Module 8

Lecture: Interfacing input and output - Switches
Interfacing input devices using Switches

You will learn in this module

- Fundamentals of switches
- How to interface switches TI’s Launchpad Development board
- Software driver (set of functions to create an abstract module)
- Motivation for lab
Switch Configuration

Not pressed \( R = 100\,\text{M}\Omega \)

Pressed \( R = 0.1\,\Omega \)

1 2

3 4

1 2

3 4

Not pressed

Open

Pressed

Closed

Interfacing input and output - Switches
Positive Logic Switch Interface

Positive Logic $t$
- pressed, 3.3V, true
- not pressed, 0V, false
Negative Logic Switch Interface

- **Pressed**
  - +3.3V
  - 10kΩ
  - 0.0V

- **Not pressed**
  - +3.3V
  - 10kΩ
  - 3.3V

**Negative Logic s**
- pressed, 0V, true
- not pressed, 3.3V, false
LaunchPad Switches and LEDs

The Switches on the LaunchPad

- Negative logic
- Require internal pull-up

The LEDs are positive logic
Software Driver (inputs)

Initialization (executed once at beginning)
1. Set \textit{DIR} to 0 for input
2. Enable pullup on inputs

Input from switches
1. Read from data input port
2. Mask (select) desired bits

\begin{verbatim}
all = P1->IN;
in = all&0x01;
\end{verbatim}
#include "msp.h"

void Port1_Init(void){
    P1->DIR = 0x00;    // 1) make P1.4 and P1.1 in
    P1->REN = 0x12;    // 2) enable pull resistors on P1.4 P1.1
    P1->OUT = 0x12;    // P1.4 and P1.1 are pull-up
}

uint8_t Port1_Input(void){
    return (P1->IN&0x12); // read P1.4,P1.1 inputs
}

See **InputOutput_MSP432** example project
#include "msp.h"

void Port1_Init(void){
    P1->DIR &= ~0x12;  // 1) make P1.4 and P1.1 in
    P1->REN |= 0x12;   // 2) enable pull resistors on P1.4 P1.1
    P1->OUT |= 0x12;   // P1.4 and P1.1 are pull-up
}

uint8_t Port1_Input(void){
    return (P1->IN&0x12); // read P1.4,P1.1 inputs
}
Application

Switches provide

1. Feedback to robot as bump sensors to determine if there is an obstruction
2. Control/command inputs to robot (e.g., start/stop)
Summary

- Positive and negative logic
- Ohm’s Law for resistors
- Switch interface with pullup or pulldown
- LaunchPad switches and LEDs
- Software driver
  - Initialization
  - Input/Output functions

\[ V = I \times R \]
Module 8

Lecture: Interfacing input and output - LEDs
Interfacing output devices using LEDs

You will learn in this module

- Fundamentals of LEDs
- How to LEDs to TI's Launchpad Development board
- Software driver (set of functions to create an abstract module)
- Motivation for lab
LED Interfacing

Resistor

\[ V_r = I_r \times R \]

LED

\[ V_f \]

Resistor LED Voltage

<table>
<thead>
<tr>
<th>Current (mA)</th>
<th>Voltage (volts)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>

Resistor Voltage

\[ R = 1k \Omega \]

LED Current

\[ I_f \]

<table>
<thead>
<tr>
<th>Current (mA)</th>
<th>Voltage (volts)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.5</td>
<td>0.5</td>
</tr>
<tr>
<td>1.8</td>
<td>1.8</td>
</tr>
<tr>
<td>2.1</td>
<td>3</td>
</tr>
</tbody>
</table>
LED Interfacing

LED current vs voltage

Anode (+)

Cathode (-)

“Big voltage connects to big pin”

1 mA, 1.6V

Brightness = power = V*I
LED Interfacing (I < 6 mA), Positive Logic

R = (3.3V – 1.6)/0.001A = 1.7 kΩ
Standard R = 1.6 kΩ

Brightness = power = V*I
LED Interfacing (I < 6 mA), Negative Logic

\[ R = \frac{(3.3V - 1.6)}{0.001A} = 1.7 \text{ k}\Omega \]

Standard \( R = 1.6 \text{ k}\Omega \)

Brightness = power = \( V \times I \)
LED Interfacing (I > 6 mA)

LED may contain several diodes in series

$$R = \frac{(3.3-1.8-0.5)}{0.01} = 100 \, \Omega$$

Brightness = power = $V \times I$
Software Driver (outputs)

Initialization (executed once at beginning)
1. Set $DIR$ to 1 for output
2. Activate increased drive strength on output

Output to LED
1. Read from data output port
2. Modify bits as desired
3. Write to data output port

Set bit
```
data = P2->OUT;
data |= 0x01;
P2->OUT = data;
```

Clear bit
```
data = P2->OUT;
data = data&0xFE;
P2->OUT = data;
```
LaunchPad Switches and LEDs

The LEDs are positive logic

The LEDs are positive logic

P2->DS = 0x07;
Software Driver (simple, not friendly)

```c
#include "msp.h"

void Port2_Init(void) {
    P2->DIR = 0x07; // 1) make P2.2-P2.0 out
    P2->DS = 0x07;  // 2) activate increased drive strength
    P2->OUT = 0x00; // all LEDs off
}

void Port2_Output(uint8_t data){ // write P2.2-P2.0 outputs
    P2->OUT = data;
}
```

See [InputOutput_MSP432](#) example project
void Port2_Init(void) {
    P2->DIR |= 0x07;  // 1) make P2.2-P2.0 out
    P2->DS |= 0x07;   // 2) activate increased drive strength
    P2->OUT &= ~0x07; // all LEDs off
}

void Port2_Output(uint8_t data){  // write P2.2-P2.0 outputs
    P2->OUT = (P2->OUT&0xF8)|data;
}

See InputOutput_MSP432 example project
Application

Debugging
1. Control
2. Observability

LEDs provide
1. Diagnostic information for debugging (e.g., heartbeat)
2. Visualization of state (e.g., flashing rate signifies status)
Summary

- Positive and negative logic
- Ohm’s Law for resistors
- LED nonlinear curve
- LED interface
  - Low current uses just a resistor
  - High current needs a driver
- Software driver
  - Initialization
  - Input/Output functions

\[ V_r = I_r \times R \]
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