

Recap

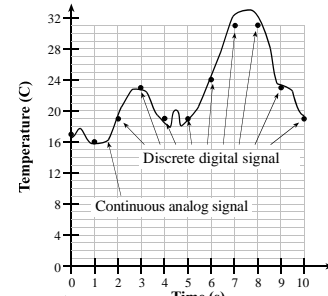
Output compare interrupts
Metrowerks Codewarrior

Overview

Analog to Digital Converter
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.



Analog to digital Converter

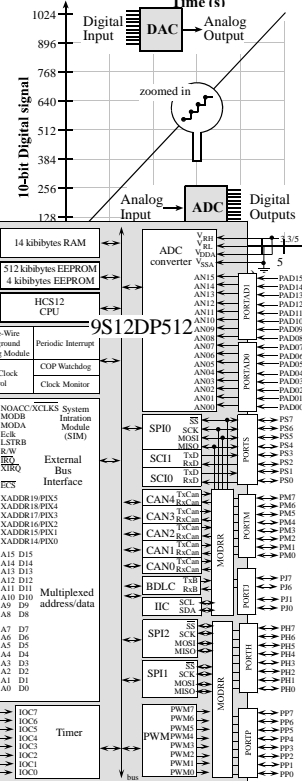
Analog input $0 \leq V_{in} \leq +5$
 Digital output $0 \leq ATD0DR0 \leq 1023$

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 10-bit DAC and a 10-bit ADC.

Find the 16 analog inputs on the 9S12DP512

Figure 4.18. Block diagram of a Freescale 9S12DP512.



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

ATD0CTL3=\$08; sequence length=1

10-bit, internal clock (how fast the ADC runs)

- Let **m** be the bottom 5 bits of **ATD0CTL4**
- Internal clock is $\frac{1}{2}E/(m+1)$ (want this to be 1 MHz)
- At 4 MHz make **ATD0CTL4=\$01** ; **m=1**
- At 8 MHz make **ATD0CTL4=\$03** ; **m=3**
- At 24 MHz make **ATD0CTL4=\$0B** ; **m=11**

Internal clock can be between 500kHz and 2 MHz

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 $(5-0)/1024 = 5 \text{ mV}$

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.

Lab 6 is real-time data acquisition system

Hardware

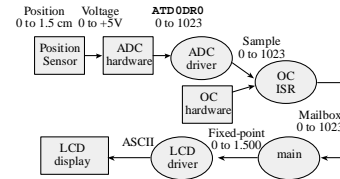
Transducer
Electronics
ADC

Software

ADC device driver
Timer routines
LCD driver
Measurement system

Output compare interrupts

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 $R_{12} + R_{23}$ at all times?**Question: what are R_{12} and R_{23} when cursor is at 1cm?***An electrical circuit converts resistance in to a voltage***Question: what is 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 6 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 6, show how to prove real time DAS****start ADC at a regular rate****measure the jitter** **$1ms - \delta t < t_n - t_{n-1} < 1ms + \delta t$** **Lab 6**

Sample ADC every 0.2s

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 $S[i] \leq \text{sample} < S[i+1]$ Use linear interpolation (look up **etbl** in TExaS help)position = $P[i] + ((\text{sample} - S[i]) * (P[i+1] - P[i])) / (S[i+1] - S[i])$

Option C) Create a 1024-entry calibration table (P[ATD0DR0])

Fixed-Point output

1234 is displayed a "1.234 cm"

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