

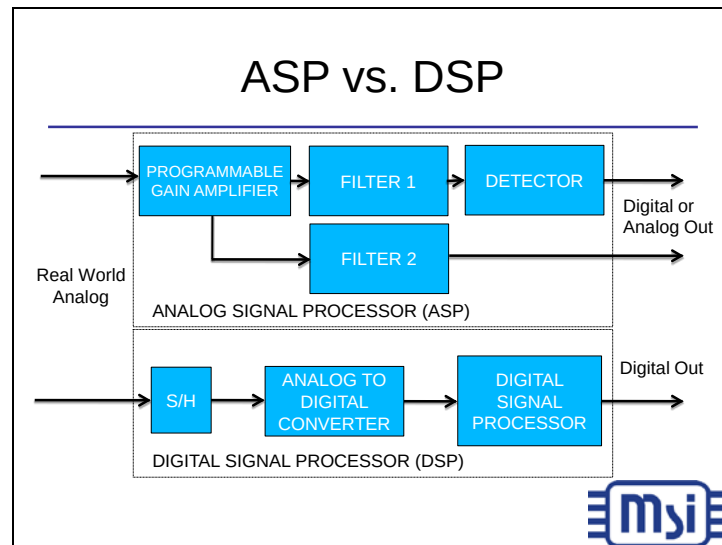
*Advantages of Analog Signal Processing
over FPGA and DSP in Fuzing*

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by Douglas Cox



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Over the last couple of decades there have been significant improvements in integrated signal processing capabilities. Much of that improvement has been in the area of Digital Signal Processing and there has been much emphasis on using those developments to enhance advanced signal processing applications. Less noticed have been the improvements in integrated Analog Signal Processing. This presentation will concentrate on those improvements and areas where there might be an advantage to using Analog Signal Processing. Here are simplified block diagrams of a Simple Analog Signal Processing Design and an equivalent Digital Signal Processing solution. Both solutions start in the analog world. In the DSP solution the analog input is converted to Digital and the processing is done via DSP.

Advantages of DSP

- Software programmability
- High noise immunity
- Implement any mathematical function
- Standard filter function codes
- Less sensitive to temperature variation
- Digital output can be stored in memory
- Large number of bits accuracy and resolution possible



The primary advantage of a Digital Signal Processing solution is that the analog signal is digitized and all signal processing is done in the digital domain. This means all of the processing functions can be programmed in software making it very powerful and flexible. Newer FPGA's are powerful enough to do many signal processing applications, improving the programmability over traditional Digital Signal Processing solutions. For many analog functions, especially filters, the code to generate the function is straight from a text book. Other advantages of digital over analog are listed in the slide.

Disadvantages of DSP

- Typically do not include the A/D and D/A
- Require more current for filter function
- External gain best if done pre DSP
- Quantization error limits dynamic range
- Large package size
- Significant software development time
- Increased development and part costs to achieve optimal performance



One of the biggest disadvantages of DSP is that significant analog is still required. Circuits like a preamp and A/D are usually required. One of the major advantages, high bit accuracy and resolution can become a disadvantage where large processing and memory circuits are required. Most applications require large high pin count FPGA's or dedicated DSP's, draw significant power and have a high per unit cost.

Advantages of ASP

- Lower cost
- Lower power consumption
- Small device sizes
- Packages as small as 3x3 mm



Analog Signal Processing is often the best or only solution when device size or power consumption are critical. High volumes applications often have a significant cost saving when Analog Signal Processing solutions are used.

Disadvantages of ASP

- Limited programmability
- Custom chip often required
- Signal to noise limited to process
- Functions limited to analog library



The biggest disadvantage of Analog Signal Processing compared to DSP is there is limited device programming. In order to achieve the desired cost savings and circuit size improvements a custom chip is often required. Though there are large circuit libraries available, not every function can be achieved.

Analog Signal Processing Functional Capabilities

- Filters
- Op Amps/Comparators
- Multiplexors
- Mixers
- Data Converters
- Limiter/Companers
- Analog Phase Locked Loop
- Analog Front End



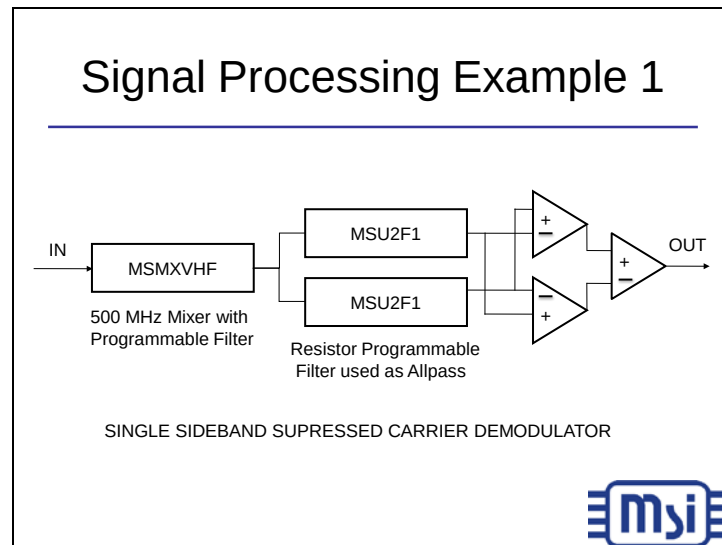
Available analog libraries have a wide range of circuit functions available. They can be optimized for the application requirements. Parameters like speed, power consumption and signal to noise can be optimized for specific applications. Using a custom analog CMOS integrated circuit, a high level of integration can be achieved for complicated and sophisticated applications.

Typical ASP Performance using CMOS technology

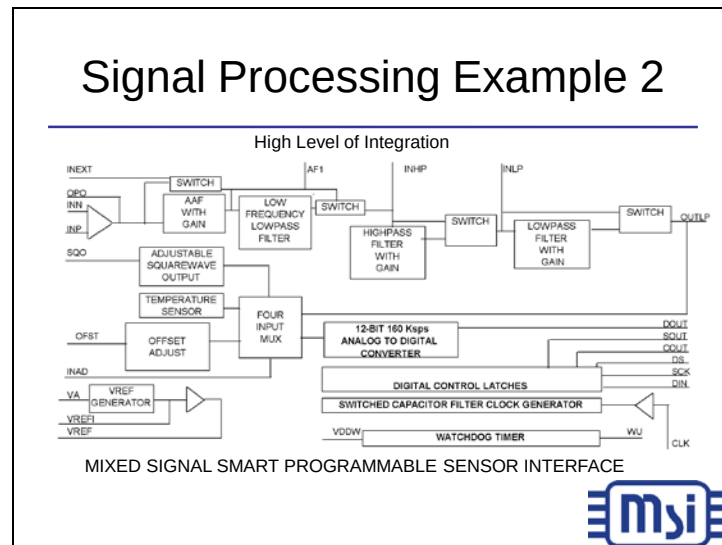
- Ultra low power of under 1mW
- Low voltage operation down to 1V
- Up to 70dB of gain
- 14-16 bits digital resolution
- 80dB overall System Signal to Noise Ratio (SNR)



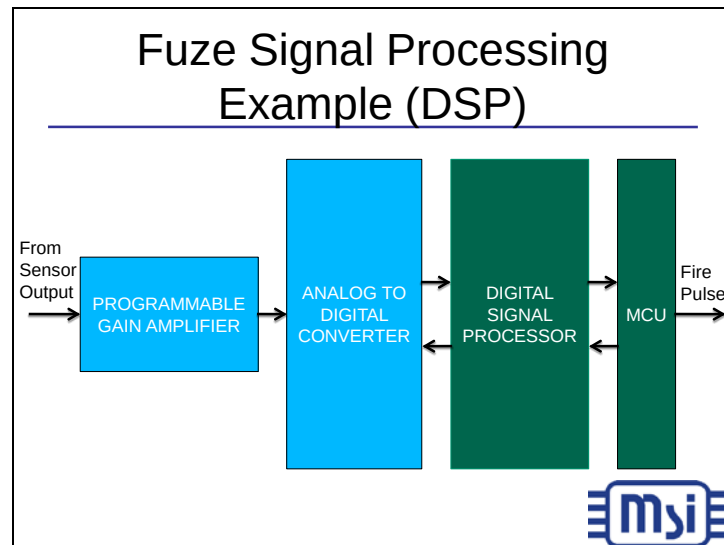
Most Fuzing applications can be achieved with the performance limits of Analog CMOS Integrated Circuits.



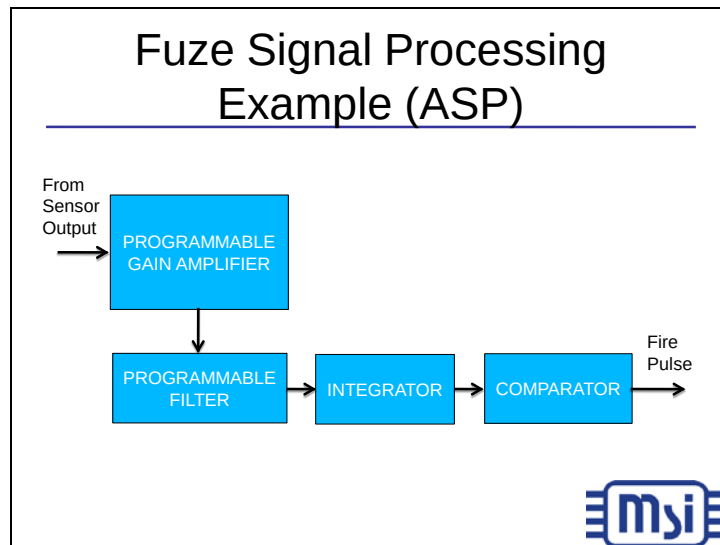
Using our standard products a single sideband demodulator can be created. These building blocks could be integrated into a single integrated circuit. The MSMXVHF contains a 500 MHz mixer with a programmable lowpass/bandpass filter. The MSU2F1 resistor programmable filter is used for an allpass filter function. The op amps provide the addition and subtraction of the I and Q signals.



This is the block diagram for Mixed Signal Integration's standard product, the MSSPSI. This shows the large number of functions that can be integrated onto a single chip and put into a 32 pin LQFP7x7 mm package.



Here is a typical DSP example for a fuzing. A wide range of sensors could be used such as barometric, heat, capacitance, etc. to detect the signal that would trigger the Fuze. Note that significant analog circuitry is still required. The sensor output would be amplified and digitized, then processed by the DSP. The microcontroller would determine if the reading was correct for triggering the primer.



Here is the full analog signal processor example. There is no need for an Analog to Digital Converter. The programmable amplifier and filter remove undesired noise from the sensor and the desired signal is integrated and compared to provides a digital output to trigger the primer.

DSP vs. ASP Size Issues

DSP	Package	Die Size	ASP	Package	Die Size
320F	26x26mm 176 pins LQFP	6051x5975 μm	MSSPSI	7x7 mm 32 pins LQFP	3560 x 3360 μm
320F	40x40mm 176 pins CPGA	6051x5975 μm	MSMXVHF	3x3mm 16 pins VQFN	1220x1660 μm



This is a table of the die size of a typical flash DSP, TMS 320F28335. This would be powerful enough for fuzing applications. The smallest offering package is a plastic LQFP. The analog solution can be up to 8 times smaller.

DSP vs ASP Power Issues

DSP	Mode	Current	ASP	Mode	Current
320F	Regular	330 mA	MSMXVHF	Regular	15 mA
320F	Reduced	30 mA	MSMXVHF	Reduced	5 mA
320F	Reduced	30 mA	MSSPSI	Regular	5 mA

Note: MSI parts are available in SnPb lead finish. DSP suppliers typically provide all RoHS parts that must be post processed to achieve Sn/Pb lead finish.



This is a comparison of the 320F28335 current consumption vs. the MSI standard product, the MSMXVHF Mixer Very high frequency filter and the MSSPSI Smart Programmable Sensor Interface. The power consumption for the analog solution can be much less than the DSP solution.

Summary

- Analog Signal Processing is very suitable for Fuzing Applications
 - Lower power than SOC DSPs
 - Smaller size than SOC DSPs
 - DSP usually needs analog pre-filtering
 - Lower cost
 - Ideal for high volume



In conclusion Analog Signal Processing is ideal for many fuzing applications, due to smaller size and lower current than the DSP solutions. A high level of integration can be achieved.



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