RF Engines Limited

Use of the Pipelined Frequency Transform (PFT) in Test Instruments and Signal Analysis Systems.

Reference No SA 005

Overview

RF Engines Ltd. (RFEL) have introduced a new core architecture which has an immediate application in the area of high performance signal analysis systems including spectrum analysers. The purpose of this note is to explain how the PFT could improve the performance of such systems.

Disadvantages of Current Methods

The two techniques traditionally used in spectrum analysers are:-

1. An analogue filter which is swept across the frequency band of interest, and
2. A digital technique involving a flash A/D converter followed by a microprocessor-based Digital Signal Processor (DSP) executing a Fast Fourier Transform (FFT) algorithm which splits the band into a number of frequency 'bins'. The signal power in each bin is then calculated and displayed.

Both these techniques have disadvantages which can be overcome using the PFT.

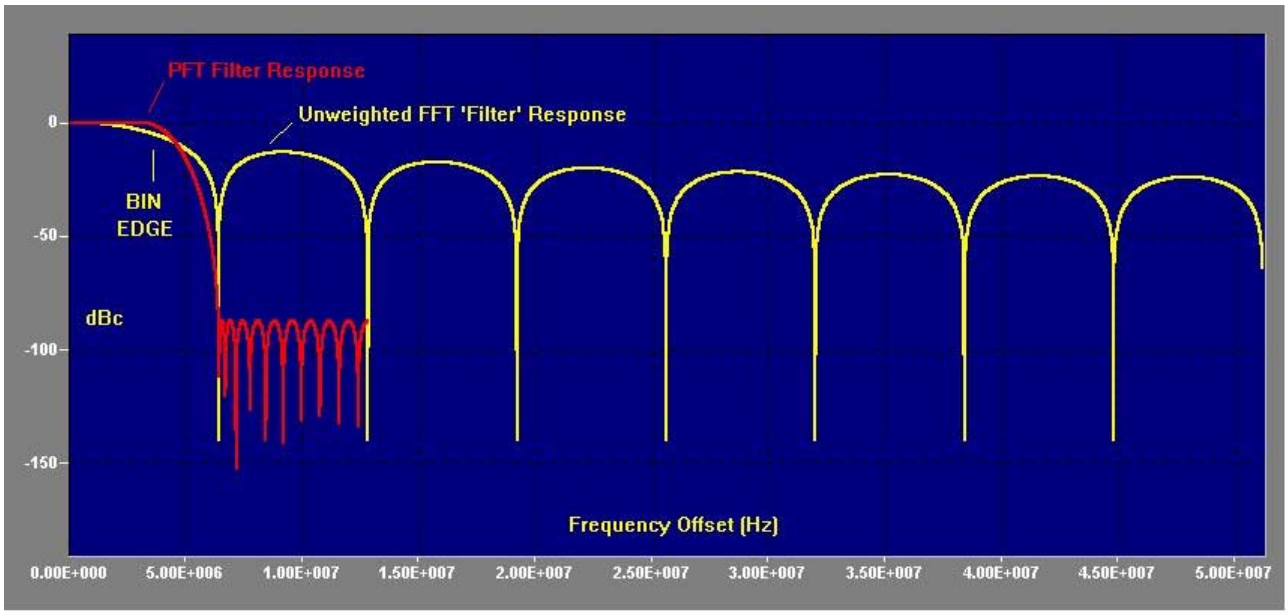
The analogue filter method is extremely slow, often taking many seconds to sweep across the frequency band of interest, so that transient signals are often missed altogether.

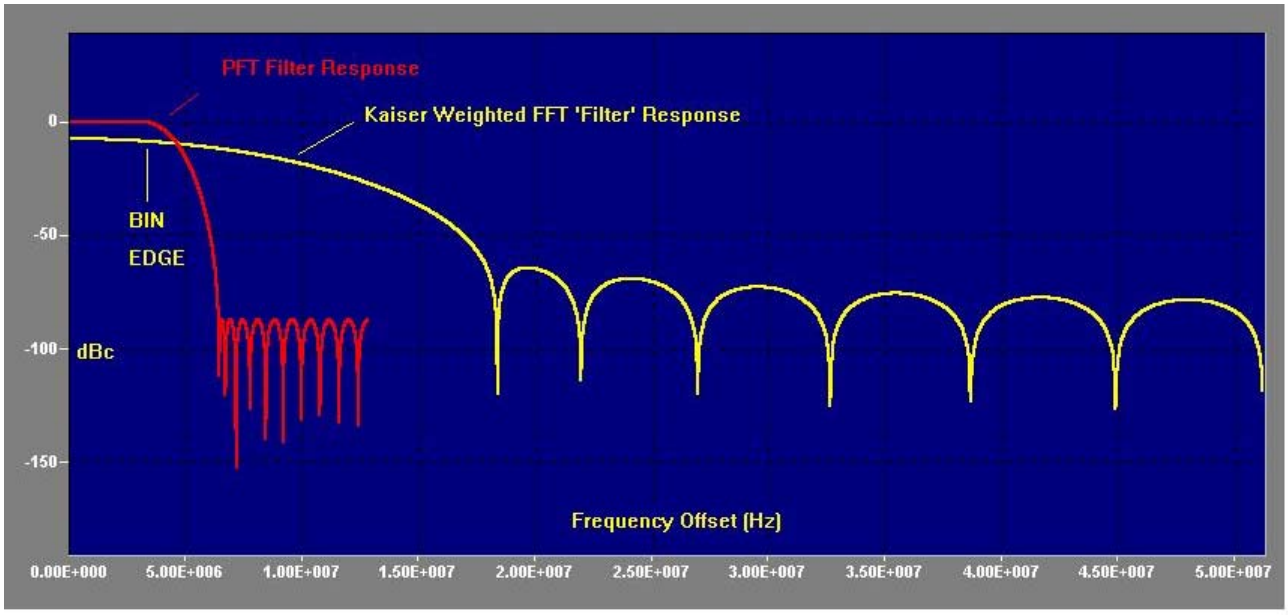
The FFT method is faster but can still miss transient signals, it suffers from relatively poor dynamic range and selectivity. The use of windowing improves dynamic range but the frequency response of each individual bin is still not flat, so the power measured will vary according to the RF position of the signal within a bin.

Alternative digital methods using banks of FIR or IIR filters are possible, but tend to be expensive to implement since a separate filter would be needed for each frequency bin.

The PFT Approach

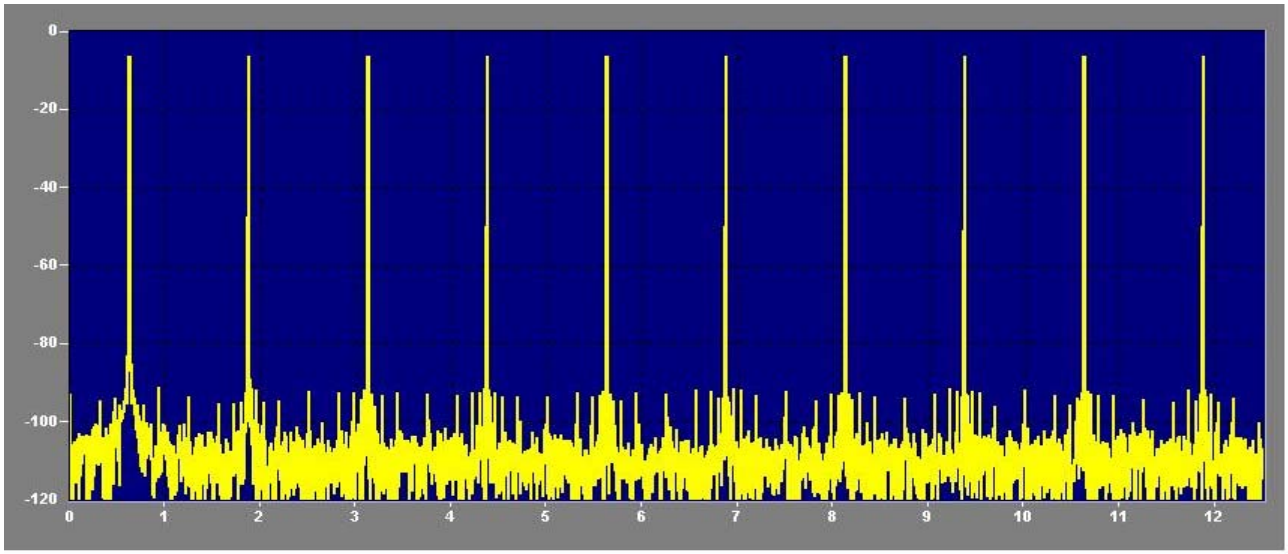
The PFT can be considered as a bank of high quality FIR filters that split a wide spectrum into a set of frequency bins, using significantly less silicon than an equivalent set of conventional digital filters.





These diagrams show the improvement in FIR filter performance offered by the PFT over FFT based approaches. In both the unweighted and Kaiser weighted cases the dynamic range and selectivity are greatly improved while the in-band response is exceptionally flat (typically within +/- 0.2dB).

Transient Signal Capture
The PFT processes *all* the data from the analogue to digital converter, *all of the time,* so that transient signals are never missed. This is achieved by the unique pipelining technique at the heart of the PFT.

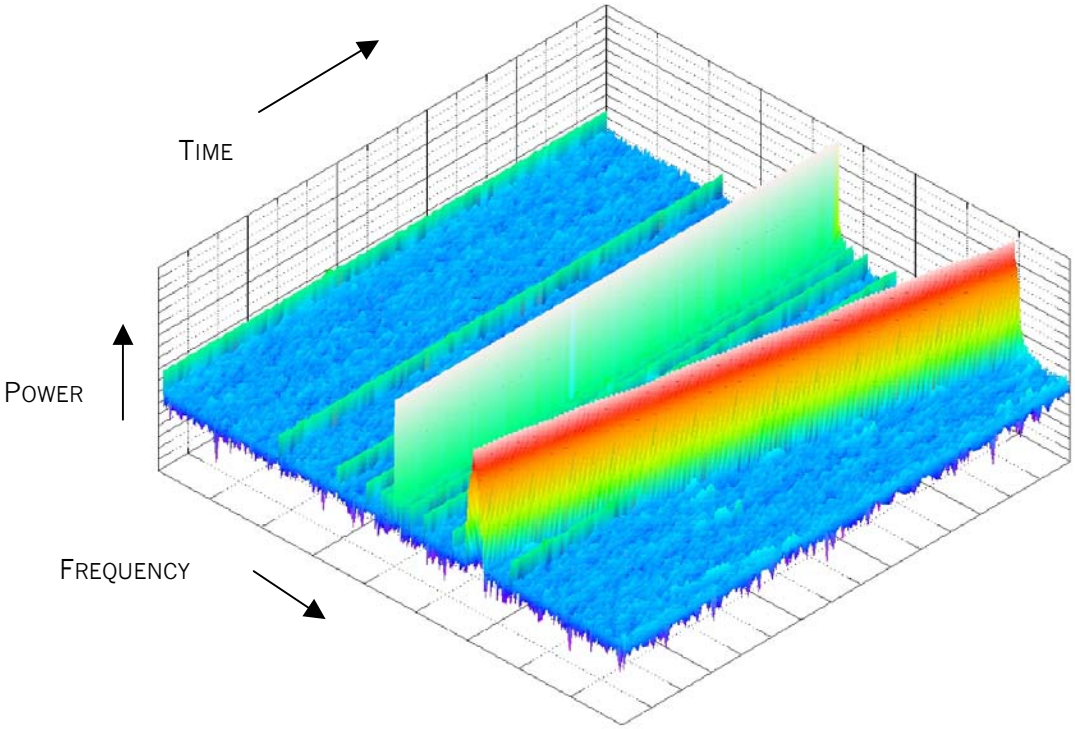


This aspect of the PFT is illustrated in the diagram above, which shows a sequence of ten consecutive 256-bin transforms with the same CW signal input.

In this example each transform takes 1.25uS so that any transient signal of at least this duration is guaranteed to be captured in at least one of the transforms.

Tracking Rapidly Changing Signals
The pipelined nature of the PFT is valuable when a spectrum analyser is required to capture frequency-hopping and similar signals of rapidly changing frequency.

The waterfall plot overleaf shows a stable CW signal at the centre of the frequency band and another CW signal that is changing frequency at 40GHz per second.



Key Features of the PFT

- The PFT is available now as a proven technology, implemented in Xilinx FPGAs. For many applications it can be housed in a single chip.
- Excellent stop-band rejection (typically 75dB with 8-bit data and 130dB with wider bit width data)
- In-band frequency response substantially flat (typically +/- 0.2dB)
- Different size PFTs can be output simultaneously with no lost data.
- Can be implemented in FPGAs or ASICs.
- Cascadable for higher resolutions.
- 20 times faster than a typical MAC-based DSP implementation.

Conclusion

At RFEL we believe that the PFT technology will enable a significant step forward in the implementation of digital techniques within the test instrumentation industry. We would welcome the opportunity to discuss the issues raised in this Application Note and to demonstrate our technology. The PFT is very flexible and there are many trade-offs to be considered. We estimate that in general, the performance characteristics of the best spectrum analyser can be matched or improved while the size and cost of the unit can be considerably reduced.

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