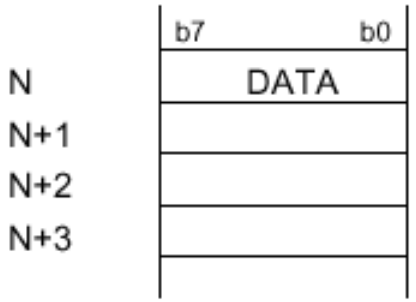
Microcontroller Introduction

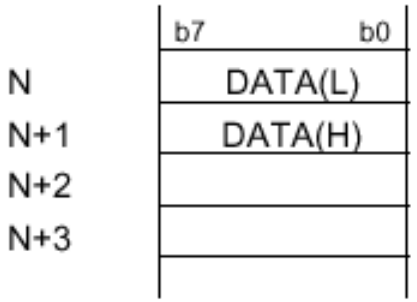
Data Formats for the Renesas Microcontroller

Byte

- 8 bits
- signed & unsigned
- unsigned range
  0 to 255
- unsigned char a;



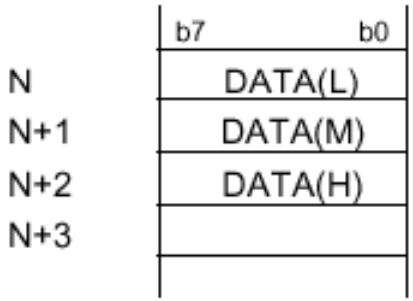
Byte (8-bit) data



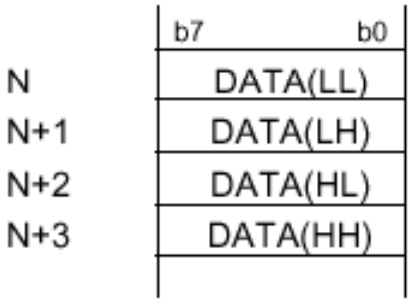
Word (16-bit) data

Word

- 16 bits
- signed & unsigned
- unsigned range
  0 to 65535
- int b; unsigned int b;



20-bit (Address) data



Long Word (32-bit) data

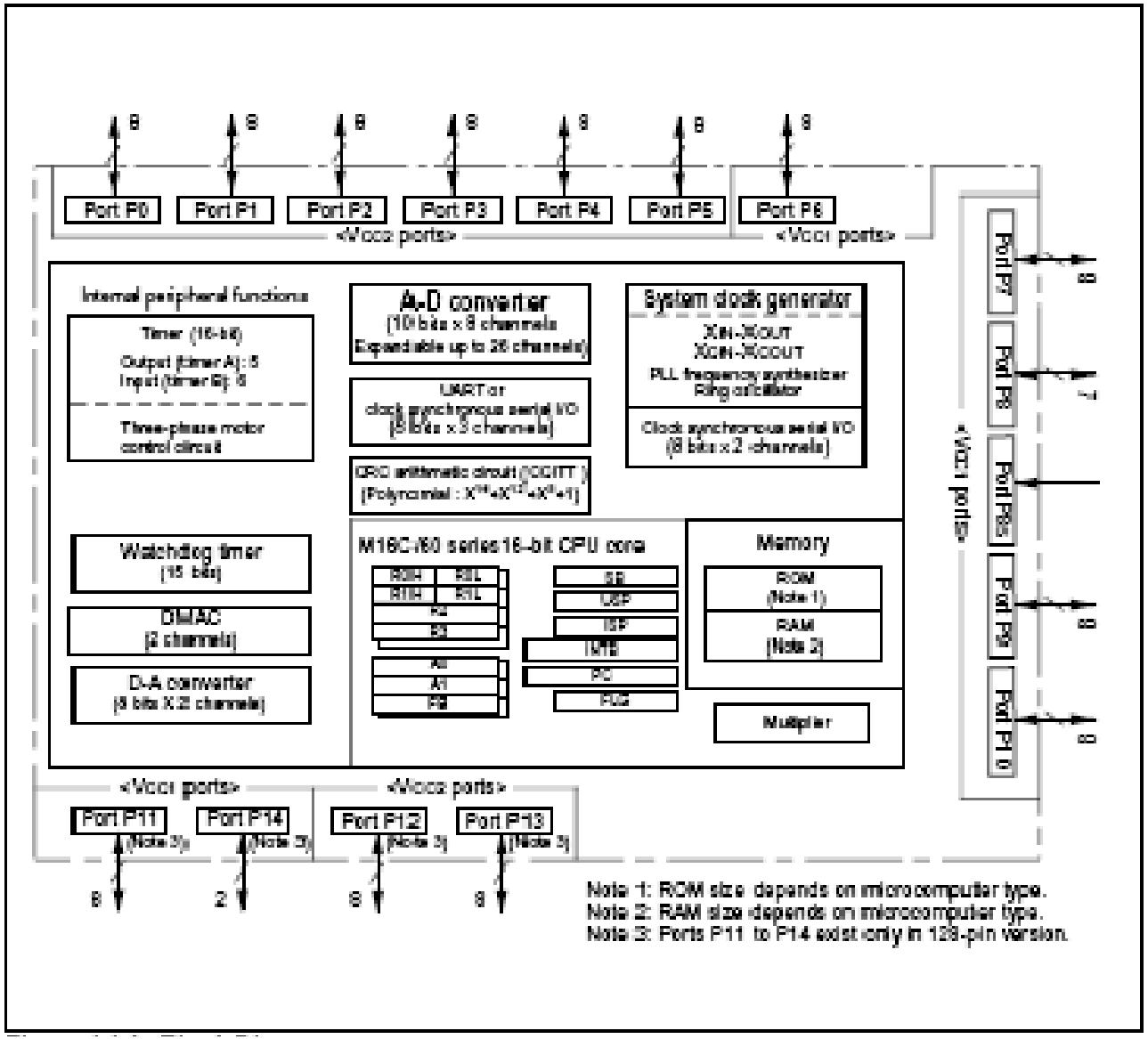
Longword

- 32 bits, signed and unsigned, unsigned range 4,294,967,294
- long int c; unsigned long int c;

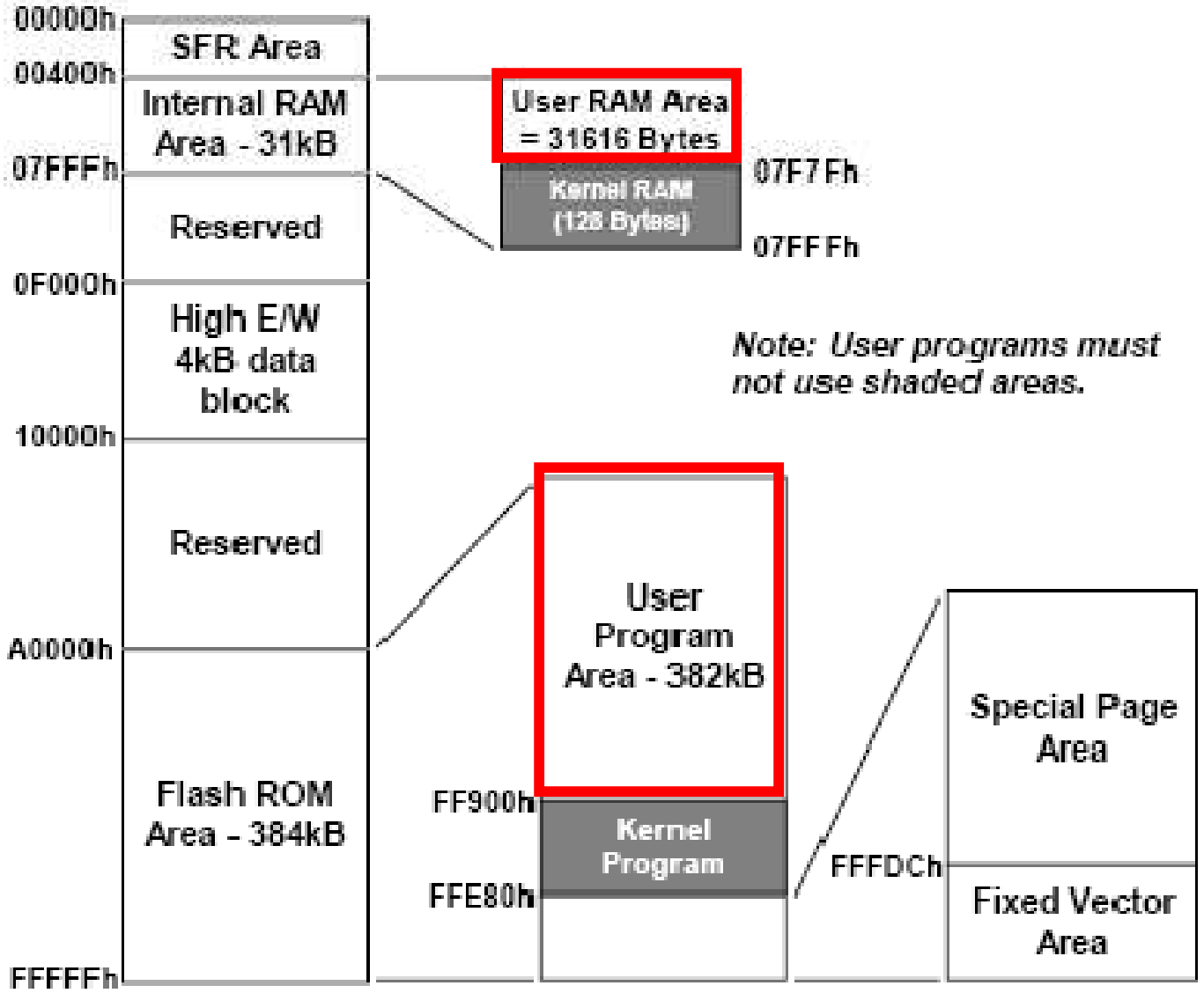
Review of the Renesas Architecture

Microcontroller has:

- General Purpose Registers
- RAM
- Flash
- EEPROM
- Digital Ports
- Analog Ports
- Timers
- Oscillator
- DMA Controller
- Reliability and safety



Memory Map for Renesas Microcontroller



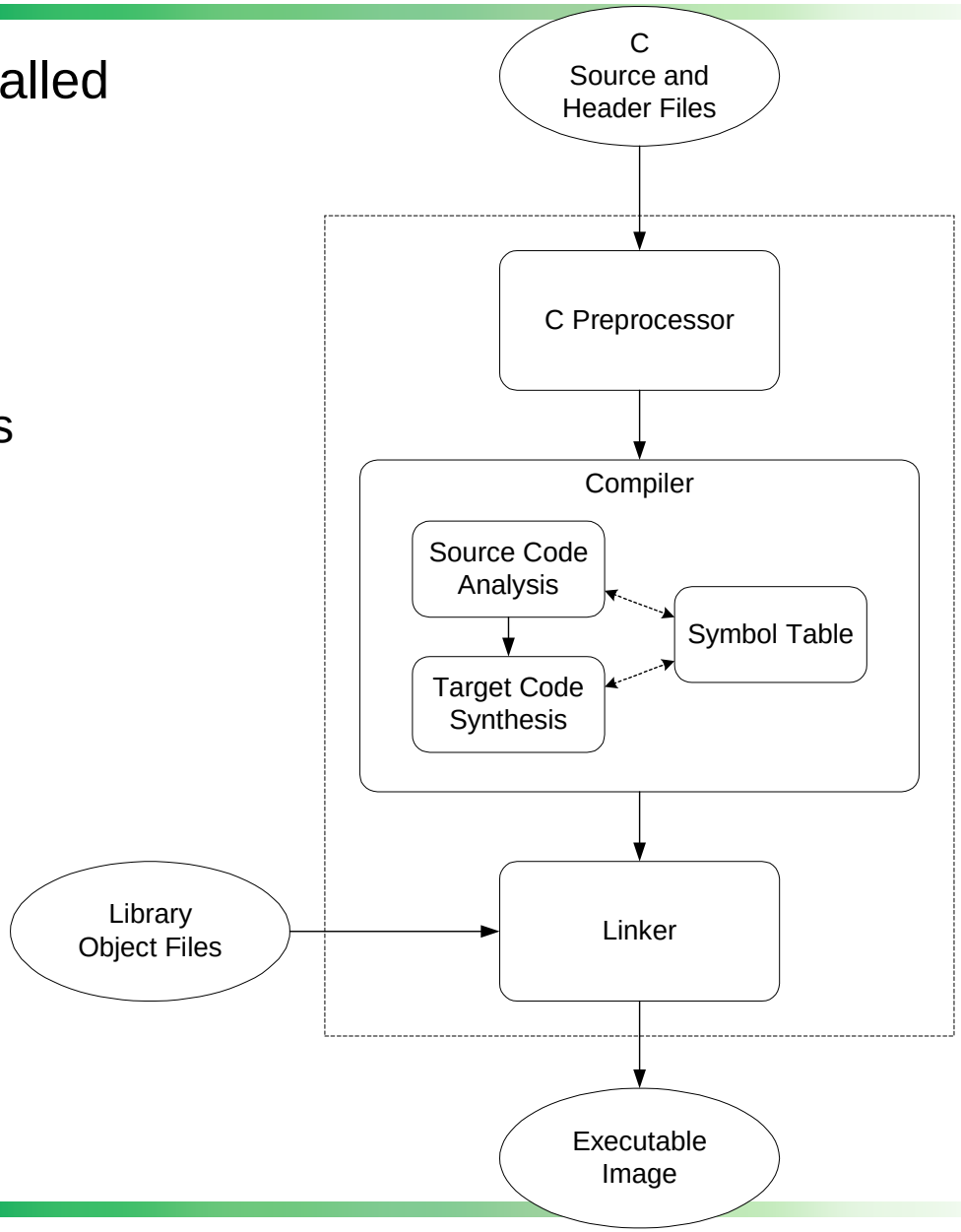
A C Code “Project”

- You will use an “Integrated Development Environment” (IDE) to develop, compile, load, and debug your code.
- Your entire code package is called a *project*. Often you create several files to spilt the functionality:
  - Several C files
  - Several include (.h) files
  - Maybe some assembly language (.a30) files
  - Maybe some assembly language include (.inc) files

- A lab, like “Lab7”, will be your project. You may have three .c, three .h, one .a30, and one .inc files.

Compiling a C Program

- Entire mechanism is usually called the “compiler”
- Preprocessor
  - macro substitution
  - conditional compilation
  - “source-level” transformations
    - output is still C
- Compiler
  - generates object file
    - machine instructions
- Linker
  - combine object files (including libraries) into executable image



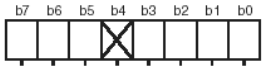
Compiler

- Source Code Analysis
  - "front end"
  - parses programs to identify its pieces
    - variables, expressions, statements, functions, etc.
  - depends on language (not on target machine)
- Code Generation
  - "back end"
  - generates machine code from analyzed source
  - may optimize machine code to make it run more efficiently
  - very dependent on target machine
- Symbol Table
  - map between symbolic names and items
  - like assembler, but more kinds of information

Digital Input/Output (I/O) Ports

- The fundamental interfacing subsystem
  - Port bits can be inputs or outputs
  - M30626 has fourteen *Programmable I/O Ports* (total of 106 digital I/O bits) (P0 to 13 = 8 bits each, P14 = 2)
  - For some other MCUs some ports may be limited to only input or output
- Direction register sets bit direction
  - Port Direction register names PDx
    - 1: Output
    - 0: Input
- Data register holds actual data
  - Port data register names: Px
- *M16C62P Hardware Manual*

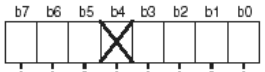
Port P8 direction register



Symbol: PD8 | Address: $03F2_{16}$ | When reset: $000X0000_2$

Bit symbol	Bit name	Function	R	W
PD8_0	Port $P8_0$ direction register	0 : Input mode (Functions as an input port) 1 : Output mode (Functions as an output port)	○	○
PD8_1	Port $P8_1$ direction register		○	○
PD8_2	Port $P8_2$ direction register		○	○
PD8_3	Port $P8_3$ direction register		○	○
Nothing is assigned. Write "0" when writing to this bit. The value is "0" when read.			—	—
PD8_5	Port $P8_5$ direction register	0 : Input mode (Functions as an input port) 1 : Output mode (Functions as an output port)	○	○
PD8_6	Port $P8_6$ direction register		○	○
PD8_7	Port $P8_7$ direction register		○	○

Port P8 register

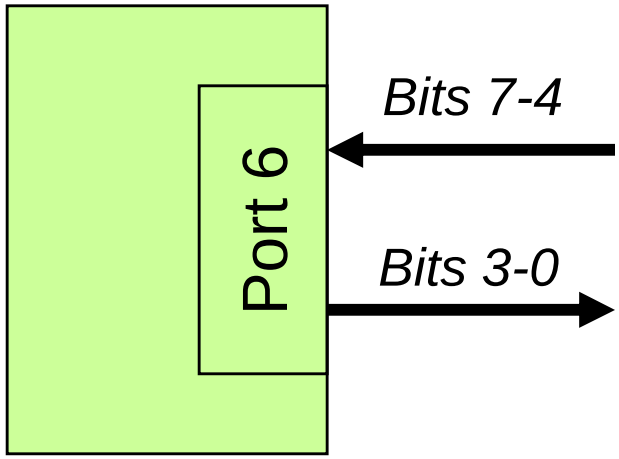


Symbol: P8 | Address: $03F0_{16}$ | When reset: XX_{16}

Bit symbol	Bit name	Function	R	W
P8_0	Port $P8_0$ register	(Note) 0 : "L" level data 1 : "H" level data	○	○
P8_1	Port $P8_1$ register		○	○
P8_2	Port $P8_2$ register		○	○
P8_3	Port $P8_3$ register		○	○
Nothing is assigned. Write "0" when writing to this bit. The value is "0" when read.			—	—
P8_5	Port $P8_5$ register	(Note) 0 : "L" level data 1 : "H" level data	○	○
P8_6	Port $P8_6$ register		○	○
P8_7	Port $P8_7$ register		○	○

Example: P6 Echoes Nibble Data

- Configuring port to desired structure
  - Top 4 bits (4-7) of P6 are inputs
    - Clear bits 4-7 of PD6
  - Bottom 4 bits of P6 are outputs
    - Set bits 0-3 of PD6



Example in C: P6 Echoes Nibble Data

- Reading and writing data
  - Load data from input port
  - Move top nibble to bottom
  - Write data to output port
  - Jump back to start
- Now let's invert the data before writing it out
  - Load data from input port
  - Move top nibble to bottom
  - Invert it (complement)
  - Write data to output port
  - Jump back to start

```
#include "sfr62p.h"
#define DIR_OUT (1)
#define DIR_IN (0)
unsigned char a;

/* pd6 = 0xf0; */
pd6_0 = pd6_1 = DIR_OUT;
pd6_2 = pd6_3 = DIR_OUT;
pd6_4 = pd6_5 = DIR_IN;
pd6_6 = pd6_7 = DIR_IN;
while (1) {
        a = p6;
        a >>= 4;
        p6 = a;
}
```

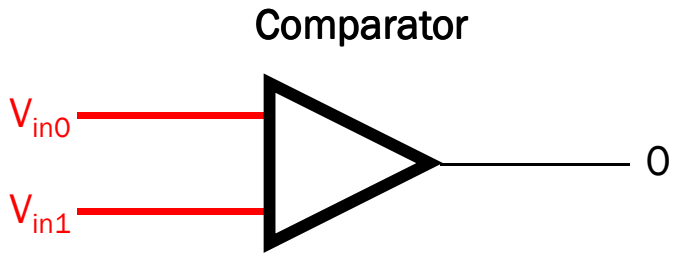
Sample Code from Demo

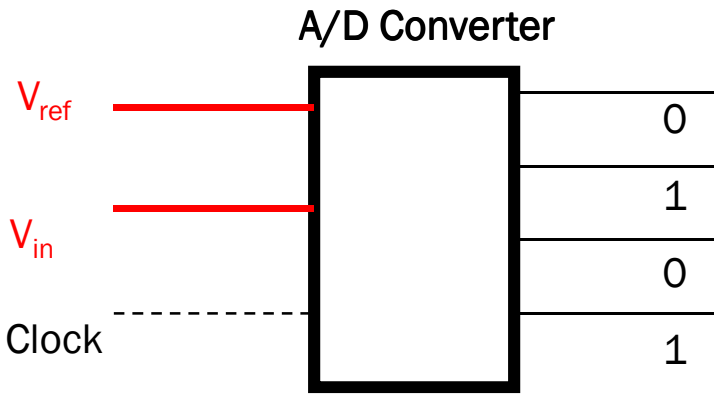
```
#include "stdio.h" /* sprintf */
#include "sfr62p.h"
#include "SKP_LCD.h"
#include "string.h"

#define RED_LED (p8_0) /* from board schem.*/
#define YEL_LED (p7_4)
#define GRN_LED (p7_2)
#define LED_ON  (0)   /* 0 is ON for LEDs */
#define LED_OFF (1)

#define DIR_IN  (0)
#define DIR_OUT (1)

#define SW1 (p8_3)
#define SW2 (p8_2)
#define SW3 (p8_1)

void init_switches() {
  pd8_1 = pd8_2 = pd8_3 = DIR_IN;
}

void init_LEDs() {
  pd8_0 = pd7_4 = pd7_2 = DIR_OUT;
  RED_LED = YEL_LED = GRN_LED = LED_ON;
  RED_LED = YEL_LED = GRN_LED = LED_OFF;
}

void test_switches(void) {
  while (1) {
    RED_LED = (!SW1)? LED_ON : LED_OFF;
    YEL_LED = (!SW2)? LED_ON : LED_OFF;
    GRN_LED = (!SW3)? LED_ON : LED_OFF;
  }
}
```

```
void main () {
  char buf[9];
  long int i, r=12345;

  init_switches();
  init_LEDs();
  InitDisplay();
#if (0)
  test_switches();
#endif
  DisplayString(LCD_LINE1, "Response");
  DisplayString(LCD_LINE2, " Timer  ");
  while(1) {
    for (i=0; i<200000+(r%50000); i++)
      ;
    i=0;
    RED_LED = YEL_LED = GRN_LED = LED_ON;
    while (SW1)
      i++;
#if (1)
    sprintf(buf, "%8ld", i);
    DisplayString(LCD_LINE1, buf);
    DisplayString(LCD_LINE2, "iters.  ");
#else
    sprintf(buf, "%8.3f", i*39.1/287674);
    DisplayString(LCD_LINE1, buf);
    DisplayString(LCD_LINE2, "millisec");
#endif
    RED_LED = YEL_LED = GRN_LED = LED_OFF;
    r=0;
    while (!SW1) /* wait for switch to come
    up */
      r++;
  }
}
```

From Analog to Digital

- Embedded systems often need to measure values of physical parameters
- These parameters are usually continuous (*analog*) and not in a digital form which computers (which operate on discrete data values) can process
- A **Comparator** is a circuit which compares an analog input voltage with a reference voltage and determines which is larger, returning a 1-bit number
- An **Analog to Digital converter** [AD or ADC] is a circuit which accepts an analog input signal (usually a voltage) and produces a corresponding multi-bit number at the output.





ADC Basic Functionality

- n = converted code
- V_{in} = sampled input voltage
- V_{+ref} = upper end of input voltage range
- V_{-ref} = lower end of input voltage range
- N = number of bits of resolution in ADC

$$n = \left[\frac{(V_{in} - V_{-ref})(2^N - 1)}{V_{+ref} - V_{-ref}} + 1/2 \right]_{\text{int}}$$

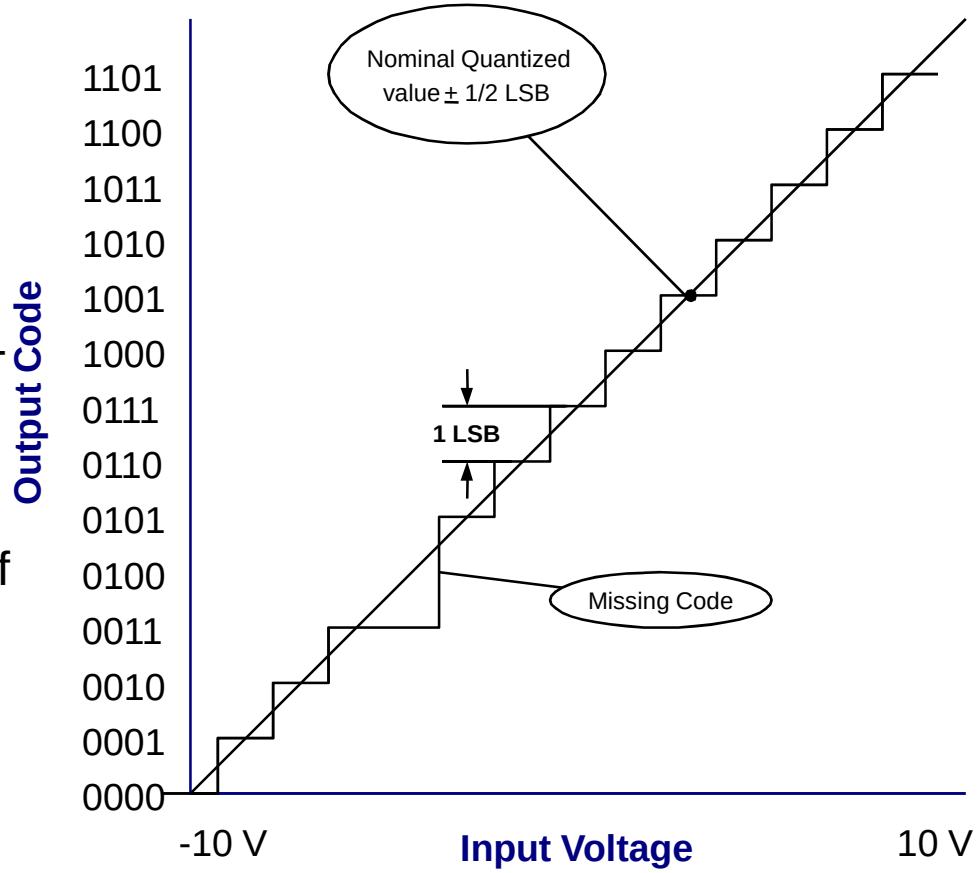
$$n = \left[\frac{(V_{in})(2^N - 1)}{V_{+ref}} + 1/2 \right]_{\text{int}} \qquad \text{if } V_{-ref} = 0\text{v}$$

$$n = \left[\frac{3.30v(2^{10} - 1)}{5v} + 1/2 \right]_{\text{int}} = 675$$

ADC Transfer Function

•The ideal output from an A/D converter is a stair-step function (see right)

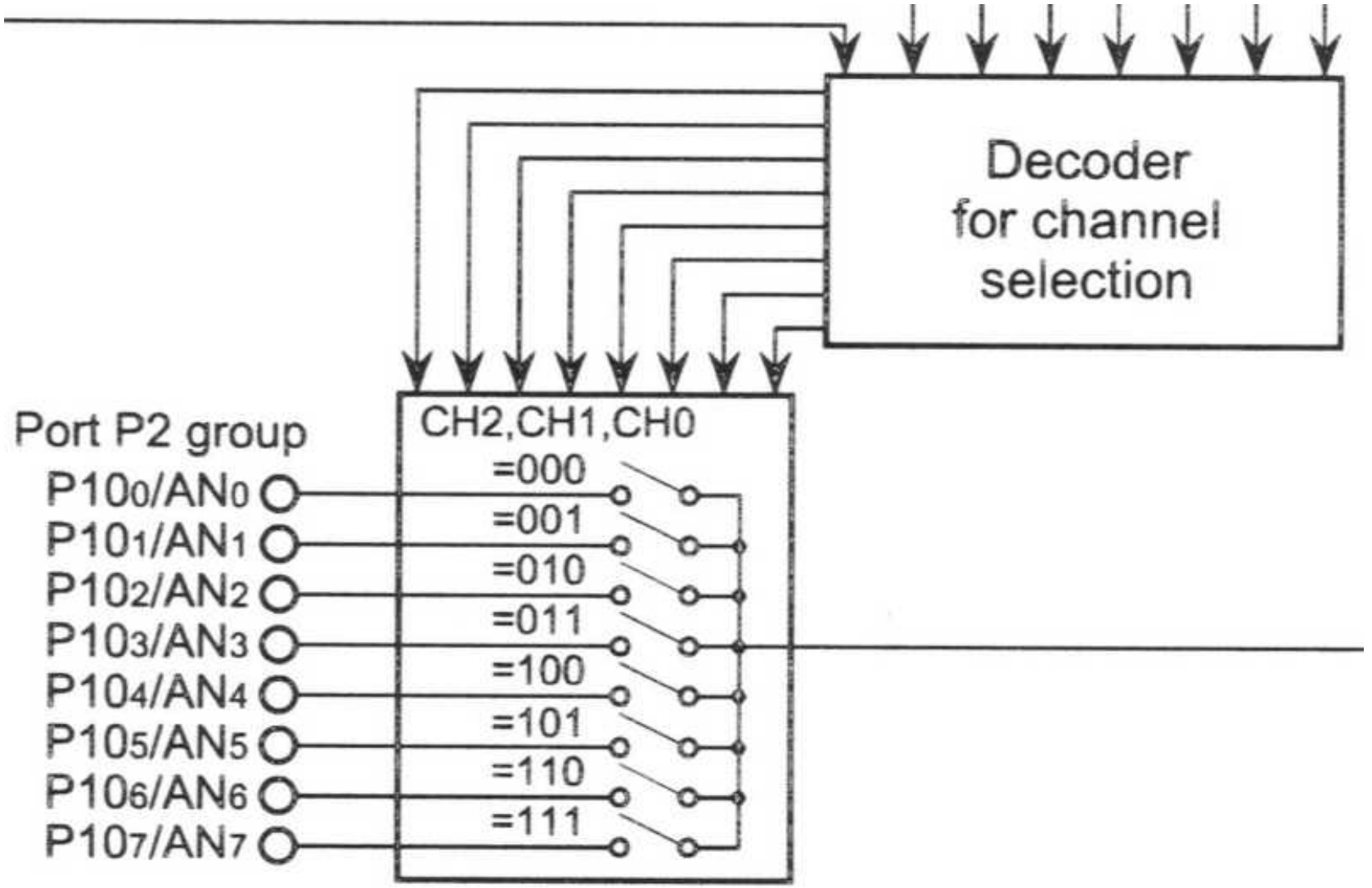
- Ideal worst case error in conversion is ± 1/2 bit.
- Missing codes or the imperfections where increasing voltage does not result in the next step being output are described as non-monotonicity.
- Errors in A/D conversion may be significant particularly if the full range of the analog signal is significantly less than the range of the analog input of the A/D.



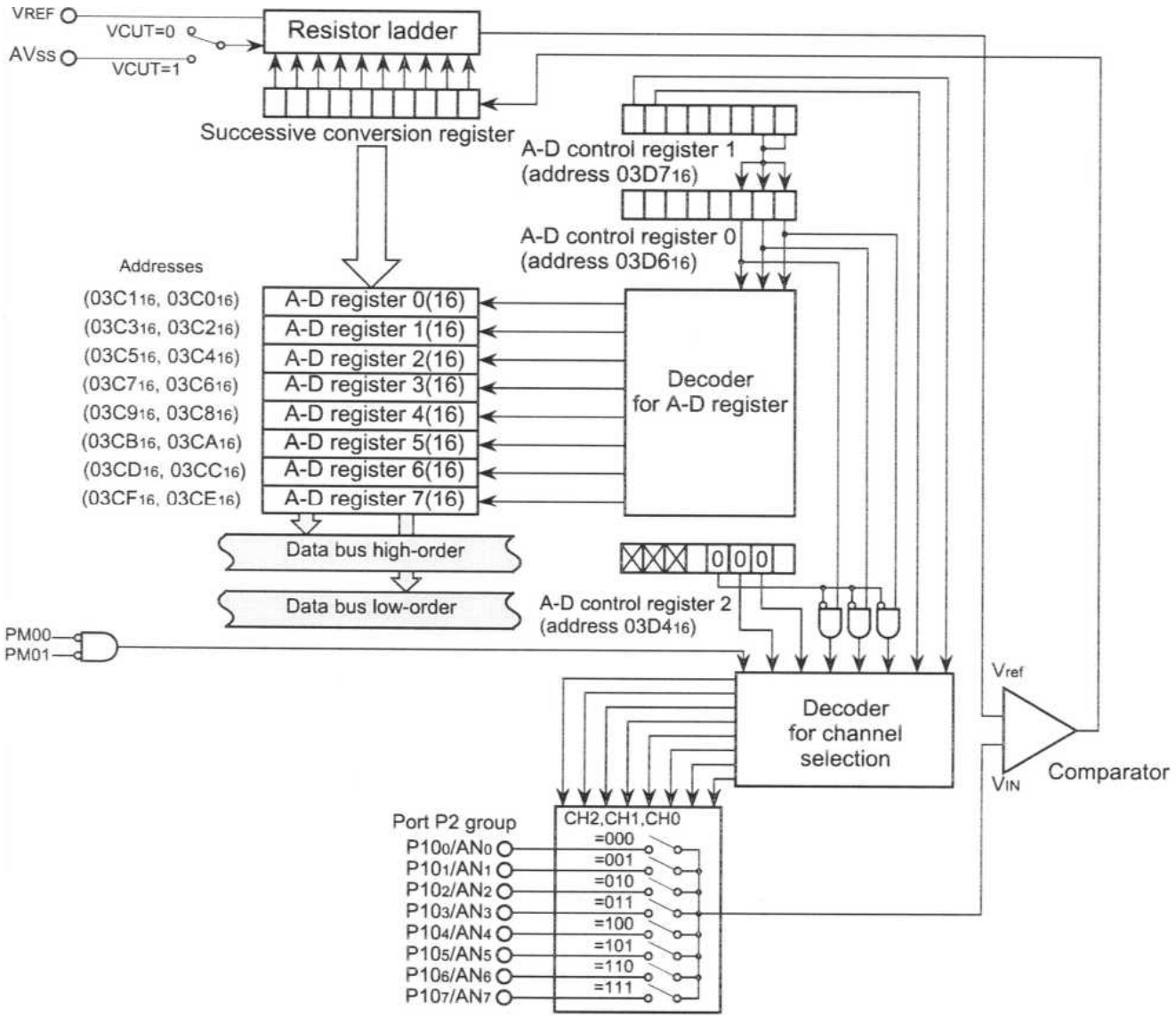
M30626P ADC Peripheral

- 10 bit successive approximation converter, can operate in 8 bit mode
- Input voltage: 0 to V_{CC}
- Reference voltage applied to V_{REF} pin
  - Can be disconnected with VCUT bit to save power
- Input Multiplexer: 8 input channels

Input Mux (262, but 626 similar)



M30262 Converter Overview (626P similar)



Repeated ADC

- The microcontroller performs repeated A/D conversions, and can read data whenever needed

```
adcon0 = 0x88;
adcon1 = 0x28;
adcon2 = 0X01;
adst = 1;   // Start a conversion here
```

Then in your procedure

```
TempStore = ad0 & 0x03ff;
```