What is the ‘fun’ of Fast Fourier Transform

- Tracking of signals...
- Digital filtering
- Spectrum Analysis
- Synthetic Aperture Radar (SAR) imaging/compression
- Image pattern recognition
- Sonar
- Pulse Compression
- Doppler Processing

This is easier to track than this
What is the ‘fun’ of Fast Fourier Transform

Better data compression

Low frequencies ➞ 4 bits (or more)
Mid frequencies ➞ 3 or 2 bits
High frequencies (oversampling) ➞ 1 bit
Interferometer

Some instruments even *require* FFT in order to be able to operate...

IASI-ng

(c) Airbus D&S
https://iasi-ng.cnes.fr
SkyFFT aka FFTC

Multi Wafer Project 180nm RHA process of Atmel

Functions:
• Full floating point accuracy (32-bits I and 32-bits Q)
• Upto 1024-point FFT FFT⁻¹
• With twiddle upto 1 million point FFT (or FFT⁻¹)
• Addition, Subtraction, Multiply, Conjugate, Conjugate multiply

Data formats:
• Floating point I and floating point Q (or only I)
• 32-bit integer I and 32-bits integer Q (or only I)
• 16-bit integer I and 16-bit integer Q (or only I)

Performance:
• 1D FFT of 1024 points in 10 us
• Long 1D FFT of 1 million points in 20 ms
• 2D FFT of 1024 x 1024 points in 20 ms
Comparison

- “Performances of LEON3 IP Core”
  64 byte (512 bit) FFT-operation in **194 us**.

- DFT implemented by Spiral
  A 1024-points FFT, 16 bits fixed point
  in Xilinx Virtex-5 QV ➔ approximately **50 Mega-single-samples** per sec
  ➔ approx **20 us**

- WvFEv3 FFTcore, developed in 2011
  in space qualified RTAX2000 FPGA
  1024-point FFT in **10.4 ms**
SkyFFT aka FFTC

- Load gain factors (or offset) Eg after every calibration cycle
- Combine gain factor x data fed to FFT core store in SDRAM
- SDRAM to output

At the same time!!

- Or use twiddle factors for long FFTs
- Or 2D-FFT operations (write horizontal – read vertical)
- Or FFT \rightarrow \text{multiply} \rightarrow \text{FFT}^{-1}
Elegant Breadboard // EM-model now available

- SkyFFT / FFTC
- MicroSemi RTG4 FPGA
- SDRAM memory of 3Dplus 2Gbit

- SpaceWire command and control 200 Mbit/s
- SpaceFibre data interface net 2.0 Gbit/s

- RTG4 is approx 10-15% full
- Boards size 245 x 125mm (could be reduced to 125 x 125mm)
- Power consumption 8 – 10 Watt
Picture of the board
FFT processing on-board the satellite
- Now available in rad-hard / rad tolerant technology
Fully engaged
Netherlands Aerospace Centre

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Michelson Interferometer

Some instruments require on-board FFT

In order to align the fringes, one needs on-board calibration that requires FFT
Pictures of the board

Termination resistors

RTG4 FPGA

SkyFFT