
Getting Started with the AVR-DA Family

Introduction

Author: Alin Stoicescu, Microchip Technology Inc.

This application note outlines how to get started with the AVR-DA family of microcontrollers.

Refer to the device data sheets for further information on the differences between the AVR-DA family devices.

Features presented in this document

- Getting Started with AVR-DA family of Microcontrollers and Tools
- Getting Started with AVR128DA48 Curiosity Nano and Atmel Studio 7.0
- Getting Started with AVR128DA48 Curiosity Nano and MPLAB® X

Table of Contents

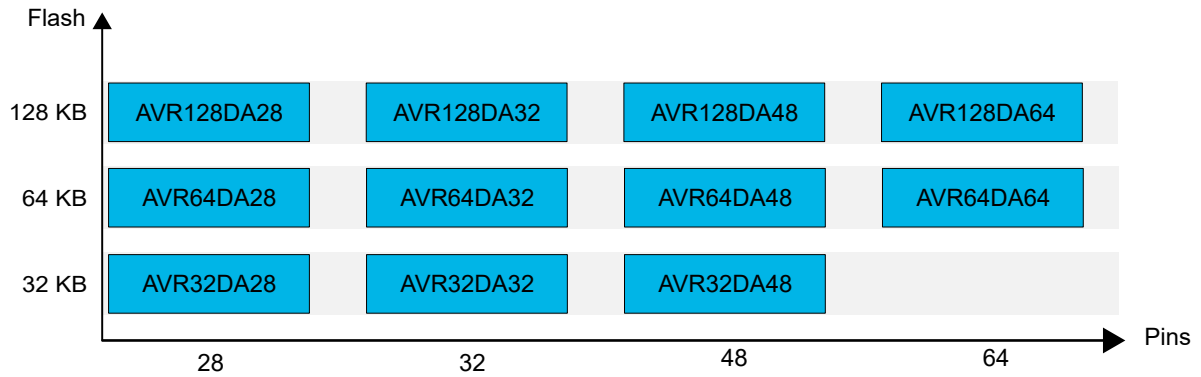
Introduction.....	1
Features presented in this document.....	1
1. Relevant Devices.....	3
2. Get the Device Data Sheet.....	4
3. Get the Tools.....	5
3.1. Get the AVR128DA48 Curiosity Nano Evaluation Kit.....	5
3.2. Get Source Code from Atmel START.....	5
3.3. Get Source Code from GitHub.....	6
3.4. Get Atmel Studio 7.0.....	6
3.5. Get Device Support for Atmel Studio.....	7
3.6. Get MPLAB® X.....	7
3.7. Get Device Support for MPLAB® X.....	7
3.8. Get IAR Embedded Workbench® for AVR®.....	7
4. Atmel Studio Users Getting Started.....	8
4.1. Atmel Studio with AVR128DA48 Curiosity Nano.....	8
5. MPLAB® X Users Getting Started.....	13
5.1. MPLAB® X with AVR128DA48 Curiosity Nano.....	13
6. What's Next.....	22
7. Revision History.....	23
The Microchip Website.....	24
Product Change Notification Service.....	24
Customer Support.....	24
Microchip Devices Code Protection Feature.....	24
Legal Notice.....	24
Trademarks.....	25
Quality Management System.....	25
Worldwide Sales and Service.....	26

1. Relevant Devices

This section lists the relevant devices for this document. The following figures show the different family devices, laying out pin count variants and memory sizes:

- Vertical migration upwards is possible without code modification, as these devices are pin-compatible and provide the same or more features
- Horizontal migration to the left reduces the pin count and, therefore, the available features
- Devices with different Flash memory sizes typically also have different SRAM and EEPROM

Figure 1-1. AVR-DA Family Overview



2. Get the Device Data Sheet

Product pages

- AVR32DA28: <https://www.microchip.com/wwwproducts/en/AVR32DA28>
- AVR32DA32: <https://www.microchip.com/wwwproducts/en/AVR32DA32>
- AVR32DA48: <https://www.microchip.com/wwwproducts/en/AVR32DA48>
- AVR64DA28: <https://www.microchip.com/wwwproducts/en/AVR64DA28>
- AVR64DA32: <https://www.microchip.com/wwwproducts/en/AVR64DA32>
- AVR64DA48: <https://www.microchip.com/wwwproducts/en/AVR64DA48>
- AVR64DA64: <https://www.microchip.com/wwwproducts/en/AVR64DA64>
- AVR128DA28: <https://www.microchip.com/wwwproducts/en/AVR128DA28>
- AVR128DA32: <https://www.microchip.com/wwwproducts/en/AVR128DA32>
- AVR128DA48: <https://www.microchip.com/wwwproducts/en/AVR128DA48>
- AVR128DA64: <https://www.microchip.com/wwwproducts/en/AVR128DA64>

Documents

- AVR-DA Product Brief (.pdf)
- AVR128DA Data Sheet (.pdf)
- AVR64DA Data Sheet (.pdf)
- AVR32DA Data Sheet (.pdf)
- AVR128DA Silicon Errata and Data Sheet Clarifications (.pdf)
- AVR64DA Silicon Errata and Data Sheet Clarifications (.pdf)
- AVR32DA Silicon Errata and Data Sheet Clarifications (.pdf)

The documentation for the AVR-DA family is split into two document types:

- Data sheet⁽¹⁾ (includes device description, number of peripherals, pinout and electrical characteristics)
- Errata (includes known errata for the device)

Note:

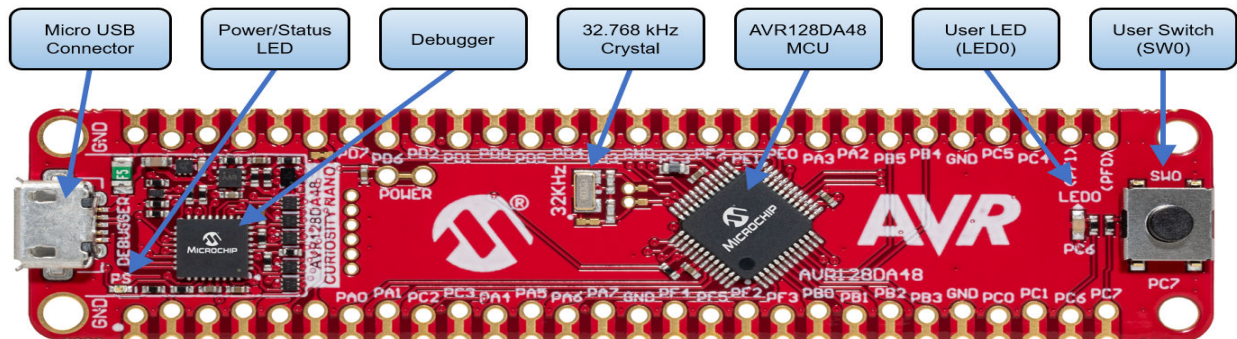
1. For devices that are future products, the product brief is available instead of the data sheet.

3. Get the Tools

Atmel Studio 7.0, which uses the GCC compiler, can be utilized as an IDE to get started with the AVR-DA family. MPLAB X, which uses the GCC or XC8 compiler, can be utilized as an IDE to get started with the AVR-DA family.

3.1 Get the AVR128DA48 Curiosity Nano Evaluation Kit

Figure 3-1. AVR128DA48 Curiosity Nano Kit



Webpage: <http://www.microchip.com/developmenttools/ProductDetails/DM164151>

Get the kit: <https://www.microchipdirect.com/product/search/all/DM164151>

Document/file:

- AVR128DA48 Curiosity Nano (.pdf)

Key Features

- AVR128DA48 Microcontroller
- One Yellow User LED
- One Mechanical User Switch
- One 32.768 kHz Crystal
- On-board Debugger
 - Board identification in Atmel Studio/Microchip MPLAB® X
 - One green power and status LED
 - Programming and debugging
 - Virtual COM port (CDC)
 - Two logic analyzer channels (DGI GPIO)
- USB-powered
- Adjustable Target Voltage
 - MIC5353 LDO regulator controlled by the on-board debugger
 - 1.8-5.1V output voltage (limited by USB input voltage)
 - 500 mA maximum output current (limited by ambient temperature and output voltage)

The AVR128DA48 Curiosity Nano user's guide shows how to power the kit and offers detailed information about the board components, the extension interface, and the hardware guide.

3.2 Get Source Code from Atmel START

The example code is available through Atmel START, which is a web-based tool that enables the configuration of the application code through a Graphical User Interface (GUI). The code can be downloaded for both Atmel Studio and IAR Embedded Workbench® via the direct example code-link below or the **Browse examples** button on the Atmel START front page.

The Atmel START webpage is the following [Atmel START](#).

Code examples

Finding code examples for devices in the AVR-DA Family can be done by searching for the device name, e.g., AVR128DA48, in the Atmel START example browser.

Click **User guide** in Atmel START for details and information about example projects. The **User guide** button can be found in the example browser, and by clicking the project name in the dashboard view within the Atmel START project configurator.

Atmel Studio

Download the code as an `.atzip` file for Atmel Studio from the example browser in Atmel START by clicking **Download selected example**. To download the file from within Atmel START, click **Export project** followed by **Download pack**.

Double click the downloaded `.atzip` file, and the project will be imported to Atmel Studio 7.0.

MPLAB X

Download the code as an `.atzip` file for MPLAB X IDE from within Atmel START by clicking **Export project** followed by **Download pack**.

To open the Atmel START example in MPLAB X, select from the menu in MPLAB X, **File -> Import -> START MPLAB Project** and navigate to the `.atzip` file.

IAR Embedded Workbench

For information on how to import the project in IAR Embedded Workbench, open the [Atmel START User Guide](#), select **Using Atmel Start Output in External Tools**, and **IAR Embedded Workbench**. A link to the Atmel START User Guide can be found by clicking *Help* from the Atmel START front page or **Help And Support** within the project configurator, both located in the upper right corner of the page.

3.3 Get Source Code from GitHub

The code examples are available through GitHub, which is a web-based server that provides the application codes through a Graphical User Interface (GUI). The code examples can be opened in both Atmel Studio and MPLAB X. To open the Atmel Studio project in MPLAB X, select from the menu in MPLAB X, **File -> Import -> Atmel Studio Project** and navigate to `.cproj` file.

The GitHub webpage is the following [GitHub](#).

Code examples

Finding code examples for devices in the AVR-DA Family can be done by searching for the device name, e.g., AVR128DA48, in the GitHub example browser.



View Code Examples on GitHub

Click to browse repositories

Download the code as a `.zip` file from the example page on GitHub by clicking the **Clone or download** button.

3.4 Get Atmel Studio 7.0

Webpage: <https://www.microchip.com/development-tools/atmel-studio-7>

Document/file:

- Atmel Studio 7.0 (build 2397 or later version)

Atmel Studio 7.0 can be utilized as an IDE for developing and debugging firmware for the AVR-DA family.

For device support, refer to [3.5 Get Device Support for Atmel Studio](#).

3.5 Get Device Support for Atmel Studio

Atmel Studio: Support for new devices in Atmel Studio can be added by using the *Device Pack Manager*, which is found under *Tools* → *Device Pack Manager*.

For the AVR-DA family, update to the latest version by performing the following steps:

1. Click **Check for Updates**.
2. For the AVR-DA family, select the latest available version of *AVR-Dx_DFP*.
3. Click **Install**.

For offline installers, go to <http://packs.download.atmel.com/>. To install a package, double click on the installer file and follow the instructions. Any open Atmel Studio window will have to be closed for the installation to take effect.

IAR: Support for new devices in IAR Embedded Workbench can be added by installing the latest service package. The service package is available at *My Pages* on <https://iar.com>.

3.6 Get MPLAB® X

Webpage: [MPLAB® X IDE](#)

Document/file:

- MPLAB X

MPLAB X can be utilized as an IDE for developing and debugging firmware for the AVR-DA family.

For device support, refer to [3.7 Get Device Support for MPLAB X](#).

3.7 Get Device Support for MPLAB® X

MPLAB X: Support for new devices in MPLAB X can be added by using the *MPLAB Pack Manager*, which is found under *Tools* → *Packs*.

For the AVR-DA family, update to the latest version by performing the following steps:

1. Click **Check for Updates**.
2. For the AVR-DA family, select the latest available version of *AVR-Dx_DFP*.
3. Click **Install**.

For offline installers, go to <https://packs.download.microchip.com/>. To install a package, double click on the installer file and follow the instructions. Any open MPLAB X window will have to be closed for the installation to take effect.

3.8 Get IAR Embedded Workbench® for AVR®

Webpage: <https://www.iar.com/iar-embedded-workbench/#!?architecture=AVR>

Document/file: IAR Embedded Workbench installer for AVR®.

4. Atmel Studio Users Getting Started

4.1 Atmel Studio with AVR128DA48 Curiosity Nano

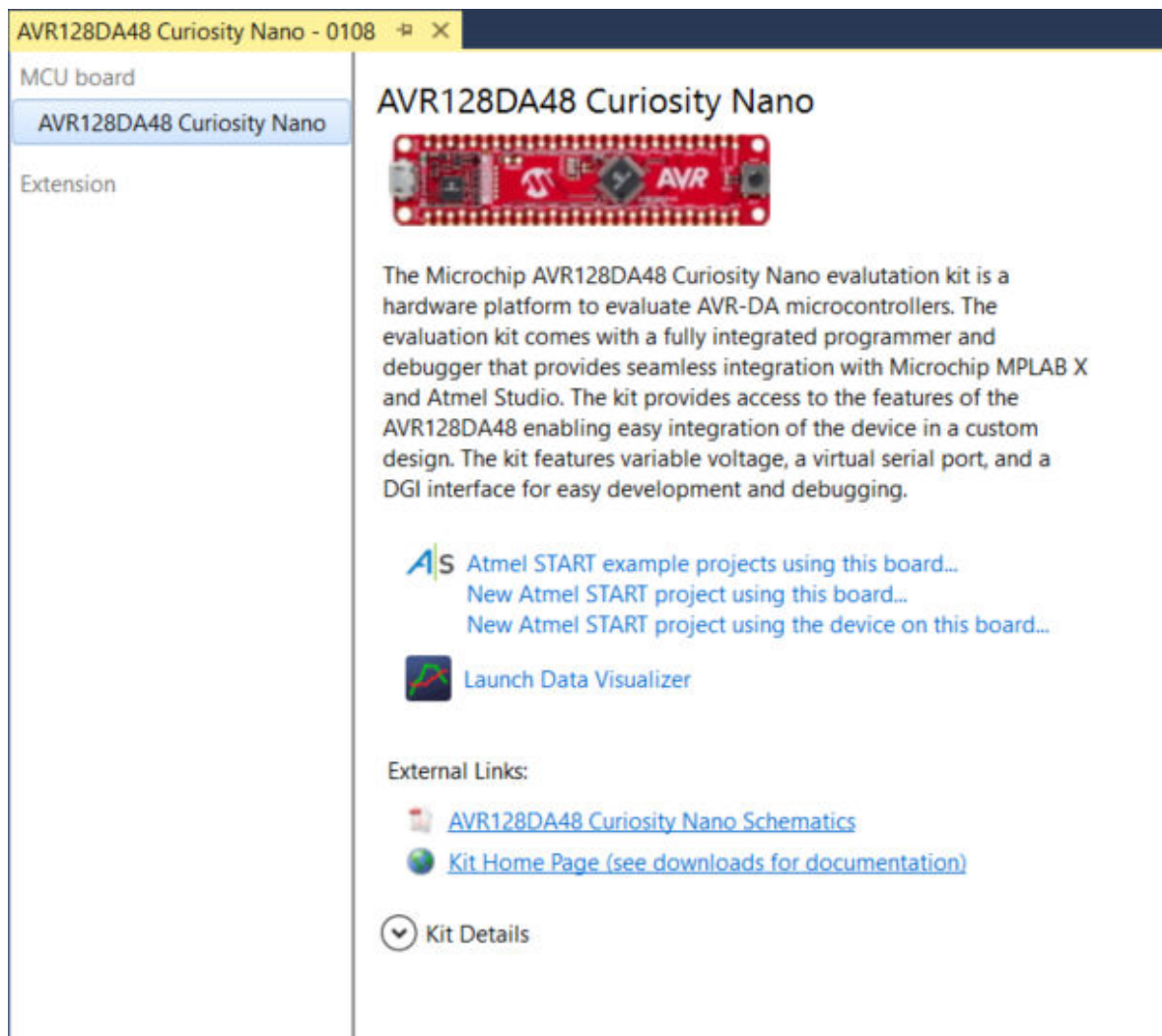
Prerequisites

- Atmel Studio 7.0.2397 or later installed
- The AVR128DA48 Curiosity Nano board connected to Atmel Studio 7.0 via the on-board USB connector, which is connected to the embedded debugger. The kit will be powered by the USB, and the embedded debugger will enable debugging and programming via the USB.

Workflow

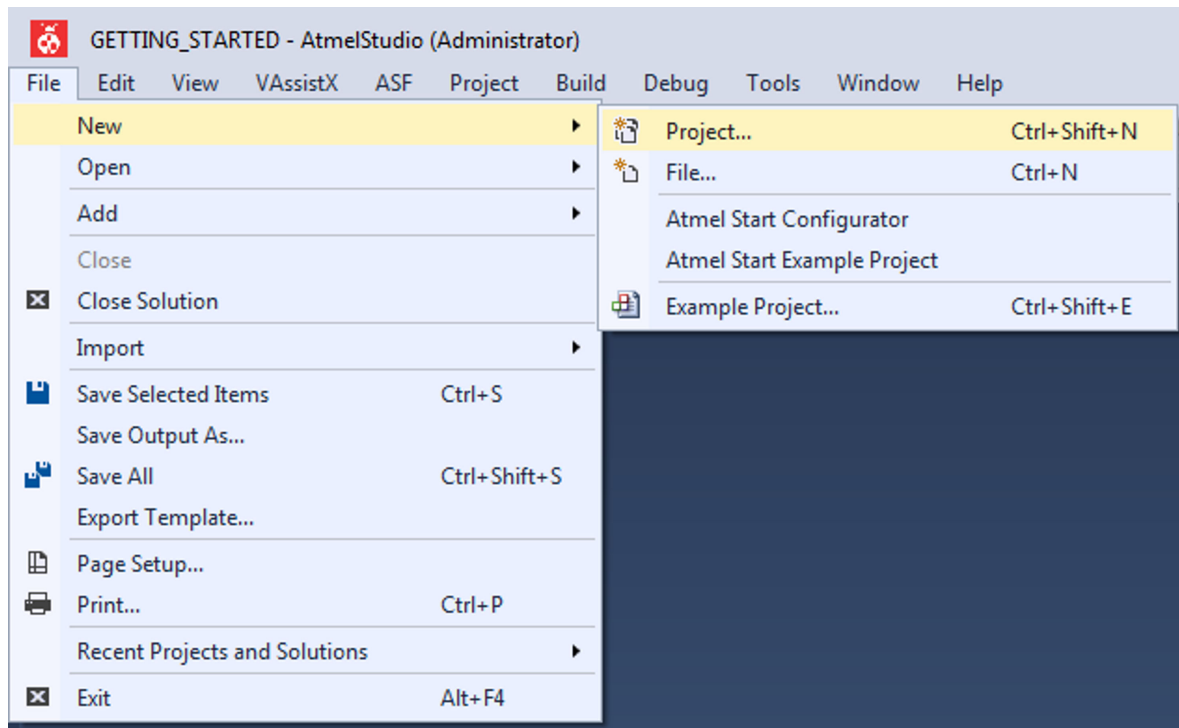
1. Launch Atmel Studio 7.0.
2. The page shown in [Figure 4-1](#) will appear when AVR128DA48 Curiosity Nano is connected to Atmel Studio 7.0.

Figure 4-1. AVR128DA48 Curiosity Nano Page in Atmel Studio



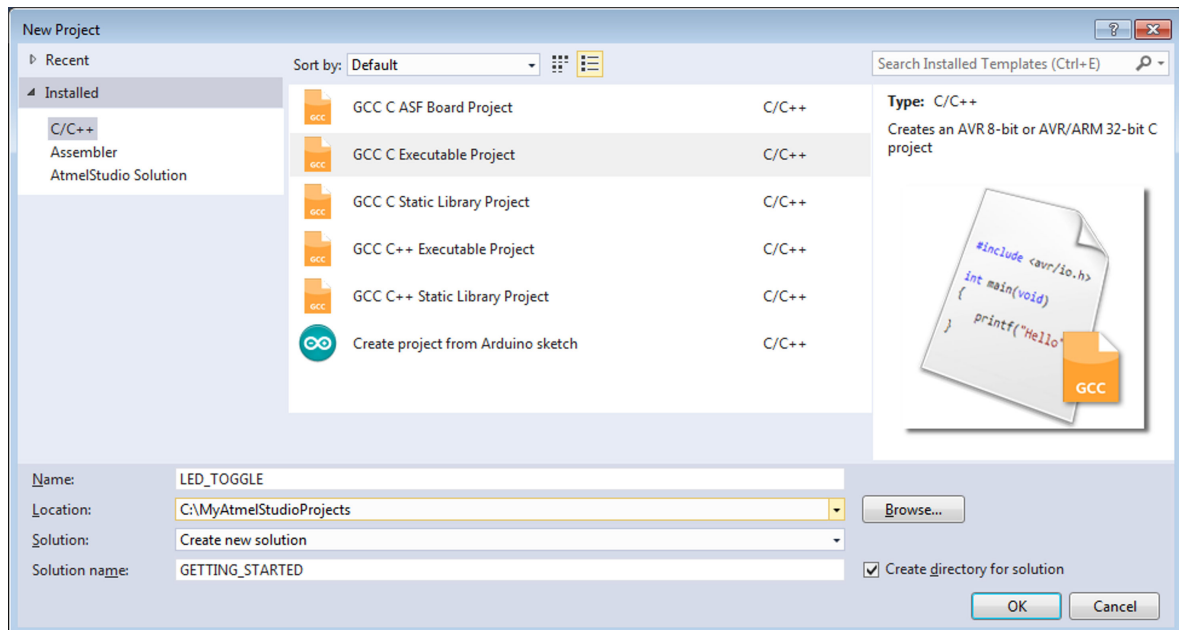
3. Start creating a new project by clicking **New** → **Project...** or by using **Ctrl+Shift+N** shortcut, as shown in [Figure 4-2](#).

Figure 4-2. Create New Project in Atmel Studio



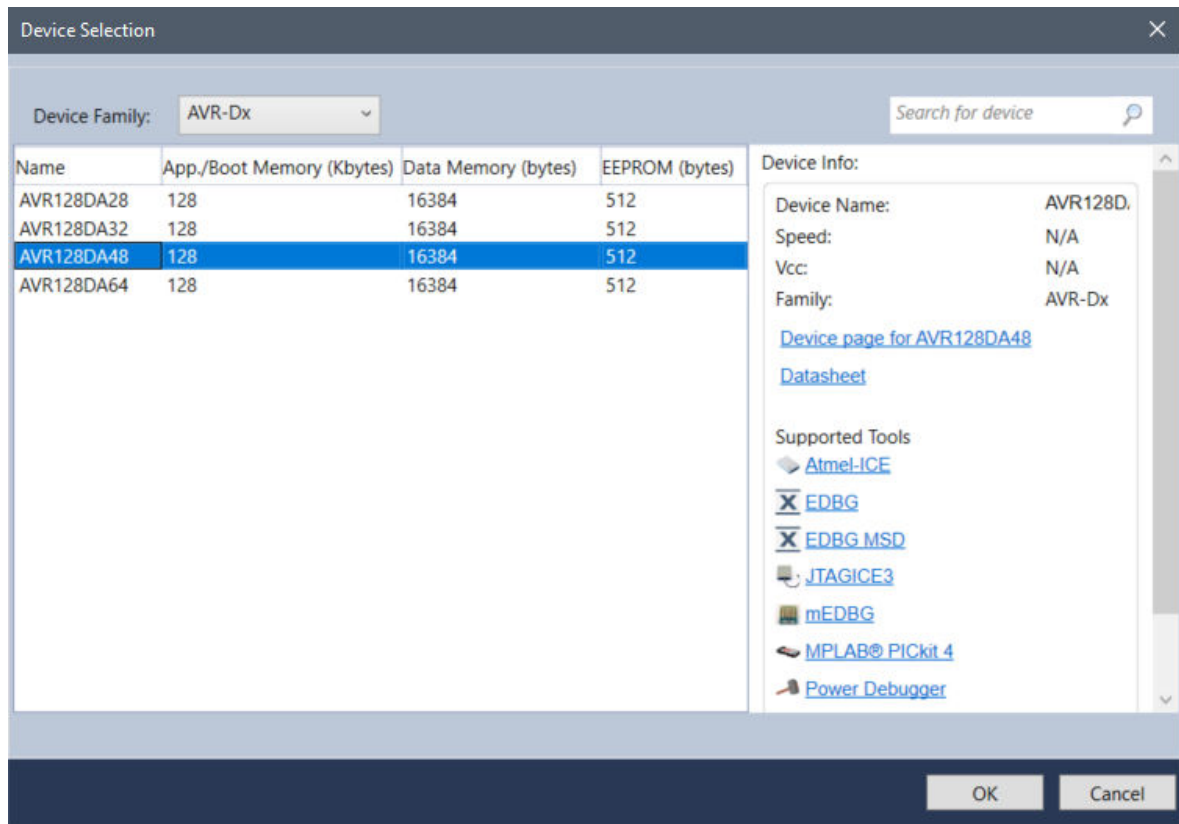
4. Select the **GCC C Executable Project** template, as shown in Figure 4-3, type in the name of the solution and project (e.g., *GETTING_STARTED* and *LED_TOGGLE*), and click **OK**.

Figure 4-3. New Project Wizard



5. Select AVR128DA48 from Figure 4-4, and click **OK**.

Figure 4-4. Device Selection Wizard



A new project with a `main.c` file associated with it will be generated in Atmel Studio.

- Replace the `main.c` file with the following code snippet:

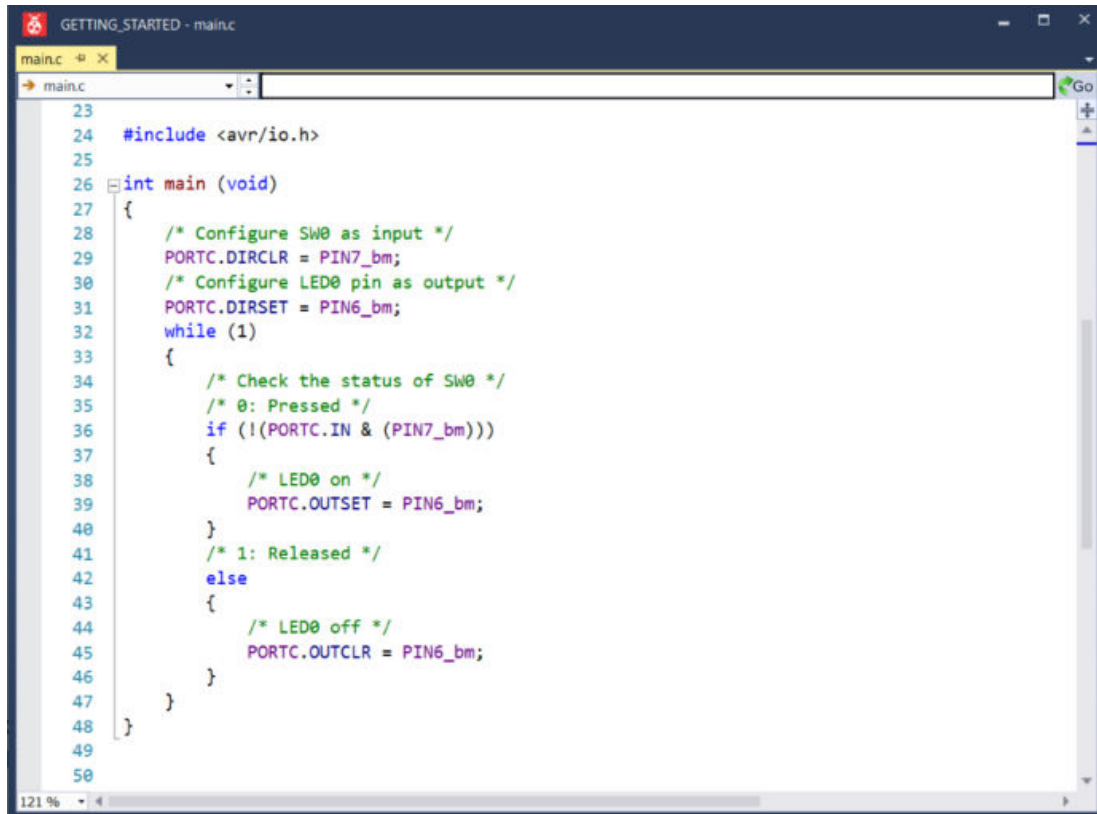
```
int main (void)
{
    /* Configure SW0 as input */
    PORTC.DIRCLR = PIN7_bm;

    /* Configure LED0 pin as output */
    PORTC.DIRSET = PIN6_bm;

    while (1)
    {
        /* Check the status of SW0 */
        /* 0: Pressed */
        if (!(PORTC.IN & (PIN7_bm)))
        {
            /* LED0 on */
            PORTC.OUTSET = PIN6_bm;
        }
        /* 1: Released */
        else
        {
            /* LED0 off */
            PORTC.OUTCLR = PIN6_bm;
        }
    }
}
```

In the code editor, the code will appear, as shown in [Figure 4-5](#).

Figure 4-5. Code Editor Window



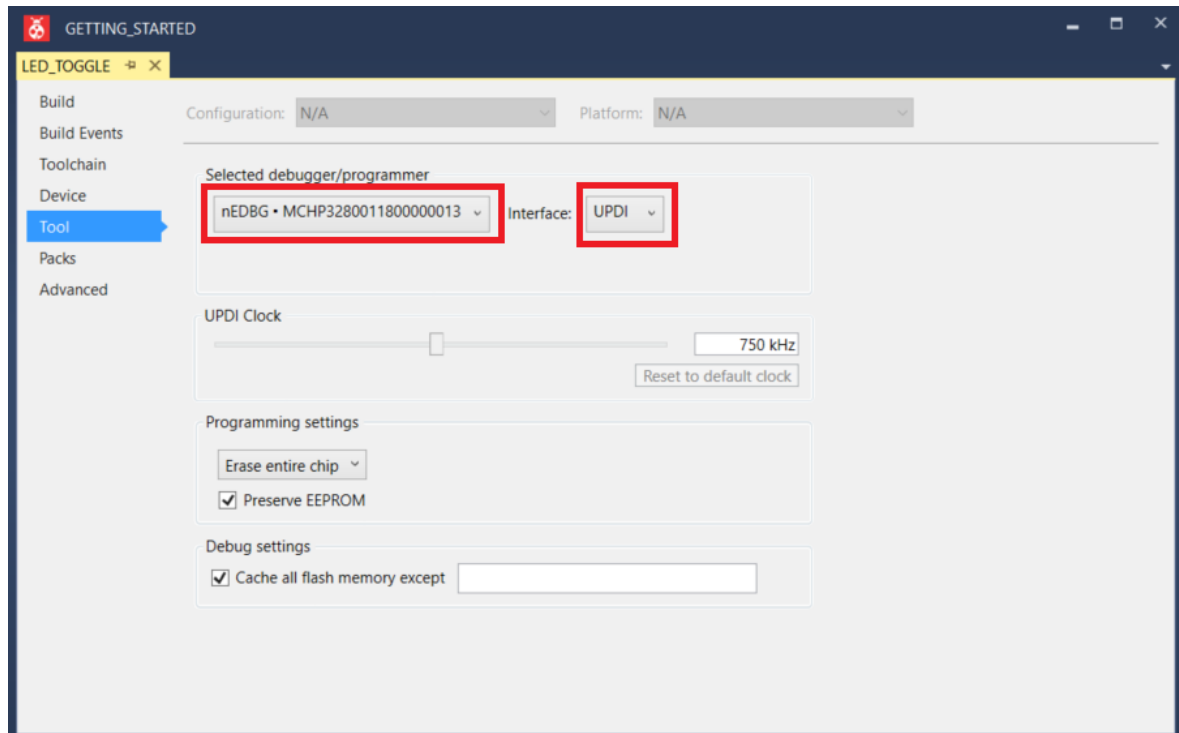
```

23
24 #include <avr/io.h>
25
26 int main (void)
27 {
28     /* Configure SW0 as input */
29     PORTC.DIRCLR = PIN7_bm;
30     /* Configure LED0 pin as output */
31     PORTC.DIRSET = PIN6_bm;
32     while (1)
33     {
34         /* Check the status of SW0 */
35         /* 0: Pressed */
36         if (!(PORTC.IN & (PIN7_bm)))
37         {
38             /* LED0 on */
39             PORTC.OUTSET = PIN6_bm;
40         }
41         /* 1: Released */
42         else
43         {
44             /* LED0 off */
45             PORTC.OUTCLR = PIN6_bm;
46         }
47     }
48 }
49
50

```

7. Open project properties by clicking **Project** → **Properties** or by using **ALT+F7** shortcut.
8. In the **Tool** view (see Figure 4-6), set *Selected debugger/programmer* to nEDBG and *Interface* to UPDI.

Figure 4-6. Debugger and Interface for AVR128DA48



9. Build the project by clicking **Build** → **Build Solution** or by using **F7** shortcut.
10. Program AVR128DA48 with the project code and start debugging by clicking **Debug** → **Start debugging and break** or by using **ALT+F5** shortcut . The application is programmed onto the device, and program execution will break in `main()` function.
11. Run the code by clicking **Debug** → **Continue** or by using **F5** shortcut .
12. Verify that LED0 is lit when SW0 is pushed on the AVR128DA48 Curiosity Nano.

5. MPLAB® X Users Getting Started

5.1 MPLAB® X with AVR128DA48 Curiosity Nano

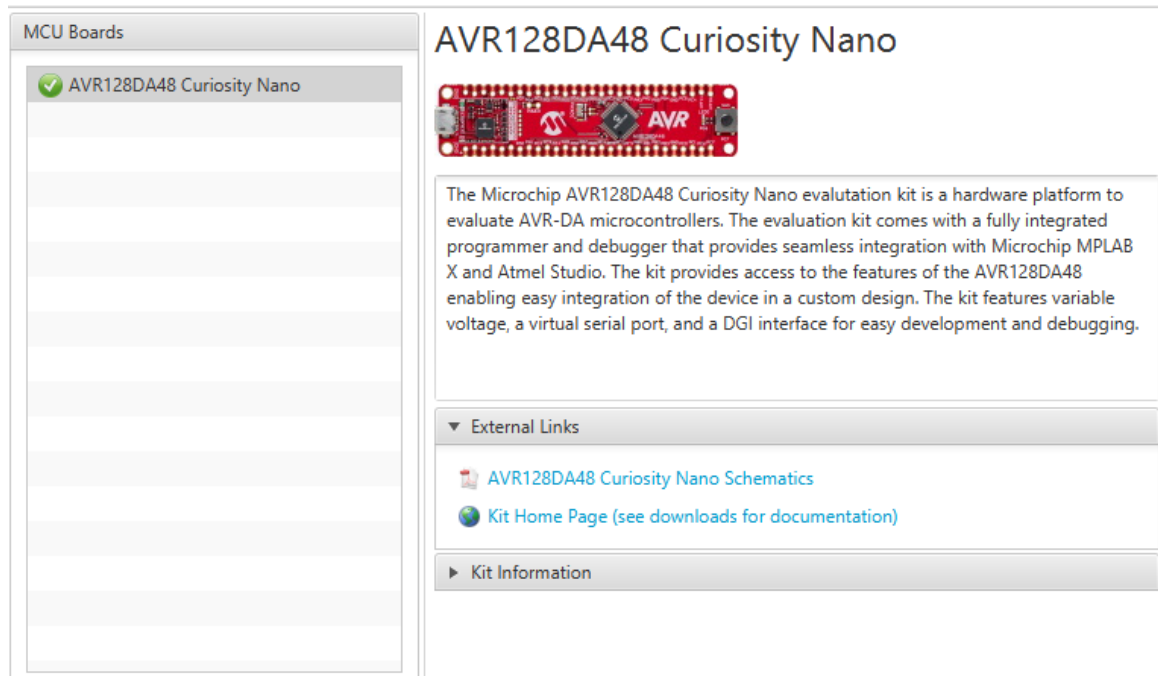
Prerequisites

- MPLAB X installed
- The AVR128DA48 Curiosity Nano board connected to MPLAB X via the on-board USB connector, which is connected to the embedded debugger. The kit will be powered by the USB, and the embedded debugger will enable debugging and programming via the USB.

Workflow

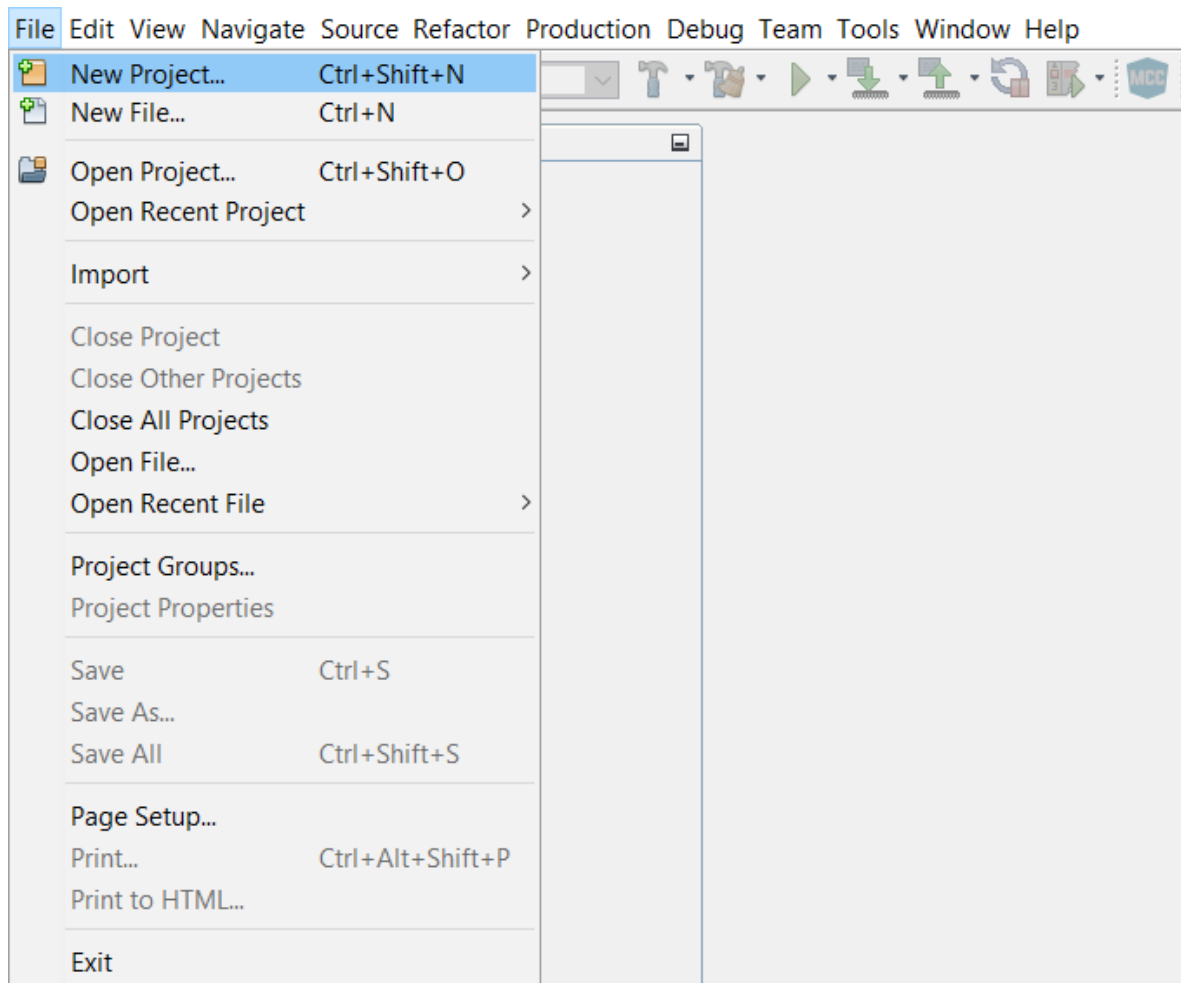
1. Launch MPLAB X.
2. The page shown in [Figure 5-1](#) will appear when AVR128DA48 Curiosity Nano is connected to MPLAB X.

Figure 5-1. AVR128DA48 Curiosity Nano Page in MPLAB® X



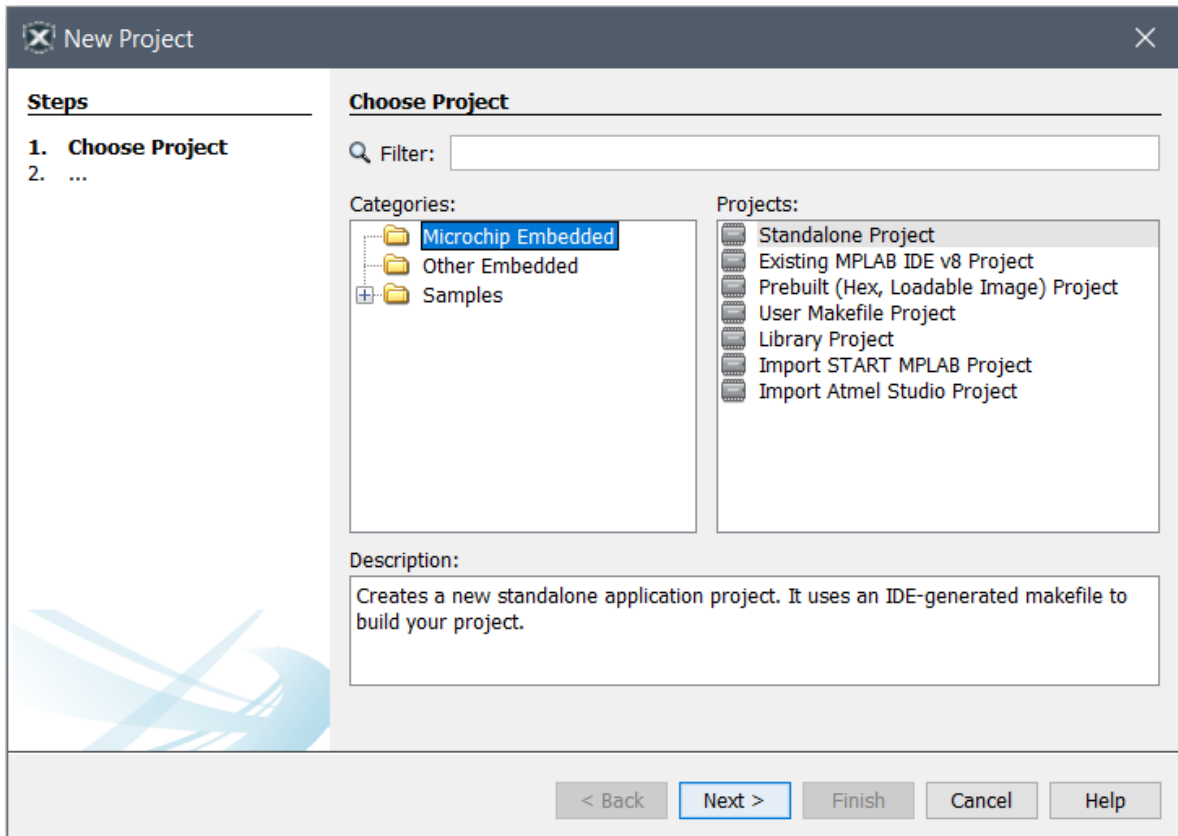
3. Start creating a new project by clicking **File** → **New Project...** or by using **Ctrl+Shift+N** shortcut, as shown in [Figure 5-2](#).

Figure 5-2. Create New Project in MPLAB® X



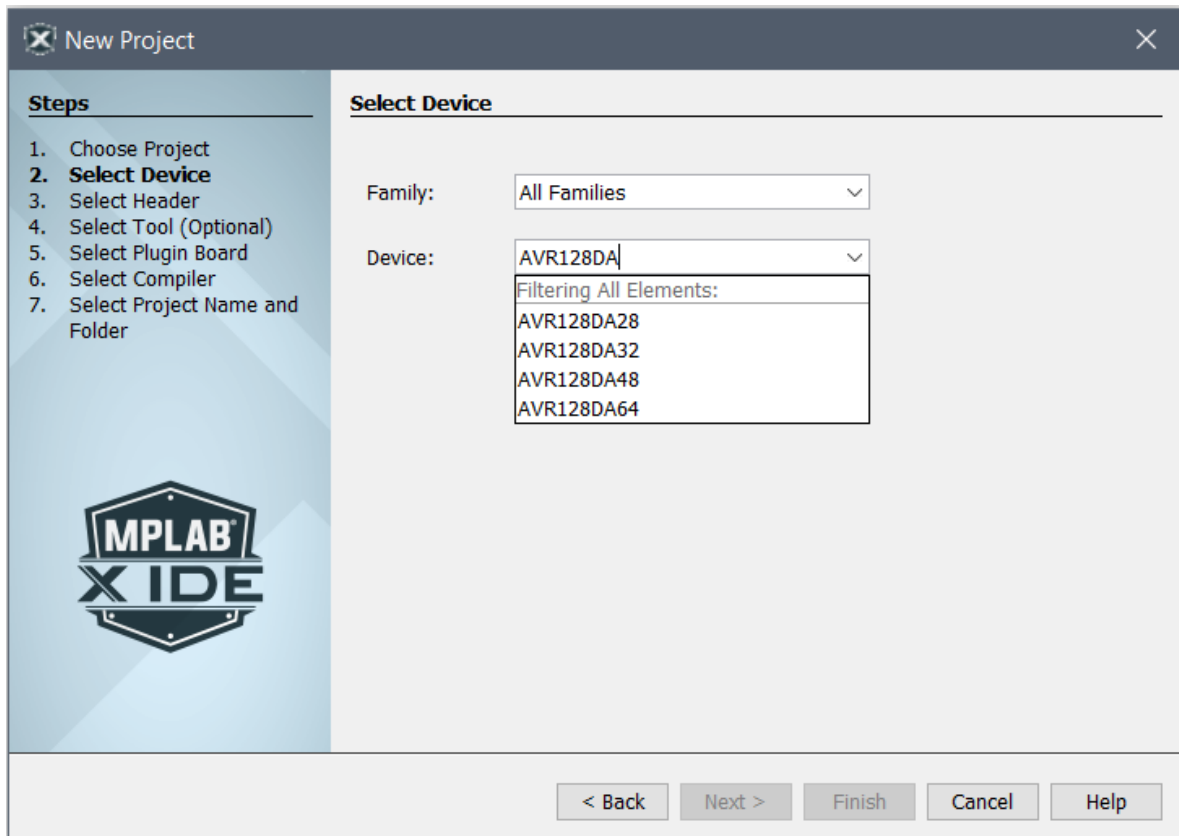
4. Select the **Categories** → **Microchip Embedded** and **Projects** → **Standalone Project** template from [Figure 5-6](#), and click **Next**.

Figure 5-3. New Project Window



5. Select AVR128DA48 from [Figure 5-4](#), and click **Next**.

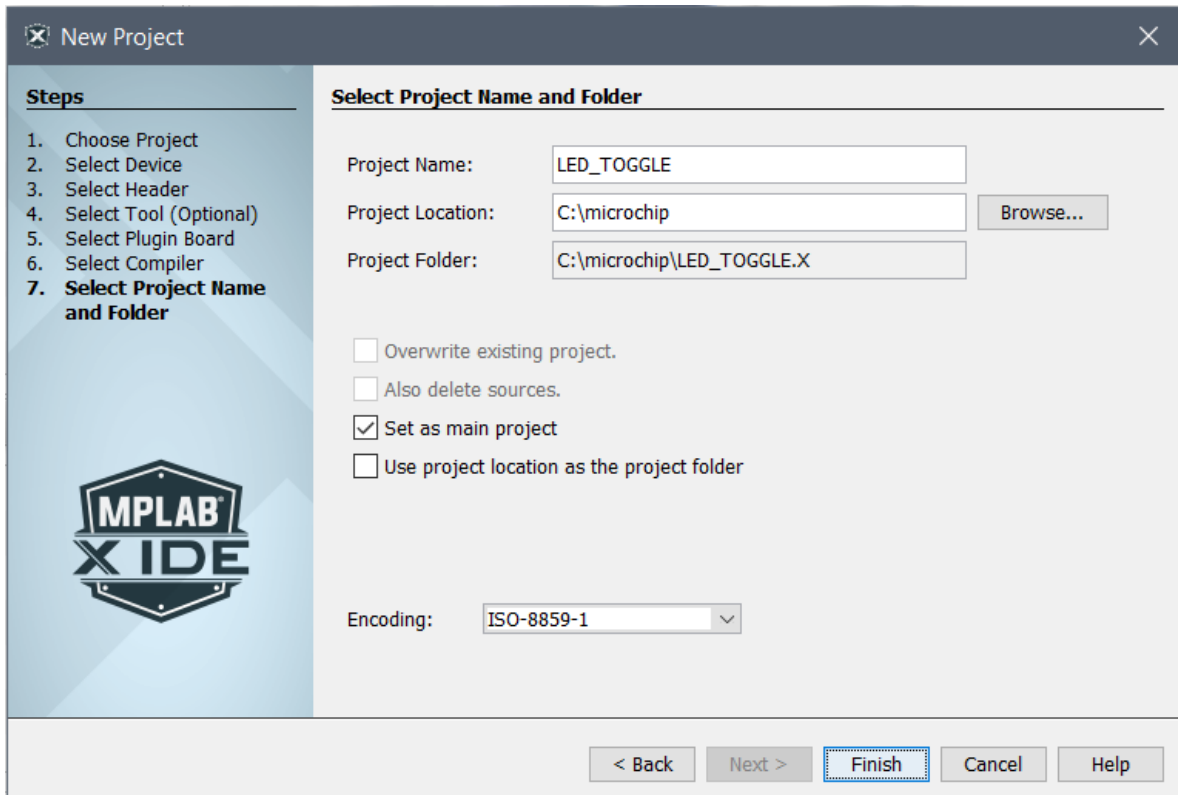
Figure 5-4. Device Selection Window



Then select the board and the desired compiler, if there are any.

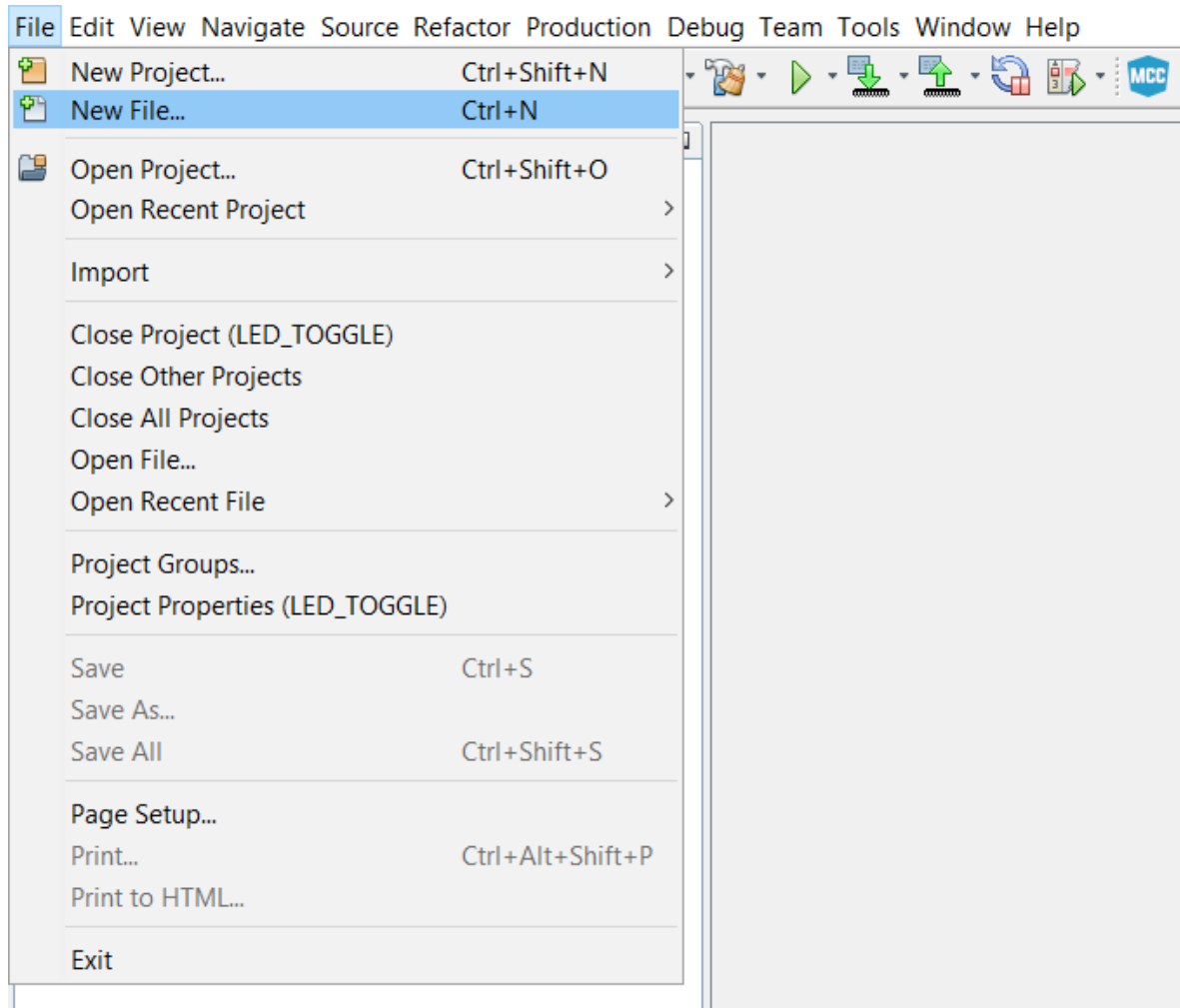
6. Type in the name of the project (e.g., *LED_TOGGLE*) and the project location (e.g., *C:\microchip*), and click **Finish**.

Figure 5-5. Project Name and Location Selection Window



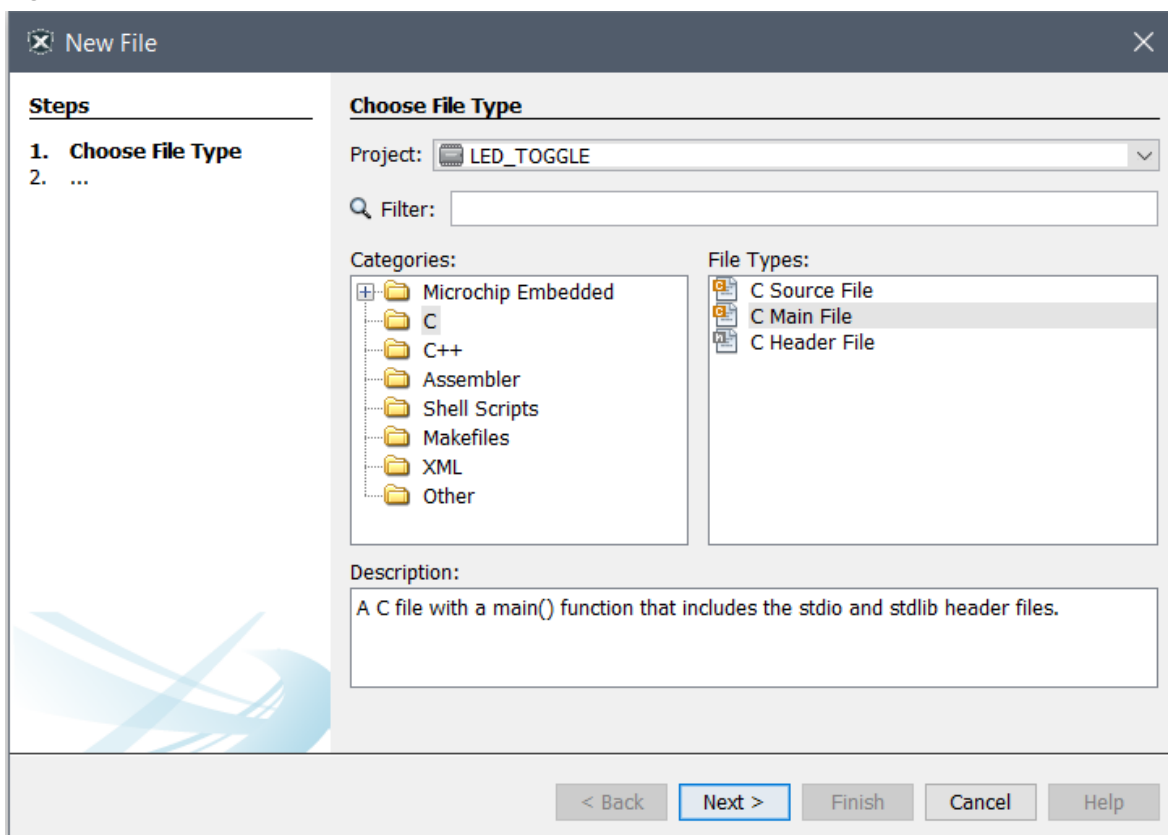
7. Create a new `main.c` file by clicking **File** → **New File...** or by using **Ctrl+N** shortcut, as shown in [Figure 5-6](#).

Figure 5-6. Create a New File in MPLAB® X



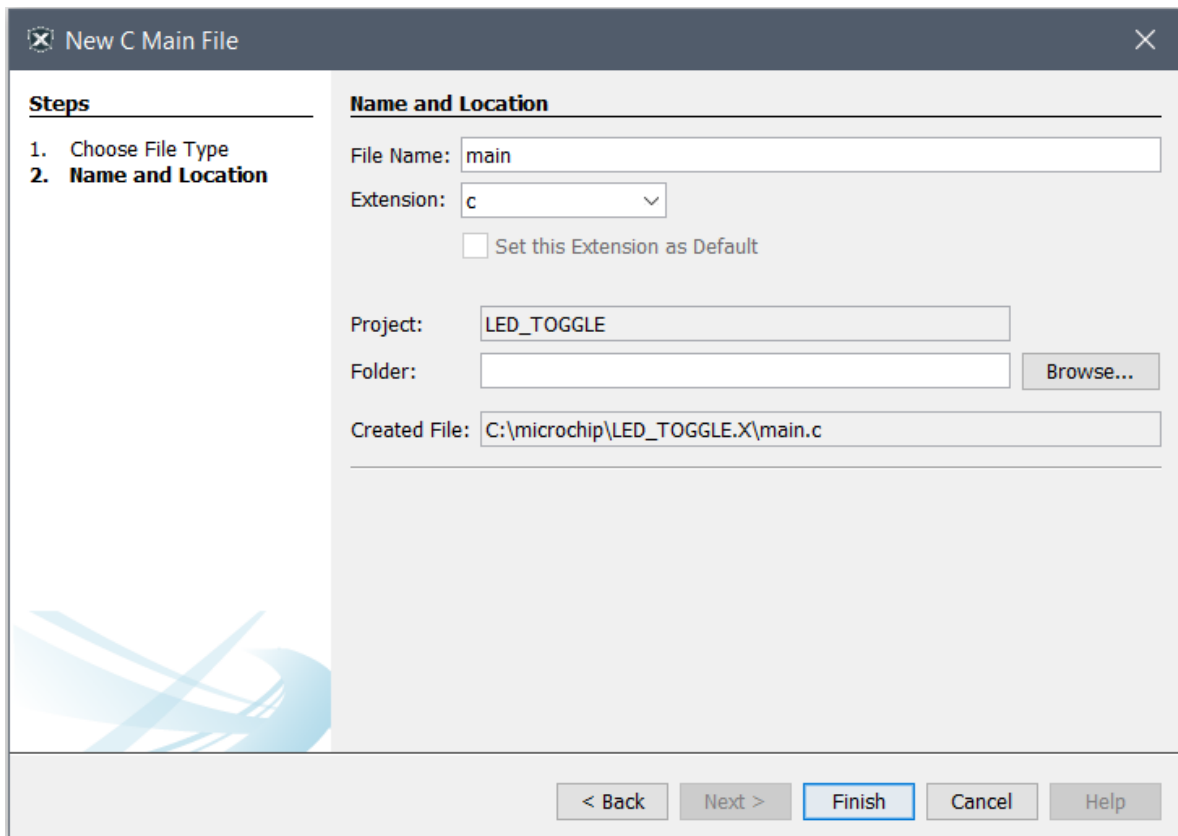
8. Select the **Categories** → **C** and **File Types** → **C Main File** template from [Figure 5-7](#), and click **Next**.

Figure 5-7. New File Window



9. Type in the name of the file (e.g., *main*) and click **Finish**.

Figure 5-8. File Name Window



10. Replace the `main.c` file with the following code snippet:

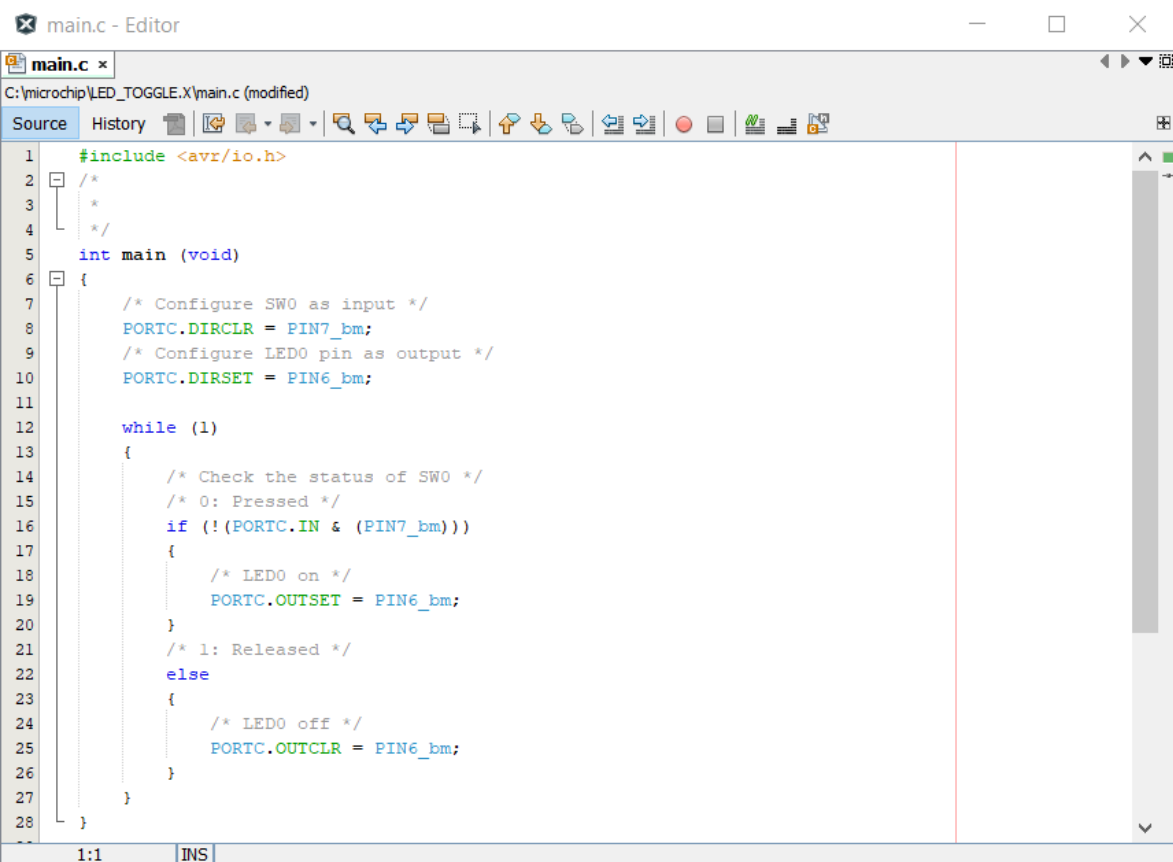
```
int main (void)
{
    /* Configure SW0 as input */
    PORTC.DIRCLR = PIN7_bm;

    /* Configure LED0 pin as output */
    PORTC.DIRSET = PIN6_bm;

    while (1)
    {
        /* Check the status of SW0 */
        /* 0: Pressed */
        if (!(PORTC.IN & (PIN7_bm)))
        {
            /* LED0 on */
            PORTC.OUTSET = PIN6_bm;
        }
        /* 1: Released */
        else
        {
            /* LED0 off */
            PORTC.OUTCLR = PIN6_bm;
        }
    }
}
```

Add `#include<avr/io.h>` in `main.c`. In the code editor, the code will appear as shown in [Figure 5-9](#).

Figure 5-9. Code Editor Window



The screenshot shows the MPLAB X IDE Code Editor Window with the file 'main.c' open. The code is as follows:

```
1  #include <avr/io.h>
2  /*
3   *
4   */
5  int main (void)
6  {
7      /* Configure SW0 as input */
8      PORTC.DIRCLR = PIN7_bm;
9      /* Configure LED0 pin as output */
10     PORTC.DIRSET = PIN6_bm;
11
12     while (1)
13     {
14         /* Check the status of SW0 */
15         /* 0: Pressed */
16         if (!(PORTC.IN & (PIN7_bm)))
17         {
18             /* LED0 on */
19             PORTC.OUTSET = PIN6_bm;
20         }
21         /* 1: Released */
22         else
23         {
24             /* LED0 off */
25             PORTC.OUTCLR = PIN6_bm;
26         }
27     }
28 }
```

11. Build the code by clicking on **Production** → **Clean and Build Main Project** or by using **Shift + F11** shortcut.
12. Program AVR128DA48 with the project code and start debugging by clicking **Debug** → **Debugging Main Project**.
13. Verify that LED0 is lit when SW0 is pushed on the AVR128DA48 Curiosity Nano.

6. What's Next

For further information on related AVR products and IDE, refer to the links below:

Software:

- [Atmel Studio](#)
- Atmel Studio help: **Help** → **View Help** (shortcut **CTRL+F1**)
- [Microchip Gallery](#)
- [MPLAB X](#)

Firmware:

- [Atmel START documentation](#)
- [Atmel START examples](#)
- [GitHub examples](#)

Hardware:

- [AVR042: AVR Hardware Design Considerations](#)
- [AVR IBIS files](#)
- [AVR BSDL files](#)

Recommended programming/debugging tools:

- Atmel-ICE:
 - [User Guide](#)
 - [Buy](#)
- Power Debugger:
 - [User Guide](#)
 - [Buy](#)

Other:

- AVR Freaks®: <http://www.avrfreaks.net/>
- Application notes: <http://www.microchip.com/paramChartSearch/chart.aspx?branchID=30047>, find the preferred device and go to the product page. All relevant application notes can be found under the Documents tab.
- AVR product selector: <http://www.microchip.com/paramChartSearch/chart.aspx?branchID=30047>
- More technical documentation concerning various products: <https://www.microchip.com/webdoc>
- Microchip Technical Support: <http://www.microchip.com/support/hottopics.aspx>

7. Revision History

Doc. Rev.	Date	Comments
A	03/2020	Initial document release

The Microchip Website

Microchip provides online support via our website at <http://www.microchip.com/>. This website is used to make files and information easily available to customers. Some of the content available includes:

- **Product Support** – Data sheets and errata, application notes and sample programs, design resources, user's guides and hardware support documents, latest software releases and archived software
- **General Technical Support** – Frequently Asked Questions (FAQs), technical support requests, online discussion groups, Microchip design partner program member listing
- **Business of Microchip** – Product selector and ordering guides, latest Microchip press releases, listing of seminars and events, listings of Microchip sales offices, distributors and factory representatives

Product Change Notification Service

Microchip's product change notification service helps keep customers current on Microchip products. Subscribers will receive email notification whenever there are changes, updates, revisions or errata related to a specified product family or development tool of interest.

To register, go to <http://www.microchip.com/pcn> and follow the registration instructions.

Customer Support

Users of Microchip products can receive assistance through several channels:

- Distributor or Representative
- Local Sales Office
- Embedded Solutions Engineer (ESE)
- Technical Support

Customers should contact their distributor, representative or ESE for support. Local sales offices are also available to help customers. A listing of sales offices and locations is included in this document.

Technical support is available through the website at: <http://www.microchip.com/support>

Microchip Devices Code Protection Feature

Note the following details of the code protection feature on Microchip devices:

- Microchip products meet the specification contained in their particular Microchip Data Sheet.
- Microchip believes that its family of products is one of the most secure families of its kind on the market today, when used in the intended manner and under normal conditions.
- There are dishonest and possibly illegal methods used to breach the code protection feature. All of these methods, to our knowledge, require using the Microchip products in a manner outside the operating specifications contained in Microchip's Data Sheets. Most likely, the person doing so is engaged in theft of intellectual property.
- Microchip is willing to work with the customer who is concerned about the integrity of their code.
- Neither Microchip nor any other semiconductor manufacturer can guarantee the security of their code. Code protection does not mean that we are guaranteeing the product as "unbreakable."

Code protection is constantly evolving. We at Microchip are committed to continuously improving the code protection features of our products. Attempts to break Microchip's code protection feature may be a violation of the Digital Millennium Copyright Act. If such acts allow unauthorized access to your software or other copyrighted work, you may have a right to sue for relief under that Act.

Legal Notice

Information contained in this publication regarding device applications and the like is provided only for your convenience and may be superseded by updates. It is your responsibility to ensure that your application meets with

your specifications. MICROCHIP MAKES NO REPRESENTATIONS OR WARRANTIES OF ANY KIND WHETHER EXPRESS OR IMPLIED, WRITTEN OR ORAL, STATUTORY OR OTHERWISE, RELATED TO THE INFORMATION, INCLUDING BUT NOT LIMITED TO ITS CONDITION, QUALITY, PERFORMANCE, MERCHANTABILITY OR FITNESS FOR PURPOSE. Microchip disclaims all liability arising from this information and its use. Use of Microchip devices in life support and/or safety applications is entirely at the buyer's risk, and the buyer agrees to defend, indemnify and hold harmless Microchip from any and all damages, claims, suits, or expenses resulting from such use. No licenses are conveyed, implicitly or otherwise, under any Microchip intellectual property rights unless otherwise stated.

Trademarks

The Microchip name and logo, the Microchip logo, Adaptec, AnyRate, AVR, AVR logo, AVR Freaks, BesTime, BitCloud, chipKIT, chipKIT logo, CryptoMemory, CryptoRF, dsPIC, FlashFlex, flexPWR, HELDO, IGLOO, JukeBlox, KeeLoq, Kleer, LANCheck, LinkMD, maXStylus, maXTouch, MediaLB, megaAVR, Microsemi, Microsemi logo, MOST, MOST logo, MPLAB, OptoLyzer, PackeTime, PIC, picoPower, PICSTART, PIC32 logo, PolarFire, Prochip Designer, QTouch, SAM-BA, SenGenuity, SpyNIC, SST, SST Logo, SuperFlash, Symmetricom, SyncServer, Tachyon, TempTrackr, TimeSource, tinyAVR, UNI/O, Vectron, and XMEGA are registered trademarks of Microchip Technology Incorporated in the U.S.A. and other countries.

APT, ClockWorks, The Embedded Control Solutions Company, EtherSynch, FlashTec, Hyper Speed Control, HyperLight Load, IntelliMOS, Libero, motorBench, mTouch, Powermite 3, Precision Edge, ProASIC, ProASIC Plus, ProASIC Plus logo, Quiet-Wire, SmartFusion, SyncWorld, Temux, TimeCesium, TimeHub, TimePictra, TimeProvider, Vite, WinPath, and ZL are registered trademarks of Microchip Technology Incorporated in the U.S.A.

Adjacent Key Suppression, AKS, Analog-for-the-Digital Age, Any Capacitor, AnyIn, AnyOut, BlueSky, BodyCom, CodeGuard, CryptoAuthentication, CryptoAutomotive, CryptoCompanion, CryptoController, dsPICDEM, dsPICDEM.net, Dynamic Average Matching, DAM, ECAN, EtherGREEN, In-Circuit Serial Programming, ICSP, INICnet, Inter-Chip Connectivity, JitterBlocker, KleerNet, KleerNet logo, memBrain, Mindi, MiWi, MPASM, MPF, MPLAB Certified logo, MPLIB, MPLINK, MultiTRAK, NetDetach, Omniscient Code Generation, PICDEM, PICDEM.net, PICkit, PICtail, PowerSmart, PureSilicon, QMatrix, REAL ICE, Ripple Blocker, SAM-ICE, Serial Quad I/O, SMART-I.S., SQI, SuperSwitcher, SuperSwitcher II, Total Endurance, TSHARC, USBCheck, VariSense, ViewSpan, WiperLock, Wireless DNA, and ZENA are trademarks of Microchip Technology Incorporated in the U.S.A. and other countries.

SQTP is a service mark of Microchip Technology Incorporated in the U.S.A.

The Adaptec logo, Frequency on Demand, Silicon Storage Technology, and Symmcom are registered trademarks of Microchip Technology Inc. in other countries.

GestIC is a registered trademark of Microchip Technology Germany II GmbH & Co. KG, a subsidiary of Microchip Technology Inc., in other countries.

All other trademarks mentioned herein are property of their respective companies.

© 2020, Microchip Technology Incorporated, Printed in the U.S.A., All Rights Reserved.

ISBN: 978-1-5224-5759-6

Quality Management System

For information regarding Microchip's Quality Management Systems, please visit <http://www.microchip.com/quality>.

Worldwide Sales and Service

AMERICAS	ASIA/PACIFIC	ASIA/PACIFIC	EUROPE
<p>Corporate Office 2355 West Chandler Blvd. Chandler, AZ 85224-6199 Tel: 480-792-7200 Fax: 480-792-7277 Technical Support: http://www.microchip.com/support Web Address: http://www.microchip.com</p> <p>Atlanta Duluth, GA Tel: 678-957-9614 Fax: 678-957-1455</p> <p>Austin, TX Tel: 512-257-3370</p> <p>Boston Westborough, MA Tel: 774-760-0087 Fax: 774-760-0088</p> <p>Chicago Itasca, IL Tel: 630-285-0071 Fax: 630-285-0075</p> <p>Dallas Addison, TX Tel: 972-818-7423 Fax: 972-818-2924</p> <p>Detroit Novi, MI Tel: 248-848-4000</p> <p>Houston, TX Tel: 281-894-5983</p> <p>Indianapolis Noblesville, IN Tel: 317-773-8323 Fax: 317-773-5453 Tel: 317-536-2380</p> <p>Los Angeles Mission Viejo, CA Tel: 949-462-9523 Fax: 949-462-9608 Tel: 951-273-7800</p> <p>Raleigh, NC Tel: 919-844-7510</p> <p>New York, NY Tel: 631-435-6000</p> <p>San Jose, CA Tel: 408-735-9110 Tel: 408-436-4270</p> <p>Canada - Toronto Tel: 905-695-1980 Fax: 905-695-2078</p>	<p>Australia - Sydney Tel: 61-2-9868-6733</p> <p>China - Beijing Tel: 86-10-8569-7000</p> <p>China - Chengdu Tel: 86-28-8665-5511</p> <p>China - Chongqing Tel: 86-23-8980-9588</p> <p>China - Dongguan Tel: 86-769-8702-9880</p> <p>China - Guangzhou Tel: 86-20-8755-8029</p> <p>China - Hangzhou Tel: 86-571-8792-8115</p> <p>China - Hong Kong SAR Tel: 852-2943-5100</p> <p>China - Nanjing Tel: 86-25-8473-2460</p> <p>China - Qingdao Tel: 86-532-8502-7355</p> <p>China - Shanghai Tel: 86-21-3326-8000</p> <p>China - Shenyang Tel: 86-24-2334-2829</p> <p>China - Shenzhen Tel: 86-755-8864-2200</p> <p>China - Suzhou Tel: 86-186-6233-1526</p> <p>China - Wuhan Tel: 86-27-5980-5300</p> <p>China - Xian Tel: 86-29-8833-7252</p> <p>China - Xiamen Tel: 86-592-2388138</p> <p>China - Zhuhai Tel: 86-756-3210040</p>	<p>India - Bangalore Tel: 91-80-3090-4444</p> <p>India - New Delhi Tel: 91-11-4160-8631</p> <p>India - Pune Tel: 91-20-4121-0141</p> <p>Japan - Osaka Tel: 81-6-6152-7160</p> <p>Japan - Tokyo Tel: 81-3-6880-3770</p> <p>Korea - Daegu Tel: 82-53-744-4301</p> <p>Korea - Seoul Tel: 82-2-554-7200</p> <p>Malaysia - Kuala Lumpur Tel: 60-3-7651-7906</p> <p>Malaysia - Penang Tel: 60-4-227-8870</p> <p>Philippines - Manila Tel: 63-2-634-9065</p> <p>Singapore Tel: 65-6334-8870</p> <p>Taiwan - Hsin Chu Tel: 886-3-577-8366</p> <p>Taiwan - Kaohsiung Tel: 886-7-213-7830</p> <p>Taiwan - Taipei Tel: 886-2-2508-8600</p> <p>Thailand - Bangkok Tel: 66-2-694-1351</p> <p>Vietnam - Ho Chi Minh Tel: 84-28-5448-2100</p>	<p>Austria - Wels Tel: 43-7242-2244-39 Fax: 43-7242-2244-393</p> <p>Denmark - Copenhagen Tel: 45-4485-5910 Fax: 45-4485-2829</p> <p>Finland - Espoo Tel: 358-9-4520-820</p> <p>France - Paris Tel: 33-1-69-53-63-20 Fax: 33-1-69-30-90-79</p> <p>Germany - Garching Tel: 49-8931-9700</p> <p>Germany - Haan Tel: 49-2129-3766400</p> <p>Germany - Heilbronn Tel: 49-7131-72400</p> <p>Germany - Karlsruhe Tel: 49-721-625370</p> <p>Germany - Munich Tel: 49-89-627-144-0 Fax: 49-89-627-144-44</p> <p>Germany - Rosenheim Tel: 49-8031-354-560</p> <p>Israel - Ra'anana Tel: 972-9-744-7705</p> <p>Italy - Milan Tel: 39-0331-742611 Fax: 39-0331-466781</p> <p>Italy - Padova Tel: 39-049-7625286</p> <p>Netherlands - Drunen Tel: 31-416-690399 Fax: 31-416-690340</p> <p>Norway - Trondheim Tel: 47-72884388</p> <p>Poland - Warsaw Tel: 48-22-3325737</p> <p>Romania - Bucharest Tel: 40-21-407-87-50</p> <p>Spain - Madrid Tel: 34-91-708-08-90 Fax: 34-91-708-08-91</p> <p>Sweden - Gothenberg Tel: 46-31-704-60-40</p> <p>Sweden - Stockholm Tel: 46-8-5090-4654</p> <p>UK - Wokingham Tel: 44-118-921-5800 Fax: 44-118-921-5820</p>