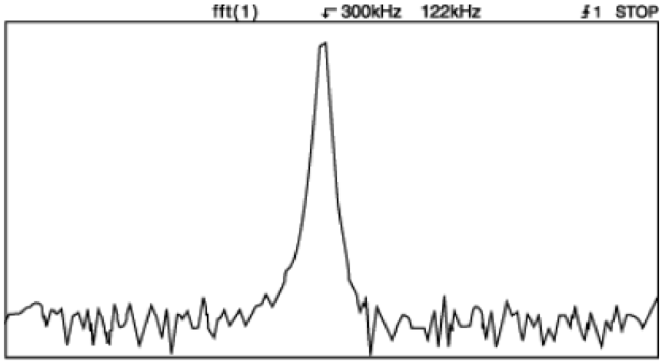
All Frequencies above $f_{eff}/2$ will fold down into the FFT And are referred to as aliasing. Input signal must always be Sampled at least twice the highest frequency component i.e. the Nyquist criteria. A low pass filter before the digitizer Called an anti-aliasing filter will limit the frequency response.



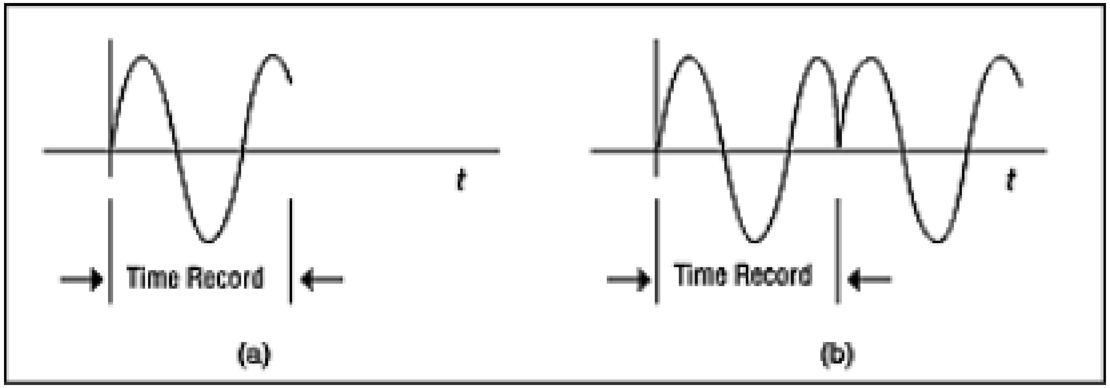
A lowpass filter can be used to band limit the signal, avoiding aliasing.

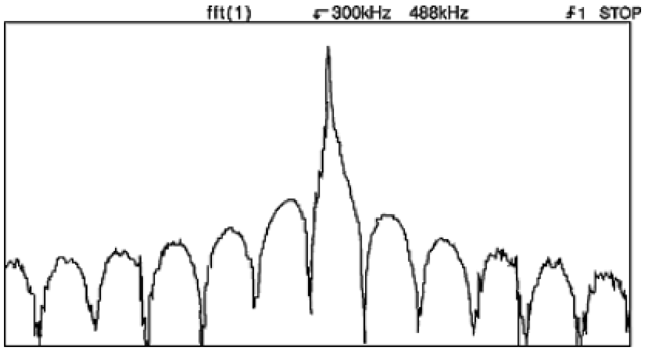
No transients in record



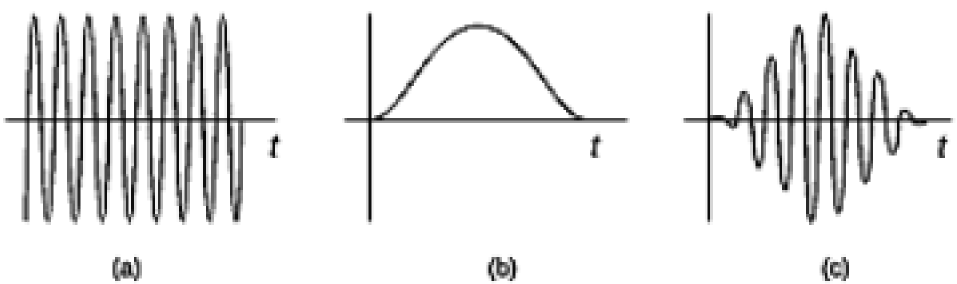


Transient in record creates "leakage"

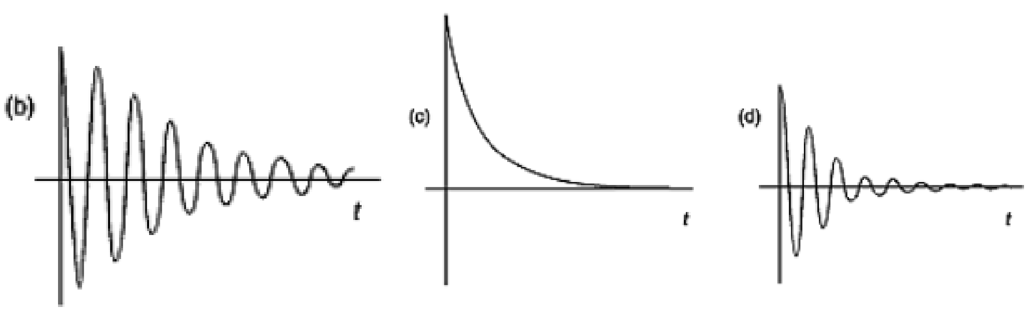




Windowing

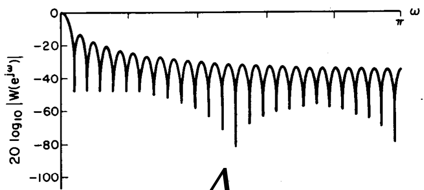


Hanning Window
Good frequency
Resolution poorer
Amplitude resolution

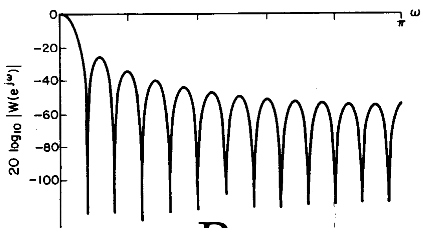


Exponential Window
For transients

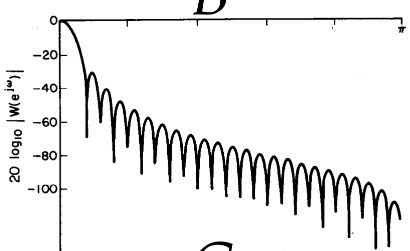
More Windows



A

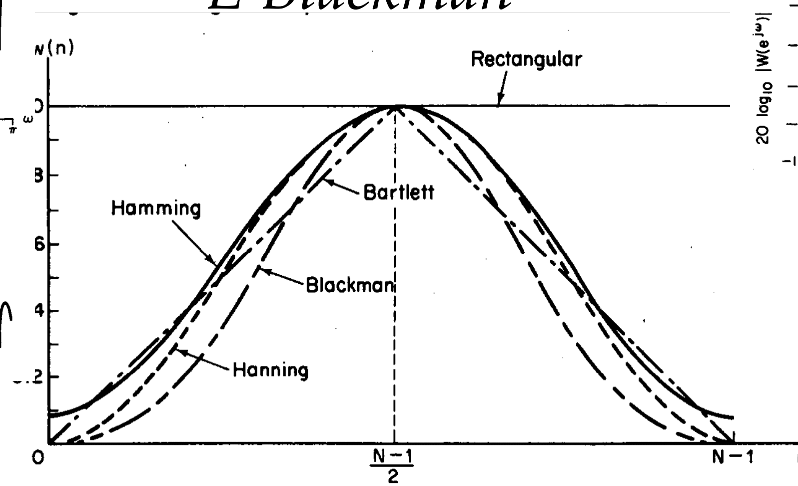


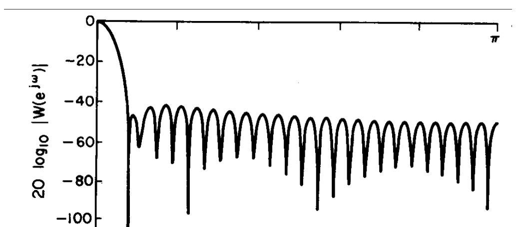
B



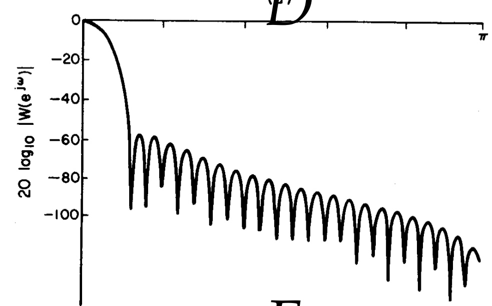
C

A Rectangular
B Triangular
C Hanning
D Hamming
E Blackman





D



E

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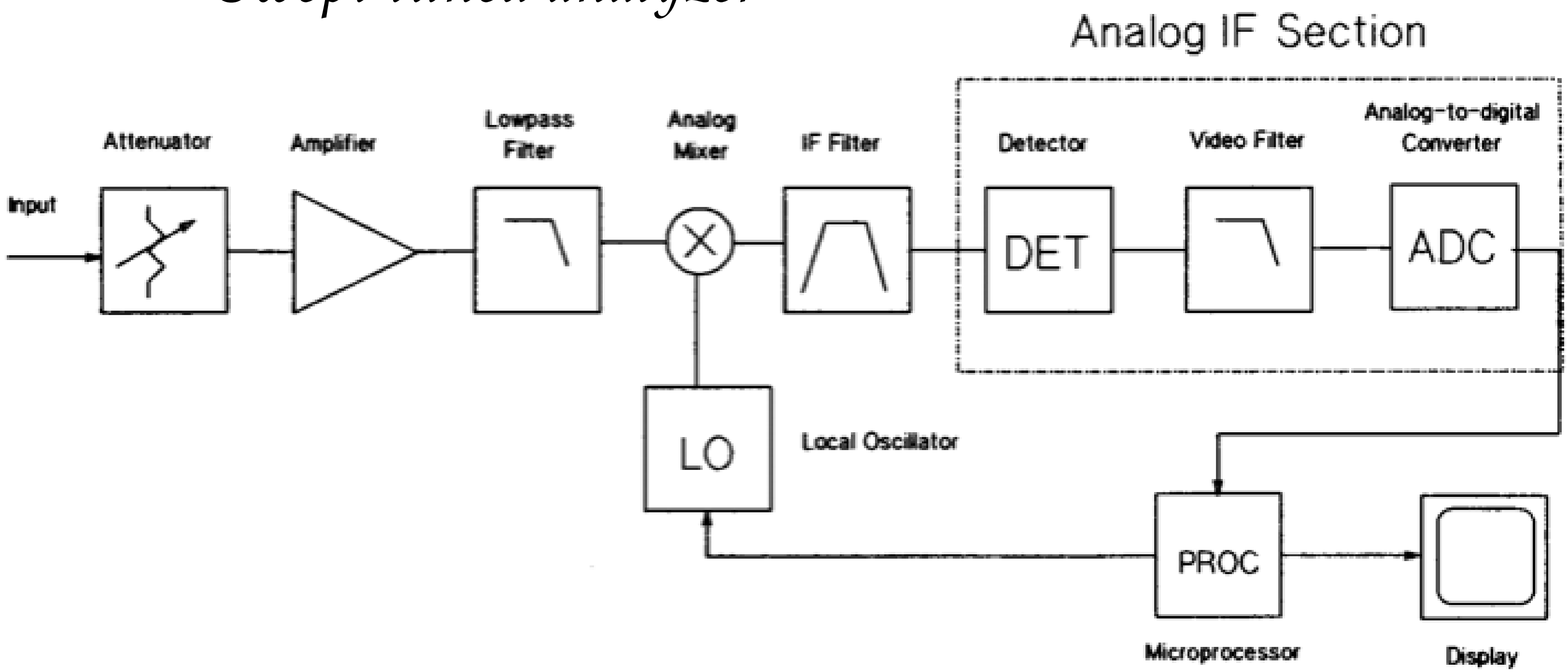
Swept tuned analyzer



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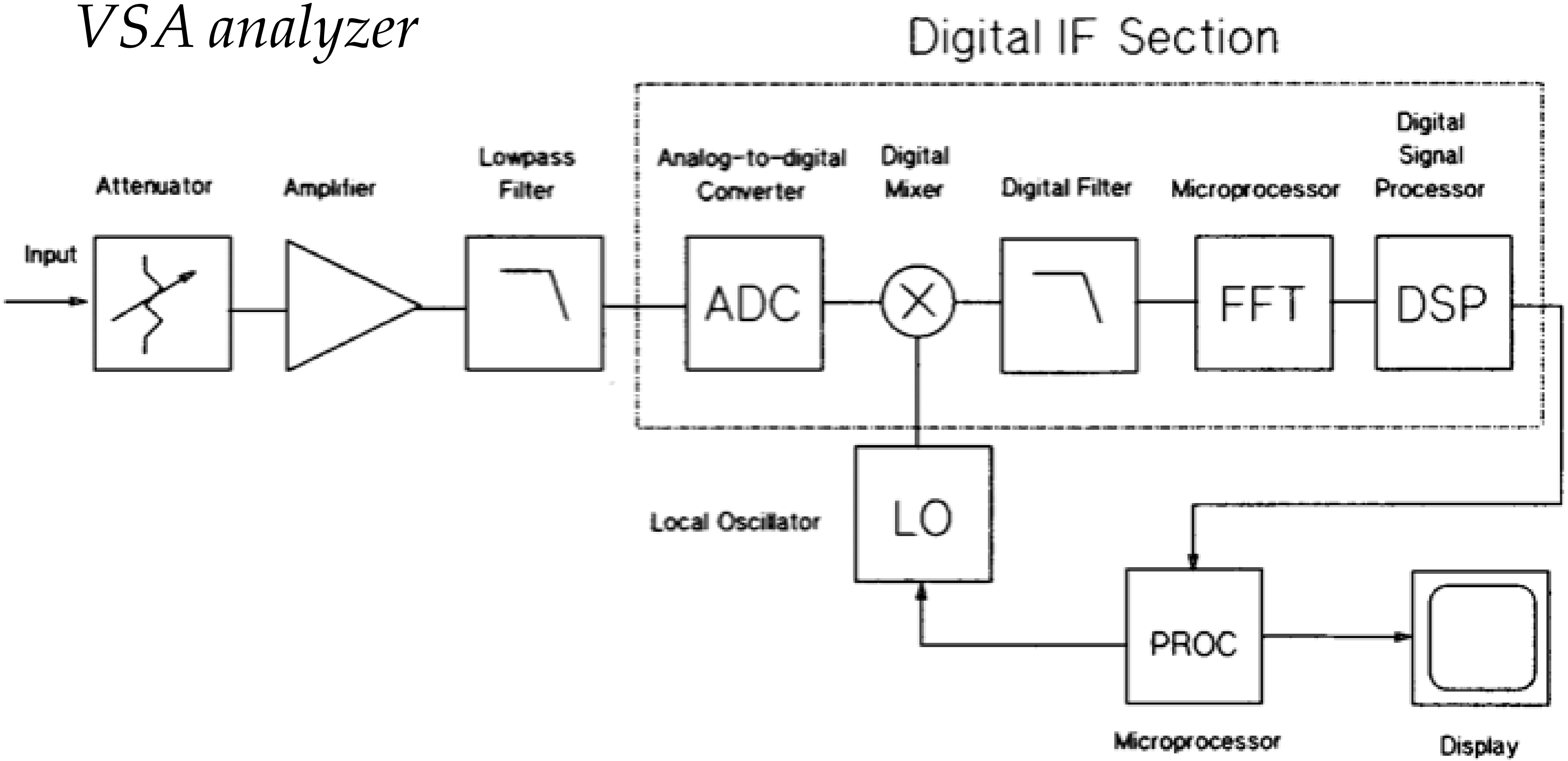
VSA analyzer



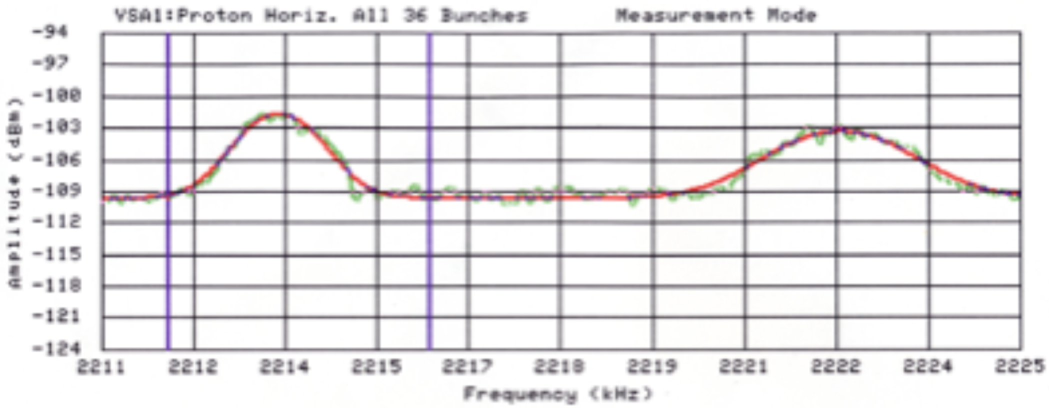
- ***Multiple Modes of Operation***
  - ***Scalar Mode***
    - ***Identify signals in wide span or small signals close to the noise floor, similar to swept tuned spectrum analyzer: measure oscillator harmonic distortion***
  - ***Vector Mode***
    - ***Analyze signals with phase and time data, fast transforms between time and frequency domain: measure oscillator side bands or phase noise***
  - ***Demodulation Mode***
    - ***Characterize amplitude, frequency and phase relationships: characterize oscillator sideband noise as AM or PM***

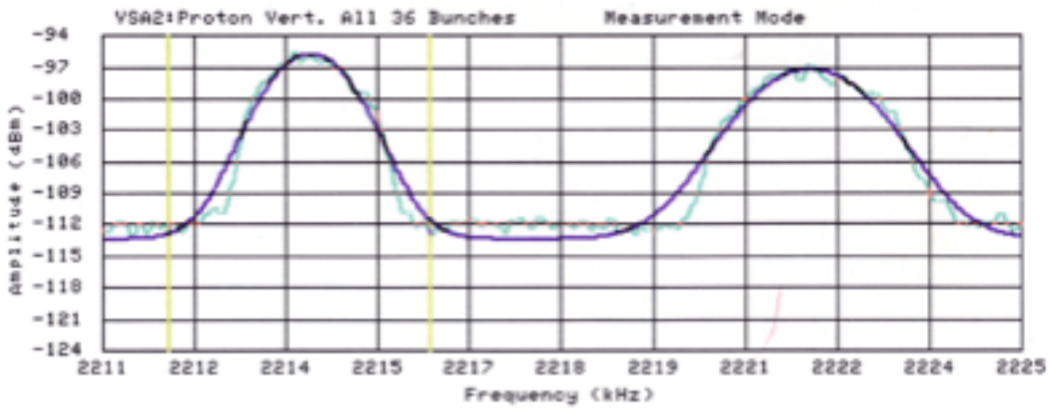
Fermilab **VSA**

- *Features*
  - *Real time frequency analysis*
  - *Fast measurements at narrow RB, up to 1000x faster than swept tuned spectrum analyzer*
  - *Spectrogram allows for frequency spectrum vs time*
  - *Water fall running plot of spectrums for transients*
  - *Time capture buffer for post analysis*

Fermilab **VSA**

Tevatron 1.7 GHz Schottky Monitor





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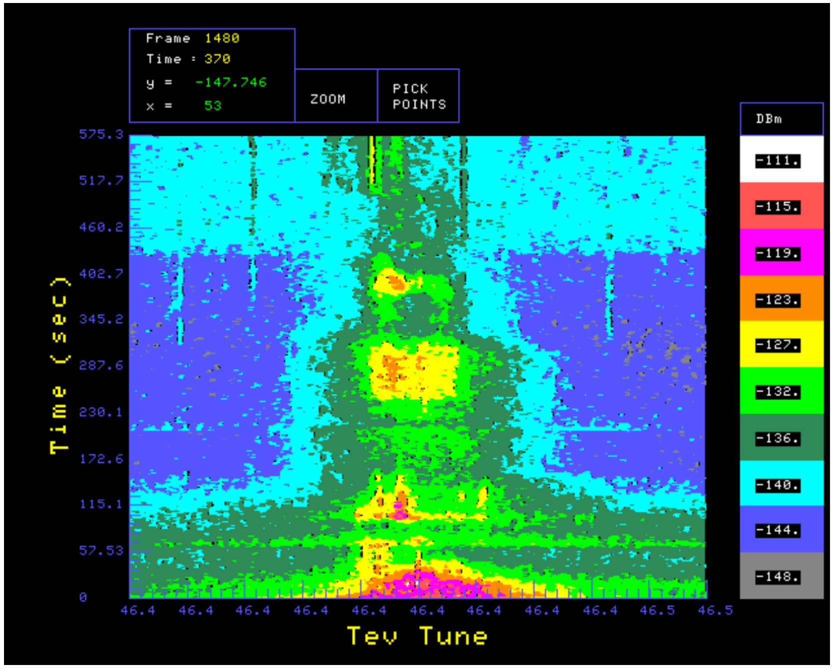
Tevatron 1.7 GHz Schottky Spectrogram



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References

Digital Signal Processing, Oppenheim & Schafer, 1975 Prentice Hall

Agilent educators corner
[Fourier Theory & Practice, Part I: Theory [Exp53a.pdf]]
Fourier Theory & Practice, Part I: Theory (Agilent Product Note **54600-4**) By: Robert Witte Agilent Technologies Introduction: This product note provides a brief review of Fourier theory, especially the unique behavior of the FFT. The note also describes some typical applications and provides some . . .
http://www.educatorscorner.com/media/Exp53a.pdf 04/09/03, 280197 bytes