CPE 323
Intro to Embedded Computer Systems
Analog-to-Digital Conversion

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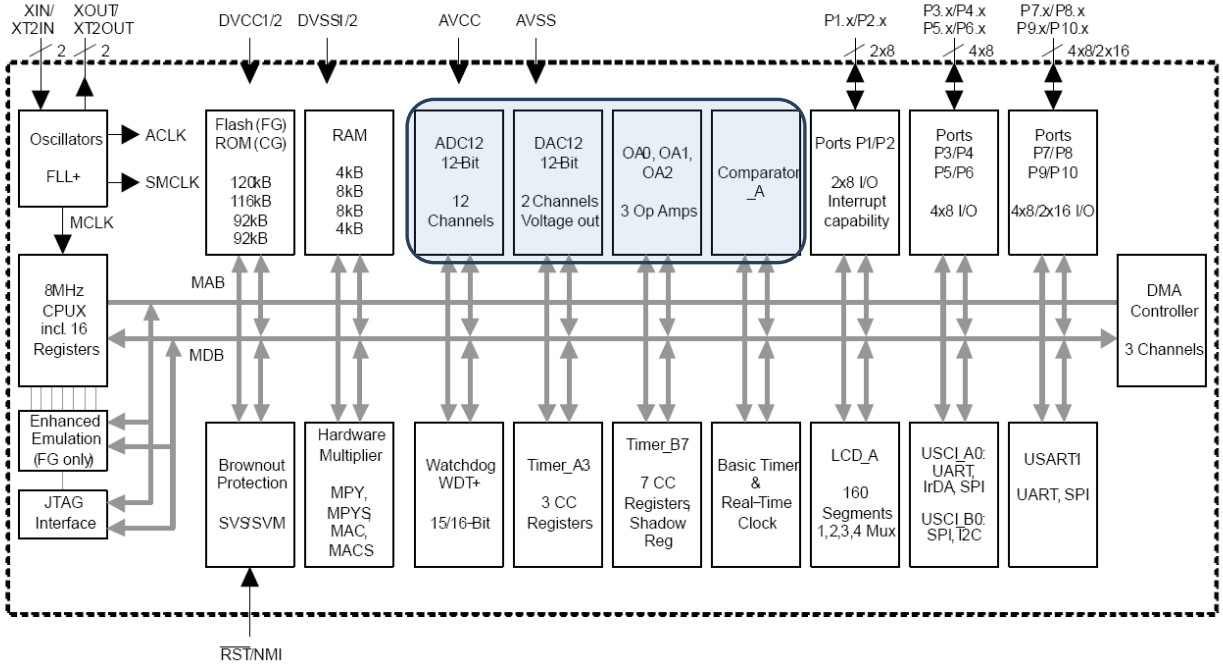
Admin

MSP430FG4618 Block Diagram



MSP430F5529 Block Diagram

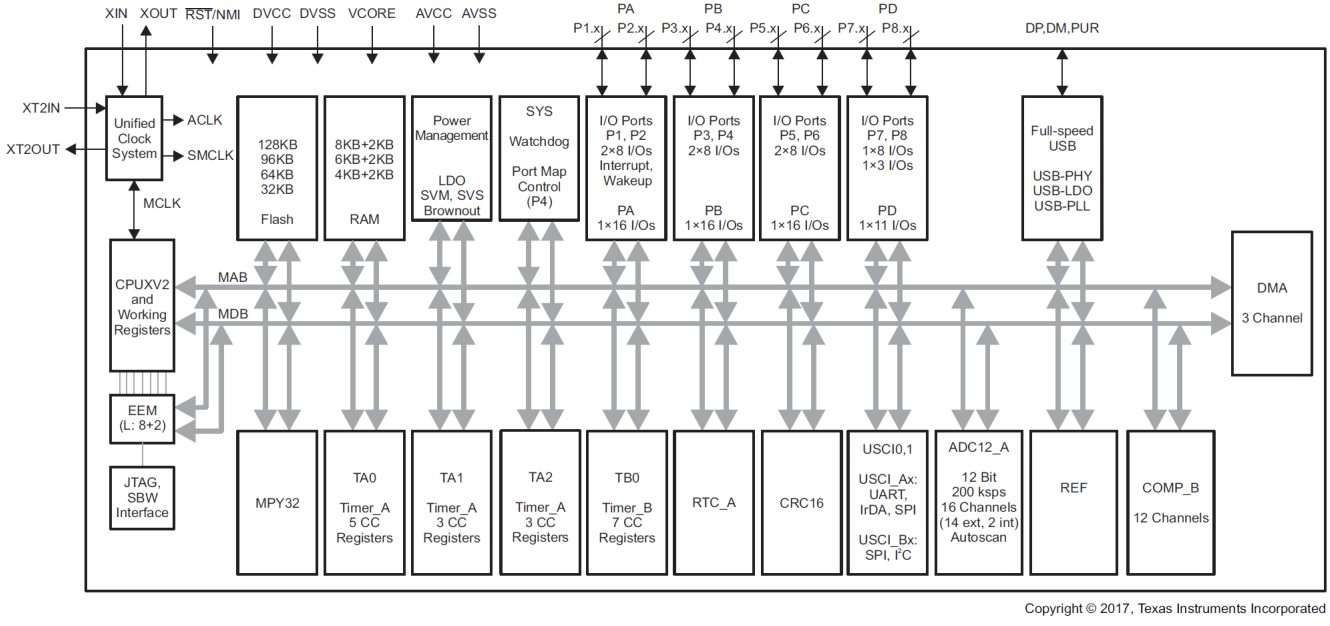


Figure 1-1. Functional Block Diagram – MSP430F5529IPN, MSP430F5527IPN, MSP430F5525IPN, MSP430F5521IPN

Interfacing Physical World: From Analog Signals to Digital Values

- Sensors/Transducers
  - convert physical quantity into an electrical signals
- Signal Conditioning
  - isolation from dangerous voltages due to static discharges
  - amplification of signals
  - bandwidth limiting: filters
- Analog-to-Digital Converters
  - convert analog signals to digital values

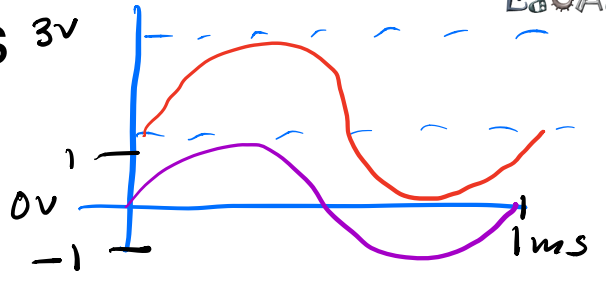
System View: From Input Analog Voltage to Bits

ADC Modules

- Analog Multiplexer
- Sample-and-hold
- AD Conversion Core
- Buffers

Definitions

$V_{LSB} = \frac{V_{FS}}{2^n}$



- Resolution
- Accuracy
- Transfer Function
- Aperture Time / sample time
- Conversion Time – time the core needs to produce digital counter part.
- Sampling Frequency – How many samples you want to get.

↳ 2x highest harmonic.

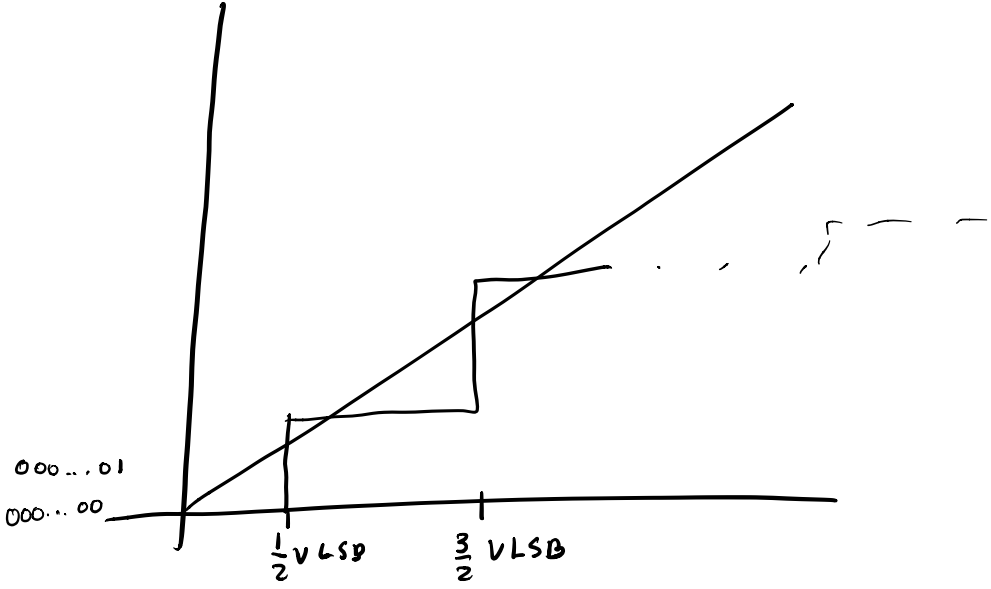
$y = \sin(2\pi \cdot f \cdot t)$

$f = \frac{1}{1ms} = 1,000Hz$

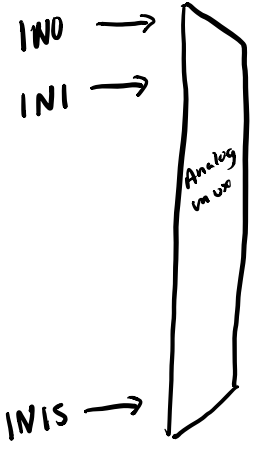
$Input = 1.5(1+\sin(2\pi f t))$

$f = 1,000\,Hz$

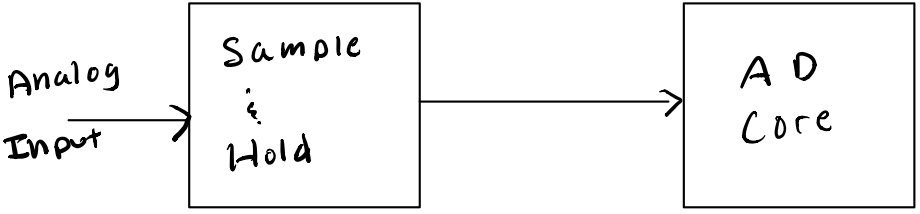
AD Transfer Function

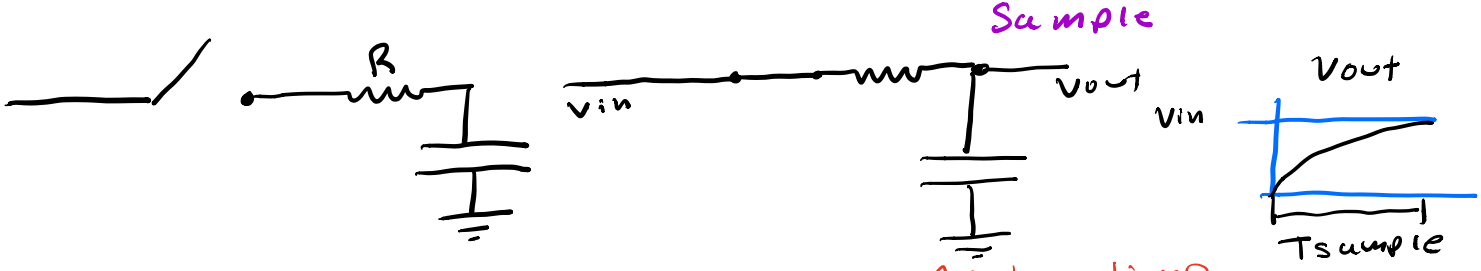


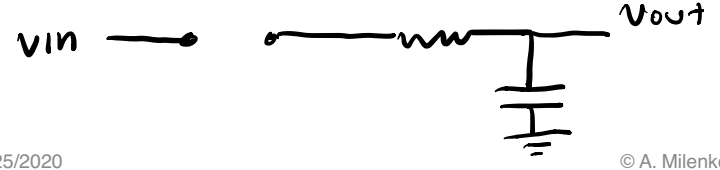
Input Analog MUX



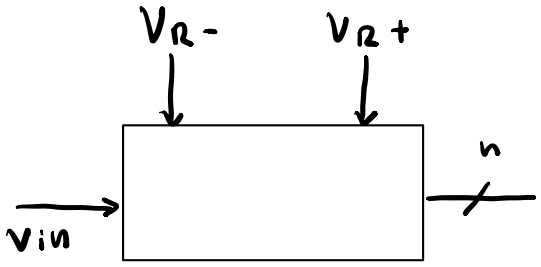
Sample&Hold







ADC Core



n bit value

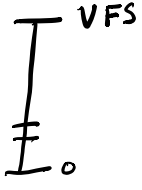
full scale voltage

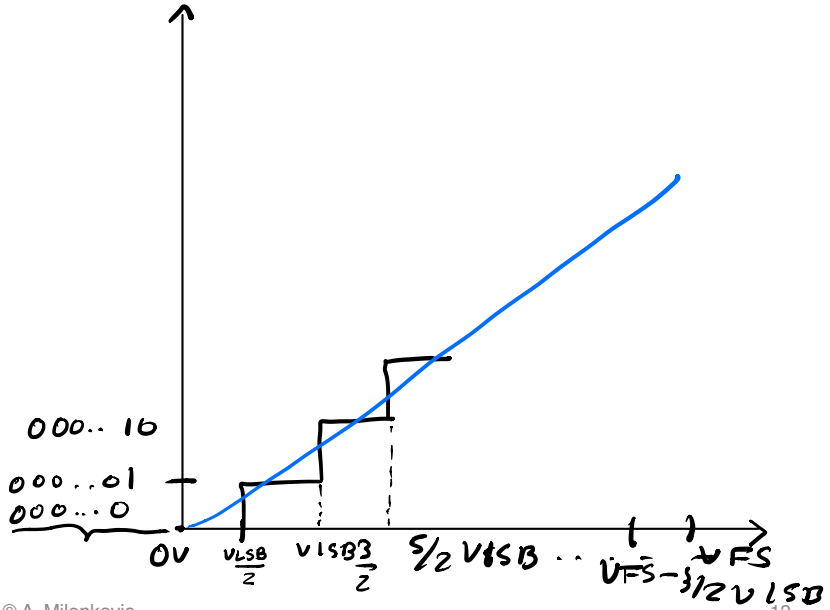
$N_{ADC} = (2^n - 1) \cdot \frac{V_{in} - V_{R-}}{V_{R+} - V_{R-}}$

$V_{FS} = V_{R+} - V_{R-}$

$V_R = V_{LSB} = \frac{V_{FS}}{2^n}$

resolution voltage



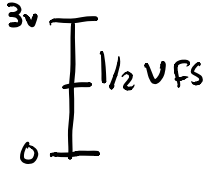


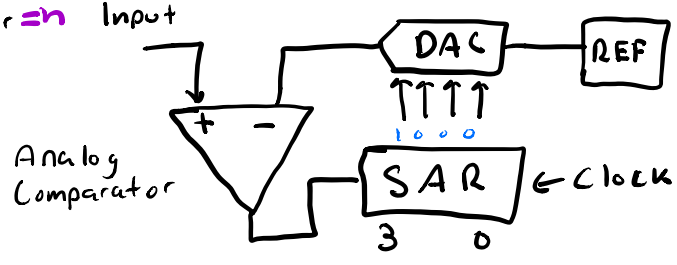
Successive Approximation Register (SAR) ADC Core

Example:

4-bit-converter $=n$

$V_{FS} = 3v$





$$V_R = \frac{V_{FS}}{2^n} = \frac{3v}{2^4}$$

$$V_R = 0.1875v$$

Input $> V_{DAC}$

$\Rightarrow 1$

Otherwise

$\Rightarrow 0$

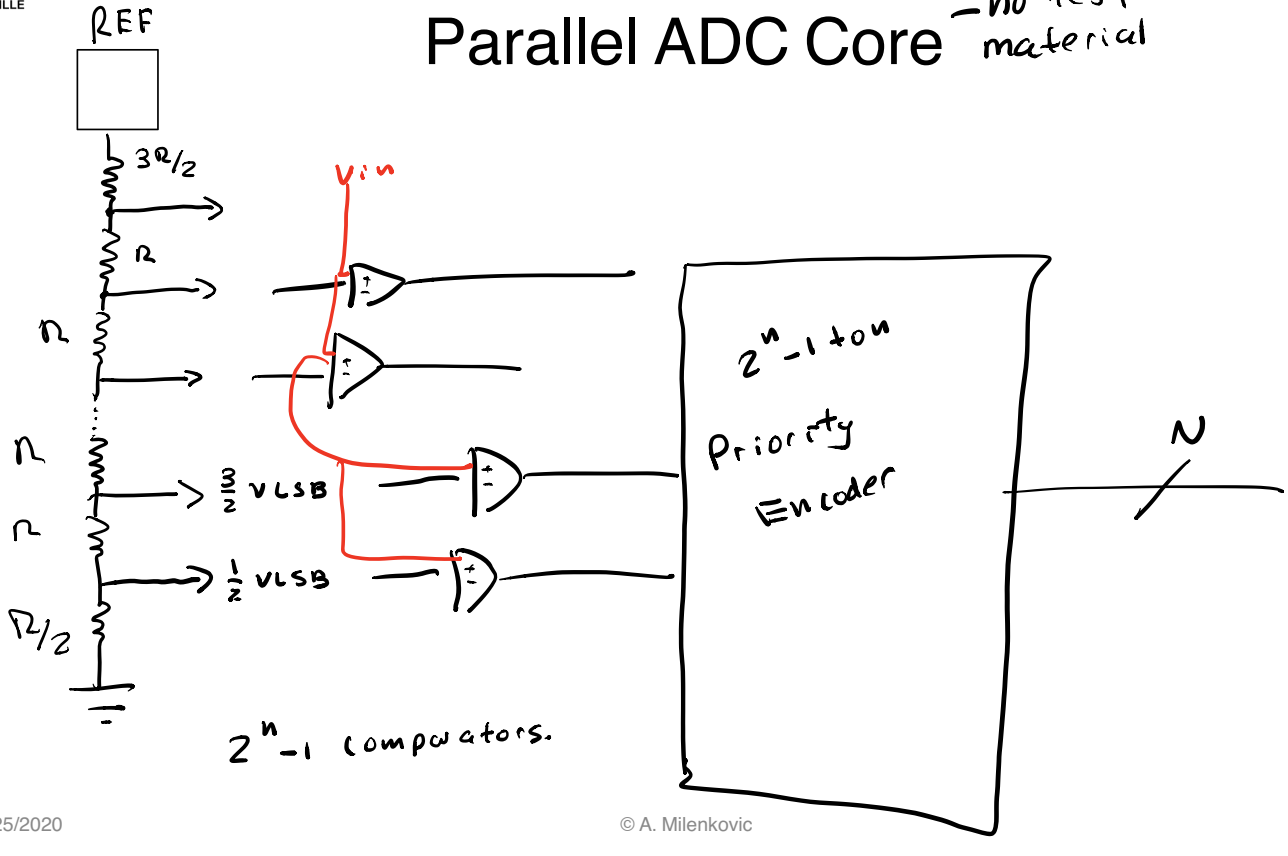
1001

Step = # bits

- Step 1: SAR : 1000 $\Rightarrow V_{DAC} = 8 \times V_{LSB} = 1.5v$
  $V_{in} > V_{DAC} \Rightarrow$ keep 1 as the MSB
- Step 2: SAR : 1100 $\Rightarrow V_{DAC} = 12 \cdot V_{LSB} = 2.25v$
  $V_{in} < V_{DAC} \Rightarrow$ bit 2 is 0
- Step 3: SAR : 1010 $\Rightarrow V_{DAC} = 10 \cdot V_{LSB} = 1.825v$
  $V_{in} < V_{DAC}$, Bit 1 is 0
- Step 4: SAR : 1001 $\Rightarrow V_{DAC} = 9 \cdot V_{LSB} = 1.687v$
  $V_{in} > V_{DAC}$ Bit 0 is 1

Parallel ADC Core

- no test material



MSP430 ADC12 — A

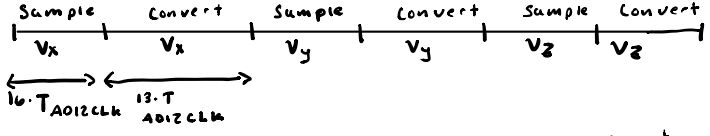
analog channels

Psu ?

V_x

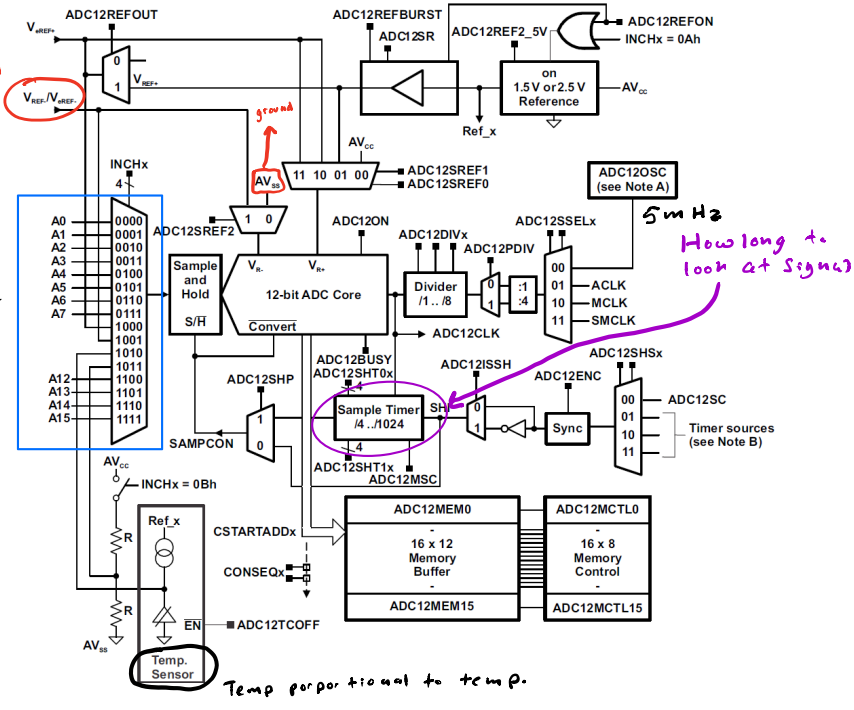
V_y

V_z



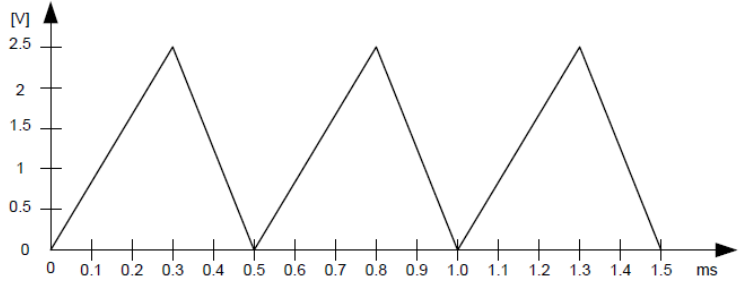
External signal

Input multiplexer



Walk Through

- Fs=10,000 Hz (sampling rate)
- Ts=
- Vmin=
- Vmax=
- Find samples for one period



Measuring Temperature (on-chip temperature sensor on MSP430F5529)

- Input channel INCHx=1010 (10)
- Temperature sensor equations
- Sample time > 30 ?s
- Calibration may be needed
- TCsensor – slope (mV/?C),
- Vsensor – intercept (mV)

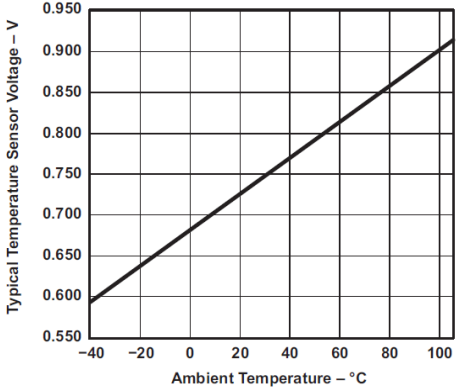


Figure 28-11. Typical Temperature Sensor Transfer Function

+ 30

Demo

Demo (cont'd)