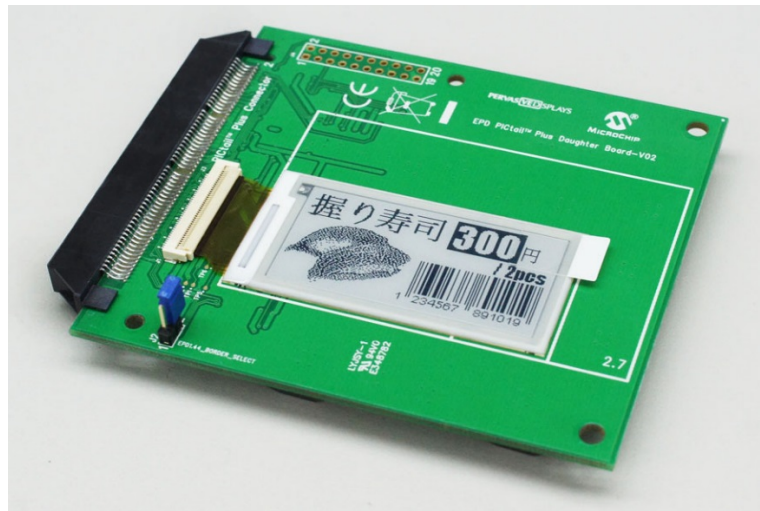

EPD PICtail™ Plus Daughter Board



Preface

EPD* PICtail™ Plus Daughter Board, part number S1000CS023, is an extension board to the Microchip® Explorer 16 Development Board. EPD PICtail Plus Daughter Board is designed to kick-start EPD development with Microchip Graphic Library and PIC Microcontrollers including PIC24, dsPIC33 and PIC32 families.

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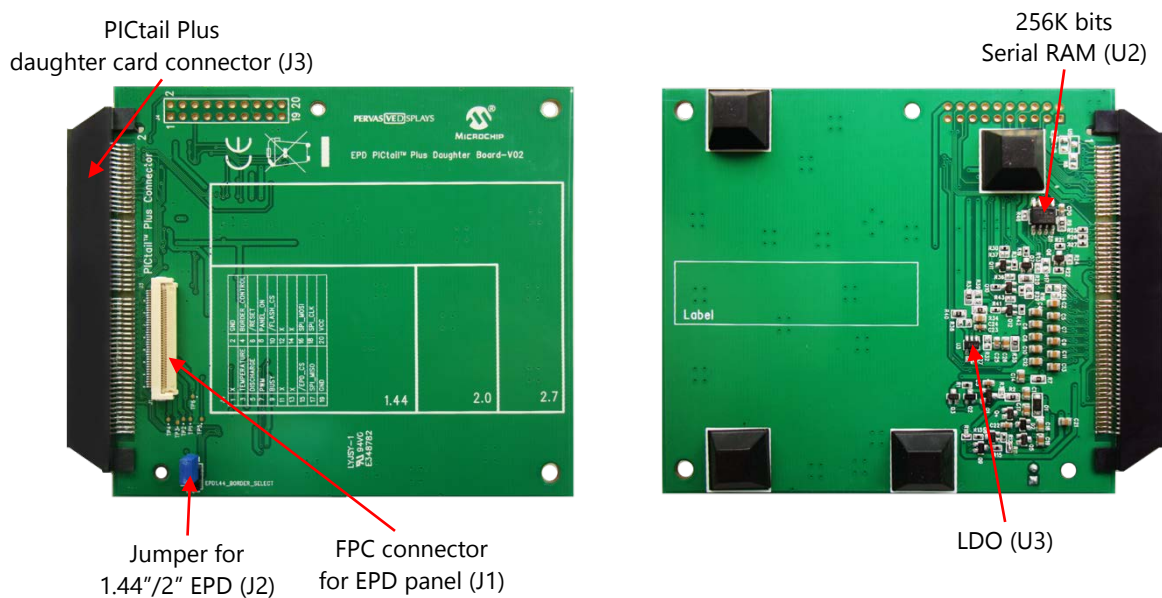
1. Introduction

1.1 Board overview

EPD PICtail Plus Daughter Board (S1000CS023) is an extension to Microchip Explorer 16 Development Board (DM240001) via standard PICtail Plus connector which allows evaluating Microchip technology, solution and graphic library for 16 and 32 bits microcontroller.

There is on board 40 pins FPC connector connects to Pervasive Displays Inc. (PDI)'s E Ink based EPD modules. The driving circuit supports driving PDI's 1.44 inch, 2 inch and 2.7 inch EPD panels via SPI interface. All three sizes of EPD ship with the EPD PICtail Plus Daughter Board. The sample Microchip MPLAB® X IDE project provides source driving waveform including global update and partial update with command interface to update content on EPD panel.

Figure 1.1 EPD PICtail Plus Daughter Board



1.2 Features

- Supports driving 1.44", 2" and 2.7" EPD panels with [Aurora Mb\(V231\)](#) and [Vizplex\(V110\) FPL \(Front Plane Laminate\)](#)
- Direct drive EPD by Microchip PIC24 microcontroller without extra graphic or timing controller
- On board 256K bits serial RAM and temperature sensor
- On board LDO voltage regulator to 3V for EPD operation
- PICtail Plus Interface for connecting to Explorer 16 Development Board
- Open documentation and driving waveform for EPD panel
- Provides Microchip MPLAB® X IDE project source code with Microchip Graphic Library
- Provides global update and partial update driving technology on EPD panels

2. Getting started

2.1 Before you get started

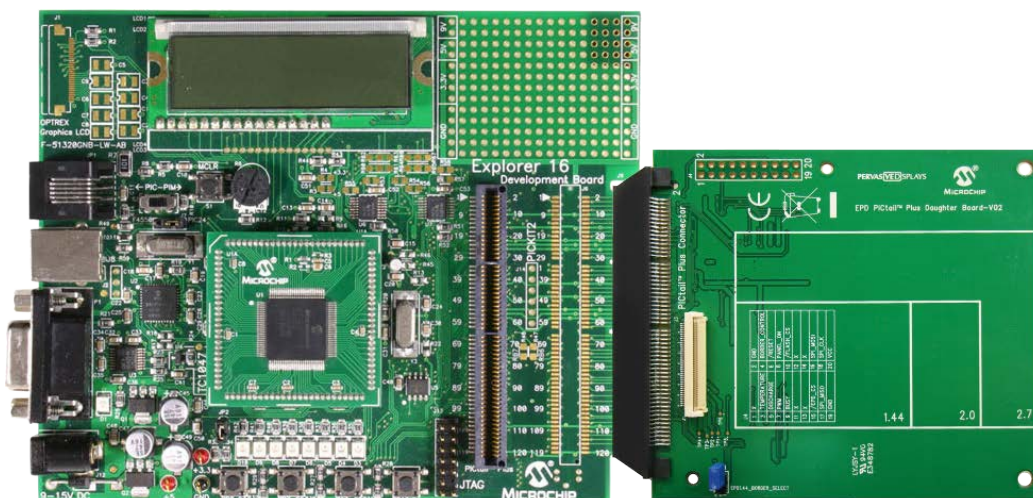
You will need the following:

- EPD PICtail Plus Daughter Board with 1.44", 2" or 2.7" for all V110 EPD (S0000AS0T3) or V231 EPD (S1000CS023, recommended)
- Explorer 16 Board (DM240001)
- PIC24FJ128GA310 or PIC24FJ128GA010 Processor Plug-in Module (PIM) (MA240029) or another PIM compatible with the Explorer 16 Board
- 9V Wall Mount Power Supply (AC002014) or another compatible power supply for the Explorer 16 Board

2.2 5 Steps to start exploring the EPD PICtail Plus Daughter Board

1. Download and install [Microchip MPLAB® X IDE](#) (v3.0 or above) and [MPLAB® XC16 compiler](#) (v1.24 or above)
2. Download [EPD PICtail Plus Daughter Board MPLAB X source project v2.00](#) and extract it.
3. Launch MPLAB X IDE and open "pic24f_pdi_epd_pictail_plus" project.
4. Connect EPD PICtail Plus Daughter Board to Microchip Explorer 16 Development Board via PICtail Plus connector.
5. Connect programmer via 6-wire MPLAB In-Circuit Debugger (ICD) connector, six-pin interface for PICKIT™ (J14) or JTAG connector (J13) on the Microchip Explorer 16 Development Board. Apply power to the Explorer 16 board.

Figure 2.1 EPD PICtail Plus Daughter Board with Microchip Explorer 16 Development Board



2.3 Design documentation and related links

The following list contains links to the most relevant documents and software for EPD PICtail Plus Daughter Board.

1. [Explorer 16 Development Board](#) – The Explorer 16 Development Board is a low-cost modular development system for Microchip’s 16-bit and 32-bit microcontrollers. Find the supported Daughter Boards and documents under this webpage.
2. [PIC24FJ128GA310 Processor Plug-In Module](#) (recommended) or [PIC24FJ128GA010](#) – This PIM plugs into the Explorer 16 Board to showcase the eXtreme Low Power features of this MCU family.
3. [MPLAB® X \(IDE\)](#) - 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.
4. [EPD PICtail Plus Daughter Board webpage](#) on PDI website.
5. [EPD PICtail Plus Daughter Board User Guide](#) - PDF version of this User Guide.
6. [EPD PICtail Plus Daughter Board Design Documentation](#) - Package containing schematics, BOM, Gerber files, 3D plots etc.
7. [EPD PICtail Plus Daughter Board MPLAB X source project](#) – The EPD waveform driving source code and demonstration with [Microchip Graphic Library](#) version 4.10 of [Microchip Libraries for Application v2014-07-22 Windows](#).
8. COG Driver Interface Timing document (hereinafter COG document) - explains the driving process (waveform) of COG driver G2 with V231 EPD for a MCU based solution. [download link](#)

3. Hardware user guide

3.1 Explorer 16 Development Board

Microchip Part Number: DM240001

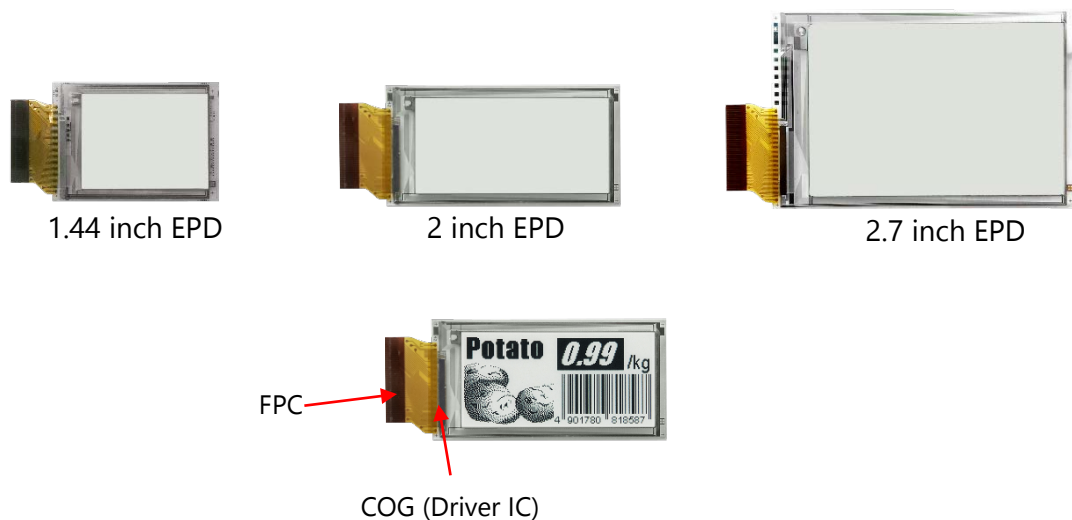
The Explorer 16 Development Board is a low-cost modular development system for Microchip’s 16-bit and 32-bit microcontrollers. It supports devices from the PIC24, dsPIC® DSC and PIC32 families. A variety of families are supported with processor Plug-In Modules (PIMs) for easy device swapping. The board includes a PICtail Plus daughter card connector for expansion boards including USB, Ethernet, wireless, graphics and many more. Coupled with the MPLAB ICD 3 (In Circuit Debugger) or MPLAB REAL ICE™ in-circuit emulator, real-time emulation and debug facilities speed evaluation and prototyping of application circuitry.

Note: The following MPLAB IDE project code default supports 100-pin PIC24FJ128GA310 or PIC24FJ128GA010 processor PIMs. The PIC24FJ128GA310 has lower power consumption which is important in many EPD applications.

3.2 EPD panel

EPD PICtail Plus Daughter Board comes with 1.44 inch, 2 inch and 2.7 inch EPD panels made by Pervasive Displays Inc. For more EPD product specification, visit <http://www.pervasivedisplays.com/products/panels>

Figure 3.1 EPD panels (V110)



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. PDi provides two versions of COG which are G1 and G2.

The EPD PICtail Plus Daughter Board supports the EPD panel that embedded FPL material (Front Plane Laminate that provided by [E-Ink](#)) are version of V110 (EOL already), V230 and V231. This document and project code will default describe with V231 only.

G1 COG is combined with V110 FPL and G2 COG is combined with V230 and V231 FPL.

For more information on COG and FPL combination, please visit [PDi product webpage](#).

3.2.1. EPD Specification

Table 3.1 EPD panel specification

Item	Specification		
EPD Size (inch)	1.44	2	2.7
Part Number (V231 FPL)	E1144CS021	E1200CS021	E1271CS021
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		
Surface Treatment	Anti-Glare		

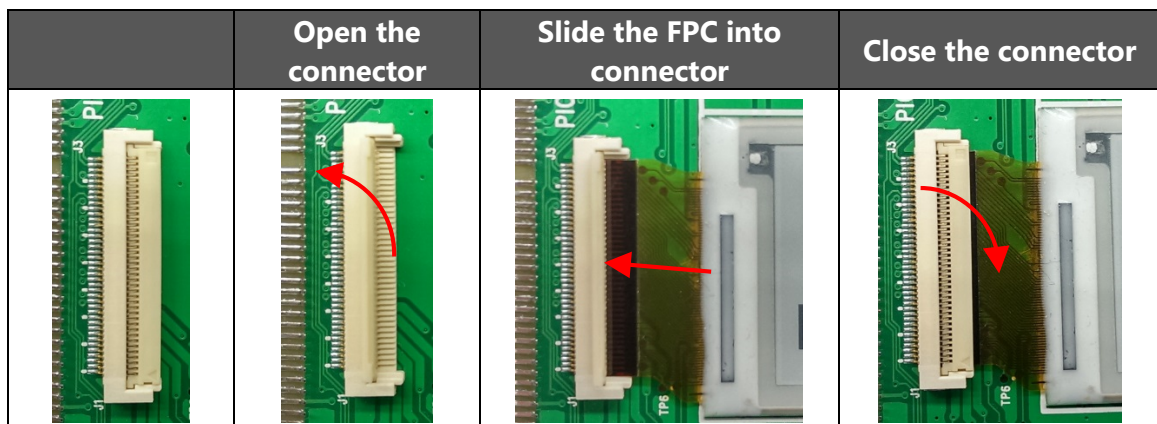
Visit www.pervasivedisplays.com/products/panels for more details on EPD panel specification.

User can recognize the FPL version by the model name at [this webpage](#).

3.2.2. Assembling EPD module to EPD PICtail Plus Daughter Board

Now you can assemble an EPD module to EPD PICtail Plus Daughter Board via the 40-pin FPC connector.

Figure 3.2 Assembling EPD module



3.2.3. 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.

- **Global Update** (also known as "Full Update") to update display from one previous image to another image and every pixel of entire display has been refreshed and updated.
- **Partial Update** (also known as "Local Update") is the process to update display from one previous image to another image directly but only the pixels to be changed are updated.
- The demonstration of the project code includes Global Update and Partial Update implementation.

- For COG document of Global Update, refer to section 2.3 [8].
- For more information about Partial Update, please contact PDi for more details.
- The waveform driving source code is provided and opened. Refer to section 2.3 Design documentation and related links the #7 EPD PICtail Plus Daughter Board MPLAB IDE X source project.
We need this project file to work with EPD PICtail Plus Daughter Board at section 4.2.

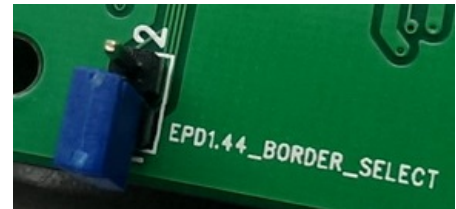
3.3 Headers and connectors

3.3.1. The jumper of EPD border select (J2)

There is a jumper J2 arranged on EPD PICtail Plus Daughter 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" EPDs to clear its border area per each update screen. When using such EPD with EPD PICtail Plus Daughter Board, the J2 jumper must be closed, otherwise the border area will get darker after several updates.

Table 3.2 J2 jumper setting for EPD border select

	1.44", 2"	2.7"
J2 jumper	Close	Open



3.3.2. PICtail Plus Connector pin-out (J3)

EPD PICtail Plus Daughter Board implements Microchip PICtail™ Plus Connector with J3 in silkscreen. The pin-out definition for the connector can be found in **Table 3.3** below.

Table 3.3 Pin-out of EPD PICtail Plus Daughter Board

Pin on J3	Function	Description
1	/EPD_CS	EPD chip select (GPIO)
3	SPI_SCLK	Clock for SPI
5	SPI_MISO	Serial output from EPD to host MCU
7	SPI_MOSI	Serial input from host MCU to EPD
9, 10, 15, 16, 41, 42, 47, 48, 119, 120	GND	Ground
11	Temperature	The non-populated temperature sensor, part number TC1047AVNBTR (U5) output (ADC) (Default use the on board thermo sensor of Explorer 16)
17	PANEL_ON	COG driver power control pin (GPIO)
18	/RESET	Reset signal. Low enable (GPIO)
19	DISCHARGE	EPD discharge when EPD power off (GPIO)
20	BUSY	COG busy pin (GPIO)
21, 22, 53, 54, 107, 108	VCC	Supply voltage 3.3V
23, 24, 55, 56	VCC	Supply voltage 5V (NC)
33	/FLASH_CS	On board SRAM chip select (GPIO)
35	FLASH_SCLK	Clock for on board SRAM
37	FLASH_SO	Serial output from SRAM to host MCU
39	FLASH_SI	Serial input from host MCU to SRAM
50	BORDER_CONTROL	Border control pin (GPIO)
93	PWM	Pulse width modulation. Square wave when EPD power on (PWM)

3.3.3. Measurement Points of EPD (J4)

There is a 20-pins J4 for developer to measure signals of EPD module. The pin assignment has arranged on silkscreen of PCB. The signals are same as **Table 3.3**.

4. Working with MPLAB X IDE project code

4.1 Project file explanation

The project code has embedded Microchip Graphic Library in directory. You can find the driving source code under “port_update\apps\gfx\e_paper_pdi\firmware\src” directory. The table below describes the files and folders of this directory.

Table 4.1 The file explanation of MPLAB X IDE project of EPD PICtail Plus Daughter Board

[Folder]/-File	Description
- main.c	The entrance file controls all of the demonstrations. There is quick start guide in this file.
[demo_screen_for_xx_inch]	The content layout and order of appearance for all of the demo screens of each EPD size
[gfx]	The directory of definitions of Graphics Library
[resources]	The converted resource files by Graphics Resource Converter
[Pervasive_Displays_small_EPD]	The EPD driving source directory
[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] where [G2_Aurora_Mb] is default supported.
- EPD_hardware_driver.*	Most of the COG hardware initialization and configuration. The provided settings and functions are Timer, SPI, PWM, temperature and EPD hardware initialization.
- EPD_interface.*	The application interface for external function to work with EPD
- COG_FPL.h	The common definition of driving process and structures

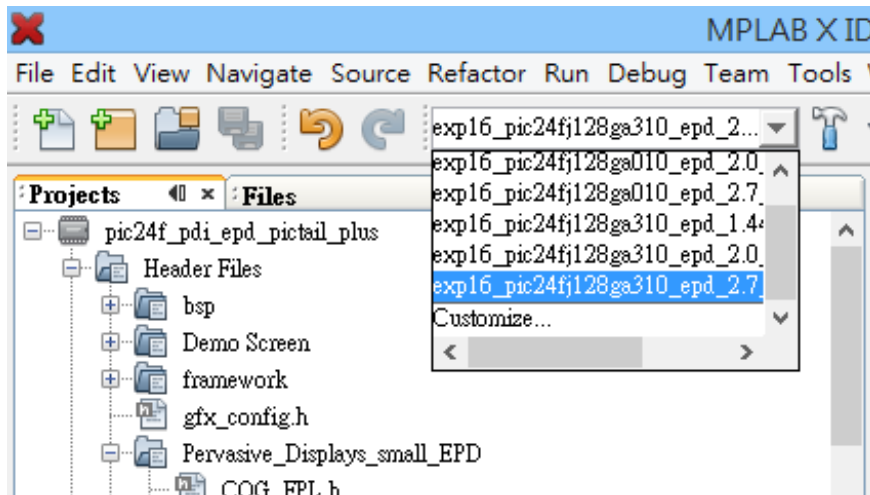
Note: The sample code has built-in touch function, but most of the code are not finished yet. Please ignore the code related to touch functions before we release new version.

4.2 Programming firmware to work with EPD PICtail Plus Daughter Board

4.2.1. Configure connected EPD size

Load the EPD PICtail Plus Daughter Board MPLAB X IDE source project.

Before programming firmware onto the MCU of Explorer 16 Development Board, user should make sure the definition of EPD size and COG version in project code is same as the connected EPD panel. To do this, please select the correct EPD size with correct PIC24 PIM from the pull-down menu of MPLAB X IDE.






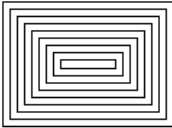
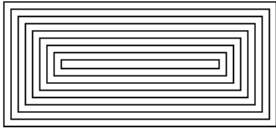
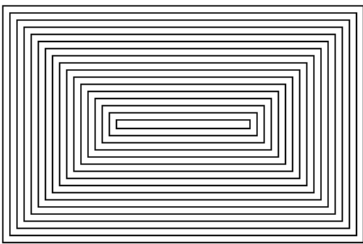





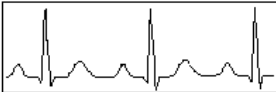
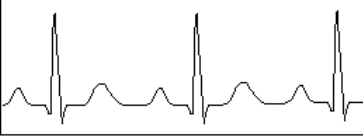
There are six configurations preset in the list which are:

- exp16_pic24f128ga010_epd_1.44_G2_AuroraMb
- exp16_pic24f128ga010_epd_2.0_G2_AuroraMb
- exp16_pic24f128ga010_epd_2.7_G2_AuroraMb
- exp16_pic24f128ga310_epd_1.44_G2_AuroraMb
- exp16_pic24f128ga310_epd_2.0_G2_AuroraMb
- exp16_pic24f128ga310_epd_2.7_G2_AuroraMb

To check the configurations, right click on the project name and select [Set Configuration] / [Customize...] / select one of the conf: item / [xc16-gcc] / [Preprocessing and messages] option category. The definition is set in the [Define C macros] item.

4.2.2. Working with Microchip MPLAB X IDE

1. Make sure your debugger/programmer is ready to program firmware code to Explorer 16 Development Board.
2. Click [Clean and Build Project]  button to make sure the project code without errors.
3. Click [Make and Program Device] from the dropdown  button to download firmware code to PIC® MCU of Microchip Explorer 16 Development Board.
4. Once building successfully without errors, you will see the demo patterns below running on EPD panel.

	1.44"	2"	2.7"
Home	<p>EPD demonstration with Microchip Graphic Library</p> <ul style="list-style-type: none"> □ Square, ○ Circle ▬ Bar Chart ⊞ HVAC Panel ⊞ Medical ECG 	<p>PERVASIVEDISPLAYS MICROCHIP</p> <p>EPD demonstration with Microchip Graphic Library</p> <ul style="list-style-type: none"> □ Square, ○ Circle ▬ Bar Chart ⊞ HVAC Panel ⊞ Medical ECG 	<p>PERVASIVEDISPLAYS</p> <p>EPD demonstration with Microchip Graphic Library</p> <ul style="list-style-type: none"> Global update □ Square, ○ Circle ▬ Bar Chart ⊞ A/C Control Panel ⊞ Medical ECG <p>MICROCHIP</p>  <p>MICROCHIP</p> <p>PERVASIVEDISPLAYS</p>
Demo1			
Demo2	<p>Revenue (\$ Billion)</p> 	<p>Revenue (\$ Billion)</p> 	<p>Revenue (\$ Million)</p> 
Demo3	<p>SET TEMP ROOM TEMP</p> <p>27 °C 28 °C</p> <p>DOWN UP</p> <p>Energy Now 254 W Fan speed 1240 rpm</p>	<p>SET TEMP ROOM TEMP</p> <p>27 °C 28 °C</p> <p>DOWN UP</p>  <p>Energy Now 254 W Avg. Cost \$ 25 /month Est. Cost Today \$ 1.2 vs 0.9</p> <p>1240 rpm</p>	<p>SET TEMP ROOM TEMP</p> <p>27 °C 28 °C</p> <p>DOWN UP</p> <p>1240 rpm</p> <p>Energy Now 254 W Last / Days 54 kWhr Avg. Cost \$25 /month Est. Cost Today \$1.2 vs 0.9</p> <p>Yesterday</p>  <p>Night Day Eve</p>
Demo4	<p>PR 0.18 QRS 0.09 QT 0.40 RR 0.65</p> <p>98.2°F PUL 70</p> <p>SYS 118 DIA 78</p>	 <p>PR 0.18 QRS 0.09 QT 0.40 RR 0.65</p> <p>98.2°F SYS 118 DIA 78 PUL 70</p>	 <p>PR 0.18 QRS 0.09 QT 0.40 RR 0.65</p> <p>98.2 °F Peak Yst.day 98.8 98.3</p> <p>SYS DIA PUL</p> <p>118 78 70</p> <p>mmHg mmHg /min</p>

5. Hardware revision history and known issues

5.1 Identifying product ID and revision

The revision and product identifier of EPD PICtail Plus Daughter Board can be found on the front side of the PCB. It always shows on the top of PCB follows "EPD PICtail™ Plus Daughter Board" as Vnn type where nn is version number, e.g. V02 is version 2.

There is a serial number for each PCBA can be found at the rear side of PCB printed on a sticker in plain text as "A1340013-00-5ymd-ssss" format with barcode (code128).

The serial number string has the following format:

```
"A1340013-00-5ymd-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
```

5.2 Revision 2

Revision 1 is working sample which is never released to the market. Revision 2 of EPD PICtail Plus Daughter Board is the initial released version. There is no known issue.

6. Document revision history

Rev.	Date	Comment
1	28 March, 2014	First release
2	5 March, 2015	<ul style="list-style-type: none"> - Compatible with MLA release 7/22/2014 with XC16 v1.24 and MPLAB X IDE v2.30 - Add supporting display for AuroraMb + G2 driver. It's also the default supported configuration in project code. - Support both of PIC24FJ128GA010 and PIC24FJ128GA310 PIMs. - Keep the previous AuroraMa+G2 and AuroraMb+G1 codes.

7. Evaluation board/kit important notice

7.1 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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