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PIC18F47Q10 Curiosity Nano

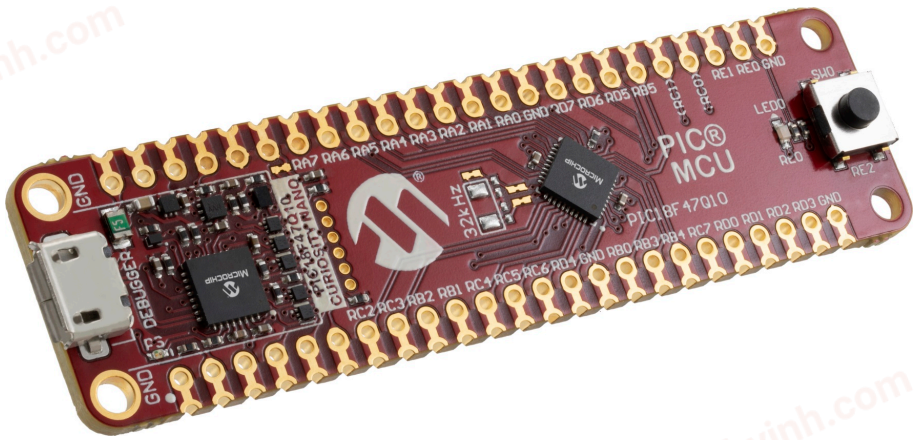
PIC18F47Q10 Curiosity Nano Hardware User Guide

Preface

The PIC18F47Q10 Curiosity Nano evaluation kit is a hardware platform to evaluate the PIC18F47Q10 microcontroller.

Supported by MPLAB® X Integrated Development Environment (IDE), the kit provides easy access to the features of the PIC18F47Q10 and explains how to integrate the device into a custom design.

The Curiosity Nano series of evaluation kits include an on-board debugger, and no external tools are necessary to program the PIC18F47Q10.



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1. Introduction

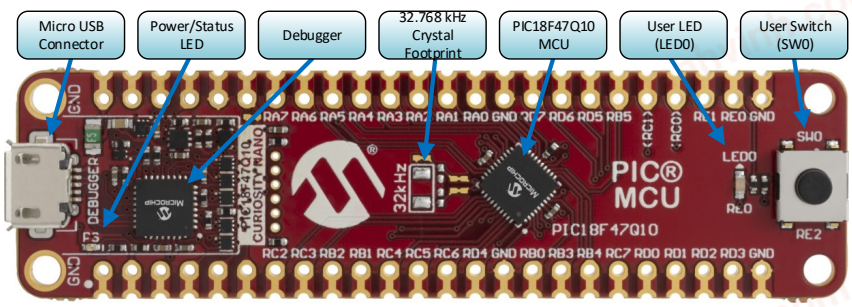
1.1 Features

- PIC18F47Q10-I/MP Microcontroller
- One Yellow User LED
- One Mechanical User Switch
- On-Board Debugger
  - Board identification in MPLAB® X
  - One green power and status LED
  - Programming and debugging
  - Virtual COM port (CDC)
  - One logic analyzer channel (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)

1.2 Kit Overview

The Microchip PIC18F47Q10 Curiosity Nano evaluation kit is a hardware platform to evaluate the PIC18F47Q10 microcontroller.

Figure 1-1. PIC18F47Q10 Curiosity Nano Evaluation Kit Overview



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2. Getting Started

2.1 Curiosity Nano Quick Start

Steps to start exploring the Curiosity Nano platform:

1. Download MPLAB® X.
2. Launch MPLAB® X.
3. Connect a USB cable (Standard-A to Micro-B or Micro-AB) between the PC and the debug USB port on the kit.

When the Curiosity Nano kit is connected to your computer for the first time, the operating system will perform a driver software installation. The driver file supports both 32- and 64-bit versions of Microsoft® Windows® XP, Windows Vista®, Windows 7, Windows 8, and Windows 10. The drivers for the kit are included with MPLAB® X.

Once the Curiosity Nano board is powered the green status LED will be lit and MPLAB® X will auto-detect which Curiosity Nano board is connected. MPLAB® X will present relevant information like data sheets and kit documentation. The PIC18F47Q10 device is programmed and debugged by the on-board debugger and therefore no external programmer or debugger tool is required.

2.2 Design Documentation and Relevant Links

The following list contains links to the most relevant documents and software for the PIC18F47Q10 Curiosity Nano.

- **MPLAB® X IDE** - MPLAB® X IDE is a software program that runs on a PC (Windows®, Mac OS®, Linux®) to develop applications for Microchip microcontrollers and digital signal controllers. It is called an Integrated Development Environment (IDE) because it provides a single integrated "environment" to develop code for embedded microcontrollers.
- **MPLAB® Code Configurator** - MPLAB® Code Configurator (MCC) is a free software plug-in that provides a graphical interface to configure peripherals and functions specific to your application.
- **Microchip Sample Store** - Microchip sample store where you can order samples of devices.
- **Data Visualizer** - Data Visualizer is a program used for processing and visualizing data. The Data Visualizer can receive data from various sources such as the EDBG Data Gateway Interface found on Curiosity Nano and Xplained Pro boards and COM Ports.
- **PIC18F47Q10 Curiosity Nano website** - Kit information, latest user guide and design documentation.
- **PIC18F47Q10 Curiosity Nano on Microchip Direct** - Purchase this kit on Microchip Direct.

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3. Curiosity Nano

Curiosity Nano is an evaluation platform that provides a set of small boards with access to most of the microcontrollers I/Os. The platform consists of a series of low pin-count microcontroller (MCU) boards, which are integrated with MPLAB® X to present relevant user guides, application notes, data sheets, and example code. The platform features a Virtual COM port (CDC) for serial communication to a host PC and a Data Gateway Interface (DGI) GPIO.

3.1 On-Board Debugger

The PIC18F47Q10 Curiosity Nano contains an on-board debugger for programming and debugging. The on-board debugger is a composite USB device of several interfaces: a debugger, a mass storage device, a data gateway, and a Virtual COM port (CDC).

Together with MPLAB® X, the on-board debugger interface can program and debug the PIC18F47Q10.

A Data Gateway Interface (DGI) is available for use with the logic analyzer channels for code instrumentation, to visualize the program flow. DGI GPIOs can be graphed using the Data Visualizer.

The Virtual COM port is connected to a UART on the PIC18F47Q10 and provides an easy way to communicate with the target application through terminal software.

The on-board debugger controls one Power and Status LED (marked PS) on the PIC18F47Q10 Curiosity Nano board. The table below shows how the LED is controlled in different operation modes.

Table 3-1. On-board Debugger LED Control

Operation Mode	Status LED
Boot Loader mode	LED blink at 1 Hz during power-up.
Power-up	LED is lit - constant.
Normal operation	LED is lit - constant.
Programming	Activity indicator; the LED flashes slowly during programming/debugging.
Fault	The LED flashes fast if a power fault is detected.
Sleep/Off	LED is off. The on-board debugger is either in Sleep mode or powered down. This can occur if the kit is externally powered.

3.1.1 Virtual COM Port

A general purpose bridge between a host PC and a target device.

3.1.1.1 Overview

The debugger implements a composite USB device that includes a standard Communications Device Class (CDC) interface, which appears on the host as a Virtual COM Port. The CDC can be used to stream arbitrary data in both directions between the host and the target: the characters sent from the host will appear in the UART form on the CDC TX pin, and the UART characters sent into the CDC RX pin will be sent back to the host.

On Windows machines, the CDC will enumerate as Curiosity Virtual COM Port and appear in the Ports section of the device manager. The COM port number is usually shown here.

Info: On older Windows systems, a USB driver is required for CDC. This driver is included in Atmel® Studio and MPLAB X installations.

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On Linux machines, the CDC will enumerate and appear as `/dev/ttyACM#`.

On MAC machines, the CDC will enumerate and appear as `/dev/tty.usbmodem#`. Depending on which terminal program is used, it will appear in the available list of modems as `usbmodem#`.

3.1.1.2 Limitations

Not all UART features are implemented in the debugger CDC. The constraints are outlined here:

- **Baud rate** must be in the range 1200 bps to 500 kbps. Values outside this range will be capped to these values, without warning. Baud rate can be changed on-the-fly.
- **Character format**: only 8-bit characters are supported.
- **Parity**: can be odd, even, or none.
- **Hardware flow control**: not supported.
- **Stop bits**: one or two bits are supported.

3.1.1.3 Signaling

During the USB enumeration, the host OS will start both communication and data pipes of the CDC interface. At this point, it is possible to set and read back the baud rate and other UART parameters of the CDC, but data sending and receiving will not be enabled.

When a terminal connects on the host, it must assert the DTR signal. This is a virtual control signal that is implemented on the USB interface, but not in hardware on the debugger. Asserting DTR from the host will indicate to the debugger that a CDC session is active, will enable its level shifters (if available), and will start the CDC data send and receive mechanisms.

Deasserting the DTR signal will not disable the level shifters, but it will disable the receiver, so no further data will be streamed to the host. Data packets that are already queued up for sending to the target will continue to be sent out, but no further data will be accepted.

3.1.1.4 Advanced Use

CDC Override Mode

In normal operation, the on-board debugger is a true UART bridge between the host and the device. However, under certain use cases, the debugger can override the Basic Operating mode and use the CDC pins for other purposes.

Dropping a text file (with extension `.txt`) into the debugger's mass storage drive can be used to send characters out of the CDC TX pin. The text file must start with the characters:

```
CMD:SEND_UART=
```

The maximum message length is 50 characters - all remaining data in the frame are ignored.

The default baud rate used in this mode is 9600 bps, but if the CDC is already active or has been configured, the baud rate last used still applies.

USB-Level Framing Considerations

Sending data from the host to the CDC can be done byte-wise or in blocks, which will be chunked into 64-byte USB frames. Each such frame will be queued up for sending to the CDC TX pin. Sending a small amount of data per frame can be inefficient, particularly at low baud rates, since the debugger buffers frames, not bytes. A maximum of 4 x 64-byte frames can be active at any time, the debugger will throttle the incoming frames accordingly. Sending full 64-byte frames containing data is the most efficient.

When **receiving data** from the target, the debugger will queue up the incoming bytes into 64-byte frames, which are sent to the USB queue for transmission to the host when they are full. Incomplete frames are

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also pushed to the USB queue at approximately 100 ms intervals, triggered by USB start-of-frame tokens. Up to 8 x 64-byte frames can be active at any time.

If the host, or the software running on it, fails to receive data fast enough, an overrun will occur. When this happens, the last-filled buffer frame will be recycled instead of being sent to the USB queue, and a full frame of data will be lost. To prevent this occurrence, the user must ensure that the CDC data pipe is being read continuously, or the incoming data rate must be reduced.

3.1.2 Mass Storage Disk

A simple way to program the target device is through drag and drop with `.hex` files.

3.1.2.1 Mass Storage Device

The debugger implements a highly optimized variant of the FAT12 file system that has a number of limitations, partly due to the nature of FAT12 itself, and partly due to optimizations made to fulfill its purpose in this development kit.

The CURIOSITY drive is USB Chapter 9 compliant as a mass storage device, but does not in any way fulfill the expectations of a general purpose mass storage device. This behavior is intentional.

The debugger enumerates as a Curiosity Nano USB device that can be found in the disk drives section of the Windows device manager. The CURIOSITY drive appears in the file manager and claims the next available drive letter in the system.

The CURIOSITY drive contains approximately one MB of free space. This does not reflect the size of the target device's Flash in any way. When programming a `.hex` file, the binary data are encoded in ASCII with metadata providing a large overhead, so one MB is a trivially chosen value for disk size.

It is not possible to format the CURIOSITY drive. When programming a file to the target, the filename may appear in the disk directory listing - this is merely the operating system's view of the directory, which, in reality, has not been updated. It is not possible to read out the file contents. Removing and replugging the kit will return the file system to its original state, but the target will still contain the application that has been previously programmed.

To erase the target device, simply copy a text file starting with "CMD:ERASE" onto the disk.

By default, the CURIOSITY drive contains several read-only files for generating icons as well as reporting status and linking to further information:

- `AUTORUN.ICO` - icon file for the Microchip logo.
- `AUTORUN.INF` - system file required for Windows Explorer to show the icon file.
- `KIT-INFO.HTM` - redirect to the development board website.
- `KIT-INFO.TXT` - a text file containing details about the kit firmware, name, serial number and device.
- `STATUS.TXT` - a text file containing the programming status of the board.

Info: When `STATUS.TXT` is updated by the debugger dynamically, the contents may be cached by the OS and not reflect the correct status.

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3.1.2.2 Configuration Words/Fuse Bytes

Configuration Words (PIC® MCU Targets)

Configuration Word settings included in the project being programmed after program Flash is programmed. The debugger will *not* mask out any bits in the Configuration Words when writing them, but since it uses Low-Voltage Programming mode, it is unable to clear the LVP Configuration bit. If the incorrect clock source is selected, for example, and the board does not boot, it is always possible to perform a bulk erase (always done before programming) and restore the device to its default settings.

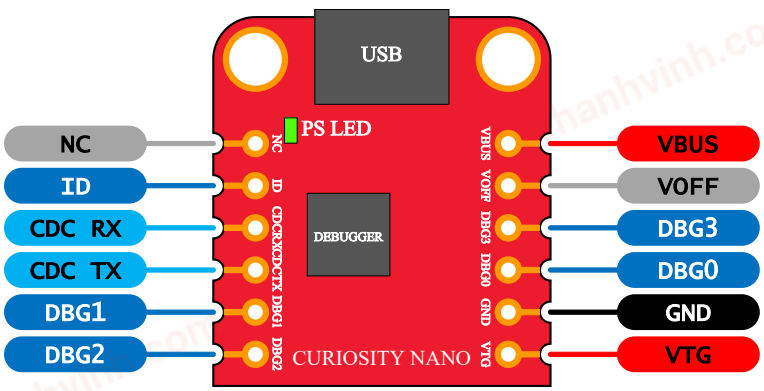
3.2 Curiosity Nano Standard Pinout

The twelve edge connections closest to the USB connector on Curiosity Nano kits have a standardized pinout. The program/debug pins have different functions depending on the target programming interface as shown in the table and figure below.

Table 3-2. Curiosity Nano Standard Pinout

Debugger Signal	ICSP Target	Description
ID	-	ID line for extensions.
CDC TX	UART RX	USB CDC TX line.
CDC RX	UART TX	USB CDC RX line.
DBG0	ICSPDAT	Debug data line.
DBG1	ICSPCLK	Debug clock line/DGI GPIO.
DBG2	GPIO0	DGI GPIO.
DBG3	MCLR	Reset line.
NC	-	No connect.
VBUS	-	VBUS voltage for external use.
VOFF	-	Voltage Off input.
VTG	-	Target voltage.
GND	-	Common ground.

Figure 3-1. Curiosity Nano Standard Pinout

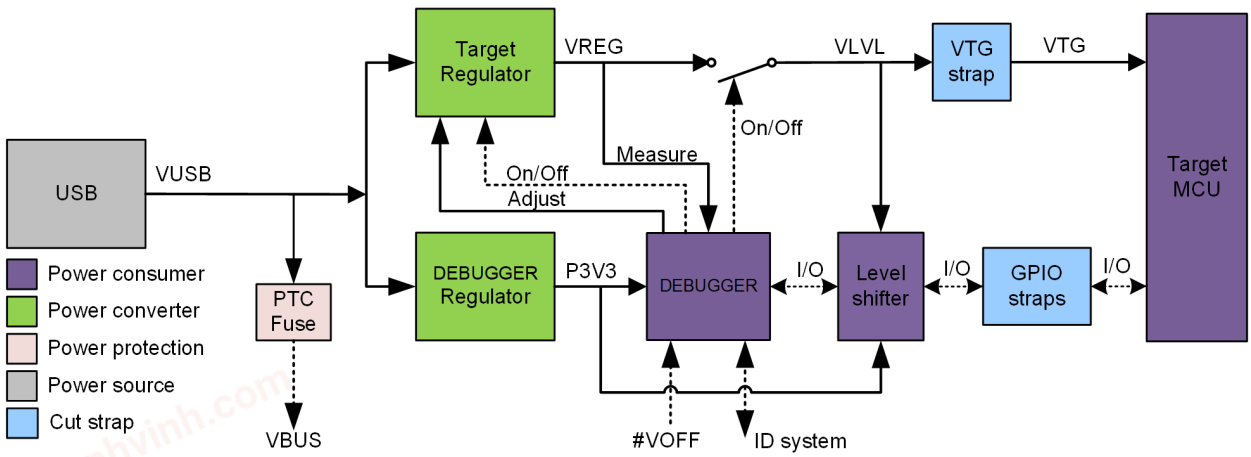


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3.3 Power Supply

The kit is powered through the USB port and contains two regulators for generating 3.3V for the debugger and an adjustable regulator for the target. The voltage from the USB connector can vary between 4.4V to 5.25V (according to the USB specification) and will limit the maximum voltage to the target. The figure below shows the entire power supply system on PIC18F47Q10 Curiosity Nano.

Figure 3-2. Power Supply Block Diagram



3.3.1 Target Regulator

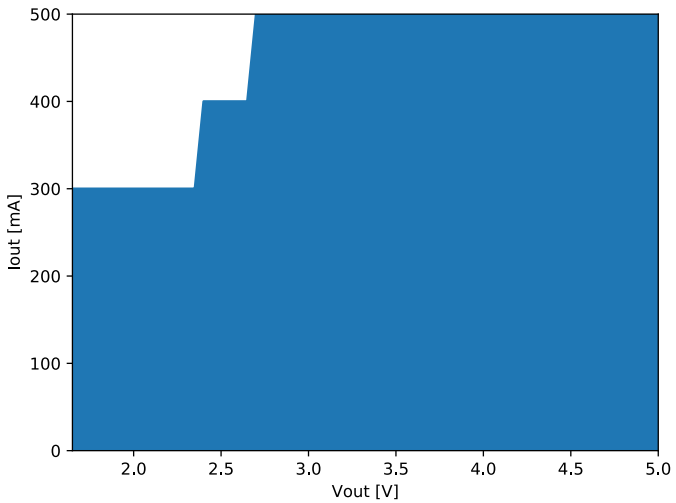
The target voltage regulator is a MIC5353 variable output LDO. The on-board debugger can adjust the voltage output that is supplied to the kit target section by manipulating the MIC5353's feedback voltage. The hardware implementation is limited to an approximate voltage range from 1.7V to 5.1V. Additional output voltage limits are configured in the debugger firmware to ensure that the output voltage never exceeds the hardware limits of the PIC18F47Q10 microcontroller. The voltage limits configured in the on-board debugger on PIC18F47Q10 Curiosity Nano are 1.8-5.1V.

The target voltage is set to 3.3V in production and can be changed through Atmel Studio. Any change to the target voltage done in Atmel Studio is persistent, even through a power toggle.

The MIC5353 supports a maximum current load of 500 mA. It is an LDO regulator in a small package, placed on a small PCB, and the thermal shutdown condition can be reached at lower loads than 500 mA. The maximum current load depends on the input voltage, set output voltage, and the ambient temperature. The figure below shows the safe operation area for the regulator, with an input voltage of 5.1V and an ambient temperature of 23°C.

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Figure 3-3. Target Regulator Safe Operation Area



3.3.2 External Supply

PIC18F47Q10 Curiosity Nano can be powered by an external voltage instead of the on-board target regulator. When the Voltage Off (*VOFF*) pin is shorted to ground (*GND*) the on-board debugger firmware disables the target regulator and it is safe to apply an external voltage to the VTG pin.

WARNING Applying an external voltage to the VTG pin without shorting *VOFF* to *GND* may cause permanent damage to the kit.

WARNING Absolute maximum external voltage is 5.5V for the level shifters on board. Applying a higher voltage may cause permanent damage to the kit.

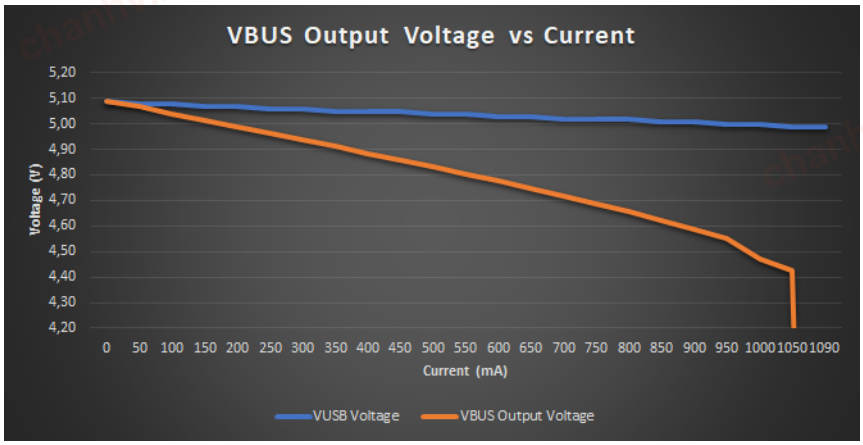
Programming, debugging, and data streaming is still possible while using external power: the debugger and signal level shifters will be powered from the USB cable. Both regulators, the debugger, and the level shifters are powered down when the USB cable is removed.

3.3.3 VBUS Output Pin

PIC18F47Q10 Curiosity Nano has a VBUS output pin which can be used to power external components that need a 5V supply. The VBUS output pin has a PTC fuse to protect the USB against short circuits. A side effect of the PTC fuse is a voltage drop on the VBUS output with higher current loads. The chart below show the voltage versus the current load of the VBUS output.

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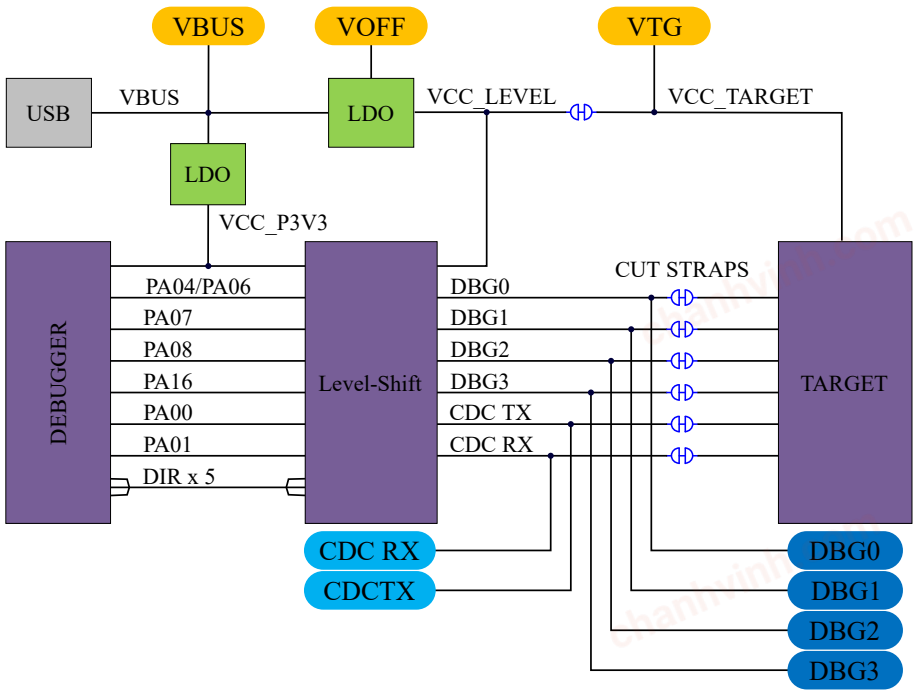
Figure 3-4. VBUS output voltage vs current



3.4 Disconnecting the On-Board Debugger

The block diagram below shows all connections between the debugger and the PIC18F47Q10 microcontroller. The rounded boxes represent connections to the board edge on PIC18F47Q10 Curiosity Nano. The signal names are shown in Figure 3-1 and printed in silkscreen on the bottom side of the board.

Figure 3-5. On-board Debugger Connections to the PIC18F47Q10



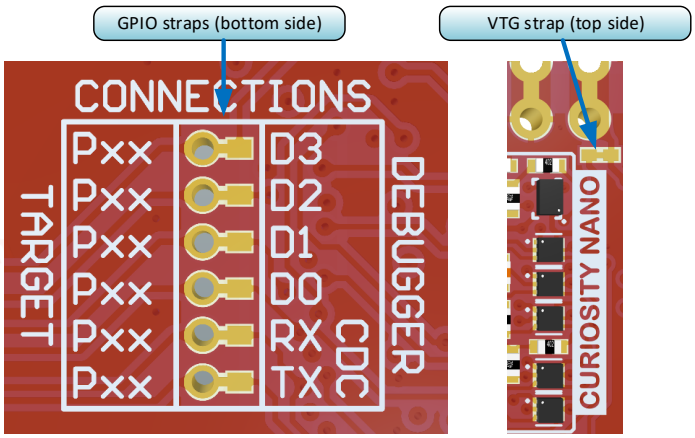
By cutting the *GPIO straps* with a sharp tool, as shown in Figure 3-6, all I/Os connected between the debugger and the PIC18F47Q10 are completely disconnected. To completely disconnect the target regulator, cut the VTG strap shown in Figure 3-6.

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Info: Cutting the connections to the debugger will disable programming, debugging, data streaming, and the target power supply. The signals will also be disconnected from the board edge next to the on-board debugger section.

Info: Solder in 0Ω resistors across the footprints or short-circuit them with tin solder to reconnect any cut signals.

Figure 3-6. Kit Modifications



3.5 Current Measurement

The power to the PIC18F47Q10 is connected from the on-board power supply to the target voltage supply (*VTG*) with a cut strap as shown in Section 3.4 Disconnecting the On-Board Debugger. To measure the power consumption of the PIC18F47Q10 and other peripherals connected to the board, cut the strap and connect an ammeter over the strap. The ammeter can be connected between the target *VTG* pad edge connector and an external power supply for easy measurement. Alternatively, an external power supply can be used as described in Section 3.3.2 External Supply.

Info: The on-board level shifters will draw a small amount of current even when they are not in use. A maximum of 10 µA can be drawn from the VTG net and an additional 2 µA can be drawn from each I/O pin connected to a level shifter for a total of 20 µA. Disconnect the on-board debugger and level shifters as described in Section 3.4 Disconnecting the On-Board Debugger to prevent any leakage.

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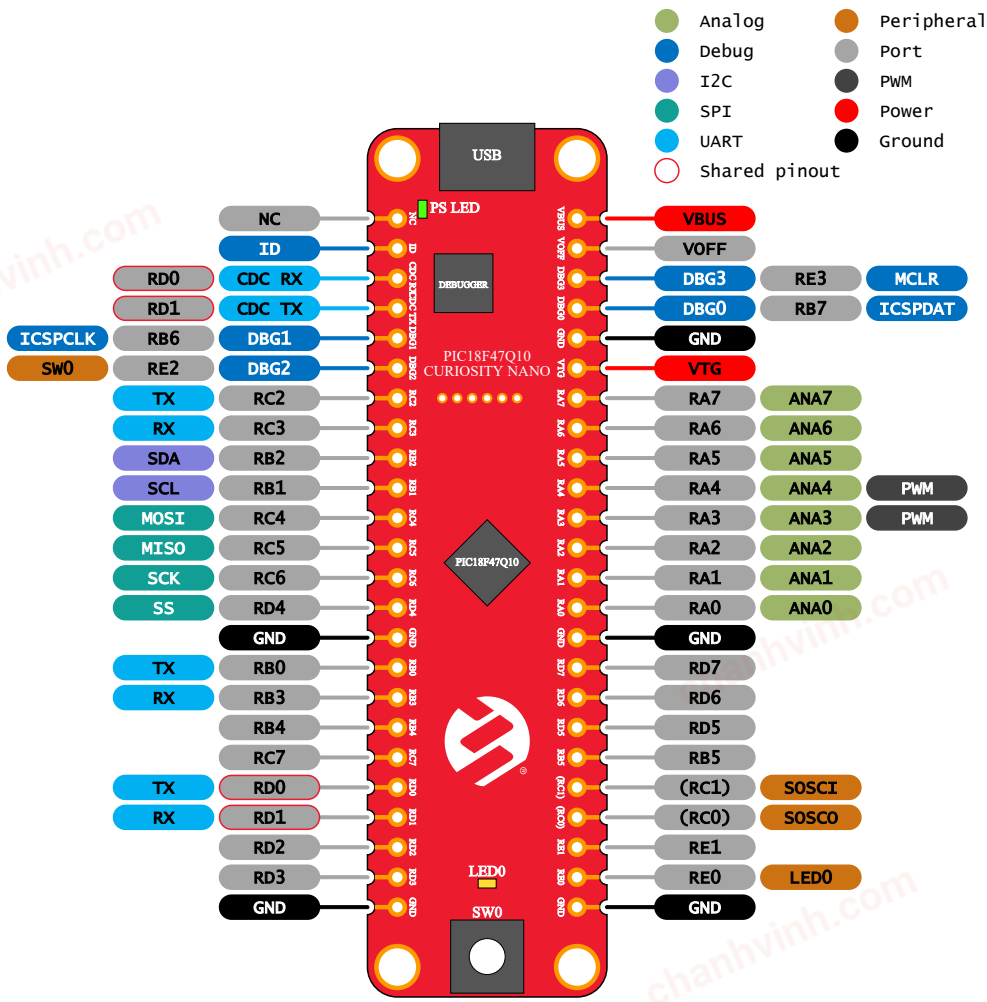
4. Hardware User Guide

4.1 Connectors

4.1.1 PIC18F47Q10 Curiosity Nano Pinout

All the PIC18F47Q10 I/O pins are accessible at the edge connectors on the board. The image below shows the kit pinout.

Figure 4-1. PIC18F47Q10 Curiosity Nano Pinout



4.2 Peripherals

4.2.1 LED

There is one yellow user LED available on the PIC18F47Q10 Curiosity Nano kit that can be controlled by either GPIO or PWM. The LED can be activated by driving the connected I/O line to GND.

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Table 4-1. LED Connection

PIC18F47Q10 Pin	Function	Shared Functionality
RE0	Yellow LED0	Edge connector

4.2.2 Mechanical Switch

PIC18F47Q10 Curiosity Nano has one mechanical switch. This is a generic user configurable switch. When the switch is pressed, it will drive the I/O line to ground (GND).

Table 4-2. Mechanical Switch

PIC18F47Q10 Pin	Description	Shared Functionality
RE2	User switch (SW0)	Edge connector

4.2.3 Crystal

The PIC18F47Q10 Curiosity Nano board has a footprint for a 32.768 kHz crystal.

The crystal footprint is connected to the PIC18F47Q10 by default, but the GPIOs are routed out to the edge connector through open solder straps. The two I/O lines routed to the edge connector are disconnected by default to both reduce the chance of contention to the crystal as well as removing excessive capacitance on the lines when using the crystal. To use the pins RC0 and RC1 as GPIO on the edge connector, some hardware modification is needed. Add a solder blob to the open straps on the bottom side to connect the routing. The crystal should be disconnected when using the pin as GPIO, as this might harm the crystal.

Table 4-3. Crystal Connections

PIC18F47Q10 Pin	Function	Shared Functionality
RC0	SOSC0 (Crystal output)	Edge connector
RC1	SOSCI (Crystal input)	Edge connector

4.2.4 On-Board Debugger Implementation

PIC18F47Q10 Curiosity Nano features an on-board debugger that can be used to program and debug the PIC18F47Q10 using ICSP. The on-board debugger also includes a Virtual Com port interface over UART and DGI GPIO. MPLAB® X can be used as a front-end for the on-board debugger for programming and debugging. Data Visualizer can be used as a front-end for the CDC and DGI GPIO.

4.2.4.1 On-Board Debugger Connections

The table below shows the connections between the target and the debugger section. All connections between the target and the debugger are tri-stated as long as the debugger is not actively using the interface, hence there is little contamination of the signals, the pins can be configured to anything the user wants.

For further information on how to use the capabilities of the on-board debugger, see Section 3. Curiosity Nano.

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Table 4-4. On-Board Debugger Connections

PIC18F47Q10 Pin	Debugger Pin	Function	Shared Functionality
RD1	CDC TX	UART RX (PIC18F47Q10 RX line)	Edge connector
RD0	CDC RX	UART TX (PIC18F47Q10 TX line)	Edge connector
RB7	DBG0	ICSPDAT	Edge connector
RB6	DBG1	ICSPCLK	Edge connector
RE2	DBG2	GPIO	Edge connector
RE3	DBG3	$\overline{\text{MCLR}}$	Edge connector
VCC_TARGET	VCC_LEVEL	1.8-5.1V Supply	
GND	GND	Common ground	

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5. Hardware Revision History

This user guide provides the latest available revision of the kit. This chapter contains information about known issues, a revision history of older revisions, and how older revisions differ from the latest revision.

5.1 Identifying Product ID and Revision

The revision and product identifier of the PIC18F47Q10 Curiosity Nano can be found in two ways; either through MPLAB® X or by looking at the sticker on the bottom side of the PCB.

By connecting a PIC18F47Q10 Curiosity Nano to a computer with MPLAB® X running, an information window will pop up. The first six digits of the serial number, which is listed under kit details, contain the product identifier and revision.

The same information can be found on the sticker on the bottom side of the PCB. Most kits will print the identifier and revision in plain text as A09-nnnn\rr, where “nnnn” is the identifier and “rr” is the revision. The boards with limited space have a sticker with only a QR-code, containing the product identifier, revision and the serial number.

The serial number string has the following format:

"nnnnrrssssssssss"

n = product identifier

r = revision

s = serial number

The product identifier for PIC18F47Q10 Curiosity Nano is A09-3246.

5.2 Revision 2

Revision 2 is the initially released revision.

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6. Document Revision History

Doc. rev.	Date	Comment
A	03/2019	Initial document release.

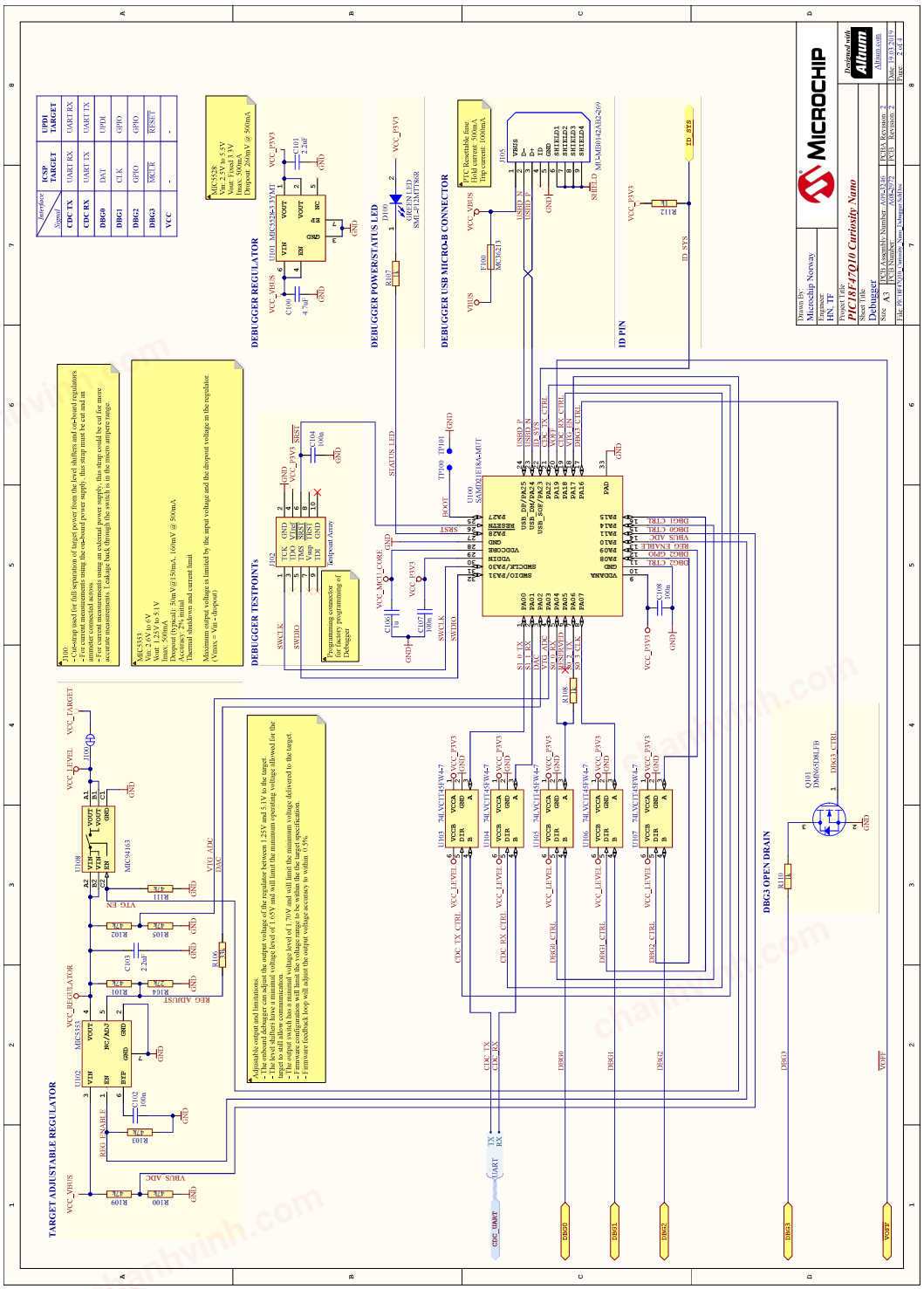
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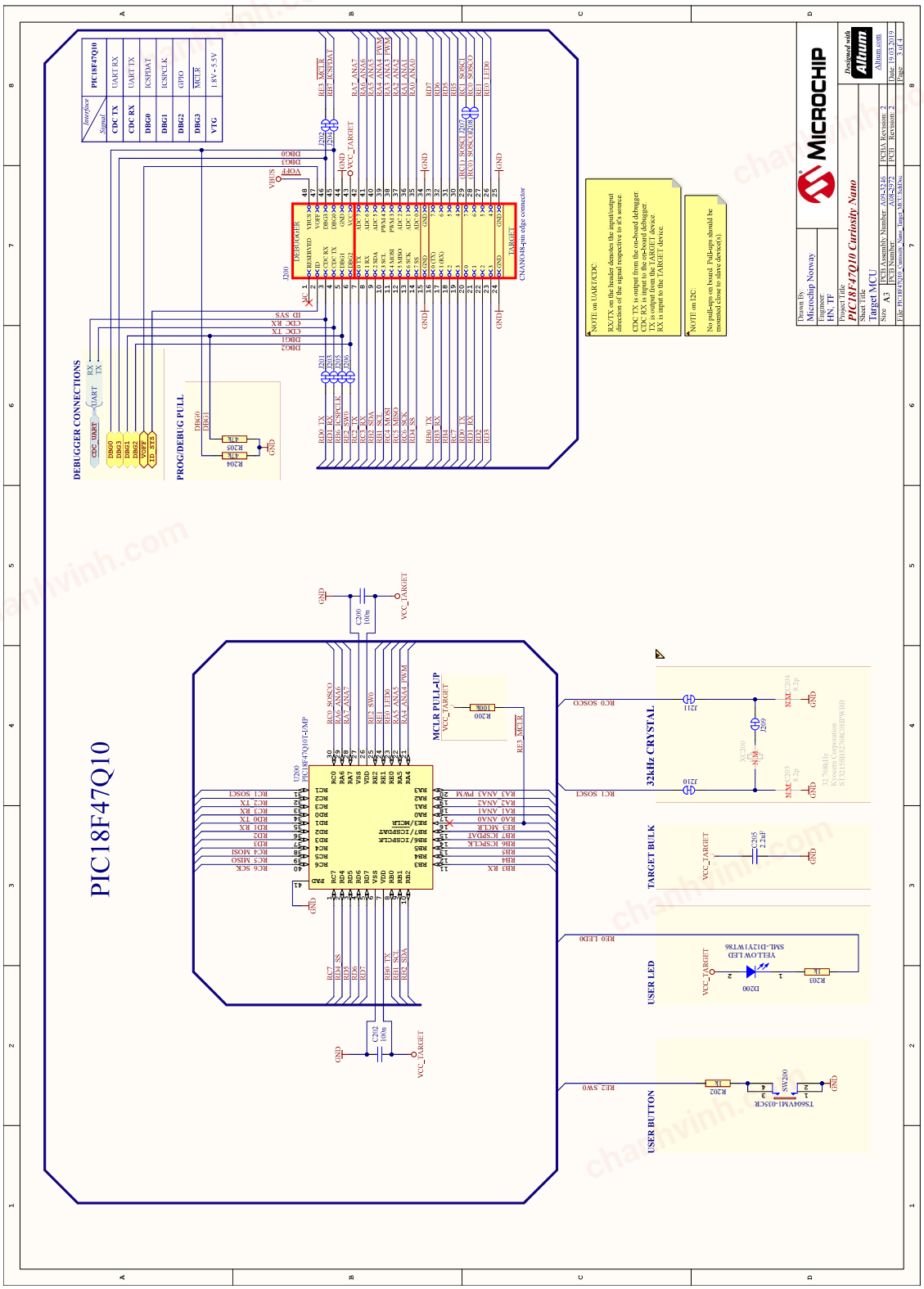
7. Appendix

7.1 Schematic

Figure 7-1. PIC18F47Q10 Curiosity Nano Schematic



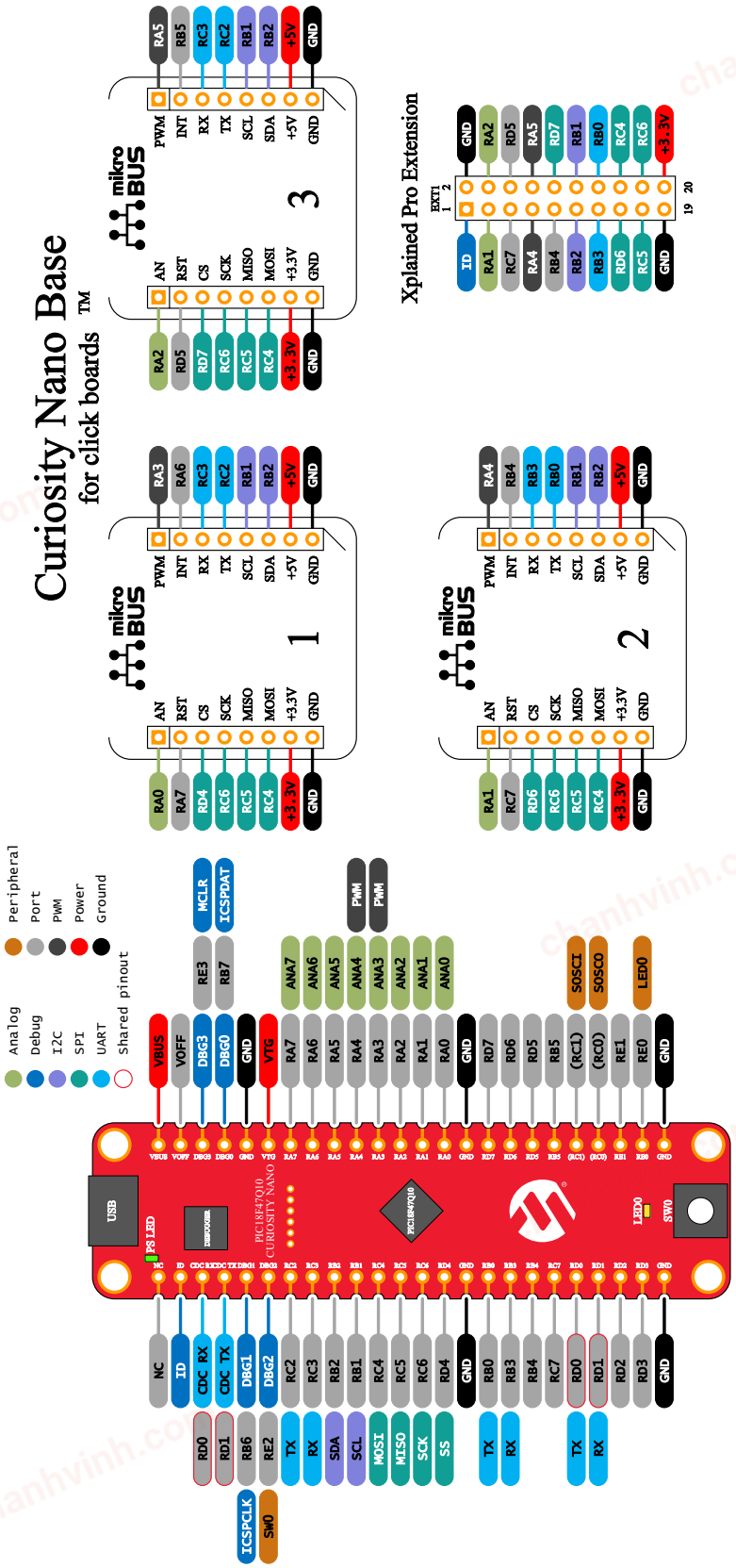
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7.2 Curiosity Nano Base for click Boards™

Figure 7-2. PIC18F47Q10 Curiosity Nano pinout mapping

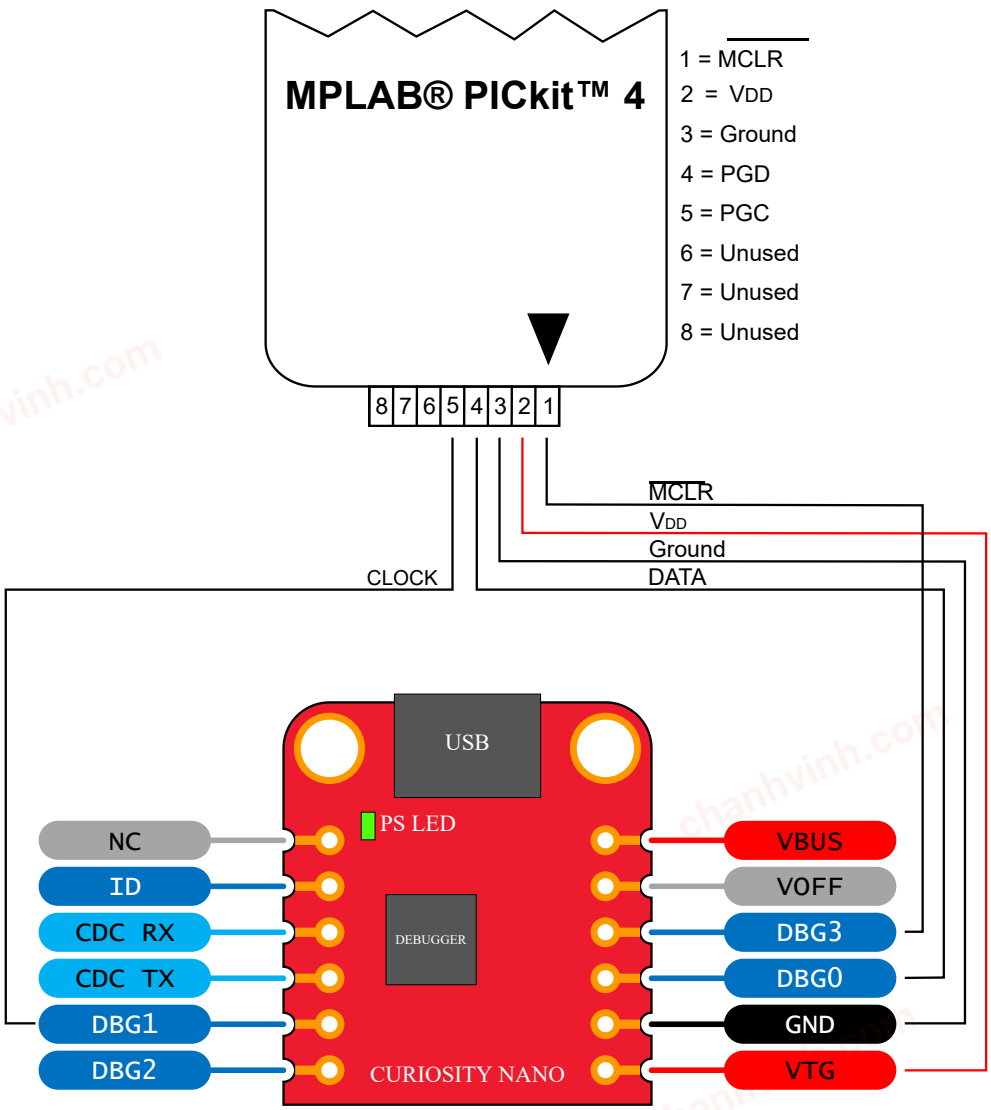


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7.3 Connecting External Debuggers

Even though there is an on-board debugger, external debuggers can be connected directly to PIC18F47Q10 Curiosity Nano to program/debug the PIC18F47Q10. The on-board debugger keeps all the pins connected to the PIC18F47Q10 and board edge in tri-state when not actively used. Therefore, the on-board debugger will not interfere with any external debug tools.

Figure 7-3. Connecting the MPLAB PICkit™ 4 In-circuit Debugger/Programmer to PIC18F47Q10 Curiosity Nano



⚠ CAUTION To avoid contention between the external debugger and the on-board debugger, do not start any programming/debug operation with the on-board debugger through MPLAB® X or mass storage programming while the external tool is active.

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ISBN: 978-1-5224-4372-8

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