SiLabs/Tiva/ATtiny Programming Guide

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This document centralizes the key configuration steps, software identification, and hardware needed to allow a developer to program (and debug) the following microcontrollers (MCUs): SiLabs 8-bit (page 1), TI Tiva (page 4), and Microchip ATtiny-UPDI variants (page 6). The optional Small-Form-Factor (SFF) connector standard developed and used by the author is also presented in enough detail to allow one to reproduce the needed hardware and accessories. This allows for interchangeable cabling for interface to cost-effective program and debug solutions.

SiLabs Microcontrollers

Programming the SiLabs 8051 microcontroller (MCU) on a target PCB can be accomplished using the SiLabs USB debug adapter, the SiLabs FLASH Programming Utility program, and a source file for the desired application to program. The steps defined below apply to both C2D-style and JTAG style SiLabs 8051 variants.

The Debug adapter can be obtained from Mouser Electronics (www.mouser.com) or DigiKey Electronics (www.digikey.com) using the part number DEBUGADPTR1-USB. The cost (as of this writing) is about $49 plus applicable tax and shipping charges. A "standard" USB "printer" cable is also needed (these cables feature the rectangular "A" style connector that plugs into the PC at one end, and the square-ish "B" style connector that plugs into something like a printer or scanner at the other end). Mouser or DigiKey are also good sources for the USB cable. The Qualtek 3021001-03 or 3021062-06 each lists for about $3.

The Flash Programming Utility software is available at:

http://www.silabs.com/products/development-tools/software/8-bit-8051-microcontroller-software#flash

Select "Downloads" and scroll to "Download Utility".
If this link does not work, go to www.silabs.com and search for "flash programming utility".

Follow the installation instructions on the web site and in the debug adapter documentation.

Connect the debug adapter ribbon cable connector to the target connector either directly or by using an adapter to connect to the Molex 6-pin SFF programming connector (details on this adapter appear later in this document). To program the MCU, execute the following steps:

- Obtain the object file for the application to program (typically, this is a "*.hex" file).
- Connect the debug adapter to the programming connector on the target.
- Plug in the USB cable to the debug adapter and the PC. Some targets may require power to be applied to the target separately, while others may be powered from the USB Programming Adapter.
- Open the flash programming utility software and refer to Figures 1 – 3.
- Under the "Download Hex File/Go/Stop" tab, select the object application file (.hex) and check the "Erase all of Code Space" box.
- Under the "Connect/Disconnect" tab, make sure all of the check boxes match the image and that the "USB Debug Adapter" is checked (if not, you must make sure the debug adapter is connected

and that the drivers are working properly). Click “Connect” and click “OK” when the “Connected” box appears.

- Return to the “Download Hex File/Go/Stop” tab and click “Download” (there should be erase, program, and verify progress screens displayed). Programming should take no more than 15 seconds.
- Return to the “Connect/Disconnect” and click “Disconnect”.
- Remove Power from the Orion and disconnect the debug adapter.
- The target device is now ready to operate with the new application software.

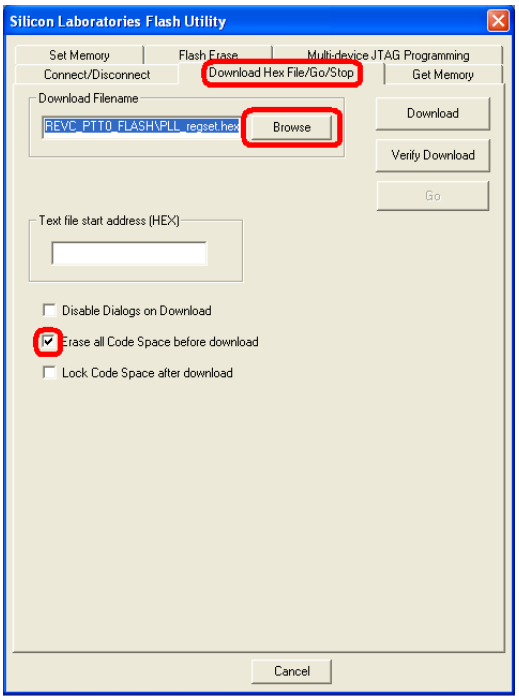


Figure 1. FLASH Utility setup dialog box.

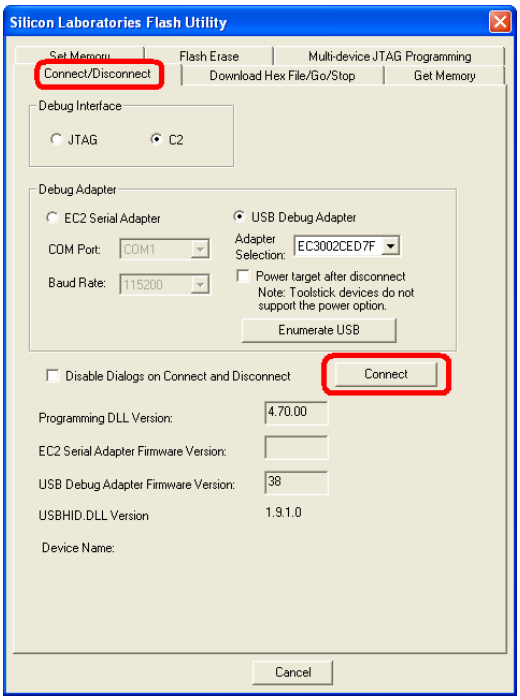


Figure 2. FLASH Utility connect dialog box.

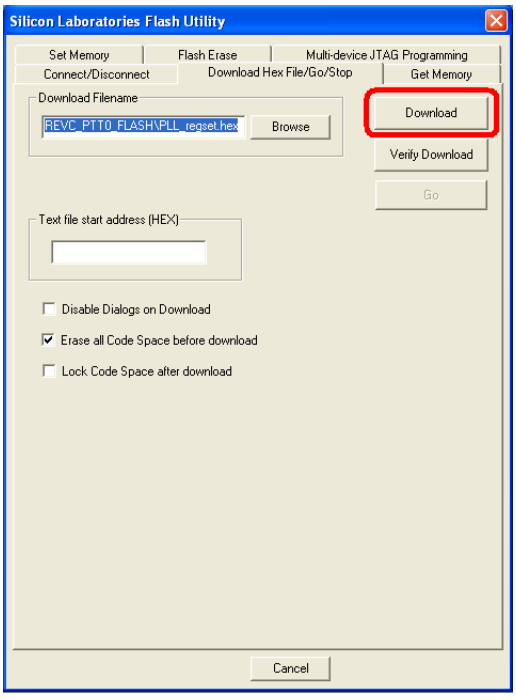


Figure 3. FLASH Utility setup dialog box (download).

Small Form-Factor Programming Connections

Many of my designs use an SFF connector to minimize the PCB space required for in-circuit programming capability. A connection pinout that I have standardized for my projects uses a Molex, 1.25mm, 6-position connector, PN **53261-0671** (R/A) or PN **53398-0671** (vertical) for the target PCB connector. This connector has a small footprint, and the right-angle and vertical versions can both be soldered to the same PCB footprint. All that is required to connect the SiLabs programming adapter is an intermediate cable which accepts a 10-position ribbon cable connector and converts this to the 6-position cable with the mating Molex connector required for the PCB connection.

The transition cable (see Photo 1) consists of a 10-pin, dual row, 0.1" spaced ribbon header (TE Connectivity 5103309-1, or equivalent) and a cable terminated with the appropriate 6-positon Molex connector (Molex PN 15134-0602, or equivalent). The 15134-0602 cable comes with two ends and should be cut in half (more or less – the other half may be saved or discarded). *Note: Other lengths of this cable are generally available and may be used in place of that part# if it is out of stock*. A small piece of pad-per-hole protoboard (approximately 0.75" square) should be used to stabilize the 10-pin connector and wires. Strip and tin the leads approximately 0.1", then form each tinned wire into a "J-hook". Solder the 10-pin header to the protoboard and then solder the GND net connections (pins 2, 3, and 9 – a piece of ¼W leaded resistor lead can accomplish this nicely) then solder each wire according to Table 1.

JTAG Signal	C2D Signal	P1	**10-pin**		P1	C2D Signal	JTAG Signal
-	-	-	**1**	**2**	5	GND	GND
GND	GND	5	**3**	**4**	2	C2D	TCK
TMS	/RESET	1	**5**	**6**	4	P0.6	TDO
TDI	/RST_C2K	3	**7**	**8**	-	-	-
GND	GND	5	**9**	**10**	6	+5V (note)	+3.3V (note)

Table 1. SiLabs to SFF programming adapter. P1 is the target device connector pinout. *Note: Some targets require +3.3V supply. For these target devices, DO NOT connect +5V to P1-6.*

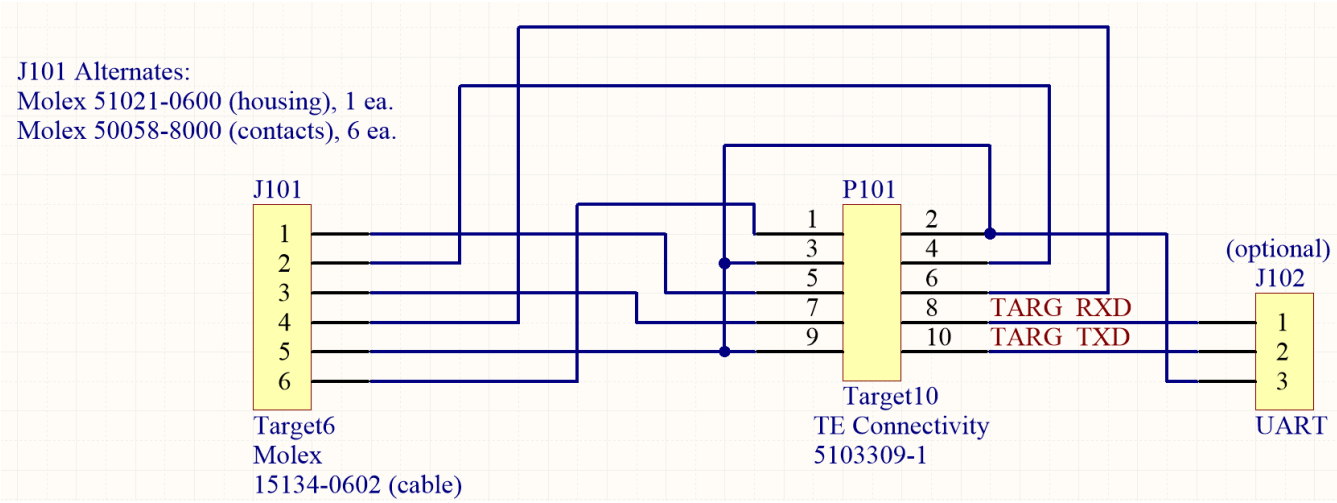
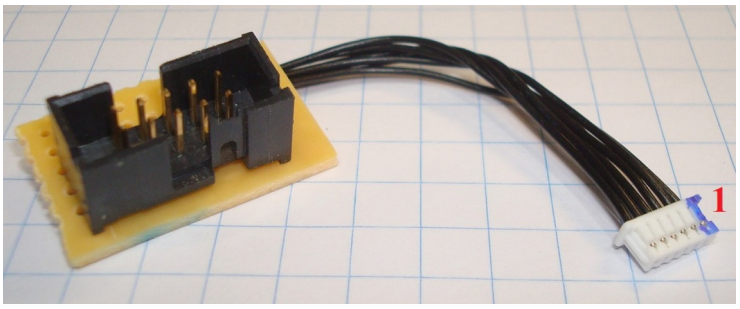


Figure 4. SFF adapter schematic



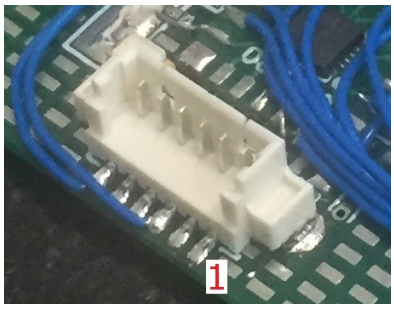


Photo 1. Programming adapter cable (left) & target connector (right).

To support Tiva MCUs, a 3-pin, single-row, header must be affixed to the pad-per-hole board. The center-pin of this header would connect to pin 6 of the SFF connector. The "Other" side of the 3-pin header would connect to pin-10 of the 10-pin connector while the remaining side ("Tiva") would connect to pin-1 of the 10-pin connector. Place a jumper-shunt to select "Other" or "Tiva" as needed.

Tiva Programming Hardware Guide

The same SFF connector and 10-pin adapter used for the SiLabs processors is also used in my Tiva designs for programming/debugging. The connections are similar with a couple of exceptions noted in Table 2.

LP Signal	P1	**10-pin**		P1	LP Signal
X1>>RESET	6	**1**	**2**	5	GND
GND	5	**3**	**4**	2	X1>>TCK
X1>>TMS	1	**5**	**6**	4	X1<<TDO
X1>>TDI	3	**7**	**8**	-	X1>>targRXD
GND	5	**9**	**10**	-	targTXD>>X1

Table 2. Tiva to SFF programming adapter. P1 is the target device connector pinout. *Note: X1 is located on the EK-TM4C1294XL LaunchPad. An "SiLabs/Tiva" shunt jumper required. Pins 8 & 10 must be separately routed to the target if the LaunchPad COM port is desired. See page 3 for SFF adapter construction details.*

Any of the Tiva LaunchPad evaluation boards can be modified to act as a programming interface for a target board. This is generally much less expensive than buying a commercial programmer. Photo 2 illustrates the connection to an EK-TM4C1294XL Launchpad that has had its target MCU removed (this is not necessary to use the LaunchPad as a programmer).

Note: A set of 3D models for an enclosure for the Tiva EK-TM4C1294XL evaluation board can be found on my github repo at: https://github.com/ke0ff/TivaLP_1294. The available files include the OpenSCAD source and STL files for the enclosure, lid, and cover (to cover unused connectors on the LaunchPad board). Be sure to solder the programming cable to the top side of the LaunchPad as shown in Photo 2 if you wish to use the 3D-printed enclosure.

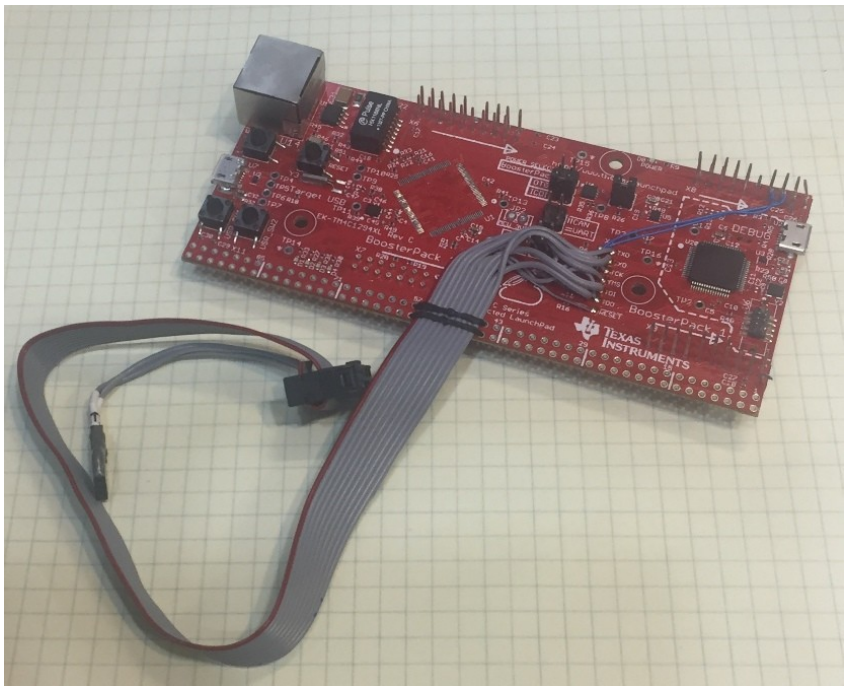


Photo 2. A modified Tiva LaunchPad for use as a programmer (*Note: the programming USB connector is on the right as shown in the photo*).

To modify a LaunchPad, start by fabricating a 10-pin ribbon cable (8", max) with an IDC connector at one end (e.g., Kobi Conn: 164-9006-E (conn) and 3M: 3801/10 (100') (cable)). Separate the wires at the un-terminated end of the ribbon cable, then strip and tin each wire 0.1". *Note: Some LaunchPads feature a dual row header with shorting jumpers while others have a hole-pattern for such a header-jumper but have traces connecting the holes, and no header is installed*.

For the boards that have no header – cut the traces connecting each pad pair (cut BETWEEN the pads only). Then install a header (so that the LaunchPad target device can be programmed if desired) and solder the ribbon cable wires to the back side of the board on the side closest to the programming MCU. *Note that the LaunchPad shown in Photo 2 has had its dual-row header removed, so the ribbon cable is shown connected to the top side*.

For the boards with a header, remove the jumpers and store them on the same header such that they are secured on only one of the header pins. Solder the ribbon cable wires to the back side of the board on the side closest to the programming MCU.

The LaunchPad programmers also feature a serial port service that can be used for debug or user interface with the target device. This connection is generally a 3-pin, 0.1" spacing header on my target boards. To use this serial connection, connect a 3-conductor cable to the appropriate target connector, and solder the appropriate wires to GND, RXD, and TXD on either the SFF 10-pin connector, or on the LaunchPad board. To use the serial port, simply connect the LaunchPad programmer USB connection to the PC, start the terminal emulator of your choice, and select the appropriate COM port.

To use the programmer with Code Composer Studio (https://www.ti.com/tool/CCSTUDIO), add or edit a target configuration file to the project and select the "Stellaris In-Circuit Debug Interface" along with the target processor – see Figure 5. To program the Tiva target device, simply start a debug session in Code Composer Studio. Use the CCS debug icons to start/stop/reset the target software/hardware.

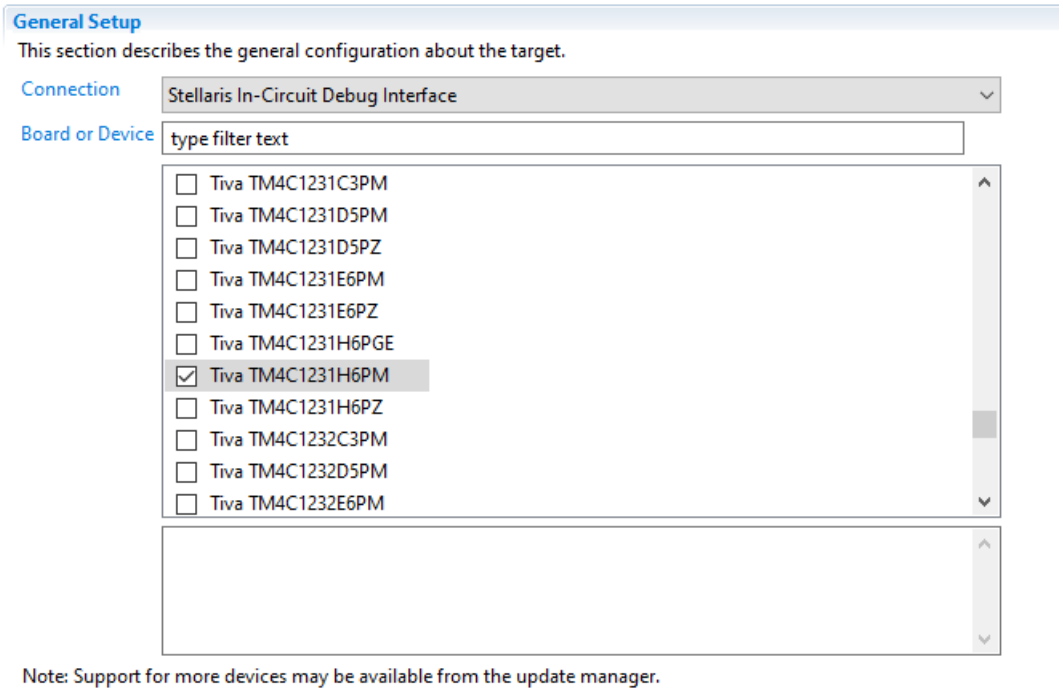


Figure 5. TI's Code Composer Studio 6 target configuration.

ATtiny (UPDI) Programming Hardware Guide

The small form-factor connector used for the SiLabs processors is also used in some of my ATtiny designs for programming. The connections are shown in Table 3.

Target pin (notes)	Nano pin	PGMR Signal	P1	**10-pin** pgmr		P1	PGMR Signal	Nano pin	Target pin (notes)
PB3 (opt)	4	TARG_RXD	6	**1**	**2**	5	GND	30	GND
GND	15	GND	5	**3**	**4**	2	TARG_Vdd	29	Vdd
/RESET_UPDI	31	TARG_UPDI	1	**5**	**6**	4	-	-	-
PB2 (opt)	3	TARG_TXD	3	**7**	**8**	-	-	-	(Tiva TXD)
GND	20	GND	5	**9**	**10**	-	-	-	(Tiva RXD)

Table 3. ATtiny-to-SFF programming adapter. P1 is the SFF target device connector pinout. *See page 3 for SFF adapter construction details.*

An ATTINY3217 Curiosity Nano evaluation board can be modified to act as a programming interface for any UPDI-based ATtiny target MCU. In addition to performing UPDI programming, the Nano programmer also offers a USB COM-PORT that can be used to communicate with the target device UART, if so connected (these are the TARG_RXD and TARG_TXD signals indicated in Table 3). Using a Nano as a programmer is generally much less expensive than buying a commercial programmer but requires some "assembly" to get a working system. Photo 3 illustrates the pad-cuts needed to isolate the target MCU on the Nano board allowing the Nano programmer processor to access an external device.

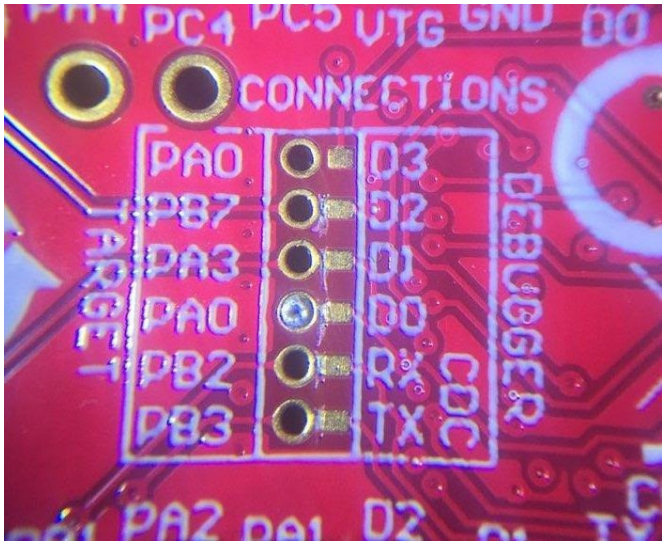


Photo 3. Cut-pads on the Curiosity Nano 3217 (located on the bottom of the board).

Figure 6 shows a schematic of a simple programming adapter and Photo 4 illustrates a jumper to allow the UPDI signal to be externally re-routed back to the Nano target MCU if it is later desired to access that device (externally connect Nano pin 31 to Nano pin 1, typically through a switch or shunt-jumper).

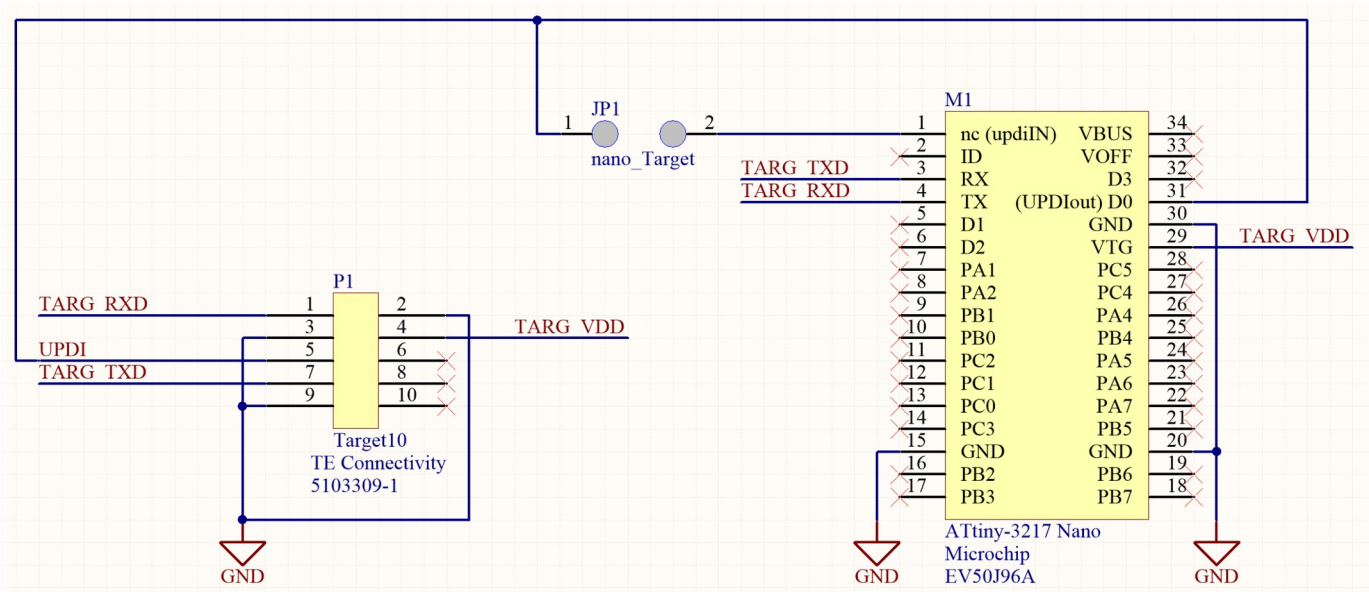


Figure 6. Attiny Curiosity-Nano Programmer schematic

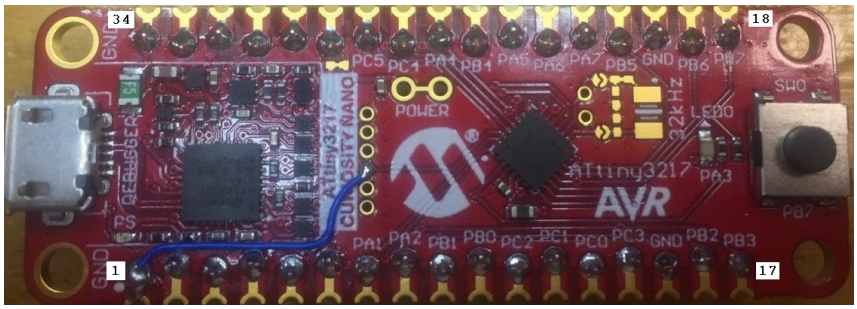


Photo 4. A modified Curiosity Nano 3217 showing the jumper needed (from "Target D0" to header pin 1) to allow the external re-connection of the Nano 3217-target to the programming interface.

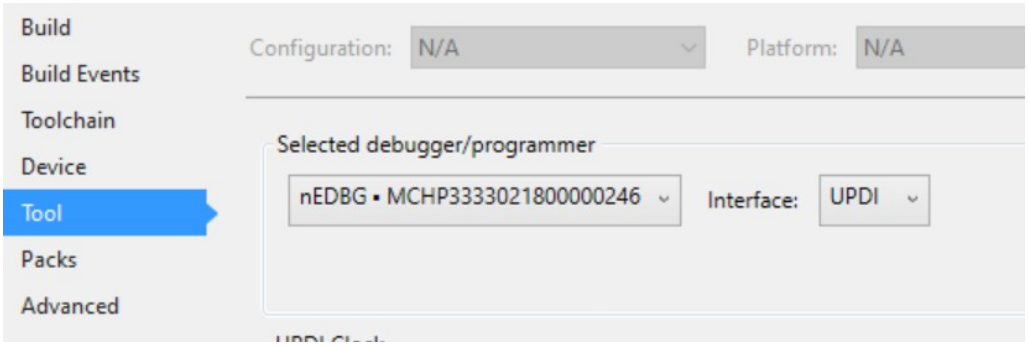
Atmel Studio 7 Setup

Note: Microchip has acquired Atmel and re-branded much of the Atmel IP. These instructions should work for Microchip Studio, but have not been tested with the re-branded application.

Atmel Studio 7 is a full-featured IDE which includes Edit, Compile/Link, Debug, and device programming functions. Projects created for the Curiosity Nano 3217 will seamlessly connect to the application allowing easy debug and programming connection. However, using an MCU other than the 3217 is not directly supported. This is likely due to the fact that the Atmel Studio application gets the target device info from data on the ersatz disk-drive that opens when the CuriosityNano is connected to the PC's USB port. However, performing some adjustments to the Atmel Studio configuration can allow the user to debug devices other than the 3217.

To configure Atmel Studio for debugging, start the application and open or create the project for the desired MCU. Connect the Curiosity Nano 3217 that has been configured to operate as a stand-alone programmer to a USB port on the PC (ideally, the actual target MCU will also be connected):

- Go to "Project" and select "<proj> Properties..." (where <proj> is the project name).
- Click on "Device" then "Change Device". Select the ATTINY3217.
- Click on "Tool", then click on the drop-down under "Selected debugger/programmer" and select the nEDBG option that shows up. Make sure that the "Interface" is set to "UPDI":

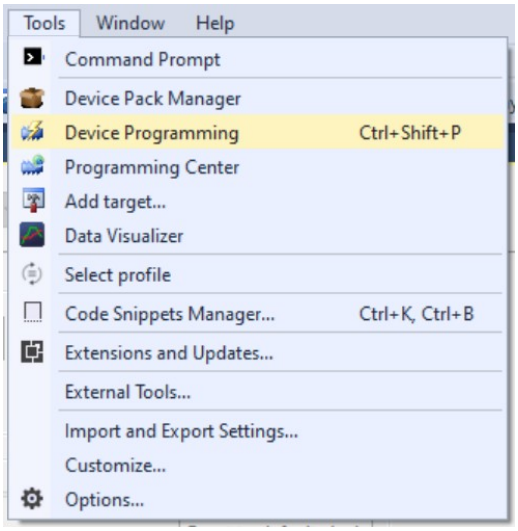


- Click on "Device" then "Change Device" (again). Select the actual target device number (e.g., ATtiny1616).
- Click on "Tool" (again), the nEDBG option should still be visible and selected.
- ***Note: Repeat this process any time Atmel Studio is started or the nEDBG option fails to appear in the drop-down list.***

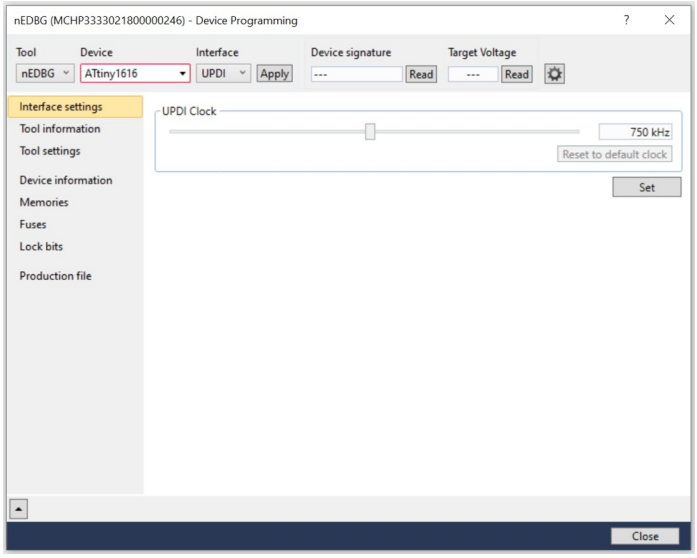
While somewhat inconvenient, these steps seem to allow one to use the debugger feature of the Atmel/Microchip IDE to load and monitor the device object code using the CuriosityNano 3217 board.

Device Programming Settings

Some projects require the device settings to be modified. In particular, the device Vdd voltage can be adjusted. To make this adjustment, go to “Tools” and select “Device Programming”:



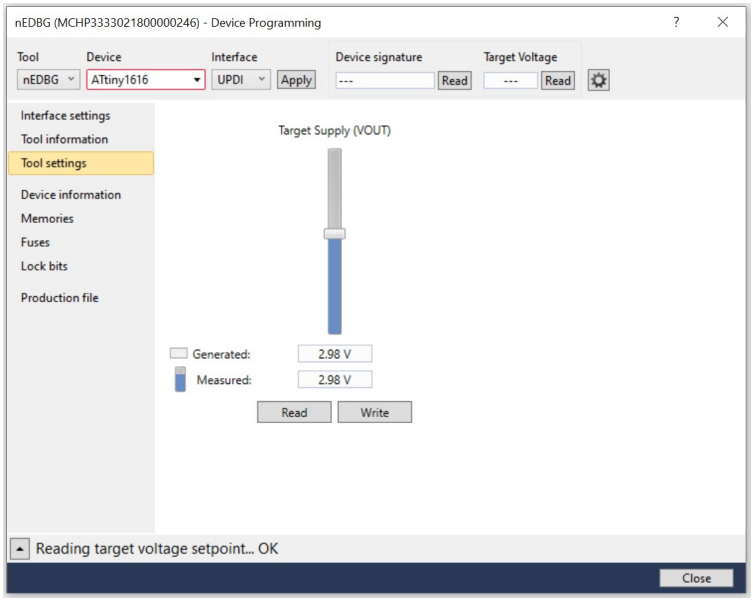
Manually type in the device type in the “Device” drop-down field then click “Apply”:



Typically, the device type will be “ATtinyXXXX”, where the “XXXX” are the digits of the device part#.

!! Note: Unfortunately, this step must be performed each time the “Device Programming” window is selected !!

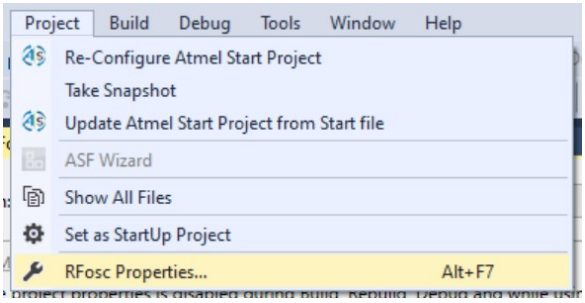
Adjust the supply voltage to the desired value (0V and values between 1.6V and 5.5V are available) and click “Write”:



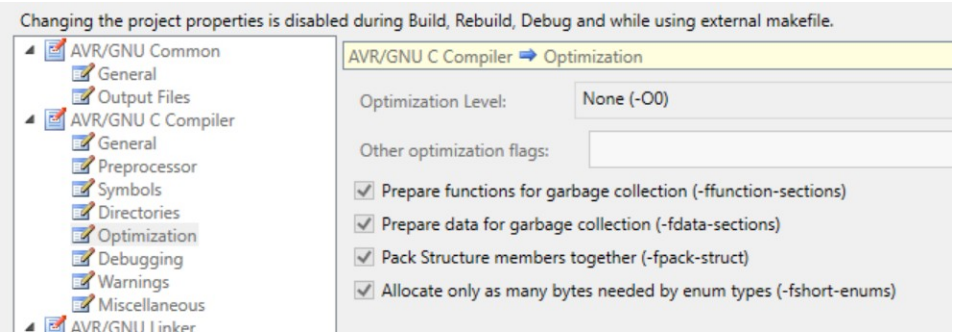
After all required configuration settings are completed, click “Close”.

Atmel Studio Optimization Settings

Some projects require the compiler optimizations to be removed. If this is needed, go to the "Project" menu and select "<proj> Properties..." (where <proj> is the project name):



Click on "Toolchain" then, under "AVR/GNU C Compiler", select "Optimization". Click on the "Optimization Level:" drop-down field and select "None":



Deep Thoughts on Compiler Software...

As with most computer applications, compiler software is often updated. Changes due to OS migrations as well as feature and new processor additions are common reasons for these applications to be upgraded. However, I recommend sticking with a particular compiler version until it becomes absolutely untenable. Using the same version helps ensure that subtle compiler differences don't produce undesired target device results and is also required in some certified industries to make sure that you can re-create a bit-for-bit object file from the original source files. It also helps in that one doesn't have to re-learn how to adjust the compiler/device settings.

If you wish to download the most current versions of the tools referenced herein, it is likely that you won't experience any insurmountable problems, but the user-interface may be different to the point that my step-by-step instructions are not usable. Most companies offer deprecated versions of their IDE to support those who, by need or desire, wish to access them. In general, the links I have provided seem get one reasonably close, but be aware that some digging might be in store. FWIW, My versions are:

- Tiva: TI Code Composer Studio, V6.2.0.00050
- SiLabs C8051: Keil V5 (latest version) – Note: When I last tried to install this, a free license for 8-bit devices was still available – caveat emptor. *Note: Keil is not needed to program object files compiled elsewhere.*
- ATtiny: Atmel Studio 7 (latest version)

Revision History

Rev 3.4, 09/22/2024:
- Corrected typo in Table 3 (/RESET_UPDI pin# was incorrect).
- Added schematic for SFF adapter, re-ordered Figure numbers.
- Added ATtiny CuriosityNano Programmer schematic.
- Added “Deep-Thoughts” RE compilers.

Rev 3.3, 02/27/2024:
- Updated email address image.
- Various grammatical edits from the latest proofread scrub.

Rev 3.2, 06/21/2022:
- Edited “Tiva Setup” section to clarify the directivity of the JTAG and debug UART signals.
- Various grammatical edits from the latest proofread scrub.

Rev 3.1, 06/10/2022:
- Edited “Atmel Studio 7 Setup” section to clarify the use of non-3217 MCUs and add a note about repeating the nEDBG setup as needed.

Rev 3.0, 06/09/2022:
- Added ATtiny section
- Added JTAG signals to SiLabs SFF pinout
- Added details for modifying the SFF adapter to support Tiva connections
- Cleaned up headers/footers

Rev 2.0, 08/04/2021:
- Added Tiva section

Rev 1.0, circa 2016
- Initial release