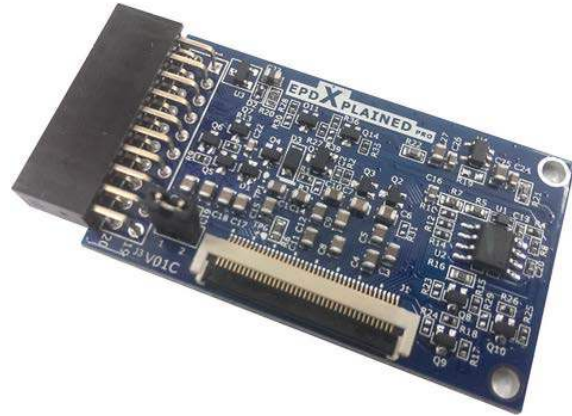# PERVASIVE DISPLAYS

USER GUIDE

Doc Rev. 3

EPD Explained Pro

Preface

EPD* Xplained Pro is an extension board to the Atmel Xplained Pro evaluation platform. EPD Xplained Pro is designed to kick-start EPD development with Atmel® microcontrollers.

* EPD: Electrophoretic display, Electronic paper display. E-Paper display

PERVAS[VE DISPLAYS

## Table of Contents

PERVASIVE DISPLAYS

1.   Introduction

1.1   Overview

EPD Xplained Pro is an extension board to the Atmel Xplained Pro evaluation platform. It connects to any Xplained Pro standard extension header on any Atmel Xplained Pro Evaluation Kits. The default supported evaluation kits are SAM4L Xplained Pro and SAM D20 Xplained Pro.

There is on board 40 pins FPC connector connects to Pervasive Displays Inc. (PDI)'s E Ink based EPD panels. The driving circuit supports driving PDI's 1.44 inch, 1.9 inch, 2 inch, 2.6 inch and 2.7 inch EPD panels via SPI interface. The sample Atmel Studio ASF project provides open source driving waveform and command interface to update content on EPD panel for developer to start working with EPD application easily.

Figure 1.1   EPD Xplained Pro extension board

Xplained Pro
ID Chip
ATSHA204

8M bits Serial
Flash memory

Jumper for
1.44" EPD

FPC connector
for EPD panel
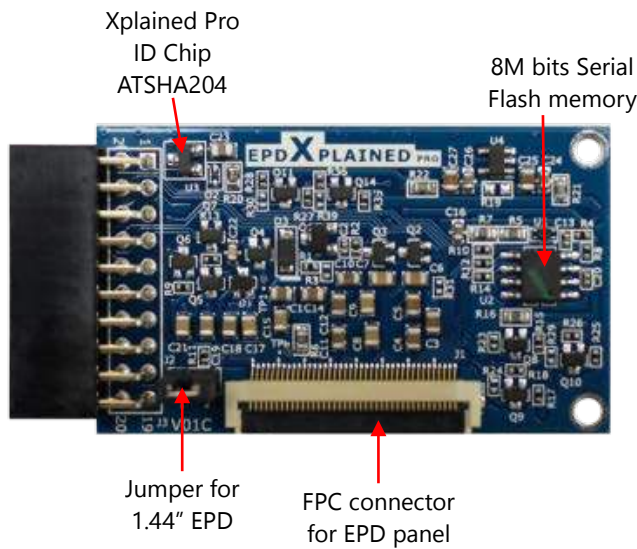
1.2   Features

- Supports driving 1.44", 1.9″, 2", 2.6″ and 2.7" EPD Panels including Aurora_Ma and Aurora_Mb FPL (Front Plane Laminate)

- On board 8M bits serial flash memory and temperature sensor

- On board LDO voltage regulator to 3V for EPD operation

- Open documentation, driving waveform for EPD panel

- Provides Atmel Studio - Atmel Software Framework (ASF) project source code

- Xplained Pro hardware identification system

1.3 Dimension

Figure 1.2 The dimension of EPD Xplained Pro extension board
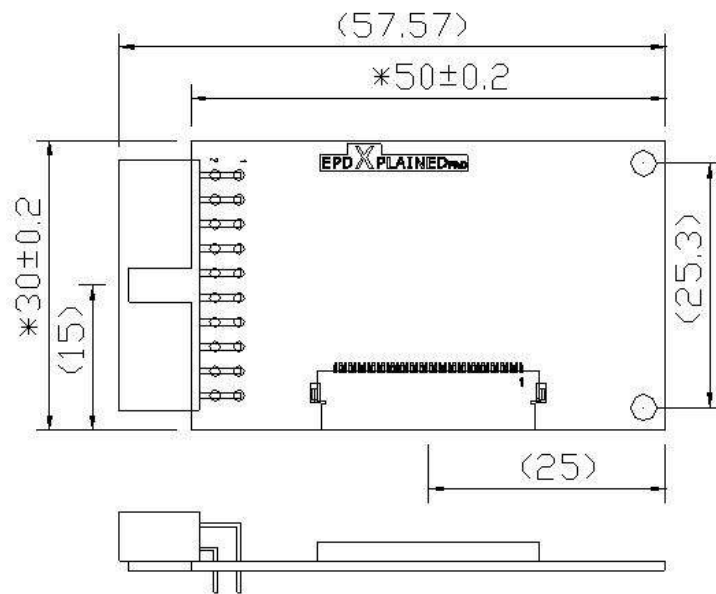
2. Getting started

2.1 3 Steps to start exploring the Atmel Xplained Pro platform

1. Download and install [Atmel Studio](#).

2. Launch Atmel Studio.

3. Connect EPD Xplained Pro to an Xplained Pro MCU board and connect a USB cable to DEBUG USB port on the Xplained Pro MCU board.

2.2 Connecting EPD Xplained Pro to the Xplained Pro MCU board

EPD Xplained Pro has been designed to be connected to the Xplained Pro header marked EXT3. The default supported boards are Atmel SAM4L Xplained Pro and SAM D20 Xplained Pro.

Once the Xplained Pro MCU board is powered the green power LED will be lit and Atmel Studio will auto detect which Xplained Pro MCU and extension board that is connected. You will be presented with relevant information like datasheets and kit documentation. You also have the option to launch Atmel Software Framework (ASF) example applications. The target device is programmed and debugged by the on-board Embedded Debugger. No external programmer or debugger tool is needed.

2.3 Design documentation and related links

You can find the latest update and documents at Atmel and Pervasive Displays website.

Atmel website: http://www.atmel.com/tools/EPD-XPRO.aspx

Pervasive Displays website: http://www.pervasivedisplays.com/kits/epd_xpro

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

1. [Xplained Pro products](#) - Atmel Xplained Pro is a series of small-sized and easy-to-use evaluation kits for 8- and 32-bit Atmel microcontrollers. It consists of a series of low cost MCU boards for evaluation and demonstration of features and capabilities of different MCU families.

2. [EPD Xplained Pro User Guide](#) - PDF version of this User Guide.

3. [EPD Xplained Pro Design Documentation](#) - Package containing schematics, BOM and Gerber files.

4. [Atmel Studio](#) - Free Atmel IDE for development of C/C++ and assembler code for Atmel microcontrollers.

5. [EPD Xplained Pro Atmel Studio ASF source project](#) – The EPD waveform driving source code for Atmel SAM 4L and SAM D20 Xplained Pro kit.

3. Xplained Pro

Xplained Pro is an evaluation platform that provides the full Atmel microcontroller experience. The platform consists of a series of Microcontroller (MCU) boards and extension boards that are integrated with Atmel Studio, have Atmel Software Framework (ASF) drivers and demo code, support data streaming and more.

Xplained Pro MCU boards support a wide range of Xplained Pro extension boards that are connected through a set of standardized headers and connectors. Each extension board has an identification (ID) chip to uniquely identify which boards are mounted on an Xplained Pro MCU board. This information is used to present relevant user guides, application notes, datasheets and example code through Atmel Studio. Available Xplained Pro MCU and extension boards can be purchased in the Atmel Web Store.

3.1 Hardware identification system

All Xplained Pro compatible extension boards have an Atmel ATSHA204 crypto authentication chip mounted. This chip contains information that identifies the extension with its name and some extra data. When an Xplained Pro extension board is connected to an Xplained Pro MCU board the information is read and sent to Atmel Studio. The Atmel Kits extension, installed with Atmel Studio, will give relevant information, code examples and links to relevant documents. Table 3.1, "Xplained Pro ID chip content" 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	Pervasive Displays'\0'
Product Name	ASCII string	EPD Xplained Pro'\0'
Product Revision	ASCII string	01C'\0'
Product Serial Number	ASCII string	XPL-33B6-0321'\0'
Minimum Voltage [mV]	uint16_t	3000
Maximum Voltage [mV]	uint16_t	5000
Maximum Current [mA]	uint16_t	8

Note: To recognize the EPD Xplained Pro and show landing page on Atmel Studio automatically when connecting with Atmel Xplained Pro kit, please install the latest "Atmel Kits" on Atmel Gallery.

Atmel Kits
Atmel (Atmel)
Getting started help for kits provided by Atmel, such as the Xplained Pro series. New boards in version...
Download

3.2 Standard headers and connectors

3.2.1. Xplained Pro EPD extension connector

All Xplained Pro kits contains one or more dual row, 20 pin, 100 mm and 2.54mm pitch extension headers. Xplained Pro MCU boards have male headers while Xplained Pro extensions have their female counterparts. Note that all pins are not always connected; However, all the connected pins follow the defined pin-out described in Table 3.2, "Standard extension header". The extension headers can be used to connect a wide variety of Xplained Pro extensions to Xplained Pro MCU boards and to access the pins of the target MCU on

Xplained Pro MCU board directly.

Table 3.2   Standard extension header

| Pin number	Name	Description
1	ID	Communication line to the ID chip on extension board.
2	GND	Ground
3	ADC(+)	Analog to digital converter, alternatively positive part of differential ADC
4	ADC(-)	Analog to digital converter, alternatively negative part of differential ADC
5	GPIO1	General purpose IO
6	GPIO2	General purpose IO
7	PWM(+)	Pulse width modulation, alternatively positive part of differential PWM
8	PWM(-)	Pulse width modulation, alternatively positive part of differential PWM
9	IRQ/GPIO	Interrupt request line and/or general purpose IO.
10	SPI_SS_B/GPIO	Slave select for SPI and/or general purpose IO.
11	TWI_SDA	Data line for two wire interface. Always implemented, bus type.
12	TWI_SCL	Clock line for two wire interface. Always implemented, bus type.
13	USART_RX	Receiver line of Universal Synchronous and Asynchronous serial Receiver and Transmitter
14	USART_TX	Transmitter line of Universal Synchronous and Asynchronous serial Receiver and Transmitter
15	SPI_SS_A	Slave select for SPI. Should be unique if possible.
16	SPI_MOSI	Master out slave in line of Serial peripheral interface. Always implemented, bus type
17	SPI_MISO	Master in slave out line of Serial peripheral interface. Always implemented, bus type
18	SPI_SCK	Clock for Serial peripheral interface. Always implemented, bus type
19	GND	Ground
20	VCC	Power for extension board

4. Hardware user guide

4.1 EPD panel

EPD Xplained Pro features 1.44 inch, 1.9 inch, 2 inch, 2.6 inch and 2.7 inch EPD panels made by Pervasive Displays Inc. which supports the FPL film type "Aurora". For more EPD product specification, visit http://www.pervasivedisplays.com/products/panels

For how to recognize the material of your display by the rear labels, please visit this webpage.

Figure 4.1   EPD panels

1.44"

2.0"

2.7"

1.9"

2.6"

FPC
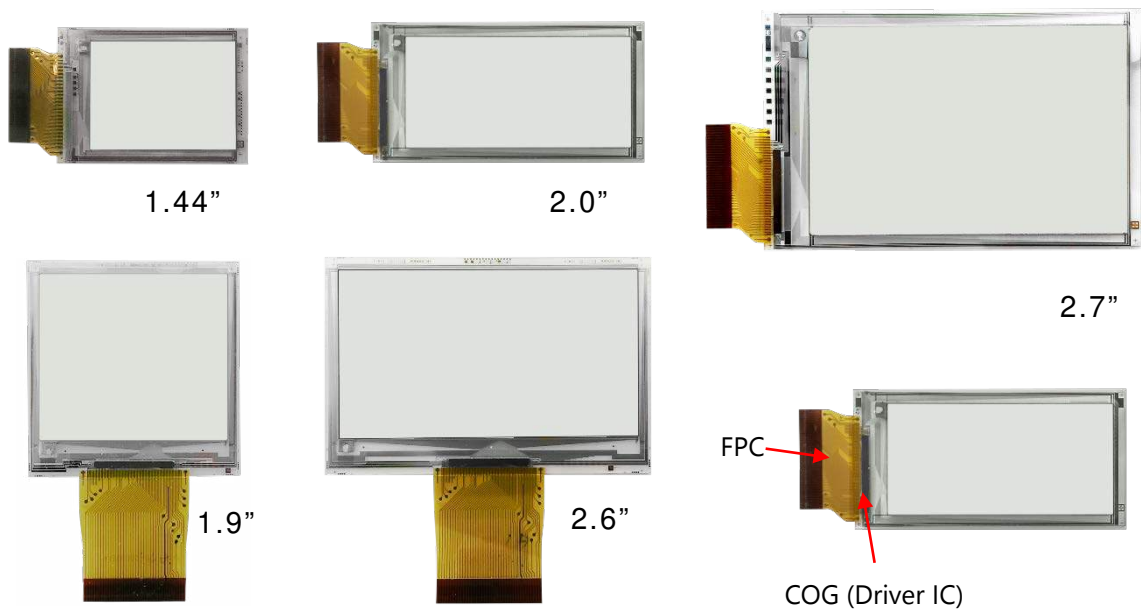
COG (Driver IC)

COG (chip on glass) is the driver IC for display construction where the row and column drivers are mounted directly to the glass substrate to drive TFT.

Size	PDI Model Name	Material Film
1.44"	E1144CS021	Aurora Mb(V231)
	EK014BS011	Aurora Ma(V230)
1.9"	E1190CS021	Aurora Mb(V231)
2.0"	E1200CS021	Aurora Mb(V231)
	EG020BS011	Aurora Ma(V230)
2.6"	E1260CS021	Aurora Mb(V231)
2.7"	E1271CS021	Aurora Mb(V231)
	EM027BS013	Aurora Ma(V230)

4.1.1. EPD Specification

Table 4.1   EPD panel specification

| Item	Specification		
EPD Size (inch)	1.44	2	2.7
Outline Dimension (mm)	40.512*28.90*1.00	57*28.80*1.00	70.42*45.80*1.00
Active Area (mm)	29.312 * 21.984	45.8 * 21.984	57.288 * 38.192
Pixel Number (pixel)	128 * 96	200 * 96	264 * 176
Pixel Pitch (mm) (dpi)	0.229 * 0.229 (111)		0.217 * 0.217 (117)
Digital Power(VDD/VCC)	3.0V		
Pixel Arrangement	Vertical stripe		
Display Colors	Black/White		

Visit www.pervasivedisplays.com/products/panels for more details on EPD panel specification.

User can recognize the FPL version by the model name at this webpage.

4.1.2. Assembling EPD panel to EPD Xplained Pro

Figure 4.2 Assembling EPD panel

	Open the connector	Slide the FPC into connector	Close the connector
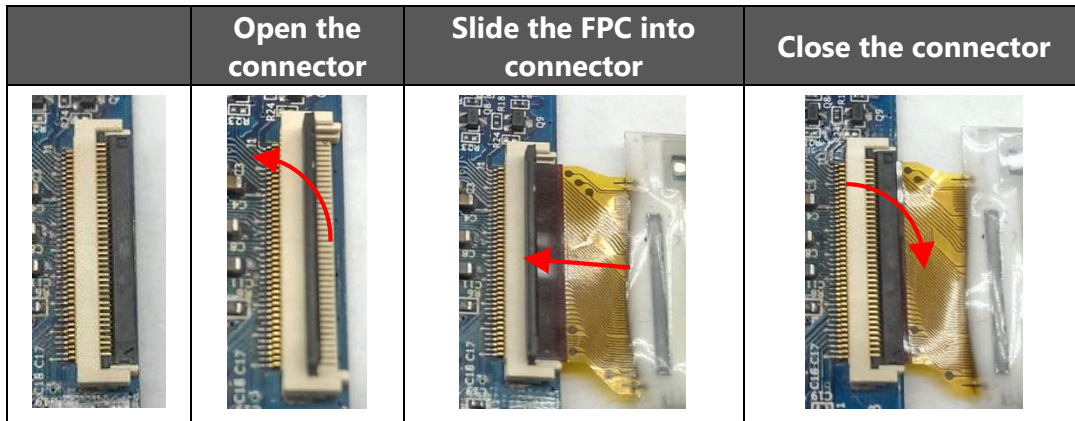
4.1.3. COG Driver Interface Timing

For driving PDI's small size EPDs above, user can refer to the "COG Driver Interface Timing" document (hereinafter COG Document). It explains the driving process of COG driver of EPD for a MCU based solution.

- The G2 COG document number with Aurora_Ma is 4P015-00. Download URL

- The G2 COG document number with Aurora_Mb is 4P018-00. Download URL

- The waveform driving source code is provided and opened. Download URL
  We need this project file to work with EPD Xplained Pro kit.

4.2   Headers and connectors

4.2.1.   EPD Xplained Pro extension header

EPD Xplained Pro implements one Xplained Pro Standard Extension Header marked with EXT3 in silkscreen. This header makes it possible to connect the board to any Xplained Pro MCU board. The pin-out definition for the extension header can be seen in Table 4.1, "EPD Xplained Pro extension header".

Table 4.2   EPD Xplained Pro extension header

Pin on EXT3	Function	Description
1	ID	Communication line to the ID chip on extension board.
2	GND	Ground
3	Temperature	On board temperature sensor output (ADC)
4	Border_Control	Border control pin (GPIO)
5	Discharge	EPD discharge when EPD power off (GPIO)
6	/Reset	Reset signal. Low enable (GPIO)
7	PWM	Pulse width modulation. Square wave when EPD power on (PWM)
8	Panel_On	COG driver power control pin (GPIO)
9	Busy	COG busy pin (GPIO)
10	Flash_CS	On board flash chip select (GPIO)
11~14	-	-
15	/EPD_CS	Chip Select. Low enable (GPIO)
16	SPI_MOSI	Serial input from host MCU to EPD
17	SPI_MISO	Serial output from EPD to host MCU
18	SPI_SCLK	Clock for SPI
19	GND	Ground
20	VCC	Target supply voltage

4.2.2.   The jumper of EPD border select

There is a jumper J2 arranged on EPD Xplained Pro board. Around the active area of the EPD is a 0.5mm width blank area called the border. The J2 jumper is special used for 1.44" and 2" EPD to clear its border area per each update screen. When using 1.44" or 2" EPD with EPD Xplained Pro board, the J2 jumper must be closed, otherwise the border area will getting barker after several updates.

Note: Although the silkscreen was printed "EPD1.44_BORDER_SELECT", but this jumper is now for 2" and 1.44" EPD.

Table 4.3   J2 jumper setting for EPD border select

	1.44" or 2"	1.9", 2.6", 2.7"
J2 jumper	Close	Open

4.2.3. Assembling EPD Xplained Pro to Xplained Pro MCU boards

Align with the 20 pins connector of EPD Xplained Pro board to connect with the EXT3 header of Xplained Pro MCU board. The connected structure likes the figure below.

Figure 4.3 EPD Xplained Pro with EPD and Atmel Xplained Pro
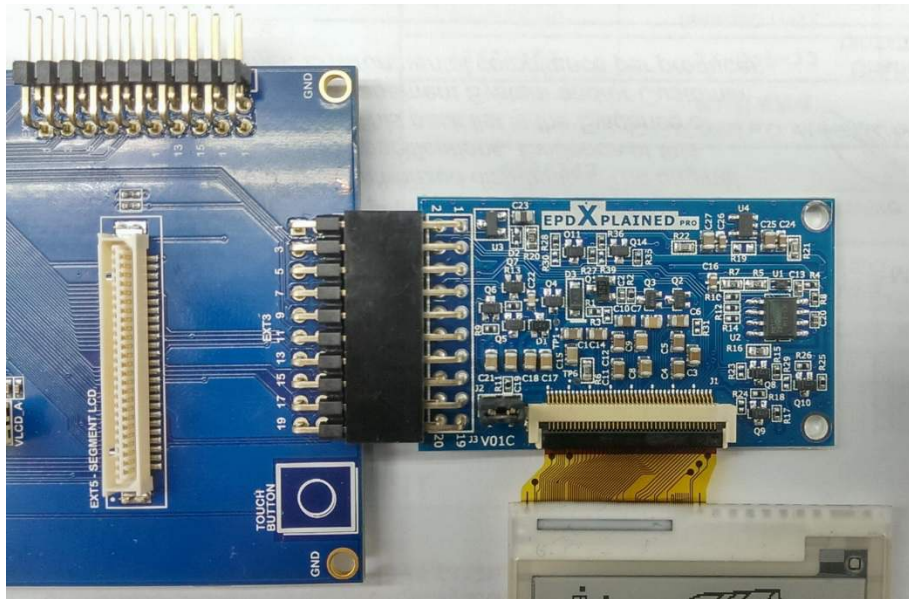
5. Working with Atmel Studio project code

5.1 Open Project

You can download the ASF project from [5]. For how to install new extensions in Atmel Studio, please refer to this link.

5.1.1. Open ASF Project

Extract the project if it was compressed as RAR file format. Double click on the "Atmel EPD Xplained Pro.atsln" to launch EPD Xplained Pro project.

5.2 Project file explanation

Table 5.1   The file structure of Atmel Studio project of EPD Xplained Pro

Folder/File	Description
[src]	All of the source code files including Atmel® Software Framework (ASF) library
- main.c	The entrance main.c file including quick start guide
- image_data.*	It defines the image arrays of each EPD size
- [config]/conf_EPD	The EPD configurations. • GX_Aurora_Mx: defines which COG driving waveform model will be used • COG_SPI_baudrate: SPI speed
\ASF\sam\components\display\Pervasive_Displays_small_EPD	The EPD driving source code
- EPD_hardware_driver.*	Most of the COG hardware initialization and configuration. The provided settings and functions are Timer, SPI, PWM, temperature, GPIO pins configuration and EPD hardware initialization.
- COG_FPL.h	The definitions of COG driving data and process
- EPD_interface.*	The application interface for external function to work with EPD
- [COG_FPL]	Each COG driving file presents the different waveform driving processes of COG and updating stages under this folder. There are [G1_Aurora_Mb], [G2_Aurora_Ma] and [G2_Aurora_Mb]
[doc]	There are three documents in this folder: - EPD Xplained Pro User Guide_rev3.pdf (this file) - EPD Xplained Pro-V01C-BOM.xlsx - EPD Xplained Pro-V01C-Schematic.pdf

5.3   Programming firmware to work with EPD Xplained Pro

5.3.1. Configure connected EPD size

Load the EPD Xplained Pro ASF project. The solution name is Atmel EPD Xplained Pro.atsln

Before programming firmware onto the MCU of Atmel Xplained Pro kit, user should make sure the definition of EPD size and COG/FPL version in project code is same as the connected EPD panel. To do this:

–   Find #define Gx_Aurora_Mx in "conf_EPD.h" file. Change to the correct type of EPD you are connecting.

–   Change the USE_EPDXXX to the correct size.

–   Close the J2 jumper on board if you are connecting with 1.44" or 2"

5.3.2. Working with EPD Xplained Pro

1.   When you connect the Atmel Xplained Pro kit with your computer via USB port, the Atmel MCU Xplained Pro kit will be recognized and show its landing page on Atmel Studio. Information about connected EPD Xplained Pro extension board via EXT header will also appear in the Atmel Kits window.

2.   Click the button ▷|| "Start Debugging and Break" to start programming the firmware to the MCU of Xplained Pro kit.

3.   Once building successfully without errors, you will see two images change on EPD panel alternately.

6.   Hardware revision history and known issues

6.1   Identifying product ID and revision

The revision and product identifier of EPD Xplained Pro boards can be found on the front side of the PCB. It always shows on the left bottom side as Vnnx type where nn is version number and x is subedition, e.g V01C

By connecting an Xplained Pro MCU board to a computer with Atmel Studio running, an information window will pop up. The first 6 digits of the serial number, which is listed under kit details, contain the product identifier and revision. Information about connected Xplained Pro extension boards will also appear in the Atmel Kits window.

There is a serial number for each PCBA can be found on the bottom side of the PCB printed on a sticker in plain text as "XPL-3ymd-ssss" format with barcode (code128).

The serial number string has the following format:

```
"XPL-3ymd-ssss"
y = the last digit of manufacturing year, 2013=3, 2020=A
m = the manufacturing month, 1=1, 10=A, 12=C
d = the manufacturing day, 1=1, 10=A, 31=X
s = serial number
```

6.2   Revision 1

Revision 01 of EPD Xplained Pro is the initial released version. There are no known issues.

7. Document revision history

Rev.	Date	Comment
1	14 Jan, 2014	First release
2	29 Jan, 2014	Support driving V230 G2 EPD. Modified configurations, product and jumper setting.
3	31 Mar, 2015	- Support driving V231 G2 EPD. - Support 1.9" and 2.6". - Change naming convention: V230=G2_Aurora_Ma, V231=G2_Aurora_Mb or G1_Aurora_Mb - Add driving waveform of Aurora_Mb and Aurora_Ma (100% compatible with EPD Xplained Pro extension board) - Move all configurations to conf_EPD.h - Move original EPD_hardware_GPIO.* into EPD_hardware_driver.* - Rename original EPD_controller.* as EPD_interface.*. Some functions were moved to EPD_Gx_Aurora_Mx.c

8. Evaluation board/kit important notice

8.1 Evaluation board/kit important notice

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

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