Recap

Output compare interrupts
Metrowerks Codewarrior

Overview

Analog to Digital Convertor
Transducer: mechanical, electrical
Using output compare interrupts to establish sampling

Range(volts) = Precision(alternatives) • Resolution(volts)

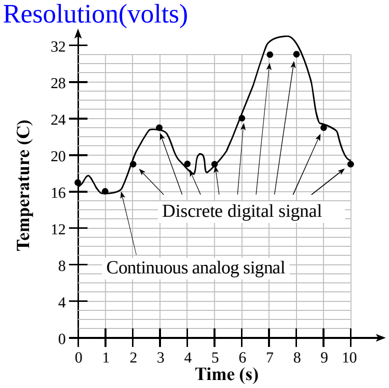


Figure 11.1. An analog signal is represented in the digital domain as discrete samples.

10-bit Analog to digital Converter

Analog input $0 \le V_{in} \le +5$
Digital output $0 \le$ `ATD0DR0` ≤ 1023
Digital Output is about $1024*V_{in}/5$
or Digital Output is about $1023*V_{in}/5$

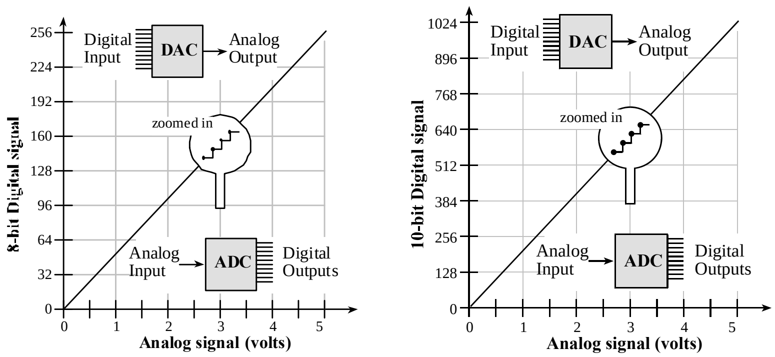


Figure 11.2. Input/output functions of a DAC and an ADC.

8-bit Analog to digital Converter

Analog input $0 \le V_{in} \le +5$
Digital output $0 \le$ `ATD0DR0` ≤ 255
Digital Output is about $256*V_{in}/5$
or Digital Output is about $255*V_{in}/5$

Find the 16 analog inputs on the 9S12DG128

See Figure 4.18. Block diagram of a Freescale 9S12DP512.
9S12DG128 has less RAM/ROM and CAN ports

`ATD0CTL2=$80;` set bit 7 to enable ADC

ATD0CTL3=$08; sequence length=1
ATD0CTL4 bit 7=0 for 10-bit, =1 for 8-bit ADC
Bits 4-0 internal clock (how fast the ADC runs)
Let **m** be the bottom 5 bits of **ATD0CTL4**
Internal clock is ½E/(**m**+1)

Internal clock can be between 500kHz and 2 MHz

At 24 MHz
2 MHzmake **ATD0CTL4=$85 ; m=5 (7us)**
1 MHzmake **ATD0CTL4=$8B ; m=11(14us)**

ATD0CTL5 write channel number to start ADC

- channel number $80 to $87

ATD0STAT bit 7 SCF

- cleared by write to **ATD0CTL5**
- set when ADC finished

ATD0DR0 first 10-bit ADC result

- precision 10-bit, 1024 alternatives
- range 0 to +5V
- resolution (5-0)/1024 = 5 mV

Analog Input (V)	Digital Output		
0.000	%0000000000	$000	0
0.005	%0000000001	$001	1
2.500	%1000000000	$200	512
3.750	%1100000000	$300	768
5.000	%1111111111	$3FF	1023

Table 11.6. **Straight binary** format used.

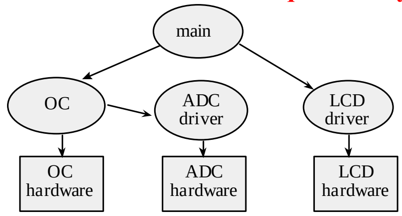
ATD0DR0 first 8-bit ADC result

- precision 8-bit, 256 alternatives
- range 0 to +5V
- resolution (5-0)/256 = 19.5 mV

Analog Input (V)	Digital Output		
0.00	%00000000	$00	0
0.02	%00000001	$01	1
2.50	%10000000	$80	128
3.75	%11000000	$C0	192
5.00	%11111111	$FF	255

Table 11.6. **Straight binary** format used.

Lab 7 is real-time data acquisition system

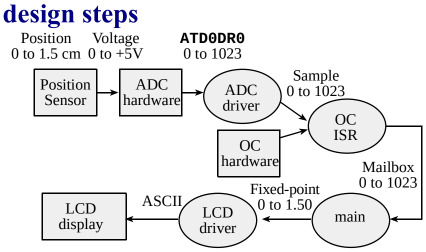


Lab 7: Design a position meter

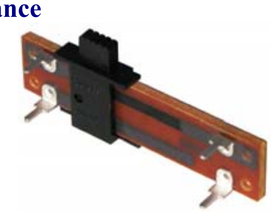
- **Hardware**
- **Software**

- **Hardware**
  - **Transducer**
  - **Electronics**
  - **ADC**
- **Software**
  - **ADC device driver**
  - **Timer routines**
    - **Output compare interrupts**
  - **LCD driver**
  - **Measurement system**
    - **How fast to update**
    - **Fixed-point number system**
    - **Algorithm to convert ADC into position**

A data flow graph is one of the first design steps



A transducer converts position into resistance

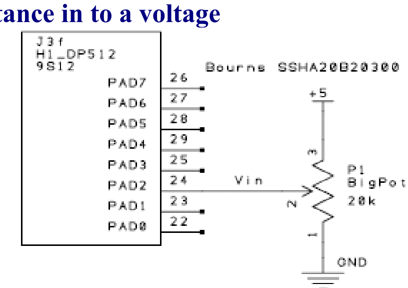


Solder wires to pins 1,2,3
Glue transducer to a solid
Position metric ruler (for calibration and testing)
Create a hair-line cursor

Question: what is $\mathbf{R_{12}}$ + $\mathbf{R_{23}}$ at all times?

Question: what are $\mathbf{R_{12}}$ and $\mathbf{R_{23}}$ when cursor is at 1cm?

An electrical circuit converts resistance in to a voltage



Question: what is $\mathbf{V_{in}}$ at 1cm?

Question: what is **`ATD0DR0`** at 1cm?

Question: what do you want to display on the **LCD** at 1cm?

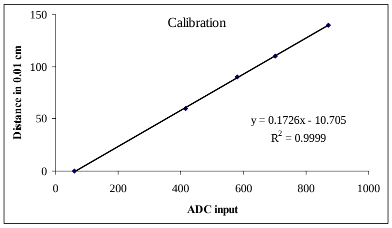
1) run **Lab 7 starter file, first main program, write ADC**

2) see ADC device driver
3) show `ADC_Init`
Turns it on
Sets it to 10-bit mode
4) show `ADC_In`
write channel number to `ATD0CTL5`
wait for SCF flag in `ATD0STAT`
read 10-bit result from `ATD0DR0`
5) show `Data`

complexity abstraction (what we want to do)
divide a complex problem into simple subcomponents

functional abstraction (how we do it)
divide a problem into modules
grouped by function
draw a data flow graph

Run solution to Lab 7, show how to prove real time DAS
start ADC at a regular rate (every 100ms)
measure the jitter
$100ms-\delta t < t_n - t_{n-1} < 100ms+\delta t$



Lab 7
Sample ADC every 0.1s
Map (Data is 0 to 1023) into (Position is 0000 to +1500)
Option A) use a linear function
Position = (Constant1*Sample)/Constant2 + Constant3
Position = (65536*Sample)/Constant4 + Constant3
Option B) Use a paired calibration table (S[i],P[i])
S[i] are ADC samples measured at corresponding positions P[i]
Given sample, find i such that S[i]<=sample<S[i+1]
Use linear interpolation (look up **etbl** in TExaS help)
position = P[i]+((sample-S[i])*(P[i+1]-P[i]))/(S[i+1]-S[i])
Option C) Create a 256-entry calibration table (P[ATD0DR0])
Fixed-Point output (using Lab 6 code)
123 is displayed a "1.23 cm"

The bottom line
ADC converts analog to digital
Controlling time is important