Microcontroller Interfacing Lab

ECE 3720

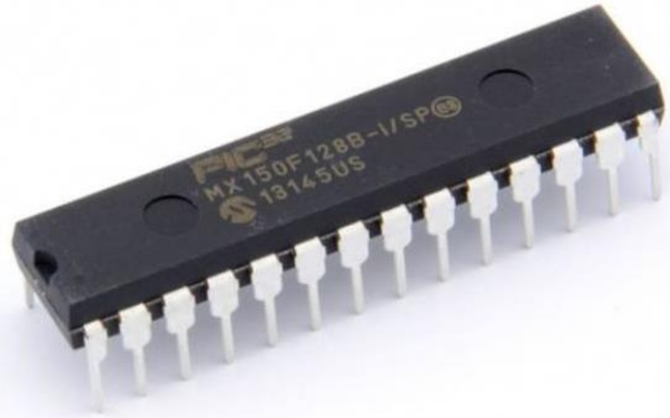
Syllabus

- **Course objective:** Learn about the functionality and modules of a microcontroller, and how to use it to interface with various devices.
- **Attendance/Participation:** must be present and working on lab during the section's meeting time.
- **Pre-Labs:** wiring diagram for upcoming lab
  - https://www.circuit-diagram.org/editor/
- **Post-Labs:** follow outline provided on Canvas
- **Quizzes:** cover material from preceding lab and upcoming lab
  - Of the three weekly assignments, this should be done last
- **Final design project:** design a project that incorporates elements of multiple previous labs
  - More details will be provided closer to the end of the semester

These three assignments will be due before each lab.

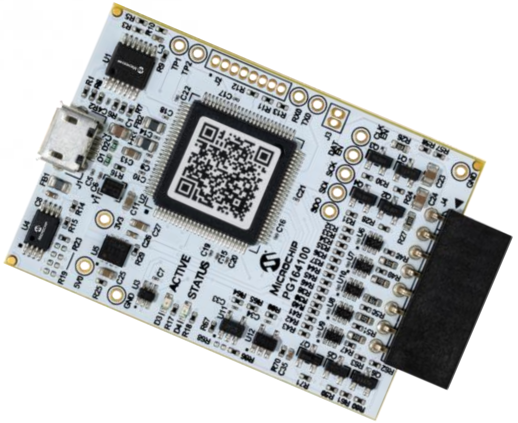
Grade Distribution	
Post-Lab Reports	40%
Pre-Labs	5%
Attendance/Participation	15%
Quizzes	15%
Design Project	25%

Equipment



PIC32MX150F128B
Microcontroller IC

Analog Discovery 2 (AD2)
Will be used to supply power, inputs, and outputs for the MC



MPLAB Snap Debugger
Allows programming of the MC with MPLAB X IDE

Software Development Environment

MPLAB X will be used to write and compile code, and load the executable onto the microcontroller

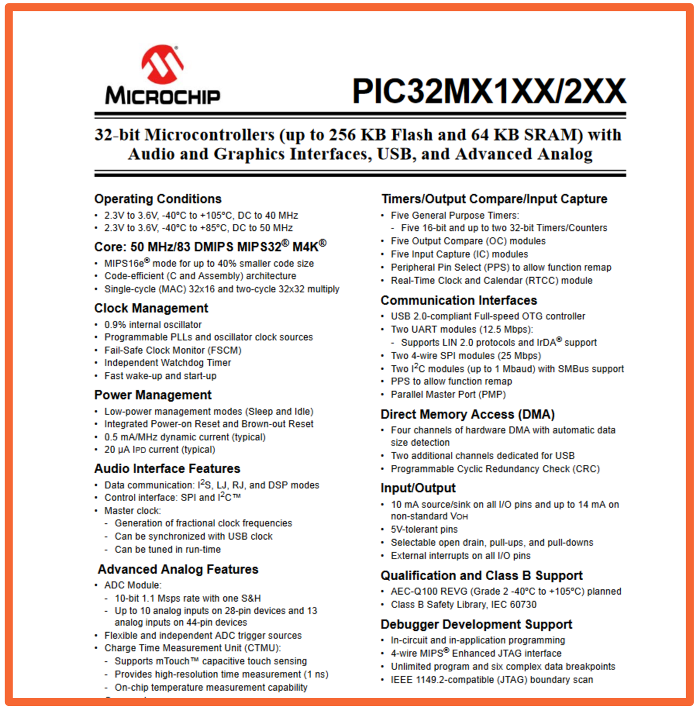
What is MPLAB X IDE?

MPLAB® X IDE IS A SOFTWARE PROGRAM THAT IS USED TO DEVELOP APPLICATIONS FOR MICROCHIP MICROCONTROLLERS AND DIGITAL SIGNAL CONTROLLERS.

This development tool is called an Integrated Development Environment, or IDE, because it provides a single integrated "environment" to develop code for embedded microcontrollers. MPLAB X IDE incorporates powerful tools to help you discover, configure, develop, debug and qualify your embedded designs. MPLAB X IDE works seamlessly with the MPLAB development ecosystem of software and tools, many of which are completely free.

MPLAB X user's guide, pg. 7

Documentation



MICROCHIP

PIC32MX1XX/2XX

32-bit Microcontrollers (up to 256 KB Flash and 64 KB SRAM) with Audio and Graphics Interfaces, USB, and Advanced Analog

Operating Conditions

- 2.3V to 3.6V, -40°C to +105°C, DC to 40 MHz
- 2.3V to 3.6V, -40°C to +85°C, DC to 50 MHz

Core: 50 MHz/83 DMIPS MIPS32® M4K®

- MIPS16e® mode for up to 40% smaller code size
- Code-efficient (C and Assembly) architecture
- Single-cycle (MAC) 32x16 and two-cycle 32x32 multiply

Clock Management

- 0.9% internal oscillator
- Programmable PLLs and oscillator clock sources
- Fail-Safe Clock Monitor (FSCM)
- Independent Watchdog Timer
- Fast wake-up and start-up

Power Management

- Low-power management modes (Sleep and Idle)
- Integrated Power-on Reset and Brown-out Reset
- 0.5 mA/MHz dynamic current (typical)
- 20 µA I_{PD} current (typical)

Audio Interface Features

- Data communication: I²S, LJ, RJ, and DSP modes
- Control interface: SPI and I²C™
- Master clock:
  - Generation of fractional clock frequencies
  - Can be synchronized with USB clock
  - Can be tuned in run-time

Advanced Analog Features

- ADC Module:
  - 10-bit 1.1 Msps rate with one S&H
  - Up to 10 analog inputs on 28-pin devices and 13 analog inputs on 44-pin devices
- Flexible and independent ADC trigger sources
- Charge Time Measurement Unit (CTMU):
  - Supports mTouch™ capacitive touch sensing
  - Provides high-resolution time measurement (1 ns)
  - On-chip temperature measurement capability

Timers/Output Compare/Input Capture

- Five General Purpose Timers:
  - Five 16-bit and up to two 32-bit Timers/Counters
- Five Output Compare (OC) modules
- Five Input Capture (IC) modules
- Peripheral Pin Select (PPS) to allow function remap
- Real-Time Clock and Calendar (RTCC) module

Communication Interfaces

- USB 2.0-compliant Full-speed OTG controller
- Two UART modules (12.5 Mbps):
  - Supports LIN 2.0 protocols and IrDA® support
- Two 4-wire SPI modules (25 Mbps)
- Two I²C modules (up to 1 Mbaud) with SMBus support
- PPS to allow function remap
- Parallel Master Port (PMP)

Direct Memory Access (DMA)

- Four channels of hardware DMA with automatic data size detection
- Two additional channels dedicated for USB
- Programmable Cyclic Redundancy Check (CRC)

Input/Output

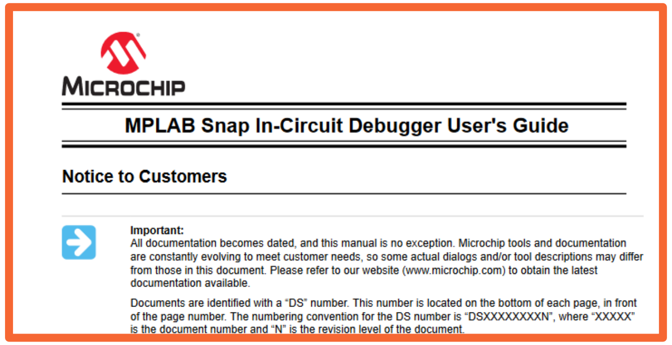
- 10 mA source/sink on all I/O pins and up to 14 mA on non-standard V_{OH}
- 5V-tolerant pins
- Selectable open drain, pull-ups, and pull-downs
- External interrupts on all I/O pins

Qualification and Class B Support

- AEC-Q100 REVG (Grade 2 -40°C to +105°C) planned
- Class B Safety Library, IEC 60730

Debugger Development Support

- In-circuit and in-application programming
- 4-wire MIPS® Enhanced JTAG interface
- Unlimited program and six complex data breakpoints
- IEEE 1149.2-compatible (JTAG) boundary scan



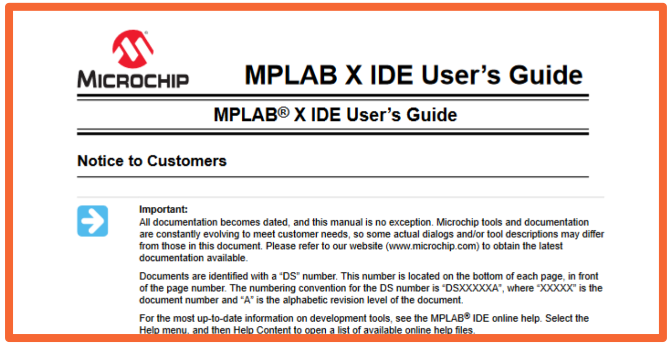
MICROCHIP

MPLAB Snap In-Circuit Debugger User's Guide

Notice to Customers

Important:
All documentation becomes dated, and this manual is no exception. Microchip tools and documentation are constantly evolving to meet customer needs, so some actual dialogs and/or tool descriptions may differ from those in this document. Please refer to our website (www.microchip.com) to obtain the latest documentation available.

Documents are identified with a "DS" number. This number is located on the bottom of each page, in front of the page number. The numbering convention for the DS number is "DSXXXXXXXXN", where "XXXXX" is the document number and "N" is the revision level of the document.



MICROCHIP

MPLAB X IDE User's Guide

MPLAB® X IDE User's Guide

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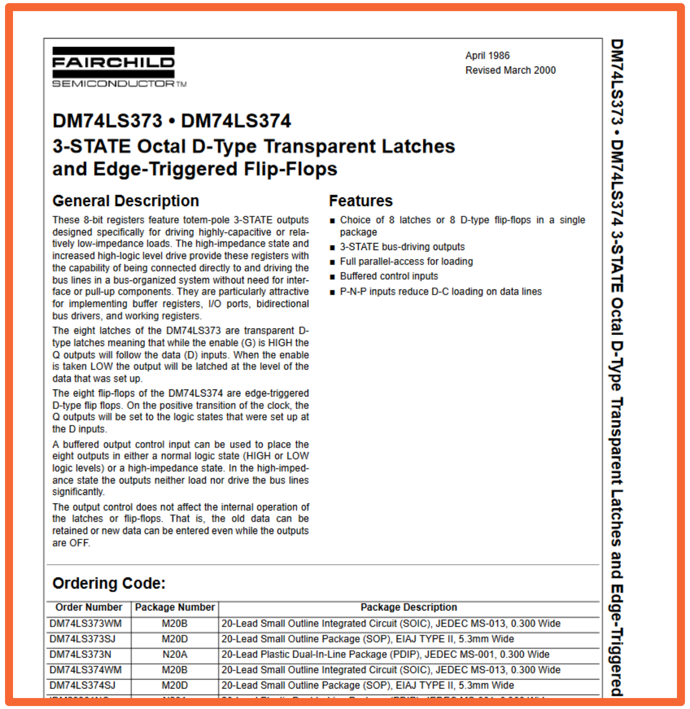
For the most up-to-date information on development tools, see the MPLAB® IDE online help. Select the Help menu, and then Help Content to open a list of available online help files.



FAIRCHILD SEMICONDUCTOR™

April 1986
Revised March 2000

DM74LS373 • DM74LS374
3-STATE Octal D-Type Transparent Latches and Edge-Triggered Flip-Flops

General Description

These 8-bit registers feature totem-pole 3-STATE outputs designed specifically for driving highly-capacitive or relatively low-impedance loads. The high-impedance state and increased high-logic level drive provide these registers with the capability of being connected directly to and driving the bus lines in a bus-organized system without need for interface or pull-up components. They are particularly attractive for implementing buffer registers, I/O ports, bidirectional bus drivers, and working registers.

The eight latches of the DM74LS373 are transparent D-type latches meaning that while the enable (G) is HIGH the Q outputs will follow the data (D) inputs. When the enable is taken LOW the output will be latched at the level of the data that was set up.

The eight flip-flops of the DM74LS374 are edge-triggered D-type flip flops. On the positive transition of the clock, the Q outputs will be set to the logic states that were set up at the D inputs.

A buffered output control input can be used to place the eight outputs in either a normal logic state (HIGH or LOW logic levels) or a high-impedance state. In the high-impedance state the outputs neither load nor drive the bus lines significantly.

The output control does not affect the internal operation of the latches or flip-flops. That is, the old data can be retained or new data can be entered even while the outputs are OFF.

Features

- Choice of 8 latches or 8 D-type flip-flops in a single package
- 3-STATE bus-driving outputs
- Full parallel-access for loading
- Buffered control inputs
- P-N-P inputs reduce D-C loading on data lines

Ordering Code:

Order Number	Package Number	Package Description
DM74LS373WM	M20B	20-Lead Small Outline Integrated Circuit (SOIC), JEDEC MS-013, 0.300 Wide
DM74LS373SJ	M20D	20-Lead Small Outline Package (SOP), EIAJ TYPE II, 5.3mm Wide
DM74LS373N	N20A	20-Lead Plastic Dual-In-Line Package (PDIP), JEDEC MS-001, 0.300 Wide
DM74LS374WM	M20B	20-Lead Small Outline Integrated Circuit (SOIC), JEDEC MS-013, 0.300 Wide
DM74LS374SJ	M20D	20-Lead Small Outline Package (SOP), EIAJ TYPE II, 5.3mm Wide

DM74LS373 • DM74LS374 3-STATE Octal D-Type Transparent Latches and Edge-Triggered

PIC32 Datasheet

For information about the modules and registers of the microcontrollers

MPLAB and SNAP User's Guides

For additional info on programming the PIC32

Other Datasheets

Describe pinout and behavior of the devices used in each lab

Lab 1: Intro

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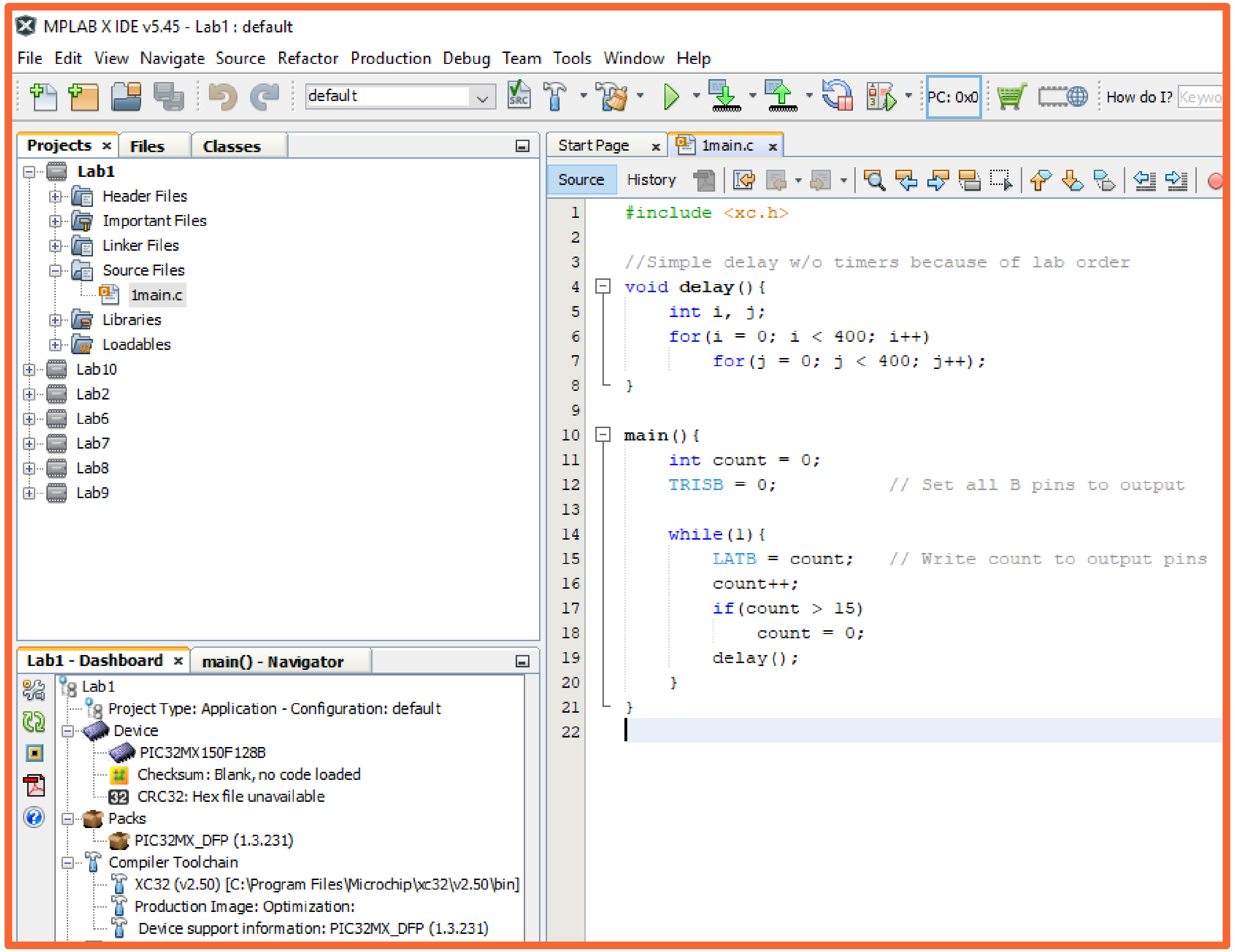
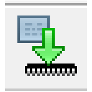
Lab 1 Program

- Navigate to the *Lab 1* module in Canvas and download *Lab1.X.zip*
- Extract the *Lab1.X* project folder to your profile.
- Open MPLAB X, then click *File > Open Project…* and select and open the project.
- Under the *Projects* tab on the left side of the screen, expand *Lab1* and *Source Files*. You should see *1main.c*. Double-click on it to open it.
- Observe how this program counts from 0 to 15, outputting the value on Port B
  - Lab 2 will cover the details of how this works.

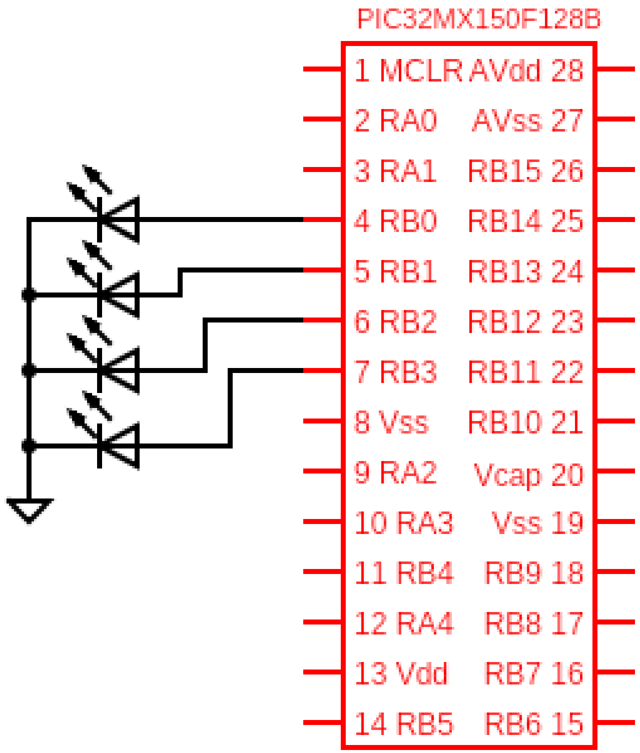


Programming the Microcontroller

- Click the hammer icon () to confirm the program will build.
    - Look for the green *Build Successful* text.
- Connect the SNAP to the appropriate pins of the PIC32 and plug the SNAP into your computer's USB port.
    - Refer to the *Setup for Programming the PIC32* document for guidance on how to wire the SNAP.
    - **Note that the PIC32 must be powered on to be programmed.**
- To load the program onto the microcontroller, click *Make and Program Device* ().
    - If asked to choose a device, look for the SNAP debugger at the bottom of the list.
    - Watch the output window to see when the process is complete (it may take a while the first time).
    - Notice that the program is built as part of this process.

Lab 1 Wiring

- Refer to the *Setup for Programming the PIC32* for how to wire the PIC32 for power and programming.
  - Only the wiring specific to Lab 1 is shown in the diagram here.
  - Similarly, your pre-labs will only need to show the wiring unique to that lab.
- Pins 4-7 should be connected to the AD2 to display the output.
  - These pins correspond to the 4 least-significant bits of Port B.



Note that you will not be given the wiring for future labs. The slides will provide a simple diagram showing the inputs and outputs, and you will have to submit a more detailed diagram as your pre-lab.

Lab 1 Modification

Once you have the program running on your microcontroller, attempt the following:

- Modify the code to count backwards, looping from 0 back up to 15.
- Modify *delay* to take a longer or shorter period of time.