



SAM E54 Xplained Pro

SAM E54 Xplained Pro User's Guide

Preface

The SAM E54 Xplained Pro evaluation kit is a hardware platform to evaluate the ATSAME54P20A microcontroller.

Supported by the integrated development platform Atmel Studio, the kit provides easy access to the features of the ATSAME54P20A 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 ATSAME54P20A.

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

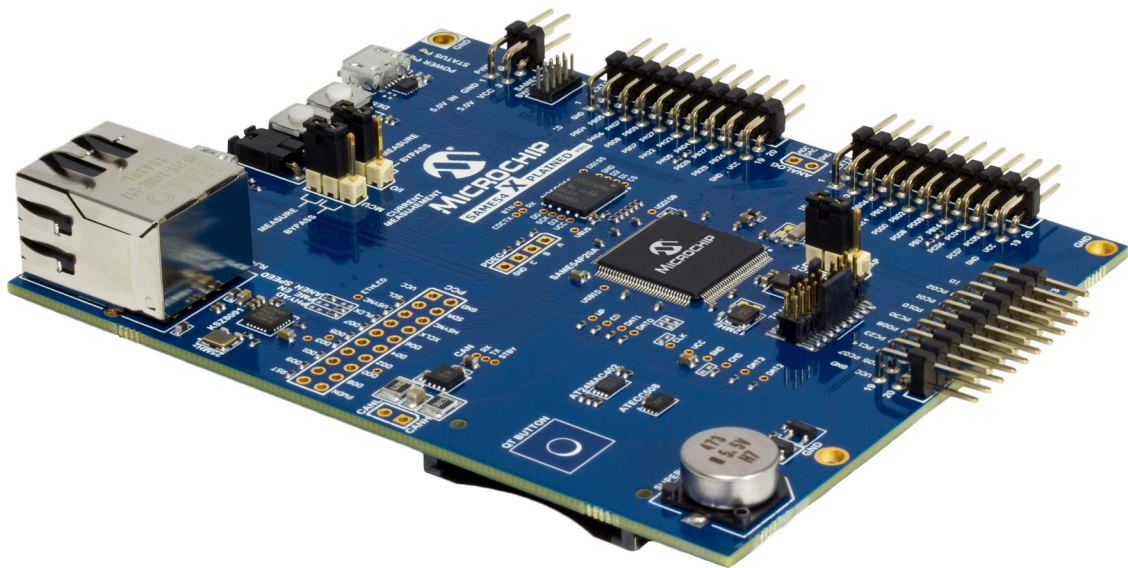


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1. Object of Declaration

EU Declaration of Conformity for SAM E54 Xplained Pro

This declaration of conformity is issued by the manufacturer.

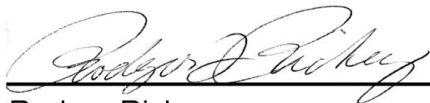
The development/evaluation tool is designed to be used for research and development in a laboratory environment. This development/evaluation tool is not a Finished Appliance, nor is it intended for incorporation into Finished Appliances that are made commercially available as single functional units to end users under EU EMC Directive 2004/108/EC and as supported by the European Commission's Guide for the EMC Directive 2004/108/EC (8th February 2010).

This development/evaluation tool complies with EU RoHS2 Directive 2011/65/EU.

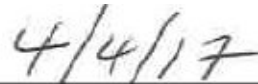
This development/evaluation tool, when incorporating wireless and radio-telecom functionality, is in compliance with the essential requirement and other relevant provisions of the R&TTE Directive 1999/5/EC and the FCC rules as stated in the declaration of conformity provided in the module datasheet and the module product page available at www.microchip.com.

For information regarding the exclusive, limited warranties applicable to Microchip products, please see Microchip's standard terms and conditions of sale, which are printed on our sales documentation and available at www.microchip.com.

Signed for and on behalf of Microchip Technology Inc. at Chandler, Arizona, USA.



Rodger Richey
Director of Development Tools



Date

2. Introduction

2.1 Features

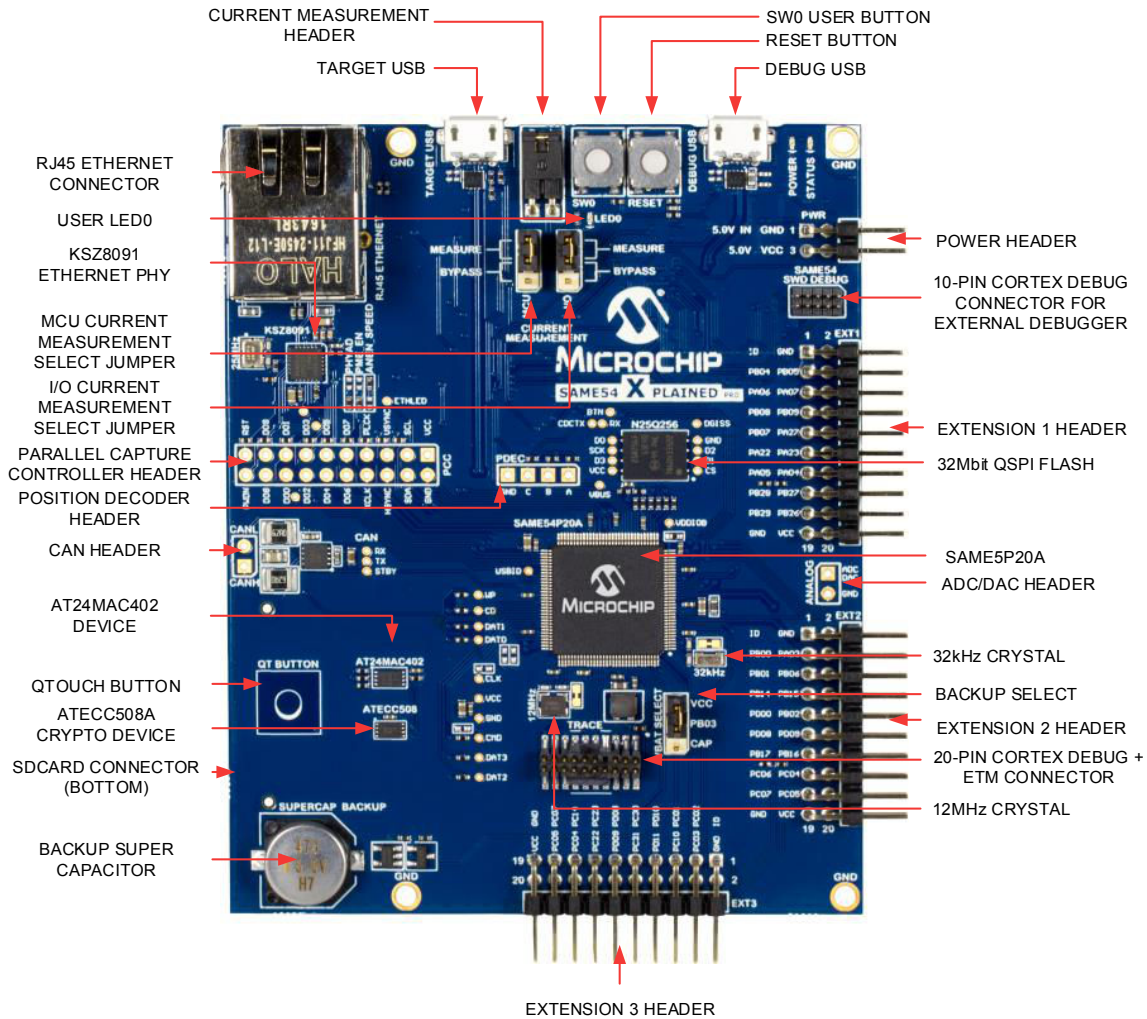
- ATSAME54P20A microcontroller
- One mechanical reset button
- One mechanical programmable button
- One QTouch[®] PTC button
- One yellow user LED
- 256 Mb QSPI Flash
- ATECC508 CryptoAuthentication[™] device
- AT24MAC402 serial EEPROM with EUI-48[™] MAC address
- Ethernet
 - RJ45 connector with built-in magnetics
 - KSZ8091RNA PHY
 - 10Base-T/100Base-TX IEE 802.3 compliant Ethernet transceiver
- SD/SDIO card connector
- Parallel Capture Controller header (ArduCAM compatible)
- CAN connector
- Backup super capacitor
- 32.768 kHz crystal
- 12 MHz crystal
- USB interface, host, and device
- Three Xplained Pro extension headers
- 10-pin Cortex[®] Debug Connector with SWD
- 20-pin Cortex Debug + ETM Connector with SWD and four bit trace
- Embedded Debugger
 - Auto-ID for board identification in Atmel Studio
 - One yellow status LED
 - One green board power LED
 - Symbolic debug of complex data types including scope information
 - Programming and debugging, including power measurements
 - Data Gateway Interface: SPI, I²C, four GPIOs
 - Virtual COM port (CDC)
- Embedded current measurement circuitry (XAM)
 - Measures power consumption of the ATSAME54P20A and / or peripherals
 - Measures current between 100 nA and 400 mA
 - Current measurement data shown in Microchip [Data Visualizer](#)
- USB powered
- Supported with application examples in Atmel START

2.2 Kit Overview

The SAM E54 Xplained Pro evaluation kit is a hardware platform to evaluate the ATSAME54P20A.

The kit offers a set of features that enables the ATSAME54P20A user to get started with the SAM E54 peripherals right away and to get an understanding of how to integrate the device in their own design.

Figure 2-1. SAM E54 Xplained Pro Evaluation Kit Overview



3. Getting Started

3.1 Xplained Pro Quick Start

Steps to start exploring the Xplained Pro platform:

1. Download and install [Atmel Studio](#).
2. Launch Atmel Studio.
3. Connect the DEBUG USB port on the evaluation kit to the computer using a USB cable (Standard-A to Micro-B or Micro-AB).

The operating system installs the driver software automatically the first time the Xplained Pro evaluation kit is connected to a PC. This driver supports 32-bit and 64-bit versions of Microsoft® Windows® XP, Windows Vista®, Windows 7, Windows 8, Windows 10, and Windows Server 2012.

When the Xplained Pro MCU board is powered, the power LED (green) glows and Atmel Studio automatically detects the specific Xplained Pro MCU and extension board(s) that are connected. The kit landing page in Atmel Studio comes with an option to launch Atmel Software Framework (ASF) and Atmel START example application codes for the kit. The SAM E54 device is programmed and debugged by the on-board Embedded Debugger and therefore no external programmer or debugger tool is required.

3.2 Design Documentation and Relevant Links

The following list contains links to the most relevant documents and software for the SAM E54 Xplained Pro.

- **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.
- **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.
- **QTouch® tools** - A collection of tools to design capacitive touch applications.
- **<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.

- [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.
- [SAM E54 Xplained Pro website](#) - Kit information, latest user guide and design documentation.
- [SAM E54 Xplained Pro on Microchip Direct](#) - Purchase this kit on Microchip Direct.

4. Xplained Pro

Xplained Pro is an evaluation platform which contains a series of microcontroller boards (evaluation kits) and extension boards. Atmel Studio is used to program and debug the microcontrollers on these boards. Atmel Studio includes ASF and Atmel START, which has drivers and demo code, and Data Visualizer, which supports data streaming and advanced debugging. Xplained Pro evaluation kits can be connected to a wide range of Xplained Pro extension boards through standardized headers and connectors. Xplained Pro extension boards have identification (ID) chips to uniquely identify which boards are connected to the Xplained Pro evaluation kits.

4.1 Embedded Debugger

The SAM E54 Xplained Pro contains an Embedded Debugger (EDBG) for on-board debugging. The EDBG is a USB composite device with the following interfaces:

- Debugger
- Virtual COM Port
- Data Gateway Interface (DGI)

The EDBG can program and debug the ATSAME54P20A with the help of Atmel Studio. The SWD interface is connected between the EDBG and the ATSAME54P20A on the SAM E54 Xplained Pro.

The Virtual COM Port is connected to a UART on the ATSAME54P20A and provides an easy way to communicate with the target application through terminal software. It offers variable baud rate, parity, and stop bit settings. The settings on the ATSAME54P20A must match the settings given in the terminal software.



Info: The Virtual COM Port in the EDBG requires the terminal software to set the Data Terminal Ready (DTR) signal to enable the UART pins connected to the ATSAME54P20A. If the DTR signal is not enabled, the UART pins on the EDBG are kept in tri-state (high-z) to render the COM Port not usable. The DTR signal is automatically set by some terminal software, but it may have to be manually enabled in your terminal.

The DGI consists of several physical interfaces for bidirectional communication with the host computer. Communication over the interfaces is bidirectional. It can be used to send event values, and data from the ATSAME54P20A. Traffic over the interfaces can be timestamped by the EDBG for more accurate tracing of events, but timestamping reduces the maximal data throughput. The [Data Visualizer](#) is used to send and receive data through DGI.

The EDBG controls two LEDs on the SAM E54 Xplained Pro: a power LED and a status LED. The table below shows how the LEDs are controlled in different operation modes.

Table 4-1. EDBG LED Control

| Mode | Power LED | Status LED |
|------------------------------------|---|---|
| Normal mode | The power LED is on when power is applied to the board. | Activity indicator, the LED flashes when any communication happens to the EDBG. |
| Bootloader mode (idle) | The power LED and the status LED blink simultaneously. | |
| Bootloader mode (firmware upgrade) | The power LED and the status LED blink in an alternating pattern. | |

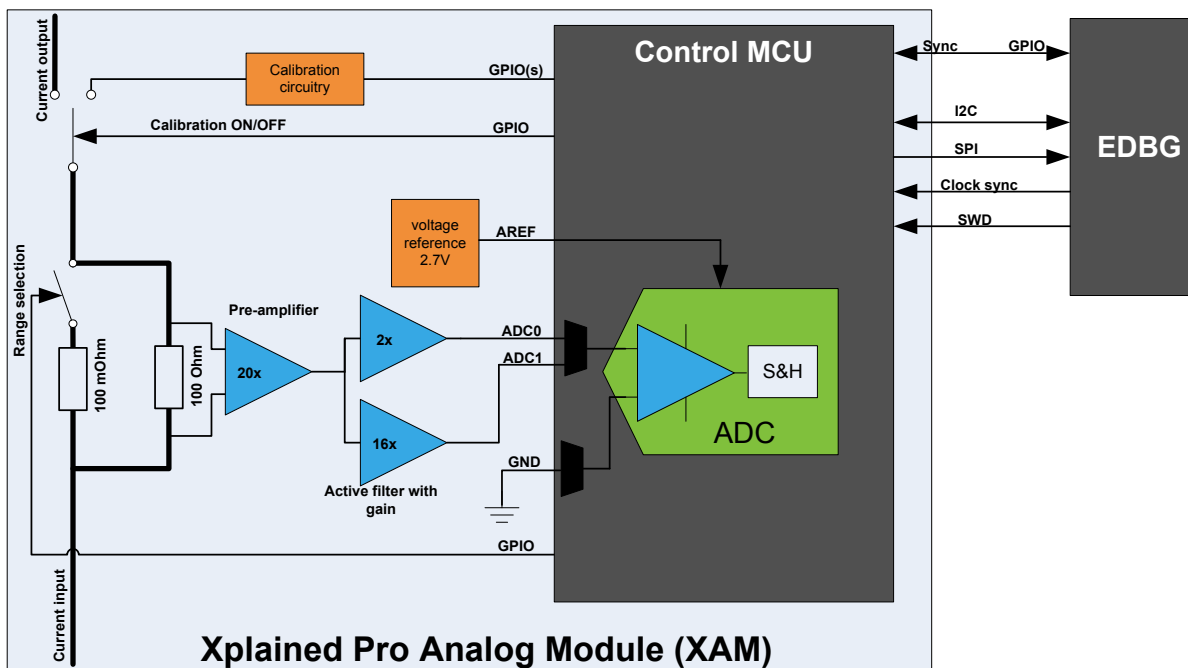
For additional information on the EDBG, see the [EDBG User Guide](#).

4.2 Xplained Pro Analog Module (XAM)

4.2.1 Overview

The Xplained Pro Analog Module (XAM) extends the embedded debugger with high dynamic range current measurement. This enables power profiling of the target system.

Figure 4-1. XAM Block Diagram



The XAM consists of:

- Calibration circuitry
- Voltage reference circuitry
- Analog front-end:
 - Shunt resistors with a range selection switch
 - Pre-amplifier
 - Two active filters with gain
- Control MCU

- Analog-to-Digital Converter
- Signal processing
- Control/communication interface to the EDBG

The current measurement front-end is a high side shunt measurement with a pre-amplifier and a second active filter stage with gain as shown in [Figure 4-1](#). The wide dynamic range is achieved by four measurement ranges, which are defined by two shunt resistors and the two parallel second stage active filters with gain.

4.2.2 EDBG Interface

The XAM is connected to the EDBG with the following interfaces:

- **I²C**: This is used to control and configure the XAM.
- **SPI**: Current measurement data is streamed to the EDBG via this interface. This is a unidirectional channel from the XAM to the EDBG.
- **SWD**: The MCU in the XAM is programmed via SWD from the EDBG.
- **Clock sync**: Signal used to synchronize ADC measurements with the EDBG.
- **Reference clock**: Reference clock for the XAM.

4.2.3 Sample Rate

The raw sampling rate of the XAM is up to 250 kHz and with the default averaging configuration (average of 16 samples), the actual output of the XAM is 16.67 ksps.



Info: The XAM output sample rate is not an integer fraction of the raw sampling.

4.2.4 Measurement Ranges and Accuracy

The XAM has four measurement ranges. These are defined by two shunt resistors and two gain stages.

Table 4-2. XAM Measurement Ranges and Accuracy

| Measurement Range | Hardware | Resolution | Accuracy | Comments |
|-------------------|--|------------|-----------|--|
| Range 1 | Low current shunt and high gain stage | 20 nA | 1 LSB ±1% | Accuracy will decrease below 1µA. Typical accuracy for 300nA is 1 LSB ± 10%. |
| Range 2 | Low current shunt and low gain stage | 150 nA | 1 LSB ±1% | |
| Range 3 | High current shunt and high gain stage | 10 µA | 1 LSB ±1% | |
| Range 4 | High current shunt and low gain stage | 100 µA | 1 LSB ±1% | Accuracy will decrease above 100 mA. Typical accuracy is 1 LSB ±5% at 400 mA. Maximum current is 400 mA. |

The ranges are automatically switched by the XAM to achieve the best measurement results and the currently active range is visualized in the [Data Visualizer](#) front-end tool. The maximum voltage drop over the shunt resistor is 100 mV, and the XAM switches the range automatically before reaching this limit.

4.3 Hardware Identification System

All Xplained Pro extension boards come with an identification chip (ATSHA204A CryptoAuthentication™ chip) to uniquely identify the boards that are connected to the Xplained Pro evaluation kit. 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 evaluation kit, the information is read and sent to Atmel Studio. The following table shows the data fields stored in the ID chip with example content.

Table 4-3. 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 |

4.4 Power Sources

The SAM E54 Xplained Pro kit can be powered by several power sources, as listed in the table below.

Table 4-4. Power Sources for SAM E54 Xplained Pro

| Power Source | Voltage Requirements | Current Requirements | Connector Marking |
|-----------------------|--|---|-------------------|
| External Power | 5V ±2% (±100mV) for USB host operation. 4.3V to 5.5V if a USB host operation is not required. | In USB host applications a minimum of 1A is recommended to supply the kit and the USB device. Maximum recommended current is 2A. | PWR |
| Embedded debugger USB | 4.4V to 5.25V (according to USB spec.) | 500 mA (according to USB spec.) | DEBUG USB |
| Target USB | 4.4V to 5.25V (according to USB spec.) | 500 mA (according to USB spec.) | TARGET USB |

The kit automatically detects which power sources are available and chooses which one to use according to the following priority:

1. External power.

2. Embedded Debugger USB.
3. Target USB.



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.

4.5 Xplained Pro Headers and Connectors

4.5.1 Xplained Pro Standard Extension Header

All Xplained Pro kits have one or more dual row, 20-pin, 100-mil extension header. The Xplained Pro MCU boards have male headers, while the Xplained Pro extensions have their female counterparts. All connected pins follow the defined pin description in the table.



Info: All pins are not always connected on all extension headers.

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 microcontroller on Xplained Pro MCU boards directly.

Table 4-5. Xplained Pro Standard Extension Header

| Pin Number | Pin Name | Description |
|------------|----------------------|---|
| 1 | ID | Pin to communicate with the ID chip on an extension board |
| 2 | GND | Ground |
| 3 | ADC(+) | Analog-to-Digital Converter; alternatively, a pin for the positive terminal of a differential ADC |
| 4 | ADC(-) | Analog-to-Digital Converter; alternatively, a pin for the negative terminal of a differential ADC |
| 5 | GPIO1 | General purpose I/O pin |
| 6 | GPIO2 | General purpose I/O pin |
| 7 | PWM(+) | Pulse width modulation; alternatively, a pin for the positive part of a differential PWM |
| 8 | PWM(-) | Pulse width modulation; alternatively, a pin for the negative part of a differential PWM |
| 9 | IRQ/GPIO | Interrupt request pin and/or general purpose I/O pin |
| 10 | SPI_SS_B/ GPIO | Slave select pin for Serial Peripheral Interface (SPI) and/or general purpose I/O pin |
| 11 | I ² C_SDA | Data pin for I ² C interface. Always connected, bus type |
| 12 | I ² C_SCL | Clock pin for I ² C interface. Always connected, bus type |

| Pin Number | Pin Name | Description |
|------------|----------|---|
| 13 | UART_RX | Receiver pin of target device UART |
| 14 | UART_TX | Transmitter pin of target device UART |
| 15 | SPI_SS_A | Slave select for SPI. This pin should preferably not be connected to anything else. |
| 16 | SPI_MOSI | SPI master out slave in pin. Always connected, bus type |
| 17 | SPI_MISO | SPI master in slave out pin. Always connected, bus type |
| 18 | SPI_SCK | SPI clock pin. Always connected, bus type |
| 19 | GND | Ground pin for extension boards |
| 20 | VCC | Power pin for extension boards |

4.5.2 Xplained Pro Power Header

The power header can be used to connect external power to the SAM E54 Xplained Pro kit. The kit automatically detects and switches to any external power if supplied. The power header can also be used to supply power to external peripherals or extension boards. Ensure that the total current does not exceed the recommended current limit of the on-board regulator when using the 3.3V pin.

Table 4-6. Xplained Pro Power Header

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

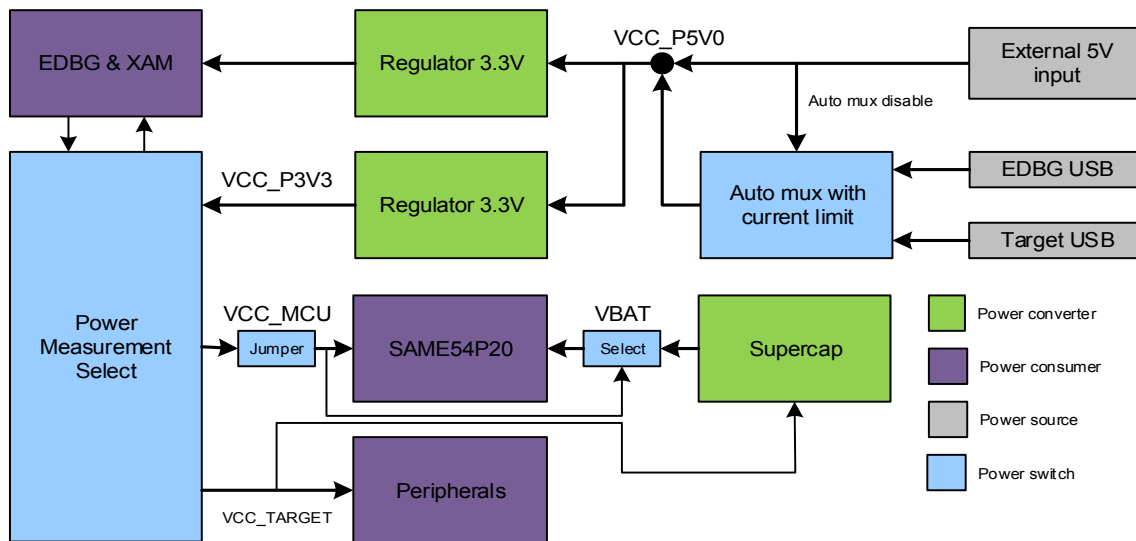
5. Hardware User Guide

5.1 Power Distribution

SAM E54 Xplained Pro has three power sources: EDBG USB, Target USB, and/or external 5.0V. The kit will automatically select a source to draw power from. The kit has two on-board 3.3V voltage regulators, one for the EDBG and XAM, and one for the ATSAME54P20A and other peripherals.

An onboard super capacitor (47 mF) is charged to 3.3V from the target 3.3V net. The super capacitor is connected to PB03 (VBAT) through a selection header and is intended for backup use in sleep modes.

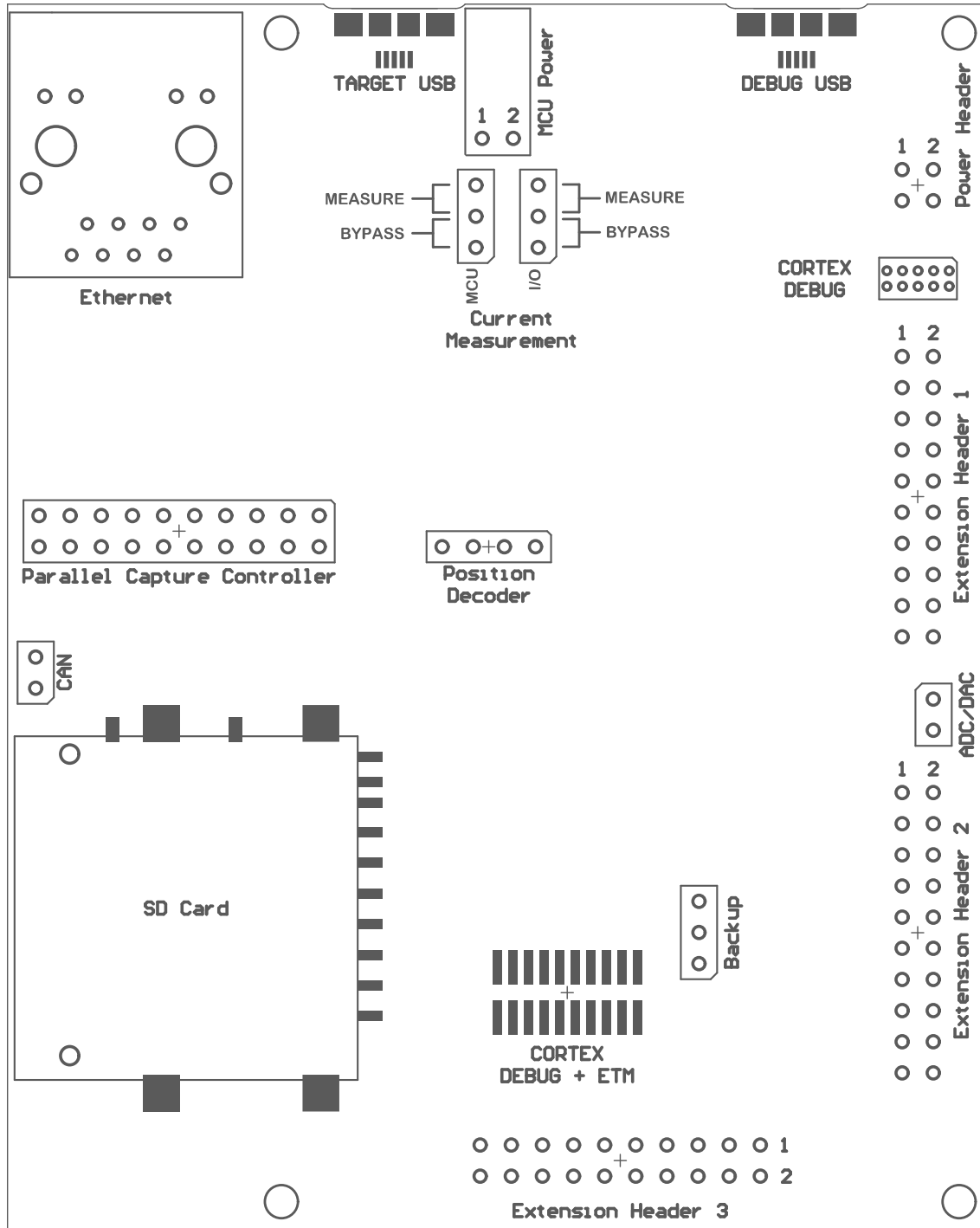
Figure 5-1. Power Supply Block Diagram



5.2 Connectors

The following sections describes the implementation of the relevant connectors and headers on SAM E54 Xplained Pro and their connection to the ATSAME54P20A. The tables of connections in the sections also describes which signals are shared between the headers and on-board functionality. The figure below shows all available connectors and jumpers on SAM E54 Xplained Pro.

Figure 5-2. SAM E54 Xplained Pro Connector Overview



5.2.1 Xplained Pro Standard Extension Headers

The Xplained Pro extension headers EXT1, EXT2, and EXT3 offer access to the I/O of the microcontroller to expand the board, for example, by connecting extensions to the board. These headers are based on the standard Xplained Pro extension header specification and the connections are shown in the table below. The headers have a pitch of 2.54 mm.

Table 5-1. Extension Header EXT1

| EXT1 pin | SAM E54 pin | Function | Shared functionality |
|--------------------|-------------|-------------------------------------|---|
| 1 [ID] | - | - | Communication line to the ID chip on an extension board |
| 2 [GND] | - | - | Ground |
| 3 [ADC(+)] | PB04 | ADC1/AIN[6] | - |
| 4 [ADC(-)] | PB05 | ADC1/AIN[7] | - |
| 5 [GPIO1] | PA06 | GPIO (RTS) | - |
| 6 [GPIO2] | PA07 | GPIO (CTS) | - |
| 7 [PWM(+)] | PB08 | TC4/WO[0] | - |
| 8 [PWM(-)] | PB09 | TC4/WO[1] | - |
| 9 [IRQ/GPIO] | PB07 | IRQ7/GPIO | - |
| 10 [SPI_SS_B/GPIO] | PA27 | GPIO | - |
| 11 [TWI_SDA] | PA22 | SERCOM3 PAD[0] I ² C SDA | PCC |
| 12 [TWI_SCL] | PA23 | SERCOM3 PAD[1] I ² C SCL | PCC |
| 13 [USART_RX] | PA05 | SERCOM0 PAD[1] UART RX | - |
| 14 [USART_TX] | PA04 | SERCOM0 PAD[0] UART TX | - |
| 15 [SPI_SS_A] | PB28 | SERCOM4 PAD[2] SPI SS | - |
| 16 [SPI_MOSI] | PB27 | SERCOM4 PAD[0] SPI MOSI | - |
| 17 [SPI_MISO] | PB29 | SERCOM4 PAD[3] SPI MISO | - |
| 18 [SPI_SCK] | PB26 | SERCOM4 PAD[1] SPI SCK | - |
| 19 [GND] | - | - | Ground |
| 20 [VCC] | - | - | Power for extension board |

Table 5-2. Extension Header EXT2

| EXT2 pin | SAM E54 pin | Function | Shared functionality |
|------------|-------------|--------------|---|
| 1 [ID] | - | - | Communication line to the ID chip on an extension board |
| 2 [GND] | - | - | Ground |
| 3 [ADC(+)] | PB00 | ADC0/AIN[12] | - |
| 4 [ADC(-)] | PA03 | ADC0/AIN[1] | - |
| 5 [GPIO1] | PB01 | GPIO | - |
| 6 [GPIO2] | PB06 | GPIO | - |
| 7 [PWM(+)] | PB14 | TCC4/WO[4] | PCC |

| EXT2 pin | SAM E54 pin | Function | Shared functionality |
|--------------------|-------------|-------------------------------------|---|
| 8 [PWM(-)] | PB15 | TCC4/WO[5] | PCC |
| 9 [IRQ/GPIO] | PD00 | IRQ0/GPIO | - |
| 10 [SPI_SS_B/GPIO] | PB02 | GPIO | - |
| 11 [TWI_SDA] | PD08 | SERCOM7 PAD[0] I ² C SDA | AT24MAC402, ATECC508, PCC, EXT3, and EDBG DGI |
| 12 [TWI_SCL] | PD09 | SERCOM7 PAD[1] I ² C SCL | AT24MAC402, ATECC508, PCC, EXT3, and EDBG DGI |
| 13 [USART_RX] | PB17 | SERCOM5 PAD[1] UART RX | - |
| 14 [USART_TX] | PB16 | SERCOM5 PAD[0] UART TX | - |
| 15 [SPI_SS_A] | PC06 | SERCOM6 PAD[2] SPI SS | - |
| 16 [SPI_MOSI] | PC04 | SERCOM6 PAD[0] SPI MOSI | EXT3 and EDBG DGI |
| 17 [SPI_MISO] | PC07 | SERCOM6 PAD[3] SPI MISO | EXT3 and EDBG DGI |
| 18 [SPI_SCK] | PC05 | SERCOM6 PAD[1] SPI SCK | EXT3 and EDBG DGI |
| 19 [GND] | - | - | Ground |
| 20 [VCC] | - | - | Power for extension board |

Table 5-3. Extension Header EXT3

| EXT3 pin | SAM E54 pin | Function | Shared functionality |
|--------------------|-------------|-------------------------------------|---|
| 1 [ID] | - | - | Communication line to the ID chip on an extension board |
| 2 [GND] | - | - | Ground |
| 3 [ADC(+)] | PC02 | ADC1/AIN[4] | |
| 4 [ADC(-)] | PC03 | ADC1/AIN[5] | |
| 5 [GPIO1] | PC01 | GPIO | |
| 6 [GPIO2] | PC10 | GPIO | - |
| 7 [PWM(+)] | PD10 | TCC0/WO[3] | - |
| 8 [PWM(-)] | PD11 | TCC0/WO[4] | - |
| 9 [IRQ/GPIO] | PC30 | IRQ14/GPIO | - |
| 10 [SPI_SS_B/GPIO] | PC31 | GPIO | - |
| 11 [TWI_SDA] | PD08 | SERCOM7 PAD[0] I ² C SDA | AT24MAC402, ATECC508, PCC, EXT2, and EDBG DGI |
| 12 [TWI_SCL] | PD09 | SERCOM7 PAD[1] I ² C SCL | AT24MAC402, ATECC508, PCC, EXT2, and EDBG DGI |

| EXT3 pin | SAM E54 pin | Function | Shared functionality |
|---------------|-------------|-------------------------|---|
| 13 [USART_RX] | PC23 | SERCOM1 PAD[1] UART RX | - |
| 14 [USART_TX] | PC22 | SERCOM1 PAD[0] UART TX | - |
| 15 [SPI_SS_A] | PC14 | GPIO | - |
| 16 [SPI_MOSI] | PC04 | SERCOM6 PAD[0] SPI MOSI | EXT2 and EDBG DGI |
| 17 [SPI_MISO] | PC07 | SERCOM6 PAD[3] SPI MISO | EXT2 and EDBG DGI |
| 18 [SPI_SCK] | PC05 | SERCOM6 PAD[1] SPI SCK | EXT2 and EDBG DGI |
| 19 [GND] | - | - | Ground |
| 20 [VCC] | - | - | Power for extension board |

5.2.2 SD/SDIO Card

SAM E54 Xplained Pro has one standard SD card connector which is connected to the SD/MMC Host Controller (SDHC) of the SAM E54. The table below lists all I/O-lines connected to the SD card connector.

Table 5-4. SD/SDIO Card Connection

| SAM E54 pin | Function | Shared functionality |
|-------------|--------------------|----------------------|
| PB18 | MCDA0 (DAT0) | |
| PB19 | MCDA1 (DAT1) | |
| PB20 | MCDA2 (DAT2) | |
| PB21 | MCDA3 (DAT3) | |
| PA21 | MCCK (CLK) | PCC |
| PA20 | MCCDA (CMD) | PCC |
| PD20 | Card Detect (C/D) | - |
| PD21 | Write Protect (WP) | - |

5.2.3 PCC Camera Connector

A 2x10, 100-mil pin-header footprint for camera connector is implemented to give access to the SAM E54's Parallel Capture Controller (PCC). The footprint is compatible with common ArduCAM modules.



Info: The PCC connector is not functional by default due to shared functionality with Ethernet, QTouch, SD Card, EXT1, and EXT2. If using the PCC, you will partially or fully lose the ability to use these other functions.



Info: Soldering is required to get the PCC functional. Refer to [Kit Modifications](#) for details on modifications needed.



Tip: The DEN1 and DEN2 signals connected to VSYNC and HSYNC on the PCC camera connector are used to tell the PCC module when there is valid data to sample on the data pins. If interrupts are required when the DEN1 and DEN2 signals changes, the I/O pins (PA12 and PA13) has to be multiplexed to the EIC function in the GPIO module. The PCC module will still sample the DEN pins when they are multiplexed to the EIC function.

Table 5-5. PCC Camera Connector

| Pin number | SAM E54 pin | Function | Shared functionality |
|-------------|--------------------|-------------------------------------|--|
| 1 [VCC] | - | VCC_TARGET_P3V3 | |
| 2 [GND] | - | GND | |
| 3 [SCL] | PD09 | SERCOM7 PAD[1] I ² C SCL | AT24MAC402, ATECC508, EXT2, EXT3, and EDBG DGI |
| 4 [SDA] | PD08 | SERCOM7 PAD[0] I ² C SDA | AT24MAC402, ATECC508, EXT2, EXT3, and EDBG DGI |
| 5 [VSYNC] | PA12 | PCC_DEN1 | Ethernet |
| 6 [HSYNC] | PA13 | PCC_DEN2 | Ethernet |
| 7 [PCLK] | PA14 | PCC_CLK | Ethernet |
| 8 [XCLK] | PA15 | GCLK_IO1 | Ethernet |
| 9 [DOUT07] | PA23 ¹⁾ | PCC_DATA7 | EXT1 |
| 10 [DOUT06] | PA22 ¹⁾ | PCC_DATA6 | EXT1 |
| 11 [DOUT05] | PA21 ¹⁾ | PCC_DATA5 | SD Card |
| 12 [DOUT04] | PA20 ¹⁾ | PCC_DATA4 | SD Card |
| 13 [DOUT03] | PA19 | PCC_DATA3 | Ethernet |
| 14 [DOUT02] | PA18 | PCC_DATA2 | Ethernet |
| 15 [DOUT01] | PA17 | PCC_DATA1 | Ethernet |
| 16 [DOUT00] | PA16 | PCC_DATA0 | QTouch |
| 17 [DOUT09] | PB15 | PCC_DATA9 | EXT2 |
| 18 [DOUT08] | PB14 | PCC_DATA8 | EXT2 |
| 19 [RESET] | PC12 | GPIO | Ethernet |
| 20 [PWDN] | PC11 | GPIO | Ethernet |



Info:

1) Connected through a 0Ω resistor. Not connected by default.

5.2.4 Position Decoder

SAM E54 Xplained Pro has a header footprint for the position decoder module. The PDEC can be used for quadrature, hall, and counter decoding.



Info: External pull-ups are mounted on the three signal lines for use with passive quadrature encoders.

Table 5-6. PDEC Header

| J407 pin | SAM E54 pin | Function | Shared functionality |
|-------------|-------------|-------------|---|
| 1 [PHASE A] | PC16 | PDEC QDI[0] | EDBG GPIO0 |
| 2 [PHASE B] | PC17 | PDEC QDI[1] | EDBG GPIO1 |
| 3 [INDEX] | PC18 | PDEC QDI[2] | EDBG GPIO2 and User LED |
| 4 | - | GND | - |

5.2.5 VBAT Backup Select

There is a 1x3, 100mil pin-header on the kit that can be used to select a power source for the VBAT pin (PB03) marked "VBAT Select". The power source can either be the onboard 3.3V that supplies the other peripherals on the board, or the onboard super capacitor. To select the source for the VBAT pin, move the jumper to the desired voltage by placing the jumper between pin 1-2 for the super capacitor, or between pin 2-3 for the targets MCU voltage. If power to the VBAT pin is not needed, the jumper can be removed and PB03 at the center pin can be used as a GPIO.

Table 5-7. VBAT Select Header

| Pin | Function | Description |
|-----|--------------|----------------------------------|
| 1 | VCC_SUPERCAP | Power from super capacitor |
| 2 | PB03 | VBAT input pin on SAM E54 |
| 3 | VCC_MCU_P3V3 | Power from the target MCU supply |

5.2.6 ADC/DAC Header

There is a 1x2, 100mil pin-header on the kit that can be used for connecting analog peripherals for use with the built in ADC or DAC.

Table 5-8. ADC/DAC Header

| Pin number | Pin/Net | Function | Shared functionality |
|------------|---------|------------------------|----------------------|
| 1 | PA02 | ADC0/AIN0 or DAC/VOUT0 | - |
| 2 | GND | Ground | - |

5.2.7 USB

SAM E54 Xplained Pro has a USB Micro-AB connector for use with the SAM E54 USB module labeled TARGET USB on the kit. To be able to detect when a target USB cable is connected in self-powered mode, a GPIO is used to detect the VBUS voltage on the connector. The USB ID is connected to a power switch, which will automatically enable power to the USB port if a device cable is detected. The USB ID

signal is connected to PC19, which can force power from the kit to the USB connector by driving PC19 low. It is not possible to override and disable the power if a device is connected as the device cable will short the USB ID to ground.

Table 5-9. USB Connections

| SAM E54 pin | USB function |
|-------------|----------------|
| PC00 | VBUS Detection |
| PC19 | USB ID |
| PA24 | USB D- |
| PA25 | USB D+ |

5.2.8 Cortex Debug Connector

SAM E54 Xplained Pro has a 10-pin 50-mil Cortex Debug Connector with SWD that can be used to attach external debuggers to the ATSAME54P20A. Microchip debugging tools like the Atmel-ICE and Power Debugger can connect directly to this connector.

Table 5-10. Cortex Debug Connector

| Cortex Debug Connector pin | Pin/Net | Function | Shared functionality |
|----------------------------|-----------------|-----------------------|------------------------------|
| 1 [VCC] | VCC_TARGET_P3V3 | ATSAME54P20A voltage | |
| 2 [SWDIO/TMS] | PA31 | SW bidirectional data | TRACE and EDBG SWD |
| 3 [GND] | GND | Ground | |
| 4 [SWCLK/TCK] | PA30 | SW clock signal | TRACE and EDBG SWD |
| 5 [GND] | GND | Ground | |
| 6 [SWO/TDO] | PB30 | SW output | TRACE and EDBG SWD |
| 7 [KEY] | - | - | |
| 8 [NC/TDI] | - | - | |
| 9 [GNDDetect] | GND | Ground | |
| 10 [nRESET] | RESETN | Target reset signal | RST BTN, TRACE, and EDBG SWD |

5.2.9 Cortex Debug Connector with Trace

ATSAME54P20A supports 4-bit parallel trace. SAM E54 Xplained Pro implements a 20-pin, 50-mil [Cortex Debug + ETM Connector](#) with SWD and 4-bit parallel trace. The connector is keyed (pin 7 is removed).

To use the parallel trace functionality an external debugger with trace support and 20-pin Cortex Debug + ETM Connector pin-out has to be used. The table below shows the connections on the kit.

Table 5-11. Cortex Debug + ETM Connector

| Pin number | Pin/Net | Function | Shared functionality |
|--------------------|-----------------|------------------------------------|-----------------------------------|
| 1 [VTREF] | VCC_TARGET_P3V3 | ATSAME54P20A voltage | |
| 2 [TMS/SWDIO] | PA31 | SWDIO | Cortex DBG and EDBG SWD |
| 3 [GND] | GND | Ground | |
| 4 [TCK/SWCLK] | PA30 | SWCLK | Cortex DBG and EDBG SWD |
| 5 [GND] | GND | Ground | |
| 6 [TDO/SWO] | PB30 | SWO | Cortex DBG and EDBG SWD |
| 7 [KEY] | - | Not connected, the pin is removed. | |
| 8 [TDI] | - | - | |
| 9 [GND] | GND | Ground | |
| 10 [nSRST] | RESET_N | Reset | RST BTN, Cortex DBG, and EDBG SWD |
| 11 [NC] | - | - | |
| 12 [RTCK/TRACECLK] | PC27 | TRACECLK | |
| 13 [NC] | - | - | |
| 14 [SWO/D0] | PC28 | TRACEDATA[0] | |
| 15 [GND] | GND | Ground | |
| 16 [ntRST/D1] | PC26 | TRACEDATA[1] | |
| 17 [GND] | GND | Ground | |
| 18 [DBGQRQ/D2] | PC25 | TRACEDATA[2] | |
| 19 [GND] | GND | Ground | |
| 20 [DBGACK/D3] | PC24 | TRACEDATA[3] | |

5.2.10 Current Measurement Header

An angled 1x2, 100-mil pin header marked with the MCU current measurement is located at the upper edge of the SAM E54 Xplained Pro. All power to the ATSAME54P20A is exclusively routed through this header (excluding power to headers and peripherals). 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 ATSAME54P20A to be powered through its I/O pins. This may cause permanent damage to the device.

5.3 Peripherals

5.3.1 Crystals

SAM E54 Xplained Pro has a 32.768 kHz and a 12 MHz crystal that can be used as clock source for the SAM E54 device. There are cut-straps located close to the crystals 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 are available in the [AVR4100](#) application note.

The 32.768 kHz crystal on SAM E54 Xplained Pro is a Kyocera Crystal Device Corporation ST3215SB32768A0HPWBB 5pF crystal. The crystal has been matched to be driven in high drive mode by the SAM E54.

The 12 MHz crystal on SAM E54 Xplained Pro is a Kyocera Crystal Device Corporation CX3225CA12000D0KPSC1. The crystal has been matched to be driven with Automatic Loop Control enabled in the SAM E54.

Both crystals have been formally tested and matched to the SAM E54 by Kyocera. The test reports are available in the design documentation distributed with this document for SAM E54 Xplained Pro.



Info: Kyocera Crystal Device Corporation crystals that are matched with specific products can be found on their web site: http://prdct-search.kyocera.co.jp/crystal-ic/?p=en_search/

Table 5-12. External 32.768kHz Crystal

| SAM E54 pin | Function |
|-------------|----------|
| PA00 | XIN32 |
| PA01 | XOUT32 |

Table 5-13. External 12MHz Crystal

| SAM E54 pin | Function |
|-------------|----------|
| PB22 | XIN1 |
| PB23 | XOUT1 |

Related Links

[Design Documentation and Relevant Links](#)

5.3.2 Mechanical Buttons

SAM E54 Xplained Pro contains two mechanical buttons. One button is the RESET button connected to the SAM E54 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.



Info: There is no pull-up resistor connected to the generic user button. Remember to enable the internal pull-up in the SAM E54 to use the button.

Table 5-14. Mechanical Buttons

| SAM E54 pin | Silkscreen text | Shared functionality |
|-------------|-----------------|---|
| RESET | RESET | Cortex DBG , TRACE , and EDBG SWD |
| PB31 | SW0 | EDBG GPIO3 |

5.3.3 LED

There is one yellow LED available on the SAM E54 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 5-15. LED Connection

| SAM E54 pin | Function | Shared functionality |
|-------------|-------------|---|
| PC18 | Yellow LED0 | PDEC and EDBG GPIO2 |

5.3.4 QTouch Button

There is one self capacitance button available on the SAM E54 Xplained Pro board that can be used as user button. This QTouch button is intended to be driven by the built-in Peripheral Touch Controller (PTC) of the device.



Info: To get started with QTouch, refer to [QTouch® Library](#), or find examples in Atmel START.

Table 5-16. QTouch Connection

| SAM E54 pin | Silkscreen text | Shared functionality |
|-------------|-----------------|----------------------|
| PA16 | QT BUTTON | PCC |

5.3.5 Backup Super Capacitor

SAM E54 Xplained Pro has a 47 mF backup super capacitor for use with the SAM E54 backup system. The super capacitor can be connected to the device as described in [VBAT Backup Select](#).

Due to the high capacitive load represented by the super capacitor, a 220Ω limiting resistor is added to reduce inrush current. The source for charging is the targets main supply and a low-power opamp is used for disconnecting the charger input when removing power. This is added to avoid a current leak back to the main supply from the super capacitor when power is removed.

A full charge of the super capacitor from an empty state will take approximately 45 seconds and can supply the target device in backup mode with ULP running for up to ~20 hours. Other modes are not characterized, but will reduce the available time in backup mode respectively. For more information about the current consumption in other modes, refer to the electrical characteristics chapter in the SAM E54 datasheet.



Caution: Due to an issue with the VBAT pin in the A0 revision of ATSAME54P20A there is an over-consumption of current in the VBAT pin when VBAT > VDDIO. This issue renders the on-board super capacitor backup solution not usable.

Related Links

VBAT Pin

5.3.6 CAN

SAM E54 Xplained Pro has two CAN modules that performs communication according to ISO11898-1 (Bosch CAN specification 2.0 part A,B) and Bosch CAN FD specification V1.0.

CAN1 is connected to an on-board [ATA6561](#) CAN physical-layer transceiver, the table below shows connections between the ATSAME54P20A and the ATA6561.

Table 5-17. ATA6561 Connections

| SAM E54 pin | Function | ATA6561 function | Shared functionality |
|-------------|----------|------------------|----------------------|
| PB12 | CAN1/TX | TXD | - |
| PB13 | CAN1/RX | RXD | - |
| PC13 | GPIO | Standby | - |

5.3.7 Ethernet

ATSAME54P20A has a built-in 10/100Mbps Ethernet IEEE® 802.3 compatible MAC with RMII interface. The MAC also supports energy efficient Ethernet (IEEE 802.3az). SAM E54 Xplained Pro connects the MAC to a Micrel *KSZ8091RNACA* RMII physical-layer transceiver (PHY), with IEEE 802.3az support, which is connected to one RJ45 Ethernet connector.

A unique EUI-48 address is available on every SAM E54 Xplained Pro through the onboard [AT24MAC402](#), the EUI-48 address can be used as a MAC address for the *KSZ8091RNACA*. The address is also programmed into the onboard EDBG. For more information, see [Kit Specific Data](#).

The table below lists all pins connected from the ATSAME54P20A to the Ethernet PHY.



Info: Several of the Ethernet signals are shared with the [PCC](#) connector. This means that there is no Ethernet support if [PCC](#) is used in an application.

Table 5-18. KSZ8061RNBW Connections

| SAM E54 pin | Function | Ethernet function | Shared functionality |
|-------------|----------|-------------------|----------------------|
| PA14 | GTXCK | REF_CLK | PCC |
| PA17 | GTXEN | TXEN | PCC |
| PA18 | GTX0 | TXD0 | PCC |
| PA19 | GTX1 | TXD1 | PCC |
| PC20 | GRXDV | CRS_DV | |
| PA13 | GRX0 | RXD0 | PCC |
| PA12 | GRX1 | RXD1 | PCC |
| PA15 | GRXER | RXER | PCC |
| PC11 | GMDC | MDC | PCC |
| PC12 | GMDIO | MDIO | PCC |

| SAM E54 pin | Function | Ethernet function | Shared functionality |
|-------------|----------|-------------------|----------------------|
| PD12 | GPIO | INTERRUPT | |
| PC21 | GPIO | RESET | |

The *KSZ8091RNACA* also has a set of parameters that are latched in during reset based on I/O pin levels. These configuration options have a default mode on the kit done by external pull-up and pull-down resistors. For detailed information about the configuration, see the *KSZ8091RNACA* datasheet.

Table 5-19. KSZ8091RNACA Kit Configuration

| Configuration name | Default value on kit | Default configuration |
|--------------------|----------------------|---|
| PHYAD | 00 | The PHYs address is 00000 |
| PME_EN | 0 | Disable PME Enable output for Wake-On-LAN |
| ANEN_SPEED | 1 | Auto negotiation enabled and 100Mbps link speed enabled |

5.3.8 AT24MAC402

SAM E54 Xplained Pro features one external [AT24MAC402](#) serial EEPROM with a EIA-48 MAC address connected to the SAM E54 through I²C. This device contain a MAC address for use with the [Ethernet](#) interface. The table below lists all I/O-lines connected to the ATMAC402 device.



Info: The I²C EEPROM address is 0x56 and extended address is 0x5E (7-bit, right adjusted without R/W bit).

Table 5-20. AT24MAC402 Connections

| AT24MAC402 pin | SAM E54 pin | Function | Shared functionality |
|----------------|-------------|--------------------------------------|---|
| 1 [A0] | - | Address bit 0 config (Pulled to GND) | - |
| 2 [A1] | - | Address bit 1 config (Pulled to VCC) | - |
| 3 [A2] | - | Address bit 2 config (Pulled to VCC) | - |
| 4 [GND] | - | GND | - |
| 5 [SDA] | PD08 | SERCOM7 PAD[0] I ² C SDA | ATECC508 , PCC , EXT2 , EXT3 , and EDBG DGI |
| 6 [SCL] | PD09 | SERCOM7 PAD[1] I ² C SCL | ATECC508 , PCC , EXT2 , EXT3 , and EDBG DGI |
| 7 [WP] | - | Write Protect (Pulled to GND) | - |

| AT24MAC402 pin | SAM E54 pin | Function | Shared functionality |
|----------------|-------------|-----------------|----------------------|
| 8 [VCC] | - | VCC_TARGET_P3V3 | - |
| 9 [PAD] | - | - | - |

5.3.9 ATECC508A

SAM E54 Xplained Pro implements a [ATECC508A](#) Crypto Authentication device. The table below shows all the connections between the ATECC508A and the ATSAME54P20A.



Info: The I²C address is 0x60 (7-bit, right adjusted without R/W bit).

Table 5-21. ATECC508A Connections

| ATECC508A pin | SAM E54 pin | Function | Shared functionality |
|---------------|-------------|-------------------------------------|---|
| 1 [NC] | - | - | - |
| 2 [NC] | - | - | - |
| 3 [NC] | - | - | - |
| 4 [GND] | - | GND | - |
| 5 [SDA] | PD08 | SERCOM7 PAD[0] I ² C SDA | AT24MAC402 , PCC , EXT2 , EXT3 , and EDBG DGI |
| 6 [SCL] | PD09 | SERCOM7 PAD[1] I ² C SCL | AT24MAC402 , PCC , EXT2 , EXT3 , and EDBG DGI |
| 7 [NC] | - | - | - |
| 8 [VCC] | - | VCC_TARGET_P3V3 | - |
| 9 [PAD] | - | GND | - |

5.3.10 QSPI Flash

The SAM E54 Xplained Pro features one external MICRON, N25Q256A, 256Mbit QSPI NOR Flash Memory. QSPI Flash access can be configured in the QSPI module in the SAM E54, with support for XIP to run firmware directly from external flash. The table below lists all I/O-lines connected to the QSPI Flash.



Info: The PCB tracks between the QSPI flash and the ATSAME54P20A are routed with 60Ω impedance. The I/O drivers in the ATSAME54P20A should be set in high drive mode. The QSPI flash I/O drive level can be configured to match 60Ω tracks in configuration registers in the QSPI flash, refer to the QSPI datasheet for more information.

Table 5-22. QSPI Flash Connections

| SAM E54 pin | Function | QSPI Flash function | Shared functionality |
|-------------|----------|---------------------|----------------------|
| PA08 | QIO0 | Slave In/IO0 | - |
| PA09 | QIO1 | Slave Out/IO1 | - |
| PA10 | QIO2 | Write Protect/IO2 | - |
| PA11 | QIO3 | Hold/IO3 | - |
| PB10 | QSCK | Clock | - |
| PB11 | QCS | Chip Select | - |

5.3.11 I²S Signals

The ATSAME54P20A has a built in two channel Inter-IC Sound Controller (I²S).

There is no on-board IC connected to this module, but the signals are available on the different pin-headers on the kit as shown in the table below.

Table 5-23. I²S Signals on SAM E54 Xplained Pro

| Microcontroller Pin | I ² S Signal | Pin-Header Location | On-board Shared |
|---------------------|-------------------------|---|------------------------------|
| PB16 | SCK0 | EXT2 pin 14 | |
| PB17 | MCK0 | EXT2 pin 13 | |
| PA20 | FS0 | Camera pin 12 ¹⁾ | SDCARD MCCDA |
| PA21 | SDO | Camera pin 11 ¹⁾ | SDCARD MCCK |
| PA22 | SDI | EXT1 pin 11 / Camera pin 10 ¹⁾ | |
| PA23 | FS1 | EXT1 pin 12 / Camera pin 9 ¹⁾ | |
| PB28 | SCK1 | EXT1 pin 15 | |
| PB29 | MCK1 | EXT1 pin 17 | |



Info:

1) Soldering is required to connect these pins to the camera connector. The resistor footprint *R205*, *R206*, *R207*, and *R208* have to be populated by 0-ohm resistors. The location of the footprints can be found in the [Kit Modifications](#) chapter.



Info: The I²S module can use more pins than listed in the table above. These signals are not listed in the table as they are shared with the on-board QSPI Flash and CAN transceiver.

Related Links

[Kit Modifications](#)

5.4 Embedded Debugger Implementation

SAM E54 Xplained Pro contain an Embedded Debugger (EDBG) that can be used to program and debug the ATSAME54P20A using Serial Wire Debug (SWD). The Embedded Debugger also includes a Virtual Com port interface over UART, a Data Gateway Interface over SPI, and I²C, and it includes four of the SAM E54 GPIOs. The kit also includes an XAM extension processor to the Embedded Debugger for on-board current measurement. Atmel Studio can be used as a front end for the Embedded Debugger.

5.4.1 Serial Wire Debug

The Serial Wire Debug (SWD) uses two pins to communicate with the target. For further information on how to use the programming and debugging capabilities of the EDBG, see [Embedded Debugger](#).

Table 5-24. SWD Connections

| SAM E54 pin | Function | Shared functionality |
|-------------|-------------|--|
| PA30 | SWCLK clock | Cortex DBG and TRACE |
| PA31 | SWDIO data | Cortex DBG and TRACE |
| PB30 | SWO output | Cortex DBG and TRACE |
| RESET_N | RESET | Cortex DBG , TRACE , and RST BTN |

5.4.2 Virtual COM Port

The Embedded Debugger acts as a Virtual Com Port gateway by using one of the ATSAME54P20A UARTs. For further information on how to use the Virtual COM port, see [Embedded Debugger](#).

Table 5-25. Virtual COM Port Connections

| SAM E54 pin | Function | Shared functionality |
|-------------|---|----------------------|
| PB24 | SERCOM2 PAD[1] UART RXD (SAM E54 RX line) | - |
| PB25 | SERCOM2 PAD[0] UART TXD (SAM E54 TX line) | - |

5.4.3 Data Gateway Interface

The Embedded Debugger features a Data Gateway Interface (DGI) by using either an SPI or I²C. The DGI can be used to send a variety of data from the ATSAME54P20A to the host PC. For further information on how to use the DGI interface, see [Data Visualizer](#) and the [EDBG User Guide](#).

Table 5-26. DGI Interface Connections when using SPI

| SAM E54 pin | Function | Shared functionality |
|-------------|--|---|
| PD01 | GPIO SPI SS (Slave select) (SAM E54 is Master) | - |
| PC04 | SERCOM6 PAD[0] SPI MOSI (Master Out, Slave in) | EXT2 and EXT3 |
| PC07 | SERCOM6 PAD[3] SPI MISO (Master In, Slave Out) | EXT2 and EXT3 |
| PC05 | SERCOM6 PAD[1] SPI SCK (Clock Out) | EXT2 and EXT3 |

Table 5-27. DGI Interface Connections when using I²C

| SAM E54 pin | Function | Shared functionality |
|-------------|---------------------------------|---|
| PD08 | SERCOM7 PAD[0] SDA (Data line) | AT24MAC402 , ATECC508 , PCC , EXT2 , and EXT3 |
| PD09 | SERCOM7 PAD[1] SCL (Clock line) | AT24MAC402 , ATECC508 , PCC , EXT2 , and EXT3 |

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 SAM E54 application code. For further information on how to configure and use the GPIO monitoring features, see [Data Visualizer](#) and the [EDBG User Guide](#).

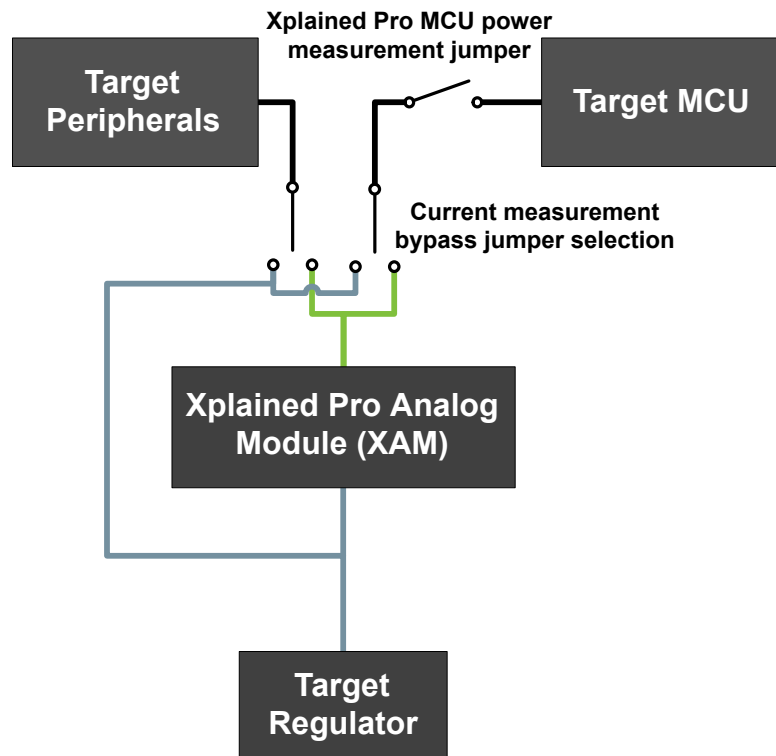
Table 5-28. GPIO Lines Connected to the EDBG

| SAM E54 pin | Function | Shared functionality |
|-------------|----------|---|
| PC16 | GPIO0 | PDEC |
| PC17 | GPIO1 | PDEC |
| PC18 | GPIO2 | PDEC and User LED |
| PB31 | GPIO3 | User SW0 |

5.4.4 XAM Configuration

On the SAM E54 Xplained Pro the MCU and the MCU peripherals (e.g. extensions) are powered by its own regulator as shown in the figure below. All other parts of the board, mainly embedded debugger and accompanying Xplained Pro Analog Module (XAM), are powered from a separate regulator. The current to the MCU and peripherals can be measured by connecting them to the XAM output through jumper settings.

Figure 5-3. SAM E54 Xplained Pro XAM Implementation Block Diagram



On the SAM E54 Xplained Pro the XAM can be used in four configurations:

1. **No current measurement or external MCU current measurement:** The XAM is bypassed and thus the MCU and peripherals are supplied directly by the regulator. Set both jumpers in the "BYPASS" position. In this configuration it is also possible to connect external measurement tools on the Xplained Pro MCU power measurement header to measure MCU current directly instead of using the XAM.
2. **MCU current measurement:** The XAM measures only the MCU current while the peripherals are supplied directly by the regulator. For this configuration place the jumper for "I/O" (peripherals) into the "BYPASS" position and the "MCU" into the "MEASURE" position.
3. **Peripherals measurement:** The XAM measures only the peripherals current while the MCU is directly supplied by the regulator. For this configuration place the jumper for "MCU" into the "BYPASS" position and the "I/O" jumper into the "MEASURE" position.
4. **MCU and peripherals measurement:** In this configuration both the MCU and peripherals are measured by the XAM. Place both jumpers on "I/O" and "MCU" headers in the "MEASURE" position.

5.5 Kit Modifications

SAM E54 Xplained Pro has several resistors that can be used to disconnect I/O pins of the ATSAME54P20A from connectors and on-board ICs, and to disconnect power signals.



Info: Note that there are some resistors that aren't mounted by default on the kit listed in the table below.

Table 5-29. Resistors

| Designator | Value | From | To | Comment |
|------------|--------------|-------------------|------------------------------|--|
| J101 | cut-strap | VCC_P3V3 | VCC_P3V3_CM_IN | ATSAME54P20A, peripherals and connectors power supply |
| R101 | 0Ω | U100 OUT | VCC_CM_P3V3 | XAM power supply |
| R103 | 0Ω | U100 OUT | VCC_EDBG_P3V3 | EDBG power supply |
| R205 | 0Ω [N.M.] | J406 PCC DATA04 | PA20 SDHC CMD | Allows complete or partial disconnect of header J406, Parallel Capture Controller, header from ATSAME54P20A, and shared signals. Remove the mounted resistors and mount the unmounted resistors if using the PCC header. |
| R206 | 0Ω [N.M.] | J406 PCC DATA05 | PA21 SHDC CK | |
| R207 | 0Ω [N.M.] | J406 PCC DATA06 | PA22 I ² C HS SDA | |
| R208 | 0Ω [N.M.] | J406 PCC DATA07 | PA23 I ² C HS SCL | |
| R308 | 10kΩ | PCC DATA0 | QTouch Button | |
| R621 | 0Ω | PA17 ETH GTXEN | PHY_TXEN | |
| R622 | 0Ω | PA18 ETH GTX0 | PHY_TXD0 | |
| R623 | 0Ω | PA19 ETH GTX1 | PHY_TXD1 | |
| R624 | 0Ω | PA13 ETH GRX0 | PHY_RXD0 | |
| R625 | 0Ω | PA12 ETH GRX1 | PHY_RXD1 | |
| R626 | 0Ω | PA15 ETH GRXER | PHY_RXER | |
| R628 | 0Ω | PC12 ETH GMDIO | PHY_MDIO | |
| R629 | 0Ω | PC11 ETH GMDC | PHY_MDC | |
| R630 | 0Ω | PA14 ETH GTXCK | PHY_REFCLK | |
| R609 | 4.7kΩ [N.M.] | PHYAD | VCC_TARGET_P3V3 | Configuration for default start-up conditions for the Ethernet PHY. |
| R616 | 1kΩ | PHYAD | GND | |
| R613 | 4.7kΩ [N.M.] | PME_EN | VCC_TARGET_P3V3 | |
| R618 | 1kΩ [N.M.] | PME_EN | GND | |
| R605 | 4.7kΩ | ANEN_SPEED | VCC_TARGET_P3V3 | |
| R619 | 1kΩ | ANEN_SPEED | GND | |
| R802 | 39Ω | EDBG TARGET RESET | TARGET MCU RESET | Debug interface from the EDBG to the ATSAME54P20A |
| R803 | 0Ω | EDBG SWCLK | PA30 SWCLK | |

| Designator | Value | From | To | Comment |
|------------|-------|---------------------------|---------------------------|---|
| R824 | 0Ω | EDBG SWDIO | PA31 SWDIO | EDBG CDC and DGI interfaces to the ATSAME54P20A |
| R827 | 0Ω | EDBG SWO | PB30 SWO | |
| R808 | 0Ω | EDBG CDC RX | PB25 UART TX | |
| R809 | 330Ω | EDBG CDC TX | PB24 UART RX | |
| R810 | 330Ω | EDBG DGI_GPIO0 | PC16 GPIO | |
| R811 | 330Ω | EDBG DGI_GPIO1 | PC17 GPIO | |
| R813 | 0Ω | EDBG I ² C SDA | PD08 I ² C SDA | |
| R814 | 0Ω | EDBG I ² C SCL | PD09 I ² C SCL | |
| R815 | 330Ω | EDBG SPI MISO | PC07 SPI MISO | |
| R816 | 0Ω | EDBG SPI MOSI | PC04 SPI MOSI | |
| R817 | 0Ω | EDBG SPI SCK | PC05 SPI SCK | |
| R818 | 0Ω | EDBG SS | PD01 SPI SS | |
| R825 | 330Ω | EDBG DGI_GPIO2 | PC18 GPIO | |
| R826 | 330Ω | EDBG DGI_GPIO3 | PB31 GPIO | |
| R812 | 0Ω | TARGET RESET SENSE | TARGET_MCU_RESET | |

Figure 5-4. Assembly Drawing Top

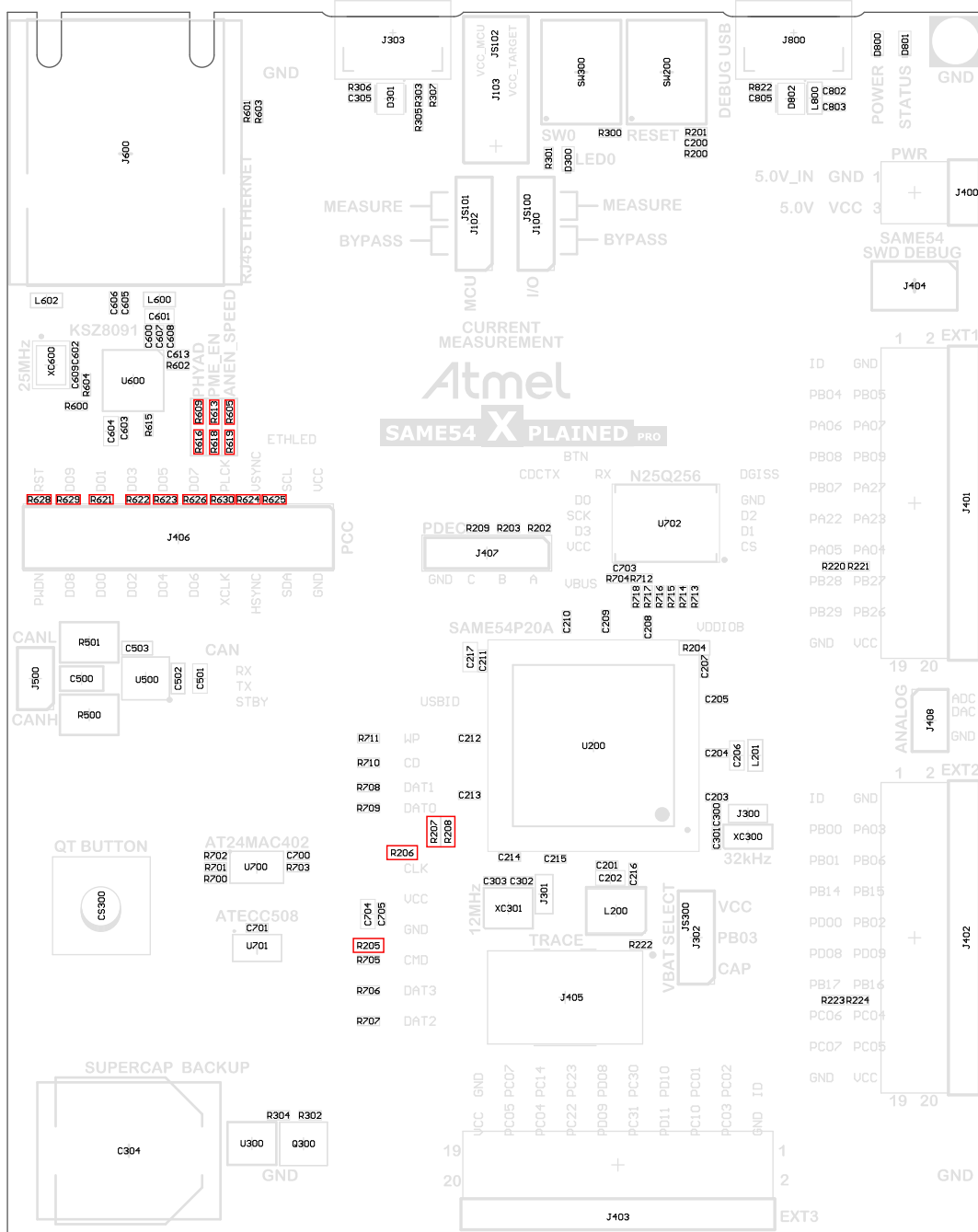
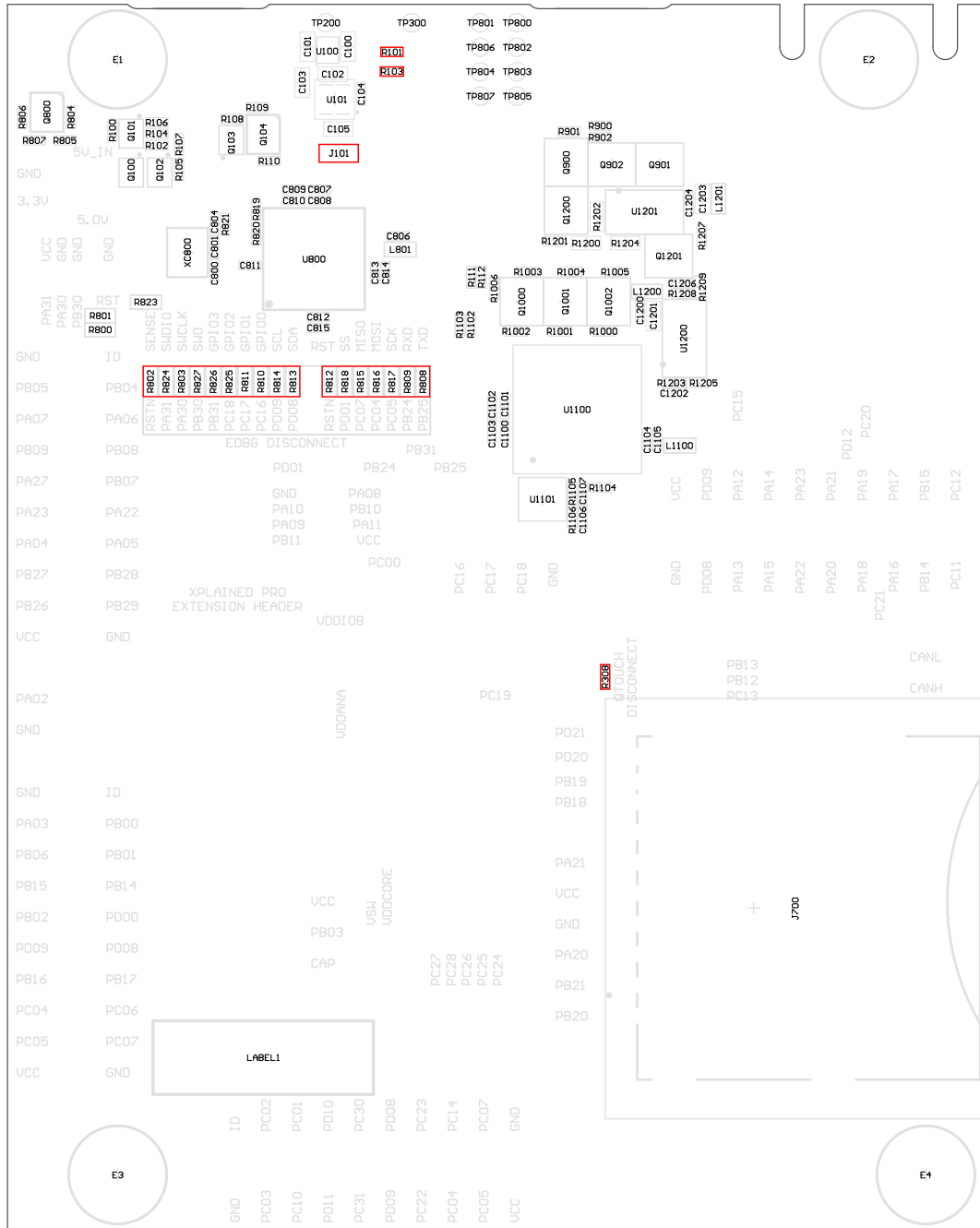


Figure 5-5. Assembly Drawing Bottom



5.5.1 Enable PCC Header

The **PCC** header on the SAM E54 Xplained Pro board is by default not functional due to shared connections with Ethernet, QTouch, SD Card, EXT1, and EXT2.

To modify the kit to fully enable the PCC header, do the following:

- Remove the resistors: R621, R622, R623, R624, R625, R626, R628, R629, R630 to separate the Ethernet PHY from the lines
- Mount 0Ω resistors: R205, R206, R207, R208

- Optionally remove: R308 (There is no contention here, but can represent a large load on the signal.)
- Remove any SD/SDIO cards from the SD Card connector



caution: PCC will not work at the same time as Ethernet, SD Card, QTouch, and I²C on EXT1.



Info: Revert the steps to restore the original functionality. Use 0Ω resistors or solder blobs to short strap.

5.5.2 Operation at Other Voltages

The SAM E54 Xplained Pro board is operated at 3.3V by default, but it also has the possibility of running at lower voltages from an external supply. The EDBG is designed to run from a 3.3V supply and won't work on other voltages, therefore all connections from the EDBG and the on board 3.3V regulator to the ATSAME54P20A have to be removed.

To completely disconnect the EDBG and the on-board power supply from the ATSAME54P20A do the following:

- Remove the two jumpers from the on-board 3-pin current measurement headers (J100 and J102), and connect the two center pins (pin 2) together with a wire or an ammeter, as shown in [Figure 5-7](#)
- Remove R802, R803, R808, R809, R810, R811, R812, R813, R814, R815, R816, R817, R818, R824, R825, R826, R827
- Optionally cut J101 to remove power to the on-board current measurement headers (J100 and J102) from the on-board regulator

[Figure 5-6](#) shows all components that have to be removed from the bottom side of the PCB for operation at other voltages. To locate the other components, see the assembly drawing in the section above. When the components are removed, the kit can be supplied with a desired voltage through the pins marked 3.3V (pin four) and GND (pin two) on the Xplained Pro power header. To program and debug the ATSAME54P20A the 2x5 50mil Cortex debug connector has to be used with an external debugger.



Info: Operating the ATSAME54P20A on other voltages than 3.3V requires physical modifications on the kit using a soldering iron and an external debugger for programming the ATSAME54P20A. The on-board current measurement only works at 3.3V. The on-board LED is selected for 3.3V operation, the light level at 1.8V operation is very low. To increase the emitted light level the value of the series resistor can be lowered. The EDBG functionality can be restored by re-soldering the removed components and soldering a 0Ω resistor over J101.



Caution: The voltage supplied through the power header is applied directly to the ATSAME54P20A and the extension headers. Applying a voltage greater than 3.3V may damage the board permanently.

Figure 5-6. SAM E54 Xplained Pro EDBG Disconnect

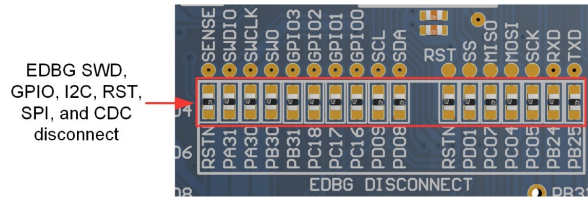
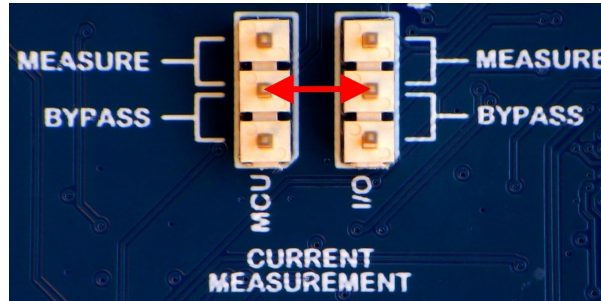


Figure 5-7. SAM E54 Xplained Pro Current Measurement Headers



Related Links

- [Xplained Pro Power Header](#)
- [Cortex Debug Connector Connectors](#)

5.6 Low-Power Mode

Acquiring the lowest power consumption of the device requires some specific settings of the GPIOs in relation to the connected peripherals. The table below describes the settings needed for the lowest possible power consumption. If not otherwise noted, all pins should disable all digital logic ($DIR = 0$, $INEN = 0$ and $PULLEN = 0$).



Info: The power consumption on the microcontrollers VDD will be higher than specified in the electrical characteristics of the device due to connected peripherals.

Table 5-30. Low Power Settings

| SAM E54 pin | Signal | State | Description |
|-------------|-----------|------------|--|
| PC21 | ETH RESET | Output low | The on-board Ethernet PHY KSZ8091 continuously generates a 50 MHz clock signal to PA14 on the SAM E54. When the KSZ8091 is in reset the clock signal is not generated and the power consumption of the SAM E54 is reduced. |

6. Kit Specific Data

One of the Flash user pages in the EDBG is programmed with data specific to the SAM E54 Xplained Pro. The data can be read through the I²C interface connected to the EDBG from the target application. For detailed information, refer to the [EDBG User Guide](#). All data is stored as little endian. The table below shows the memory map for the Flash user page.

Table 6-1. MAC48Register, Offset: 0x00

| Name | Description | Size [bits] |
|-------|--|-------------|
| MAC48 | Unique address assigned to the kit, value taken from the onboard AT24MAC402. | 48 |

7. Appendix

7.1 Getting Started with IAR

IAR Embedded Workbench® for ARM® is a proprietary, high-efficiency compiler not based on GCC. The 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 programming and debugging to work.

The following steps explain how to set up a project for programming and debugging:

1. Open the project that needs to be configured. Open the **OPTIONS** dialog for the project.
2. In the **General Options** category, select the **Target** tab. [Select the "Device" for the project or the "Core" of the device.](#)
3. In the **Debugger** category, select the **Setup** tab. [Select CMSIS DAP as the driver.](#)
4. In the **Debugger** category, select the **Download** tab. [Select the Use flash loader\(s\) option.](#)
5. In the **Debugger > CMSIS DAP** category, 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

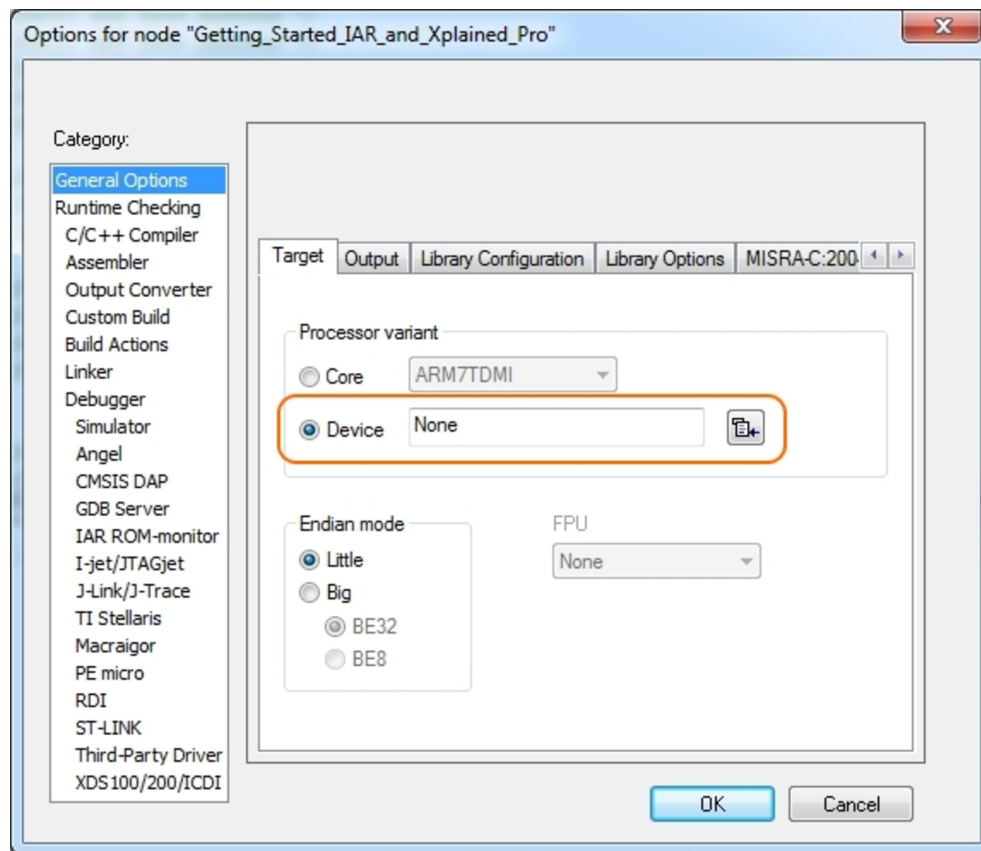


Figure 7-2. Select Debugger

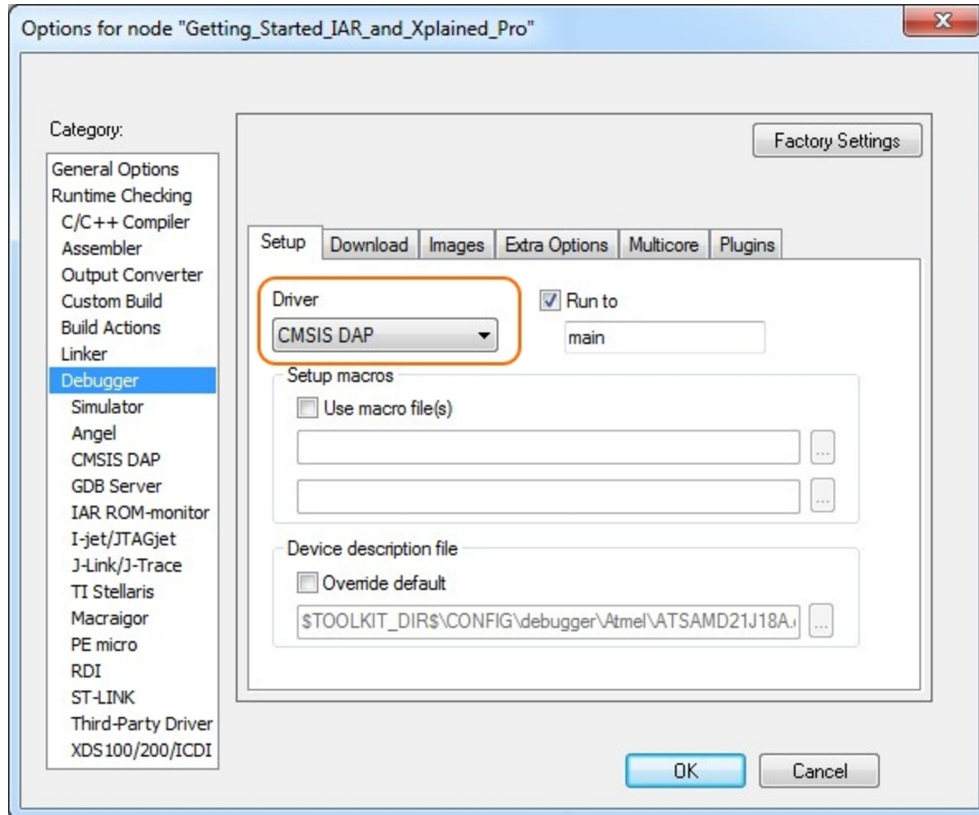


Figure 7-3. Configure Flash Loader

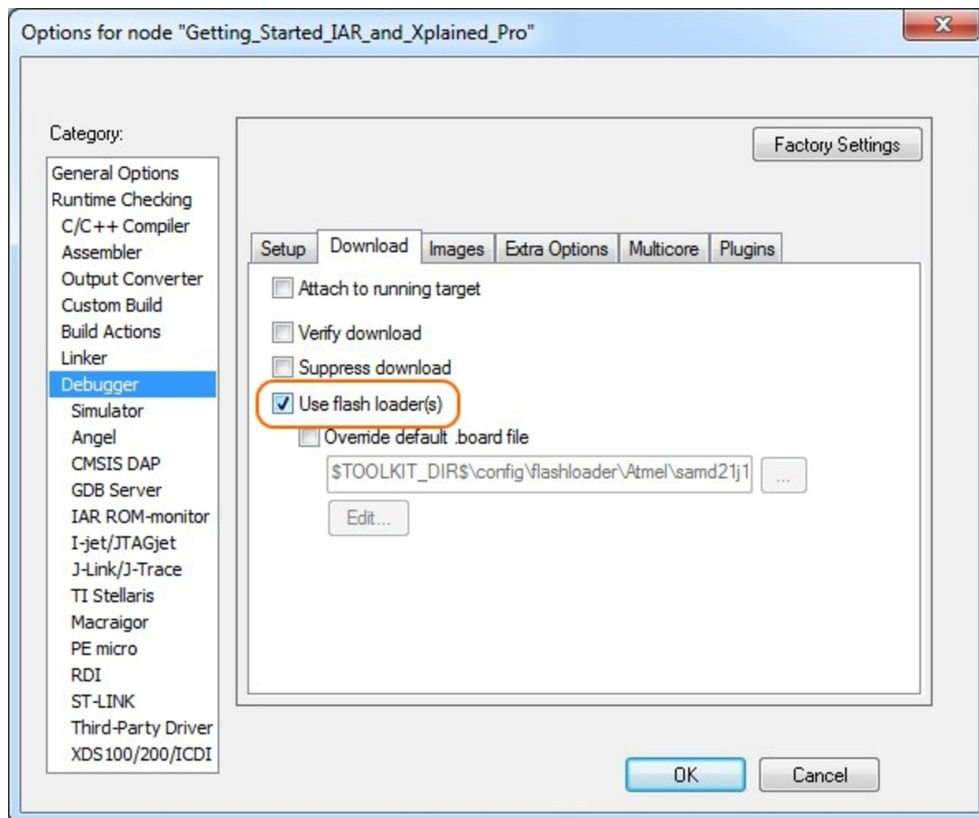


Figure 7-4. Configure Reset

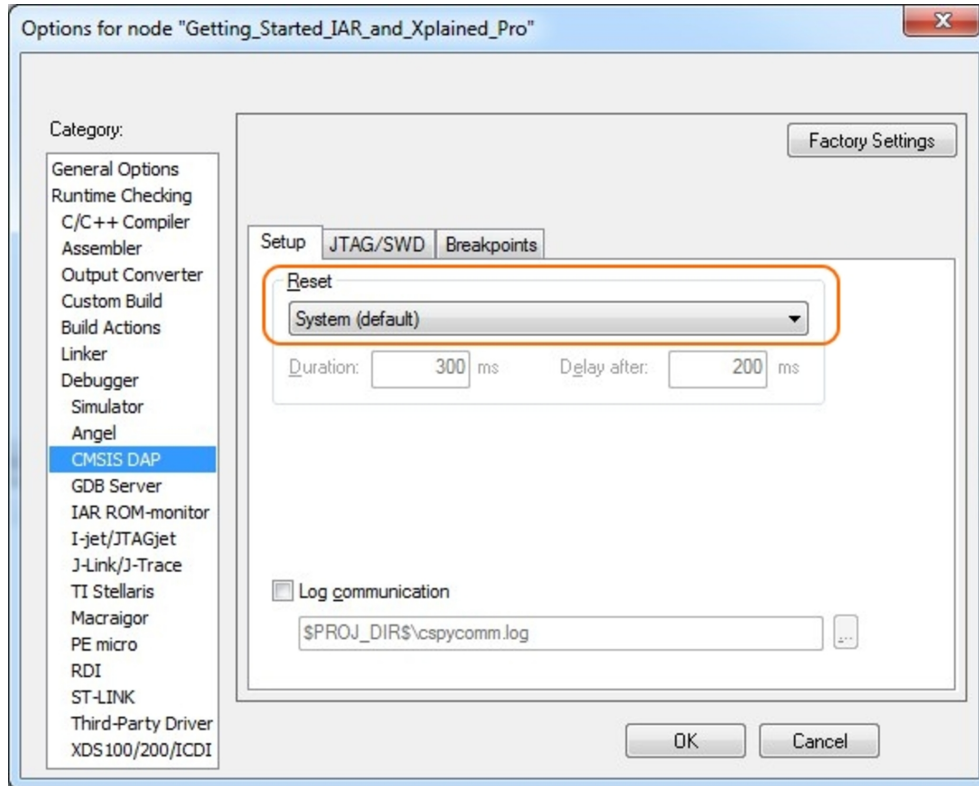
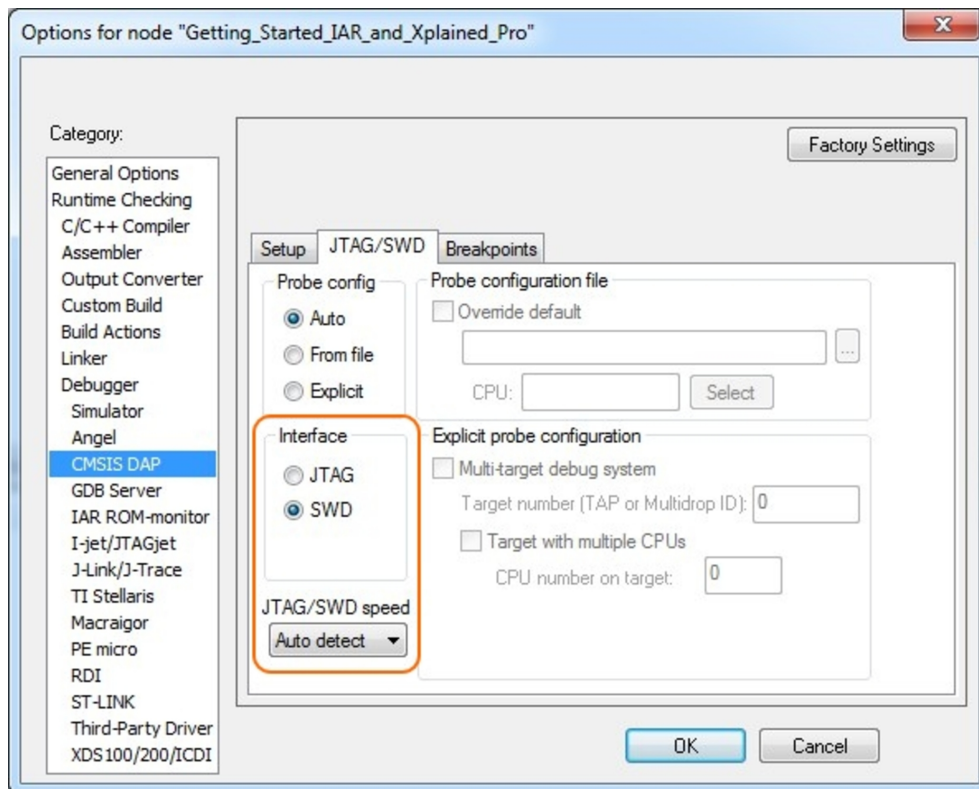


Figure 7-5. Configure Interface



7.2 Connecting External Debuggers to an Xplained Pro Board

The Xplained Pro kits that features a 10-pin 50mil debug connector can use external debug tools like SAM-ICE™ or Atmel-ICE instead of the built-in EDBG. Evaluation kits with devices using the SWD interface on-board has a connector that is pinout compatible with the [Cortex Debug Connector](#).

The SAM-ICE is connected to the debug connector on an Xplained Pro using either an Atmel-ICE adapter, SAM-ICE adapter, or a 10-pin 50-mil header to squid cable. When using a squid cable, see the table and figures below for how to connect the SAM-ICE to the Xplained Pro board.

Table 7-1. Squid Cable Connections

| Squid Cable Pin | SAM-ICE Pin |
|-----------------|-------------------------|
| 1 (VCC) | 1 (VTref) |
| 2 (SWDIO/TMS) | 7 (TMS) |
| 3 (GND) | 4 (GND) |
| 4 (SWCLK/TCK) | 9 (TCK) |
| 5 (GND) | 6 (GND) |
| 6 (SWO/TDO) | 13 (TDO) ⁽¹⁾ |
| 7 (Not used) | |
| 8 (Not used) | |
| 9 (Not used) | |
| 10 (RESET) | 15 (RESET) |

Note:

1. Optional pin; used only when the device functionality supports TDO.

Figure 7-6. SAM-ICE using a Squid Cable



Figure 7-7. SAM-ICE using an Atmel-ICE Adapter



Important:

If contention with the on-board EDBG occurs, power the Xplained Pro board from another input like the external power header or from the target USB. Physically removing the connection between the EDBG and the debug header by removing 0Ω resistors, where available, or cutting the tracks to the EDBG can also be done.

8. 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.

8.1 Identifying Product ID and Revision

The revision and product identifier of the 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.

When an Xplained Pro MCU board is connected to a computer with Atmel Studio running, an information window with the serial number is shown. The first six digits of the serial number contain the product identifier and revision. Information about connected Xplained Pro extension boards is also shown in the window.

The same information can be found on the sticker on the bottom side of the PCB. Most kits have stickers that have the identifier and revision printed 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:

```
"nnnnrrssssssss"  
n = product identifier  
r = revision  
s = serial number
```

The product identifier for the SAM E54 Xplained Pro is A09-2748.

8.2 Revision 5

Device revision A0 of ATSAME54P20A is mounted on revision 5 of SAM E54 Xplained Pro.

8.2.1 VBAT Pin

There is an issue with the VBAT pin in ATSAME54P20A revision A0. When VBAT > VDDIO there is a current over-consumption rendering the on-board super-capacitor backup solution unusable.

8.3 Revision 4

Revision 4 is the initially released revision.

The Early Adopter version of ATSAME54P20A is mounted on revision 4 of SAM E54 Xplained Pro.

8.3.1 VBAT Pin

There is an issue with the VBAT pin in ATSAME54P20A revision A0. When VBAT > VDDIO there is a current over-consumption rendering the on-board super-capacitor backup solution unusable.

8.3.2 32.768 KHz Crystal

The 32.768 KHz crystal mounted on revision 4 of SAM E54 Xplained Pro is a Kyocera Crystal Device Corporation ST3215SB32768E0HPWBB 9 pF crystal. The external matching capacitors C300 and C301 are 15 pF. The crystal is matched to be driven by the SAM E54 in standard mode.



Info: Using a crystal with lower capacitive load will reduce the required drive level to keep the crystal oscillation. Revision 5 of SAM E54 Xplained Pro replaced the 32.768kHz crystal with the 5 pF version ST3215SB32768A0HPWBB to reduce the drive level from 62nW to 15nW.

9. Document Revision History

| Date | Comment |
|---------|---------------------------|
| 07/2017 | Initial document release. |

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