Real-Time Signal Analyzer Enhancement for Radar Measurement by the use of Variable-Length FFT Transforms

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***Abstract* — A method is described for measurement capability of RF modulated Radar Pulses. This method improves the Real-TimeSignal Analysercapabilitiesusing modern DSP Signal Processing.By the use of variable length FFT signal processing, the ability to independently vary the span of measurement and the resolution bandwidth of the measurement is obtained. It can be used on the digitized acquisition of analog RF radar pulses. This method can discoververy narrow frequency-domain characteristics of wideband signals.**

***Index Terms* — Radar signal, FFT length, variable resolution bandwidth, RF Measurement.**

I. Introduction

The method described here uses variable digital signal processing to filter the signal being measured, separating narrow signal spectrum components from a wideband signal acquisitionof the radar environment. The traditional method of Real-Time FFT processing uses fixed-length FFT processing (usually 1024 point FFT blocks.) With variable-length FFT record length, the ability to display both a wide span of signals at the same time as viewing this wide band with a narrow resolution bandwidth filter allows viewing of spectrum components as narrow as 20 kHz within a full 110 MHz of viewable spectrum span.For real-Time Signal analysis, this processing must keep up with the incoming signal. Advances in digital computation hardware have provided the needed computation speed.

II. Traditional FFT methods

1. RF measurements with fixed FFT length.

Most Spectrum analysis equipment uses a fixed-length FFT with 1024 samples. The frequency span covered is a simple function of the sample rate delivered to the FFT processor. This relationship can be approximated by the formula:

$$\textbf{Frequency Span} = \frac{\boldsymbol{Sample\ Frequency}}{\mathbf{2.5}}$$

2. Variation of measurement time.

Traditional methods for obtaining narrow resolution bandwidth simply use the same FFT length, but use slower digitizing. This provides the narrow resolution bandwidth. But it also provides a much narrower span of the incoming signal and cannot see the entire signal bandwidth.

III. DSP Improvement of Resolution

1. Digitizing and Filtering.

This paper describes a method of varying the FFT length to provide narrow bandwidth viewing of the spectral components of a wideband signal.

After the incoming signal is digitized, it is passed through the FFT process which provides a “resolution bandwidth” filter that can process modulated pulses up to the full acquisition bandwidth of the IF system in the analyser. This can be 80 MHz, 110 MHz, or even greater bandwidths.

This filtering can be performed by an FPGA to provide for processing that keeps up with the incoming signal.

The Sample rate determines the maximum frequency span that can be seen in the spectrum display.

The time window applied to the FFT samples before processing determines the resolution bandwidth that filters and separates the frequency components within the signal for display.

$$\textbf{RBW} = \frac{\mathbf{2.2}}{\frac{\mathbf{2}}{\textbf{Number of Samples}}\ \boldsymbol{Sample\ Frequency}}$$

Traditionally the time window is the same length as the FFT frame, and therefore provides a fixed ratio between the Span of the resulting spectrum and the resolution bandwidth that separates the frequency components.

2. Independent FFT length and FFT Time Window.

Many FFT systems use a fixed 1024 point FFT. While this is usually sufficient for viewing a spectrum display, it may be insufficient if the spectrum needs greater resolution and will be zoomed for display.

In this method, the FFT is allowed to have up to 16k or 32k points in powers of 2.

In traditional DSP processing, the shape of the time window applied to the FFT frame can be altered. This will allow small changes in the ratio of the Full displayed frequency span to the Resolution Bandwidth (RBW).

However, this also has the effect of changing the shape of the resolution bandwidth filters in addition to the filter width.

In the DSP method described here, the FFT time window can independently be made smaller than the length of the FFT itself. This allows for independent variation of the RBW for each different full-span setting.

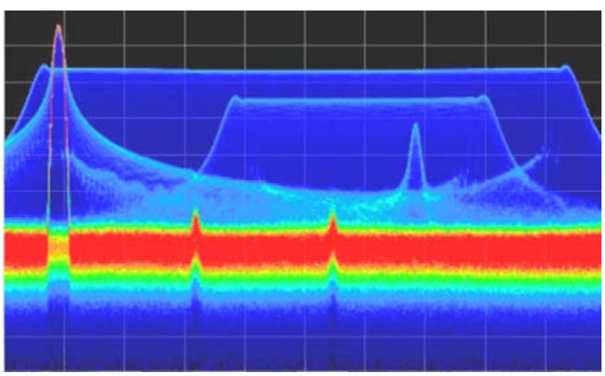
Additionally, this allows very fine-grain changes to the RBW, such that changes can be made by the user of the analyzer in much smaller steps than the usual “power of two” steps.

With the above described FFT methods, a frequency spectrum can be measured with a result of 110 MHz frequency span, and 20 kHz RBW, and with 10,401 points in the resulting trace.

2. Fast FFT processing and Compression.

Real-Time Signal Analysers require the FFT processing is fast enough to keep up with the incoming signal.The FFT acquisitions must also be overlapped to assure that no signals are missed.

The Real-Time analyser may need as many as 250,000 spectrum acquisitions per second.



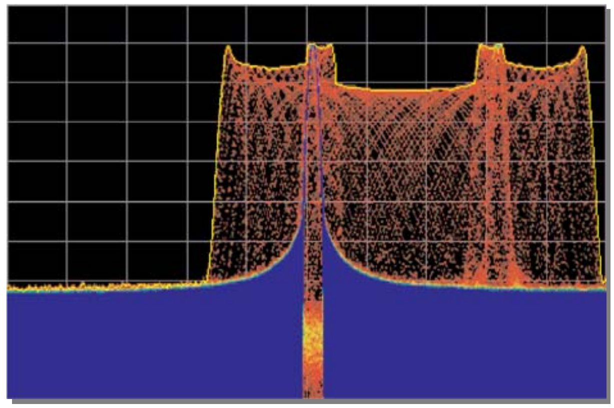
2. Conversion and display of full resolution signals using extended trace-points.

The number of FFT spectrum results (in excess of 250,000 per second) must be compressed about 8000 to 1 to fit them all into a normal LCD display and be viewed by the human eye. This compression can be accomplished by taking each spectrum display and adding it to a bitmap as if it had been sent to the display. Each addition of a new spectrum adds a “1” to the bit locations where the spectrum has signals.

This bitmap can now be sent to the screen and use color to show the density of each frequency or amplitude.

While the bitmap provides unprecedented visibility of multiple signals sharing the spectrum, it has limited frequency resolution.

When the RBW is made narrow by this DSP method, the increased resolution is displayed by having an overlaid high-resolution trace that has as many points as the FFT is set to produce. This can be as many as 10,401 points



Overlaid Hi-Resolution Trace

CONCLUSION

An improved method of measurement and presentation of the RF modulated radar pulses has been presented. This method provides improved capability for discovering narrow spectral components of pulses and other Radar signals within full bandwidth measurements.

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REFERENCES

[1] IEC Standard 60469-2, “Pulse Techniques and Apparatus, Part 2” 60469-2, Second edition, 1987.

[2] Louis L. Scharf, “Statistical Signal Processing Detection, Estimation, and Time Series Analysis” Addison-Wesley Publishing Company, 1991.

[3] T. C. Hill, “Measuring Modern Frequency Chirp Radars,” *Microwave Journal Magazine*,Vol 51, No. 8, August 2008.

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Thomas Hill is Principal Engineer in the RF test group at Tektronix. He has over 43 years of experience with RF test and measurement, 39 of those years at Tektronix. Tom has held various Engineering and Technical Marketing positions with Tektronix since 1974, including general purpose and RF specific measurement equipment. He holds more than ten patents.