MCU-based IoT Designs: Analog and Linear Peripherals

Class 2: A to D Conversion for IoT Applications

3/14/2017

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Presented by:

This Week's Agenda

3/13/17	An Introduction to MCU IoT Designs
3/14/17	A to D Conversion for MCU IoT Designs
3/15/17	D to A Conversion for MCU IoT Designs
3/16/17	Analog Support for MCU IoT Designs
3/17/17	Analog Front Ends (AFEs)

Course Description

- MCUs provide the foundation on which the IoT is being created and at some point the digital Microcontroller world needs to meet the real analog world.
- Whether with analog sensors, coils for mechanical actuators or motors, high temperature thermocouples or simple battery level detectors connecting to the analog world is required.
- This course is an overview of the many types of analog and linear peripherals available for IoT applications, and quick description of the most common peripherals.
- Some specialized analog elements will also be included. Some example implementations will provide a ‘hands-on’ element for the course.

Today's Topics

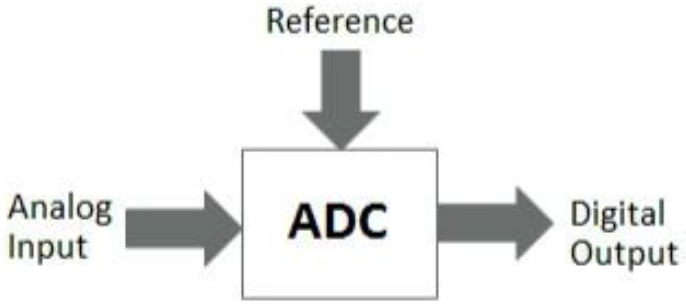
Using Analog to Digital conversion is the most common method for sensing the IoT physical environment.

- How do A to D converters work?
- What are the key specifications for A to D Converters?
- What are typical uses in the IoT?
- Where can you find example designs?
- What resources are available to learn more?

What is An A to D Converter?

What is an ADC?

- Mixed signal device
  - > Analog input
  - > Digital output

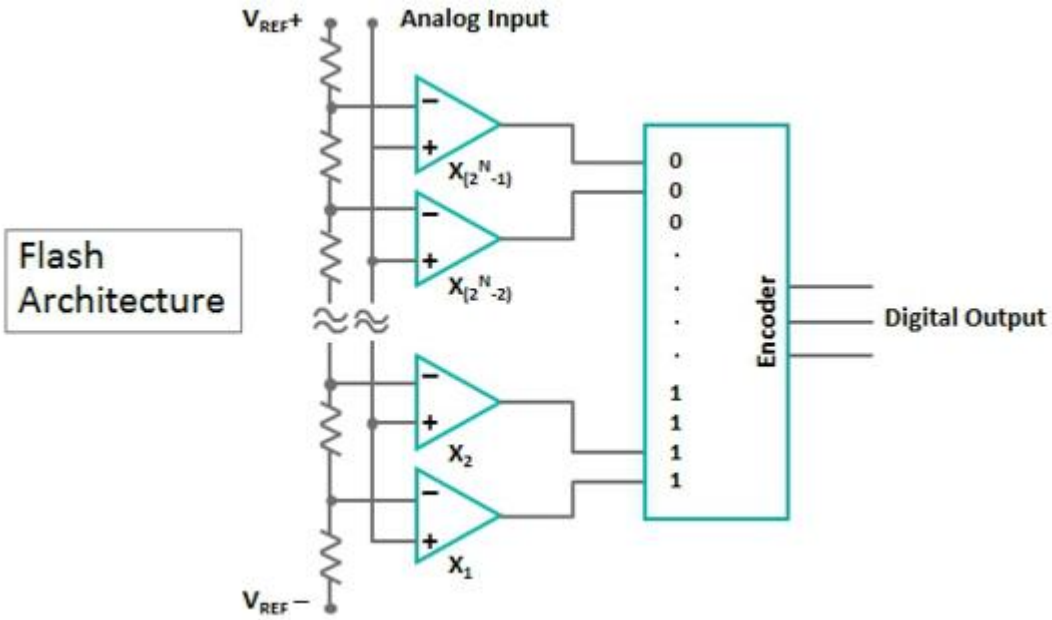


- Converts continuous time signals (analog) to discrete binary coded form (digital)
  - > For micro analysis of the signal
  - > To enable digital transmission or storage of the signal
- Voltage or current based
- Dependent on reference

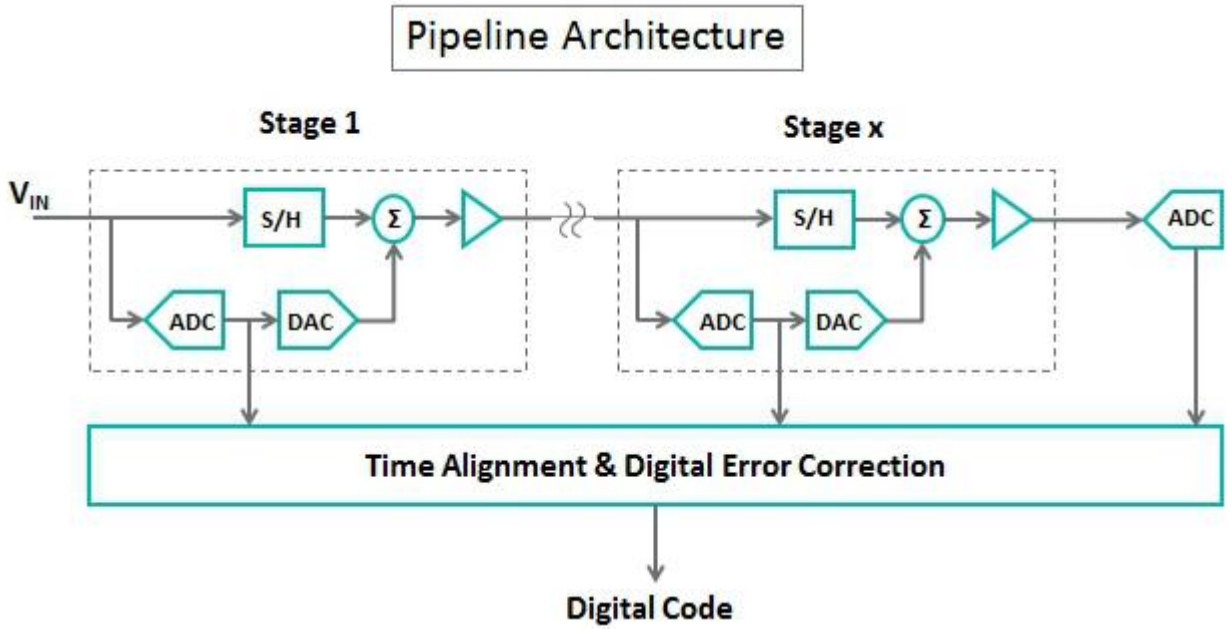
Types of ADCs

Four Technology Types of ADCs

- Flash
- Pipeline
- SARs (successive approximation register)
- Sigma Delta (ΣΔ)

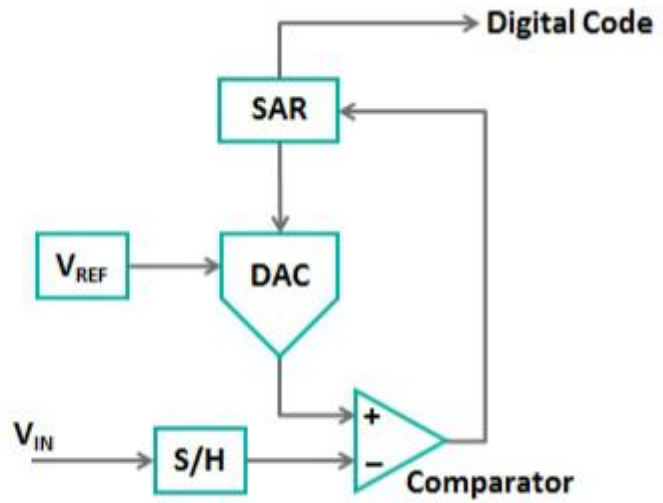


Pipeline ADC

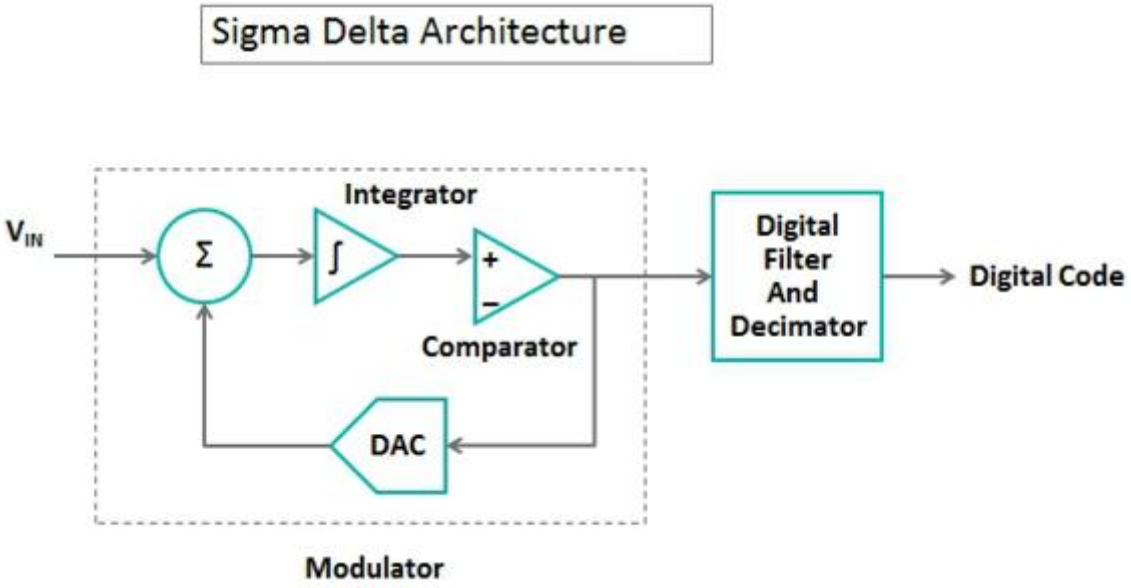


SAR ADC

SAR Architecture

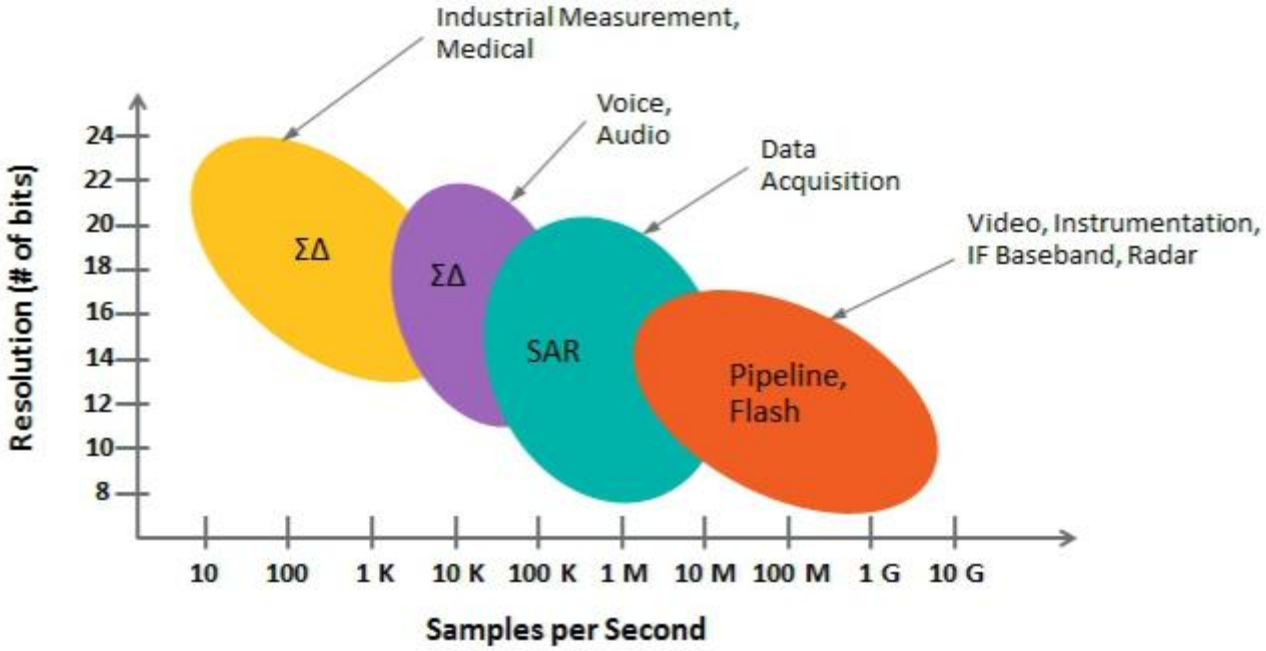


Sigma Delta ADC



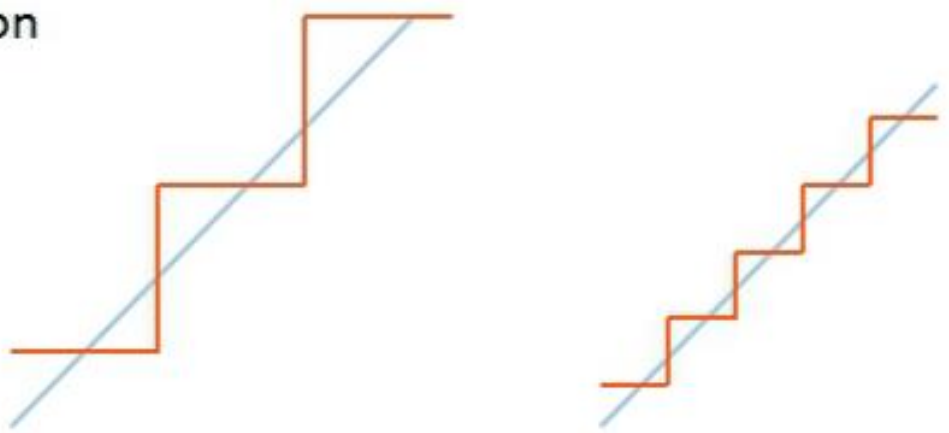
Applications for ADCs

- Flash
- Pipeline
- SARs (successive approximation register)
- Sigma Delta (ΣΔ)



Key ADC Parameters- Resolution

- Resolution



Low Resolution

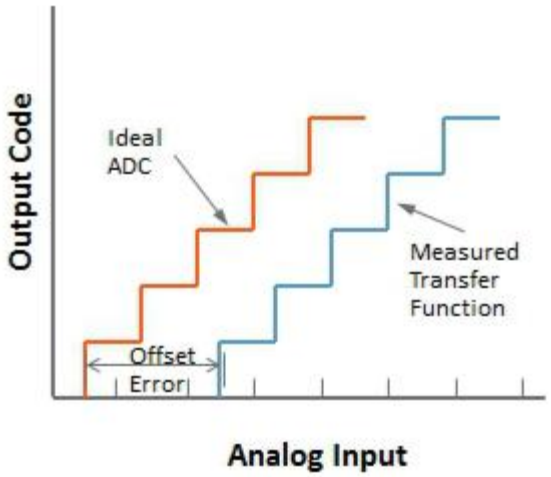
High Resolution

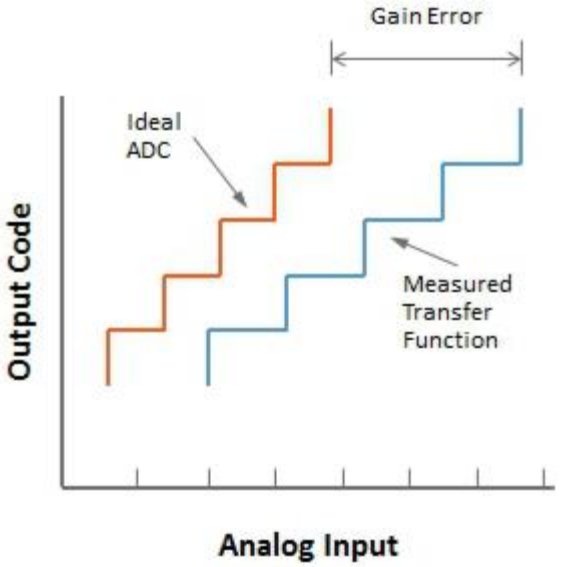
Voltage Reference = 5 V, and 16-bit ADC

A single step is $5\ V/2^{16} = 75.3\ \mu V = 1$ LSB (least significant bit)

Key ADC Parameters Error

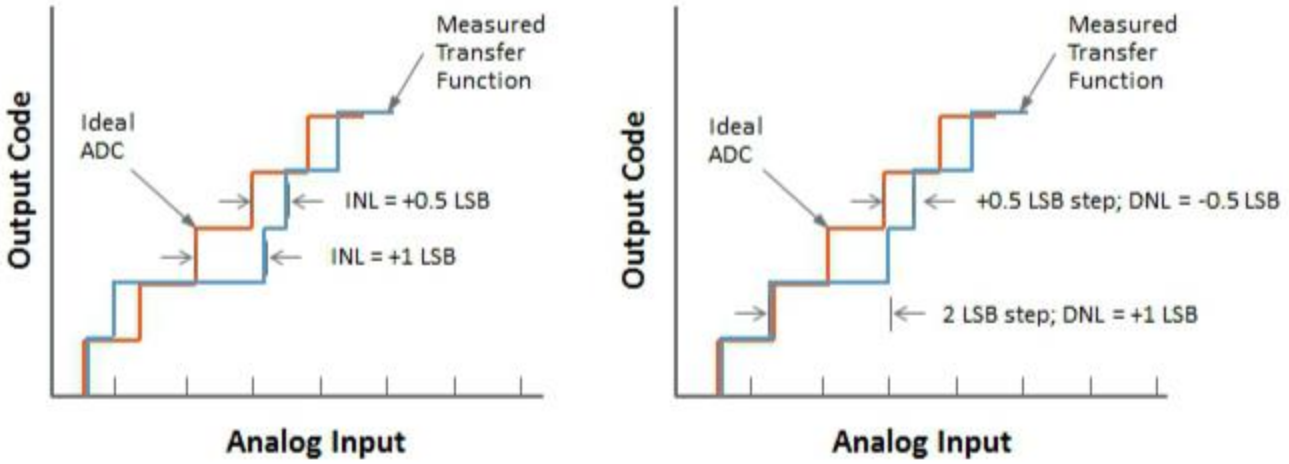
- Offset Error
- Converter Gain Error



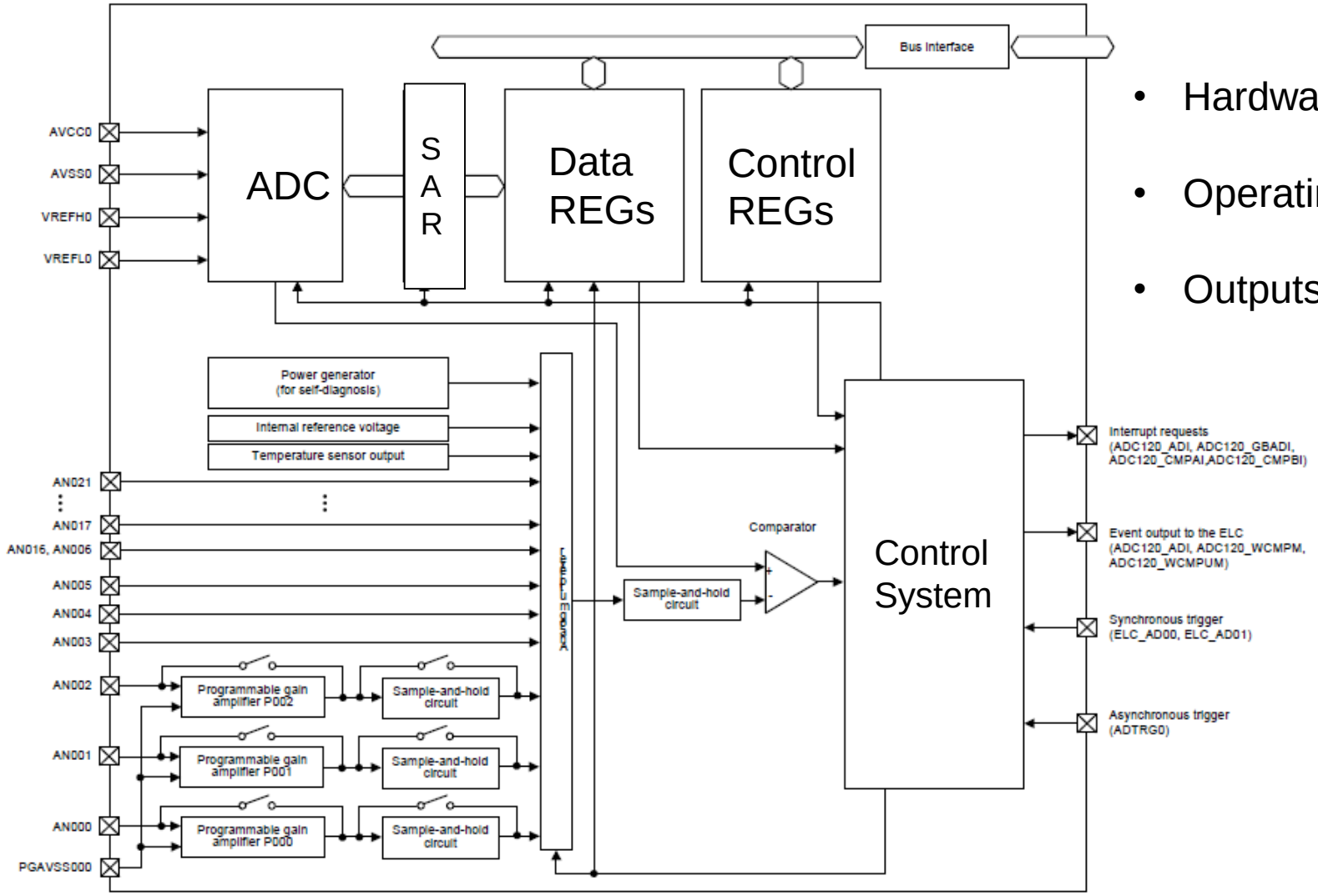


Key Parameters- Linearity

- INL (Integrated Non-Linearity) Error
- DNL (Differential Non-Linearity) Error

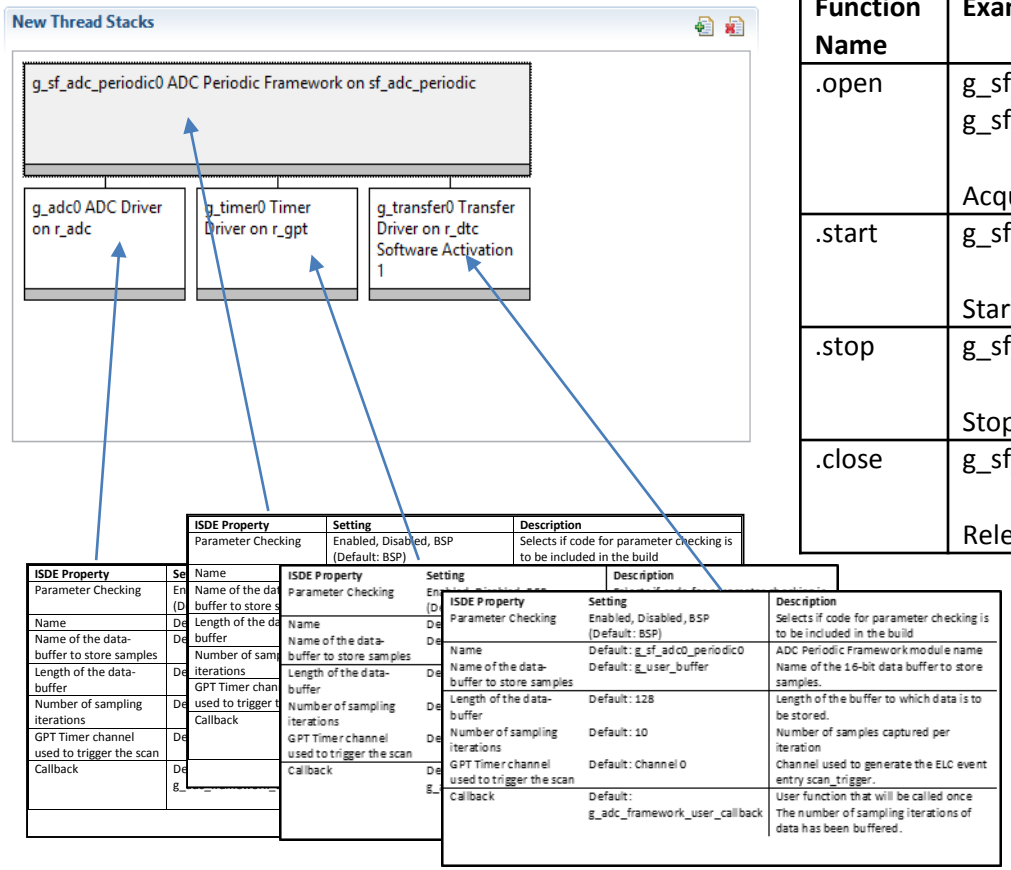


A ‘Real’ MCU-based ADC



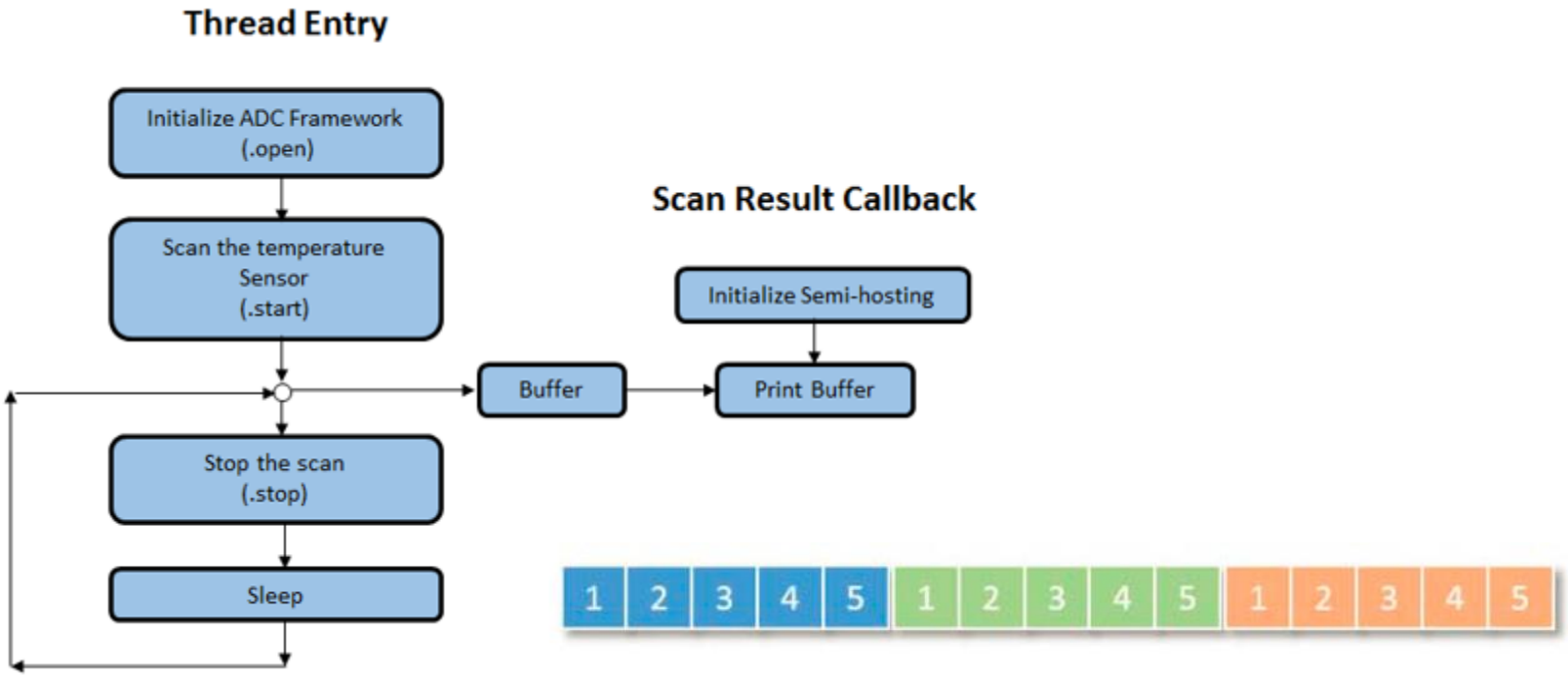
- Hardware Resources
- Operating Modes
- Outputs

A ‘Real’ MCU-based ADC



Function Name	Example API Call and Description
.open	g_sf_adc_periodic.p_api->open(g_sf_adc_periodic.p_ctrl, g_sf_adc_periodic.p_cfg); Acquires mutex, then initializes driver at the HAL layer
.start	g_sf_adc_periodic.p_api->start(g_sf_adc_periodic.p_ctrl); Starts the scan.
.stop	g_sf_adc_periodic.p_api->stop(g_sf_adc_periodic.p_ctrl); Stops the hardware trigger (timer) from triggering any more ADC scans.
.close	g_sf_adc_periodic.p_api->close(g_sf_adc_periodic.p_ctrl); Releases channel mutex and closes channel at HAL layer.

A ‘Real’ MCU-based ADC



Resources for this Class

Product Training Modules

- Analog Devices: ADC Architecture
  http://www.digikey.com/en/ptm/a/analog-devices/data-converters-adc-architecture
- Maxim: ADC Overview
  http://dkc1.digikey.com/US/en/TOD/Maxim/MAX1301ADC/MAX1301ADC.html

Application Notes

- Maxim: Understanding SAR ADCs
  https://www.maximintegrated.com/en/app-notes/index.mvp/id/1080

Course Resources (Product Training Modules)

Digital to Analog Converters:

- http://www.digikey.com/en/ptm/r/renesas-electronics-america/digital-to-analog-converter-part-1
- http://www.digikey.com/en/ptm/r/renesas-electronics-america/digital-to-analog-converter-part-2
- Concerto Analog Sub-system: http://www.digikey.com/en/ptm/t/texas-instruments/microcontrollers-concerto-training-topic-5-the-analog-sub-system

PSoC Analog Co-processor:

- http://www.digikey.com/en/ptm/c/cypress/psoc-analog-coprocessor

Peripheral Devices:

- Maxim ADChttp://www.digikey.com/en/product-highlight/m/maxim-integrated/max11410-24-bit-multi-channel-low-power-adc

Course Resources (MCUs)

- Atmel http://www.digikey.com/en/product-highlight/a/atmel/sam-v-microcontrollers
- Microchip http://www.digikey.com/en/product-highlight/m/microchip-technology/pic32mm-mcu-family
- Renesas RL78 http://www.digikey.com/product-detail/en/renesas-electronics-america/YRDKRL78G13/YRDKRL78G13-ND/2796058
- Texas Instruments http://www.digikey.com/product-detail/en/texas-instruments/MSP-EXP430G2/296-27570-ND/2331789

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