TI-RSLK MAX

Texas Instruments Robotics System Learning Kit

Texas Instruments

Module 6

Lecture: General Purpose Input Output – MSP432

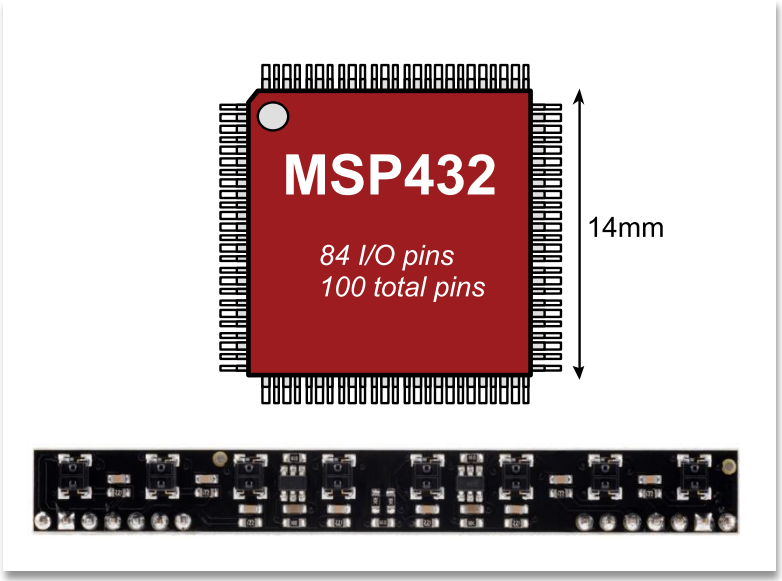
General Purpose Input Output

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

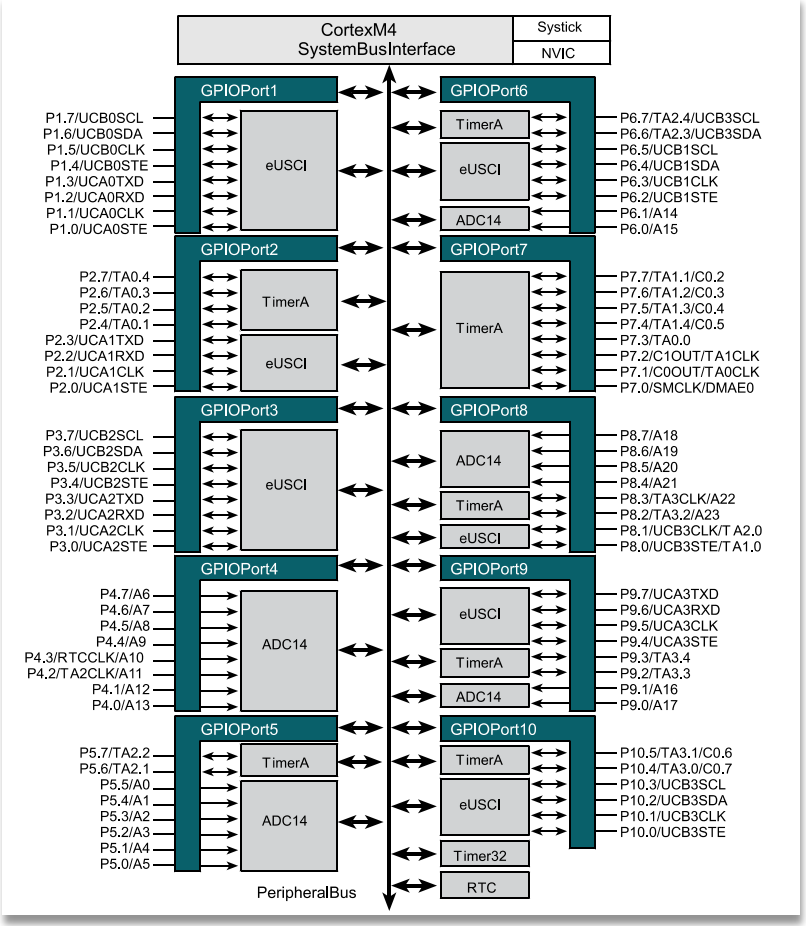
Timer

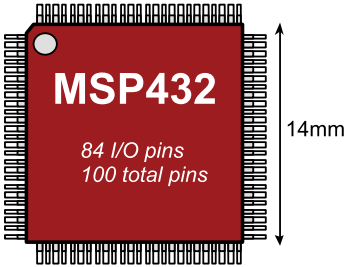
- TimerA — Periodic interrupts, input capture, and output
- Timer32 — Periodic interrupts

Analog

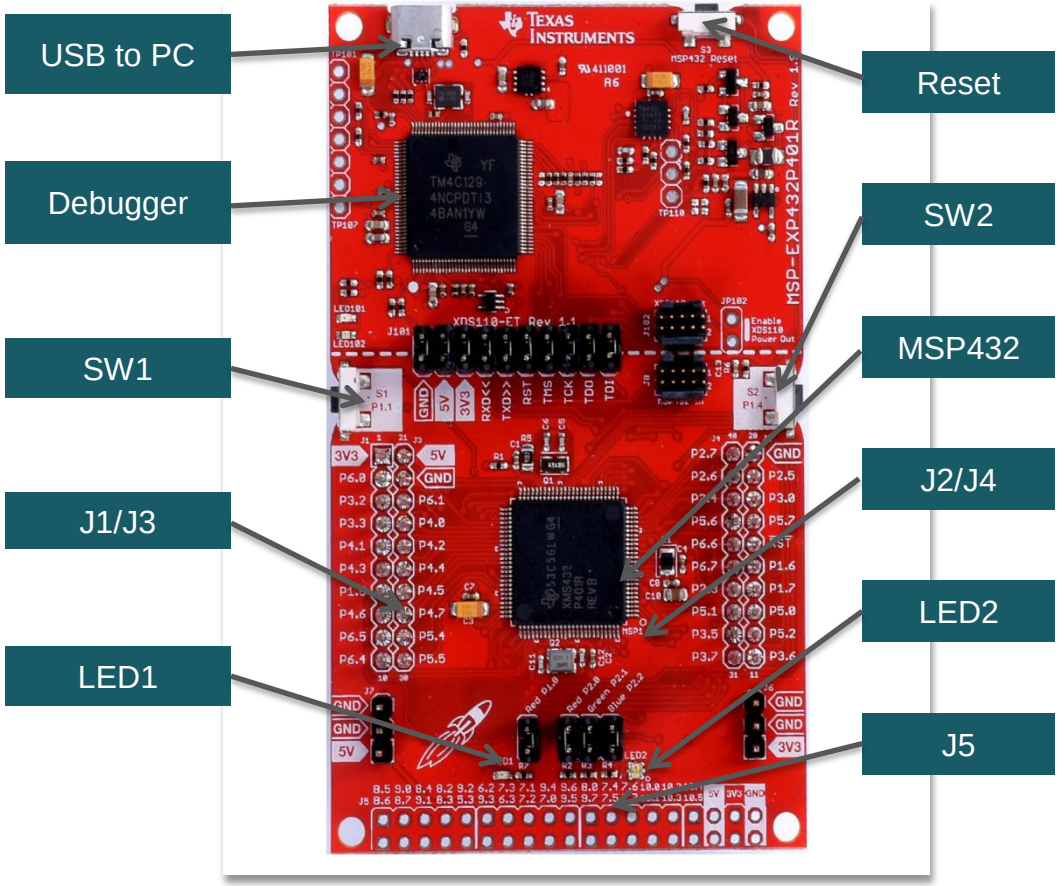
- ADC14 — Analog to digital converter
- Analog Comp — Compare two analog signals

MSP432 Input/Output

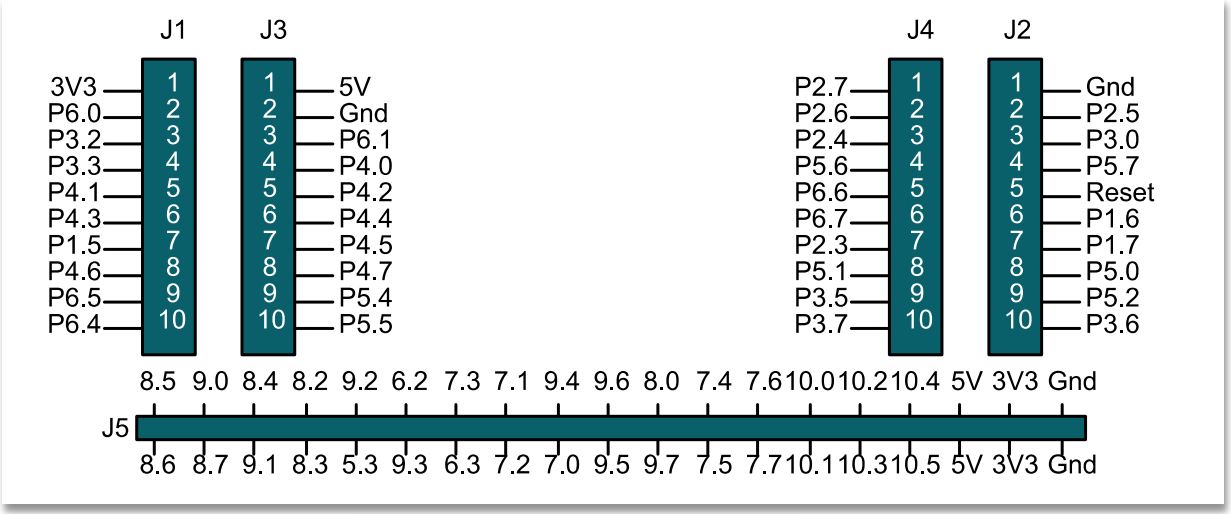




MSP432 LaunchPad



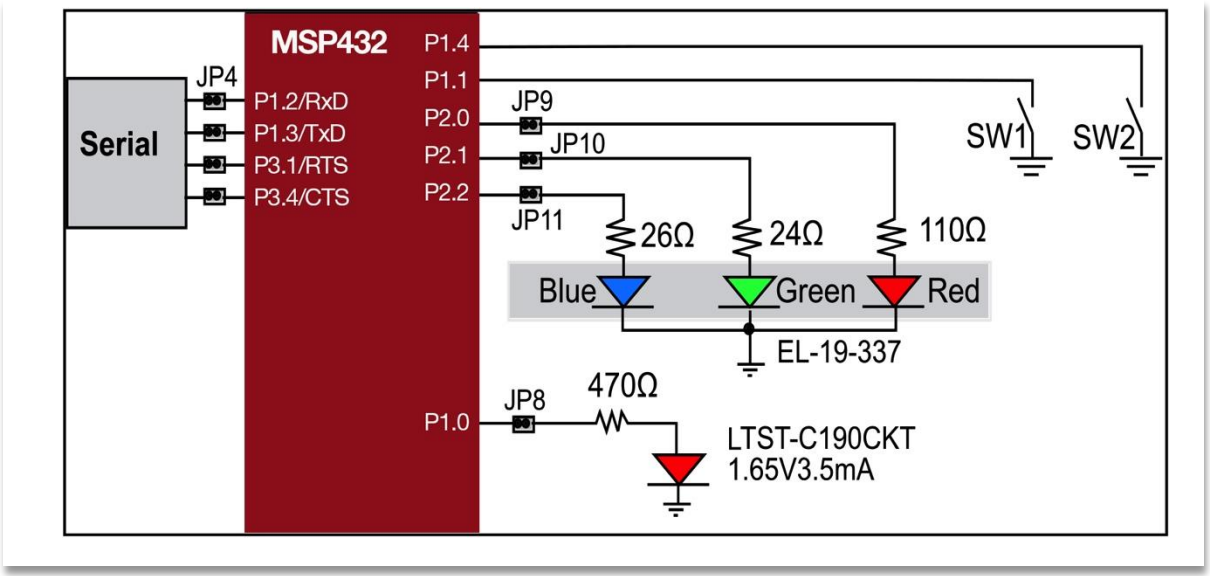
MSP432 LaunchPad



BoosterPacks

MSP432 LaunchPad

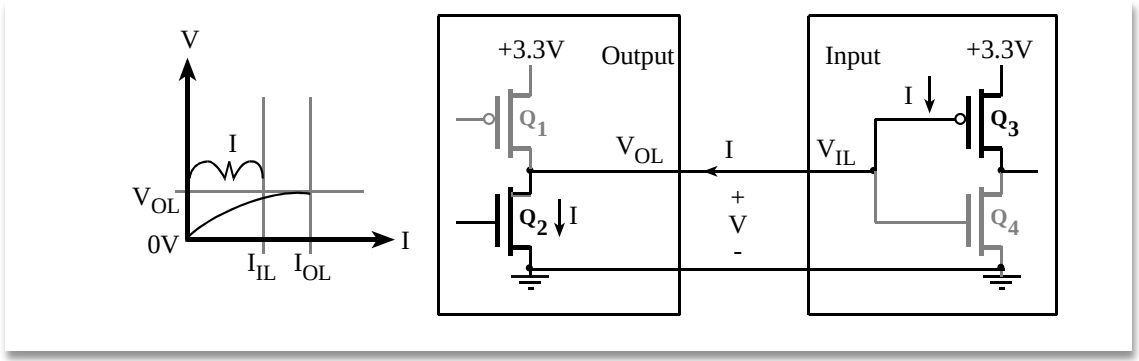
Negative logic: low voltage means true

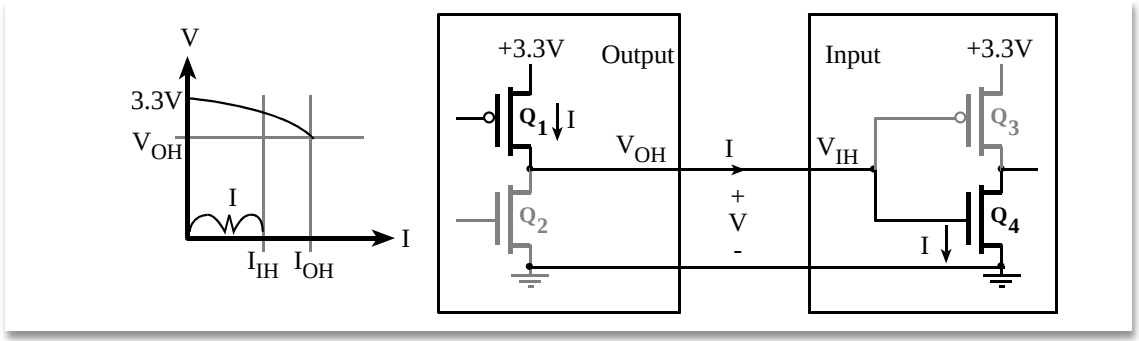


Positive logic: high voltage means true

Digital Interfacing (Circuit Model)

Voltage ↔ Digital

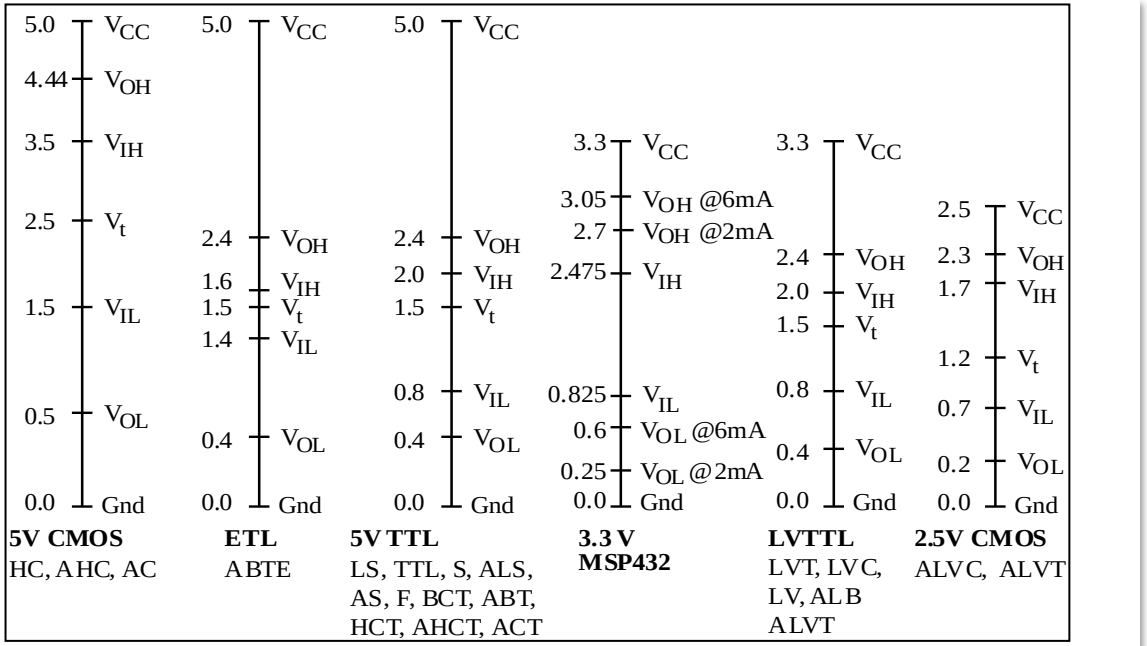




$V_{OL} \le V_{IL}$ for all inputs and $V_{OH} \ge V_{IH}$ for all inputs
$I_{OL} \ge \sum I_{IL}$ for all inputs and $I_{OH} \ge \sum I_{IH}$ for all inputs

Digital Interfacing (Voltages)

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



$V_{OL} \leq V_{IL}$ for all inputs and $V_{OH} \geq V_{IH}$ for all inputs
$I_{OL} \geq \sum I_{IL}$ for all inputs and $I_{OH} \geq \sum I_{IH}$ for all inputs

Digital Interfacing (Currents)

Family	Example	I_{OH}	I_{OL}	I_{IH}	I_{IL}
Standard TTL	7404	0.4 mA	16 mA	40 µA	1.6 mA
Schottky TTL	74S04	1 mA	20 mA	50 µA	2 mA
Low Power Schottky	74LS04	0.4 mA	4 mA	20 µA	0.4 mA
High Speed CMOS	74HC04	4 mA	4 mA	1 µA	1 µA
Adv High Speed CMOS	74AHC04	4 mA	4 mA	1 µA	1 µA
MSP432 regular drive	MSP432	6 mA	6 mA	20 nA	20 nA
MSP432 high drive	MSP432	20 mA	20 mA	20 nA	20 nA
TM4C 8mA-drive	TM4C123	8 mA	8 mA	2 µA	2 µA
TM4C 12mA-drive	TM4C1294	12 mA	12 mA	2 µA	2 µA

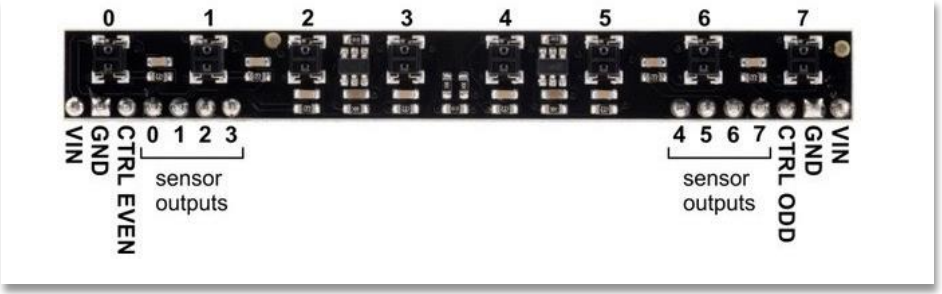
Increased drive strength on P2.0, P2.1, P2.2, and P2.3

$V_{OL} \leq V_{IL}$ for all inputs and $V_{OH} \geq V_{IH}$ for all inputs
$I_{OL} \geq \sum I_{IL}$ for all inputs and $I_{OH} \geq \sum I_{IH}$ for all inputs

Summary

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

- Interfacing
  - Voltage/current
  - Input/output



Module 6

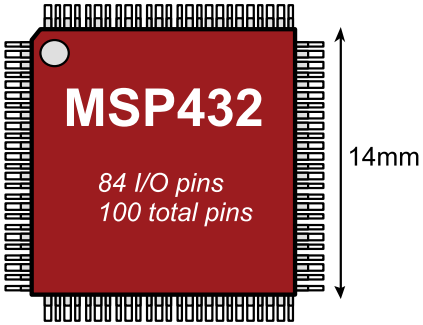
Lecture: General Purpose Input Output - Programming

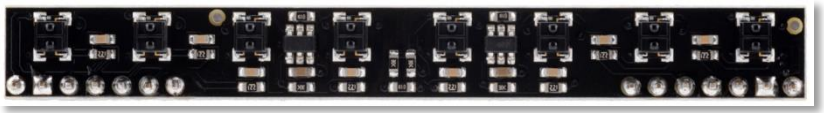
General Purpose Input Output – Programming

You will learn in this module

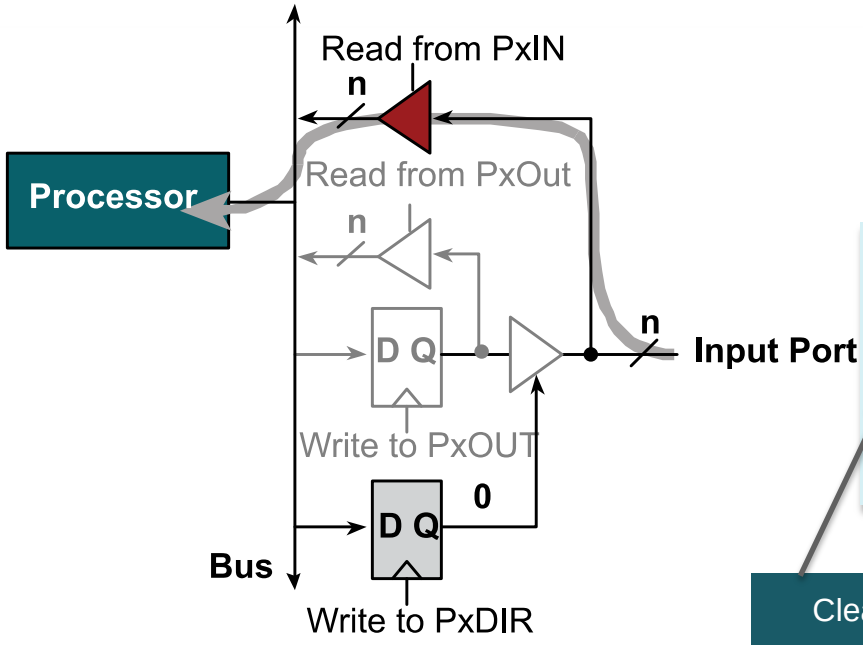
- General Purpose Input Output
  - Direction register
  - Input,
  - Output,
  - Friendly

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





MSP432 Input Initialization



Alternate function
0 for GPIO
1 for alternate

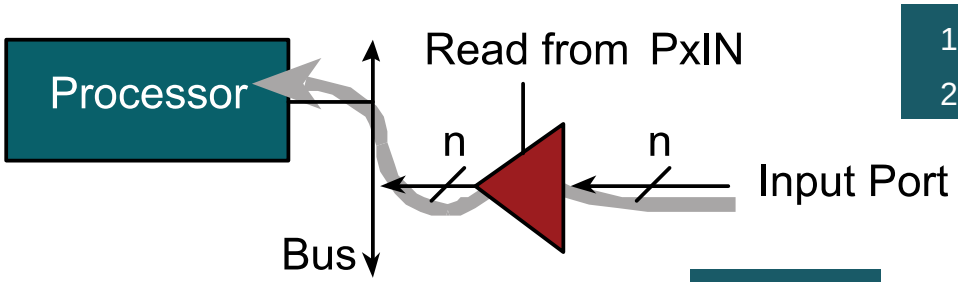
```
// Make P1.1 an input
void SW1_Init(void){
  P1->SEL0 &= ~0x02;
  P1->SEL1 &= ~0x02;
  P1->DIR &= ~0x02;
}
```

Clear bit 1

Direction
0 for input
1 for output

Friendly means just changes the bits you need,
without changing the bits you do not need.

MSP432 Input



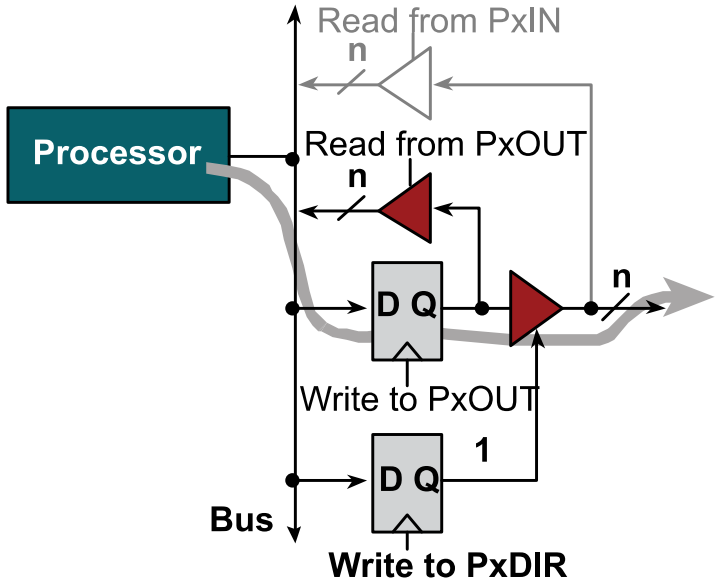
1. Read from port
2. Select bits of interest

Mask

```
// 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;
}
```

Returns 0 or 2

MSP432 Output Initialization




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

Output Port

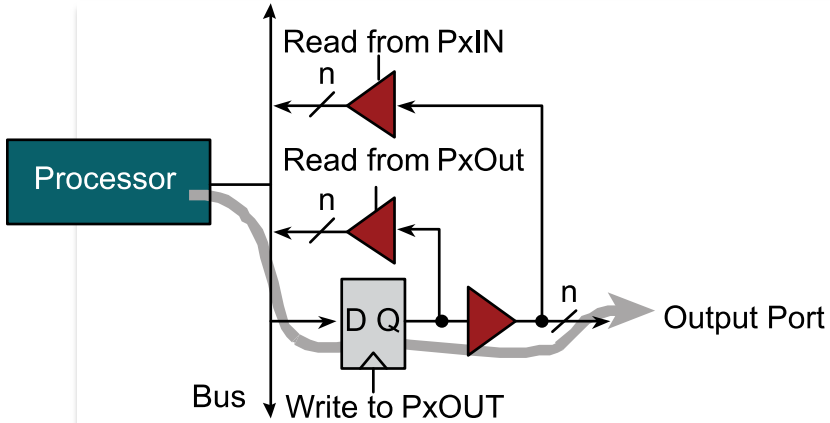
Alternate function
0 for GPIO
1 for alternate

Direction
0 for input
1 for output

Set bit 1

Friendly means just changes the bits you need,
without changing the bits you do not need.

MSP432 Output



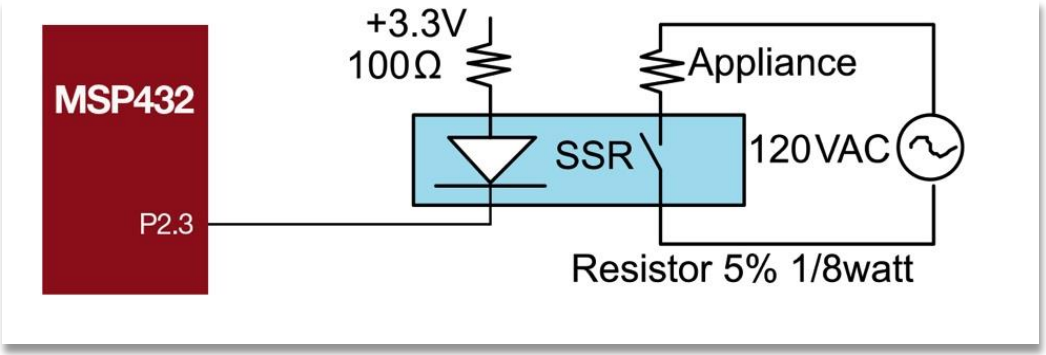
1. Read from port
2. Clear bits of interest
3. Set/clear bits of interest
4. Write back to port

```
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;
}
```

Friendly

Friendly means just changes the bits you need,
without changing the bits you do not need.

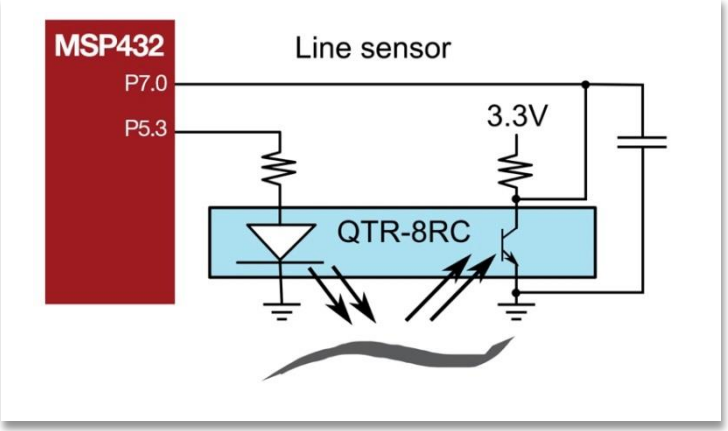
Solid State Relay Interface

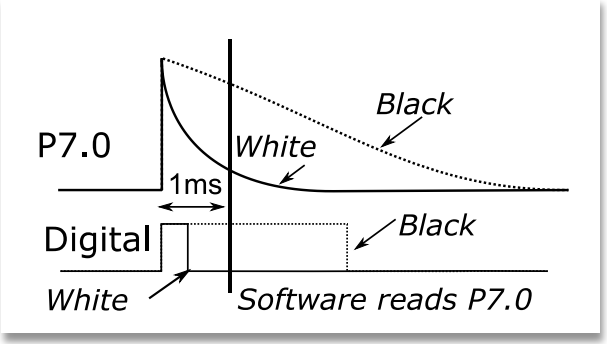



```
void SSR_Init(void){
  P2->SEL0 &= ~0x08;
  P2->SEL1 &= ~0x08; // GPIO
  P2->DIR |= 0x08;   // make pin out
  P2->DS |= 0x08;    // high current
}
void SSR_On(void){
  P2->OUT &= ~0x08;  // P2.3=0
}
void SSR_Off(void){
  P2->OUT |= 0x08;   // P2.3=1
}
```

Negative logic

Optical Sensor Interface



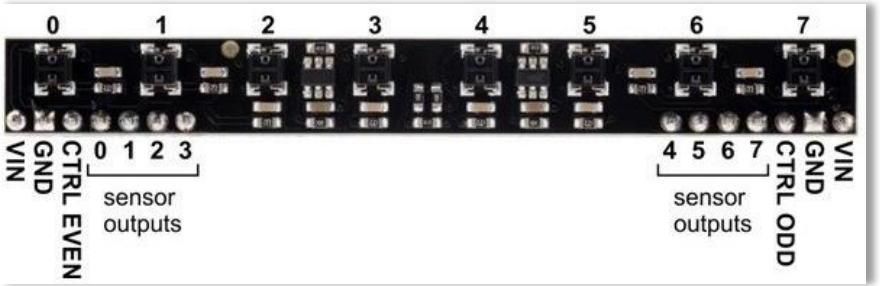


1. P5.3 output high
2. P7.0 output high
3. Wait 10 us
4. P7.0 input
5. Wait 1 ms
6. Read P7.0
7. P5.3 output low

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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