SMART ARM-based Microcontrollers

SAM4E Xplained Pro

USER GUIDE

Preface

The Atmel® SAM4E Xplained Pro evaluation kit is a hardware platform to evaluate the ATSAM4E16E microcontroller.

Supported by the Atmel Studio integrated development platform, the kit provides easy access to the features of the Atmel ATSAM4E16E and explains how to integrate the device in a custom design.

The Xplained Pro MCU series evaluation kits include an on-board Embedded Debugger, and no external tools are necessary to program or debug the ATSAM4E16E.

The Xplained Pro extension series evaluation kits offers additional peripherals to extend the features of the board and ease the development of custom designs.
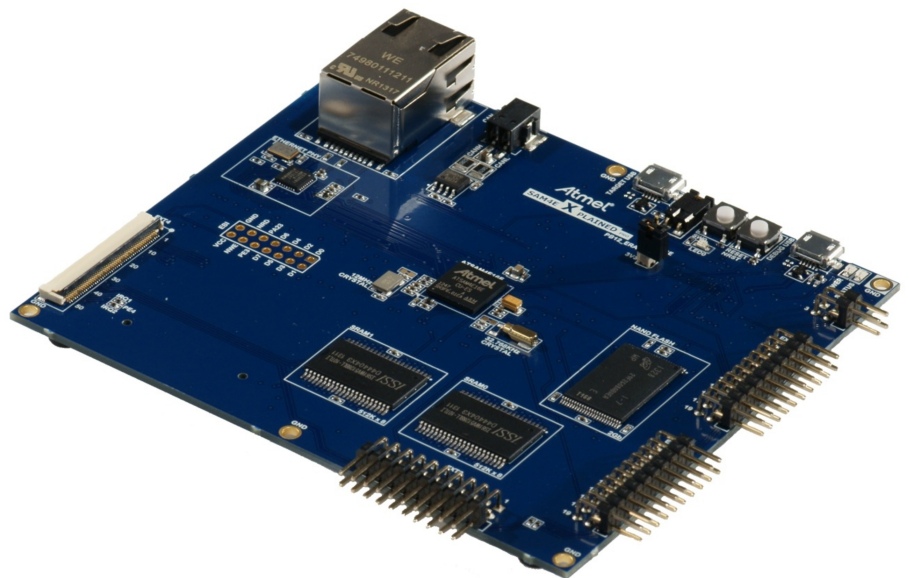
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1.2. Kit Overview

The Atmel SAM4E Xplained Pro evaluation kit is a hardware platform to evaluate the Atmel ATSAM4E16E.

The kit offers a set of features that enables the ATSAM4E16E user to get started using the ATSAM4E16E peripherals right away and to get an understanding of how to integrate the device in their own design.

Figure 1-1 SAM4E Xplained Pro Evaluation Kit Overview
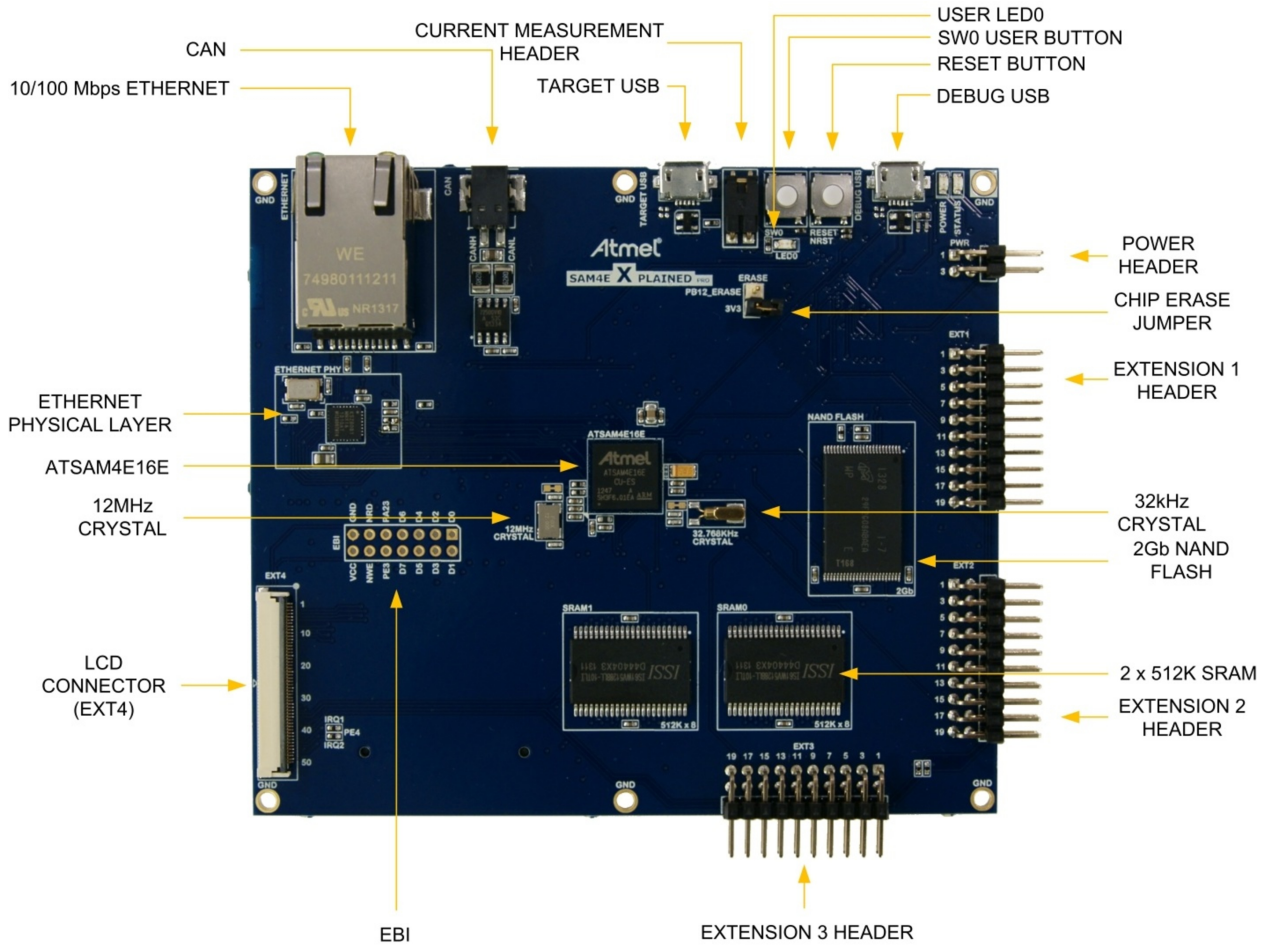
2. Getting Started

2.1. Xplained Pro Quick Start

Three steps to start exploring the Atmel Xplained Pro 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 DEBUG USB port on the kit.

When the Xplained Pro MCU 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, and Windows 8.

Once the Xplained Pro MCU board is powered the green power LED will be lit and Atmel Studio will auto detect which Xplained Pro MCU- and extension board(s) are connected. Atmel Studio will present relevant information like datasheets and kit documentation. The kit landing page in Atmel Studio also has the option to launch Atmel Software Framework (ASF) example applications for the kit. The SAM4E device is programmed and debugged by the on-board Embedded Debugger and therefore no external programmer or debugger tool is needed.

2.2. Design Documentation and Relevant Links

The following list contains links to the most relevant documents and software for SAM4E Xplained Pro:

- **Xplained Pro products** - Atmel Xplained Pro is a series of small-sized and easy-to-use evaluation kits for Atmel microcontrollers and other Atmel products. It consists of a series of low cost MCU boards for evaluation and demonstration of features and capabilities of different MCU families.
- **Atmel Studio** - Free Atmel IDE for development of C/C++ and assembler code for Atmel microcontrollers.
- **Atmel sample store** - Atmel sample store where you can order samples of devices.
- **EDBG User Guide** - User guide containing more information about the on-board Embedded Debugger.
- **IAR Embedded Workbench® for ARM** - This is a commercial C/C++ compiler that is available for ARM. There is a 30 day evaluation version as well as a code size limited kick-start version available from their website. The code size limit is 16KB for devices with M0, M0+, and M1 cores and 32KB for devices with other cores.
- **Atmel Data Visualizer** - Atmel Data Visualizer is a program used for processing and visualizing data. Data Visualizer can receive data from various sources such as the Embedded Debugger Data Gateway Interface found on Xplained Pro boards, and COM ports.
- **Design Documentation** - Package containing CAD source, schematics, BOM, assembly drawings, 3D plots, layer plots, etc.
- **Hardware Users Guide in PDF format** - PDF version of this User Guide.
- **SAM4E Xplained Pro on Atmel website** - Atmel website link.

3.   Xplained Pro

Xplained Pro is an evaluation platform that provides the full Atmel microcontroller experience. The platform consists of a series of Microcontroller (MCU) boards and extension boards which are integrated with Atmel Studio, have Atmel Software Framework (ASF) drivers and demo code, support data streaming, and more. Xplained Pro MCU boards support a wide range of Xplained Pro extension boards which are connected through a set of standardized headers and connectors. Each extension board has an identification (ID) chip to uniquely identify which boards are connected to an Xplained Pro MCU board. This information is used to present relevant user guides, application notes, datasheets, and example code through Atmel Studio.

3.1.   Embedded Debugger

The SAM4E Xplained Pro contains the Atmel Embedded Debugger (EDBG) for on-board debugging. The EDBG is a composite USB device of three interfaces; a debugger, Virtual COM Port, and a Data Gateway Interface (DGI).

Together with Atmel Studio, the EDBG debugger interface can program and debug the ATSAM4E16E. On SAM4E Xplained Pro, the SWD interface is connected between the EDBG and the ATSAM4E16E.

The Virtual COM Port is connected to a UART on the ATSAM4E16E and provides an easy way to communicate with the target application through terminal software. It offers variable baud rate, parity, and stop bit settings. Note that the settings on the ATSAM4E16E must match the settings given in the terminal software.

> **Info:**   If not set automatically, data terminal ready (DTR) must be set in the terminal software.

The DGI consists of several physical interfaces for communication with the host computer. Communication over the interfaces is bidirectional. It can be used to send events and values from the ATSAM4E16E or as a generic printf-style data channel. Traffic over the interfaces can be timestamped on the EDBG for more accurate tracing of events. Note that timestamping imposes an overhead that reduces maximal throughput. Atmel Data Visualizer is used to send and receive data through DGI.

The EDBG controls two LEDs on SAM4E Xplained Pro; a power LED and a status LED. Table 3-1 EDBG LED Control on page 7 shows how the LEDs are controlled in different operation modes.

Table 3-1 EDBG LED Control

Operation mode	Power LED	Status LED
Normal operation	Power LED is lit when power is applied to the board.	Activity indicator, LED flashes when any communication happens to the EDBG.
Bootloader mode (idle)	The power LED and the status LED blinks simultaneously.	
Bootloader mode (firmware upgrade)	The power LED and the status LED blinks in an alternating pattern.	

For further documentation on the EDBG, see the EDBG User Guide.

3.2. Hardware Identification System

All Xplained Pro compatible extension boards have an Atmel ATSHA204 CryptoAuthentication™ chip mounted. This chip contains information that identifies the extension with its name and some extra data. When an Xplained Pro extension is connected to an Xplained Pro MCU board the information is read and sent to Atmel Studio. The Atmel Kits extension, installed with Atmel Studio, will give relevant information, code examples, and links to relevant documents. Table 3-2 Xplained Pro ID Chip Content on page 8 shows the data fields stored in the ID chip with example content.

Table 3-2 Xplained Pro ID Chip Content

Data field	Data type	Example content
Manufacturer	ASCII string	Atmel'\0'
Product Name	ASCII string	Segment LCD1 Xplained Pro'\0'
Product Revision	ASCII string	02'\0'
Product Serial Number	ASCII string	1774020200000010'\0'
Minimum Voltage [mV]	uint16_t	3000
Maximum Voltage [mV]	uint16_t	3600
Maximum Current [mA]	uint16_t	30

3.3. Power Sources

The SAM4E Xplained Pro kit can be powered by several power sources listed in Table 3-3 Power Sources for SAM4E Xplained Pro on page 8.

Table 3-3 Power Sources for SAM4E Xplained Pro

Power input	Voltage requirements	Current requirements	Connector marking
External power	5V ±2% (±100mV) for USB host operation. 4.3V to 5.5V if USB host operation is not required.	Recommended minimum is 1A to be able to provide enough current for connected USB devices and the board itself. Recommended maximum is 2A due to the input protection maximum current specification.	PWR
Embedded debugger USB	4.4V to 5.25V (according to USB spec.)	500mA (according to USB spec.)	DEBUG USB
Target USB	4.4V to 5.25V (according to USB spec.)	500mA (according to USB spec.)	TARGET USB

The kit will automatically detect which power sources are available and choose which one to use according to the following priority:

1. External power.
2. Embedded Debugger USB.
3. Target USB.

> ℹ️ **Info:** External power is required when 500mA from a USB connector is not enough to power the board with possible extension boards. A connected USB device in a USB host application might easily exceed this limit.

3.4. Xplained Pro Headers and Connectors

3.4.1. Xplained Pro Standard Extension Header

All Xplained Pro kits have one or more dual row, 20-pin, 100mil extension header. Xplained Pro MCU boards have male headers, while Xplained Pro extensions have their female counterparts. Note that all pins are not always connected. All connected pins follow the defined pin-out description in Table 3-4 Xplained Pro Standard Extension Header on page 9.

The extension headers can be used to connect a variety of Xplained Pro extensions to Xplained Pro MCU boards or to access the pins of the target MCU on Xplained Pro MCU boards directly.

Table 3-4 Xplained Pro Standard Extension Header

Pin number	Name	Description
1	ID	Communication line to the ID chip on an 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 select for SPI and/or general purpose I/O
11	I2C_SDA	Data line for I^{2}C interface. Always implemented, bus type.
12	I2C_SCL	Clock line for I^{2}C interface. Always implemented, bus type.
13	UART_RX	Receiver line of target device UART
14	UART_TX	Transmitter line of target device UART

Pin number	Name	Description
15	SPI_SS_A	Slave select for SPI. Should preferably be unique.
16	SPI_MOSI	Master out slave in line of serial peripheral interface. Always implemented, bus type.
17	SPI_MISO	Master in slave out line of serial peripheral interface. Always implemented, bus type.
18	SPI_SCK	Clock for serial peripheral interface. Always implemented, bus type.
19	GND	Ground
20	VCC	Power for extension board

3.4.2.   Xplained Pro LCD Extension Connector

The LCD connector provides the ability to connect to display extensions that have a parallel interface. The connector implements signals for a MCU parallel bus interface and a LCD controller interface as well as signals for a touch controller. The connector pin-out definition is shown in Table 3-5 Xplained Pro LCD Connector on page 10. Note that usually only one display interface is implemented, either the LCD controller or the MCU bus interface.

A FPC/FFC connector with 50 pins and 0.5mm pitch is used for the LCD connector. The connector XF2M-5015-1A from Omron is used on several Xplained Pro designs and can be used as a reference.

Table 3-5 Xplained Pro LCD Connector

Pin number	Name	RGB interface description	MCU interface description
1	ID	Communication line to the ID chip on an extension board	
2	GND	Ground	
3	D0	Data line	
4	D1	Data line	
5	D2	Data line	
6	D3	Data line	
7	GND	Ground	
8	D4	Data line	
9	D5	Data line	
10	D6	Data line	
11	D7	Data line	
12	GND	Ground	
13	D8	Data line	
14	D9	Data line	
15	D10	Data line	
16	D11	Data line	
17	GND	Ground	

Pin number	Name	RGB interface description	MCU interface description
18	D12	Data line	
19	D13	Data line	
20	D14	Data line	
21	D15	Data line	
22	GND	Ground	
23	D16	Data line	
24	D17	Data line	
25	D18	Data line	
26	D19	Data line	
27	GND	Ground	
28	D20	Data line	
29	D21	Data line	
30	D22	Data line	
31	D23	Data line	
32	GND	Ground	
33	PCLK / CMD DATA SEL	Pixel clock	Display RAM select. One address line of the MCU for displays where it is possible to select either register or data interface.
34	VSYNC / CS	Vertical Synchronization	Chip select
35	HSYNC / WE	Horizontal Synchronization	Write enable signal
36	DATA ENABLE / RE	Data enable signal	Read enable signal
37	SPI SCK	Clock for serial peripheral interface	
38	SPI MOSI	Master out slave in of serial peripheral interface	
39	SPI MISO	Master in slave out of serial peripheral interface	
40	SPI SS	Slave select for serial peripheral interface. Preferably a dedicated pin.	
41	ENABLE	Display enable	
42	I^2C SDA	I^2C data	
43	I^2C SCL	I^2C clock	
44	IRQ1	Interrupt 1	
45	IRQ2	Interrupt 2	
46	PWM	Backlight control	

Pin number	Name	RGB interface description	MCU interface description
47	RESET	Extension reset	
48	VCC	3.3V power supply for extension board	
49	VCC	3.3V power supply for extension board	
50	GND	Ground	

3.4.3. Xplained Pro Power Header

The power header can be used to connect external power to the SAM4E Xplained Pro kit. The kit will automatically detect and switch to any external power if supplied. The power header can also be used as supply for external peripherals or extension boards. Care must be taken not to exceed the total current limitation of the on-board regulator when using the 3.3V pin.

Table 3-6 Xplained Pro Power Header

Pin number	Pin name	Description
1	VEXT_P5V0	External 5V input
2	GND	Ground
3	VCC_P5V0	Unregulated 5V (output, derived from one of the input sources)
4	VCC_P3V3	Regulated 3.3V (output, used as main power supply for the kit)

4.   Hardware User Guide

4.1.   Connectors

This chapter describes the implementation of the relevant connectors and headers on SAM4E Xplained Pro and their connection to the ATSAM4E16E. The tables of connections in this chapter also describes which signals are shared between the headers and on-board functionality.

4.1.1.   Xplained Pro Extension Headers

The SAM4E Xplained Pro headers EXT1, EXT2, and EXT3 offers access to the I/O of the microcontroller in order to expand the board e.g. by connecting extensions to the board. These headers all comply with the standard extension header specified in Xplained Pro Standard Extension Header on page 9. All headers have a pitch of 2.54mm.

Table 4-1 Extension Header EXT1

Pin on EXT1	SAM4E pin	Function	Shared functionality
1	-	Communication line to ID chip on extension board	
2	-	GND	
3	PB2	AFE AD0	
4	PB3	AFE AD1	
5	PA24	GPIO	
6	PA25	GPIO	
7	PA15	TIOA1	
8	PA16	TIOB1	
9	PA11	WKUP7	
10	PD25	GPIO	
11	PA3	TWD0	EXT2, EXT3, LCD connector, and EDBG
12	PA4	TWCK0	EXT2, EXT3, LCD connector, and EDBG
13	PA21	RXD1	
14	PA22	TXD1	
15	PB14	NPCS1	
16	PA13	MOSI	EXT2 and EXT3
17	PA12	MISO	EXT2 and EXT3
18	PA14	SPCK	EXT2 and EXT3

Pin on EXT1	SAM4E pin	Function	Shared functionality
19	-	GNC	
20	-	VCC	

Table 4-2 Extension Header EXT2

Pin on EXT2	SAM4E pin	Function	Shared functionality
1	-	Communication line to ID chip on extension board	
2	-	GND	
3	-	-	
4	-	-	
5	PE2	GPIO	VBUS Sense and EDBG DGI
6	PB5	GPIO	EDBG TRACESWO
7	PD21	PWMHI1	
8	-	-	
9	PD29	GPIO	ETHERNET
10	PB4	GPIO	
11	PA3	TWD0	EXT1, EXT3, LCD connector, and EDBG
12	PA4	TWCK0	EXT1, EXT3, LCD connector, and EDBG
13	PA5	URXD1	EXT3
14	PA6	UTXD1	EXT3
15	PD23	GPIO	
16	PA13	MOSI	EXT1 and EXT3
17	PA12	MISO	EXT1 and EXT3
18	PA14	SPCK	EXT1 and EXT3
19	-	GND	
20	-	VCC	

Table 4-3 Extension Header EXT3

Pin on EXT3	SAM4E pin	Function	Shared functionality
1	-	Communication line to ID chip on extension board	
2	-	GND	

Pin on EXT3	SAM4E pin	Function	Shared functionality
3	PA17	AD0	
4	PC13	AD6	
5	PD28	GPIO	
6	PD17	GPIO	
7	PD20	PWMH0	
8	PD24	PWML0	
9	PE1	GPIO	
10	PD26	GPIO	
11	PA3	TWD0	EXT1, EXT2, LCD connector, and EDBG
12	PA4	TWCK0	EXT1, EXT2, LCD connector, and EDBG
13	PA5	URXD1	EXT2
14	PA6	UTXD1	EXT2
15	PD30	GPIO	
16	PA13	MOSI	EXT1 and EXT2
17	PA12	MISO	EXT1 and EXT2
18	PA14	SPCK	EXT1 and EXT2
19	-	GND	
20	-	VCC	

4.1.2. LCD Extension Connector

Extension connector EXT4 is a special connector for LCD displays. The physical connector is a TE Connectivity 5-1734839-0 FPC connector.

Table 4-4 LCD Display Connector EXT4

Pin on EXT4	SAM4E pin	Function	Shared functionality
1 [ID]	-	Communication line to ID chip on extension board	
2 [GND]	-	GND	
3 [D0]	PC0	D0	SRAM, NAND, and EBI spare header
4 [D1]	PC1	D1	SRAM, NAND, and EBI spare header
5 [D2]	PC2	D2	SRAM, NAND, and EBI spare header
6 [D3]	PC3	D3	SRAM, NAND, and EBI spare header
7 [GND]	-	GND	

Pin on EXT4	SAM4E pin	Function	Shared functionality
8 [D4]	PC4	D4	SRAM, NAND, and EBI spare header
9 [D5]	PC5	D5	SRAM, NAND, and EBI spare header
10 [D6]	PC6	D6	SRAM, NAND, and EBI spare header
11 [D7]	PC7	D7	SRAM, NAND, and EBI spare header
12 [GND]	-	GND	
13 [D8]	-	-	
14 [D9]	-	-	
15 [D10]	-	-	
16 [D11]	-	-	
17 [GND]	-	GND	
18 [D12]	-	-	
19 [D13]	-	-	
20 [D14]	-	-	
21 [D15]	-	-	
22 [GND]	-	GND	
23 [D16]	-	-	
24 [D17]	-	-	
25 [D18]	-	-	
26 [D19]	-	-	
27 [GND]	-	GND	
28 [D20]	-	-	
29 [D21]	-	-	
30 [D22]	-	-	
31 [D23]	-	-	
32 [GND]	-	GND	
33 [PCLK / CMD_DATA_SEL]	PE5	GPIO	
34 [VSYNC / CS]	PA23	GPIO	EBI spare header
35 [HSYNC / WE]	PC8	NWE	SRAM and EBI spare header
36 [DATA ENABLE / RE]	PC11	NRD	SRAM and EBI spare header
37 [SPI SCK]	-	-	
38 [SPI MOSI]	-	-	

Pin on EXT4	SAM4E pin	Function	Shared functionality
39 [SPI MISO]	-	-	
40 [SPI SS]	-	-	
41 [DISP ENABLE]	PE3	GPIO	EDBG DGI and EBI spare header
42 [TWI SDA]	PA3	TWD0	EXT1, EXT2, EXT3, and EDBG
43 [TWI SCL]	PA4	TWCK0	EXT1, EXT2, EXT3, and EDBG
44 [IRQ1]	PE4	IRQ1	IRQ2 and EDBG DGI
45 [IRQ2]	PE4	IRQ2	IRQ1 and EDBG DGI
46 [PWM]	PD27	PWML3	EDBG DGI
47 [RESET]	PE0	GPIO	
48 [VCC]	-	VCC_P3V3	
49 [VCC]	-	VCC_P3V3	
50 [GND]	-	GND	

4.1.3. Chip Erase Header

There is a 1x2 pin-header that is connected to the SAM4E chip erase pin (PB12) and 3V3 marked ERASE as shown in Figure 1-1 SAM4E Xplained Pro Evaluation Kit Overview on page 5. This header can be used to chip erase the SAM4E by placing a jumper on the header and toggle the power to the board. After the power is toggled the jumper should be removed. Using the chip erase jumper is the only way to erase a chip with the security bit set, an application that immediately sets invalid clock options or goes into deep sleep without any wake-up sources.

4.1.4. Current Measurement Header

An angled 1x2, 100mil pin-header marked with MCU current measurement is located at the upper edge of the SAM4E Xplained Pro. All power to the ATSAM4E16E is routed through this header. To measure the power consumption of the device remove the jumper and replace it with an ammeter.

> **Caution:**   Removing the jumper from the pin-header while the kit is powered may cause the ATSAM4E16E to be powered through its I/O pins. This may cause permanent damage to the device.

4.1.5. Other Headers

In addition to the Xplained Pro standard connectors, SAM4E Xplained Pro has one header with spare signals that offers access to the I/O of the microcontroller which are otherwise not easily available elsewhere or might be favourable to have collected toghether. The headers has a pitch of 2.54mm.

Table 4-5 EBI Spare Signal Header

Pin on header	SAM4E pin	Function	Shared functionality
1	PC0	Data line 0	SRAM, NAND, and LCD connector
2	PC1	Data line 1	SRAM, NAND, and LCD connector

Pin on header	SAM4E pin	Function	Shared functionality
3	PC2	Data line 2	SRAM, NAND, and LCD connector
4	PC3	Data line 3	SRAM, NAND, and LCD connector
5	PC4	Data line 4	SRAM, NAND, and LCD connector
6	PC5	Data line 5	SRAM, NAND, and LCD connector
7	PC6	Data line 6	SRAM, NAND, and LCD connector
8	PC7	Data line 7	SRAM, NAND, and LCD connector
9	PA23	CS	LCD connector
10	PE3	DISPLAY ENABLE	EDBG DGI and LCD connector
11	PC11	RE	SRAM and LCD connector
12	PC8	WE	SRAM and LCD connector
13	-	GND	
14	-	VCC	

4.2. Peripherals

4.2.1. SRAM

The SAM4E Xplained Pro features two external ISSI *IS61WV5128BLL-10TLI*, 512Kx8, 10ns, SRAMs, SRAM0 and SRAM1. SRAM0 is connected to chip select NCS1 and SRAM1 is connected to chip select NCS3. SRAM access can be configured in the Static Memory Controller in the SAM4E.

Table 4-6 SRAM Connections on page 18 lists all I/O-lines connected to the SRAMs.

Table 4-6 SRAM Connections

Pin on SAM4E	Function	SRAM function	Shared functionality
PC0	D0	Data line 0	NAND, LCD connector, and EBI spare header
PC1	D1	Data line 1	NAND, LCD connector, and EBI spare header
PC2	D2	Data line 2	NAND, LCD connector, and EBI spare header
PC3	D3	Data line 3	NAND, LCD connector, and EBI spare header
PC4	D4	Data line 4	NAND, LCD connector, and EBI spare header
PC5	D5	Data line 5	NAND, LCD connector, and EBI spare header
PC6	D6	Data line 6	NAND, LCD connector, and EBI spare header

Pin on SAM4E	Function	SRAM function	Shared functionality
PC7	D7	Data line 7	NAND, LCD connector, and EBI spare header
PC18	A0	Address line 0	
PC19	A1	Address line 1	
PC20	A2	Address line 2	
PC21	A3	Address line 3	
PC22	A4	Address line 4	
PC23	A5	Address line 5	
PC24	A6	Address line 6	
PC25	A7	Address line 7	
PC26	A8	Address line 8	
PC27	A9	Address line 9	
PC28	A10	Address line 10	
PC29	A11	Address line 11	
PC30	A12	Address line 12	
PC31	A13	Address line 13	
PA18	A14	Address line 14	
PA19	A15	Address line 15	
PA20	A16	Address line 16	
PA0	A17	Address line 17	
PA1	A18	Address line 18	
PD18	NCS1	#Chip Enable (on SRAM0)	
PD19	NCS3	#Chip Enable (on SRAM1)	
PC8	NWE	#Write Enable	LCD Connector and EBI spare header
PC11	NRD	#Output Enable	LCD Connector and EBI spare header

4.2.2. NAND Flash

The SAM4E Xplained Pro kit has one external Micron *MT29F2G08ABAEAWP:E* 2Gb NAND flash connected to the external bus interface of the SAM4E. The NAND flash is connected to chip select NCS0. NAND flash access can be configures in the Static Memory Controller in the SAM4E.

The R/B (read/busy) signal from the NAND flash is connected to PB12, which is configured as SAM4E chip erase by default. In order to utilize the R/B signal PB12 must be configured as a normal I/O pin in the CCFG_SYSIO register located in the MATRIX module and the internal pull-up has to be enabled. For more information see the SAM4E datasheet.

Table 4-7 NAND Flash Connections on page 20 lists all I/O-lines connected to the NAND flash.

Table 4-7 NAND Flash Connections

SAM4E pin	Function	NAND Flash function	Shared functionality
PC0	D0		SRAM, LCD connector, and EBI spare header
PC1	D1		SRAM, LCD connector, and EBI spare header
PC2	D2		SRAM, LCD connector, and EBI spare header
PC3	D3		SRAM, LCD connector, and EBI spare header
PC4	D4		SRAM, LCD connector, and EBI spare header
PC5	D5		SRAM, LCD connector, and EBI spare header
PC6	D6		SRAM, LCD connector, and EBI spare header
PC7	D7		SRAM, LCD connector, and EBI spare header
PC17	NANDCLE	CLE	
PC16	NANDALE	ALE	
PC10	NANDWE	#Write Enable	
PC9	NANDOE	#Read Enable	
PC14	NCS0	#Chip Enable	
PB12	GPIO	Ready/#Busy	ERASE pin

4.2.3. Ethernet

The ATSAM4E16E has a built in 10/100Mbps Ethernet IEEE[®] 802.3 MAC with an MII interface. SAM4E Xplained Pro connects the MAC to a Micrel *KSZ8081MNXIA* physical-layer transceiver, which is connected to one RJ45 Ethernet connector.

Every SAM4E Xplained Pro kit is assigned a unique MAC48 address that can be used in an application. This address is printed on the label on the bottom side of the kit and stored in the EDBG. For more information, see Identifying Product ID and Revision on page 26 and Kit Specific Data on page 25.

Table 4-8 Ethernet Connections on page 20 lists all I/O-lines connected to the Ethernet PHY.

Table 4-8 Ethernet Connections

SAM4E pin	Function	Ethernet function	Shared functionality
PD0	GTXCK	TXC	
PD1	GTXEN	TXEN	

SAM4E pin	Function	Ethernet function	Shared functionality
PD2	GTX0	TXD0	
PD3	GTX1	TXD1	
PD4	GRXDV	RXDV/CONFIG2	
PD5	GRX0	RXD0/DUPLEX	
PD6	GRX1	RXD1/PHYAD2	
PD7	GRXER	RXER/ISO	
PD8	GMDC	MDC	
PD9	GMDIO	MDIO	
PD10	GCRS	CRS/CONFIG1	
PD11	GRX2	RXD2/PHYAD1	
PD12	GRX3	RXD3/PHYAD0	
PD13	GCOL	COL/CONFIG0	
PD14	GRXCK	RXC/B-CAST_OFF	
PD15	GTX2	TXD2	
PD16	GTX3	TXD3	
PD29	GPIO	INTRP/ #NAND_TREE	EXT2 GPIO
PD31	GPIO	#RST	

4.2.4. SD Card Connector

The SAM4E Xplained Pro kit has one SD card connector which is connected to High Speed Multimedia Card Interface (HSMCI) of the SAM4E

Table 4-9 SD Card Connections on page 21 lists all I/O-lines connected to the SD card connector.

Table 4-9 SD Card Connections

SAM4E pin	Function	SD card function	Shared functionality
PA30	MCDA0	DAT0	
PA31	MCDA1	DAT1	
PA26	MCDA2	DAT2	
PA27	MCDA3	DAT3	
PA29	MCCK	CLK	
PA28	MCCDA	CMD	

4.2.5. CAN

The SAM4E Xplained Pro kit has CAN1 connected to the an Infineon TLE7250GVIOXUMA1 high speed CAN transceiver.

Table 4-10 CAN Connections on page 22 lists the I/O-lines connected to the CAN transceiver.

Table 4-10 CAN Connections

SAM4E pin	Function	CAN function	Shared functionality
PC12	CANRX1	CAN RX	
PC15	CANTX1	CAN TX	

4.2.6. USB

The SAM4E Xplained Pro has a Micro-USB receptable for use with the SAM4E USB device module labeled "target usb" on the board. To be able to detect when a USB cable is connected, a GPIO (PE2) is used to detect the VBUS voltage on the connector.

Table 4-11 USB Connections on page 22 lists all I/O-lines connected to the USB connector.

Table 4-11 USB Connections

SAM4E pin	Function	USB function	Shared functionality
PE2	GPIO	VBUS detection	EXT2 GPIO
PB10	DFSD_N	USB D-	
PB11	DFSD_P	USB D+	

4.2.7. Crystals

The SAM4E Xplained Pro kit contains two crystals that can be used as clock sources for the SAM4E device. Each crystal has a cut-strap next to it that can be used to measure the oscillator safety factor. This is done by cutting the strap and adding a resistor across the strap. More information about oscillator allowance and safety factor can be found in the Atmel application note AVR4100: Selecting and testing 32kHz crystal oscillators for Atmel AVR microcontrollers.

Table 4-12 External 32.768kHz Crystal

Pin on SAM4E	Function
PA7	XIN32
PA8	XOUT32

Table 4-13 External 12MHz Crystal

Pin on SAM4E	Function
PB9	XIN
PB8	XOUT

> **Important:**   Load capacitor calculation, selection and verification was done wrong in the design of the SAM4E Xplained Pro evaluation kit, see the errata section for more information.

Related Links

12MHz Crystal on page 26

4.2.8. Mechanical Buttons

SAM4E Xplained Pro contains two mechanical buttons. One button is the RESET button connected to the SAM4E reset line and the other is a generic user configurable button. When a button is pressed it will

drive the I/O line to GND. Note that in order to read the button status the internal pull-up must be enabled on PA2.

Table 4-14 Mechanical Buttons

Pin on SAM4E	Silkscreen text
NRST	RESET
PA2	SW0

4.2.9. LED

There is one yellow LED available on the SAM4E Xplained Pro board that can be turned on and off. The LED can be activated by driving the connected I/O line to GND.

Table 4-15 LED Connections

Pin on SAM4E	LED
PD22	Yellow LED0

4.3. Embedded Debugger Implementation

SAM4E Xplained Pro contains an Embedded Debugger (EDBG) that can be used to program and debug the ATSAM4E16E using Serial Wire Debug (SWD). The Embedded Debugger also include a Virtual Com port interface over UART, an Atmel Data Gateway Interface over SPI and TWI and it monitors four of the SAM4E GPIOs. Atmel Studio can be used as a front end for the Embedded Debugger.

4.3.1. Serial Wire Debug

The Serial Wire Debug (SWD) use two pins to communicate with the target. For further information on how to use the programming and debugging capabilities of the EDBG, see the EDBG User Guide.

Table 4-16 SWD Connections

Pin on SAM4E	Function
PB7	SWD clock
PB6	SWD data
PB5	SWD trace output
PB12	Erase

4.3.2. Virtual COM Port

The Embedded Debugger act as a Virtual Com Port gateway by using one of the ATSAM4E16E UARTs. For further information on how to use the Virtual COM port, see Embedded Debugger on page 7.

Table 4-17 Virtual COM Port Connections

Pin on SAM4E	Function
PA9	URXD0 (SAM4E RX line)
PA10	UTXD0 (SAM4E TX line)

4.3.3. Atmel Data Gateway Interface

The Embedded Debugger features an Atmel Data Gateway Interface (DGI) by using either a USART or TWI port. The DGI can be used to send a variety of data from the SAM4E to the host PC. For further information on how to use the DGI interface, see Embedded Debugger on page 7.

Table 4-18 DGI Interface Connections when using USART

Pin on SAM4E	Function
PB0	RXD0
PB1	TXD0
PB13	SCK0

Table 4-19 DGI Interface Connections when using TWI

Pin on SAM4E	Function
PA3	SDA (Data line)
PA4	SCL (Clock line)

Four GPIO lines are connected to the Embedded Debugger. The EDBG can monitor these lines and time stamp pin value changes. This makes it possible to accurately time stamp events in the SAM4E application code. For further information on how to configure and use the GPIO monitoring features, see Embedded Debugger on page 7.

Table 4-20 GPIO Lines Connected to the EDBG

Pin on SAM4E	Function
PD27	GPIO0
PE3	GPIO1
PE4	GPIO2
PE2	GPIO3

5. Kit Specific Data

One of the user pages in the EDBG is programmed with data specific to the SAM4E Xplained Pro. The data can be read through the I^{2}C interface connected to the EDBG. For detailed information, see the **EDBG User Guide** . All data is stored as little endian.

Table 5-1 MAC48Register, Offset: 0x00

Name	Description	Size [bits]
MAC48	Unique address assigned to the kit.	48

6.   Hardware Revision History and Known Issues

6.1.   Identifying Product ID and Revision

The revision and product identifier of Xplained Pro 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 Pro MCU 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. Information about connected Xplained Pro extension boards will also appear in the Atmel Kit's window.

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 QR-code, which contains a serial number string.

The serial number string has the following format:

"nnnnrrssssssssss"

n = product identifier

r = revision

s = serial number

The product identifier for SAM4E Xplained Pro is A09-2081.

6.2.   Revision 3

Revision 3 is the initially released revision.

6.2.1.   12MHz Crystal

The calculation, selection, and verification of the external load capacitors C317 and C318 for the on-board 12MHz crystal was done wrong in design phase of the SAM4E Xplained Pro evaluation kit. The capacitors mounted on the board are 6.8pF, while they should have been 18pF. The difference in capacitance will cause the frequency generated by the crystal to be ~500Hz (~44ppm) too high.

 Fix/Workaround: Replace C317 and C318 with 18pF capacitors.

Load capacitance calculation

$C_{crystal}$ = 20pF (crystal datasheet),

C_L = 9.5pF (SAM4E datasheet), C_{PCB} = 2.0pF (estimate)

$C = 2 \times (C_{crystal} - C_L - C_{PCB})$

$C = 2 \times (20pF - 9.5pF - 2.0pF)$

C = 17pF

Design selection:

C = 18pF

The selected 12MHz crystal *FQ5032B-12-C-C-C-200-1* has a load of 20pF, this is outside the recommended range of 12.5pF to 17.5pF in the ATSAM4E16E datasheet. Using a crystal with loads outside the recommended range can cause instability when operating the device close to maximum/ minimum parameters for supply voltage and temperature.

Fix/Workaround: None, any new design should select a crystal within the limits specified in the datasheet.

Related Links

Crystals on page 22

7. Appendix

7.1. Getting Started with IAR

IAR Embedded Workbench® for ARM® is a proprietary high efficiency compiler not based on GCC. Programming and debugging of Xplained Pro kits are supported in IAR™ Embedded Workbench for ARM using the common CMSIS-DAP interface. Some initial settings have to be set up in the project to get the programming and debugging to work.

The following steps will explain how to get your project ready for programming and debugging:

1. Make sure you have opened the project you want to configure. Open the **OPTIONS** dialog for the project.
2. In the category **General Options**, select the **Target** tab. Select the device for the project or, if not listed, the core of the device.
3. In the category **Debugger**, select the **Setup** tab. Select **CMSIS DAP** as the driver.
4. In the category **Debugger**, select the **Download** tab. Check the check box for **Use flash loader(s)** option.
5. In the category **Debugger** > **CMSIS DAP**, select the **Setup** tab. Select **System (default)** as the reset method.
6. In the category **Debugger** > **CMSIS DAP**, select the **JTAG/SWD** tab. Select **SWD** as the interface and optionally select the **SWD speed**.

Figure 7-1 Select Target Device
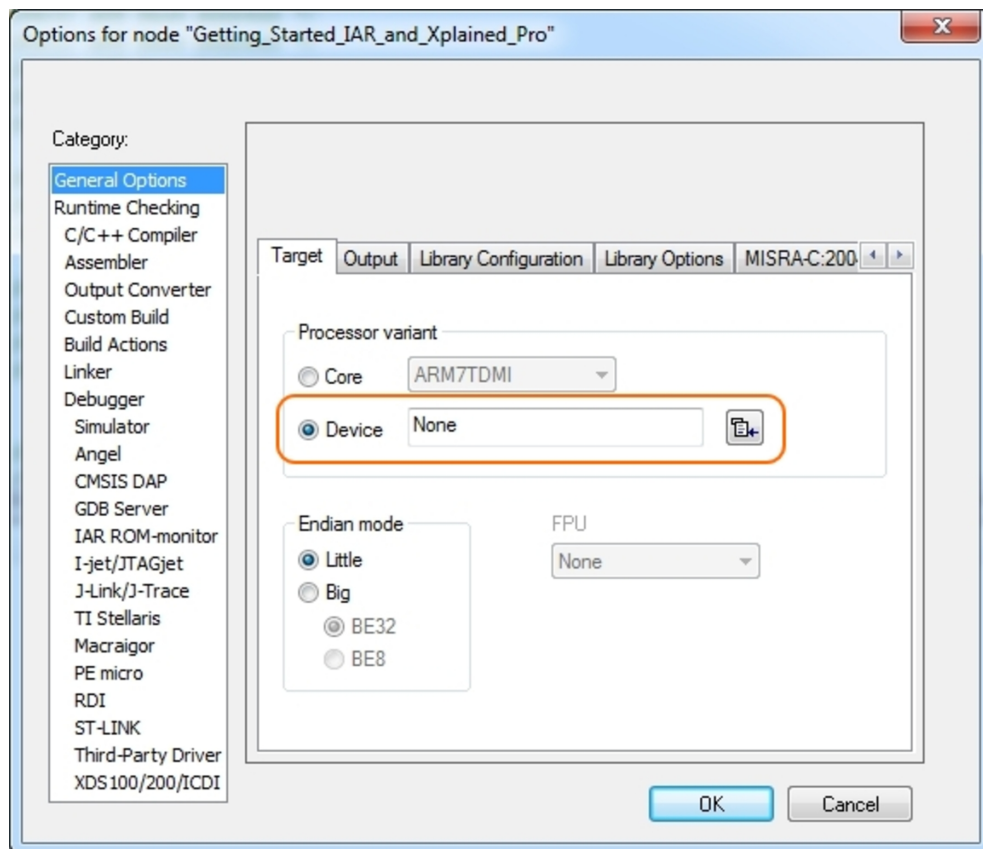
Figure 7-2 Select Debugger
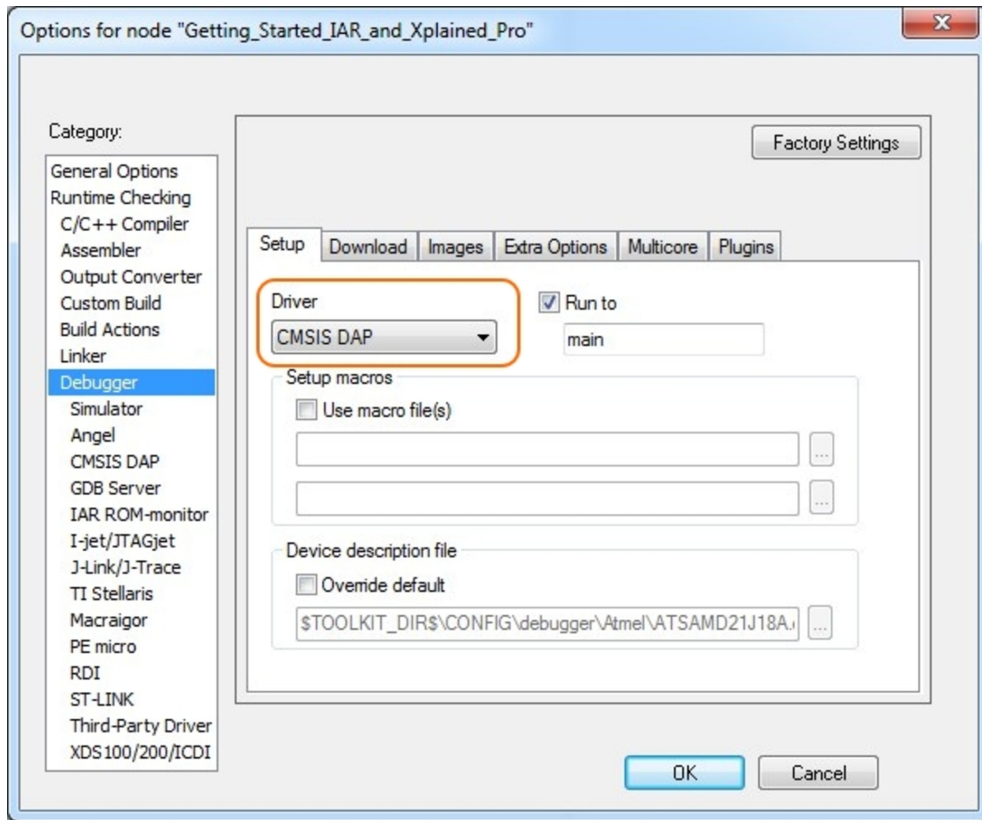
Figure 7-3 Configure Flash Loader
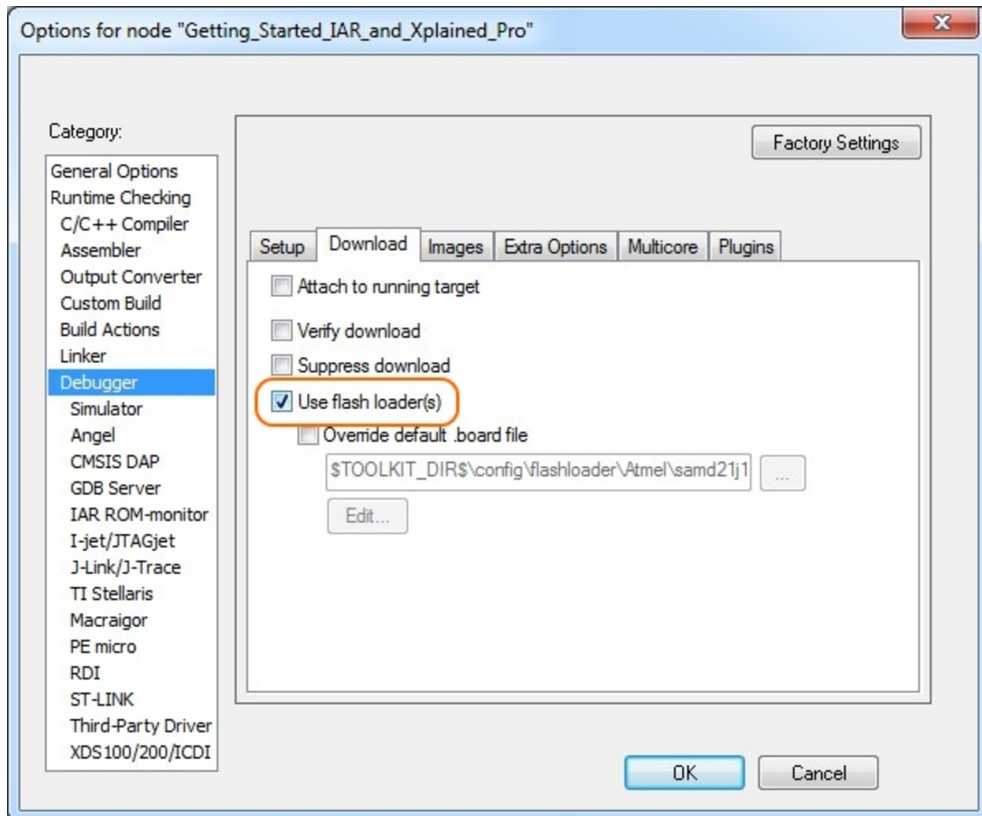
Figure 7-4 Configure Reset
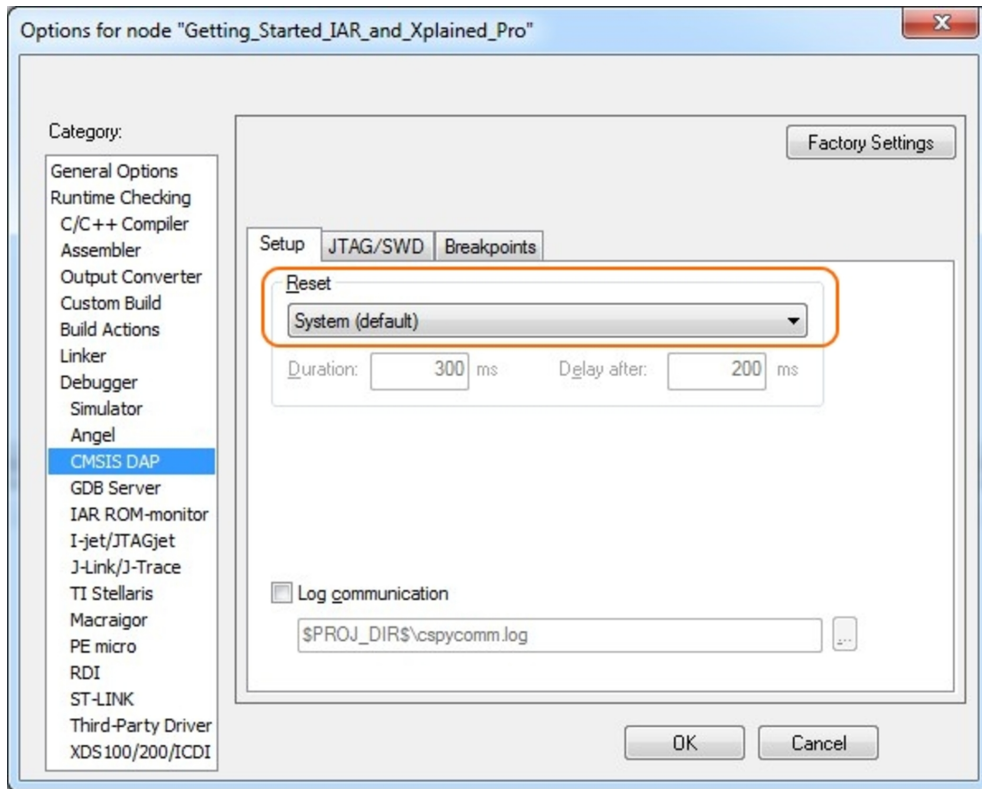
Figure 7-5 Configure Interface
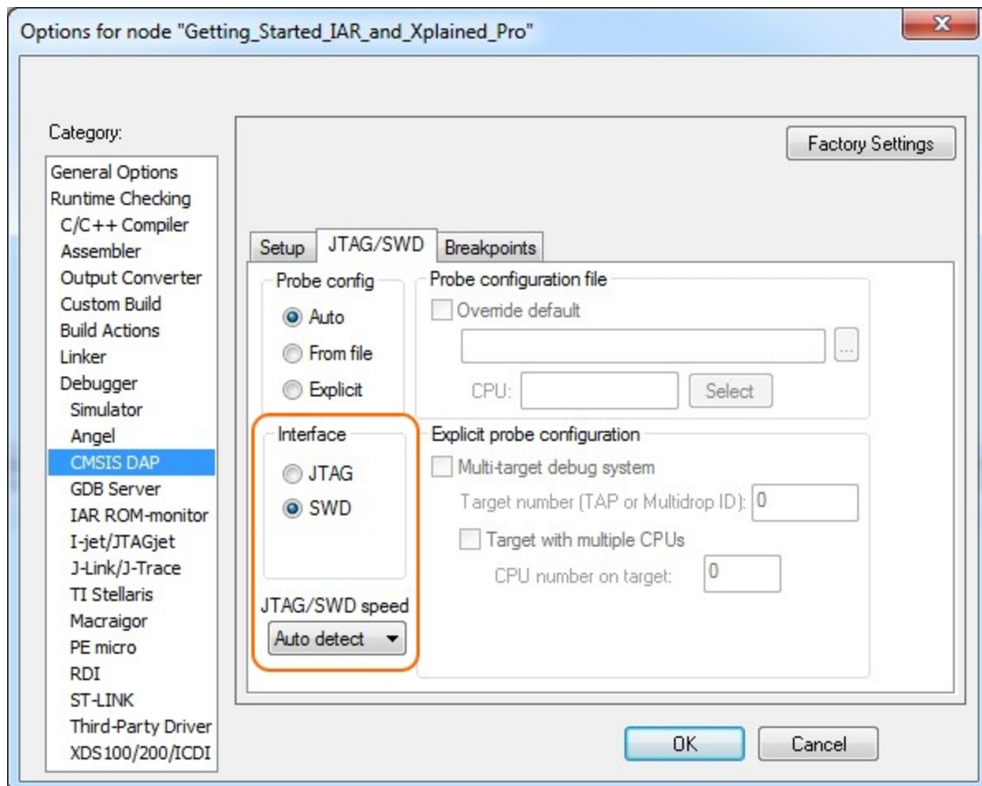
8. Document Revision History

Doc. rev.	Date	Comment
42216C	09/2015	Updated ERRATA about 12MHz crystal.
42216B	09/2015	Added ERRATA about 12MHz crystal and IAR getting started guide.
42216A	02/2013	Initial document release.

9. Evaluation Board/kit Important Notice

This evaluation board/kit is intended for use for **FURTHER ENGINEERING, DEVELOPMENT, DEMONSTRATION, OR EVALUATION PURPOSES ONLY.** It is not a finished product and may not (yet) comply with some or any technical or legal requirements that are applicable to finished products, including, without limitation, directives regarding electromagnetic compatibility, recycling (WEEE), FCC, CE or UL (except as may be otherwise noted on the board/kit). Atmel supplied this board/kit "AS IS," without any warranties, with all faults, at the buyer's and further users' sole risk. The user assumes all responsibility and liability for proper and safe handling of the goods. Further, the user indemnifies Atmel from all claims arising from the handling or use of the goods. Due to the open construction of the product, it is the user's responsibility to take any and all appropriate precautions with regard to electrostatic discharge and any other technical or legal concerns.

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