BIST Xplained Pro User Guide

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Preface

The Build In Self-Test (BIST) Xplained Pro extension kit (BIST-XPRO) is a daughter board compatible with the Xplained Pro and Curiosity platform. It is an optional kit connected between an XPRO motherboard and any extension sensor board. It is optimized to work out of the box with the QT7 Xplained Pro Extension Kit.
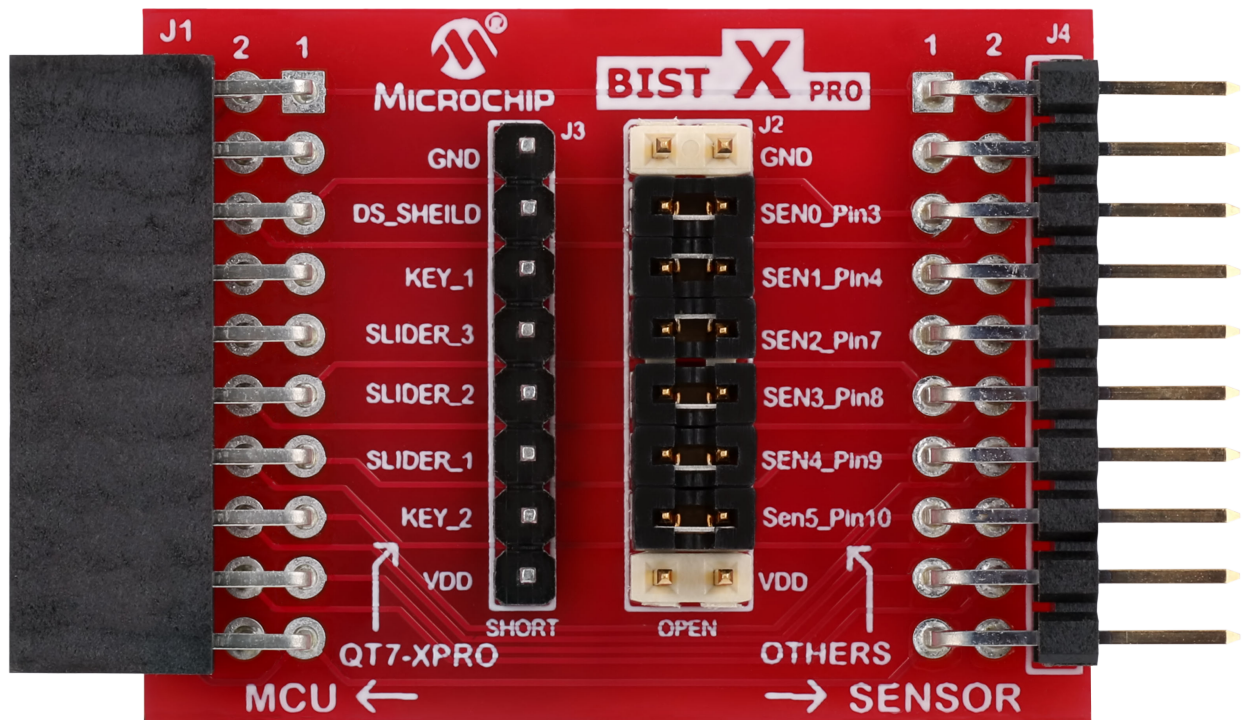
Figure 1. BIST Xplained Pro

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1. Introduction

1.1 Features and Overview

The BIST-XPRO enables selective introduction of failures, such as shorts or open, to the feeding lines of the sensor. The real time detection of these failures is an essential part of these safety-related applications:

- ISO26262 (ASIL) for Automotive
- IEC60730 for Appliances
- IEC 61508 (SIL) for Industrial
- IEC 62304 for Medical

The board connects between compatible XPRO MCU boards or to Curiosity Nano MCU boards via the Curiosity Nano Touch Adapter and extension sensor boards, such as the QT7-XPRO.

The BIST-XPRO enables quick testing of the BIST and Power-up Self-Test (POST) routines for their effectiveness to test common pin failures:

- Pin short to V_{DD}
- Pin short to V_{SS} / GND
- Pin short to another pin
- Pin open (e.g. broken sensor feeding line)

1.2 Kit Components

- One standard 20-pin XPRO male header
- One standard 20-pin XPRO female header
- Jumper cap for open pin tests
- Options to demonstrate tests, such as:
  - Short to V_{CC}
  - Short to V_{SS}
  - Short between PTC pins
  - Open pins

1.3 Kit Compatibility

The BIST-XPRO is designed to support Touch XPRO extension kits with a focus on the QT7-XPRO. The nature of the BIST allows for usage with any other extension kit and is not limited to touch.

This kit is supported by Xplained Pro Microcontroller boards that have a capacitive touch enabled MCU and a matching pinout that connects support extension sensors.

The MCU boards currently supported are:

- ATtiny817 Xplained Pro
- ATtiny3217 Xplained Pro
- ATmega324PB Xplained Pro
- SAM D11 Xplained Pro
- SAM D20 Xplained Pro
- SAM D21 Xplained Pro
- SAM DA1 Xplained Pro
- SAM C21 Xplained Pro
- SAM L10 Xplained Pro
- SAM L11 Xplained Pro

- SAM L22 Xplained Pro
- SAM E54 Xplained Pro

If using the Curiosity Nano Touch Adapter or the Curiosity Nano Base for Click boards™, the BIST-XPRO can also be used with the following Curiosity Nano MCU boards:

- ATmega4809 Curiosity Nano
- ATtiny3217 Curiosity Nano
- PIC16F15244 Curiosity Nano
- PIC16F15376 Curiosity Nano
- PIC16F18446 Curiosity Nano
- PIC18F47K42 Curiosity Nano
- SAM D21 Curiosity Nano
- SAM E51 Curiosity Nano

The supported extension sensor kits include:

- QT5 Xplained Pro
- QT7 Xplained Pro
- T9 Xplained Pro
- T10 Xplained Pro

Learn more about the Curiosity Nano Development Platform.

1.4   BIST-XPRO Functional Block Diagram

Figure 1-1. BIST-XPRO Functional Block Diagram
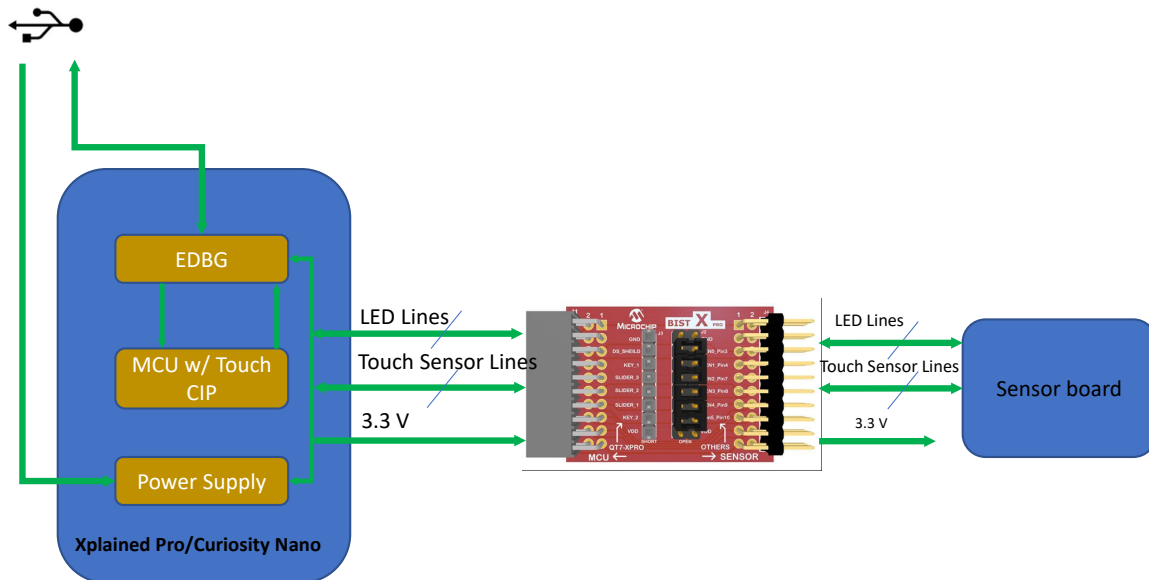
2. Getting Started

2.1 Quick Start

Figure 2-1. BIST-XPRO Interconnect
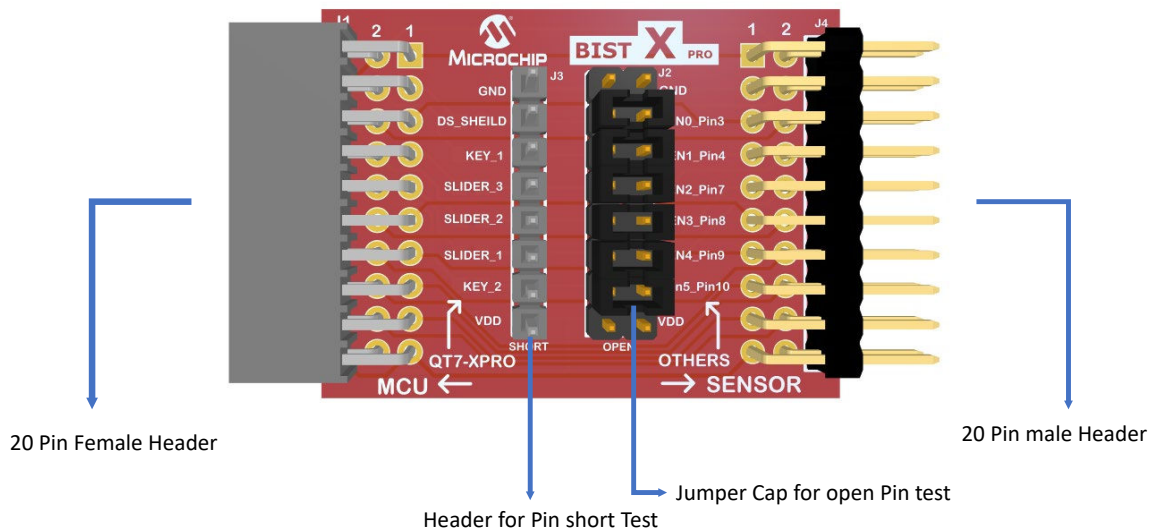
The BIST-XPRO interconnects between a microcontroller (MCU) board and a sensor board. Below are two examples:

Table 2-1. BIST-XPRO Interconnection Examples

• **SAMDA1-XPRO** • **BIST-XPRO** • **QT8-XPRO**	• **PIC18F57Q10 Curiosity Nano** • **Curiosity Nano Touch Adapter** • **BIST-XPRO** • **QT7-XPRO**

2.2 How to Introduce Controlled Failures

Open pin failures::

Remove one or more jumpers on the J2 - OPEN to introduce an open pin failure (= broken PCB track, broken feeding line, open sensor connection).

Short to V_{DD} / GND / another pin:

Use a dual female jumper cable and short J3 pin headers, SHORT to introduce the short to V_{DD}/ GND/ another pin failure. For ease of use, J3 – SHORT provides access to V_{DD} and GND pin headers.

2.3 Documentation and Relevant Links

Hardware:

- **Curiosity Products**: Curiosity is a cost-effective, fully integrated 8-bit development platform targeted at first-time users, Makers, and those seeking a feature-rich rapid prototyping board. Designed from the ground-up to take full advantage of Microchip's MPLAB® X development environment, Curiosity includes an integrated programmer/debugger and requires no additional hardware.
- **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 an Arduino Uno compatible header footprint and a prototyping area.
  - Xplained Pro: Used for medium to high pin count devices that feature advanced debugging and standardized extensions for peripheral functions.
- **Note:** All of 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.

Software/ IDE:

- **MPLAB® X Integrated Development Environment (IDE)**: MPLAB X IDE is a software program that runs on a PC (Windows®, Mac OS®, Linux®) to develop applications for Microchip microcontrollers and digital signal controllers. It is called an Integrated Development Environment (IDE) because it provides a single integrated 'environment' to develop code for embedded microcontrollers.
- **MPLAB® Code Configurator (MCC)**: MPLAB MCC is a free, graphical programming environment that generates seamless, easy-to-understand C code to be inserted into the project. Using an intuitive interface, it enables and configures a rich set of peripherals and functions specific to the application.
- **MPLAB® Harmony v3**: MPLAB Harmony v3 is a fully integrated embedded software development framework that provides flexible and interoperable software modules that allow for the dedication of resources to create applications for the 32-bit PIC® and SAM devices, rather than dealing with device details, complex protocols, and library integration challenges. It works seamlessly with MPLAB X IDE and the MPLAB® XC32 Compiler to enable a smooth transition and maximum code reuse between PIC32 MCUs and SAM MCUs and MPUs. It also has drivers, demo code and Data Visualizer that supports data streaming and advanced debugging.
- **Atmel Start**: Atmel START is an online tool that helps the user to select and configure software components and tailor embedded application in a usable and optimized manner.
- **Atmel Studio**: Free IDE for the development of C/C++ and assembler code for microcontrollers.
- **Data Visualizer**: Data Visualizer is a program used for processing and visualizing data. The Data Visualizer can receive data from various sources, such as the EDBG Data Gateway Interface found on Curiosity Nano and Xplained Pro boards and COM Ports.
- **Design Documentation**: Package containing CAD source, schematics, BOM, assembly drawings, 3D plots, layer plots and more.
- **Hardware User's Guide**: PDF version of the user's guide.
- **BIST-Xplained Pro**: On Microchip's website.
- **RoHS Declaration Letter**.

3. Hardware

3.1 Xplained Pro

The Xplained Pro is an evaluation platform that contains a series of microcontroller boards (evaluation kits) and extension boards. Atmel Studio/MPLAB® is used to program and debug the microcontrollers on these boards. Atmel Studio includes an Advanced Software Framework (ASF) and Atmel START/MPLAB Harmony v3, which has drivers, demo code and Data Visualizer that supports data streaming and advanced debugging.

The 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.

3.2 Curiosity Nano

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

3.3 Xplained Pro Standard Connectors

3.3.1 Xplained Pro Standard Extension Headers

All Xplained Pro kits have dual row, 20-pin 100-mil extension headers. The Xplained Pro MCU boards have male headers while the Xplained Pro extensions have the female counterparts. The following table provides the pin description for all the connected pins.

Note: Not all pins are 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 the Xplained Pro boards.

Table 3-1. 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 (ADC); 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 (PWM); 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	Client select pin for Serial Peripheral Interface (SPI) and/or general purpose I/O pin
11	I2C_SDA	Data pin for I^2C interface. Always connected, bus type
12	I2C_SCL	Clock pin for I^2C interface. Always connected, bus type
13	UART_RX	Receiver pin of target device UART
14	UART_TX	Transmitter pin of target device UART
15	SPI_SS_A	Client select for the Serial Peripheral Interface (SPI). This pin should preferably not be connected to anything else
16	SPI_MOSI	SPI host out, client in pin. Always connected, bus type
17	SPI_MISO	SPI host in, client 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. Hardware Users Guide

4.1 Headers and Connectors

4.1.1 Extension Headers

The BIST-XPRO implements two Xplained Pro Standard Extension Headers (see Xplained Pro Standard Extension Header) marked with J1 and J4 in silkscreen. This header makes it possible to connect the board to an Xplained Pro MCU and sensor boards. The pinout definition for the extension header scan be seen in the table below.

Table 4-1. BIST Xplained Pro Extension Header J1

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	Host select pin for Serial Peripheral Interface (SPI) and/or general purpose I/O pin
11	I2C_SDA	Data pin for I2C interface. Always connected, bus type
12	I2C_SCL	Clock pin for I2C interface. Always connected, bus type
13	UART_RX	Receiver pin of target device UART
14	UART_TX	Transmitter pin of target device UART
15	SPI_SS_A	Client select for SPI. This pin should preferably not be connected to anything else
16	SPI_MOSI	SPI host out, client in pin. Always connected, bus type
17	SPI_MISO	SPI host in, client 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

Pin on EXT	Function	Description
1	ID	Communication Line to ID Chip
2	GND	Ground
3	Y-LINE-5	Y-line 5: Connected to Driven Shield

4	Y-LINE-1	Y-line 1: Connected to Button 1
5	LED0	Touch Status LED for Slider
6	LED6	Touch Status LED for Button 1
7	Y-LINE-2	Y-line 2: Connected to Slider
8	Y-LINE-3	Y-line 3: Connected to Slider
9	Y-LINE-4	Y-line 4: Connected to Slider
10	Y-LINE-0	Y-line 4: Connected to Button 2
11	LED7	Touch Status LED for Button 2

Table 4-2. BIST Xplained Pro Extension Header J4

12	LED1	Touch Status LED for Slider
13	Not Connected	
14	Not Connected	
15	LED2	Touch Status LED for Slider
16	LED 3	Touch Status LED for Slider
17	LED 4	Touch Status LED for Slider
18	LED 5	Touch Status LED for Slider
19	GND	Ground
20	VCC	Target Supply Voltage

5. Application Flow

The following diagram shows the application flow with touch measurement performed at regular intervals. At the end of each measurement, the data is processed to find touch states; depending on the touch states, the LEDs are updated.

Figure 5-1. BIST Flow Diagram
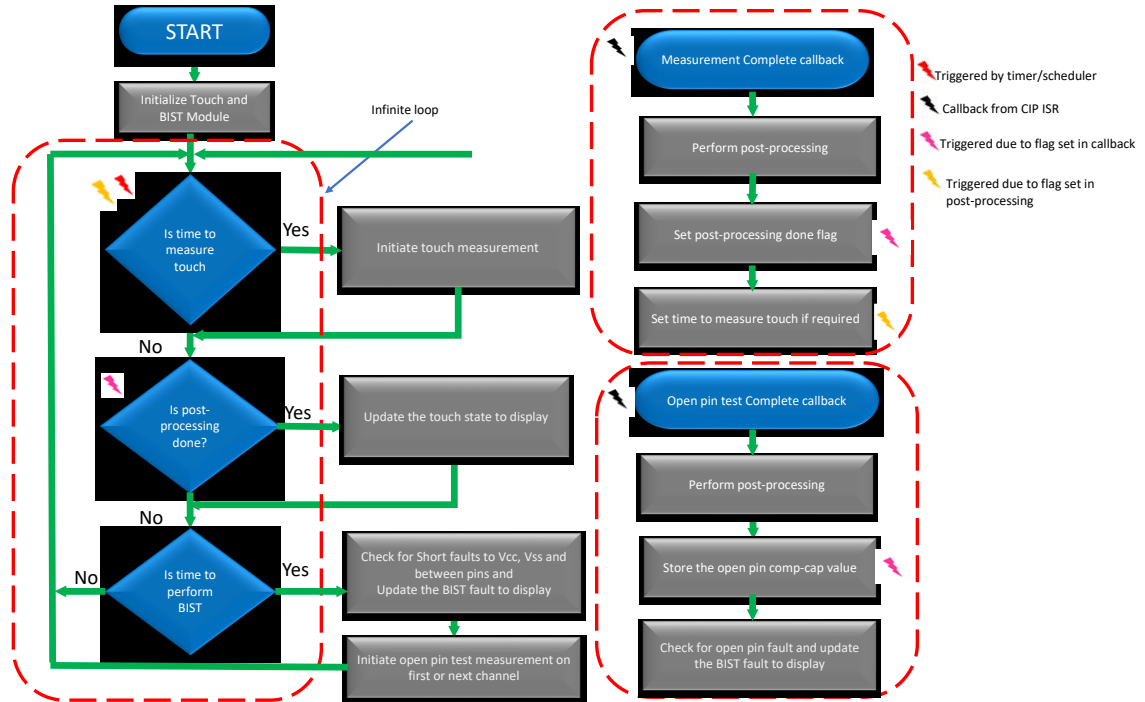
6. Schematics

Figure 6-1. Schematics

7. Hardware Revision History and Known Issues

7.1 Identifying Product ID and Revision

When an evaluation board is connected to a computer with MPLAB running, an information window with the serial number is shown. The first six digits of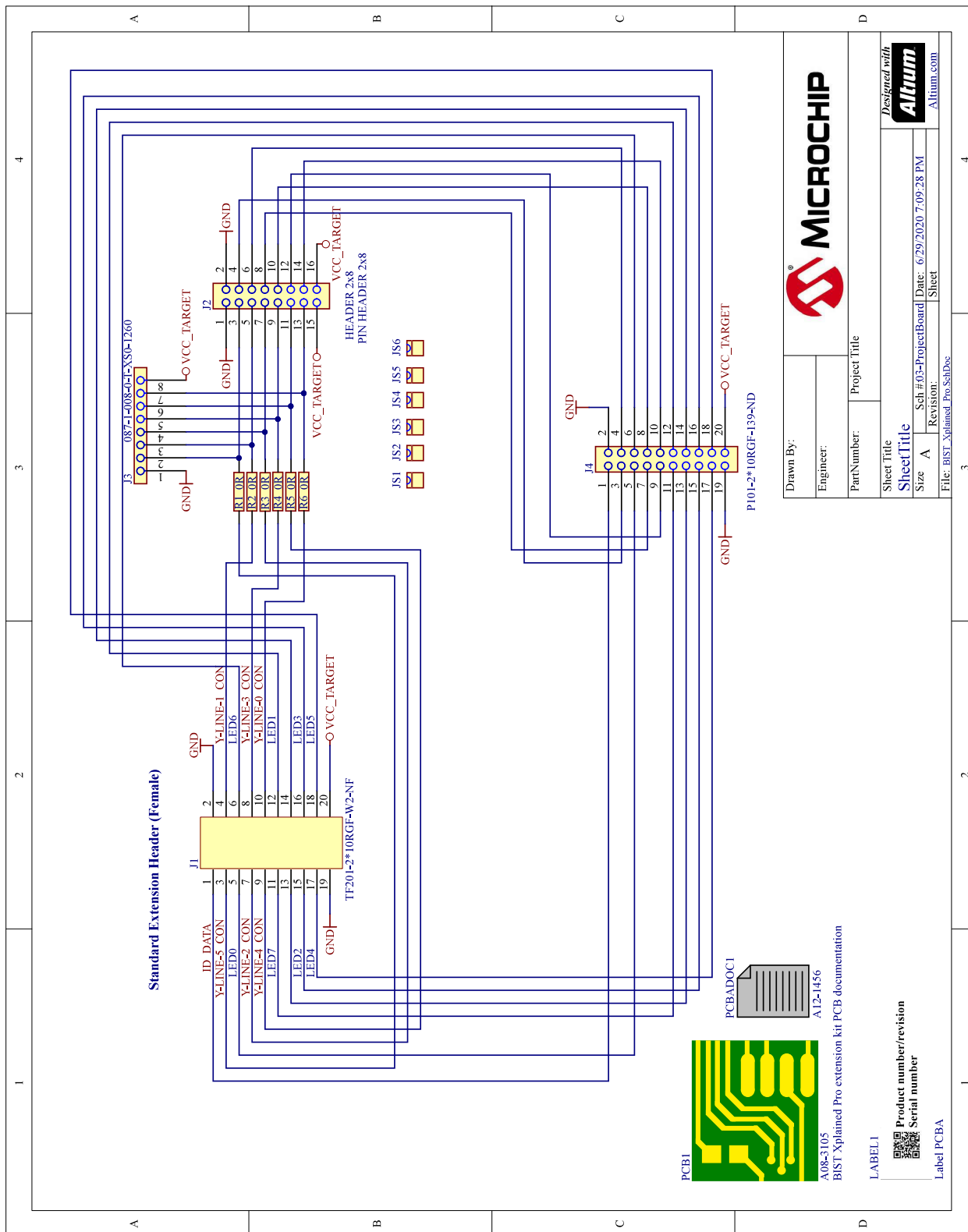 the serial number contain the product identifier and revision. Information about connected evaluation boards is also shown in that window.

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:

"nnnnrrssssssssss"

n = product identifier r = revision

r = revision

s = serial number

The product identifier for the BIST Xplained Pro is A08-3105.

7.2 Revision One

Revision one of the BIST Xplained Pro (A08-3105/01) is the initial released version. There are no known issues.

8.   Document Revision History

Document Revision	Date	Comment
A	11/2020	Initial document release

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