Introduction

- µMAVRK Unit
- ADC Concepts
  - Important Specifications
  - Error Sources
- Architectures
  - Flash
  - SAR
  - Sigma–Delta
μMAVRK Unit

- μMAVRK provides embedded computing combined with RF communication
- Primary components
  - CC430 microcontroller
  - 902–928 MHz antenna
  - 40-pin connector
  - 6-pin analog header
CC430F5137

- 16-bit CPU
- Features
  - 32kB Flash memory
  - 4kB RAM
  - 12-bit SAR ADC
  - 16-bit Timers
  - UART, SPI, I2C, IrDA ports
  - 30 I/O pins
  - <1Ghz Transceiver
ADC Concepts

- ADCs provide a bridge between the physical world and embedded computing
- CC430 contains a 12-bit SAR type ADC
- MSP430 contains a 12-bit SAR as well as a 16-bit $\Sigma$–$\Delta$ ADC.
Resolution

- Quantity of digital values that be reported from a range of analog values
- \(N\)-bit resolution
- \(2^N\) quantization levels
Sampling Rate

- Rate at which discrete values are converted from a continuous signal
- Nyquist Criteria – $f_s > 2f_a$

Basic sample-and-hold circuit
Quantization Noise

- Difference between analog and digital signal.
- Can be improved with faster ADC
Non-linearity

- Integral non-linearity
- Differential non-linearity
Aliasing

- Failure to meet Nyquist criteria
- Results in undesired signals within frequency band of interest

\[ \text{ALIASED SIGNAL} = f_s - f_a \]

\[ \text{INPUT} = f_a \]

\[ \frac{1}{f_s} \]

\[ t \]

\[ \text{NOTE: } f_a \text{ IS SLIGHTLY LESS THAN } f_s \]
Flash Converter

Advantage
• Fastest ADC

Disadvantages
• High power for high speed
• Low resolution
• Large chip size
Successive Approximation ADC (SAR)

Advantages
- Low power consumption
- Small chip size
- Medium speed and resolution

Disadvantages
- N-bits conversion need N iterations
- DAC settling and accuracy limit performance
Successive Approximation ADC (SAR)

Advantages
- Low power consumption
- Small chip size

Medium speed and resolution

Disadvantages
- N-bits conversion need N iterations
- DAC settling and accuracy limit performance
Sigma Delta Converter ($\Sigma-\Delta$)

Advantages
- Finer Resolution
- Lower Noise
- Typically for audio application

Disadvantage
- Need high sampling rate (oversampling)
Sigma Delta Converter ($\Sigma-\Delta$)

- $W(s) = \frac{1}{s} \left( X(s) - W(s) \right) + N(s)$
- $W(s) = \frac{1}{s+1} X(s) + \frac{s}{s+1} N(s)$
Sigma Delta Converter ($\Sigma-\Delta$)

A. N-bit Sampling using Nyquist Criteria

B. Oversampling + Digital Filter + Decimation

C. Sigma-Delta Modulator + Digital Filter + Decimation

Quantization Noise: $q/\sqrt{12}$
$q = 1$ LSB

Digital Filter

Removed Noise

ADC Concepts
Thank You

Questions?