A Leading Provider of Microcontroller, Security, Mixed-Signal, Analog & Flash-IP Solutions

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December 6, 2018

Easy to install and Easy-to-use Arduino® Compatible chipKIT® Platform for Beginners

Agenda

Presentation will introduce software constructs and concepts:

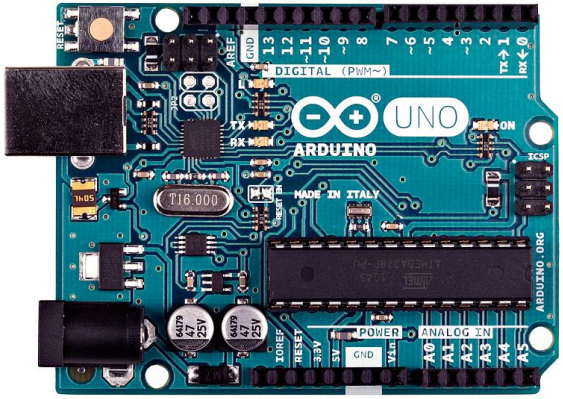
- **Arduino®/chipKIT®: What are they?**
- **Arduino IDE quick start**
- **Demo #1: Get blinky lights working**
- **Demo #2: Built in Serial I/O**
- **Using libraries**
- **How to debug a sketch with MPLAB® X Integrated Development Environment (IDE)**

Arduino®/chipKIT®: What are they?

- Both are rapid prototyping platforms
- Compatible with each other at source code and physical interface level
- Fills need for beginners to quickly construct simple microcontroller-based designs (and many more)

Arduino Beginnings

"Arduino is an open-source electronics prototyping platform based on flexible, easy-to-use hardware and software. It's intended for artists, designers, hobbyists, and anyone interested in creating interactive objects or environments."



What is Arduino Now?

- **An environment for learning embedded systems**
- **A huge ecosystem**
  - Boards and extension shields
  - Thousands of libraries
  - Projects, web pages, videos
  - IDEs (PC and web-based)
- **Learning tool for most beginners**
  - THE de facto embedded teaching tool

Arduino Vocabulary

- **Sketch**
  - Source code/program in C/C++
- **Shield**
  - An add-on board to extend functionality
  - Standard pinout – function and layout
- **Hardware Abstraction Layer**
  - Eliminates need to know hardware details
  - Refers to pins in a standard way

chipKIT Platform Project Goals

- Start with Arduino compatibility
- Use powerful 32-bit PIC32 processors
- Remain open and inviting to all developers who want to contribute – hardware or software
- Continue to improve core Arduino libraries to be higher quality, more feature rich
- Create variety of board offerings - some with physical Arduino compatibility - all easy to use
- Continue to add high-performance libraries for PIC32 peripherals

chipKIT Platform Core Software

- **Includes:**
  - Compiler tool chain
  - Standard Arduino libraries
  - Contributed libraries (e.g., SoftPWMServo, DSPI)
- **A modular distribution:**
  - For use in many different IDEs
  - Provides hardware abstraction benefits

Demo #1
Blink that LED

Demo #1 Objective/Procedure

Demonstrate how simple it is to use the Arduino IDE by writing, compiling and uploading LED blink code into the chipKIT development board.

- Open Arduino IDE
- Write code
- Select proper development board target
- Put chipKIT board into bootloader mode
- Compile, upload, and run

Arduino IDE

- **Open Arduino IDE from desktop**

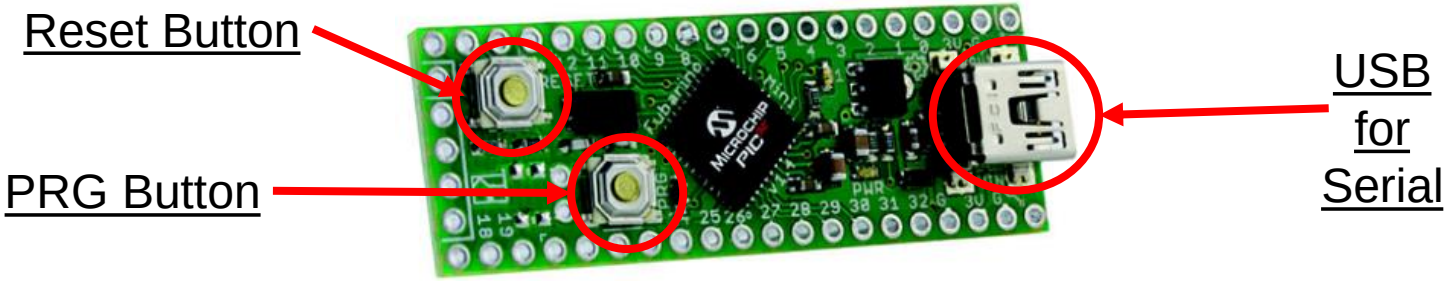
Add some code

- **Select File -> New**
- **Make your source code look like this:**

```
void setup() {
  pinMode(LED_BUILTIN, OUTPUT);
}
void loop() {
  digitalWrite(LED_BUILTIN, HIGH);
  delay(1000);
  digitalWrite(LED_BUILTIN, LOW);
  delay(1000);
}
```

Prepare for the Upload

- **Select Tools -> Board -> Fubarino® Mini**
- **Activate the bootloader**
  - Press and hold PRG (program) button while pressing and releasing RESET

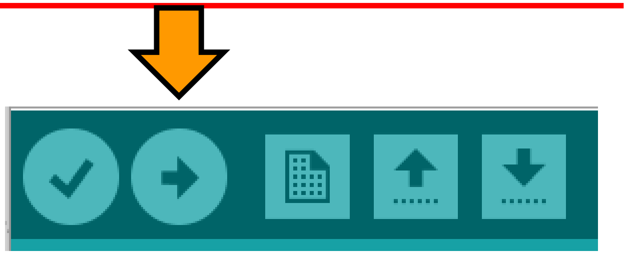


chipKIT™ Fubarino Mini

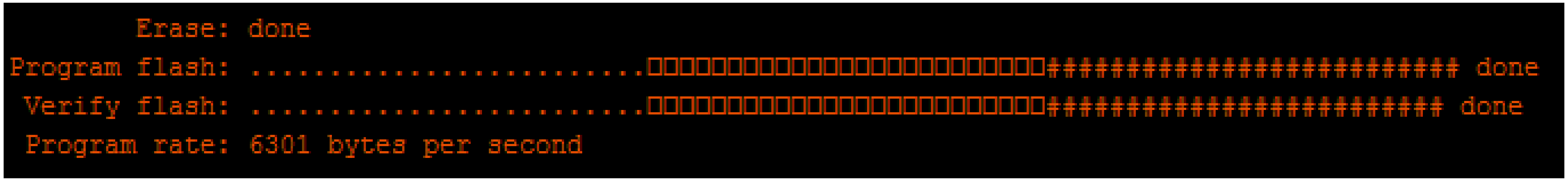
  - Should see fast blinking green LED = bootloader mode active

Compile, Program and Run

- Click the Upload button



- Arduino IDE will compile your sketch
- Arduino IDE will upload the sketch



```
        Erase: done
Program flash: .........................□□□□□□□□□□□□□□□□□□□□□□□□□########################## done
 Verify flash: .........................□□□□□□□□□□□□□□□□□□□□□□□□□######################### done
 Program rate: 6301 bytes per second
```

- Confirm that your green LED is blinking 1000 ms on, 1000 ms off

Basic Sketch

- **An Arduino program is called a sketch**
- **Language used is C++**
- **Embedded program event loop is built into the system**
- **Two required functions**
  - `setup()` – one time initialization
  - `loop()` – called repeatedly by system

Writing the Sketch

- **Every sketch must include:**

```
void setup() {
  // put your setup code here, to run once:

}

void loop() {
  // put your main code here, to run repeatedly:

}
```

Compiling

- **The sketch needs to be converted into a form that can be executed on the board**
- **After writing the sketch:**
  - The user presses the upload button
  - The sketch is compiled and a hex file is created
  - The hex file is uploaded to dev board using command-line program pic32prog
  - Any compile or upload errors are reported in the IDE output window

Bootloader

- **All chipKIT boards come pre-programmed with a bootloader**
- **Arduino IDE uses this bootloader to upload (program) the hex file to the board**
  - Replaces the need for a hardware programmer
- **There are two basic kinds of chipKIT boards:**
  - Automatic reset through on-board FTDI chip
  - Manual reset via PROGRAM button

Code – Blink LED

```
// the setup function runs once when you press reset or power the board
void setup() {
  // initialize digital pin LED_BUILTIN as an output.
  pinMode(LED_BUILTIN, OUTPUT);
}

// the loop function runs over and over again forever
void loop() {
  digitalWrite(LED_BUILTIN, HIGH);   // turn the LED on (HIGH is the voltage level)
  delay(1000);                       // wait for a second
  digitalWrite(LED_BUILTIN, LOW);    // turn the LED off by making the voltage LOW
  delay(1000);                       // wait for a second
}
```

Summary

- **Experience ArduinoIDE workflow**
  - Enter new sketch
  - Compile and upload to chipKIT® board
- **Basic code template**
- **Basic Arduino Hardware Abstraction Library (HAL) concepts**
  - Set pin as output
  - Set output pin state
  - Create time delay

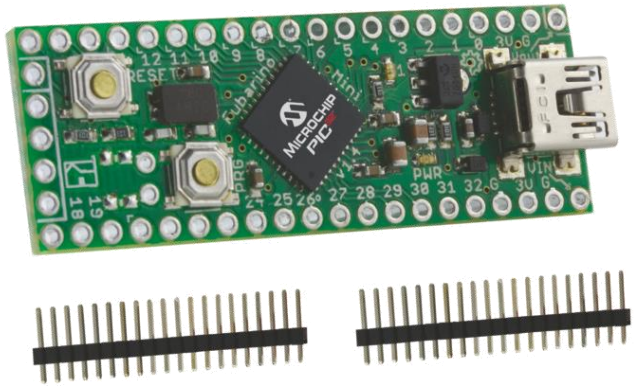
Why Use chipKIT Platform?

- **A PIC32-based, open-source software and hardware platform**
  - Compatible with Arduino code and add-on boards
- **Software tools to build, load and run Arduino sketches**
- **A diverse community of contributors, developers, and users**
  - More than just Digilent or Microchip

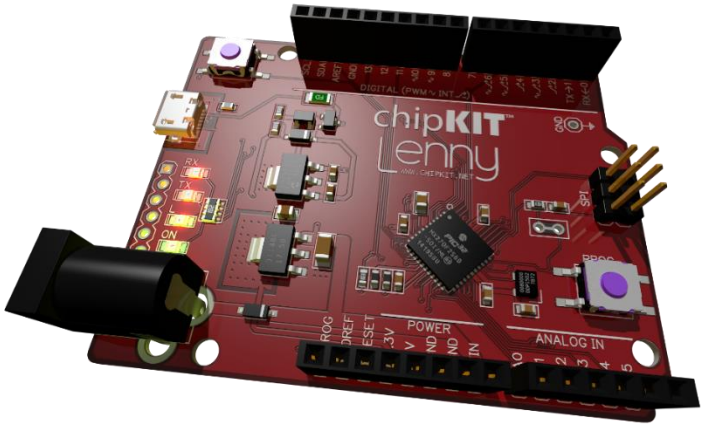
Some chipKIT Boards

uC32

Wi-FIRE

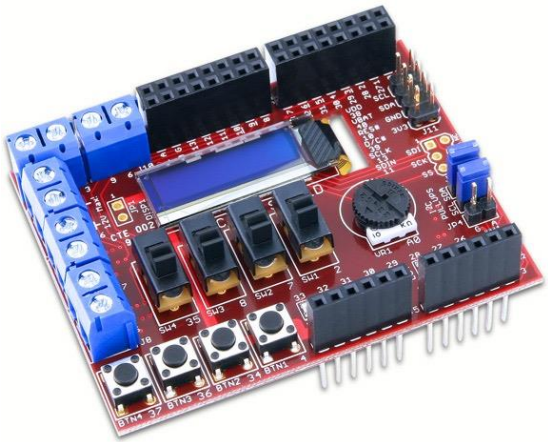


Fubarino® Mini



Lenny

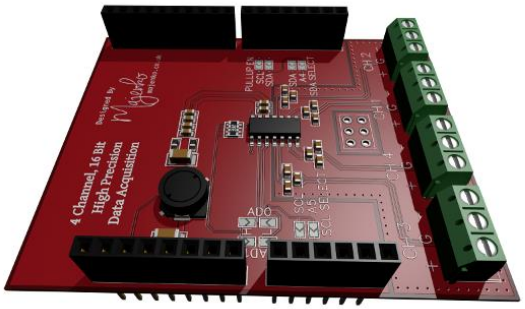
chipKIT Shields



Basic I/O Shield

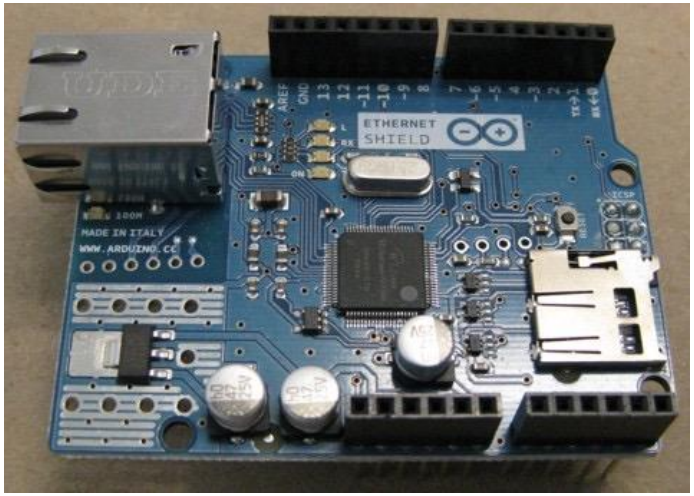
Wi-Fi® Shield

Quick IO Shield

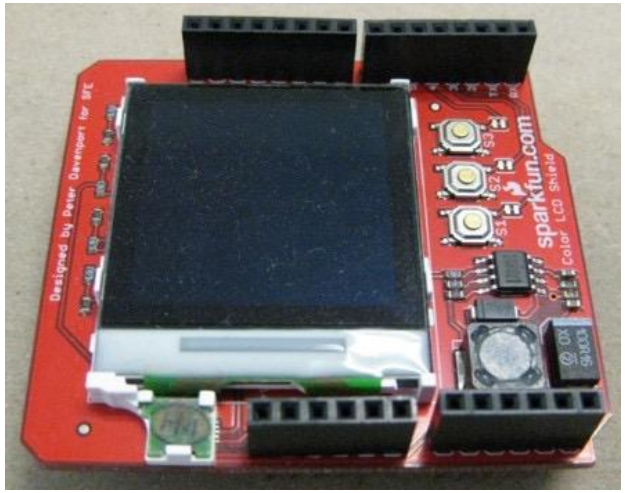


High Precision DAQ Shield

Some Arduino® Shields



Ethernet Shield



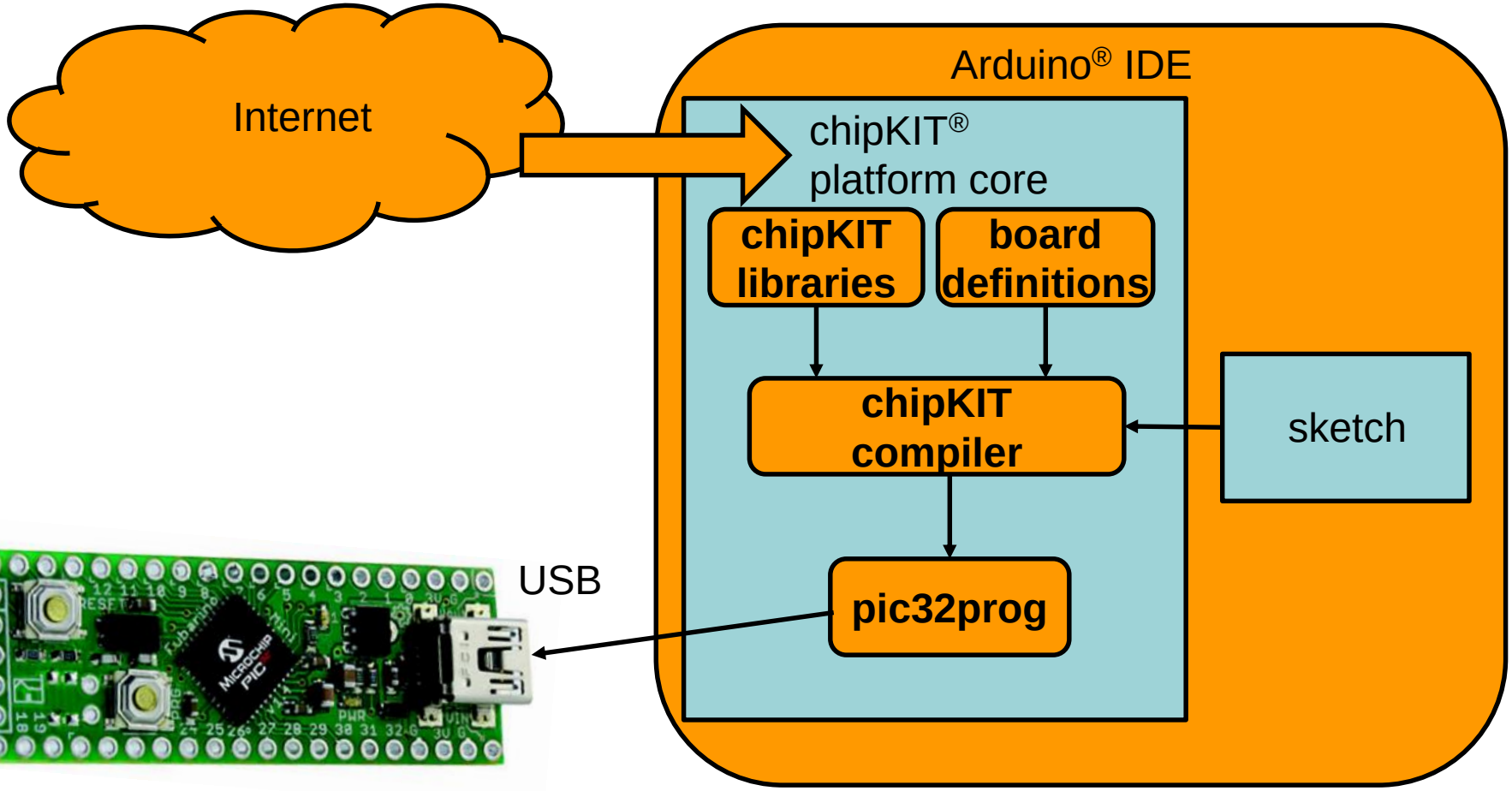
Graphic Display Shield

An enormous number of Arduino shields are suitable for use with chipKIT® boards, but you must mind your voltage levels.

Motor Drive Shield

Arduino® and ChipKIT® Software Environment

Software Architecture



chipKIT® board

chipKIT® Platform Core Software

- **Major components**
  - Compiler tool chain
  - Standard Arduino® libraries
  - Contributed libraries (e.g. SoftPWMServo, DSPI)
- **A modular distribution**
  - For use in many different IDEs
  - Provides hardware abstraction benefits

HAL Pins chipKIT® Hardware -> PIC32

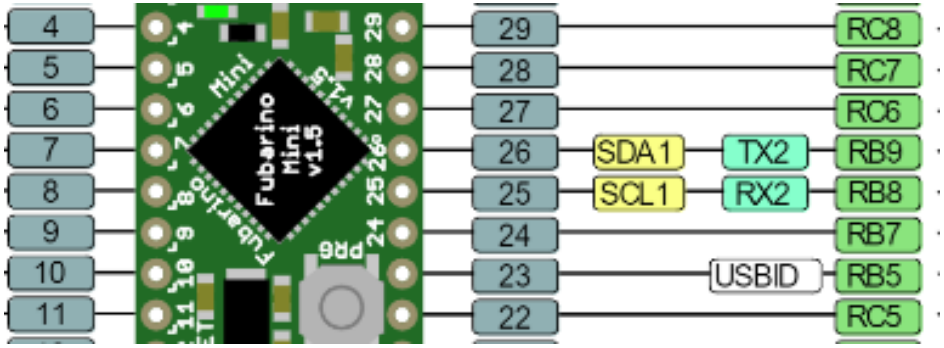
- **Every pin is given a ‘chipKIT’ number**
- **This is the only number needed in the code**

chipKIT Pin	PIC32 Pin	Port/Pin	Function
26	1	RB9	RPB9/SDA1/CTED4/PMD3/RB9

- **No need to worry about port or PIC32 pin**

```
pinMode(26, OUTPUT);
digitalWrite(26, HIGH);

TRISBbits.TRISB9 = 0;
LATBbits.LATB9 = 1;
```



Supported Toolchains

- **Arduino® IDE**
  - Supports many third-party plug-ins, including chipKIT® technology core
- **UECIDE**
  - Similar to Arduino IDE, but substantially rewritten and improved, supports chipKIT technology core
- **MPIDE**
  - An early fork of Arduino IDE, w/ chipKIT technology core built-in
  - Archived in August 2015
- **Other Sketch-Enabled Environments**
  - EmbedXcode, Visual Micro, PlatformIO, etc.
- **MPLAB® X IDE**
  - NetBeans-based professional IDE (Win, Mac, Linux)
  - Supports chipKIT hardware; sketch support (see advanced class)

MPLAB® Harmony vs. chipKIT® Platform

- **All chipKIT boards can be used directly with MPLAB X IDE and MPLAB Harmony Framework**
  - MPLAB X IDE and XC32 C/C++
  - MPLAB programmer and debugger tools
- **Note: MPLAB Harmony and chipKIT development environments are completely different**
  - Source code is not directly compatible

Programming Concepts

Programming Model

Remember: The sketch implements two required functions

```
void setup() {
  // put your setup code here, to run once:

}

void loop() {
  // put your main code here, to run repeatedly:

}
```

Programming Model

Core library adds this code behind the scenes

```
int main(void) {
  init();      // system initialization

  setup();    // sketch initialization

  while (1) {
    loop();  // sketch main loop
  }
  return 0;
}
```

Core Runtime Functions

`pinMode(pin, dir)`

- Sets pin direction and drive type

`digitalRead(pin)`

- Reads the state of a digital pin

`digitalWrite(pin, val)`

- Sets a digital pin to specified state

`delay(ms)`

- Delay for specified number of milliseconds

Example: How to Dim an LED

```
#include "SoftPWMServo.h"

// LED on pin 1 (built-in green LED on FBMini)
const int pinLed = LED_BUILTIN;
//assume pot on analog 2 (pin 4 on FBMini)
const int pinPot = A2;

void setup() {   //nothing needed
}

void loop() {
  int val;
  val = analogRead(pinPot);
  SoftPWMServoPWMWrite(pinLed, val/(1024/256));
  delay(100);
}
```

Hardware Serial

`Serial.begin(baud)`

- Initialize the UART and set the baud rate

`Serial.print(val)`

- Print the specified value to UART

`Serial.read()`

- Read characters from UART

Demo #2:
Serial Monitor

Activity

Send serial data output from chipKIT® board back to PC over USB, then view using the **Arduino®** IDE Serial Monitor

- **helloserial sketch**

Code – Hello World

```
void setup() {
  Serial.begin(9600);  // initialize UART
  delay(5000);
}

void loop() {
  Serial.println();
  Serial.println("Hello World!");
  for (int i = 1; i <= 10; i++) {
    Serial.print(" i = ");
    Serial.println(i, DEC);
  }
  delay(5000);          //wait five seconds
}
```

Summary

- **Display text output to PC over USB using Arduino® IDE Serial Monitor**

Using Libraries

Adding Libraries

- **Use built-in Library Manager to search for and install extra libraries**

- **Some libraries are not available in Library Manager; instead download zip file from GitHub repo or website**

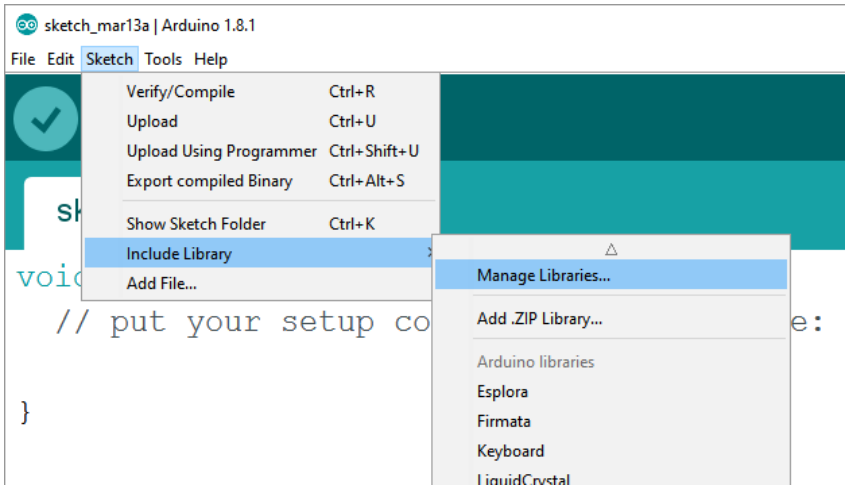
- **Adafruit DotStar Library: We will use this one to control our LED strip**

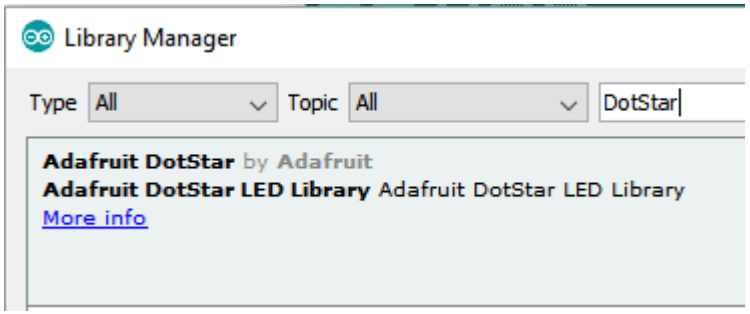
Using Libraries

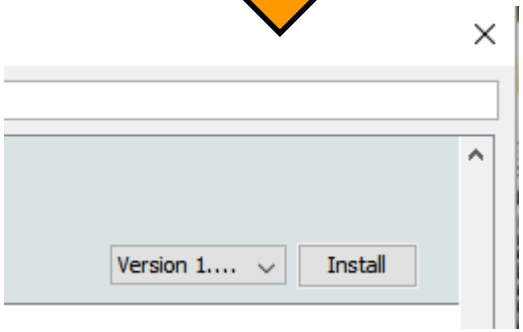
- **Pre-written libraries provide additional functionality**
- **If you add hardware to your design, there are often libraries available to help make use of the hardware**
- **Use** `#include <libraryname>` **to add a library to your sketch**
- **chipKIT® technology core includes highly optimized libraries for PIC32**

Example: Library Manager

Adafruit DotStar Library







How to Debug a Sketch with MPLAB® X

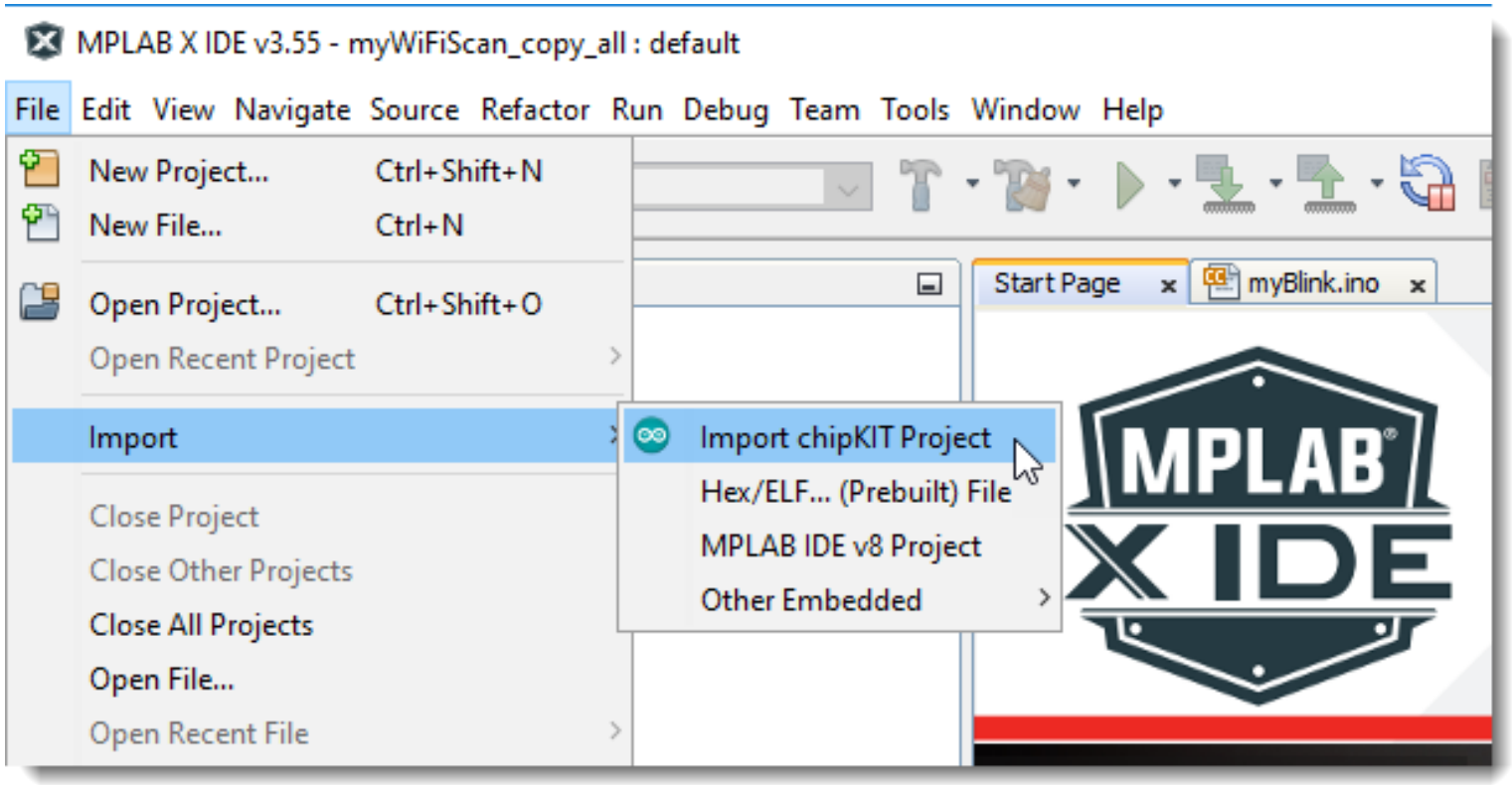
- Introduction to chipKIT® sketch importer for MPLAB X IDE
- Importing a sketch into MPLAB X IDE
- Uploading
- Debugging

chipKIT® Sketch Importer

- Takes existing sketches from Arduino® IDE
- Creates MPLAB® X IDE project, includes all code
- ‘default’ configuration – serial bootloading
- ‘debug’ configuration – hardware debugging

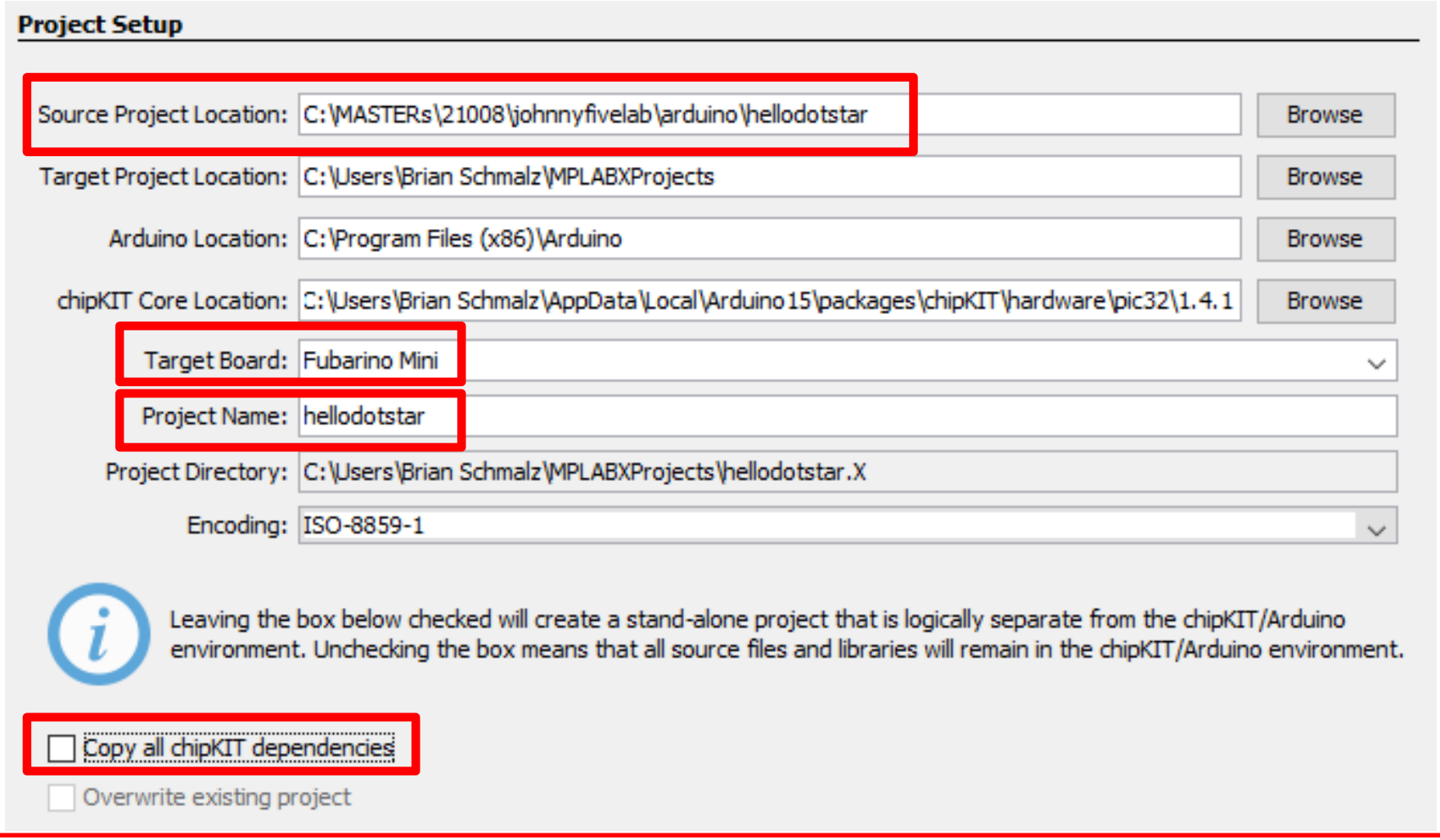
Importing chipKIT® Sketches

- **The plugin installs an Import Wizard under the File menu**

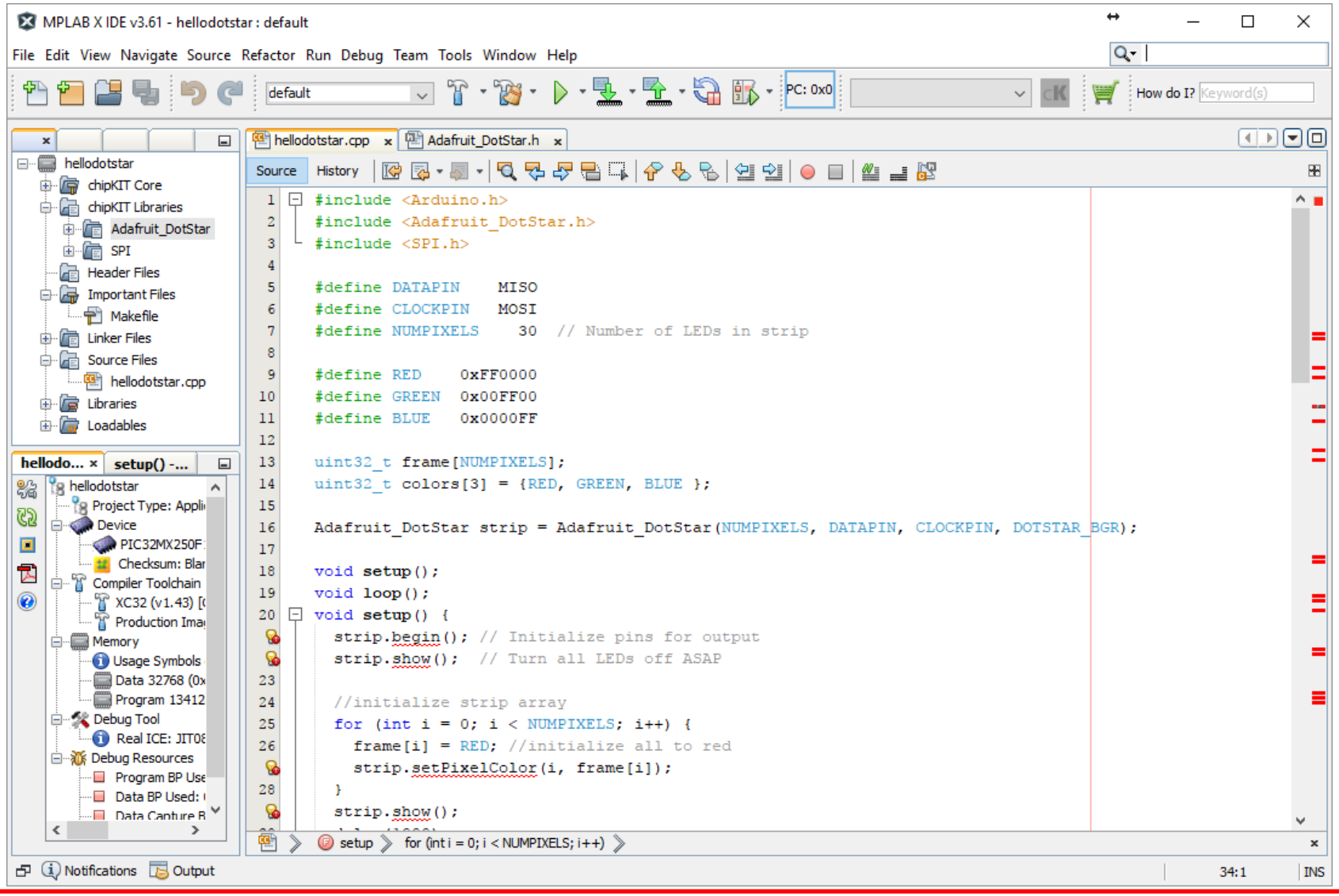


Importing chipKIT® Sketches

- **Specify sketch, Arduino® directory, and target board**



Build/Debug in MPLAB® X IDE



Debugging/Breakpoints

MPLAB X IDE v3.61 - hellodotstar : debug

File Edit View Navigate Source Refactor Run Debug Team Tools Window Help

debug | PC: 0x9D004784 | How do I? | 362.8/1020MB

hellodotstar
- chipKIT Core
- chipKIT Libraries
  - Adafruit_DotStar
  - SPI
- Header Files
- Important Files
  - Makefile
- Linker Files
- Source Files
  - hellodotstar.cpp
- Libraries

hellodotstar.cpp

Source | History

```
55
56    for (int i = 0; i <= NUMPIXELS; i++) {
57      if (i == 0) {
58        frame[i] = 0xFFFFFF;
        strip.setPixelColor(i, frame[i]);
        strip.show();
61      delay(100);
62      }
63      else {
64        frame[i - 1] = 0x000000;
65        frame[i] = 0xFFFFFF;
        strip.setPixelColor(i - 1, frame[i - 1]);
        strip.setPixelColor(i, frame[i]);
        strip.show();
69      delay(100);
70      }
71
72      for (int i = NUMPIXELS; i < 0; i--) {
73        if (i == 30) {
74          frame[i] = 0xFFFFFF;
          strip.setPixelColor(i, frame[i]);
          strip.show();
77        delay(100);
78        }
79        else {
80          frame[i + 1] = 0x000000;
```

loop > for (int i = 0; i <= NUMPIXELS; i++) > if (i == 0) > else > strip.

Variables

Name	Value
frame[15]	0x00000000
frame[16]	0x00000000
frame[17]	0x00000000
frame[18]	0x00000000
frame[19]	0x00FFFFFF
frame[20]	0x00000000
frame[21]	0x00000000
frame[22]	0x00000000
frame[23]	0x00000000
frame[24]	0x00000000
frame[25]	0x00000000

Call Stack

Name
- loop () at c:/users/brian schmalz/mplabxprojects/hell
- main () at c:/users/brian schmalz/mplabxprojects/hellodotstar.x/
- Unknown function () at C:/Users/Brian Schmalz/MPLABXProjects/

Notifications | Output | Watches | hellodotstar (Build, Load, ...) | debugger halted | 66:39/1:5 | INS

Further Information

- **The chipKIT® platform advanced class contains complete information on how to install and use the chipKIT importer plugin, along with many other advanced topics**

Summary

- Provided overview of chipKIT® platform and how it relates to Arduino®
- Learned how to write, compile, load and execute sketches
- Explored basic I/O operations, including digital, analog, serial and LED animation
- Examined debugging sketch from within MPLAB® X IDE
- Experienced wonder and excitement at PIC32 power coupled with Arduino ease of use

Appendix

Resources

- **chipKIT® Platform web site**

  http://chipkit.net

  http://chipkit.net/wiki

  http://chipkit.net/forum

- **Fubarino® Site**

  http://fubarino.org

- **Arduino®**

  https://www.arduino.cc/

chipKIT® Cores and IDEs

- **chipKIT core: How to Install in Arduino® IDE**

  http://chipkit.net/wiki/index.php?title=ChipKIT_core

- **UECIDE**

  http://uecide.org

- **Others:**
  - PlatformIO – http://platformio.org
  - Visual Micro – http://www.visualmicro.com
  - EmbedXcode – http://embedxcode.weebly.com

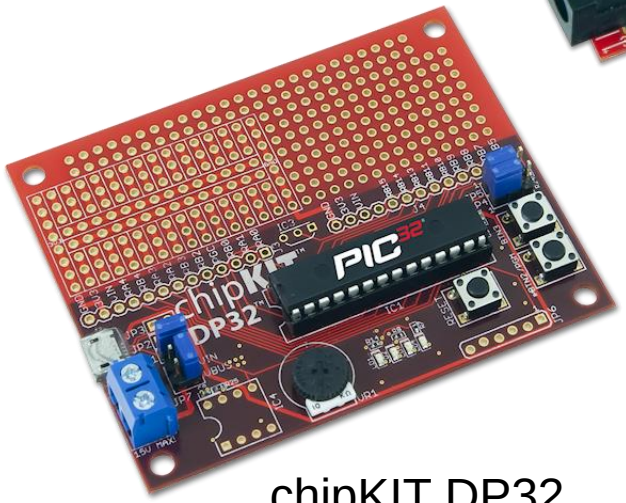
- **MPLAB X® IDE**

  http://www.microchip.com/mplabx

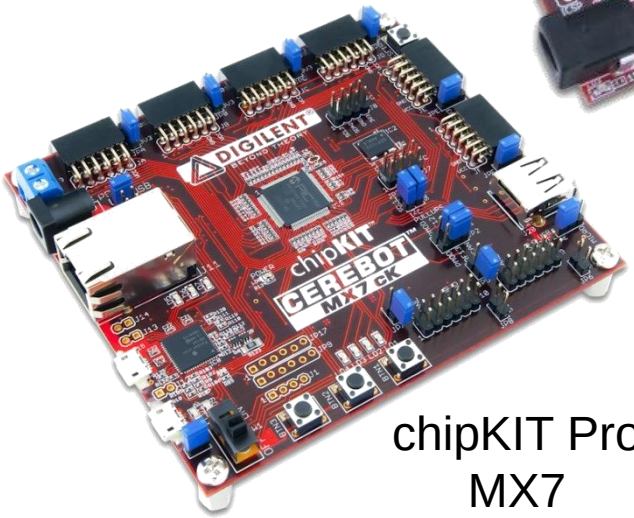
More chipKIT® Boards

chipKIT Wi•FIRE

chipKIT MAX32



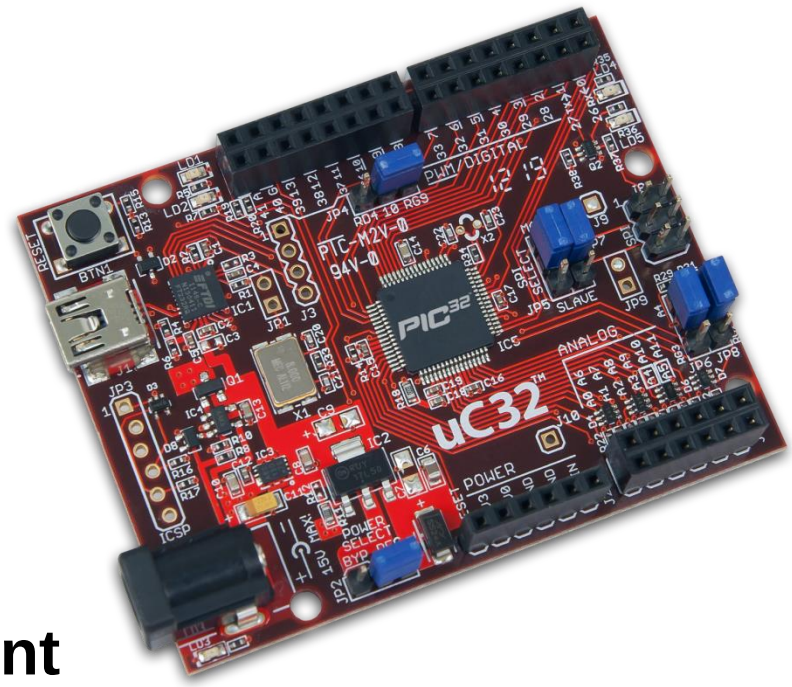
chipKIT DP32



chipKIT Pro MX7

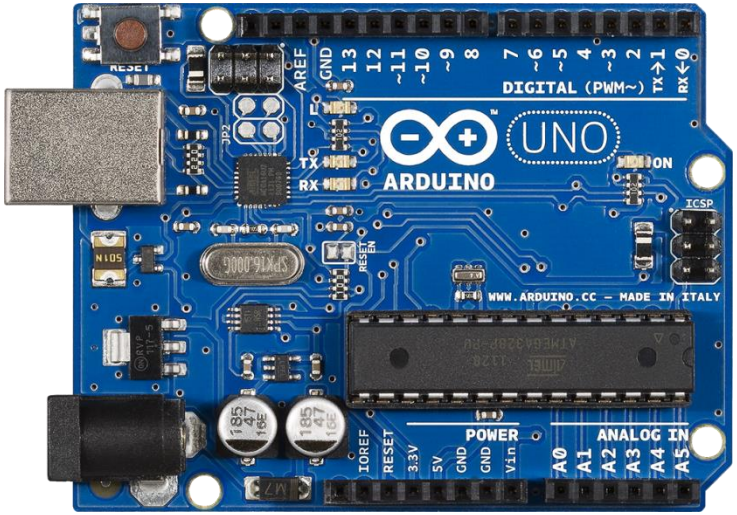
chipKIT® uC32 Board

- **Microchip PIC32MX340F512H**
  - 80 MHz 32-bit MIPS
  - 512K Flash
  - 32K SRAM
- **Arduino® Uno form factor**
- **42 available I/O pins**
- **Two user LEDs**
- **12 analog inputs**
- **75 mA typical operating current**
- **20V input voltage (maximum)**
- **0V to 3.3V analog input voltage range**
- **+/-18 mA DC current per pin**



Arduino® Uno

- ATmega328
- 32K flash, 2K RAM, 1K EEPROM
- 22 I/O pins
- 1 UART
- 1 SPI
- 1 I^2C
- 6 10-bit A/D inputs
- 6 output compare/PWMs

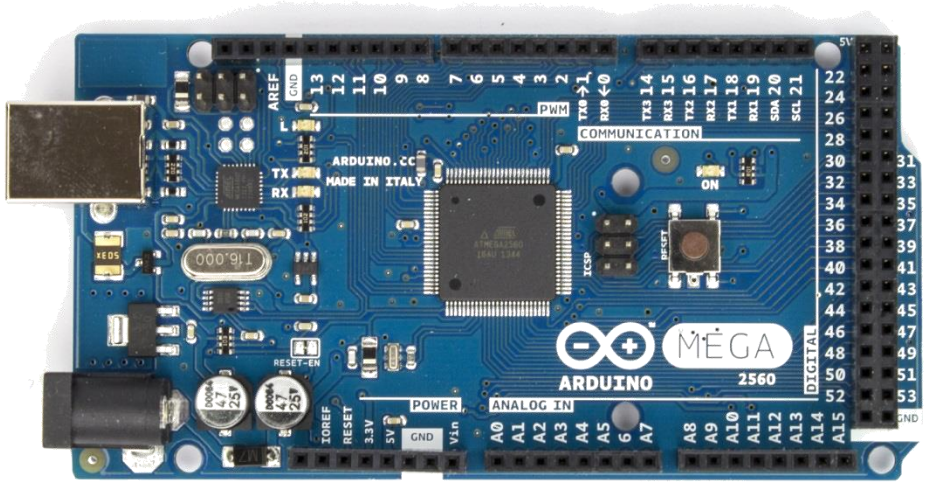


chipKIT® Max32

- PIC32MX795F512L
- 512K flash, 128K RAM
- 83 I/O pins
- 4 UARTs, 1 SPI, 2 I^2Cs
- 16 10-bit A/D inputs
- 5 output compare/PWMs
- USB 2.0 OTG controller
- 10/100 Ethernet MAC
- Dual CAN controllers

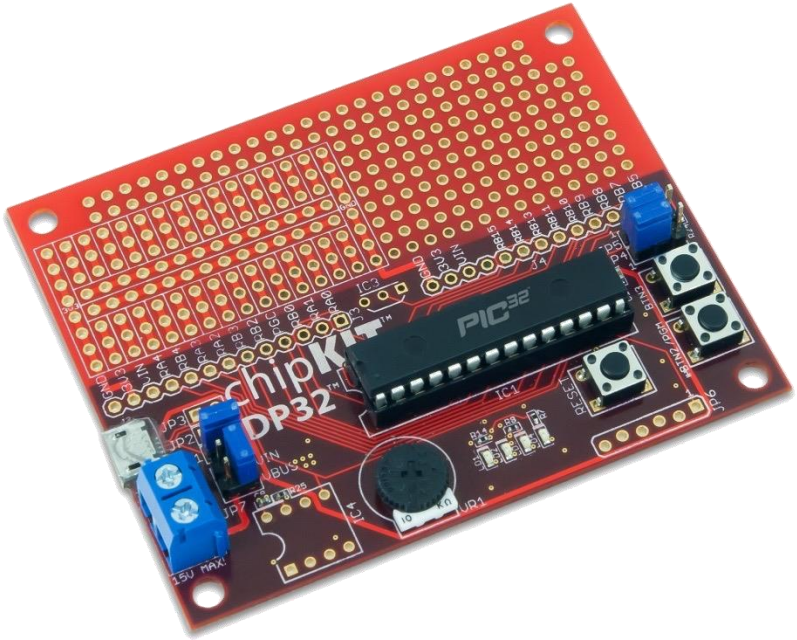
Arduino® Mega 2560

- ATmega2560
- 256K flash, 8K RAM, 4K EEPROM
- 70 I/O pins
- 4 UARTs
- 1 SPI
- 1 I^2C
- 16 10-bit A/D inputs
- 16 output compare/PWMs
- 16 pins left unconnected

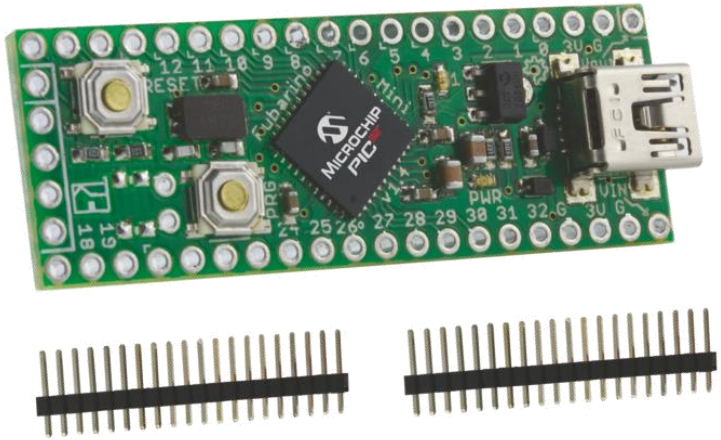


chipKIT® DP32 Board

- **Microchip PIC32MX250F128B**
  - 40/50 MHz 32-bit MIPS
  - 128K Flash
  - 32K SRAM
- **19 available I/O pins**
- **Four LEDs, two push-buttons**
- **9 analog inputs**
- **Potentiometer**
- **Wire-wrap prototype area**
- **Provision for an SPI EEPROM and an analog temperature sensor**
- **Mounting Hole compatible with Hammond 1591XXSSBK project box**



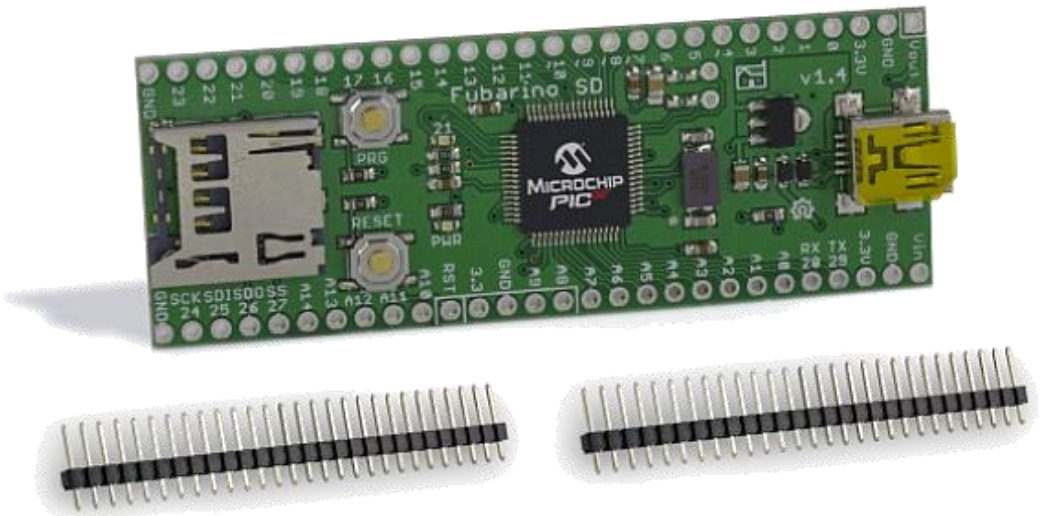
chipKIT® Fubarino® Mini



- **PIC32MX250F128D-50I/ML**
  - 48 MHz operation
  - 128K flash
  - 32K RAM
- **DIP form factor**
- **Max 33 I/O pins (normally 27)**
- **Pads for 32 kHz crystal**
- **Comes with headers (not installed) for easy mounting on a breadboard**
- **Two buttons: RESET for resetting the board, and PRG for getting into bootloader mode and user application use**

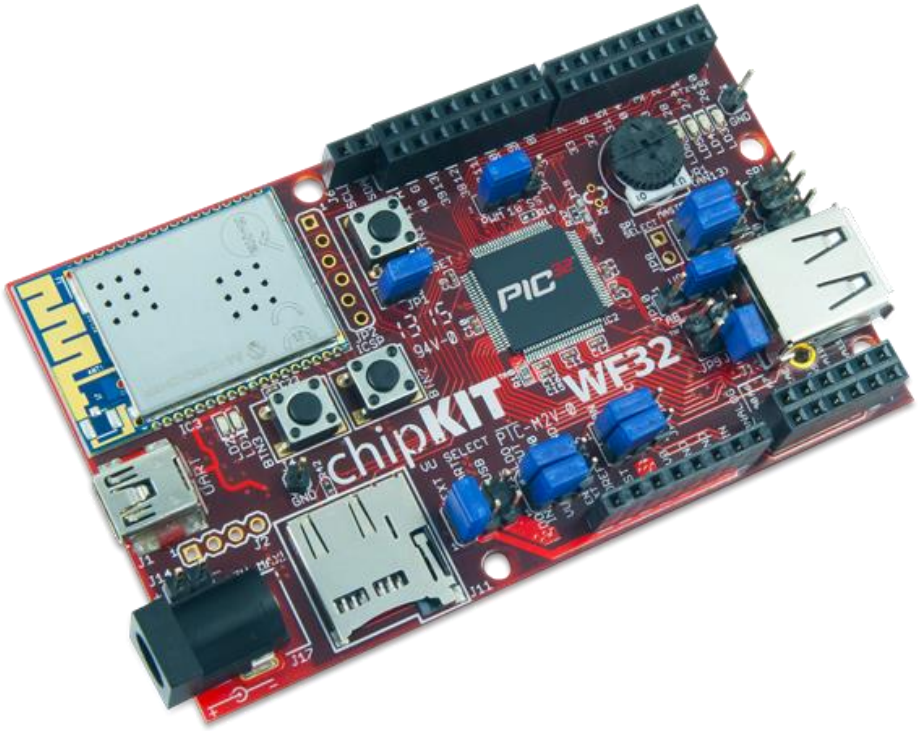
chipKIT® Fubarino® SD

- **PIC32MX795F512H**
  - 80 MHz operation
  - 512K Flash
  - 128K RAM
- **DIP form factor**
- **uSD card connector**
- **45 available I/Os**
- **15 analog inputs**
- **2 UARTs**
- **Comes with headers (not installed) for easy mounting on a breadboard**
- **Two buttons: RESET for resetting the board, and PRG for getting into bootloader mode and user application use**



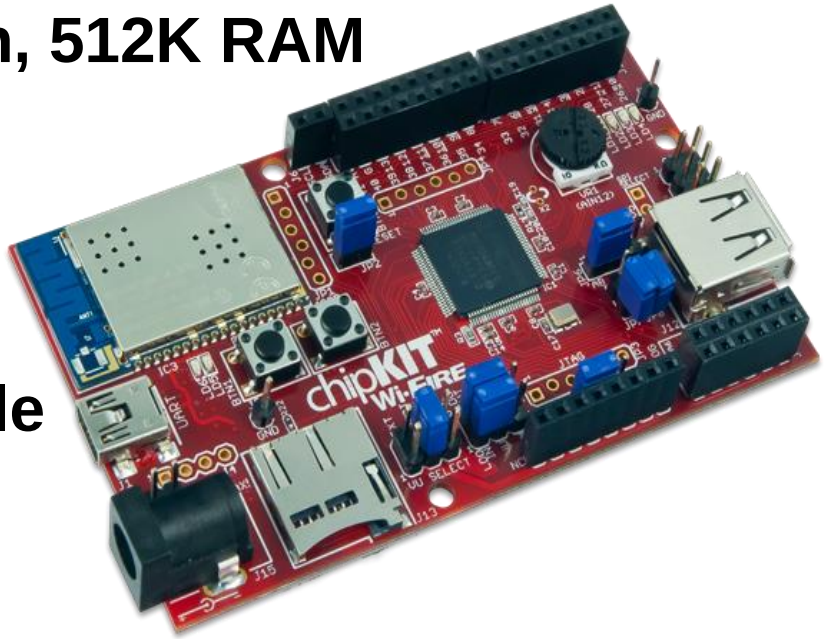
chipKIT® WF32 Board

- **Microchip PIC32MX695F512L**
  - 80 MHz 32-bit MIPS
  - 512K Flash
  - 128K SRAM
  - 802.11g Wi-Fi®, MRF24WG0MA
- **USB Host/Device**
- **uSD card connector**
- **Uno32 shield compatible**
- **42 available I/O pins**
- **Four LEDs, 2 Push buttons**
- **Potentiometer**
- **12 analog inputs**
- **Switching power supply**



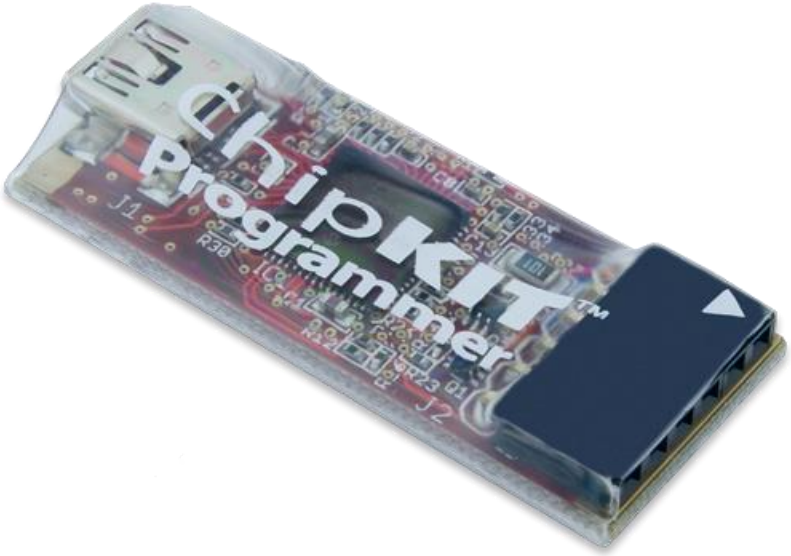
chipKIT® Wi-FIRE® Board

- **PIC32MZ MCU w/ 2 MB Flash, 512K RAM**
- **200 MHz 32-bit MIPS core**
  - Four 64-bit accumulators
  - Floating Point Unit
- **MRF24WG0MA Wi-Fi® module**
- **Micro SD card slot**
- **50 MHz SPI ports**
- **USB 2.0 Full-Speed / Hi-Speed controller**
- **43 available I/O pins with on-board user interfaces:**
  - 4 LEDs, 2 Buttons, 1 Potentiometer



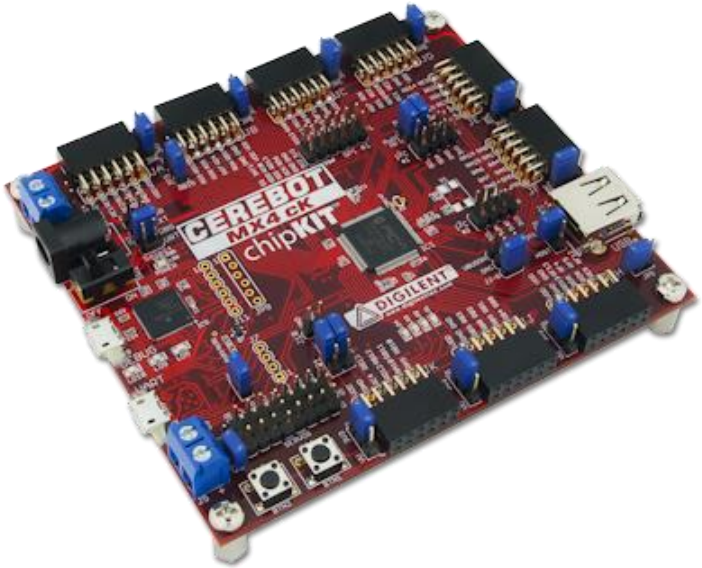
chipKIT® PGM Programmer

- **Provides in-system programming and debugging for Microchip PIC® MCU-based microcontroller boards**
- **Intended for use with chipKIT boards**
- **Works with the MPLAB® IDE and MPLAB IPE**

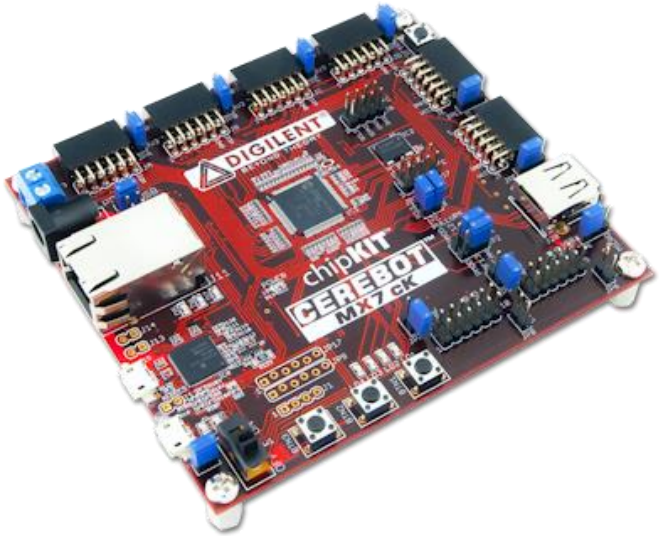


chipKIT® Pro MX4 Board

- **PIC32MX460F512L**
  - 80 MHz operation
  - 512K flash memory
  - 32K RAM memory
- **74 available I/O pins, 9 Pmods, 8 servo connectors, 2 push buttons, 4 LEDs**
- **2 UARTs, 2 SPIs, 2 I^2Cs**
- **5 output compare, PWMs**
- **14 10-bit A/D inputs**
- **MPLAB® IDE compatible licensed debugger**



chipKIT® Pro MX7 Board



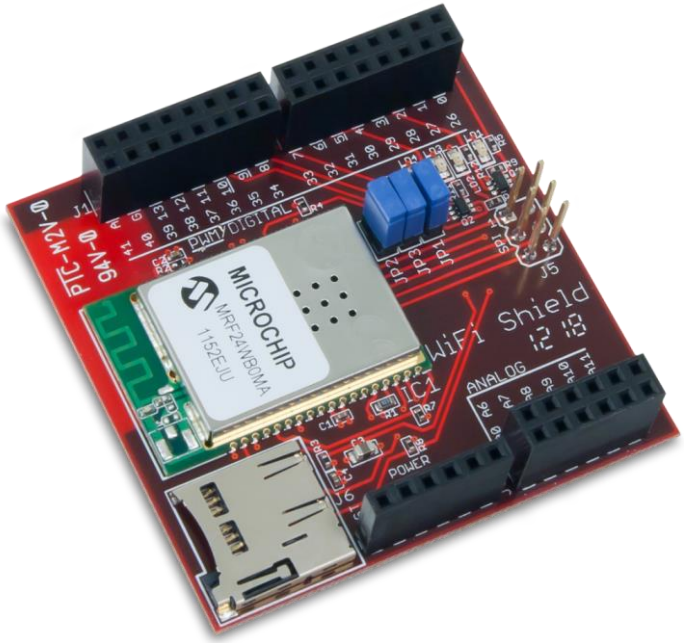
- **PIC32MX795F512L**
  - 80 MHz operation
  - 512K flash
  - 128K RAM
- **64 available I/O pins**
- **6 Pmod connectors**
- **10/100 Ethernet, 2 CANs, USB 2.0 OTG Host/Device**
- **2 UARTs, 3 SPIs, 2 I^2Cs**
- **5 output compare/PWMs**
- **12 10-bit analog inputs**
- **MPLAB® IDE compatible licensed debugger**

chipKIT® Basic I/O Shield

- Uno32 form factor
- 128x32 OLED display
- Four buttons
- Four slide switches
- Eight LEDs
- Four open drain FETs
- I^2C EEPROM
- I^2C temp sensor
- Potentiometer

chipKIT® Wi-Fi® Shield

- IEEE 802.11b-compliant RF transceiver
- Serialized unique MAC address
- 1 and 2 Mbps data rates
- IEEE 802.11b/g/n-compatible
- Integrated PCB antenna
- Range: up to 400m (1300 ft.)
- Radio regulation certification for the FCC, IC, ETSI, and ARIB
- Wi-Fi certified (WFA ID: WFA7150)
- Micro SD card connector
- Four LEDs



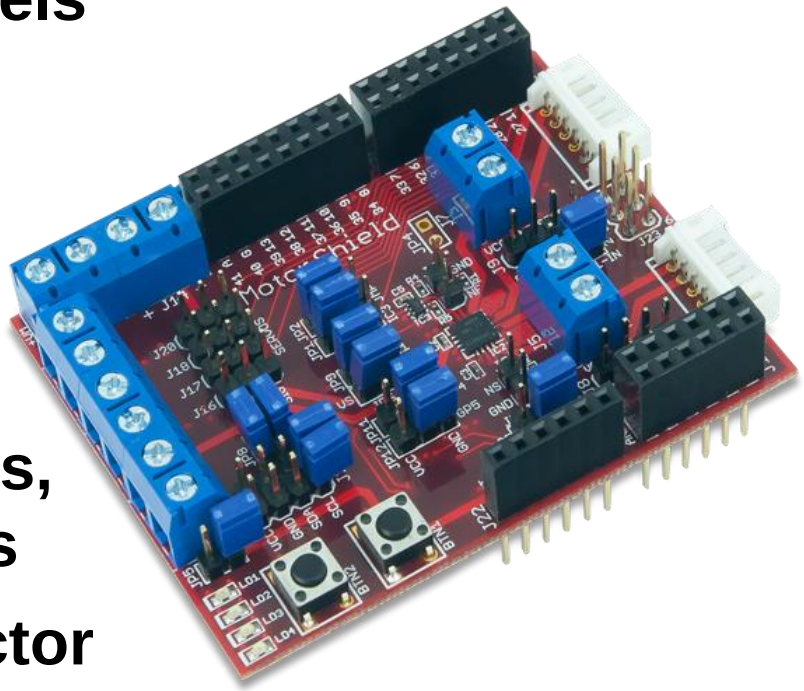
chipKIT® Network Shield

- **Expands I/O on Max32**
- **USB Host and Device connectors**
- **10/100 Ethernet PHY and connector**
- **Dual CAN transceivers and connectors**
- **Dual I^2C connectors**
- **I^2C EEPROM**
- **32 kHz oscillator**

The Network Shield in combination with the Max32 provides access to all of the features of the PIC32MX795F512L

chipKIT® Motor Shield

- Two H-bridge DC motor channels
- Quadrature encoder feedback inputs
- Four RC servo outputs
- Four low side N-FET outputs
- I^2C I/O expander with four LEDs, two push buttons, two jumpers
- Fits Uno32 style shield connector footprint



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