Introduction to Embedded System Design

MSP430 Digital I/O

Dhananjay V. Gadre

Associate Professor

ECE Division

Netaji Subhas University of Technology, New Delhi

Badri Subudhi

Assistant Professor

Electrical Engineering Department

Indian Institute of Technology, Jammu

Digital I/O

- MSP430G2553 (20 pin) has two Ports P1 and P2.
- MSP430G2553 (28 pin) has three ports P1,P2,P3.
- Each Port has 8 I/O pins.
- Any I/O can be made input or output, and can be individually read or written to.
- Individually configurable interrupts on P1 and P2.
- Choice of individually configuring pull-up or pull down resistors.
- The ports are configured by several 8 bit Peripheral Registers.

Port Schematics
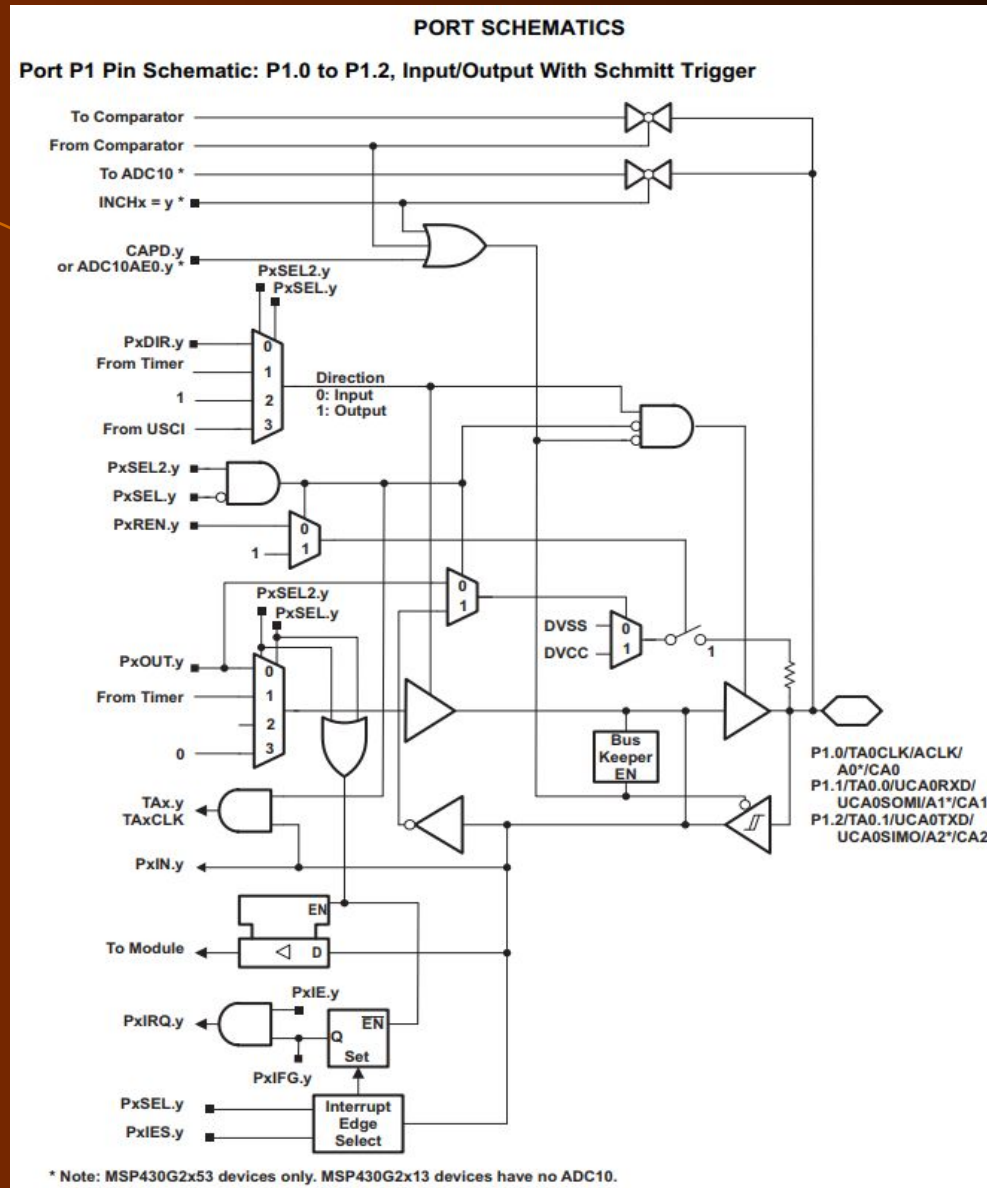
Port Schematics

Settings for selecting the function of a given pin is provided in respective datasheet. Example is provided here:-

Table 16. Port P1 (P1.0 to P1.2) Pin Functions

PIN NAME (P1.x)	x	FUNCTION	CONTROL BITS AND SIGNALS[1]				
			P1DIR.x	P1SEL.x	P1SEL2.x	ADC10AE.x INCH.x=1[2]	CAPD.y
P1.0/	0	P1.x (I/O)	I: 0; O: 1	0	0	0	0
TA0CLK/		TA0.TACLK	0	1	0	0	0
ACLK/		ACLK	1	1	0	0	0
A0[2]/		A0	X	X	X	1 (y = 0)	0
CA0/		CA0	X	X	X	0	1 (y = 0)
Pin Osc		Capacitive sensing	X	0	1	0	0
P1.1/	1	P1.x (I/O)	I: 0; O: 1	0	0	0	0
TA0.0/		TA0.0	1	1	0	0	0
		TA0.CCI0A	0	1	0	0	0
UCA0RXD/		UCA0RXD	from USCI	1	1	0	0
UCA0SOMI/		UCA0SOMI	from USCI	1	1	0	0
A1[2]/		A1	X	X	X	1 (y = 1)	0
CA1/		CA1	X	X	X	0	1 (y = 1)
Pin Osc		Capacitive sensing	X	0	1	0	0
P1.2/	2	P1.x (I/O)	I: 0; O: 1	0	0	0	0
TA0.1/		TA0.1	1	1	0	0	0
		TA0.CCI1A	0	1	0	0	0
UCA0TXD/		UCA0TXD	from USCI	1	1	0	0
UCA0SIMO/		UCA0SIMO	from USCI	1	1	0	0
A2[2]/		A2	X	X	X	1 (y = 2)	0
CA2/		CA2	X	X	X	0	1 (y = 2)
Pin Osc		Capacitive sensing	X	0	1	0	0

(1) X = don't care
(2) MSP430G2x53 devices only

Digital I/O Registers

The MSP430 communicates with the Digital I/O Peripherals through a set of 8 bit Peripheral Registers:

- PxDIR

- PxIN

- PxOUT

- PxREN

- PxSEL and PxSEL2

PxDIR

- 'P' stands for port
- 'x' stands for port number (Upto 3 ports available on MSP430G2553, based on package selected)
- It is an eight bit register. It is used to define whether a pin is to be used as an input or as an output.
- If value of a bit in PxDIR register is '0', it is set as input.
- If value of a bit in PxDIR register is '1', it is set as output.
- Default value of PxDIR register for all ports is '0'.

PxIN

- This eight bit register stores the value of input on a port. Based on the value of logic low and logic high for MSP430 MCU, the voltage value read on the input pin will be classified as logic low or logic high.
- The '0' value of a bit in PxIN register indicates the input value of bit as low.
- The '1' value of a bit in PxIN register indicates the input value of bit as high.

For reading the value of a GPIO, set the pin as input using PxDIR register then read the value of bit in PxIN register.

PxOUT

- This eight bit register sets the digital value on a port.
- Setting the value of a bit as '0' in PxOUT register sets the output value of bit as low.
- Setting the value of a bit as '1' in PxOUT register sets the output value of bit as high.

For setting the value of a GPIO, set the pin as output using PxDIR register then set the value of bit in PxOUT register.

PxREN

- This eight bit register enables the pullup or pulldown resistor for a given pin.
- Setting the value of a bit as '0' in PxREN register disables the pullup/pulldown resistor .
- Setting the value of a bit as '1' in PxREN register enables the pullup/pulldown resistor.
- Once PxREN is set, PxOUT value is set to select between pullup or pulldown on pin. If PxOUT is set as '0' then pin is pulled down. If PxOUT is set as '1' then pin is pulled up.

PxSEL and PxSEL2

- Multiple functions are available on a single pin, PxSEL and PxSEL2 register are used to select function of a given pin.

PxSEL2	PxSEL	Pin Function
0	0	I/O function is selected.
0	1	Primary peripheral module function is selected.
1	0	Reserved. See device-specific data sheet.
1	1	Secondary peripheral module function is selected.

Bit Manipulation

In order to be able to configure the I/O and program the MSP430 we need to first understand some techniques to read/assess/ configure/test/ manipulate individual bits in a register.

Bitwise Operation:-
1. OR (|)
2. AND (&)
3. XOR (^)
4. Shift Right (>>)
5. Shift Left (<<)
6. NOT (~)

We will learn some of these operations with examples in the following slides.

Setting outputs

The I/Os are independently configurable!

Example: For Port P1, suppose there are 8 LEDs connected on each pin. Suppose we have to turn on the LED on P1.3, without changing any configuration on the rest of the port. How will we do it?

Based on the logic that x | 0 = x and x | 1 = 1, there are a number of ways to set a bit:

1. P1OUT = P1OUT | BIT3;
2. P1OUT | = BIT3;
3. P1OUT = P1OUT | 0x08;

Setting outputs

Now we have to turn off the LED on P1.3, without changing the output on the rest of the port. How will we do it?

Based on the logic that x & 0 = 0 and x & 1 = x, there are a number of ways to clear a bit:

1. P1OUT = P1OUT & (~BIT3);
2. P1OUT & = ~BIT3;
3. P1OUT = P1OUT & 0xF7;

Similarly for toggling the output on any pin:

P1OUT = P1OUT ^ BIT3;

Reading inputs

Suppose there is a switch connected to P1.5 and we need to read the value of the pin.

Here is a snippet of code example for testing individual bits in a register:

```
if ((P1IN & BIT5) == 0)
    //to be done when P1.5 = 0
else
    // to be done when P1.5 = 1
```

Let's start programming!