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## Tower EPD (TWR-EPD) Module

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### Preface

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TWR-EPD Display Module is a Tower™ System peripheral module to the Freescale® Tower System MCU and Process module. Take your design to the next level of Tower System and begin constructing your ultra-low power E-Paper display (EPD\*) project with provided CodeWarrior™ Development Studio project source code giving you to create more differentiated solutions.

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

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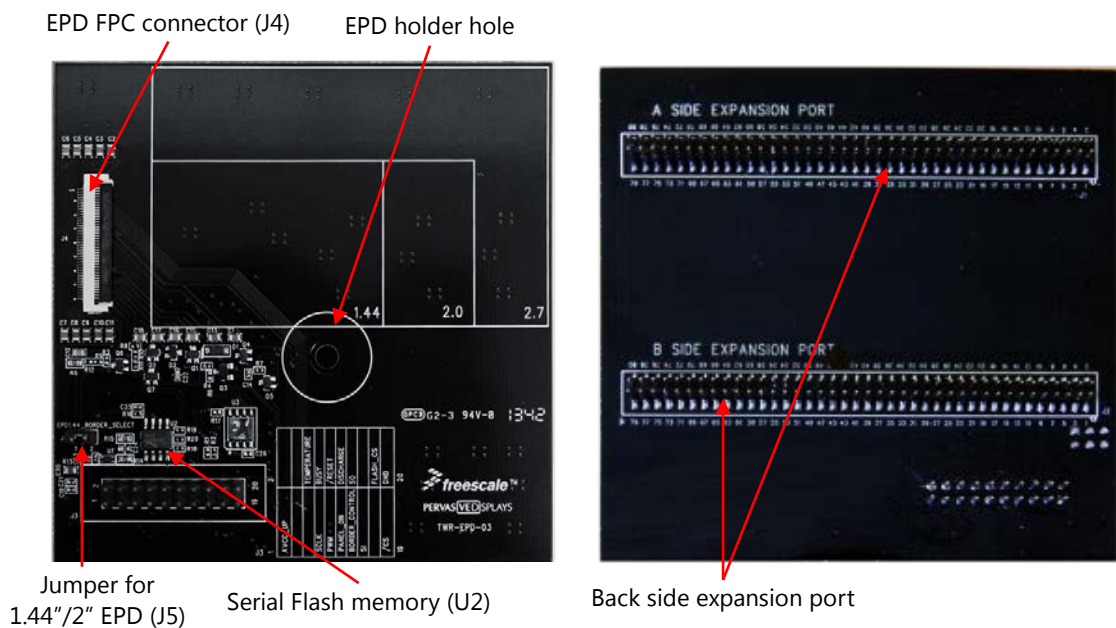
# 1. Introduction

## 1.1 Board overview

The Tower EPD display module (TWR-EPD, model name: S0000AS0T1) is a side mounting e-paper display module that is designed to add e-paper functionality to embedded designs using the [Freescale™ Tower System](#), a modular development platform that enables rapid prototyping and tool re-use through reconfigurable hardware. The TWR-EPD module is designed for use with the [TWR-KL25Z48M](#) Kinetis MCU module from Freescale.

An onboard 40 pins FPC connector attaches Pervasive Displays Inc. (PDI)'s E Ink based EPD modules. The onboard 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 TWR-EPD module. The sample CodeWarrior™ project provides source driving waveform with command interface to update content on EPD panel.

**Figure 1.1 TWR-EPD Display Module**



## 1.2 Features

- Supports driving 1.44", 2" and 2.7" EPD panels including V110 and V230 FPL (Front Plane Laminate)
- Attaches with the provided primary TWR-ELEV module
- On board 8M bits serial flash memory and temperature sensor
- Open documentation and CodeWarrior project driving source code for EPD panel
- 20 input/output test points for measuring GPIO signals

## 2. Getting started

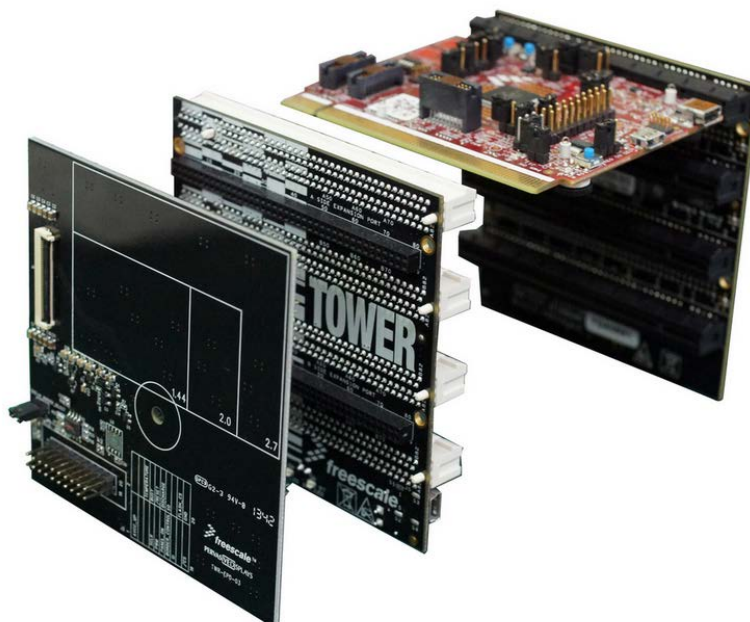
### 2.1 Before you get started

You will need the following:

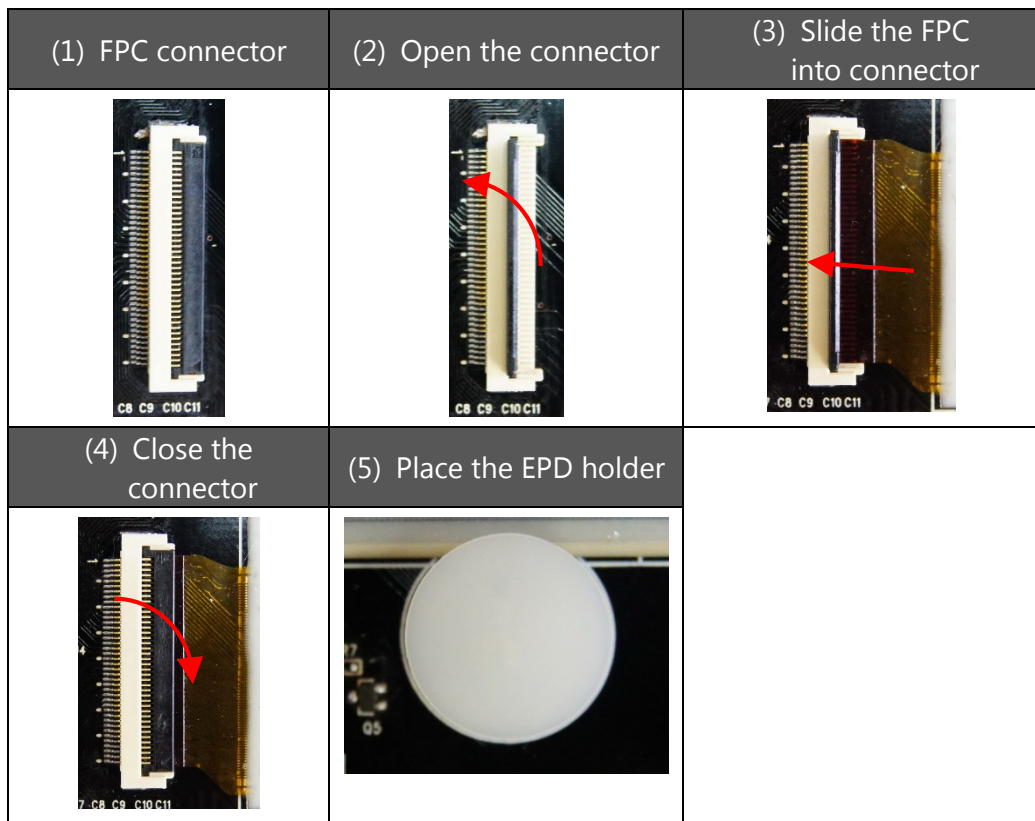
- TWR-EPD module with 1.44", 2" or 2.7" EPD (S0000AS0T1)
- Primary and secondary (optional) TWR-ELEV module (The primary TWR-ELEV has been provided with this kit.)
- TWR-KL25Z48M Kinetis KL2x MCU Module (default supported)
- One mini-USB cable
- Freescale CodeWarrior Development Studio for MCU

### 2.2 Step-by-Step Installation Instructions

1. Attach the TWR-EPD module with the provided primary TWR-ELEV module exactly.  
**Note:** To avoid damaging the TWR-EPD module, it is recommended that the TWR-EPD module not be detached from the primary TWR-ELEV later.
2. Attach a secondary TWR-ELEV module along with TWR-KL25Z48M MCU modules for complete Tower System assembly. Ensure that the Tower System modules are properly aligned to the primary and secondary edges, with the TWR-EPD attached to the primary side.



3. Connect EPD panel to TWR-EPD module



4. Download and install [CodeWarrior Development Studio for MCUs](#) version 10.6 above
5. Download [TWR-EPD for TWR-KL25Z48M](#) source project.
6. Connect one end of USB cable to the PC and other end to the mini-B connector on the TWR-KL25Z48M module. Allow the PC to automatically configure the USB driver if needed.

## 2.3 Design documentation and related links

The following list contains links to the most relevant documents and software for TWR-EPD display module.

1. [TWR-KL25Z48M](#) – the Kinetis KL2x Tower System MCU Module.
2. [CodeWarrior Development Studio for MCUs](#) - CodeWarrior Development Studio is a complete Integrated Development Environment (IDE) that provides a highly visual and automated framework to accelerate development of the most complex embedded applications.
3. [TWR-EPD display module](#) on PDI website.
4. [TWR-EPD User Guide](#) - PDF version of this User Guide.
5. [TWR-EPD Design Documentation](#) - package containing schematics, BOM, Gerber files etc.
6. [TWR-EPD CodeWarrior source project](#) – the EPD waveform driving source code and demonstration with CodeWarrior Development Studio.
7. COG Driver Interface Timing document (hereinafter COG document) - explains the driving process (waveform) of COG driver of EPD for a MCU based solution. PDi has released two versions of COG which are G1 and G2
  - G1 COG document: [download link](#).
  - G2 COG document: [download link](#)

### 3. Hardware user guide

#### 3.1 TWR-KL25Z48M: Kinetis KL2 Tower System Module

Freescale Part Number: TWR-KL25Z48M

The TWR-KL25Z microcontroller module is designed to work either in standalone mode or as part of the Freescale Tower System, a modular development platform that enables rapid prototyping and tool re-use through reconfigurable hardware. Take your design to the next level and begin constructing your Tower System today by visiting [www.freescale.com/tower](http://www.freescale.com/tower) for additional Tower System microcontroller modules and compatible peripherals.

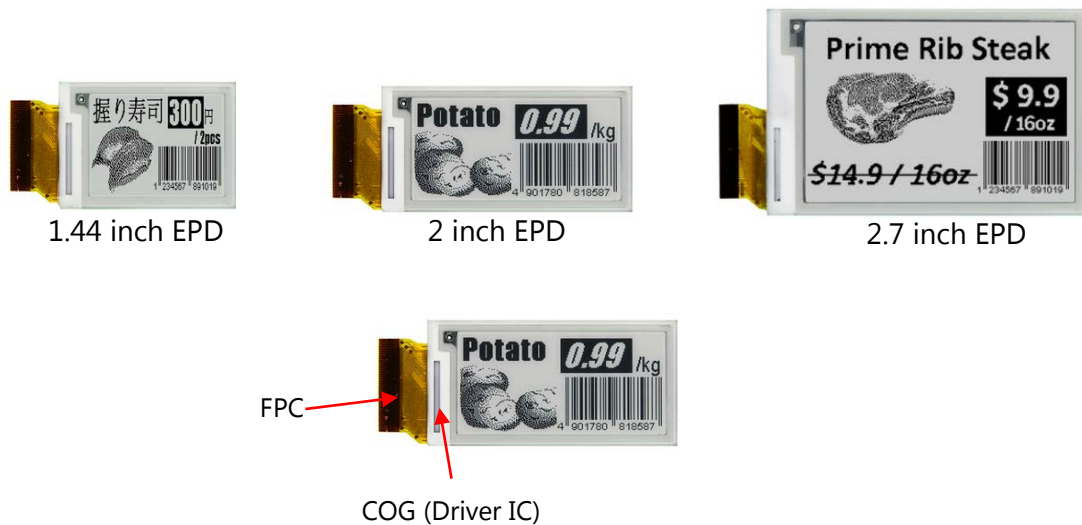
For TWR-KL25Z specific information and updates visit [www.freescale.com/TWR-KL25Z](http://www.freescale.com/TWR-KL25Z)

TWR-KL25Z48M User Manual: [TWR-KL25Z-UM](#)

#### 3.2 EPD panel

TWR-EPD display module 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 TWR-EPD display module supports the EPD panel that embedded FPL material (Front Plane Laminate that provided by [E-Ink](#)) are version of V110 and V230.

The G1 COG is combined with V110 FPL and the G2 COG is combined with V230 FPL.

### 3.3 EPD Specification

**Table 3.1 EPD panel specification**

Item	Specification		
	1.44	2	2.7
EPD Size (inch)	1.44	2	2.7
Part Number (V110 FPL)	EK014AS014	EG020AS012	EM027AS012
Part Number (V230 FPL)	EK014BS011	EG020BS011	EM027BS013
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](http://www.pervasivedisplays.com/products/panels) for more details on EPD panel specification.

User can recognize the FPL version by the model name of EPD where the 6<sup>th</sup> digit is A for V110 with G1 COG and B for V230 with G2 COG. For example, EG020AS012 is 2.0" V110 EPD, EM027BS013 is 2.7" V230 EPD.



### 3.4 Headers and connectors

#### 3.4.1. The jumper of EPD border select (J5)

There is a jumper J5 arranged on TWR-EPD module board. Around the active area of the EPD is a 0.5mm width blank area called the border. The J5 jumper is special used for 1.44" V110 and V230, and 2" V230 EPDs to clear its border area per each update screen. When connecting such EPD with TWR-EPD module, the J5 jumper must be closed, otherwise the border area will get darker after several updates.

**Note:** Although the silkscreen and Quick Start Guide printing were printed "EPD1.44\_BORDER\_SELECT", but this jumper is now for 2" and 1.44" EPD.

**Table 3.2 J5 jumper setting for EPD border select**

	1.44" V110, 1.44" V230, 2" V230	2" V110, 2.7" V110, 2.7" V230
J5 jumper	<b>Close</b>	<b>Open</b>



#### 3.4.2. Measurement Points of EPD (J3)

TWR-EPD module provides J3 for user to measure the GPIO signals. See **Table 3.3** below. User can also via this headers to bridge with other development kit or product that has MCU to drive EPD as an EPD extension board. The pin assignment has arranged on silkscreen of PCB.

**Table 3.3 J3 Pin-out of TWR-EPD module**

Pin	Function	Description
1	VCC	Supply voltage 3.3V
6	TEMPERATURE	Temperature sensor
7	SPI_SCLK	Clock for SPI
8	BUSY	COG busy pin (GPIO)
9	PWM	Pulse width modulation. Square wave when EPD power on (PWM)
10	/RESET	Reset signal. Low enable (GPIO)
11	PANEL_ON	COG driver power control pin (GPIO)
12	DISCHARGE	EPD discharge when EPD power off (GPIO)
13	BORDER_CONTROL	Border control pin (GPIO)
14	SPI_MISO	Serial output from EPD to host MCU
15	SPI_MOSI	Serial input from host MCU to EPD
18	FLASH_CS	On board Flash chip select (GPIO)
19	/EPD_CS	EPD chip select (GPIO)
20	GND	

## 4. Working with CodeWarrior project code

### 4.1 Project file explanation

The table below describes the files and folders of **Sources** directory.

**Table 4.1 The file explanation of CodeWarrior project of TWR-EPD module**

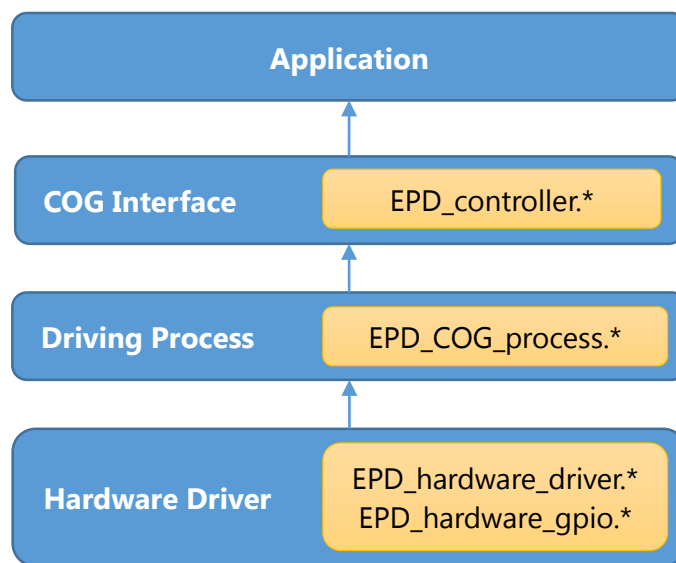
[Folder]/-File	Description
- ProcessorExpert.c	The entrance file controls all of the demonstrations. There is quick start guide described at the bottom of this file.
- conf_EPd.h	The EPD configurations: <ul style="list-style-type: none"> <li>• COG_VXXX_GX: defines which COG driving waveform model will be used</li> </ul>
- image_data.*	It defines the image arrays of each EPD size for demonstration
[Pervasive_Displays_small_EPd]	The EPD driving source directory
- 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_hardware_gpio.*	GPIO pins configuration
- EPD_COG_process.h	The common definition of COG driving process
- EPD_controller.*	The application interface for external function to work with EPD
- EPD_COG.c	The link source of different COG and EPD switching to be used
- [COG]	Each COG driving file presents the different waveform driving processes of COG and updating stages. The parameters of driving different EPD is defined at COG_parameters_t structure which is easy for developer adjusting initial parameters, resolution, frame time of MCU and the size of data line. <ul style="list-style-type: none"> <li>• [V110_G1]: The EPD has built in E Ink V110 FPL (Front Plane Laminate) with version 1 COG.</li> <li>• [V230_G2]: The EPD has built in E Ink V230 FPL with version 2 COG.</li> </ul>
- EPD_COG_process_V110_G1.c	The waveform driving processes and updating stages of G1 COG with V110 EPD

<p>- EPD_COG_process_V230_G2.c</p>	<p>The waveform driving processes and updating stages of G2 COG with V230 EPD. User is able to adjust the EPD_WaveformTable structure to fine tune the update speed or display quality.</p>
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## 4.2 Driving waveform architecture

There are command interfaces defined in EPD\_controller.c for developer to call directly. Logically developer doesn't need to change the codes in this folder in order to keep correct driving the EPD panels.

**Figure 4.1 The code structure of driving waveform**



## 4.3 Programming firmware to work with TWR-EPD module



### 4.3.1. Configure connected EPD size

Load the TWR-EPD CodeWarrior source project.

Before programming firmware onto the MCU of TWR-EPD module, user should make sure the definition of EPD size and COG/FPL version in project code are same as the connected EPD panel. To do this:

- Open the image\_data.h file and find the `#define USE_EPD_Type USE_EPD200`. If you are connecting the 2.7" EPD with TWR-EPD, the `USE_EPD200` must be changed to `USE_EPD270`, where `USE_EPD144` is for 1.44" EPD, `USE_EPD200` is for 2" EPD and `USE_EPD270` is for 2.7" EPD.
- For changing the COG and FPL version, please open the conf\_EPd.h and find the `#define COG_V110_G1`. Options are `COG_V110_G1` and `COG_V230_G2`.

### 4.3.2. Working with Freescale CodeWarrior IDE

1. Make sure you are connecting well with TWR-KL25Z48M module to your USB port of computer via USB cable.
2. Right click on project and do [Clean Project] and [Build Project] to make sure the project code without errors.
3. Click the  Debug button. A progress information window will pop up and start to download firmware code to the MCU of TWR-KL25Z48M module. Once the download process is done successfully without errors, this window will be closed. The Tower module is now built and tested of the firmware code. You can start debugging the code.
4. Click the  Terminate button, you will see two images change on EPD panel alternately.

## 5. Hardware revision history and known issues

### 5.1 Identifying product ID and revision

The revision and product identifier of TWR-EPD module can be found on the front side of the PCB. It always shows on the top of PCB follows "TWR-EPD-" as "nn" type where nn is version number, e.g. 02 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 "A1340016-00-3ymd-ssss" format with barcode (code128).

The serial number string has the following format:

```
"A1340016-00-3ymd-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
```

### 5.2 Revision 3

Revision 1 and 2 are working sample which is never released to the market. Revision 3 of TWR-EPD module is the initial released version. There is no known issue.

## 6. Document revision history

Doc. Rev.	Date	Comment
1	15 April, 2014	First release

## 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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