![MICROCHIP]
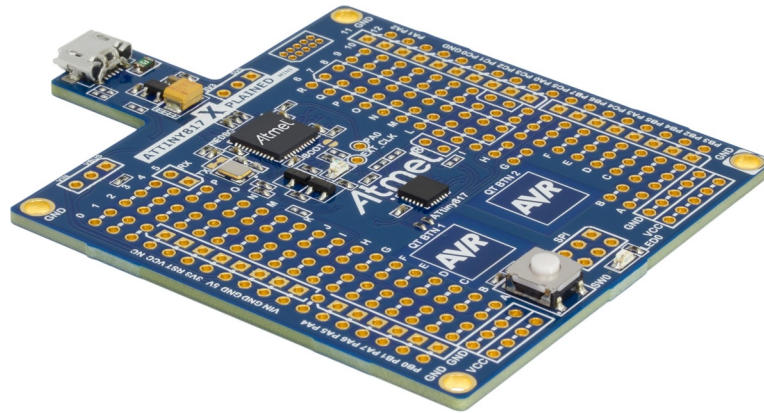
ATtiny817 Xplained Mini

ATtiny817 Xplained Mini

Preface

The ATtiny817 Xplained Mini evaluation kit is a hardware platform to evaluate the ATtiny817 microcontroller.

Supported by the Atmel Studio integrated development platform, the kit provides easy access to the features of the ATtiny817 and explains how to integrate the device into a custom design.

The Xplained Mini series evaluation kits include an on-board mini embedded debugger. No external tools are necessary to program the ATtiny817.

Table of Contents

1. Introduction

1.1 Features

- ATtiny817 microcontroller
- One yellow user LED
- One mechanical button
- Two QTouch$^®$ buttons
- mEDBG
    - Auto-ID for board identification in Atmel Studio
    - One green board status LED
    - Programming and Debugging
    - Virtual COM port (CDC)
- USB powered
- ATtiny817 power sources:
    - 5.0V from USB
    - 3.3V regulator
    - External voltage
- Arduino shield compatible footprints

1.2 Kit Overview

The ATtiny817 Xplained Mini evaluation kit is a hardware platform to evaluate the ATtiny817.

Figure 1-1. ATtiny817 Xplained Mini Evaluation Kit Overview
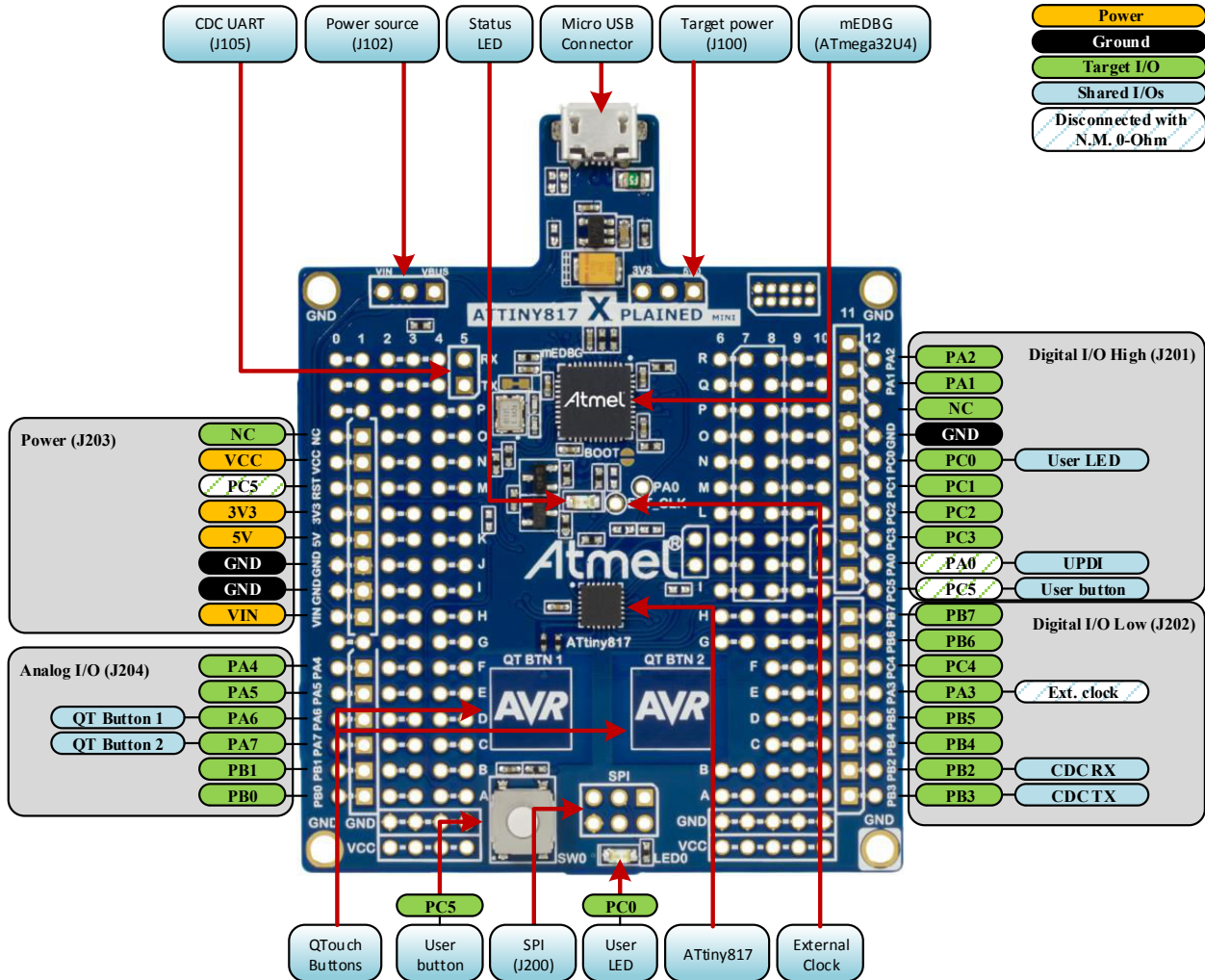
Table 1-1. Default Configurations

Function	Default configuration	Other settings
Kit power source (J102)	5.0V USB powered	External input VIN [1]
Target power (J100)	5.0V USB powered	3.3V from on-board regulator [1]
ATtiny817 clock	Internal 20 MHz oscillator	mEDBG clock [2]

Info:
Changing the default settings require modification of the kit using a soldering iron.

1) Details on how to change the power settings are described in Power Sources.

2) Details on the mEDBG clock are described in Xplained Mini Clock Output.

2. Getting Started

2.1 Xplained Mini Quick Start

Steps to start exploring the Xplained Mini platform:

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

When the Xplained Mini 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 the Atmel Studio.

Once the Xplained Mini board is powered the green status LED will blink and Atmel Studio will autodetect which Xplained Mini board is connected. Atmel Studio will present relevant information like data sheets and kit documentation. The ATtiny817 device is programmed and debugged by the on-board Mini Embedded 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 ATtiny817 Xplained Mini.

- **Xplained products** - Xplained evaluation kits are a series of easy-to-use evaluation kits for Microchip microcontrollers and other Microchip products.
  - Xplained Nano: used for low pin-count devices and provides a minimalistic solution with access to all I/O pins of the target microcontroller.
  - Xplained Mini: used for medium pin-count devices and adds Arduino Uno compatible header footprint and a prototyping area.
  - Xplained Pro: used for medium to high pin-count devices that features advanced debugging and standardized extensions for peripheral functions.

  Note: All the above kits have on-board programmers/debuggers, which creates a set of low-cost boards for evaluation and demonstration of features and capabilities of different Microchip products.
- **Atmel Studio** - Free IDE for the development of C/C++ and assembler code for microcontrollers.
- **http://start.atmel.com/** - Atmel START is an online tool to help you select and configure software components and tailor your embedded application in a usable and optimized manner.
- **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 Embedded Debugger Data Gateway Interface found on Xplained Pro boards and COM Ports.
- **QTouch® tools** - A collection of tools to design capacitive touch applications.
- **QTouch® Design Guide** - PTC Robustness design guide document for touch sensor development.
- **ATtiny817 Xplained Mini website** - Kit information, latest user guide and design documentation.
- **ATtiny817 Xplained Mini on Microchip Direct** - Purchase this kit on Microchip Direct.

3. Xplained Mini

Xplained Mini is an evaluation platform that provides a set of small boards with access to all microcontroller I/Os. The platform consists of a series of low-pin-count Microcontroller (MCU) boards, which are integrated with Atmel Studio to present relevant user guides, application notes, datasheets, and example code. The platform also features a Virtual COM port for serial communication to a host PC.

3.1 Mini Embedded Debugger

The ATtiny817 Xplained Mini contains the Mini Embedded Debugger (mEDBG) for on-board programming and debugging. The mEDBG is a composite USB device of two interfaces; a debugger and a Virtual COM Port.

Together with Atmel Studio, the mEDBG debugger interface can program and debug the ATtiny817. On ATtiny817 Xplained Mini, the UPDI interface is connected between the mEDBG and the ATtiny817.

The Virtual COM Port is connected to a UART on the ATtiny817 and provides an easy way to communicate with the target application through the terminal software. It offers variable baud rate, parity, and stop bit settings.

Note: The settings on the ATtiny817 must match the settings given in the terminal software.

Info: The virtual COM port in the mEDBG requires the terminal software to set the data terminal ready (DTR) signal to enable the UART pins connected to the ATtiny817. If the DTR signal is not enabled the UART pins on the mEDBG are kept in high-z (tri-state) rendering the COM port unusable. The DTR signal is automatically set by some terminal software, but it may have to be manually enabled in your terminal.

The mEDBG controls one status LED on the ATtiny817 Xplained Mini. The table below shows how the LED is controlled in different operation modes.

Table 3-1. mEDBG LED Control

Operation mode	Status LED
Power up	LED is briefly lit
Normal operation	LED is not lit
Programming	Activity indicator; the LED flashes when programming/debugging with the mEDBG

3.1.1 Xplained Mini Clock Output

The mEDBG outputs its CPU clock on a pin.

The clock output can be used to feed the target device with a more accurate clock if this is needed for the application. By default, this clock is disconnected from the target by a not mounted resistor.

To connect the external clock to the ATtiny817 a 0Ω resistor or strap has to be soldered in the footprint, as shown in the figure below (R205).

Figure 3-1. External Clock Footprint
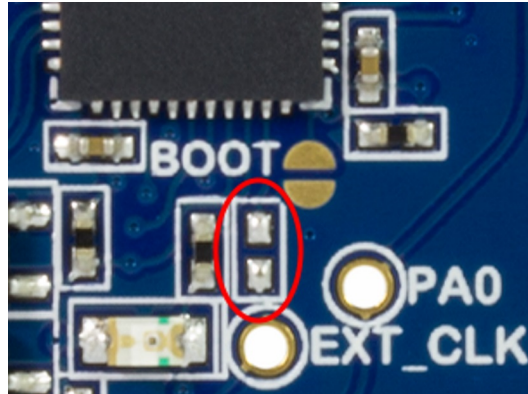
The mEDBG CPU clock frequency depends on the selected voltage, see the table below.

Table 3-2. CPU Clock vs. Voltage

Target voltage	mEDBG CPU clock
3.3V	8 MHz
5.0V	16 MHz

3.2 mEDBG Configuration

The operation of the mEDBG can be configured by writing registers in the mEDBG. No configuration is required for default operation.

3.2.1 mEDBG Low Power Modes

There are two modes that enable the mEDBG to save power when connected to an external power source.

EOF mode, where the mEDBG is disabled. When enabled the ATmega32U4 will enter sleep mode if the USB does not enumerate within 5 seconds of power-up. In this mode, the external clock is not available to the target MCU.

LOWP mode, where the mEDBG is set to run at 1 MHz. Saving power while maintaining the USB connection for the COM port. The external clock will be 1 MHz.

Table 3-3. Low Power Modes Operation

Mode	External CLK	COM port	UPDI program	UPDI debug
EOF	disabled	disabled	disabled	disabled
LOWP	forced 1 MHz	enabled	useless	useless
Factory settings	enabled	enabled	enabled	enabled

3.2.2 mEDBG Fuse Filter

The mEDBG does not initially allow users to program all fuses of the target device through Atmel Studio, as a filter is implemented to protect certain fuses. The protected fuses are different for every product using the mEDBG and are typically clock related fuses that could be set to invalid configurations.

The fuse protection can be disabled by writing the FUSE bit to 0.

> **Info:** The fuse filter prevents users from changing critical fuses using Atmel Studio; however, it does not prevent users from setting fuses freely using the command line interface atprogram bundled with Atmel Studio.

3.2.3 mEDBG Command Line Interface

The configuration of the mEDBG can be changed using a simple command line interface available on Atmel Spaces Releases (mEDBG_script.zip).

The CLI is written for Python® 2.7 and may work on other Python 2.x versions. Python can be downloaded from Python.

The register definitions are available in the following sections.

Related Links
SUFFER

3.2.4 Super User Fantastic Feature Enable Register

The Super User Fantastic Feature Enable Register allows the user to modify the behavior of the mEDBG.

Name: SUFFER
Offset: 0x0120
Reset: 0xFF
Property: N/A

Bit	7	6	5	4	3	2	1	0
						EOF	LOWP	FUSE
Access						R/W	R/W	R/W
Reset						1	1	1

Bit 2 – EOF: Extended Off
Writing the EOF bit to 1 sets default operation. Writing the EOF bit to 0 enables the extended off power mode. If no USB enumeration is successful within five seconds of power up, the mEDBG enters deep sleep.

Bit 1 – LOWP: Low Power
Writing the LOWP bit to 1 sets the system clock to its default value. Writing the LOWP bit to 0 enables low power mode. The mEDBG is set to run at 1 MHz, which decreases the power usage.

Bit 0 – FUSE: FUSE Protection
Writing the FUSE bit to 1 enables fuse protection when using Atmel Studio. The fuse protection prevents modification of specific fuses in the ATtiny817 target device that could make the mEDBG on the ATtiny817 Xplained Mini not usable. Writing the FUSE bit to 0 removes all protection of fuses in the ATtiny817 target device.

> **Warning:** Writing the FUSE bit to 0 enables modification of all fuses in the ATtiny817. Setting wrong fuse settings may render the mEDBG not usable on the ATtiny817 Xplained Mini. As an example; if an invalid clock setting is set, a recovery may require an external debugger.

3.3 mEDBG Firmware Upgrade and Manual Bootloader Entry

The mEDBG firmware is updated through the programming dialog in Atmel Studio.

If you are unable to upgrade the mEDBG firmware on your ATtiny817 Xplained Mini, you can try the command line utility *atfw.exe* provided with the Atmel Studio. *atfw.exe* is located in the *atbackend* folder in your Atmel Studio install location.

To manually upgrade the firmware, run the following command:

atfw.exe -t medbg -a ..\tools\ mEDBG\medbg_fw.zip

If *atfw.exe* is unable to find the mEDBG it may be required to force the ATmega32U4 (mEDBG) to enter its bootloader. To force the bootloader entry, short-circuit the BOOT pads (J103) and toggle power to the ATtiny817 Xplained Mini board. Run the atfw command above. When the firmware is upgraded, remove the power from the kit and remove the short-circuit of J103.

Figure 3-2. Force Boot Jumper
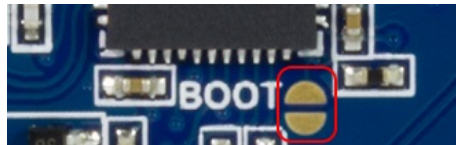
4. Hardware User Guide

The following sections describe the implementation of the relevant peripherals, headers, and connectors on ATtiny817 Xplained Mini and their connection to the ATtiny817. The tables of connections in the sections also describe which signals are shared between the headers and on-board functionality.

The figure below shows the assembly drawing of the ATtiny817 Xplained Mini to help identification of components.

Figure 4-1. ATtiny817 Xplained Mini Assembly Drawing
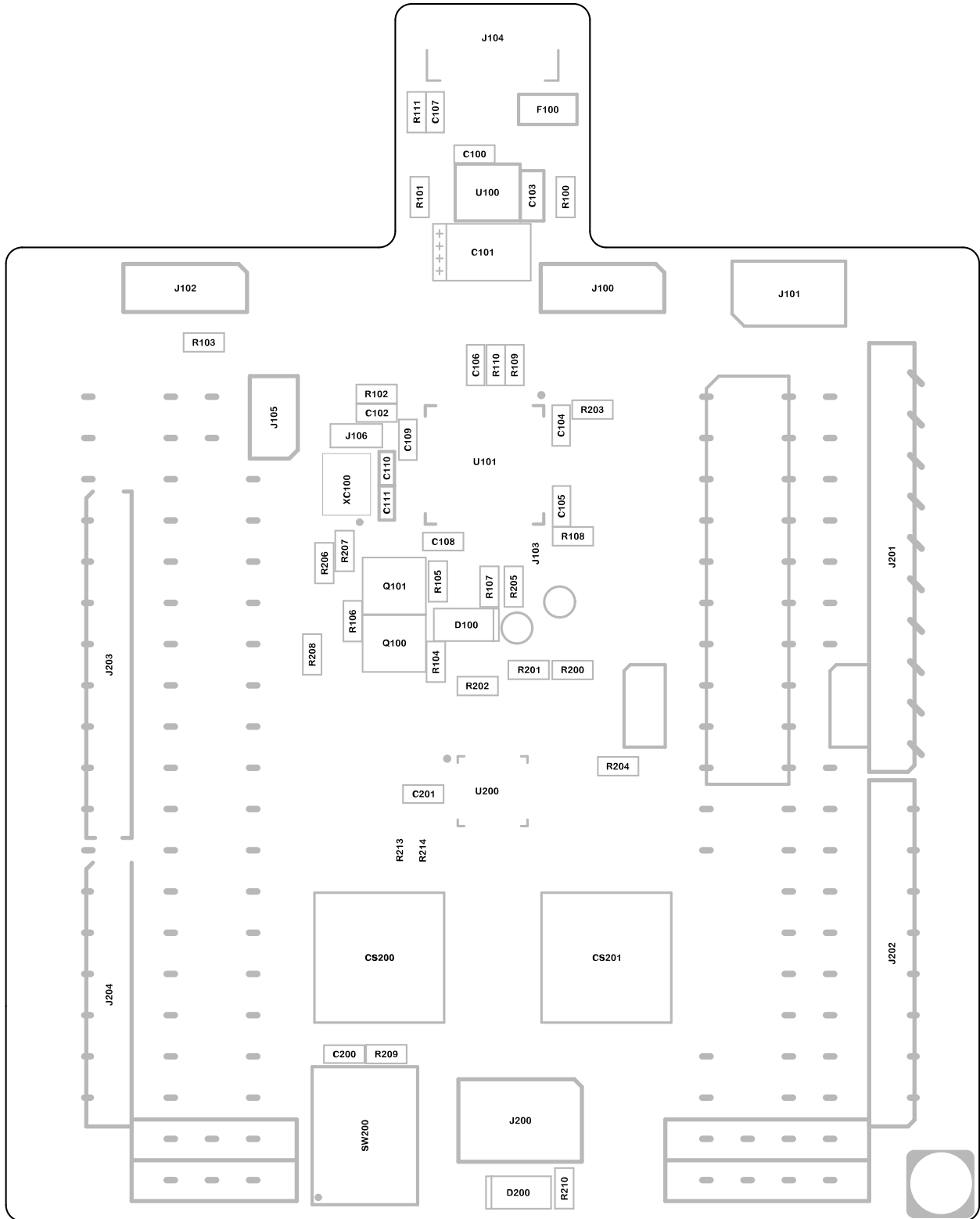
4.1 Power Sources

The ATtiny817 Xplained Mini kit can be powered by a USB or an external voltage input VIN. The default power source is 5.0V from a USB. The USB port is protected with a 500 mA PTC resettable fuse.

The ATtiny817 is powered from the 5.0V USB voltage by default.

The figure below shows the possible kit power supply connections.

Figure 4-2. Power Supply Block Diagram

The input voltage select jumper (J102, 3-pin header footprint) can be soldered in to select between power from the USB port or from the VIN pin on the Arduino power header footprint. By default, the selector is bypassed with a 0Ω resistor (R103) to connect the USB voltage to the on-board 3.3V/150 mA regulator and target voltage select header.

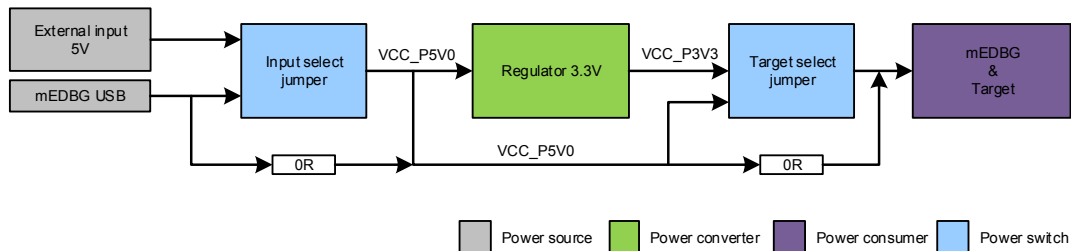The target voltage select jumper (J100, 3-pin header footprint) can be soldered in to select between the on-board 3.3V regulator or the voltage from the input voltage select jumper (J102). The selector is bypassed with a 0Ω resistor (R100) to connect the kit input voltage to the ATtiny817 and mEDBG.

> **Important:** If the target voltage and input voltage select headers are soldered in and used with a jumper, the bypass 0Ω resistors have to be removed to avoid contention.

4.2 Connectors

4.2.1 ATtiny817 Xplained Mini Arduino Compatible Footprints

The ATtiny817 Xplained Mini has a pin-out that is compatible with Arduino shields, which can be mounted in the marked positions (J200, J201, J202, J203, and J204).

Table 4-1. J200 ISP/SPI Header

J200	ATtiny817 pin	Arduino numbering	Functions	Comment
1	PC1	MISO	SPI MISO	Shared with J201
2		VCC	VCC_P5V0	
3	PC0	SCK	SPI SCK	Shared with J201
4	PC2	MOSI	SPI MOSI	Shared with J201

J200	ATtiny817 pin	Arduino numbering	Functions	Comment
5	PC5	RESET	GPIO	Shared with J201, J203, and user button
6	GND	GND	GND	

Table 4-2. J201 Digital I/O High Header

J201	ATtiny817 pin	Arduino numbering	Functions	Comment
1	PC5	D8	TCA_W5	Not connected by default. Can be connected by adding a 0Ω resistor to R204. Shared with J200, J203, and user button.
2	PA0	D9	UPDI	Not connected by default. Can be connected by adding a 0Ω resistor to R200. Shared with UPDI.
3	PC3	D10	SPI SS	
4	PC2	D11	SPI MOSI	Shared with J200
5	PC1	D12	SPI MISO	Shared with J200
6	PC0	D13	SPI SCK	Shared with J200 and user LED
7	GND	GND		
8		AREF		
9	PA1	D14	I^{2}C SDA	
10	PA2	D15	I^{2}C SCL	

Table 4-3. J202 Digital I/O Low Header

J202	ATtiny817 pin	Arduino numbering	Functions	Comment
1	PB3	D0	UART RX	Shared with mEDBG CDC
2	PB2	D1	UART TX	Shared with mEDBG CDC
3	PB4	D2	TCA W1	
4	PB5	D3	TCA W2	
5	PA3	D4	TCA W3	
6	PC4	D5	TCA W4	
7	PB6	D6		
8	PB7	D7		

Table 4-4. J203 Power Header

J203	ATtiny817 pin	Arduino numbering	Functions	Comment
1		NC		
2	VCC	IOREF	VCC_TARGET	
3	PC5	RESET	GPIO	Disconnected by not mounted 0Ω resistor R208. Shared with J200, J201, and user button.

J203	ATtiny817 pin	Arduino numbering	Functions	Comment
4		3.3V	VCC_P3V3	
5		5.0V	VCC_P5V0	
6	GND	GND		
7	GND	GND		
8		VIN		External voltage input

Table 4-5. J204 Analog I/O Header

J204	ATtiny817 pin	Arduino numbering	Functions	Comment
1	PA4	A0	AIN04	
2	PA5	A1	AIN05	
3	PA6	A2	AIN06	Shared with QTouch Button 1
4	PA7	A3	AIN07	Shared with QTouch Button 2
5	PB1	A4	AIN10	
6	PB0	A5	AIN11	

4.2.2   Extension Header Area

The marked area on the grid I7 to R8 can be used for strapping in an Xplained Pro extension header or a 10-pin legacy Xplained/RZ600 header.

Figure 4-3. Extension Header Area
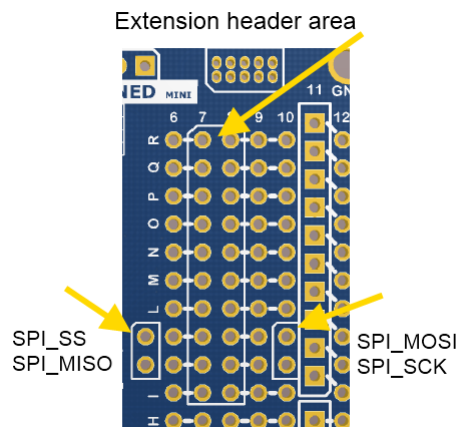
The SPI bus signals are available close to the header at row J and K, enabling easy connection to header pin 15 to 18.

Using pin 11 to 20 enables connection of the 10-pin legacy header used on the RZ600 wireless modules and the 10-pin Xplained sensor modules.

The general bus connections for an Xplained Pro Extension board are indicated in the table below. Detailed wiring can be found in the selected extension board documentation.

Table 4-6. Extension Header Typical Signals

| Pin	Signal name	Signal description
1	ID	Communication line to the ID chip on the Xplained extension board
2	GND	Ground
3	ADC(+)	Analog to digital converter, alternatively positive part of differential ADC
4	ADC(-)	Analog to digital converter, alternatively negative part of differential ADC
5	GPIO1	General purpose I/O
6	GPIO2	General purpose I/O
7	PWM(+)	Pulse width modulation, alternatively positive part of differential PWM
8	PWM(-)	Pulse width modulation, alternatively negative part of differential PWM
9	IRQ/GPIO	Interrupt request line and/or general purpose I/O
10	SPI_SS_B/ GPIO	Slave B select for SPI and/or general purpose I/O
11	I2C_SDA	Data line for I^{2}C interface
12	I2C_SCL	Clock line for I^{2}C interface
13	UART_RX	Receiver line of ATtiny817 USART
14	UART_TX	Transmitter line of ATtiny817 USART
15	SPI_SS_A	Slave A select for SPI
16	SPI_MOSI	Master out slave in line of serial peripheral interface
17	SPI_MISO	Master in slave out line of serial peripheral interface
18	SPI_SCK	Clock for serial peripheral interface
19	GND	Ground
20	VCC	Power for extension board

4.3   Current Measurement

The power to the target controller ATtiny817 and its peripherals is connected from the *VCC_BOARD* supply to the targets *VCC_TARGET* supply with a 0Ω resistor (*R104*) as shown in the figure below. To measure the power consumption of the device, remove the 0Ω resistor and replace it with an ammeter. The ammeter can be connected between the *VCC_BOARD* (pin 2 on the target voltage select header) and *VCC_TARGET* (pin 2 on the power header) pads for easy measurement.

> **Caution:** Removing the resistor while the kit is powered without an ammeter or 0Ω resistor mounted may cause the ATtiny817 to be powered through its I/O pins. This may cause permanent damage to the device.

Figure 4-4. Current Measurement
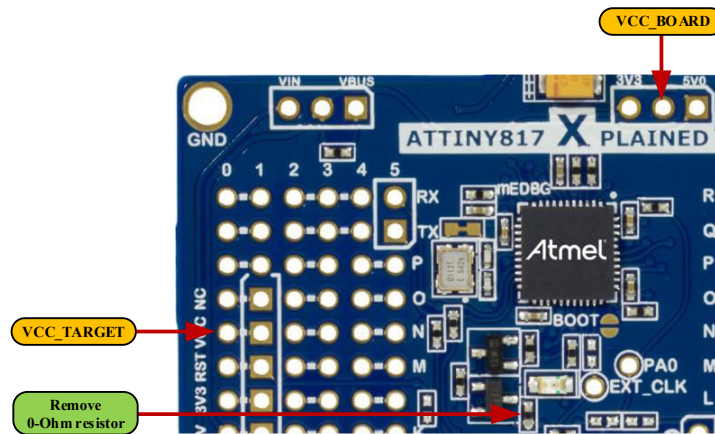
4.4   Disconnecting mEDBG

The target controller ATtiny817 can be completely separated from the mEDBG, but this requires some small modifications to the board using a soldering iron. By removing the resistors in the sections shown in the figure below, the mEDBG is completely disconnected from the target controller. To reconnect the mEDBG again, solder in 0Ω resistors or solder in 100-mil headers on the header footprints and use wire-straps to connect the interfaces.

Figure 4-5. Kit Modifications
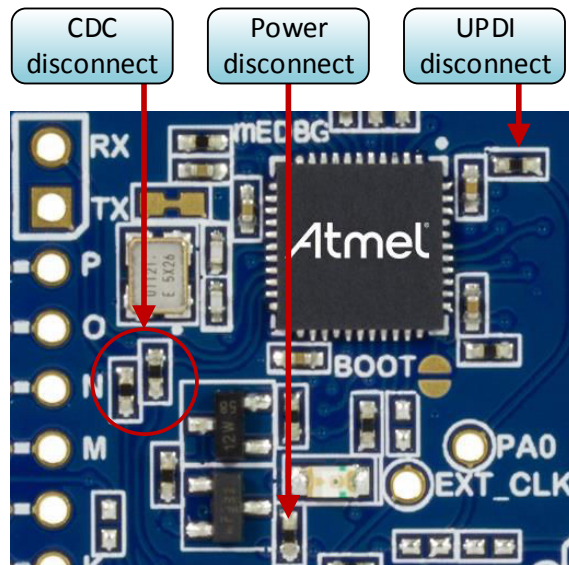
Table 4-7. mEDBG Connections

Designator	Mounted	From (mEDBG)	To (ATtiny817)
R104	Yes	VCC_BOARD	VCC_TARGET
R203	Yes	UPDI	PA0 UPDI / RESET
R205	**No**	CLK_OUT	PA3 CLKI
R206	Yes	CDC UART RX	PB2 UART TX
R207	Yes	CDC UART TX	PB3 UART RX

4.5 Peripherals

4.5.1 LED

There is one yellow LED available on the ATtiny817 Xplained Mini board that can be turned ON and OFF. The LED can be activated by driving the connected I/O line to VCC.

Table 4-8. LED Connection

ATtiny817 pin	Function	Shared functionality
PC0	Yellow LED0	Shared with J200 and J201

4.5.2 Mechanical Button

ATtiny817 Xplained Mini contains one mechanical button. This is a generic user configurable button and when a button is pressed it will drive the I/O line to GND.

> **Info:** There is an external pull-up resistor connected to the generic user button.

Table 4-9. Mechanical Button

ATtiny817 pin	Description	Shared functionality
PC5	User button	J200, J201, and J203

4.5.3 QTouch Buttons

ATtiny817 Xplained Mini contains two QTouch buttons for use with the internal PTC module of the device.

To get started using the QTouch buttons, open the *QTouch Tiny817 Xplained Mini Selfcap Example* in Atmel START (http://start.atmel.com/#examples).

> **Tip:** The touch button on the kit is placed in the inner layers of the PCB and has a very small overlay. Due to the short distance from the sensor to the touch area, it might be oversensitive. Different overlays can be used to avoid saturation of the sensor.

Table 4-10. QTouch Buttons

ATtiny817 pin	Function	Description	Shared functionality
PA6	PTC2	QTBTN1	J204
PA7	PTC3	QTBTN2	J204

4.6   Embedded Debugger Implementation

ATtiny817 Xplained Mini contains a Mini Embedded Debugger (mEDBG) that can be used to program the ATtiny817 using Unified Program and Debug Interface (UPDI). The mEDBG also include a Virtual Com port interface over UART. Atmel Studio can be used as a front end for the Mini Embedded Debugger.

4.6.1   Unified Program and Debug Interface

The Unified Program and Debug Interface (UPDI) uses one pin to communicate with the target.

Table 4-11. UPDI Connections

ATtiny817 pin	Function	Shared functionality
PA0	UPDI program/debug	mEDBG and J201 (N.M 0-ohm)

4.6.2   Virtual COM Port

The Embedded Debugger acts as a Virtual Com Port gateway by using one of the ATtiny817 UARTs.

Table 4-12. Virtual COM Port Connections

ATtiny817 pin	Function	Shared functionality
PB2	UART TXD (ATtiny817 TX line)	mEDBG CDC RX and J202
PB3	UART RXD (ATtiny817 RX line)	mEDBG CDC TX and J202

5. Hardware Revision History and Known Issues

This user guide is written to reflect 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 Xplained Mini boards can be found in two ways; either through Atmel Studio or by looking at the sticker on the bottom side of the PCB.

By connecting an Xplained Mini board to a computer with Atmel Studio 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. Boards with limited space have a sticker with only a data matrix code, which contains a serial number string.

The serial number string has the following format:

"nnnnrrsssssssssss"

n = product identifier

r = revision

s = serial number

The product identifier for ATtiny817 Xplained Mini is A09-2658.

5.2 Revision 6

Revision 6 is identical to revision 5 and revision 4 with increased test coverage.

5.3 Revision 5

Revision 5 is identical to revision 4 with increased test coverage.

5.4 Revision 4

Revision 4 is the initially released revision.

6.   Document Revision History

Doc. rev.	Date	Comment
A	08/2017	Converted to Microchip format and replaced the Atmel document number 42726A. Added links to QTouch example application in QTouch Buttons.
42726A	10/2016	Initial document release.

The Microchip Web Site

Microchip provides online support via our web site at http://www.microchip.com/. This web site is used as a means to make files and information easily available to customers. Accessible by using your favorite Internet browser, the web site contains the following information:

- **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 (FAQ), technical support requests, online discussion groups, Microchip consultant 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

Customer Change Notification Service

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

To register, access the Microchip web site at http://www.microchip.com/. Under "Support", click on "Customer Change Notification" and follow the registration instructions.

Customer Support

Users of Microchip products can receive assistance through several channels:

- Distributor or Representative
- Local Sales Office
- Field Application Engineer (FAE)
- Technical Support

Customers should contact their distributor, representative or Field Application Engineer (FAE) for support. Local sales offices are also available to help customers. A listing of sales offices and locations is included in the back of this document.

Technical support is available through the web site 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, AnyRate, AVR, AVR logo, AVR Freaks, BeaconThings, BitCloud, CryptoMemory, CryptoRF, dsPIC, FlashFlex, flexPWR, Heldo, JukeBlox, KeeLoq, KeeLoq logo, Kleer, LANCheck, LINK MD, maXStylus, maXTouch, MediaLB, megaAVR, MOST, MOST logo, MPLAB, OptoLyzer, PIC, picoPower, PICSTART, PIC32 logo, Prochip Designer, QTouch, RightTouch, SAM-BA, SpyNIC, SST, SST Logo, SuperFlash, tinyAVR, UNI/O, and XMEGA are registered trademarks of Microchip Technology Incorporated in the U.S.A. and other countries.

ClockWorks, The Embedded Control Solutions Company, EtherSynch, Hyper Speed Control, HyperLight Load, IntelliMOS, mTouch, Precision Edge, and Quiet-Wire 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, BodyCom, chipKIT, chipKIT logo, CodeGuard, CryptoAuthentication, CryptoCompanion, CryptoController, dsPICDEM, dsPICDEM.net, Dynamic Average Matching, DAM, ECAN, EtherGREEN, In-Circuit Serial Programming, ICSP, Inter-Chip Connectivity, JitterBlocker, KleerNet, KleerNet logo, Mindi, MiWi, motorBench, MPASM, MPF, MPLAB Certified logo, MPLIB, MPLINK, MultiTRAK, NetDetach, Omniscient Code Generation, PICDEM, PICDEM.net, PICkit, PICtail, PureSilicon, QMatrix, RightTouch logo, 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.

Silicon Storage Technology is a registered trademark 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.

© 2017, Microchip Technology Incorporated, Printed in the U.S.A., All Rights Reserved.

Quality Management System Certified by DNV

ISO/TS 16949

Microchip received ISO/TS-16949:2009 certification for its worldwide headquarters, design and wafer fabrication facilities in Chandler and Tempe, Arizona; Gresham, Oregon and design centers in California and India. The Company's quality system processes and procedures are for its PIC® MCUs and dsPIC® DSCs, KEELOQ® code hopping devices, Serial EEPROMs, microperipherals, nonvolatile memory and analog products. In addition, Microchip's quality system for the design and manufacture of development systems is ISO 9001:2000 certified.

Worldwide Sales and Service

AMERICAS	ASIA/PACIFIC	ASIA/PACIFIC	EUROPE
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: www.microchip.com	**Asia Pacific Office** Suites 3707-14, 37th Floor Tower 6, The Gateway Harbour City, Kowloon **Hong Kong** Tel: 852-2943-5100 Fax: 852-2401-3431	**China - Xiamen** Tel: 86-592-2388138 Fax: 86-592-2388130 **China - Zhuhai** Tel: 86-756-3210040 Fax: 86-756-3210049	**Austria - Wels** Tel: 43-7242-2244-39 Fax: 43-7242-2244-393 **Denmark - Copenhagen** Tel: 45-4450-2828 Fax: 45-4485-2829
Atlanta Duluth, GA Tel: 678-957-9614 Fax: 678-957-1455	**Australia - Sydney** Tel: 61-2-9868-6733 Fax: 61-2-9868-6755 **China - Beijing** Tel: 86-10-8569-7000 Fax: 86-10-8528-2104	**India - Bangalore** Tel: 91-80-3090-4444 Fax: 91-80-3090-4123 **India - New Delhi** Tel: 91-11-4160-8631 Fax: 91-11-4160-8632	**Finland - Espoo** Tel: 358-9-4520-820 **France - Paris** Tel: 33-1-69-53-63-20 Fax: 33-1-69-30-90-79
Austin, TX Tel: 512-257-3370	**China - Chengdu** Tel: 86-28-8665-5511 Fax: 86-28-8665-7889	**India - Pune** Tel: 91-20-3019-1500	**France - Saint Cloud** Tel: 33-1-30-60-70-00
Boston Westborough, MA Tel: 774-760-0087 Fax: 774-760-0088	**China - Chongqing** Tel: 86-23-8980-9588 Fax: 86-23-8980-9500	**Japan - Osaka** Tel: 81-6-6152-7160 Fax: 81-6-6152-9310	**Germany - Garching** Tel: 49-8931-9700 **Germany - Haan** Tel: 49-2129-3766400
Chicago Itasca, IL Tel: 630-285-0071 Fax: 630-285-0075	**China - Dongguan** Tel: 86-769-8702-9880 **China - Guangzhou** Tel: 86-20-8755-8029	**Japan - Tokyo** Tel: 81-3-6880- 3770 Fax: 81-3-6880-3771	**Germany - Heilbronn** Tel: 49-7131-67-3636 **Germany - Karlsruhe** Tel: 49-721-625370
Dallas Addison, TX Tel: 972-818-7423 Fax: 972-818-2924	**China - Hangzhou** Tel: 86-571-8792-8115 Fax: 86-571-8792-8116	**Korea - Daegu** Tel: 82-53-744-4301 Fax: 82-53-744-4302 **Korea - Seoul** Tel: 82-2-554-7200	**Germany - Munich** Tel: 49-89-627-144-0 Fax: 49-89-627-144-44 **Germany - Rosenheim** Tel: 49-8031-354-560
Detroit Novi, MI Tel: 248-848-4000	**China - Hong Kong SAR** Tel: 852-2943-5100 Fax: 852-2401-3431	Fax: 82-2-558-5932 or 82-2-558-5934 **Malaysia - Kuala Lumpur**	**Israel - Ra'anana** Tel: 972-9-744-7705 **Italy - Milan**
Houston, TX Tel: 281-894-5983	**China - Nanjing** Tel: 86-25-8473-2460 Fax: 86-25-8473-2470	Tel: 60-3-6201-9857 Fax: 60-3-6201-9859 **Malaysia - Penang**	Tel: 39-0331-742611 Fax: 39-0331-466781 **Italy - Padova**
Indianapolis Noblesville, IN Tel: 317-773-8323 Fax: 317-773-5453 Tel: 317-536-2380	**China - Qingdao** Tel: 86-532-8502-7355 Fax: 86-532-8502-7205 **China - Shanghai** Tel: 86-21-3326-8000 Fax: 86-21-3326-8021	Tel: 60-4-227-8870 Fax: 60-4-227-4068 **Philippines - Manila** Tel: 63-2-634-9065 Fax: 63-2-634-9069	Tel: 39-049-7625286 **Netherlands - Drunen** Tel: 31-416-690399 Fax: 31-416-690340 **Norway - Trondheim** Tel: 47-7289-7561
Los Angeles Mission Viejo, CA Tel: 949-462-9523 Fax: 949-462-9608 Tel: 951-273-7800	**China - Shenyang** Tel: 86-24-2334-2829 Fax: 86-24-2334-2393 **China - Shenzhen** Tel: 86-755-8864-2200 Fax: 86-755-8203-1760	**Singapore** Tel: 65-6334-8870 Fax: 65-6334-8850 **Taiwan - Hsin Chu** Tel: 886-3-5778-366 Fax: 886-3-5770-955	**Poland - Warsaw** Tel: 48-22-3325737 **Romania - Bucharest** Tel: 40-21-407-87-50 **Spain - Madrid** Tel: 34-91-708-08-90
Raleigh, NC Tel: 919-844-7510 **New York, NY** Tel: 631-435-6000	**China - Wuhan** Tel: 86-27-5980-5300 Fax: 86-27-5980-5118	**Taiwan - Kaohsiung** Tel: 886-7-213-7830 **Taiwan - Taipei**	Fax: 34-91-708-08-91 **Sweden - Gothenberg** Tel: 46-31-704-60-40
San Jose, CA Tel: 408-735-9110 Tel: 408-436-4270	**China - Xian** Tel: 86-29-8833-7252 Fax: 86-29-8833-7256	Tel: 886-2-2508-8600 Fax: 886-2-2508-0102 **Thailand - Bangkok**	**Sweden - Stockholm** Tel: 46-8-5090-4654 **UK - Wokingham**
Canada - Toronto Tel: 905-695-1980 Fax: 905-695-2078		Tel: 66-2-694-1351 Fax: 66-2-694-1350	Tel: 44-118-921-5800 Fax: 44-118-921-5820