PIC24HJ32GP202 µC

Hardware lab exercises will use the PIC24HJ32GP202 µC (28-pin DIP)

Note that most pins have multiple functions.

Pin functions are controlled via special registers in the PIC.

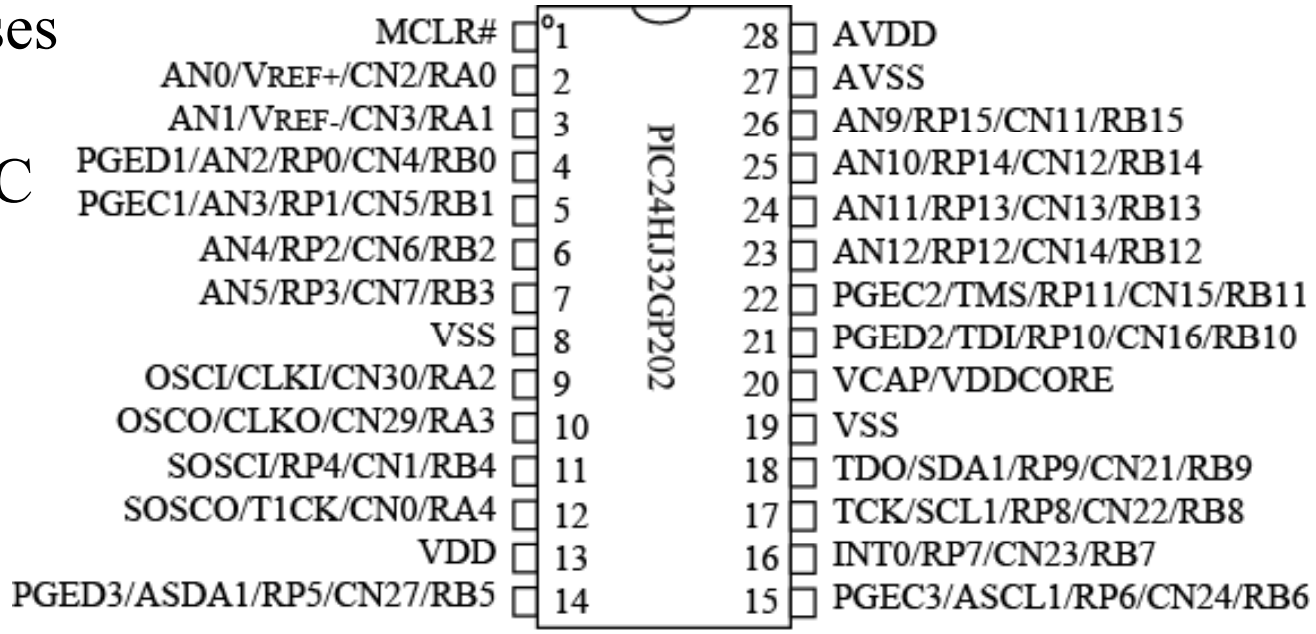


Figure redrawn by author from PIC24HJ32GP202/204 datasheet (DS70289A), Microchip Technology Inc.

Will download programs into the PIC24 µC via a serial bootloader that allows the PIC24 µC to program itself.

From: Reese/Bruce/Jones, "Microcontrollers: From Assembly to C with the PIC24 Family".

General-purpose I/O

The simplest type of I/O via the PIC24 μC external pins are **parallel I/O (PIO) ports**.

A PIC24 μC can have multiple PIO ports named PORTA, PORTB, PORTC, PORTD, etc. Each is 16-bits, and the number of PIO pins depends on the particular PIC24 μC and package. The PIC24HJ32GP202/28 pin package has:

PORTA – bits RA4 through RA0
PORTB – bits RB15 through RB0

These are generically referred to as PORT*x*.

Each pin on these ports can either be an input or output – the data direction is controlled by the corresponding bit in the TRIS*x* registers (‘1’ = input, ‘0’ = output).

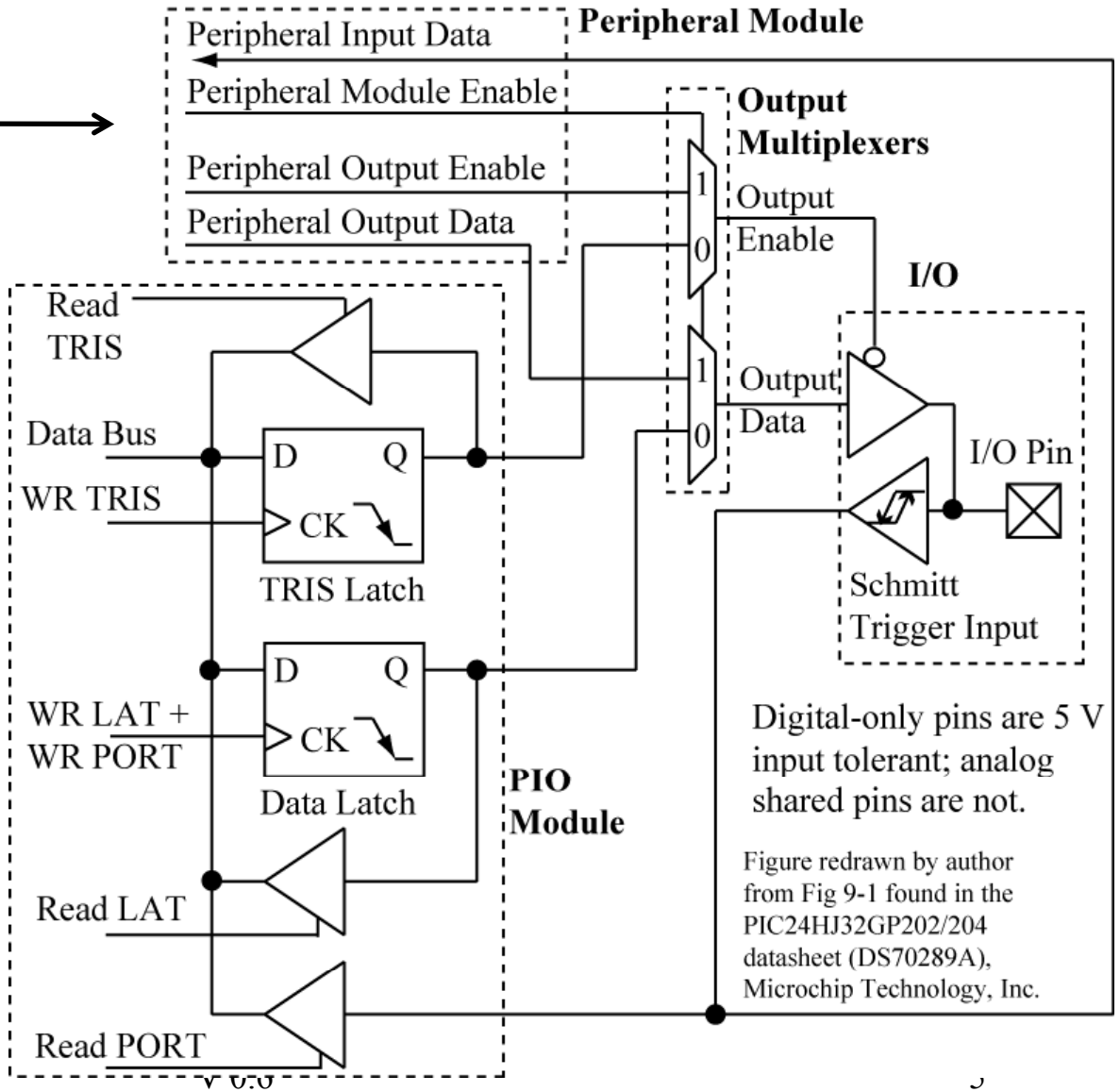
The LAT*x* register holds the last value written to PORT*x*.

PORTx Pin Diagram

External pin shared with other on-chip modules →

TRIS bit controls tristate control on output driver →

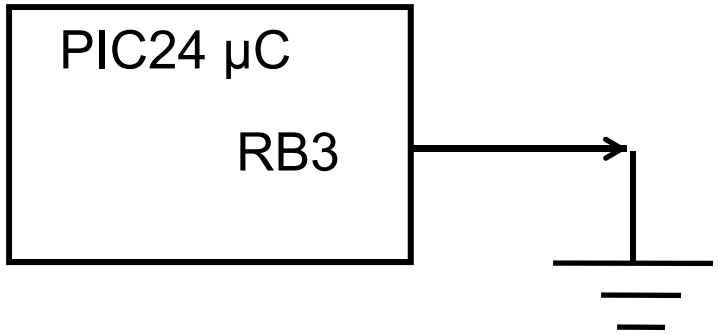
Reading LATx reads last value written; reading PORTx reads the actual pin



LATx versus PORTx

Writing LAT*x* is the same as writing PORT*x*, both writes go to the latch.

Reading LAT*x* reads the latch output (last value written), while reading PORT*x* reads the actual pin value.



Configure RB3 as an open-drain output, then write a ‘1’ to it.

The physical pin is tied to ground, so it can never go high.

Reading _RB3 returns a ‘0’, but reading _LATB3 returns a ‘1’ (the last value written).

LATx versus PORTx (cont)

```
_LATB0 = 1;
_LATB1 = 1;
```

Compiler →

```
bset LATB,#0
bset LATB,#1
```

bitset/bitclr instructions are read/modify/write, in this case, read LATB, modify contents, write LATB. This works as expected.

```
_RB0 = 1;
_RB1 = 1;
```

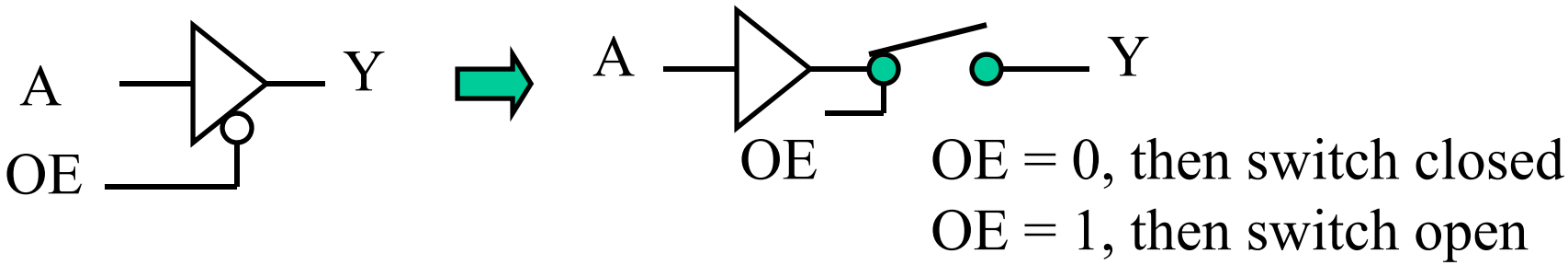
Compiler →

```
bset PORTB,#0
bset PORTB,#1
```

bset/bclr instructions are read/modify/write – in this case, read PORTB, modify its contents, then write PORTB. Because of pin loading and fast internal clock speeds, the second bset may not work correctly! (see datasheet explanation). For this reason, our examples use LATx when writing to a pin.

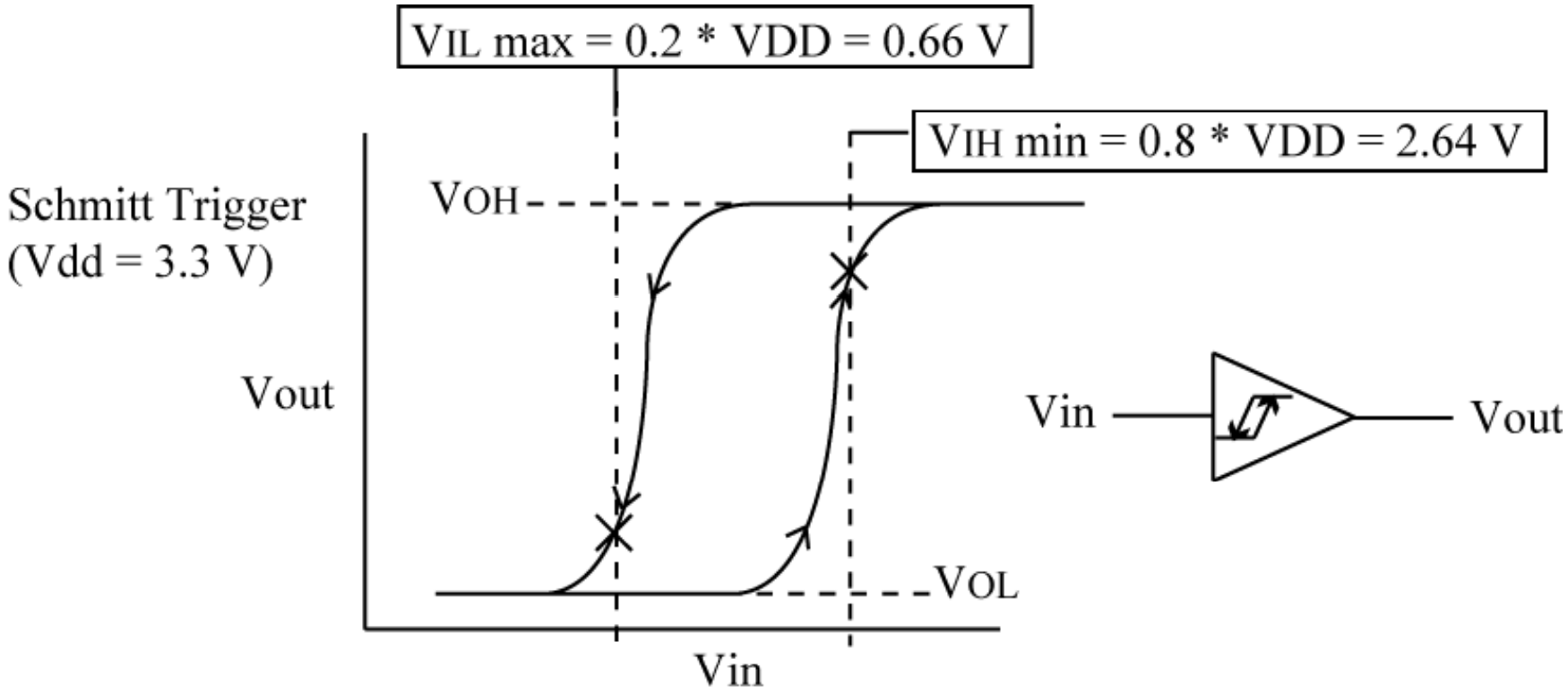
Aside: Tri-State Buffer (TSB) Review

A tri-state buffer (TSB) has input, output, and output-enable (OE) pins. Output can either be '1', '0' or 'Z' (high impedance).



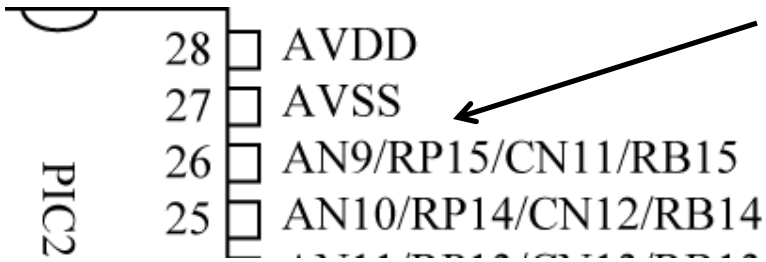
Schmitt Trigger Input Buffer

Each PIO input has a *Schmitt* trigger input buffer; this transforms slowly rising/falling input transitions into sharp rising/falling transitions internally.



PORTx Shared Pin Functions

External pins are shared with other on-chip modules. Just setting _TRISx = 1 may be not be enough to configure a PORT*x* pin as an input, depending on what other modules share the pin:



RB15 shared with AN9, which is an analog input to the on-chip Analog-to-Digital Converter (ADC). Must disable analog functionality!

```
_PCFG9 = 1;
```
← Disables analog function

```
_TRISB15 = 1;
```
← Configure as input

```
_PCFG9 = 1;
```
← Disables analog function

```
_TRISB15 = 0;
```
← Configure as output

Analog/Digital Pin versus Digital-only Pin

Pins with shared analog/digital functions have a maximum input voltage of Vdd + 0.3 V, so 3.6 V

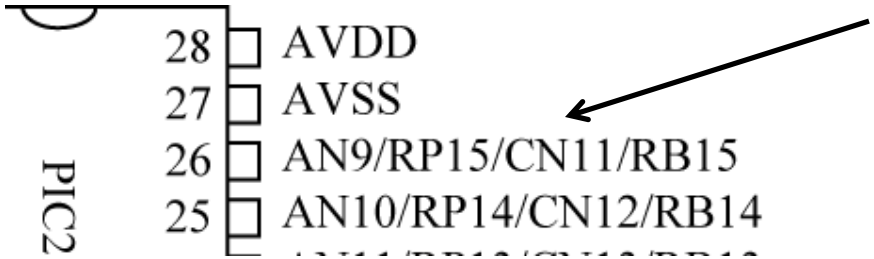
Pins with no analog functions (“digital-only” pins) are 5 V tolerant, their maximum input voltage is 5.6 V.

This is handy for receiving digital inputs from 5V parts.

Most PIO pins can only source or sink a maximum 4 mA. You may damage the output pin if you tie a load that tries to sink/source more than this current.

Internal Weak Pullups

External pins with a CN*y* pin function have a weak internal pullup that can be enabled or disabled.

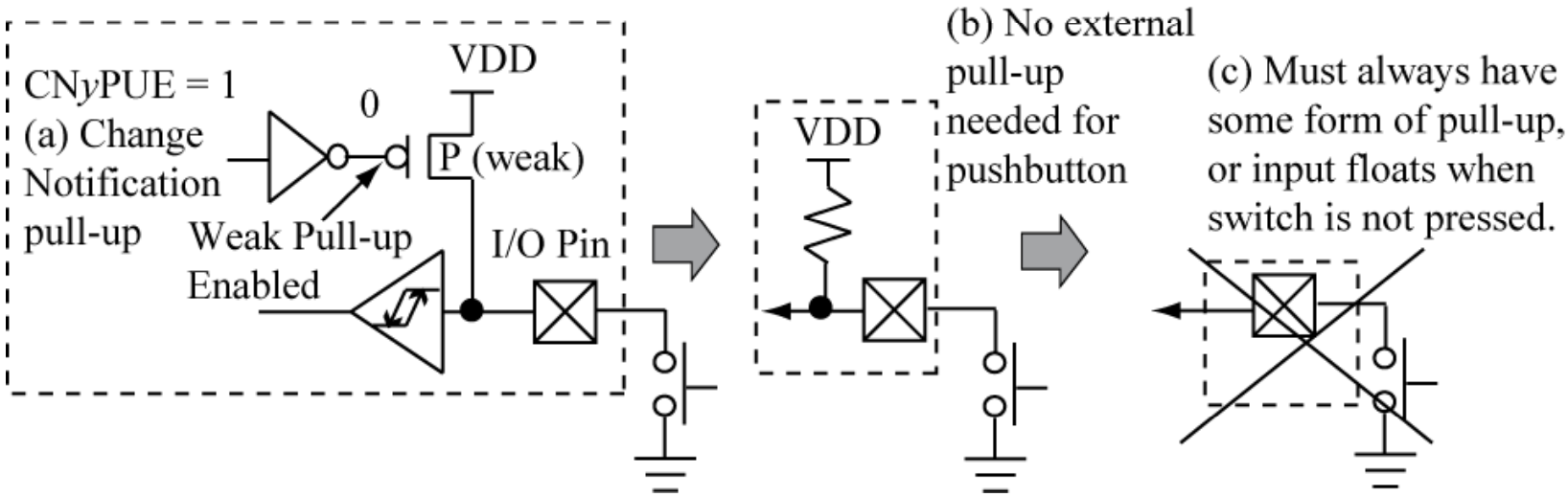


Change notification input; to enable pullup:

CN11PUE = 1;

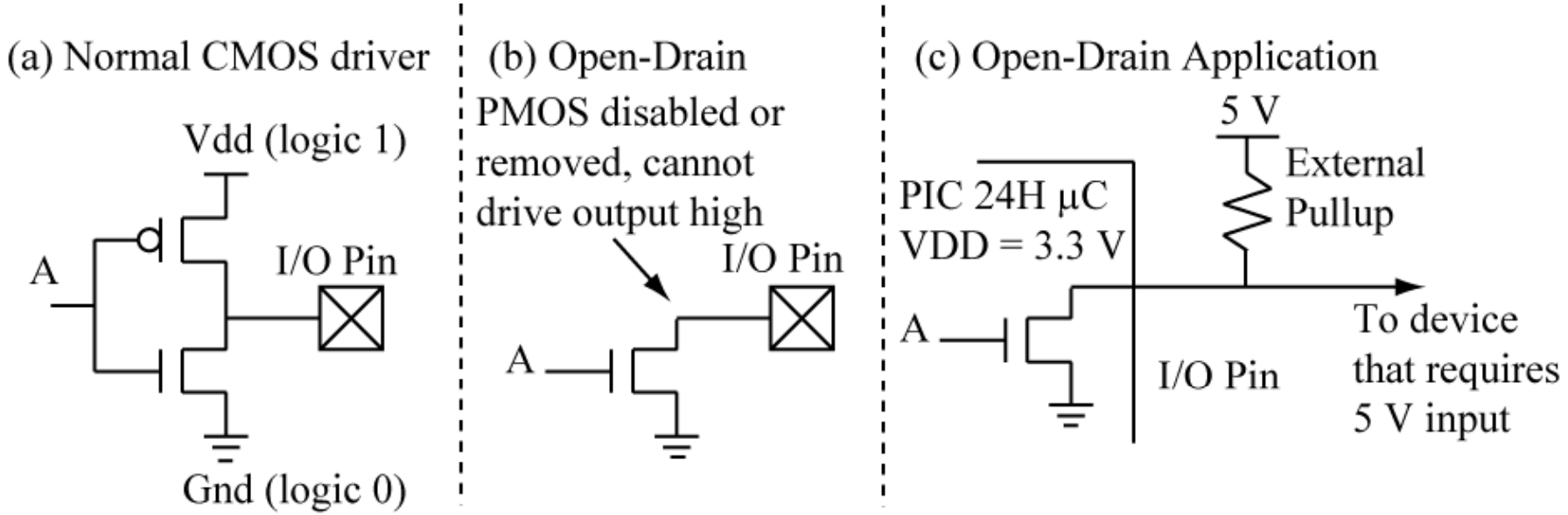
To disable pullup:

CN11PUE = 0;



Open Drain Outputs

Each PIO pin can be configured as an *open drain* output, which means the pullup transistor is disabled.



_ODC*xy* = 1 enables open drain, _ODC*xy* = 0 disables open drain

```
_ODCB15 = 1;
```
← Enables open drain on RB15

PORTB Example

Set the upper 8 bits of PORTB to outputs, lower 8 bits to be inputs:

```
TRISB = 0x00FF;
```

Drive RB15, RB13 high;
others low:

```
PORTB = 0xA000;
```

Wait until input RB0 is high:

```
while ((PORTB & 0x0001) == 0);
```

Test returns true while RB0=0
so loop exited when RB0=1

Wait until input RB3 is low:

```
while ((PORTB & 0x0008) == 1);
```

Test returns true while RB3=1
so loop exited when RB3=0

PORTB Example (cont.)

Individual PORT bits are named as _RB0, _RB1, .._RA0, etc. so this can be used in C code.

Wait until input RB2 is high:

```
while (_RB2 == 0);
```

Test returns true while RB2=0 so loop exited when RB2=1. Can also be written as:

```
while (!_RB2);
```

Wait until input RB3 is low:

```
while (_RB3 == 1) ;
```

Test returns true while RB3=1 so loop exited when RB3=0 Can also be written as:

```
while (_RB3);
```

Port Configuration Macros

For convenience, we supply macros/inline functions that hide pin configuration details:

```
CONFIG_RB15_AS_DIG_OUTPUT();
```

```
CONFIG_RB15_AS_DIG_INPUT();
```

These macros are supplied for each port pin. Because these functions change depending on the particular PIC24 μC, the *include/devices* directory has a include file for each PIC24 μC, and the correct file is included by the *include/pic24_ports.h* file.

PIO Configuration Macros/Functions

- Pull-up configuration
- Open-Drain Configuration
- Input/Output Configuration

```
static inline void CONFIG_RB15_AS_DIG_INPUT() {
    DISABLE_RB15_PULLUP();
    _TRISB15 = 1; // PIO as input
    _PCFG9 = 1; // digital mode
}
static inline void CONFIG_RB15_AS_DIG_OUTPUT() {
    DISABLE_RB15_PULLUP();
    DISABLE_RB15_OPENDRAIN();
    _TRISB15 = 0; // PIO as output
    _PCFG9 = 1; // digital mode
}
```

Other Port Configuration Macros

Other macros are provided for pull-up and open drain configuration:

```
ENABLE_RB15_PULLUP();
DISABLE_RB15_PULLUP();
ENABLE_RB13_OPENDRAIN();
DISABLE_RB13_OPENDRAIN();
CONFIG_RB8_AS_DIG_OD_OUTPUT();
```

Output + Open drain config in one macro

General forms are ENABLE_R*xy*_PULLUP(), DISABLE_R*xy*_PULLUP(), ENABLE_R*xy*_OPENDRAIN(), DISABLE_R*xy*_OPENDRAIN(), CONFIG_Rxy_AS_DIG_OD_OUTPUT()

A port may not have a pull-up if it does not share the pin with a change notification input, in this case, the macro does not exist and you will get an error message when you try to compile the code.

ledflash.c Revisited

```
#include "pic24_all.h"

/**
A simple program that
flashes an LED.
*/

#define CONFIG_LED1()

#define LED1   _LATB15

int main(void) {

  configClock();     //clock configuration
  /********** PIO config **********/
  CONFIG_LED1();   //config PIO for LED1
  LED1 = 0;

  while (1) {
    DELAY_MS(250);  //delay
    LED1 = !LED1;    // Toggle LED
  } // end while (1)
}
```

Defined in device-specific header file in *include\devices* directory in the book source distribution.
Macro `CONFIG_RB15_AS_DIG_OD_OUTPUT()` contains the statements `_TRISB15=0,_ODCB15 = 1`

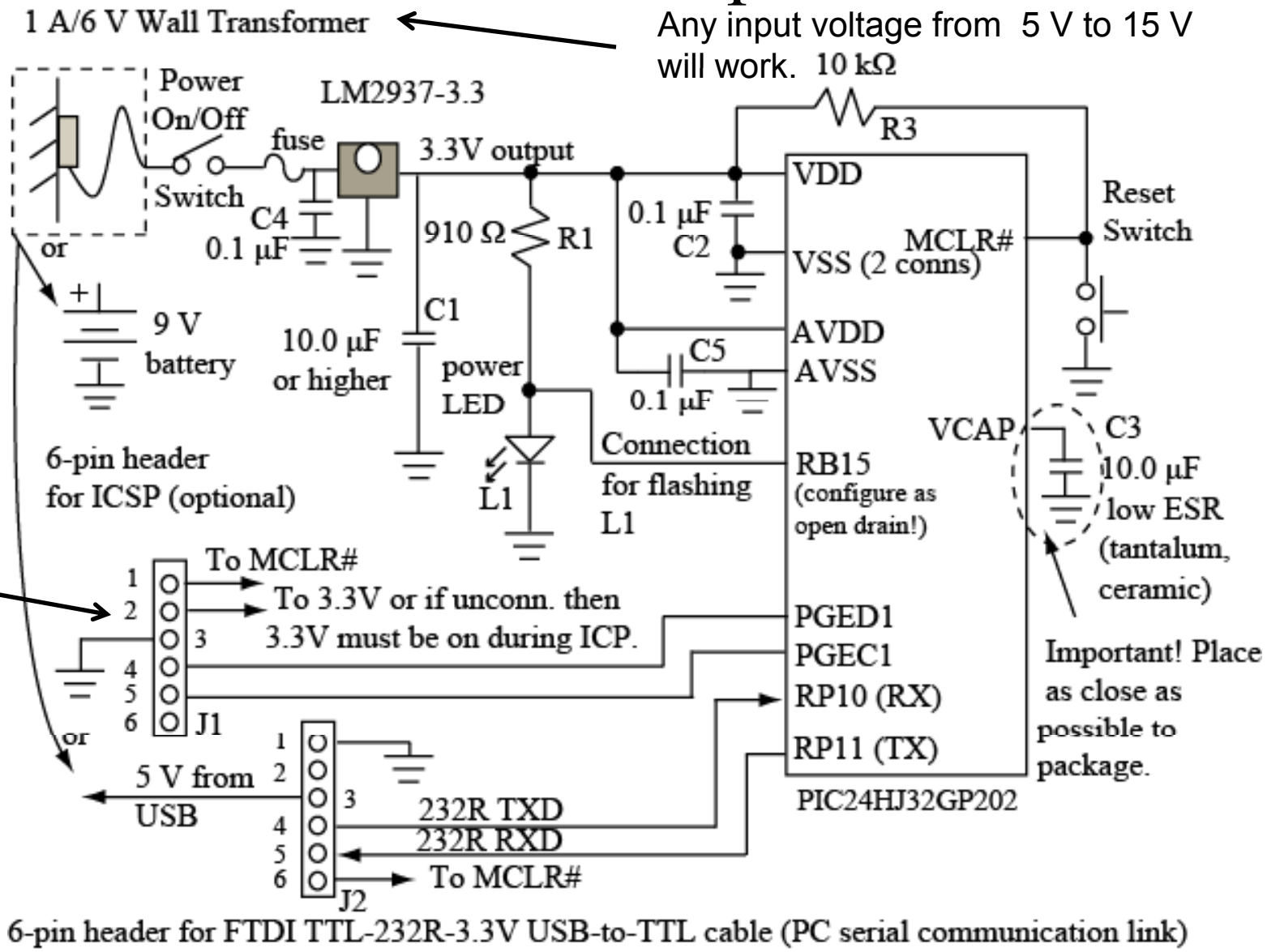
```
CONFIG_RB15_AS_DIG_OD_OUTPUT()
```

LED1 macro makes changing of LED1 pin assignment easier, also improves code clarity.

`DELAY_MS(ms)` macro is defined in *common\pic24_delay.c* in the book source distribution, `ms` is a `uint32` value.

Initial Hookup

There are multiple VDD/VSS pins on your PIC24 µC; hook them all up!!!

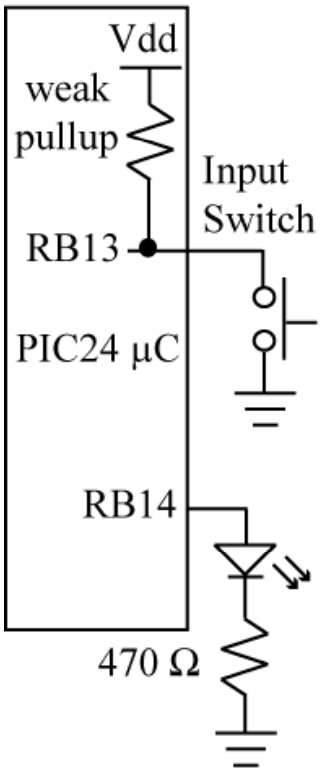


6-pin header for FTDI TTL-232R-3.3V USB-to-TTL cable (PC serial communication link)

From: Reese/Bruce/Jones, "Microcontrollers: From Assembly to C with the PIC24 Family".

LED/Switch IO: Count number of press/releases

```
/// LED1, SW1 Configuration
#define CONFIG_LED1()  CONFIG_RB14_AS_DIG_OUTPUT()
#define LED1   _LATB14      //led1 state
inline void CONFIG_SW1()  {
  CONFIG_RB13_AS_DIG_INPUT();   //use RB13 for switch input
  ENABLE_RB13_PULLUP();         //enable the pull-up
}
#define SW1                  _RB13  //switch state
#define SW1_PRESSED()    SW1==0  //switch test
#define SW1_RELEASED()   SW1==1  //switch test
```



Count number of switch presses.

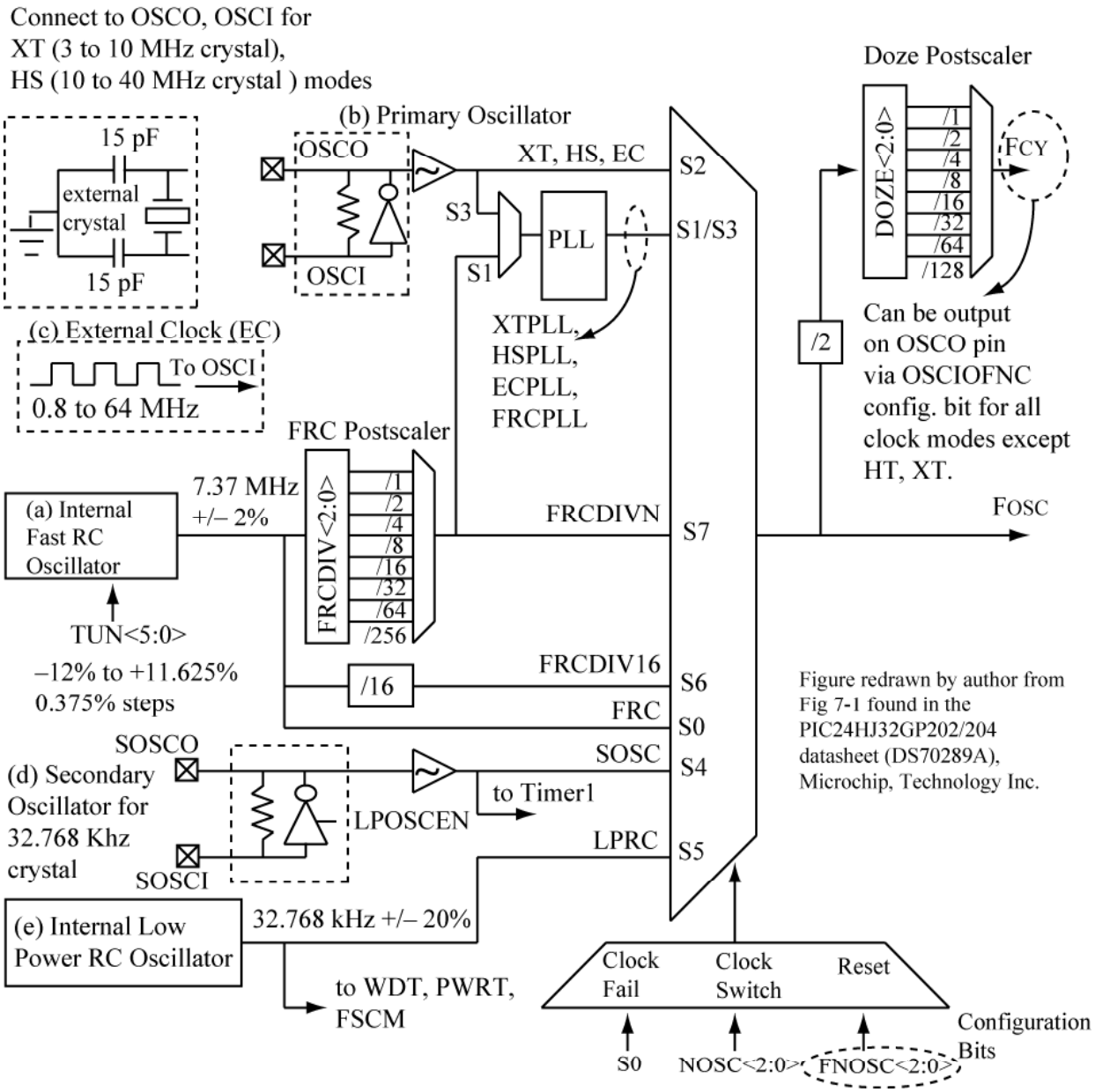
```
main(){
 ...other config...
 CONFIG_SW1();
 DELAY_US(1);
 CONFIG_LED1();
 LED1 = 0;
 while (1) {
   if (SW1_PRESSED()) {
   //switch pressed
   //toggle LED1
   LED1 = !LED1
   }
 }
}
```

a. Incorrect, LED1 is toggled as long as the switch is pushed, which could be a long time!

```
main(){
 ...other config...
 CONFIG_SW1();
 DELAY_US(1); //pull-up delay
 CONFIG_LED1();
 LED1 = 0;
 while (1) {
  // wait for press, loop(1)
  while (SW1_RELEASED());
  DELAY_MS(15); //debounce
  // wait for release, loop(2)
  while (SW1_PRESSED());
  DELAY_MS(15); // debounce
  LED1 = !LED1; //toggle LED
 }
```

b. Correct, loop(1) executed while switch is not pressed. Once pressed, code becomes trapped in loop(2) until the switch is released, at which point LED1 is toggled.

The Clock



The PIC24 μC has many options for generating a clock; can use an external crystal or internal oscillator.

We will use the internal clock.

PIC24 Reset

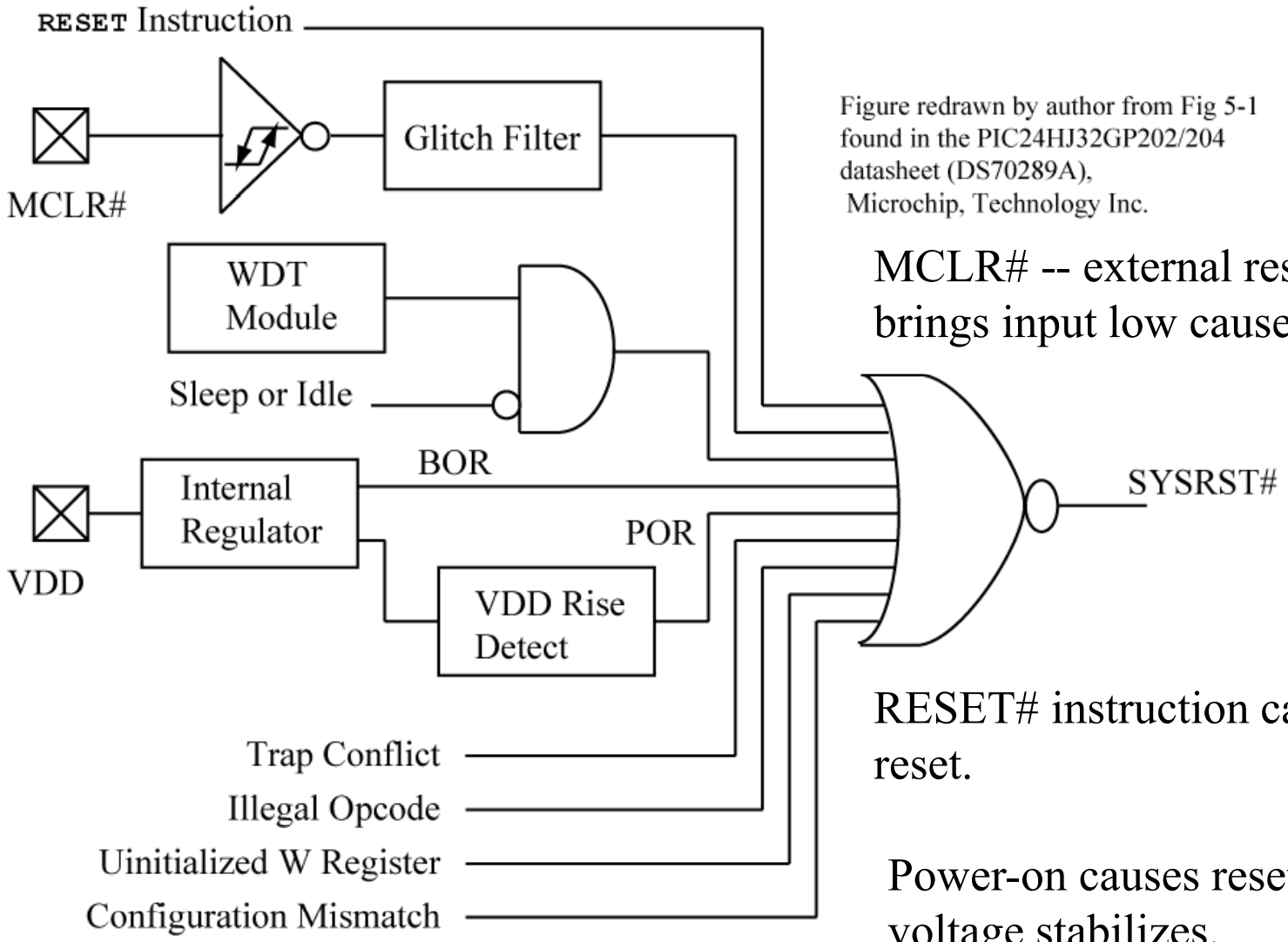


Figure redrawn by author from Fig 5-1 found in the PIC24HJ32GP202/204 datasheet (DS70289A), Microchip, Technology Inc.

MCLR# -- external reset button brings input low causes reset.

RESET# instruction causes reset.

Power-on causes reset after voltage stabilizes.

From: Reese/Bruce/Jones, "Microcontrollers: From Assembly to C with the PIC24 Family".