Texas Instruments Robotics System Learning Kit
Module 6

Lecture: General Purpose Input Output – MSP432
You will learn in this module

- Review fundamentals of C programming namely:
  - Functions, parameters, conditionals, loops
  - Integer calculations, Time delays

- General Purpose Input Output
  - Positive and negative logic
  - Direction register
  - Input, output, friendly
  - Input/output current and voltage on pins

- Implement a two-layer input interface
  - Low-level input/output to line sensor
  - Mid-level sensor integration
Overview of Input/Output

Digital
- GPIO  General Purpose Input Output
- UART  Universal asynchronous receiver/transmitter
- SPI   Serial peripheral interface
- I2C   Inter-integrated circuit

Timer
- TimerA Periodic interrupts, input capture, and output
- Timer32 Periodic interrupts

Analog
- ADC14  Analog to digital converter
- Analog Comp Compare two analog signals
Texas Instruments Robotics System Learning Kit: The Solderless Maze Edition

MSP432 Input/Output

14mm

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SEKP090
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SEKP090

| General Purpose Input Output – MSP432

MSP432 LaunchPad

- USB to PC
- Debugger
- SW1
- J1/J3
- LED1
- Reset
- SW2
- MSP432
- J2/J4
- LED2
- J5
MSP432 LaunchPad

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SEKP090
**MSP432 LaunchPad**

**Negative logic:** low voltage means true

**Positive logic:** high voltage means true
Digital Interfacing (Circuit Model)

Voltage ↔ Digital

\[ V_{OL} \leq V_{IL} \text{ for all inputs} \quad \text{and} \quad V_{OH} \geq V_{IH} \text{ for all inputs} \]

\[ I_{OL} \geq \sum I_{IL} \text{ for all inputs} \quad \text{and} \quad I_{OH} \geq \sum I_{IH} \text{ for all inputs} \]
Digital Interfacing (Voltages)

Not 5V tolerant, all inputs must be 0 to 3.3V

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V_{OL} \leq V_{IL} \text{ for all inputs} \quad \text{and} \quad V_{OH} \geq V_{IH} \text{ for all inputs}

I_{OL} \geq \sum I_{IL} \text{ for all inputs} \quad \text{and} \quad I_{OH} \geq \sum I_{IH} \text{ for all inputs}
## Digital Interfacing (Currents)

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<tr>
<th>Family</th>
<th>Example</th>
<th>$I_{OH}$</th>
<th>$I_{OL}$</th>
<th>$I_{IH}$</th>
<th>$I_{IL}$</th>
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<td>Standard TTL</td>
<td>7404</td>
<td>0.4 mA</td>
<td>16 mA</td>
<td>40 µA</td>
<td>1.6 mA</td>
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<td>Schottky TTL</td>
<td>74S04</td>
<td>1 mA</td>
<td>20 mA</td>
<td>50 µA</td>
<td>2 mA</td>
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<tr>
<td>Low Power Schottky</td>
<td>74LS04</td>
<td>0.4 mA</td>
<td>4 mA</td>
<td>20 µA</td>
<td>0.4 mA</td>
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<tr>
<td>High Speed CMOS</td>
<td>74HC04</td>
<td>4 mA</td>
<td>4 mA</td>
<td>1 µA</td>
<td>1 µA</td>
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<td>Adv High Speed CMOS</td>
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<td>20 nA</td>
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<td>MSP432 high drive</td>
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<td>20 mA</td>
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<td>20 nA</td>
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<td>TM4C 8mA-drive</td>
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<td>2 µA</td>
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Increased drive strength on P2.0, P2.1, P2.2, and P2.3

\[
V_{OL} \leq V_{IL} \text{ for all inputs} \quad \text{and} \quad V_{OH} \geq V_{IH} \text{ for all inputs}
\]

\[
I_{OL} \geq \sum I_{IL} \text{ for all inputs} \quad \text{and} \quad I_{OH} \geq \sum I_{IH} \text{ for all inputs}
\]
Summary

- General Purpose Input Output
  - Voltage ↔ Digital
  - Positive and negative logic
  - Pins
  - Ports

- Interfacing
  - Voltage/current
  - Input/output
Module 6

Lecture: General Purpose Input Output - Programming
General Purpose Input Output – Programming

You will learn in this module

- General Purpose Input Output
  - Direction register
  - Input,
  - Output,
  - Friendly

- Implement a two-layer input interface
  - Low-level input/output to line sensor
  - Mid-level sensor integration
MSP432 Input Initialization

```c
// Make P1.1 an input
void SW1_Init(void){
    P1->SEL0 &= ~0x02;  
P1->SEL1 &= ~0x02;  
P1->DIR &= ~0x02;  
}
```

Alternate function
0 for GPIO
1 for alternate

Direction
0 for input
1 for output

Clear bit 1

Friendly means just changes the bits you need, without changing the bits you do not need.
// Read from P1.1
uint8_t Sw1(void)
{
    uint8_t data;
    data = P1->IN;
    data = data&0x02;
    return data;
}

uint8_t Sw1(void)
{
    return P1->IN&0x02;
}
MSP432 Output Initialization

```c
// Make P1.0 an output
void LED_Init(void){
    P1->SEL0 &= ~0x01;
    P1->SEL1 &= ~0x01;
    P1->DIR |= 0x01;
}
```

Alternate function
0 for GPIO
1 for alternate

Direction
0 for input
1 for output

Set bit 1

Read from PxIN
Read from PxOUT
Write to PxOUT
Write to PxDIR

Friendly means just changes the bits you need, without changing the bits you do not need.
void LED(uint8_t new) {
    uint8_t old;
    old = P1->OUT;
    old = old & (~0x01);
    new = new | old;
    P1->OUT = new;
}

void LED(uint8_t new) {
    P1->OUT = (P1->OUT & (~0x01)) | new;
}

1. Read from port
2. Clear bits of interest
3. Set/clear bits of interest
4. Write back to port

Friendly means just changes the bits you need, without changing the bits you do not need.
void SSR_Init(void) {
    P2->SEL0 &= ~0x08;
    P2->SEL1 &= ~0x08; // GPIO
    P2->DIR |= 0x08;   // make pin out
    P2->DS |= 0x08;    // high current
}
void SSR_On(void) {
    P2->OUT &= ~0x08; // P2.3=0
}
void SSR_Off(void) {
    P2->OUT |= 0x08;  // P2.3=1
}

Negative logic
Optical Sensor Interface

1. P5.3 output high
2. P7.0 output high
3. Wait 10 us
4. P7.0 input
5. Wait 1 ms
6. Read P7.0
7. P5.3 output low

- **MSP432**
  - P7.0
  - P5.3

- **Line sensor**

- **QTR-8RC**

- **3.3V**

- **Digital**
  - White
  - Black

- **P7.0**
  - White
  - Software reads P7.0

- **Black**

- **White**

- **1ms**
Summary

- **General Purpose Input Output**
  - Voltage ↔ Digital
  - Positive and negative logic

- **Initialization**
  - Alternate function
  - Direction register
  - Pullup/pulldown registers
  - Increase drive strength

- **Input**
  - Read and mask

- **Output**
  - *Friendly*: Read, set/clear and write

1. Line sensor
2. Bump sensors
3. Motor direction
4. LCD output
5. Tachometer input
6. Ultrasonic I/O
7. BLE
8. Wifi
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