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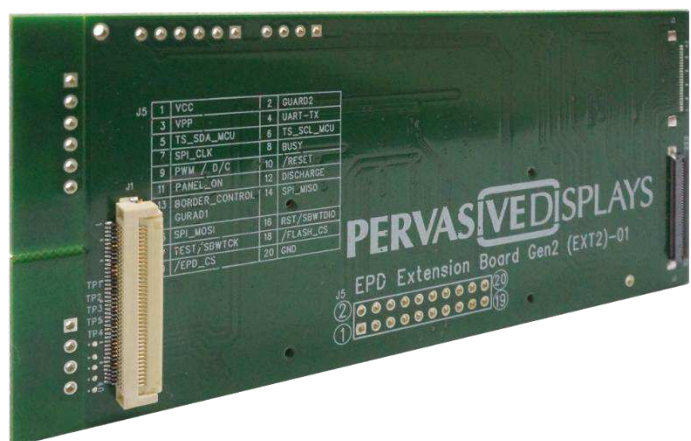
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User's Guide

Doc Rev. **05** (July 2017)

EPD Extension Kit Gen2



Preface

EPD* Extension Kit Generation 2 (**EXT2**) is a new generation of extension board to the Texas Instruments' LaunchPad development platform to drive most of Pervasive Displays' EPDs.

It is designed to kick-start EPD development with your microcontrollers. There are onboard headers can be bridged to any of your development kit and product.

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

Table of Contents

Preface	1
1. Introduction	3
1.1 Overview.....	3
1.2 EXT2 kit introduction.....	4
1.2.1 EXT2 kit contents.....	4
1.2.2 EPD Extension Board Gen2 (EXT2 board).....	4
1.3 EPD Displays	6
1.3.1 FPL (E ink Imaging film):	6
1.3.2 COG (Chip on Glass):.....	6
1.3.3 Supported EPD Display Lineup for EXT2	7
1.4 TI LaunchPads.....	9
2. Getting Started	10
2.1 Assembling the EXT2 board with LaunchPad.....	10
2.1.1 Adjust the Jumpers of LaunchPad	10
2.1.2 Getting started with EXT2 kit.....	12
2.1.3 Stack the EXT2 board on LaunchPad	12
2.1.4 Connect the EPD to the EXT2 board.....	13
2.2 Programming firmware to LaunchPad.....	14
2.2.1 Download firmware file to LaunchPad by UniFlash.....	15
2.2.2 Install CCS and setup driver library	18
2.2.3 Load project and program firmware by CCS	19
2.2.4 Set driverlib path of MSP-EXP432P401R and EK-TM4C123GXL.....	21
2.3 Installing the PDI Apps.....	22
2.4 Working with PDI Apps.....	23
2.4.1 Global Update	24
2.4.2 Fast Update.....	26
2.4.3 Bitmap Converter	28
3. Hardware Instructions of EXT2 Kit.....	30
3.1 Introduction of EXT2 board.....	30
3.1.1 Headers and Connectors.....	31
3.2 How to bridge EXT2 with other development kit.....	32
3.3 Integration with front light guide	34
3.4 Integration with touch panel.....	35
4. Working with TI CCS Project Code.....	36
4.1 EPD_drivers Project.....	36
4.2 LaunchPad Name Project.....	38
5. Document revision history	40
6. Evaluation board/kit important notice	41

1. Introduction

1.1 Overview

Thank you for purchasing the EPD Extension Kit/Board Generation 2 (EXT Gen2, **EXT2**) for low-power electrophoretic paper display (**EPD**) solutions. This document provides an overview of the kit and is organized into four main sections.

1. The EXT2 introduction and supported EPD, material and drivers
2. Getting started with the EXT2 to drive EPD
3. Hardware instruction of EXT2 kit
4. Working with TI CCS project code

The 1st and 2nd sections are most of the user guide to instruct how to use the EXT2 kit and get the EPD working. The 3rd and 4th sections are more details of developing EPDs with EXT2 kit and provided project code.

The EXT2 is a new EPD Extension board to the Texas Instruments (**TI**)'s [LaunchPads](#) development platform supports driving most of Pervasive Displays Inc. (**PDI**)'s EPD panels lineup. It has 20 to 40 pins socket at the rear side to stack on TI's LaunchPad board. It also provides a 20 pins header to bridge with your project/product or other development kit.

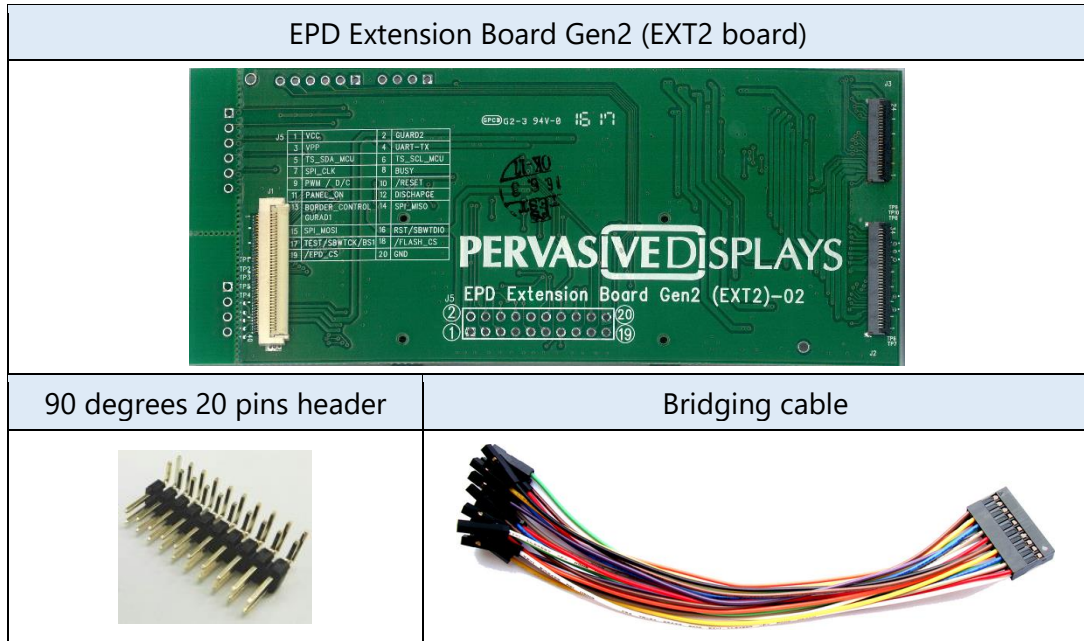
The project of EXT2 is open source code provides driving waveform and command interface to update content on EPD panel for developer to start working with EPD application easily.

1.2 EXT2 kit introduction

1.2.1 EXT2 kit contents

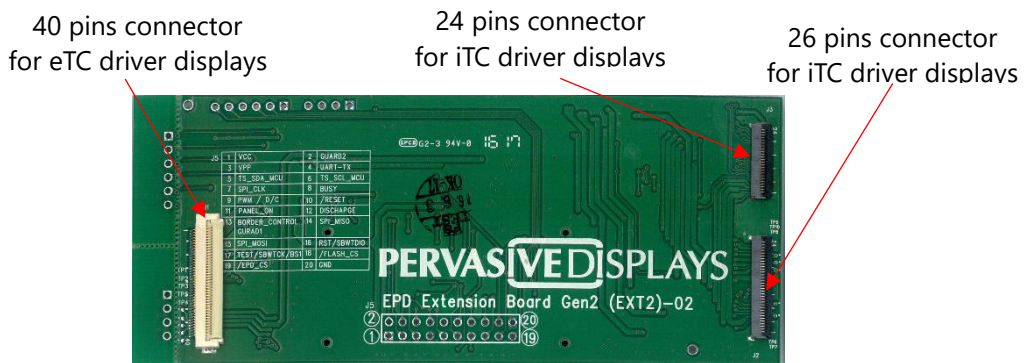
Model name of EXT2 Kit: B3000MS034(24 pin connector supported)

The EXT2 kit contents of one EXT2 board, one 90 degrees 20 pins header and one bridging cable.



1.2.2 EPD Extension Board Gen2 (EXT2 board)

Figure 1-1 EPD Extension Board Gen2 (front view)

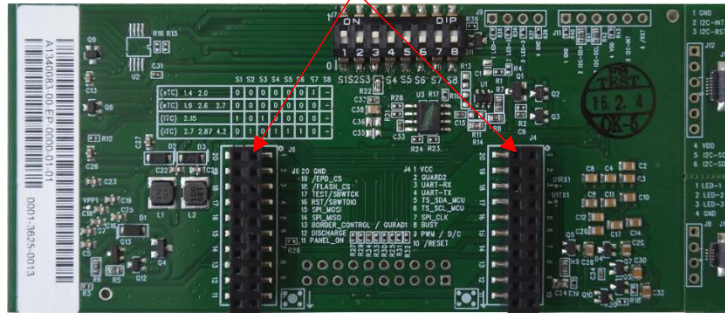


The EXT2 board supports driving most of the PDI’s EPD panels with the 40 and 24/26 pins FPC connector. The EXT2 board has embedded EPD driving circuit which are soldered at the backside.

eTC and iTC will be explained later.

Figure 1-2 EPD Extension Board Gen2 (rear view)

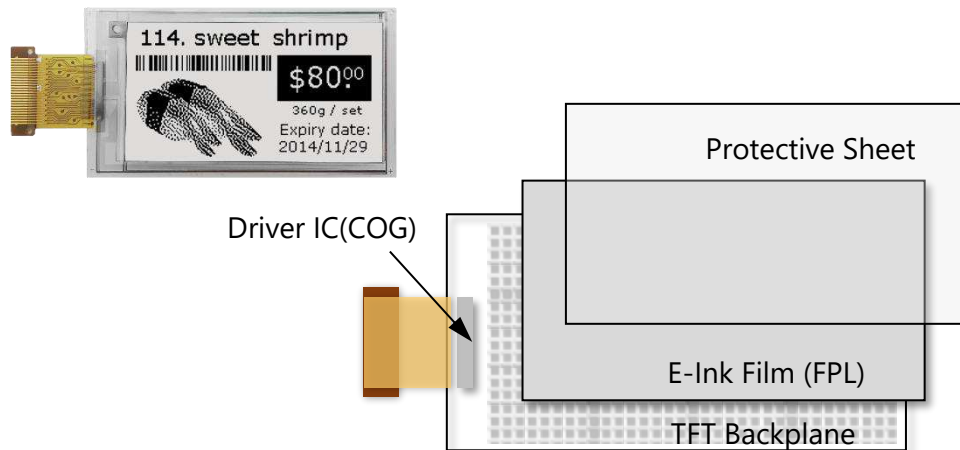
20 pins connector
for stacking on TI LaunchPads



There are two 20 pins connectors at the backside of EXT2 board is able to stack on TI LaunchPads.

1.3 EPD Displays

Figure 1-3 Structure layer of EPD



1.3.1 FPL (E ink Imaging film):

Made by E-ink which is embedded in PDI's EPD panels. The EXT2 board supports driving the following films:

- **Aurora Ma:** also call **V230**. The display color is black and white. It supports operating at wide temperature from -20°C to +50°C. It has to load special driving waveform to get the display works. This film type display is suggested for lower temperature operation is the major criteria only.
- **Aurora Mb:** also call **V231**. The display color is black and white. Most of the cases, The Aurora Mb film type display provides the best performance, faster update speed and lower power consumption. It supports operating at room temperature from 0°C to +50°C.
- **Spectra:** also call **E4**. The display color is red, black and white, three colors. The EXT2 board will support this film type driving soon. It supports operating at room temperature from +0°C to +40°C







1.3.2 COG (Chip on Glass):

also call Tcon (TC, Timing controller) or Driver IC which is mounted on TFT glass of EPD display.


- **eTC:** external Tcon, the driving waveform and flow are controlled by the host MCU (microcontroller). Developer needs to manage most of the driving stages, frame time and data flow by the MCU of host control board. The eTC includes PDI's G1, G1b and **G2** COG (where G1/G1b are EOL (end of life)). The pin number of FPC (flexible printed circuit) of eTC is 40 pins.
- **iTC:** internal Tcon, the driving waveform and settings are managed by Lookup Table (**LUT**). The LUT is serial hex array includes the waveform parameters. User will need to send defined LUT and image data to COG. The COG will extract the waveform settings from the LUT to update display by following image data. The pin number of FPC of iTC is 24 or 26.

1.3.3 Supported EPD Display Lineup for EXT2

Table 1-1 Supported EPDs for EXT2

Size	Picture	Resolution	Pixel Density (dpi)	Model No.	FPL	COG
1.44"		128 x 96	111	EK014BS011	Aurora Ma	eTC
				E1144CS021	Aurora Mb	
				E2144CS021	Aurora Mb	
1.90"		144 x 128	101.6	E1190CS021	Aurora Mb	eTC
				E2190CS021	Aurora Mb	
2.00"		128 x 96	111	EG020BS011	Aurora Ma	eTC
				E1200CS021	Aurora Mb	
				E2200BS021	Aurora Mb	
				E2200CS021	Aurora Mb	
2.15"		208 x 112	110	E2215CS062	Aurora Mb	iTC
2.60"		232 x 128	101.6	E1260CS021 (EOL)	Aurora Mb	eTC
2.71"		264 x 176	117	EM027BS013	Aurora Ma	eTC
				E1271CS021	Aurora Mb	
				E2271BS021	Aurora Mb	
				E2271CS021	Aurora Mb	

2.87"		296 x 128	112	E2287CS051	Aurora Mb	iTC
				E2287ES051	Spectra	
4.2"		400 x 300	120	E2417CS051	Aurora Mb	iTC
				E2417ES053	Spectra	

 There are more sizes with iTC COG will be added in the table above in the future, please keep watching on our release of sample project code, PDi website or contact PDI for more information.

1.4 TI LaunchPads

The Texas Instruments (TI)'s [LaunchPad](#) is **excluded** in the EXT2 kit, so user and developer has to purchase the LaunchPad on TI official website or other online webshop.

The supported LaunchPads for EXT2 kit that are provided CCS ([Code Composer Studio™](#)) project source code are

- MSP: [MSP-EXP432P401R](#), [MSP-EXP430F5529LP](#)
- Connected: [EK-TM4C123GXL](#)



There are more LaunchPads will be supported in the CCS projects. Please kindly keep watching on our updated project code in PDI website of EXT2 kit.



If you are first time with this EXT2 kit and will order TI LaunchPad to work with, we would highly suggest choosing **EK-TM4C123GXL** for more functions that we will offer.

2. Getting Started

This section provides instructions to set up the EXT2 kit with TI LaunchPads and use the **PDI Apps** to update image on EPD display.

There are four steps to prepare the kit:

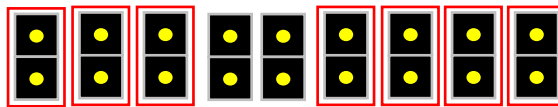
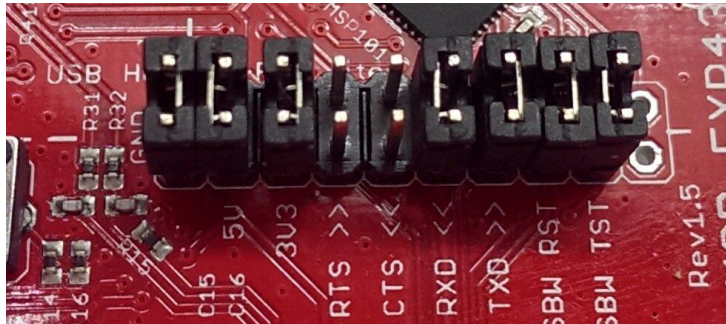
- (1) **Assembling the EXT2 board with LaunchPad**
- (2) **Programming firmware to LaunchPad**
- (3) **Installing the PDI Apps**
- (4) **Working with PDI Apps**

2.1 Assembling the EXT2 board with LaunchPad

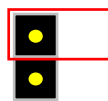
We will need to set the jumpers of LaunchPad in order to get the LaunchPad programmable.

2.1.1 Adjust the Jumpers of LaunchPad

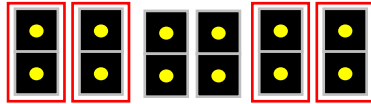
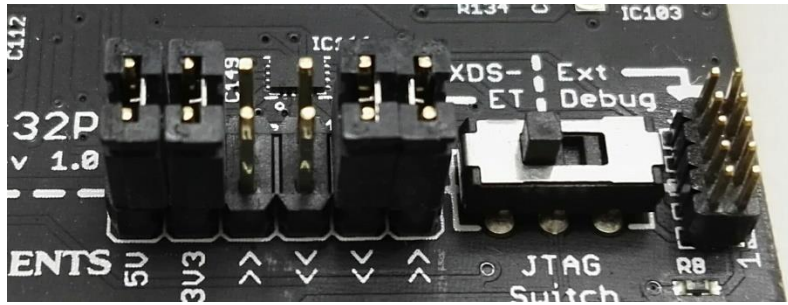
- **MSP-EXP430F5529LP LaunchPad**
 - eZ-FET Jumper:



- JP8 Jumper:



- **MSP-EXP432P401R LaunchPad(Black PCB version)**




- **EK-TM4C123GXL LaunchPad**
 - PWR Selecting switch to DEBUG side



2.1.2 Getting started with EXT2 kit

Please check with the backside of EXT2 board. You will find a table for adjusting the J7 of 8 positions of DIP switch.

Table 2-1 Configuration of the DIP switch

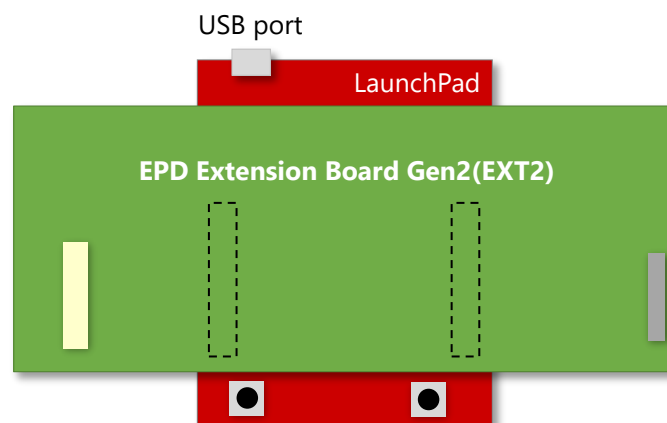
								
	S1	S2	S3	S4	S5	S6	S7	S8
(eTC) 1.44 2.0	0	0	0	0	0	0	1	-
(eTC) 1.9 2.6 2.71	0	0	0	0	0	0	0	-
(iTC) 2.15	1	0	1	0	0	0	0	-
(iTC) 2.87 4.2	0	1	0	1	0	1	0	-

When connecting with any EPD, please always check with this table and switch each shift register from S1 to S8 accordingly. The 0 means Off and set the shift register at the bottom. The 1 means On and set the shift register to the top. The dash means (don't care) either 0 or 1 is fine.

2.1.3 Stack the EXT2 board on LaunchPad

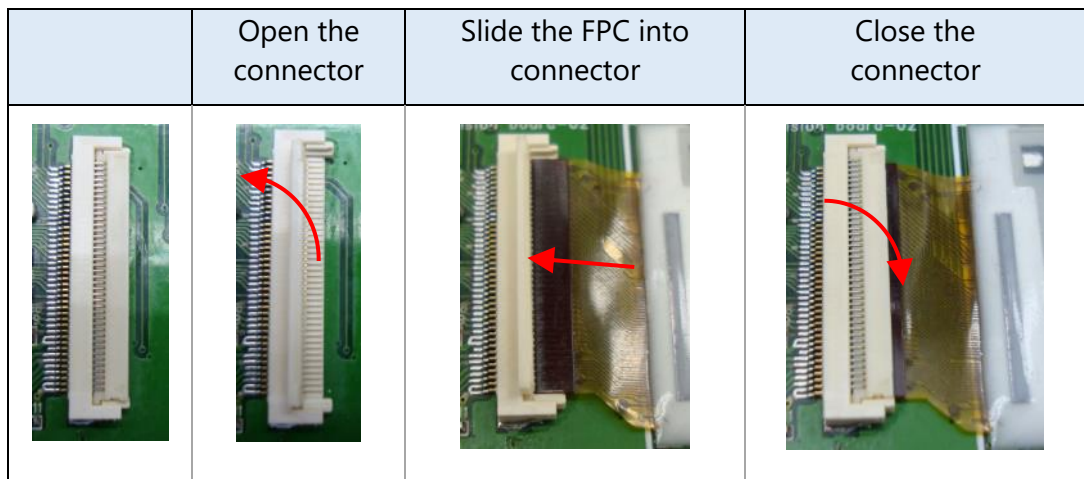
After adjusting the jumpers of LaunchPad and EXT2, please stack the EXT2 board on LaunchPad. There are two 20 pins socket at the rear of EXT2 board allows user to stack on LaunchPad board. Please make sure the assembly direction of EXT2 board to align with LaunchPad headers. Most of the cases, when facing to the LaunchPad, the USB port is at the top side.

Figure 2-1 Stack EXT2 on LaunchPad



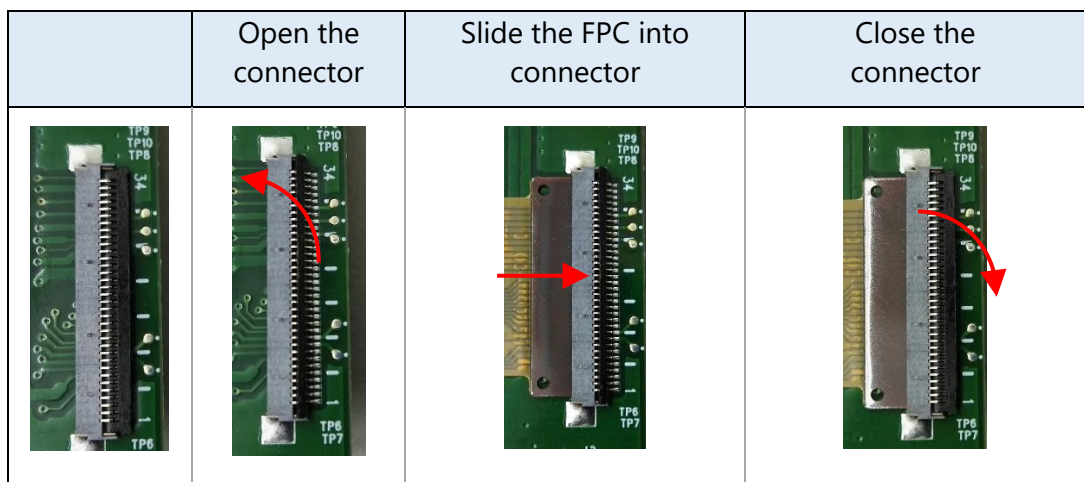
2.1.4 Connect the EPD to the EXT2 board

- Connecting with 40-pins eTC connector (J1)



Note the pin1 is at the top side.

- Connecting with 24/26-pins iTC connector (J3/J2)



Note the pin1 is at the bottom side.




2.2 Programming firmware to LaunchPad

Before you proceed to get started with EXT2 kit, you have to download the EXT2 project source code from PDI website in advance.

Download link: [EPD Extension Board Gen2 \(EXT2\)](#)

You will be asked to fill out your basic contact information and then you will receive an email to show the download link.

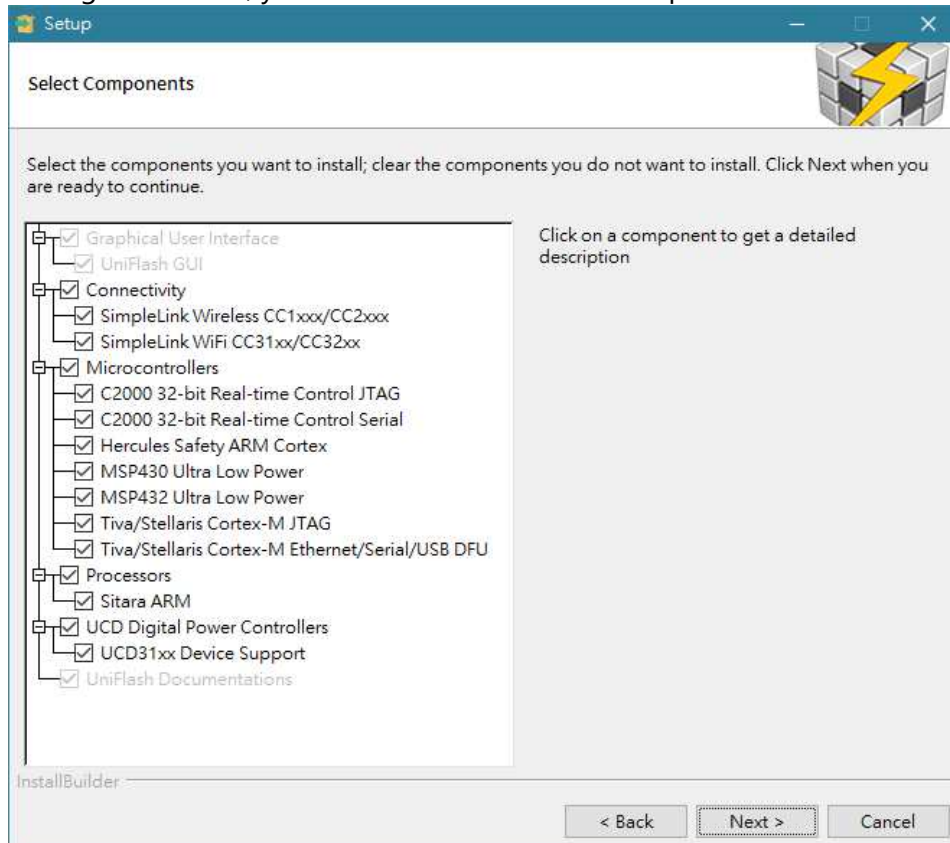
Please download and extract it (.RAR file format usually).

	 <p>If you don't have CCS or you don't plan installing CCS to develop EPD product and will just want to demo or test EPDs, please refer to section 2.2.1 Download firmware file to LaunchPad by UniFlash which is the next section.</p>
	 <p>If you have CCS installed and you will develop EPD product based on our provided project source code, please go to section 2.2.2 "Install CCS and setup driver library" to section 2.2.4 to program the project code in CCS IDE.</p>

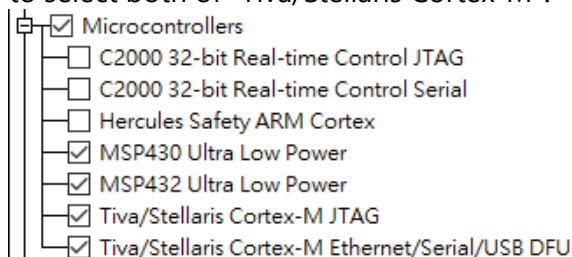
2.2.1 Download firmware file to LaunchPad by UniFlash

[CCS UniFlash](#) is a free of charge and standalone tool used to program on-chip flash memory on TI MCUs and on-board flash memory. Uniflash has a GUI, command line, and scripting interface.

- Please download CCS UniFlash tool from [this link](#) and install it in your computer. It's better you can read the [Quick Start Guide of UniFlash](#).
- During installation, you will be asked to select Components.



Depends on what LaunchPad will you connect with, you will just need to select the Microcontrollers. For example: MSP-EXP430F5529LP to select "MSP430 Ultra Low Power", MSP-EXP432P401R to select "MSP432 Ultra Low Power" and EK-TM4C123GXL to select both of "Tiva/Stellaris Cortex-M".



- In next step, deselect the Debug Probes

Drivers and support files for Blackhawk JTAG debug probes.

Blackhawk Debug Probes

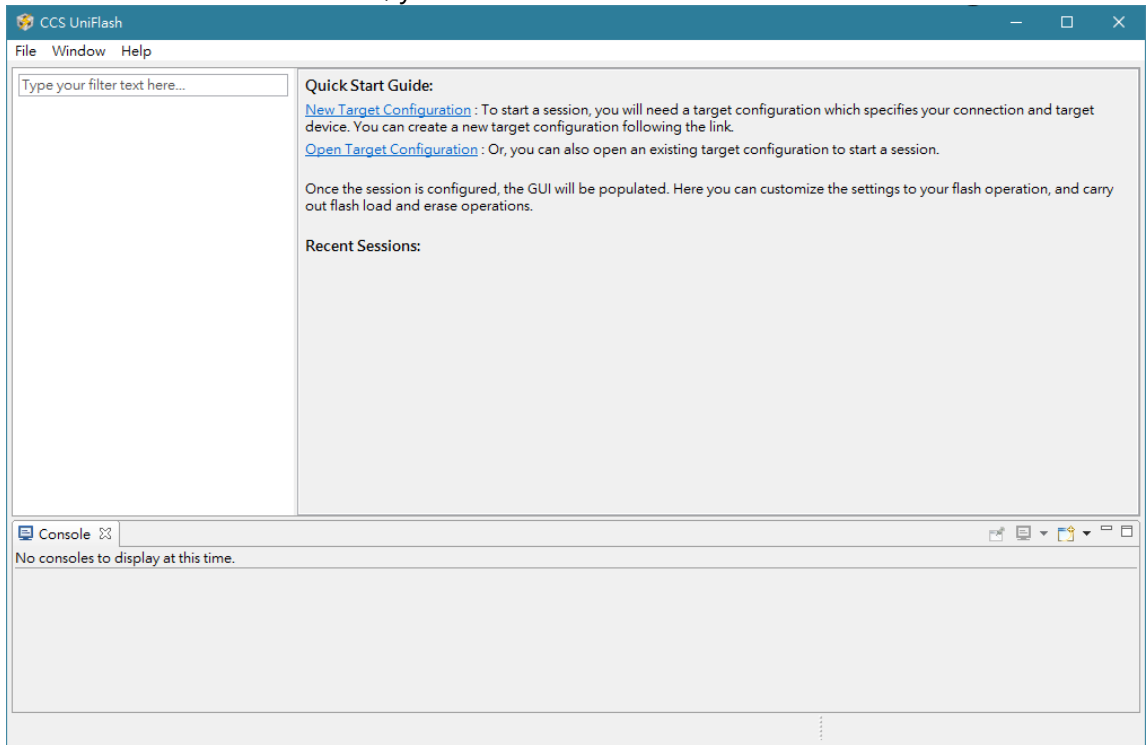
Drivers and support files for Spectrum Digital JTAG debug probes and development boards.

Spectrum Digital Debug Probes and Boards

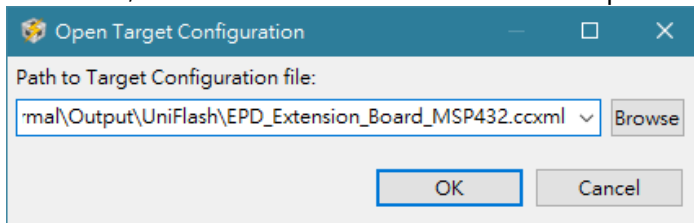
Click Next until the CCS UniFlash is installed in your computer.



- Launch the CCS UniFlash tool, you will see the clean user interface below

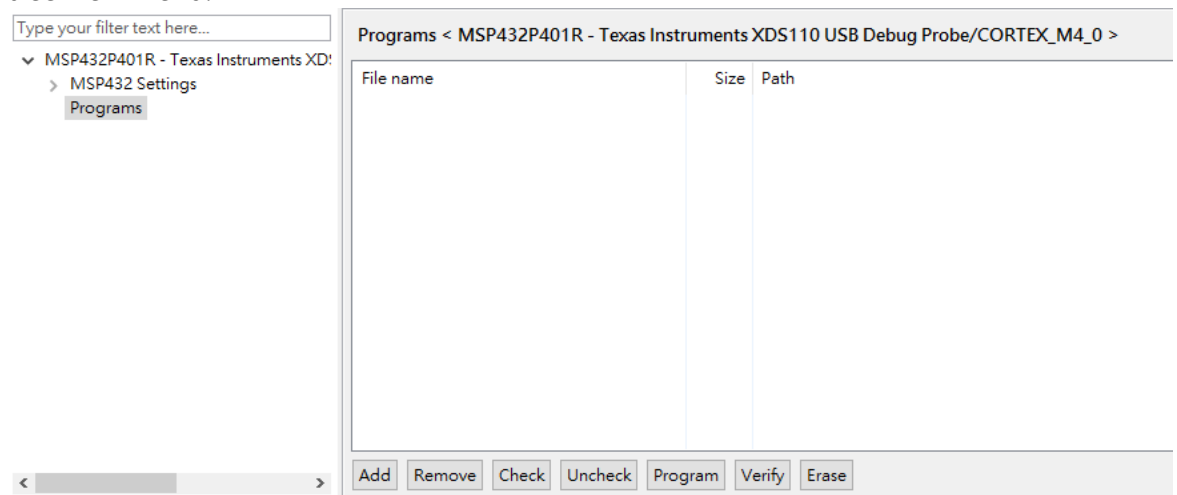


We have setup Configurations for our supported LaunchPads for you to use directly. Click on menu to select [File] / [Open Configuration] / [Browse] to select the configuration file at the extracted folder from “EPD Extension Board Gen2 (EXT2)” project code under [Output] / [UniFlash] folder. Please select the LaunchPad name accordingly (EPD_Extension_Board_LaunchPadName.ccxml). Hereafter, will use MSP-EXP432P401R as example:



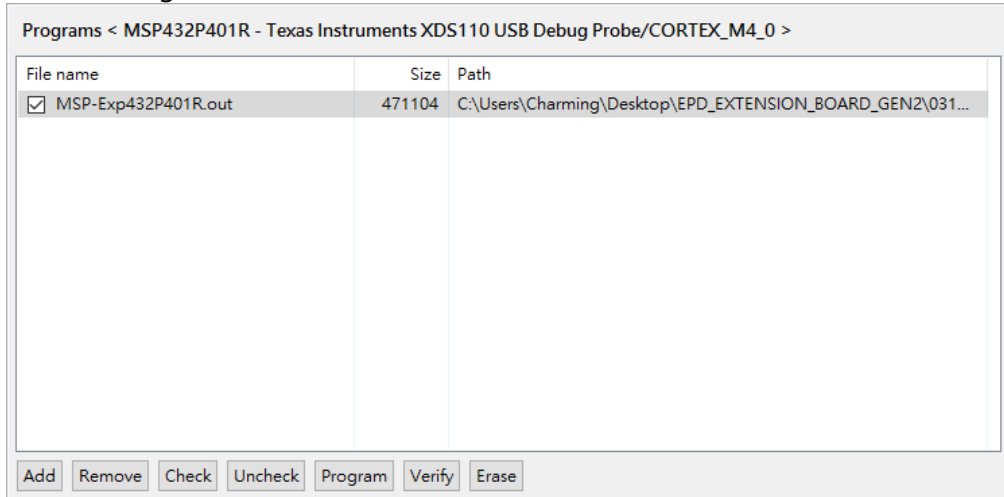
Click OK button to complete this step. You will see the configuration be loaded automatically in the CCS UniFlash tool.

- In general, you don’t need to change all the setting. Just select the [Programs] from the tree view menu.



Click the **Add** button to select the .out file for programming. Switch the folder under

[Output] of "EPD Extension Board Gen2 (EXT2)" project code and click Open button to add the Program in the list. In this case, we select MSP-EXP432P401R.out.



- Click the **Program** button to start programming the firmware into LaunchPad. If there is no error appears in the Console window and it reports "Programs operation finished." which means the programming work is loaded successfully.
- You can now close the CCS UniFlash tool and go to Section 2.3 Installing the PDI Apps.

2.2.2 Install CCS and setup driver library

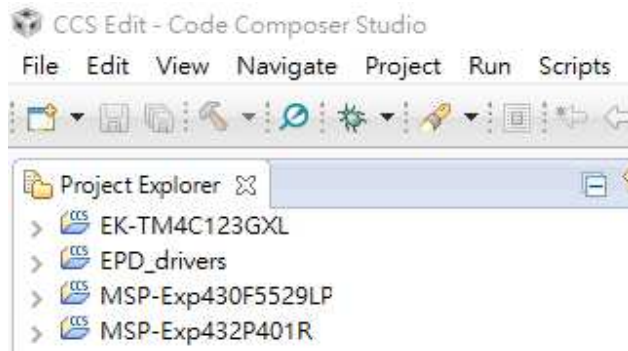
The sections from this to 2.2.4 are for user will develop EPD and debug with our provided project source code in CCS IDE.

Before proceeding to program project code into LaunchPad by CCS, you will need to download the following software.

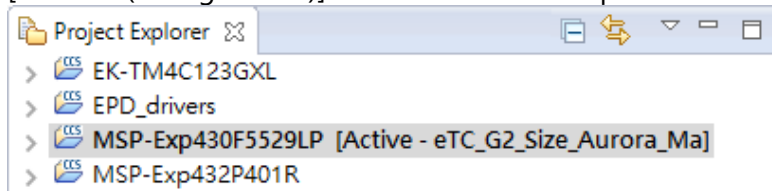
- The latest version of TI [Code Composer Studio™](#) (CCS) and install in your computer.
 - 💡 During the installation, please select **MSP430 compiler** and **ARM compiler** at least.
- After installed the CCS, you have to install the driver library to work with your LaunchPad that will develop with. Download and install the latest driver library at:
 - MSP-EXP430F5529LP LaunchPad: [MSPWare](#)
 - EK-TM4C123GXL LaunchPad: [TivaWare™ software for C Series Software \(Complete\)](#)
 - MSP-EXP432P401R LaunchPad: [MSPWare](#)
- Try to connect with your LaunchPad on USB port and see if your Device Manager can detect the COM ports (COM number may different) as follows. If not, please install the USB driver of the LaunchPad accordingly.
 - 💡 There is an alternative way to install drivers. You can install CCS UniFlash that is introduced in Section 2.2.1.
 - **MSP-EXP430F5529LP** LaunchPad:
 - 🖨️ MSP Application UART1 (COM13)
 - 🖨️ MSP Debug Interface (COM12)
 the latest MSP430Drivers Windows-installer at [this webpage](#).
 - 💡 If you cannot get the MSP-EXP430F5529LP COM port detected by Device Manager, please refer to the [user's guide of MSP430F5529](#) at section 2.2.3 to 2.2.6.
 - **EK-TM4C123GXL** LaunchPad:
 - 🖨️ Stellaris Virtual Serial Port (COM8)
 the latest Stellaris® ICDI Drivers for Windows at [this webpage](#) or [this webpage](#).
 - 💡 If you cannot get the EK-TM4C123GXL COM port detected by Device Manager, please refer to the [user's guide of TM4C123G](#) at section 2.3 to 3.2.
 - **MSP-EXP432P401R** LaunchPad:
 - 🖨️ XDS110 Class Application/User UART (COM3)
 - 🖨️ XDS110 Class Auxiliary Data Port (COM4)
 the latest XDS Emulation Software Package for Windows at [this webpage](#).
 - 💡 If you cannot get the MSP-EXP432P401R COM port detected by Device Manager, please refer to the [user's guide of MSP432P401R](#) at section 2.3.1 to 2.3.3.

2.2.3 Load project and program firmware by CCS

Open CCS and switch the workspace to the root folder of EXT2 project code. After loading the project code in CCS IDE, you will find the Project Explorer like the screen capture below. The newer project code will support more LaunchPads in the list.



- Click on the Project name of your current LaunchPad. The project name will be added [Active – (configuration)] at the end. For example:



- Right click on the project name and find [Build Configurations] / [Set Active] from the pop-up submenu. You will see the configuration list. The format is:

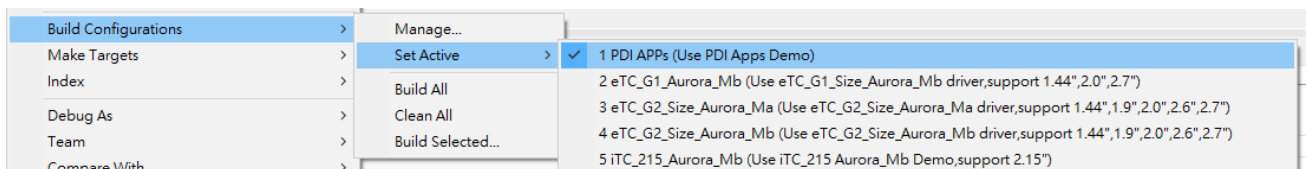
DriverType_(DriverID if eTC)_Size_FPL_Description

Where:

- DriverType = iTC, eTC
- DriverID = G1, G2
- Size = 144, 190, 200, 215, 260, 271, 287, 420 and more, or “Size” for same group
- FPL = Aurora_Ma, Aurora_Mb, Spectra
- Description = detail description of the configuration

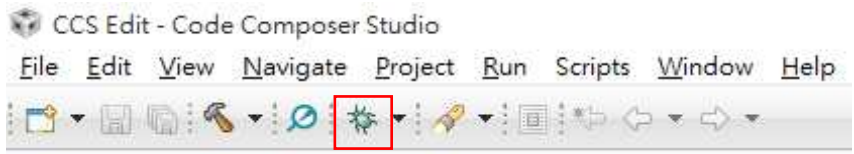


There is a configuration “**PDI APPS**” at the top for working with the PDI Apps utility that supports all models.





If you don't know **how to recognize the size, FPL and driver type**, please refer to [this webpage](#) and check the rear label of display.


- Please make sure you have selected the correct configuration before programming to LaunchPad and the project name follows correct [Active – configuration] you have selected.
- Click on the [Debug] button of tool bar or right click on the project to select [Debug As] / [1 Code Composer Debug Session].



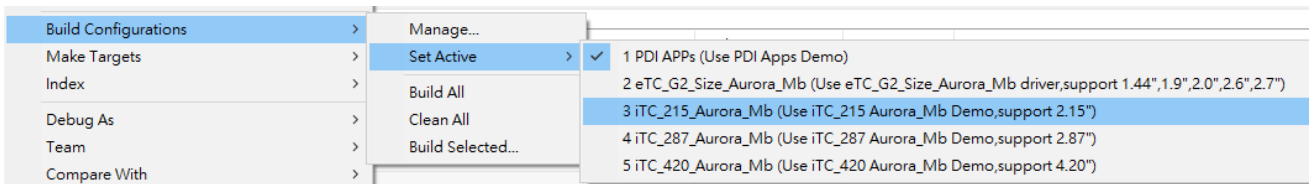
- A progress information window will pop up and start to download firmware code to the microcontroller of LaunchPad board. Once the download process is done successfully with errors, the LaunchPad board is now built and tested of the firmware code. You can start debugging the code.

Click the  Terminate button go back to CCS Edit.

 If you didn't select the configuration of "PDI APPs", you will see the display be updated between two images alternately. For more details of selecting the configuration to Single mode, please refer to the conf_EPD.h file in section 4.2 at page 39.

 If your CCS is free license, the code size is 16KB only for MSP430 family. Due to this limitation, if you are using MSP430F5529 LaunchPad, you will get the out of memory error when compiling with "PDi Apps" configuration. You may need to

- (1) order license of CCS,
- (2) program the .out file by UniFlash,
- (3) select single drive configuration without working with PDi Apps below.

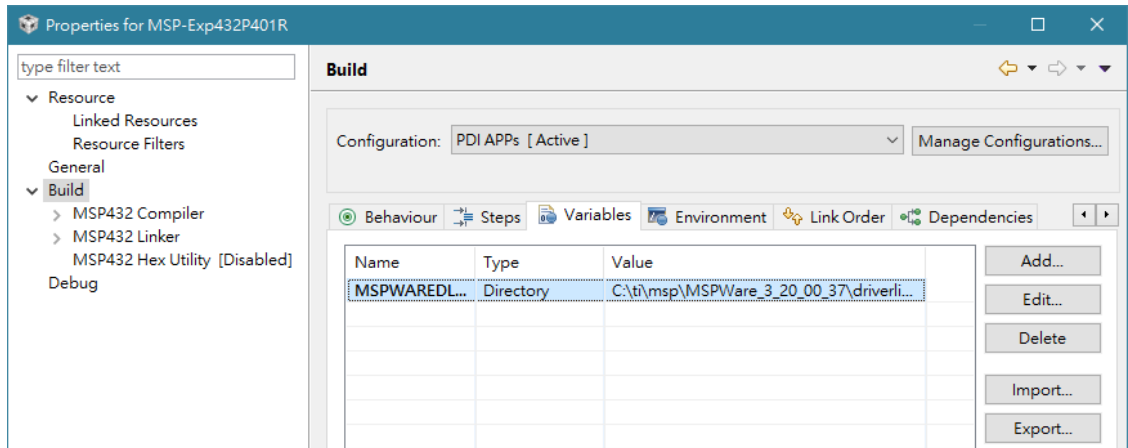


2.2.4 Set driverlib path of MSP-EXP432P401R and EK-TM4C123GXL

If you got errors with MSP-EXP432P401R or EK-TM4C123GXL when compiling, it should be caused by the wrong MSPWare/TivaWare library path settings.

- **Build Variables**

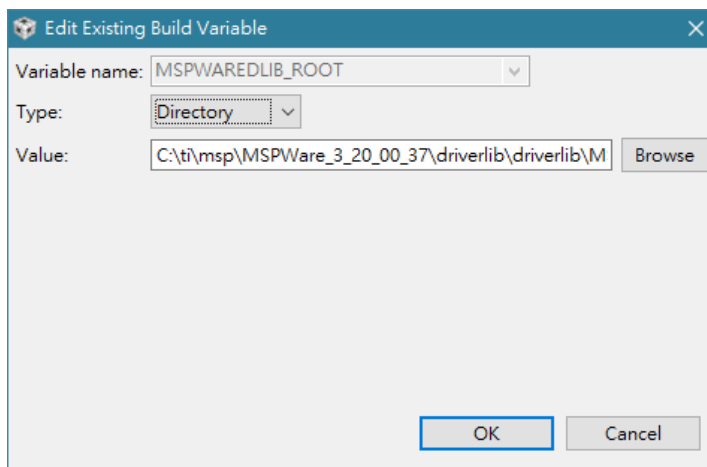
Please right click on project and select [Properties] and find [Build] from the tree view. Select [Variables] tab to set the variables name of library path in your computer.




Please make sure the value would be:

LaunchPad	Variable name	Type	Value (same as value in Linked Resources)
MSP-EXP432P401R	MSPWAREDLIB_ROOT	Directory	C:\ti\msp\MSPWare_#_##_##_##_\driverlib\driverlib\MSP432P4xx
EK-TM4C123GXL	TIVAWAREDLIB_ROOT	String	C:\ti\TivaWare_C_Series-#.#.#.###

Where the # are the version number you have installed in your computer at section 2.2.2. Please click the [Edit] button to ensure you can find the directory and have set the correct directory.



 As before 2016/Oct/1, the version of TivaWare_C_Series is v2.1.3.156, MSP430 is v3.50.00.02 and MSP432 is v3.50.00.04 for your reference. The project code of EXT2 will be updated to compile with the libraries.

2.3 Installing the PDI Apps

- Download the **PDI Apps** from [EPD Extension Board Gen2 \(EXT2\)](#) webpage. You will be asked to fill out your basic contact information and then you will receive an email to show the download link.

Please note the installer is for Microsoft Windows OS only and Windows 7 above.

The installer name is "PDI_Apps_v#.##_Setup.exe" where the # is number for tool version. Double clicks the installer to start the installation.



PDI_Apps_V1.20
Setup.exe

- Follow the instructions on the screen to install the utility. After installed, you will find there is a shortcut "PDI_Apps" placed on your desktop.

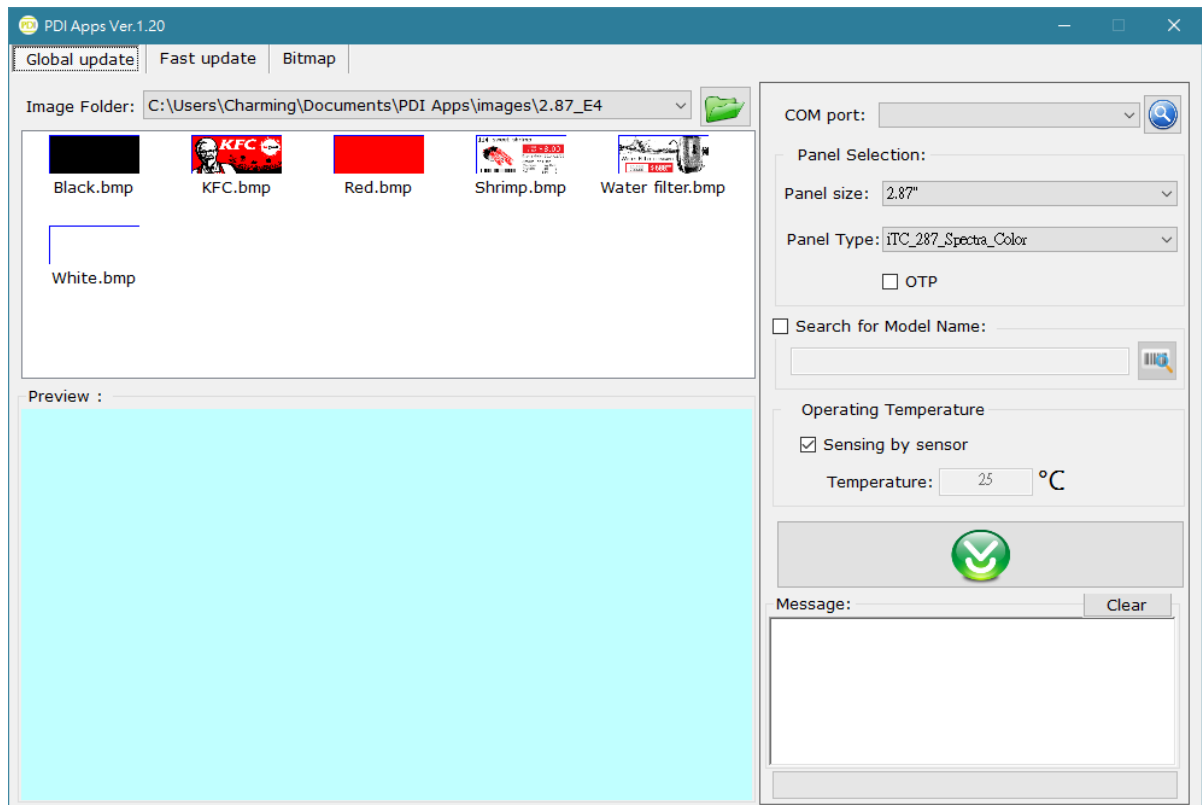


PDI_Apps

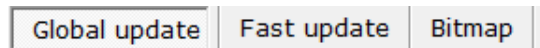
- Per the LaunchPad you will connect with EXT2, there is USB driver needs to be installed. Please refer to Section 2.2.2 to make sure you get the COM ports can be detected in Device Manager in advance.

2.4 Working with PDI Apps

Double click on the PDI_Apps icon on your desktop. The initial screen will similar to the picture below.



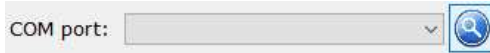
There are three main functions built in this Apps: Global Update, Fast Update and Bitmap converter.




2.4.1 Global Update

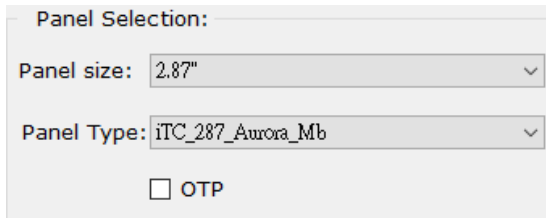
This function will send our standard driving waveform to EPD and perform a complete global (full) update cycle including power on and power off the EPD. Global Update provides the best optical performance and will perform three or four update stages.

- **COM Port:**



If you've programmed the firmware well, the COM port will be auto detected and the message area will show COM port is connected to your EXT2 board with firmware version information. If there is no COM port detected, please click the  button to detect again and select the correct COM port from the dropdown list.

- **Panel Selection:**



Here will list the supported sizes and types of EPD by the programmed firmware. Please select the size first and the second dropdown will list the supported DriverType_Size_FPL accordingly. If you don't know how to recognize the size, FPL and driver type, please refer to [this webpage](#) and check the rear label of display.

The **OTP** means **One-Time Programmable (OTP)** function which is the driving waveform preprogrammed in driver IC of EPD in factory to provide the best tuned performance.

When you are connecting with iTC EPD with EXT2, this OTP option should be always selected.

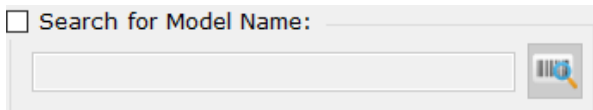



The OTP option can be selected when the Panel Type is iTC related only.



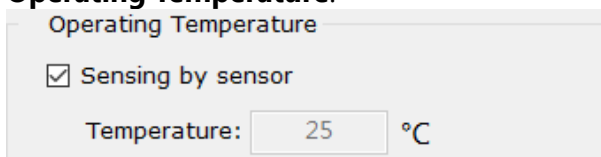
For further support of custom **LUT (Lookup Table)** not by OTP, please contact us for more information.

- **Search for Model Name:**



If it's still hard for you to select the correct EPD size and type at the previous step, you can use barcode scanner to scan the barcode or type the serial number on the rear label of the display, then click the  button to help you select the correct EPD type.

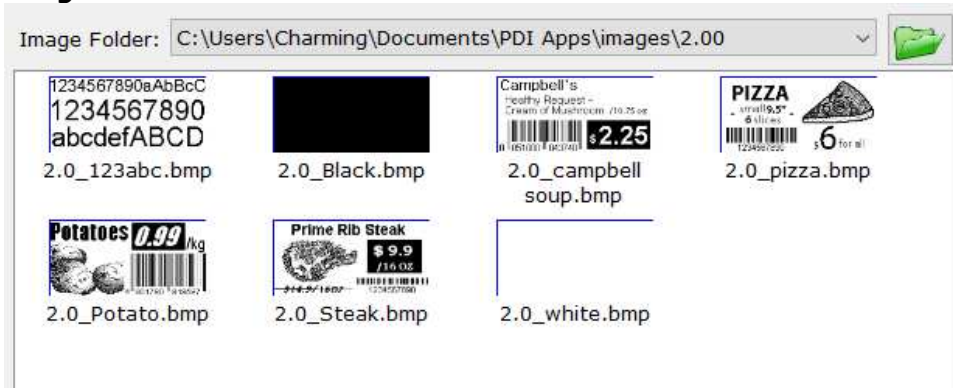
- **Operating Temperature:**




The EPD needs temperature information to compensate the total update time. If you've checked with the **Sensing by sensor**, the following update will get the temperature

value from the onboard thermal sensor. If you uncheck with the auto sensing, you can specify the temperature in the textbox to evaluate the update time accordingly. This option is used for real ambient temperature. If you define the custom temperature at different ambient temperature environment, you may get abnormal phenomenon on the display.

- **Image Folder:**



After installed the PDI Apps, we provide some demo patterns in your user folder at [C:\Users\...\Documents\PDI Apps\images]. Click on  button to select the size folder of EPD and then the thumbnails will be listed in the area below. You can also select any dimension of picture and this tool will convert it to panel size (ex.2”) as bitmap file format for update.

Double click on the image you like to update on EPD, the image will show on the preview area.

- **Download image to EPD:**



Click on this button to update the selected image to the EPD. You will get the information in the Message area including temperature and total update time.