T9 Xplained Pro

T9 Xplained Pro User Guide

Preface

The Microchip T9 Xplained Pro is a capacitive touch extension kit to demonstrate Metal over Cap (MoC). MoC is a technology that enables touch on metal, developed, and patented by Microchip.

The Xplained Pro connector ensures that the T9 XPro can be used with many MCU XPRO boards, as well as Curiosity Nano MCU boards via the Curiosity Nano Touch Adapter (AC80T88A).

Touch on metal, or MoC, utilizes the same elements as regular touch:

- Touch sensor (electrode) on a Printed Circuit Board (PCB)
- Touch Integrated Circuit (IC)
- Touch Firmware (FW)

In contrast to regular touch, the PCB (containing the electrodes) isn't covered with non-conductive material, but with metal, which is separated from the PCB by a spacer layer. For further details, consult the Mechanical Stack-Up section.

The root cause for touch detection is the deflection of the metal surface reducing the distance to the electrode by less than 10 μm. The capacitive touch IC detects the resulting change in capacitance and reports the press to the system.

Figure 1. MoC Principle
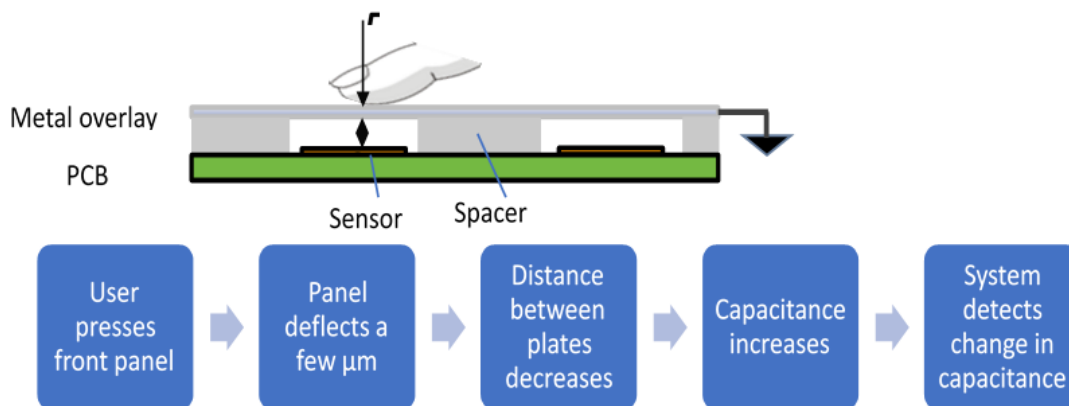
For more information on MoC, refer to the following two Application Notes:

- AN1325 – Metal over Cap Technology
- AN1626 – Implementing Metal over Cap

Figure 2. T9 Xplained Pro Extension Kit Touch Keys Metal Overlay

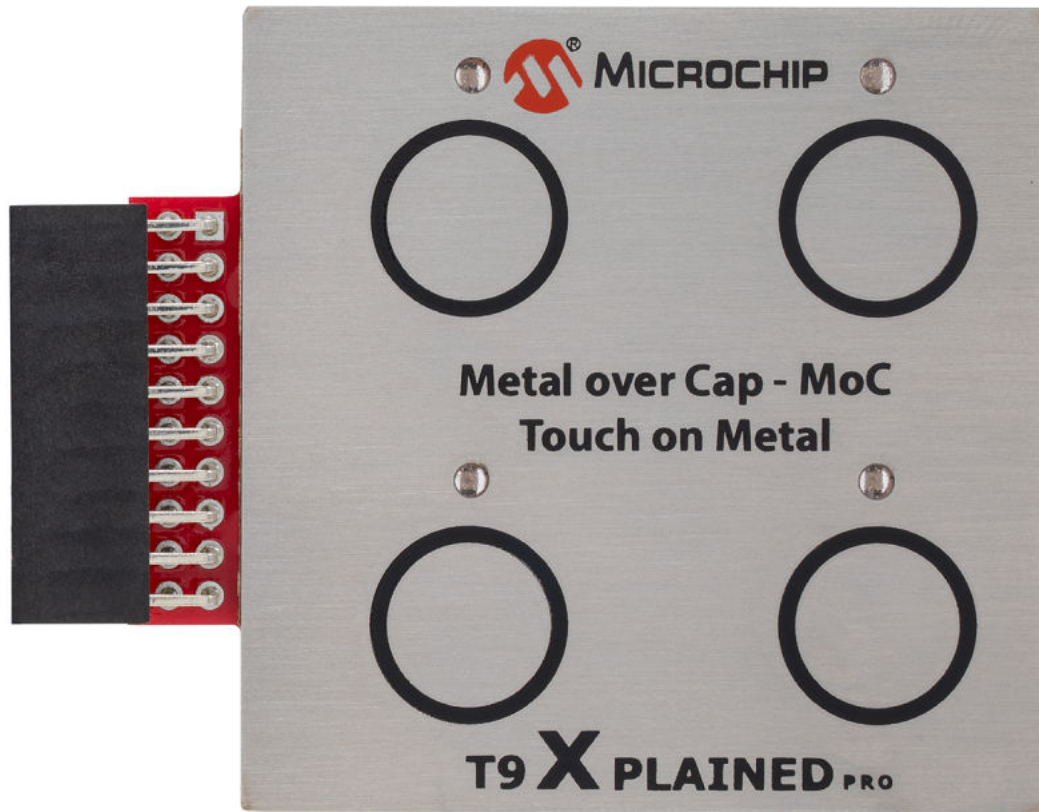## Table of Contents

1.   Introduction

1.1   Features and Overview

The board connects via a single header XPRO connector to compatible XPRO MCU boards or to Curiosity Nano MCU boards using the Curiosity Nano Touch Adapter (AC80T88A), and also provides four MoC buttons.

Every button status is indicated by an individual LED. Pressing the MoC button(s) illuminates the respective LED(s). Sample projects are provided through Microchip Code Configurators (MCC, START, Harmony 3), on the product webpage, and through the MPLAB® discovery tool.

1.2   Kit Components

- Four Self-Capacitance Buttons
- Four LEDs:
    - One LED for each key
- Xplained Pro Hardware Identification System
- Metal Overlay Mounted to the PCB by an Adhesive Spacer Layer

1.3   Kit Compatibility

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

Currently supported MCU boards 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 L21 Xplained Pro
- SAM L22 Xplained Pro
- SAM E54 Xplained Pro

By using either the Curiosity Nano Touch adapter or the Curiosity Nano adapter board, the T9 with Curiosity Nano MCU boards can also be used, such as:
- AVR128DA48 Curiosity Nano
- PIC16F18446 Curiosity Nano
- ATMega4809 Curiosity Nano
- SAMD21 Curiosity Nano
- ATTiny3217 Curiosity Nano

1.4   T9 Xplained Pro Functional Block Diagram
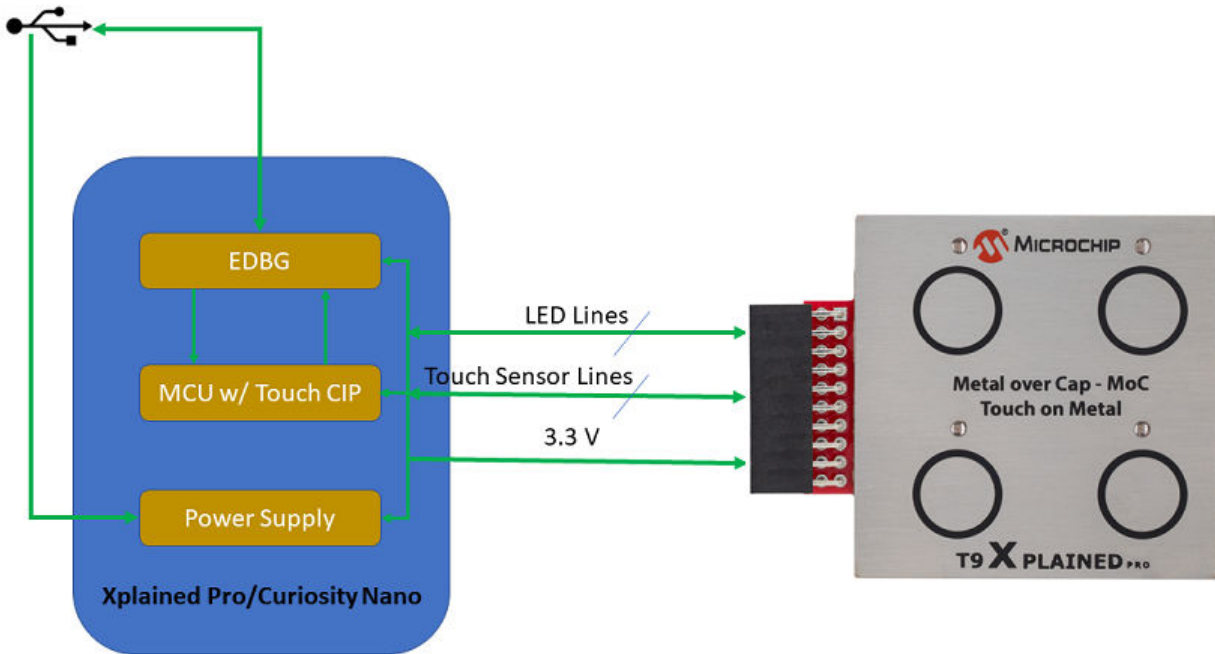
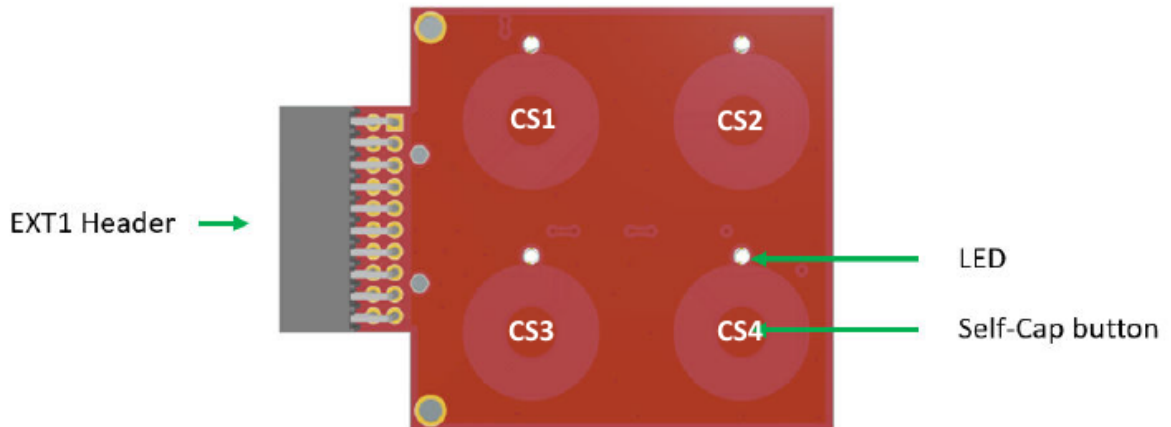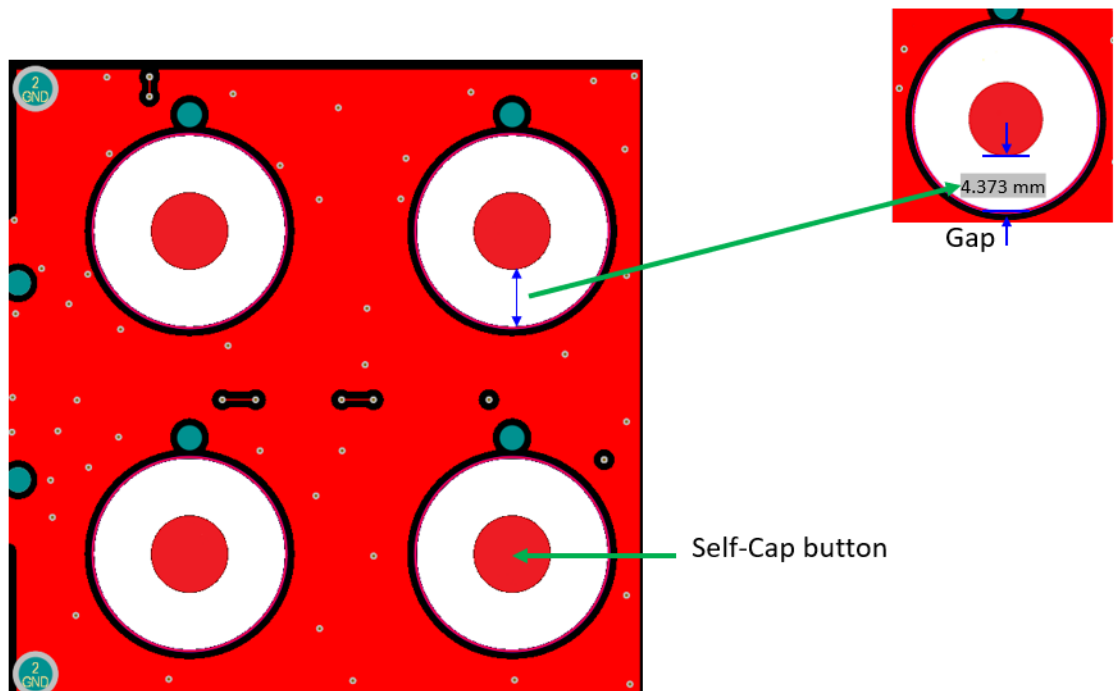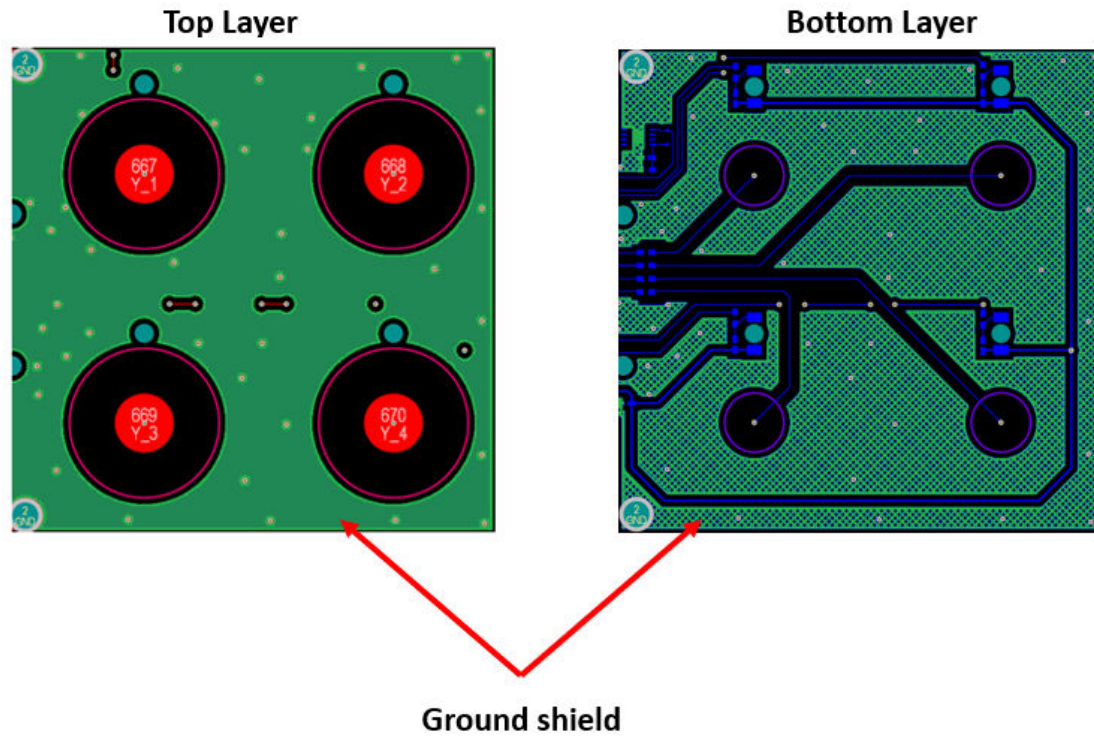# 2. Getting Started
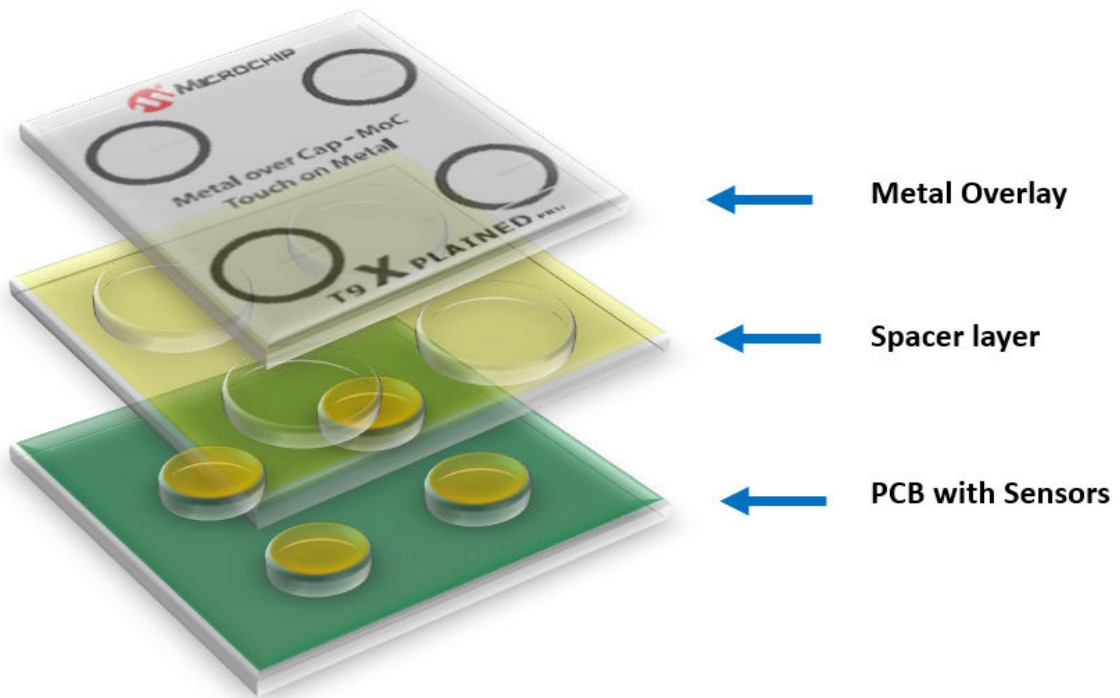
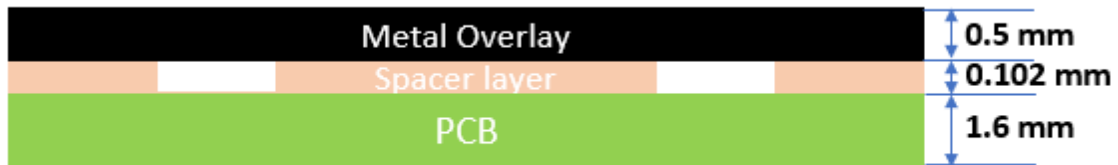## 2.1 Quick Start

2.2 Sensor Design

1. **Self-Cap Sensor**

2. **Ground Shield**

Ground shield

3. **Mechanical Stack-Up**

Metal Overlay

Spacer layer

PCB with Sensors

4. **Metal Overlay**

The typical choices for the metal overlay are stainless steel or aluminum. For the T9 Xplained Pro, stainless is used with the following dimensions: 50 mm x 50 mm x 0.5 mm (WxHxD). The print marks the locations of sensors.

The metal overlay is connected to the PCBA ground through the conductive adhesive spacer layer. This also provides a non-destructive path for the ESD energy.

5. **Spacer Layer**
Changing the state of the MoC sensor is based on the deflection of the metal overlay towards the touch electrode, caused by the press of the user. This deflection results in increasing the capacitance of the sensor due to the decreased distance between the plates of the capacitor. In consequence, MoC buttons can be activated by any thick glove or even sticks pressing the button surface. MoC buttons are, therefore, also inherently waterproof.

The T9-Xplained Pro uses Electrically Conductive Adhesive Transfer Tape 9707 with the thickness of 0.102 mm from 3M, as the spacer. This material serves two purposes:

  – It creates the intended distance between the metal overlay and the touch electrodes.
  – It connects the metal overlay to the PCB ground.

It is recommended that the spacer layer be made from a rigid non-deformable adhesive material. It may also be necessary to provide rigid mechanical support to the back of the PCB to prevent flexing of the entire target/spacer/PCB stack and potential loss of sensitivity.

Sensors are copper fills on the FR4 PCB and they form a capacitor with the metal overlay. In the T9 Xplained Pro, the top layer solder mask is limited to the electrical traces and the sensor electrodes area, while the whole ground plane on the top layer is copper exposed. This is to provide the ground connection to metal overlay through the electrically conductive adhesive spacer.

2.3 Documentation and Relevant Links

- **AN1325 – Metal over Cap Technology**
- **AN1626 – Implementing Metal over Cap**
- **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 Integrated Development Environment (IDE), 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 the above kits have on-board programmers/debuggers, which create 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™, MacOS®, Linux®) to develop applications for Microchip microcontrollers and digital signal controllers. It is called an IDE because it provides a single integrated 'environment' to develop code for embedded microcontrollers.
- **MPLAB® Code Configurator (MCC)** – MCC is a free, graphical programming environment that generates seamless, easy-to-understand C code to be inserted into a project. It uses an intuitive interface and it enables and configures a rich set of peripherals and functions specific to the application.
- **MPLAB® Harmony v3** – MPLAB Harmony is a fully integrated embedded software development framework that provides flexible and interoperable software modules that allow 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 the PIC32 MCUs, SAM MCUs, and MPUs.
  MPLAB Harmony v3 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 the 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 (DGI) found on the Curiosity Nano and Xplained Pro boards and COM Ports.
- **Design Documentation** – A package containing CAD source, schematics, BOM, assembly drawings, 3D plots, layer plots, etc.
- **T9 Xplained Pro Video link** – Explains overlay stack up used in T9 Xplained Pro.
- **Hardware User's Guide** – PDF version of this user's guide.
- **T9 Xplained Pro** – On Microchip's website.

Turnkey Touch Devkits:

- CAP1188 Evaluation Kit : http://www.microchip.com/DevelopmentTools/ProductDetails/PartNo/dm160222
- CAP1298 Evaluation Kit : http://www.microchip.com/DevelopmentTools/ProductDetails/PartNo/dm16022
- MTCH108 Evaluation Board: http://www.microchip.com/DevelopmentTools/ProductDetails/PartNo/dm160229
- AT42QT1010 Evaluation Kit: https://www.microchip.com/developmenttools/ProductDetails/AC160219

3. 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.

Curiosity Nano

The Curiosity Nano is an evaluation platform that provides a set of small boards with access to most of the microcontrollers I/Os. The platform consists of a series of low pin count microcontroller boards, which are integrated with Atmel Studio/Microchip MPLAB X IDE 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 DGI GPIO.

3.1 Hardware Identification System

All Xplained Pro extension boards come with an identification CryptoAuthentication™ chip (ATSHA204A) to uniquely identify the boards that are connected to the Xplained Pro evaluation kit. This chip contains information that identifies the extension by its name and other additional 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 3-1. Xplained Pro ID Chip Content

Data Field	Data Type	Example Content
Manufacturer	ASCII string	Microchip'\0'
Product name	ASCII string	Segment T9Xplained Pro'\0'
Product revision	ASCII string	01'\0'
Product serial number	ASCII string	3338011800000001'\0'
Minimum voltage [mV]	uint16_t	3000
Maximum voltage [mV]	uint16_t	3600
Maximum current [mA]	uint16_t	30

3.2 Xplained Pro Standard Connectors

3.2.1 Xplained Pro Standard Extension Headers

All Xplained Pro kits have many dual row, 20-pin, 100-mil extension headers. The Xplained Pro MCU boards have male headers, while the Xplained Pro extensions have female counterparts. The following table provides the pin description of 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 3-2. 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 PWN
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	I2C _SDA	Data pin for I^{2}C interface. Always connected, bus type
12	I2C _SCL	Clock pin for I^{2}C 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	Slave select for SPI. Preferably, this pin should 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. Hardware Users Guide

4.1 Electrical Characteristics

T9 Xplained Pro can be connected to several Xplained Pro MCU boards and manually connected to other pieces of hardware. An Xplained Pro MCU board that does not have 3.3V as its primary target voltage will read all ID devices on connected extensions to check if they support the target voltage before enabling it to the extension headers. The table below shows the static content written in the ID chip.

Table 4-1. T9 Xplained Pro ID Chip Content

Data Field	Content
Product name	T9 Xplained Pro
Minimum operation voltage	2.7V
Maximum operation voltage	5.5V
Maximum current	45 mA

For further information, consult the Hardware Identification System section.

4.2 Headers and Connectors

4.2.1 Extension Headers

The T9 Xplained Pro implements three Xplained Pro standard extension headers (see Section Xplained Pro Standard Extension Header) marked with EXT1 in silkscreen. These headers make it possible to connect the board to an Xplained Pro MCU board with a capacitive touch-enabled microcontroller. The pinout definition for each extension headers can be found in the table below.

Table 4-2. T9 Xplained Pro Extension

| Pin on EXT1	Function	Description
1	ID	Communication Line to ID Chip
2	GND	Ground
3	Not Connected	—
4	Not Connected	—
5	LED_2	LED line for Sensor CS2
6	LED_1	LED line for Sensor CS1
7	Y-Line-1	For Button CS1
8	Y-Line-2	For Button CS2
9	Y-Line-4	For Button CS4
10	Y-Line-3	For Button CS3
11	Not Connected	—
12	Not Connected	—
13	Not Connected	—
14	Not Connected	—

| Pin on EXT1	Function	Description
..........continued		
15	LED_3	LED line for Sensor CS3
16	LED_4	LED line for Sensor CS4
17	Not Connected	—
18	Not Connected	—
19	GND	Ground
20	VCC	Target Supply Voltage

5. Application Flow

The following diagram shows the application flow. Touch measurement is performed at regular intervals and at the end of each measurement, and then the data is processed to find touch states. Depending on the touch states, the LEDs are updated accordingly.

Figure 5-1. Application Flow
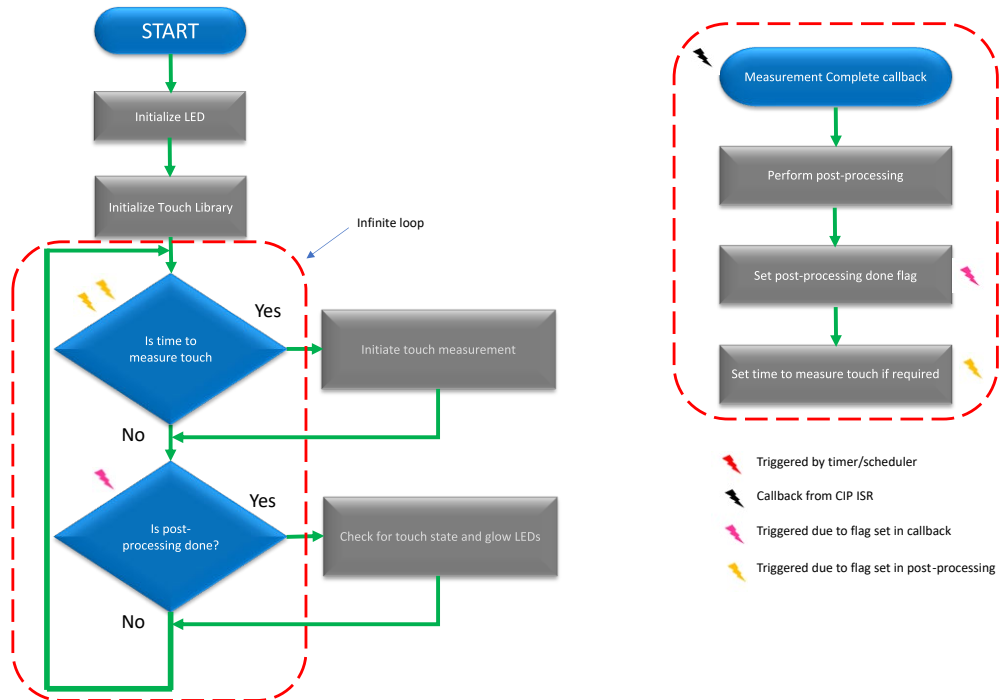
6. Schematics
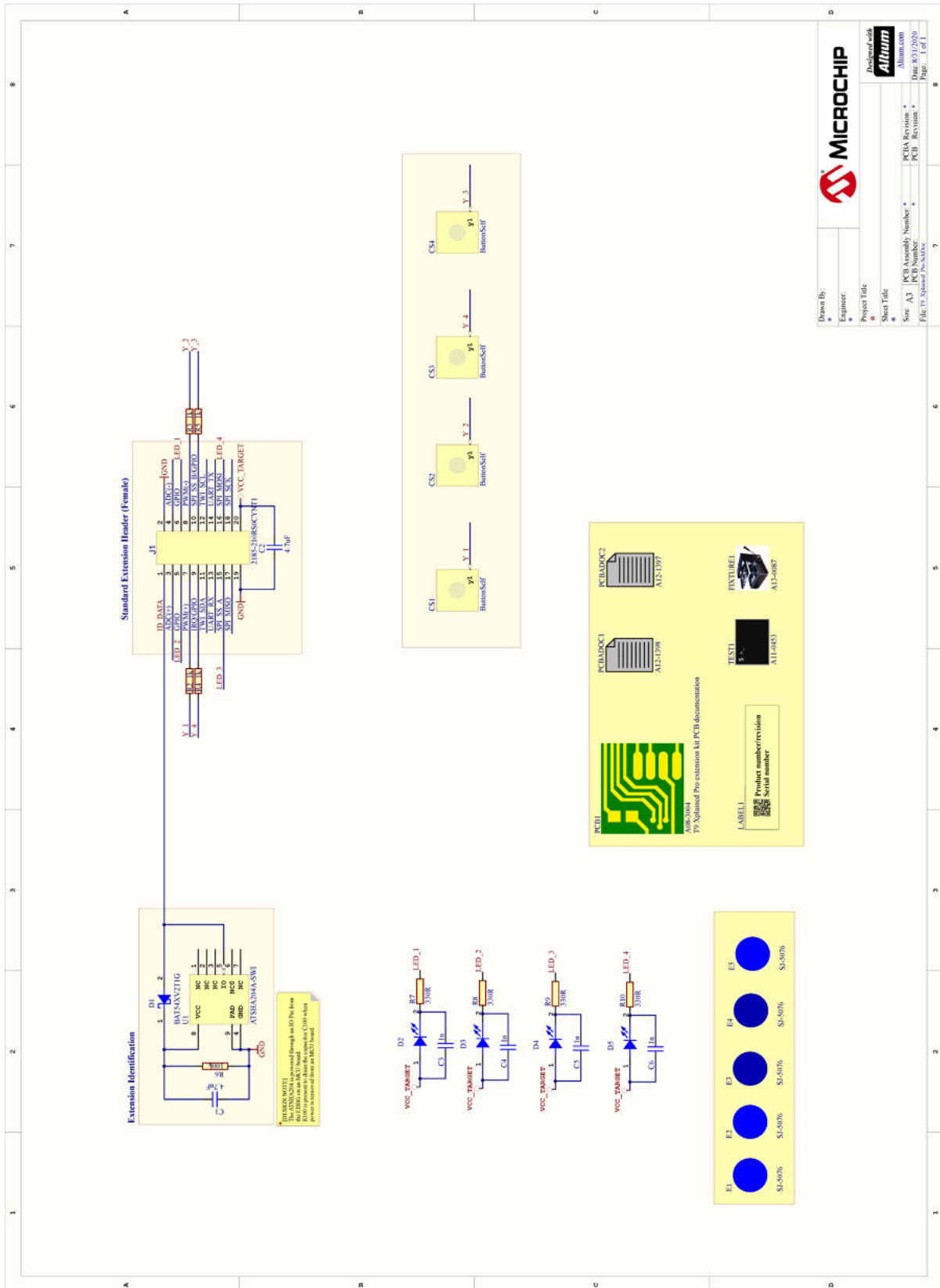
7. Hardware Revision History and Known Issues

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 the window.

The same information can be found on the sticker located 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 T9 Xplained Pro is A09-3271.

7.2 Revision 1

Revision 1 of T9-Xplained Pro (A09-3268/02) is the initial released version. There are no known issues.

8. Revision History

Revision	Date	Description
A	09/2020	Initial document release
B	10/2020	Fixed link to AN in Preface

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