ECE 265 – LECTURE 14

Analog Signal Acquisition

The A/D converters

12/1/2010

Lecture Overview

- Analog signal acquistion
- The A/D Converters on the 68HC11

- REF: Chapters 7 and 8 plus the 68HC11 reference manual.

Analog signals

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  - Maximum and minimum voltages
  - Precise continuous signals
  - Rate of voltage change
  - Frequency if not a steady state signal

Analog-to-Digital Converters

- The ideal transfer function of a 3-bit ADC
- Full-scale (input voltage) range (FSR)
- Analog signal is continuous
- Digital – finite and discrete
  - In general n-bit converter
  - Total of 2^n output codes

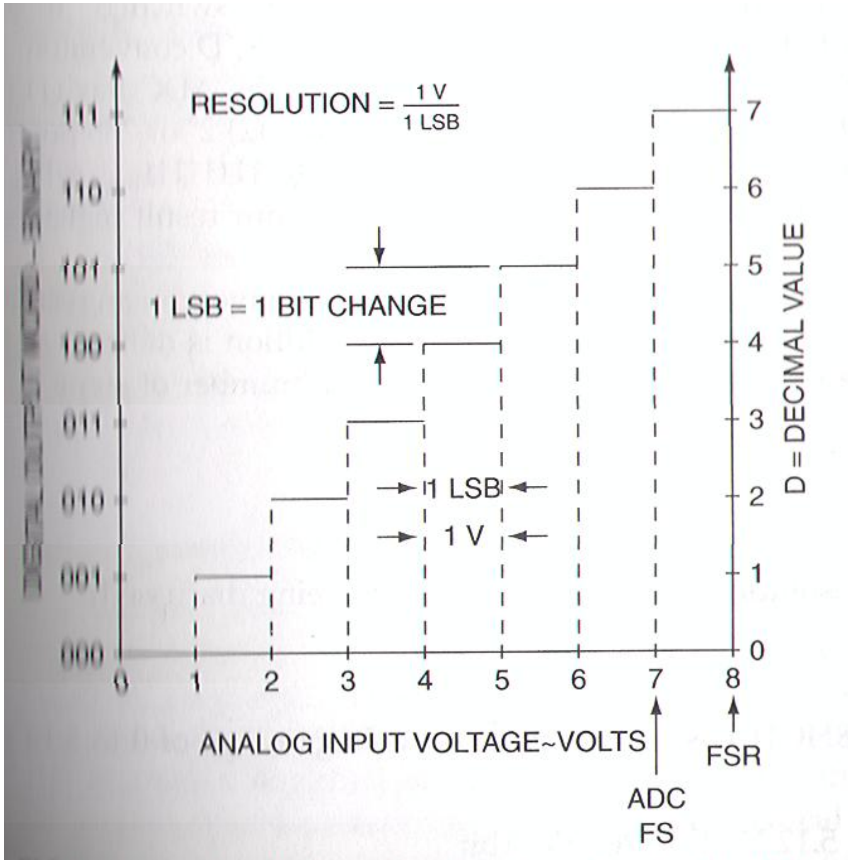


FIGURE 7.1 The ideal transfer function of a simple 3-bit analog-to-digital converter.

Quantization Error and FS

- The smallest input change that can be detected.
- In the 3 bit example it would be 1 Volt and defines the converters LSB accuracy.

- Another term – Full Scale input – the largest analog voltage that a converter can detect. Voltages greater than the FS input will result in a converted value of 111---11.
- Similarly inputs less than the minimum input voltage result in 000---00.

Quantization Error of the 68HC11

- Graphical view
- Note how discrete
- values represent
- the analog signal

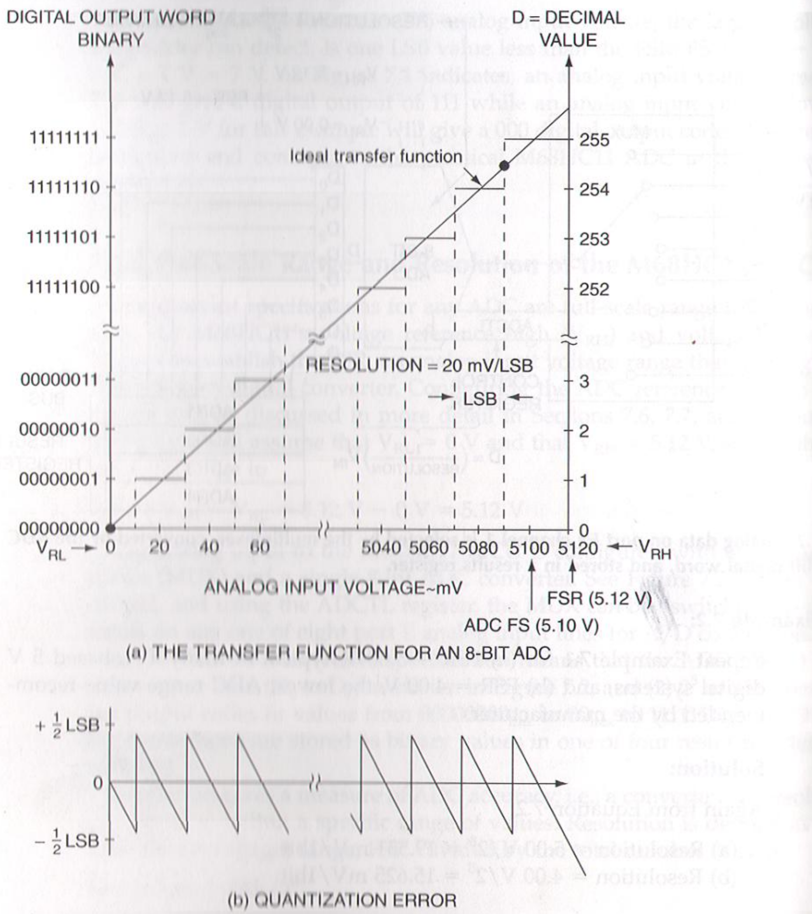


FIGURE 7.3 The characteristics of Motorola's M68HC11 8-bit analog-to-digital converter.

The 68HC11

- The 68HC11 has an 8 bit A/D converter which results in 256 possible digital output values.
- The resolution = FSR/256
- The FSR of the 68HC11 is 0 to 5.12V so the resolution is 20mV/1bit
  - 5.12V/256 = .02031 V/bit = 20.3 mV/bit
  - Meaning – input change of 20mV changes LSB

68HC11 ADRs

- 68HC11 has 4 A-to-D conversion registers
- When a conversion is done, result is placed in one of the ADRx registers, where x is 1 to 4.

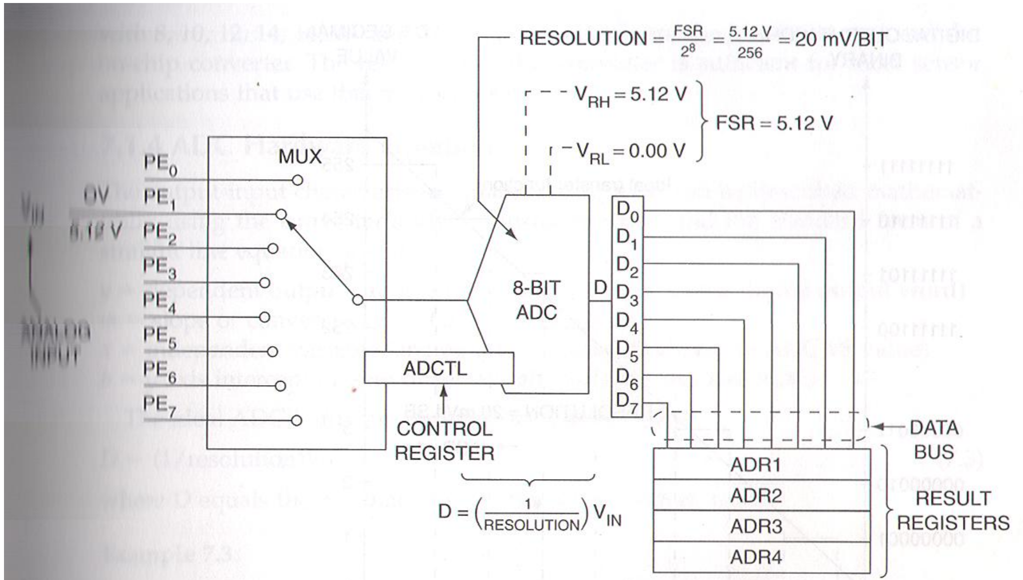


FIGURE 7.2 Analog data on port E's channel 1 is selected by the multiplexer, converted by the ADC into an 8-bit digital word, and stored in a results register.

Math Conversion equation

- The output-input characteristic equation of an ADC
  - D = (1/resolution)V_m
  - Where D is the decimal value of the output word and V_m is the measured voltage.
  - Example (from Ex 7.3)
  - The input voltage is 2.56V – what is the converted digital value?
  - Output
    - D = (1bit/20mV)2560mV = 128
    - Converting to binary gives 1000 0000 which will be stored in one of the 4 result registers.

Port E and ADR addresses

- When using Port E as a digital port the port is accessed through address $100A
- The A/D control register, ADCTL, is at address $1030
- The ADR registers are at addresses – these are read only registers.
  - ADR1 - $1031
  - ADR2 - $1032
  - ADR3 - $1033
  - ADR4 - $1034

ADCTL register

- To use the A/D converter on the 68HC11 the users only needs to write to ADCTL for the CPU to read results from the register. There are 8 A/D channels but only 4 results from one of the two groups of 4 can be stored at any one time.
  - Could also use the 4 registers to save 4 conversions from one input pin
- ADCTL register – controls how the A/D converter works and how the registers are used.

The bits in the control register

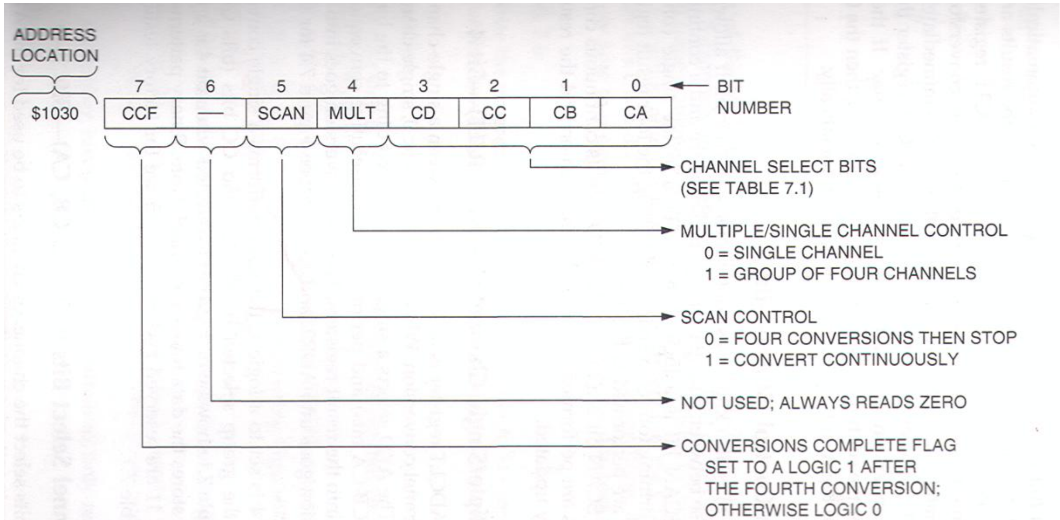


FIGURE 7.6 A/D control and status register (ADCTL).

- Bit 7 – Conversion complete – a read only bit
  - Cleared any time the control register written to
  - Set when the A/D completes the 4th conversion and results stored in registers.
  - Conversion starts immediately after a write to this register. If a conversion was in progress it is aborted to allow the initiation of the new conversion.
  - When set up for continuous conversion results are updated automatically.

Control register continued

- Bit 6 – unused
- Bit 5 – SCAN
  - Value of 0 – single conversion mode – conversion takes place after a write to the register.
  - Value of 1 – continuous conversion mode – conversions take place in round robin mode on the enabled analog input pins.
- Bit 4 – Multiple/Single Channel Control (MULT)
  - Value of 0 – Single channel – Consecutive conversions results are stored in consecutive ADRx registers
  - Value of 1 – each pin in the group is converted and the result stored in the ADR register.

More on control register

- Bits 3,2,1,0 – Channel select bits
  - For the 48-pin package – only 4 A/D inputs
  - How the CD, CC, CB, CA control bits work
- The MULT bit says
- 1 channel or all 4
- Table lists specific group
- and pin(s)

TABLE 7.1 Channel Selection When Bit 4 = 1

CD	CC	CB	CA	Port E	Result Register
0	0	0	0	PE0	ADRI
0	0	0	1	PE1	ADR2
0	0	1	0	PE2	ADR3
0	0	1	1	PE3	ADR4
0	1	0	0	PE4	ADR1
0	1	0	1	PE5	ADR2
0	1	1	0	PE6	ADR3
0	1	1	1	PE7	ADR4

Example of interface setup

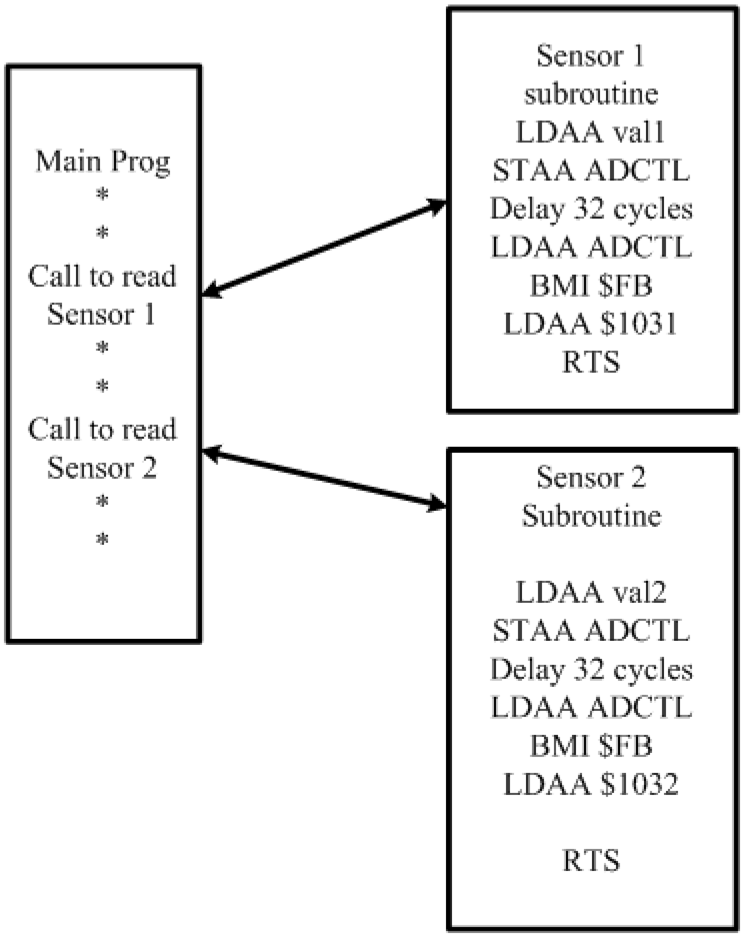
- What configuration is needed in the ADCTL register for the A/D to convert continuously group 0?
- Solution: Bits 7 and 6 are don't cares
- Bit 5 = 1 convert continuously
- Bit 4 = 1 group of 4 channels
- Bits 3 and 2 = 00 group 0, PE0-3
- Bits 1 and 0 are not used.
- Value of xx11 00xx or could store 0011 0000
- $30

Setup example 2

- What value needs to be written to the ADCTL register to have continuous conversions of pin PE0? What assembler language instructions would you use to set up this?
- Set ADCTL as follows:
  - Bits 7 and 6 – don't cares
  - Bit 5 – 1 convert continuously val – 0010 0000
  - Bit 4 – 0 single channel
  - Bit 3,2,1,0 – 0000 the value for PE0
- The assembler code (assumes A accumulator is free)
  - LDAA #$20
  - STAA $1030

Example 3

- Your system has 2 analog sensors. You only need to acquire the value of a given sensor at certain points. How would this be set up.
- Probably through subroutines.
- Specifications of the problem
  - Sensor 1 – on pin PE0-ADR1
  - Sensor 2 – on pin PE1-ADR2
- The valx values for the code
  - val1 – 0010 0000
  - val2 – 0010 0001
- How is the A/D being set up for conversion?
  - Could also be done with 0000 0000 and 0000 0001



Signal setup for A/D use

- The 68HC11 needs 2 reference input voltages.
  - A low voltage reference – V_{RL} – pin 51
  - A high voltage reference – V_{RH} – pin 52
- To prevent damage the analog input signals must be current limited.
  - Input current should not exceed 25mA
- Connect signal through a resistor of value 1kΩ to 10kΩ

Input sensors

- Transducers, such as pressure, temperature, and acceleration, covert the physical quantity being monitored into and output of voltage, current, or resistance.
- To get the signal to the 68HC11 the signal needs to be a voltage.
- A simple connection for the LM335 temperature sensor can be accomplished.
  - Application circuit from Jameco page.

Lecture summary

- Use of the 68HC11 A to D converter
  - Basic setup of use
  - The A/D configurations
  - Software setup
  - Interfacing signals

Assignment

- None