Partial Update Application Guide

Description	**This application guide describes the method to implement partial update in PDi's EPD**
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Revision History

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Ver. 02	2014/12/01	6, 9, 11 5 10 12	All 1.1 2.21 2.3	Add FAQ Add Note Add Figure 2.2 Add suggested stage time description

1. General Description

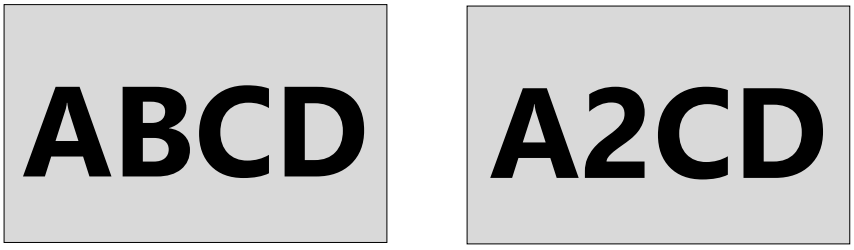
1.1 Overview

Global Update (also known as "Full Update") to update display from one previous image to another image and looks like 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 looks like only the pixels to be changed are refreshed.

Approach	Image	Stage 1	Stage 2	Stage 3	Stage 4
Global Update (For Vizplex and Aurora Mb)	1 Previous image	1 Inverse previous image	White image	2 Inverse new image	2 New image
Partial Update	1 Previous image	2 New image			

Table 1.1 Update stages of Global Update and Partial Update

Take Figure 1.1 as example, the Partial Update just changes from "B" to "2" and keep the other portion unchanged. Compared to Global Update, Partial Update doesn't insert other images (e.g. the entire Black or White pattern) to provide better visual experience and quality.



Before update After update

Figure 1.1 Partial Update

Note: Before you get started reading this Partial Update application guide, please make sure you've understood the Global Update driving waveform. You can download our COG document (Doc No. 4P008-00_03, Doc name is E-Paper Display COG Driver Interface Timing document) for more details.

FAQ:

(1) Why Global Update needs four stages per update cycle but Partial Update just needs one stage?

➔ Any operation to the pixels per update, we must have the total moving distance of black and white particles is equidistant (balance). The standard four stages with suggested stage time (ex. 2" needs 480ms per stage and 2.7" needs 630ms) is the rule to provide the best optical performance and lifetime guarantee by PDi's experiments. It provides the best solution to remove ghosting effect and extend the lifetime of particles. Shorter stage duration can cause easy to see the ghosting image or lighter color.

Partial Update is imbalance movements to particles actually. We use the last stage of Global Update (send new image data directly) to provide the better visual experience and faster update speed. It prevents user to see the blinking effect caused by Global Update. For how to reduce the impact, please read section 2 for more details.

(2) What kind of EPD material type is suitable to implement Partial Update?

➔ We recommend the EPD made by the film material for Vizplex (V110, was EOL) or Aurora Mb (V231). They are more suitable to implement Partial Update.

Due to the material of Aurora Ma (V230) is for wide temperature, the driving waveform is quite different from the other EPDs. The update speed and refresh behavior are not so suited for Partial Update.

1.2 Pros and Cons of Partial Update

1.2.1. Pros of Partial Update

- Better user experience

  In most of cases, the flashing of black and white images causes observers unconformable when user requires continuous viewing screen. There's no similar problem with Partial Update.

- Faster update time

  In the case of Global Update, typically, there are four image stages are used to update EPD to complete an update cycle. Excluding the power-on and power-off stage, the refresh time of Partial Update is 1/4 of Global Update.

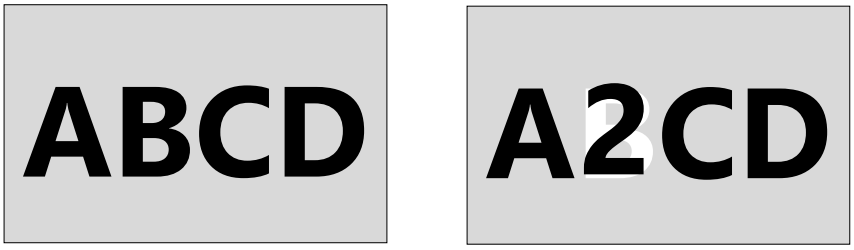
- Less power to move E-paper material

  Since there is only a portion of E-paper material are moved in the case of Partial Update, the power applied on E-paper material is less than that for Global Update.

1.2.2. Cons of Partial Update

- Ghosting of previous image

  Because the characteristic of E-paper material, it's very difficult to make the behavior of every update identical, the reflectance of either black or white may be different. In this case, people will see below image.



Before update After update

Figure 1.2 Ghosting of Partial Update

- More power budget for calculation

  Even less energy is needed to move the E-paper material, we need more calculation to count the coordination and image data from inputs, and it may need more power than ordinary case (i.e. Global Update) to prepare the data for EPD. Hence, including the fixed part (i.e. power-on and power-off) and data preparation, it is possible to require more total power budget to finish a Partial Update than Global Update.

- Current leakage under direct sunlight

  Because EPD uses TFT backplane with ITO electrodes, TFT would be occurred current leakage under sunlight illumination. TFT can't hold voltage and the data is getting down when current leakage happened. Global Update will always refresh every pixel of entire EPD per update cycle. For better visual experience, the Partial Update is just to refresh the pixels to be updated. Due to this feature and there is current remains on the TFT (not always power off EPD per update), it's easy to see the current leakage and ghosting happened on the unchanged pixels/area of EPD under direct sunlight illumination when Partial Update continuously. Global Update has no such issue.

2. Implement Partial Update

2.1 Driving Flow of Partial Update

The Figure 2.1 below is the EPD driving flow chart. The black line blocks are the Global Update stages which is described in PDI's COG document (Doc No. 4P008-00 03, Doc name is E-Paper Display COG Driver Interface Timing). The difference of Partial Update (shown in blue line blocks) is if there is next pattern to be updated on EPD, you are able to write next image data to memory and COG without powering off the COG for better visual experience and faster update time.

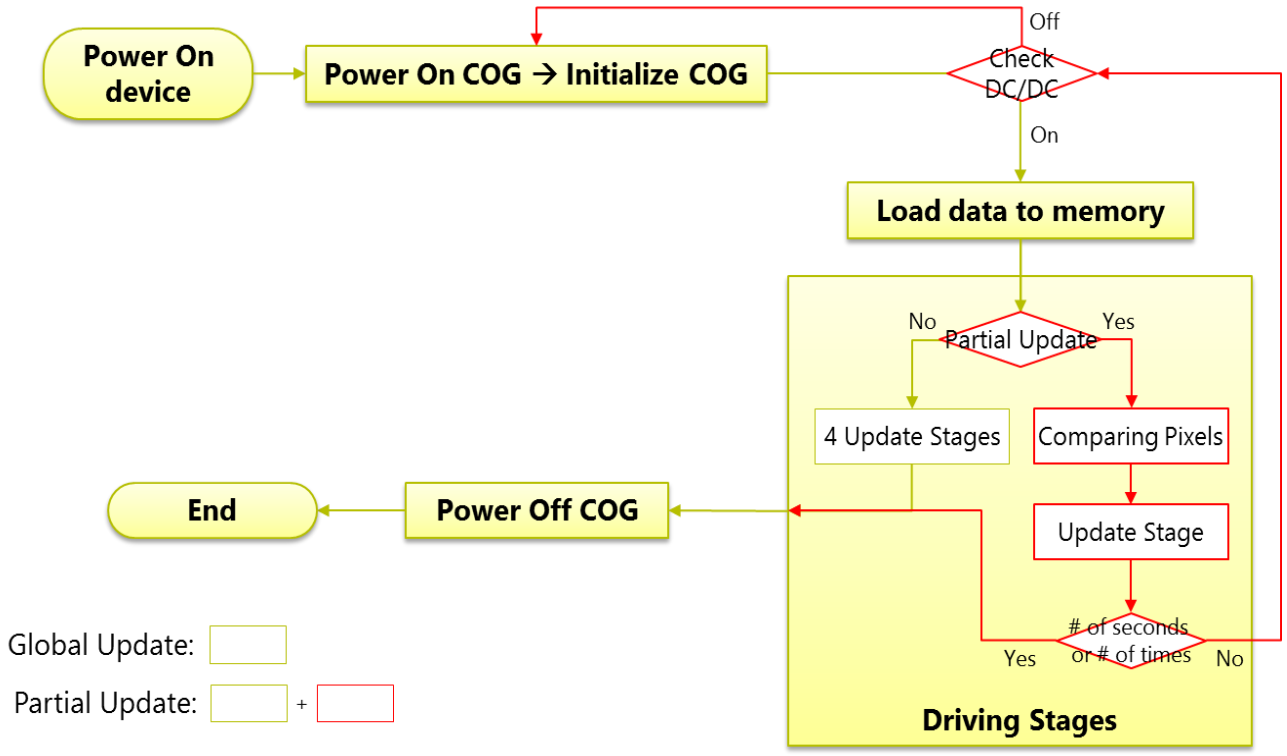


Figure 2.1 Driving flow chart of Global and Partial Update

We highly recommend after several partial patterns have been updated on EPD or finished a demonstration cycle or after a short while without updates (means the "# of seconds or # of times" decision box in Figure 2.1. Please refer to FAQ (3)), it's suggested to perform a standard Global Update stage or Power OFF COG and Power ON while next update to get good optical performance back. It also improves the ghosting.

FAQ:

(3) How many updates or how long of the Partial Update will need a Global Update?

➔ It varies by your scenario, use case, acceptable level and tolerance for ghost images. Please list the detailed screen flows of your case and determine the suitable points to insert Global Update:

- Different template or scene
- A number of partial patterns have been updated, ex. 10 patterns
- After a short while without screen changes, ex. 10 seconds
- Ghosting effect starts to appear on display

(4) Do I need to power ON COG and initial COG per Partial Update?

➔ No, otherwise the COG will be reset again and charge pump of COG may fail to power up. You will see abnormal image on EPD.

2.2 Method to Implement Partial Update

The Partial Update needs two data buffers to store image data. One is for previous image and the other is for new image. The method is new image to compare with previous image data pixel by pixel. Table 2.1 below describes the sending data to do partial update.

Partial Update		Previous Image	
		Black	White
New Image	White	**White**	**Nothing**
	Black	**Nothing**	**Black**

Table 2.1 Sending Data for Partial Update

- If the new data byte is same as previous data byte, send "Nothing" data byte which means the data byte on EPD won't be changed.
- If the new data byte is different from the previous data byte, send the new data byte.
- After updated the image on EPD, the result image should save as previous image in order to be compared with upcoming new image.

See below is an example to compare the data pixel by pixel. Please note you will need to compare each pixel of whole display and decide the data to be sent.

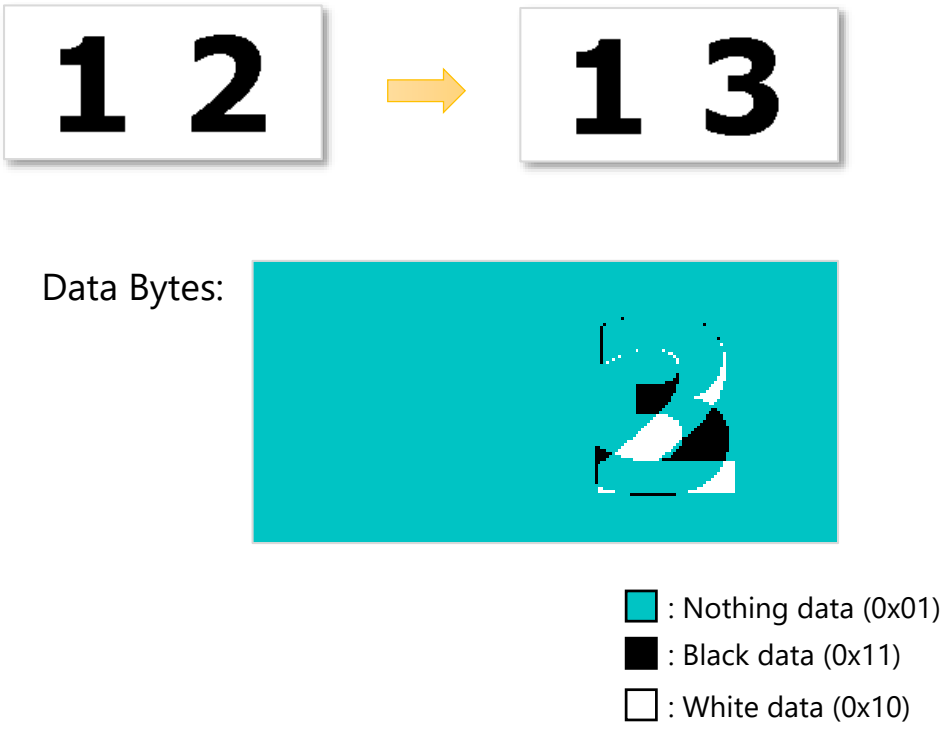


Figure 2.2 An example for sanding data for Partial Update

FAQ:

(5) What will happen if I didn't send "Nothing" data to the unchanged pixels?

➔ When you send the Black or White data to the changed pixels, the particles did move but just not balance. We can run some Global Updates to reduce the impact.
However, if you remove the Nothing data and still send color data (Black to Black, White to White) to the unchanged pixels, the particles were overdriven actually. You will get good image temporarily and clean up the remaining ghosting. Please note the ghosting and overdriven effects are cumulative. You will get abnormal behaviors in the upcoming patterns, especially in lower temperature. When powering off the EPD, you will see the overlapping images obviously. If such wrong driving continues, the situation will worsen resulting in reducing the lifetime of the particles in EPD.

(6) Do I need to refresh every pixel of EPD for Partial Update?

➔ Yes, you will need to compare the data pixel by pixel between previous and new image, and determine sending Black, White or Nothing data byte to each pixel accordingly.

(7) Do I need to choose a more powerful MCU for Partial Update?

➔ Before any pattern of Partial Update to be updated on EPD, the MCU will need extra works to compare the pixel data and store the data byte to memory, It's better to choose a more powerful MCU to implement Partial Update.

Considering the lifetime of Flash memory and operating speed, we also recommend using SRAM as the swapping memory to accelerate the update rate.

2.3 Stage Time and Temperature Factor

Partial update uses same stage time to finish a stage (ex. 2" needs 480ms per stage and 2.7" needs 630ms) and same temperature factors to compensate the different E-paper material speed at different temperature.

You could try to reduce the stage time if update speed for your case is quite critical. If you want faster update rate for Partial Update, you will need to get the frame time of your microcontroller (MCU) in advance. We highly recommend 5 frames at least per stage.

For example, if your frame time is 50ms, the stage time will be 250ms at least which means there will be 4 patterns change in a second. The more frames in a stage, the better optical performance and image quality.

We highly recommend implementing Partial Update for room temperature applications due to the update duration is multiple times of temperature factor.

2.4 Power Estimation of Partial Update

Refer to Table 1.1 and Figure 2.1, excluding the Power On, Initialize COG and Power off, the stage time of Partial Update is 1/4 of Global Update.

Additionally, it's necessary to include in the calculation as well as:

(1) Compare the data of previous image and new image

(2) Prepare the new image data and upload to memory

(3) Extra energy to Power off COG or perform Global Update while cleaning display is needed

The Power On, Initialize COG and Power Off take 30~40% of energy consumption in an update cycle. Excluding the energy to prepare the image data, the Partial Update is able to save around 15% power budget in an update cycle if there is no change of the stage time and update flow.

Glossary of Acronyms

EPD	Electrophoretic Display (e-Paper Display)
COG	Chip on Glass, Driver IC
TFT	Thin-Film Transistor
ITO	Indium Tin Oxide
PDI, PDi	Pervasive Displays Incorporated