



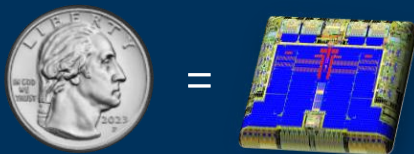
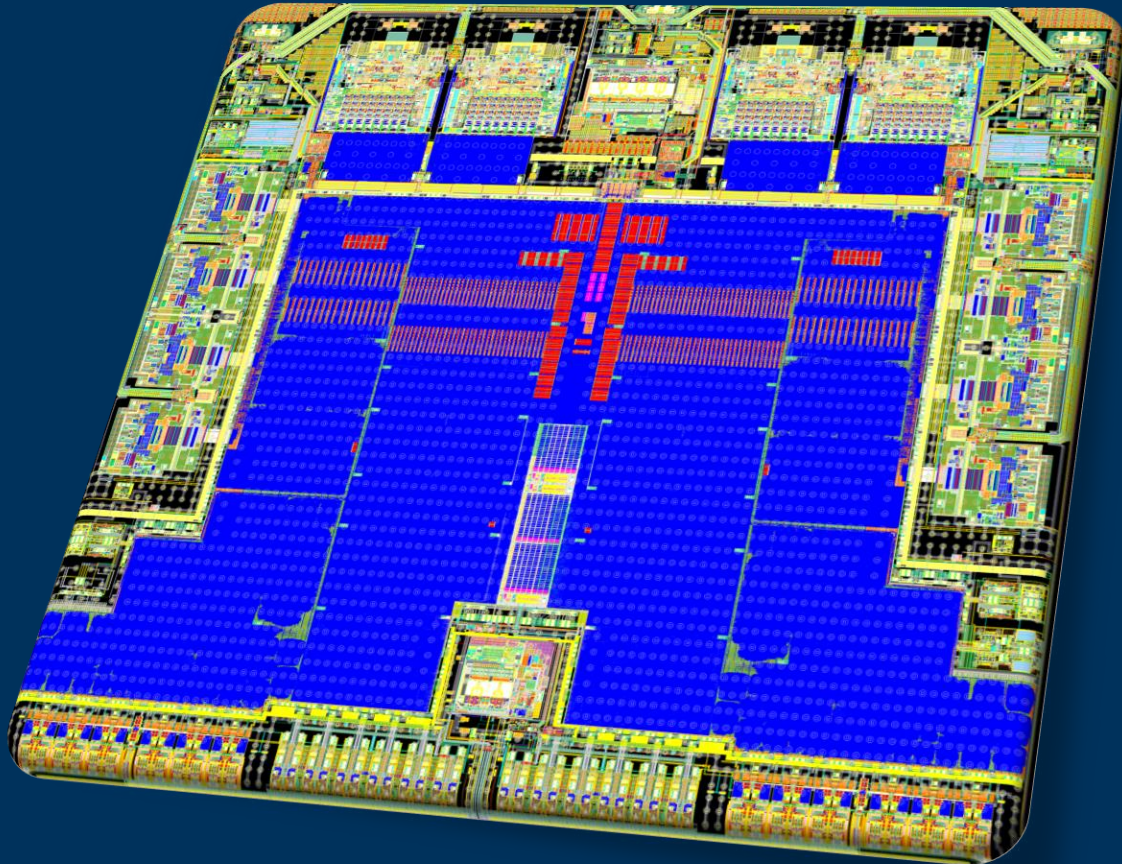
Apollo MxFE[®]

DSP Features for System Level Power Savings

Advanced Data Converter
Platform Group

analog.com

Apollo MxFE®: Wideband TRx for ADEF, INS, & COMS



Wideband Direct RF Sampling Software-Defined MxFE

20+ GSPS
ADCs & DACs

70+ dB
DYNAMIC RANGE

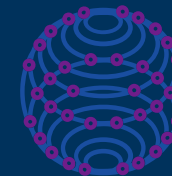
2.8B+
TRANSISTORS

Up to 18GHz
RF BANDWIDTH

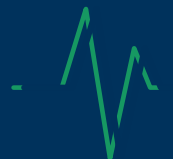
Up to 10GHz
INSTANTANEOUS BW



**AEROSPACE &
DEFENSE**



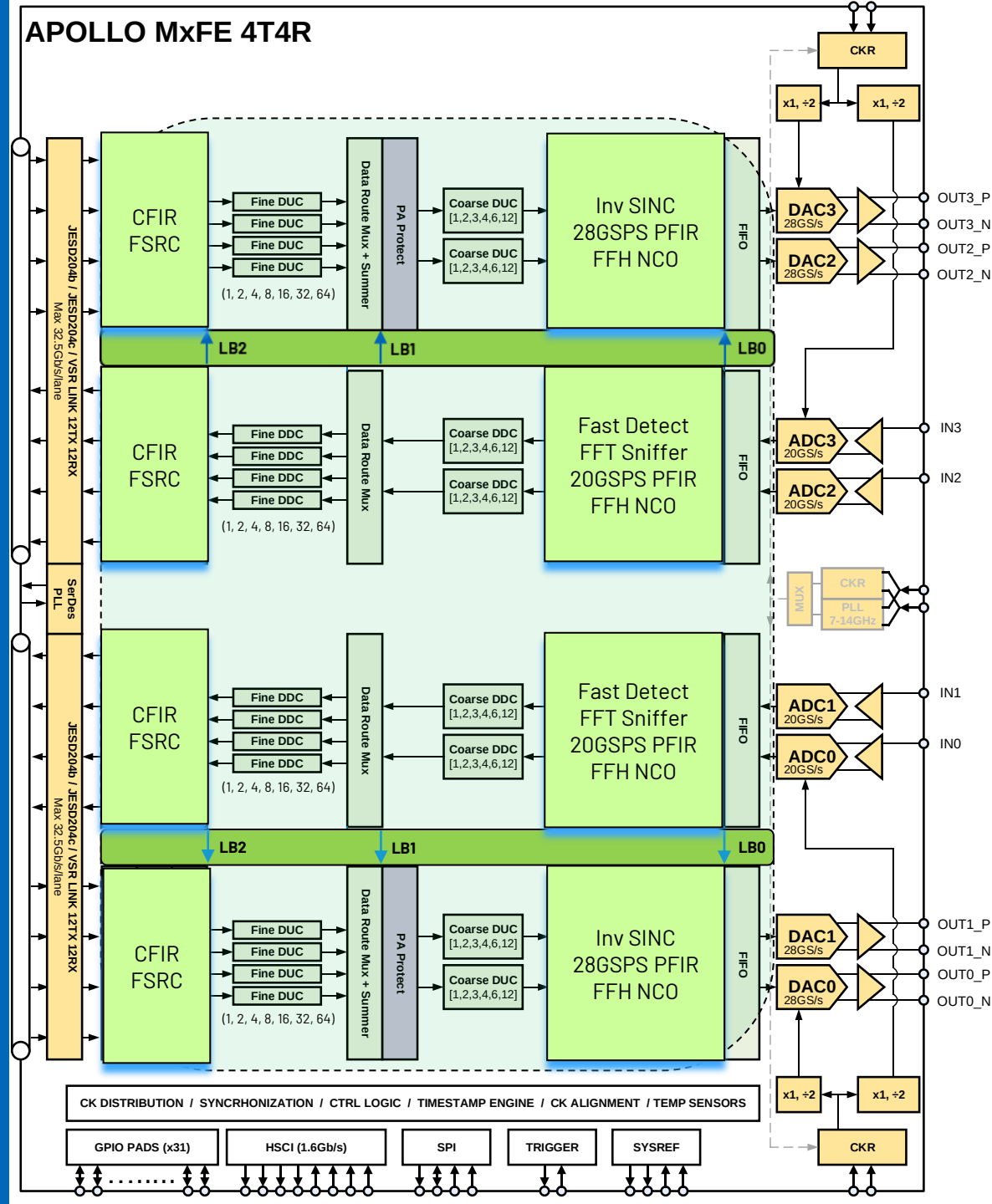
**NEXT GEN
COMMS**



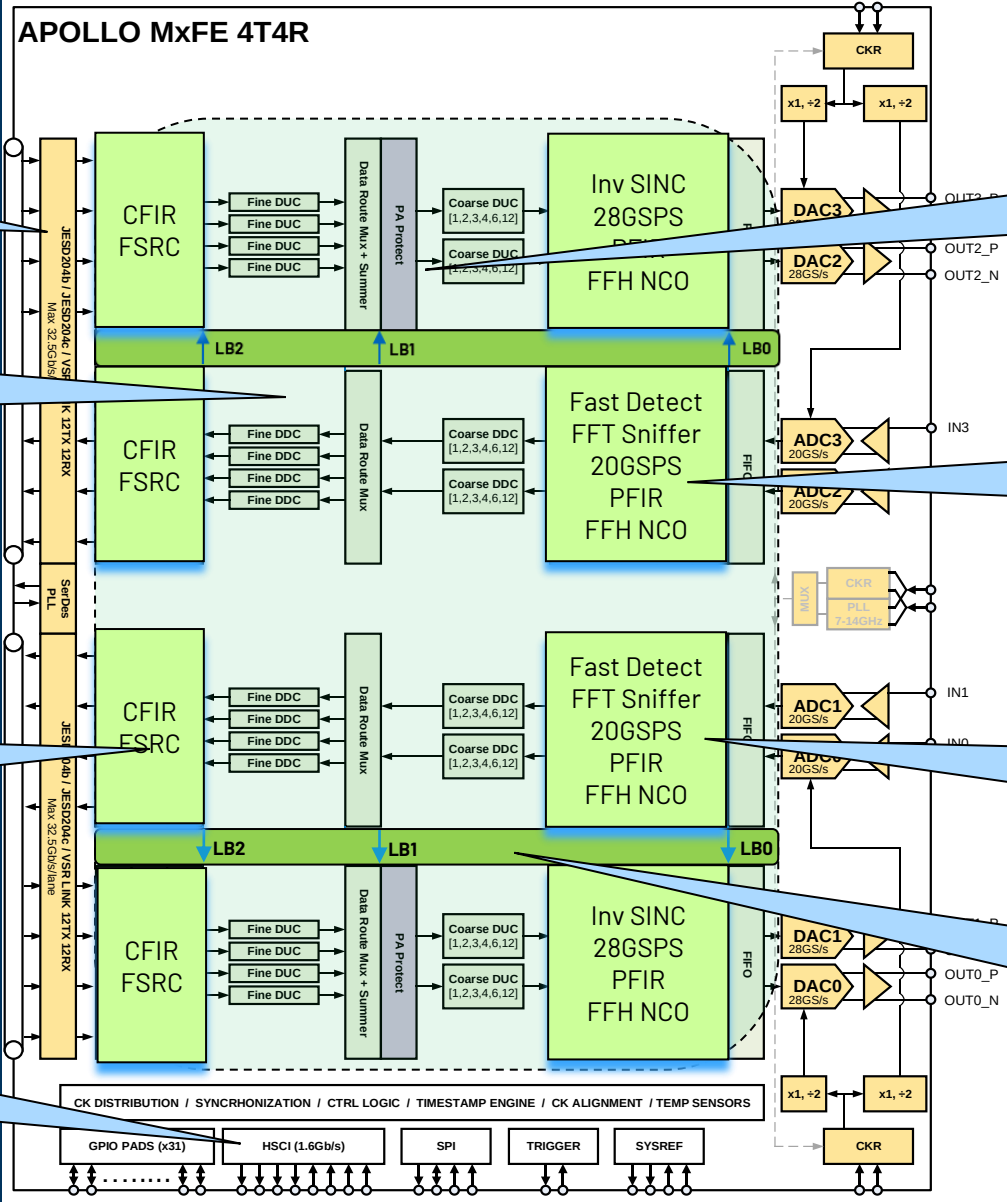
INSTRUMENTATION

Apollo MxFE® – 4T4R AD9084

- ▶ **4 Channel 20GSPS Rx, 28GSPS Tx**
- ▶ **RF Bandwidth: DC to 18GHz**
- ▶ **Frequency Agile across L,S,C, X, Ku-Band**
 - iBW: 10GHz/channel in Full Bandwidth Mode (2T2R)
 - iBW: 4GHz/channel with DSP enabled (4T4R)
- ▶ **Programmable & Dynamically Reconfigurable DSP**
 - Coarse & Fine Decimation / Interpolation 1x-1536x
 - Coarse & Fine Independent FFH NCOs
- ▶ **Offload FPGA Compute from Fabric to ASIC**
 - FFT Sniffer, PFILT, CFIR, FSRC
- ▶ **Differential & Single Ended Input Variants**



Apollo MxFE[®] – Software Agile Digital Signal Processing



SERDES
204B/C & VSR Interface
24 lanes Tx/Rx @ 32.5Gbps
provide 780Gbps payload

Dynamic Re-Config
Reconfigure DSP from
Narrowband to Wideband
Profile in 1-5 μ s w/o taking
down JESD link

FSRC
Fractional Sample Rate
Converter decouple Data Rate
from Clock Rate

HSCI
1.6G LVDS interface for rapid
dynamic reconfiguration

Integrated 2 Stage DDC/DUC
On chip decimation & interpolation
from 1x-1,536x, with fast hopping
NCOs

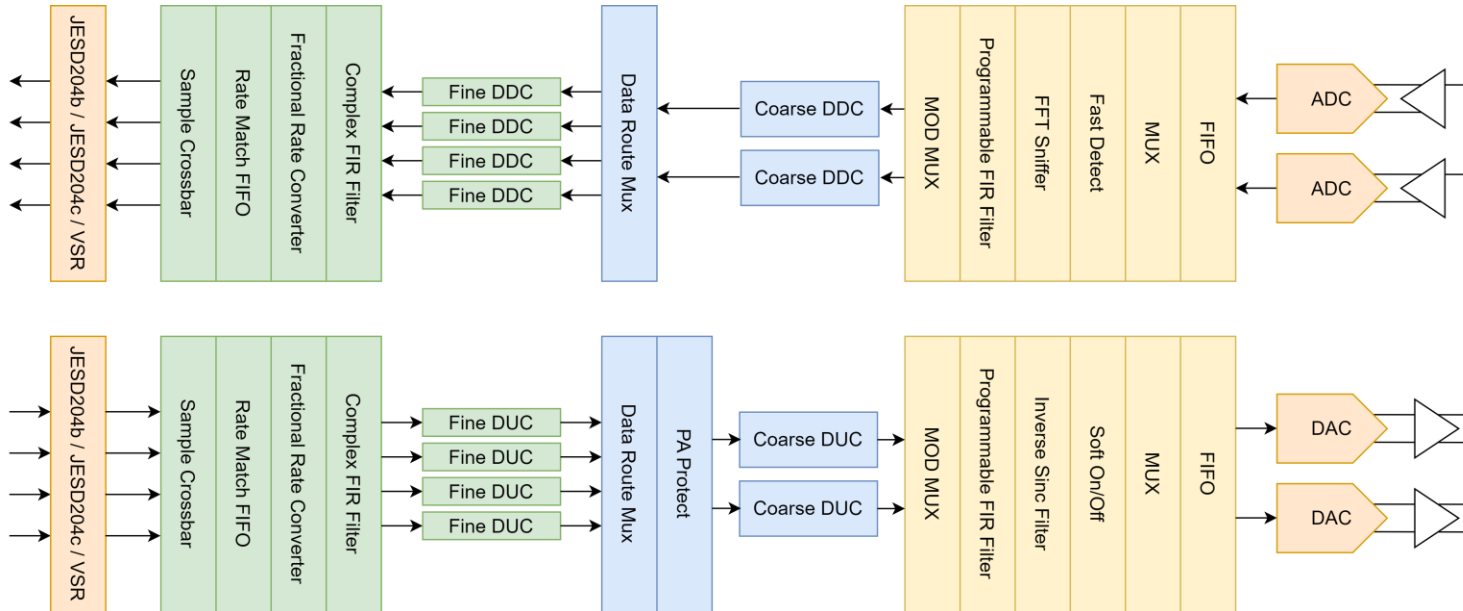
FFT Sniffer
512 point FFT based sniffer provides
L,S,C, X-Band
Situational Awareness

Programmable Digital Filters
32 Tap Full rate PFILT
128 Tap IQ rate CFIR
programmable coefficients

3 Loopback Paths
For EW & DRFM
50ns LB0
Programmable Memory

Quantify the advantage of hardened DSP

Apollo MxFE™ 4T/4R Digitizer



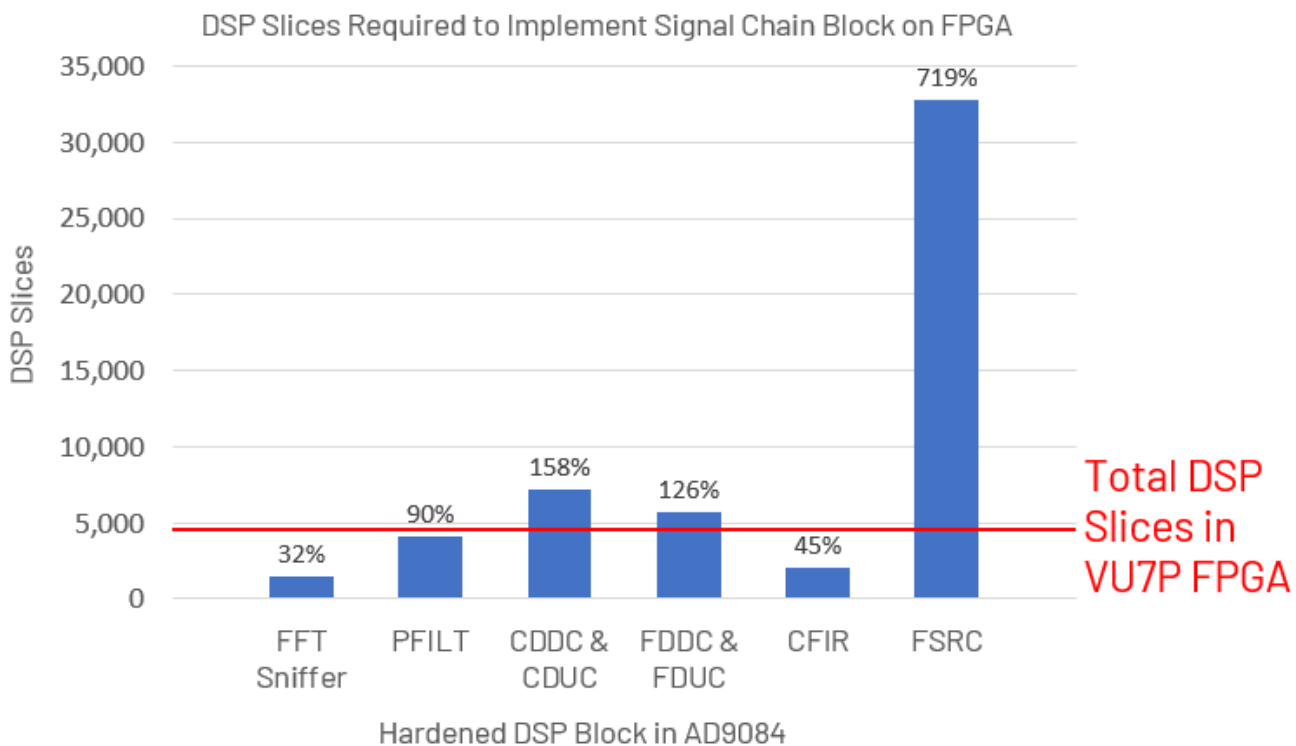
Hardened DSP in the digital signal chain of the AD9084 Apollo MxFE™ digitizer

Apollo MxFE™ Hardened DSP

- 28 GSPS / 20 GSPS
- 512pt FFT
- 8 Complex Fine DDCs/DUCs
- 4 Complex Coarse DDCs/DUCs
- 32-tap Programmable FIR
- 160-tap Complex FIR
- Fast Frequency Hopping NCOs
- Fast detect, low latency AGC support
- Fractional Sample Rate Converter

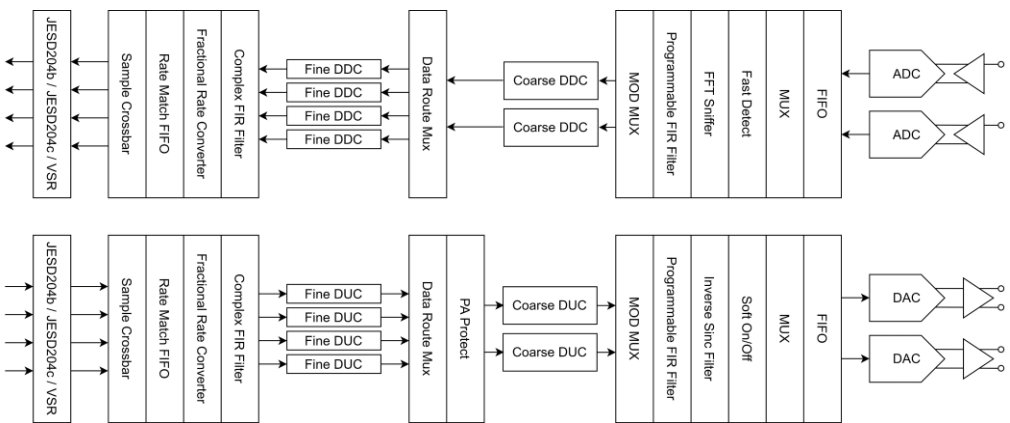
DSP Equivalency

Power Savings



FPGA DSP Slices Required to Implement Apollo MxFE™ Signal Chain

AD9084 Hardened DSP Block	FPGA DSP Slices	Percent (%)
FFT Sniffer	1,460	32
Programmable FIR (PFILT)	4,096	90
Coarse DDC/DUC (CDDC/CDUC)	7,200	158
Fast-Hopping Fine DDC/DUC (FDDC/FDUC)	5,728	126
Complex FIR (CFIR)	2,048	45
Fractional Sample Rate Converter (FSRC)	32,768	719
Total	53,300	1,169

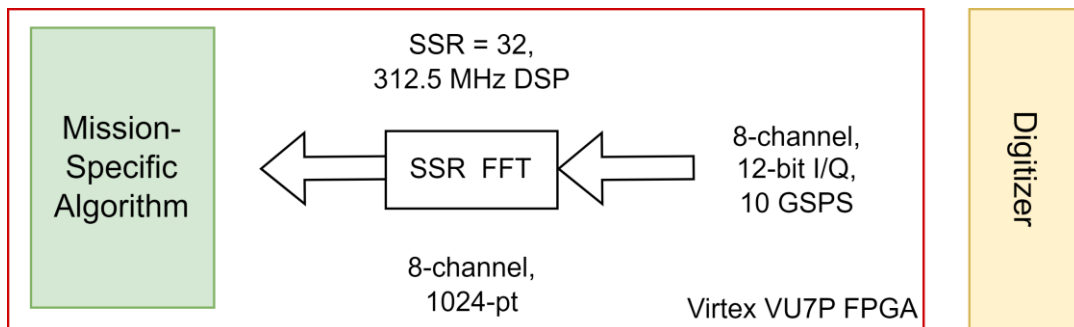


DSP Equivalency

Power Savings

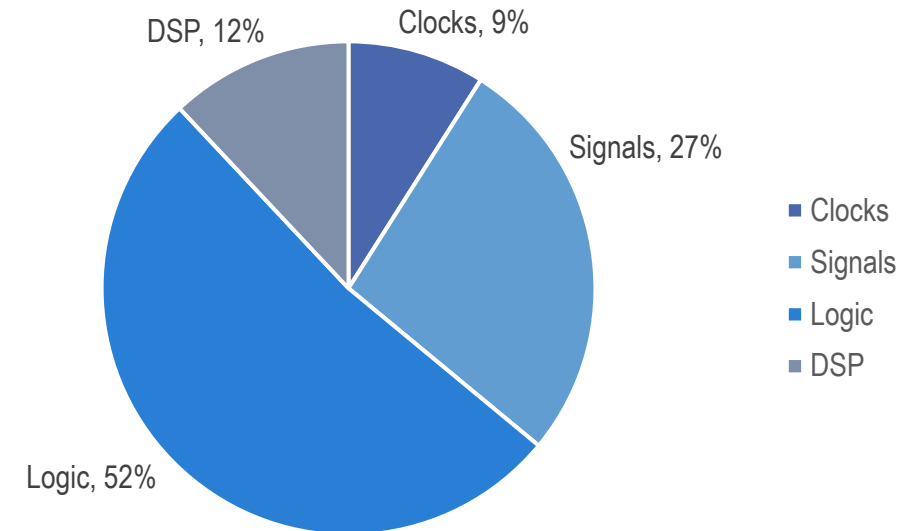
Estimated Power Savings

- Many signal chain blocks within the Apollo MxFE™ cannot be implemented in an FPGA
- A super sample rate FFT was used to baseline power consumption in an AMD Virtex™ Ultrascale+™ VU7P
- The per-DSP48 power of 2.3 mW was used to estimate the total power of signal chain blocks that were too large for implementation in a single VU7P FPGA



DSP Equivalency

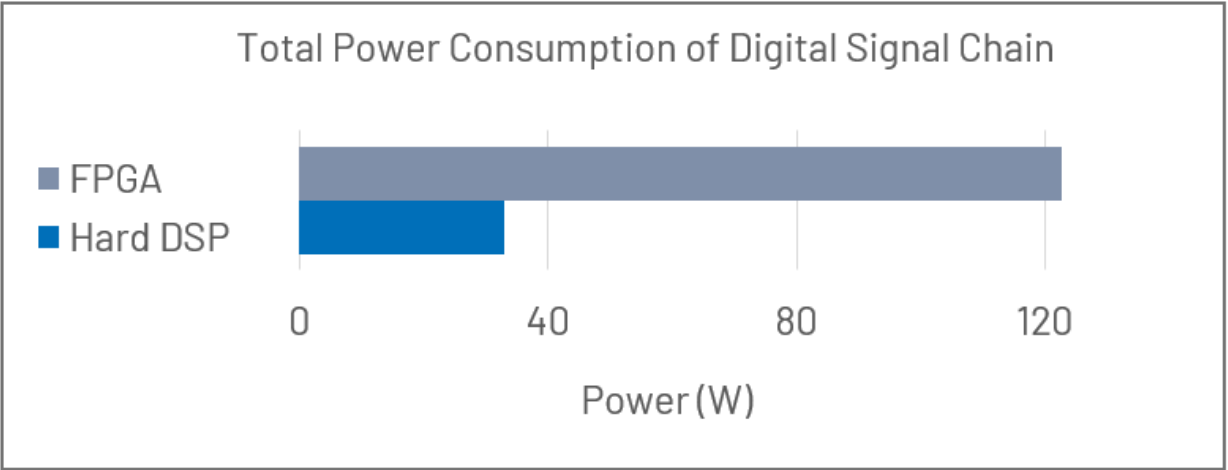
Device Dynamic Power



Resource	Power (W)	Percent (%)
Clocks	2.799	9
Signals	8.965	27
Logic	17.172	52
DSP	3.848	12
Total	32.785	100

Power Savings

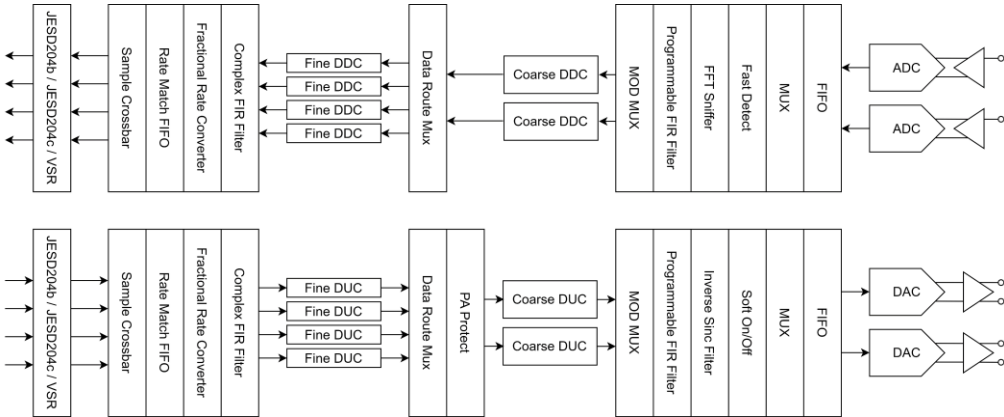
Estimated Power Savings



- Several blocks consumed more DSP slices than are available in the AMD Virtex™ Ultrascale+™ VU7P FPGA
- An estimated comparison of power consumption derived from the per-DSP SSR FFT results

Estimated Power Required to Implement Signal Chain on FPGA

AD9084 Hardened DSP Block	Power (W)
FFT Sniffer	3.4
Programmable FIR (PFILT)	9.4
Coarse DDC/DUC (CDDC/CDUC)	16.6
Fast-Hopping Fine DDC/DUC (FDDC/FDUC)	13.2
Complex FIR (CFIR)	4.7
Fractional Sample Rate Converter (FSRC)	75.4
Total	122.6

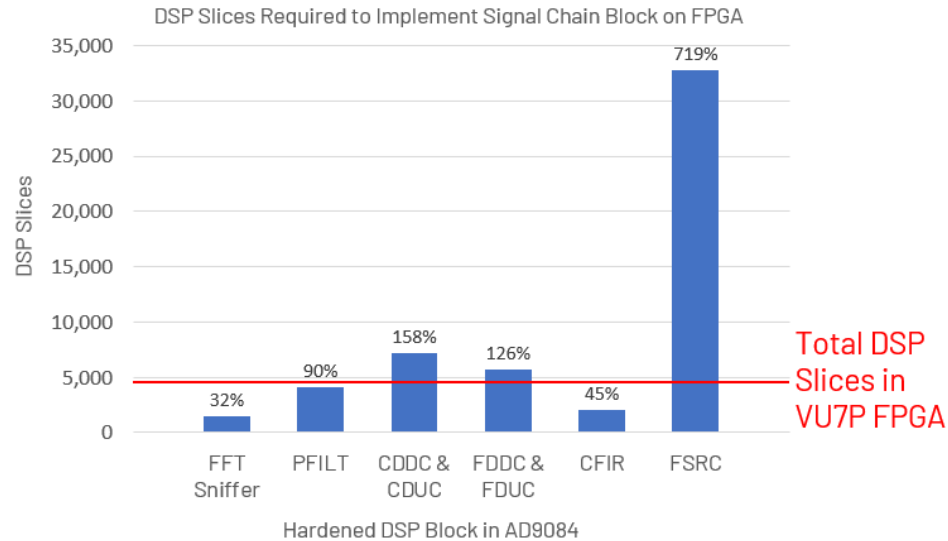


DSP Equivalency

Power Savings

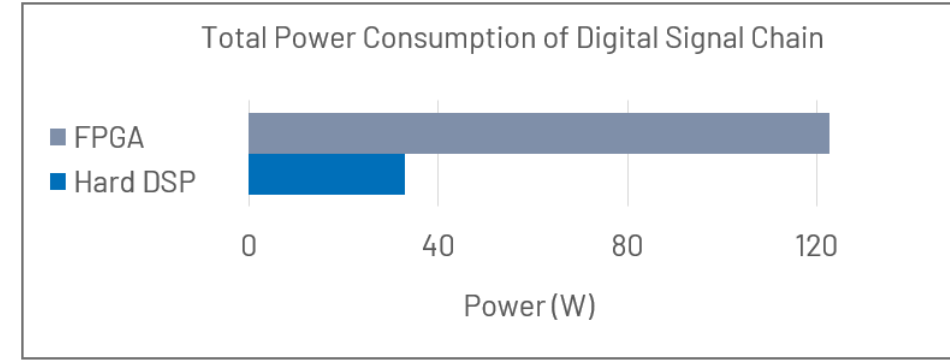
Advantage of Hardened DSP

DSP Equivalency



1,169% DSP Slice

Power Savings



73% Power Savings

Offloading the digital signal chain to ASIC enables

- Scalability for large systems
- Wider bandwidth for the same power
- Greater number of elements for the same size, cost, and power budget

AHEAD OF WHAT'S POSSIBLE

analog.com

