EPD Module Requirements Specification

Version 2.0

May 20, 2016

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1. Executive Summary

1.1 Project Overview

The overall project is to specify and designing a complete electrophoretic display (EPD) module, customized for a small sized optimized for low power consumption and miniaturization. A customized EPD module will be able to make a simple and low power interface between an EPD and a host MCU. By making an EPD module specified for low driving voltages, it would also provide necessary background to further explore the EPD technology and make use for it in new products powered by a single coin cell battery or energy harvesting.

1.2 Purpose and Scope of this Specification

This document specifies the functional, non-functional and hardware requirements for a complete EPD module. It will also specify necessary functions performed by the system in response of inputs and outputs. The requirements are intended to provide necessary basis for development of an EPD module, with respect to electrical properties and hardware setup.

2. Revision History

Revision	Date	Responsible	Action
1.0	April 17, 2016	S. Gunnerød	First revision
2.0	May 20, 2016	S. Gunnerød	Adapt specification for EPD module design with low voltage unipolar driving waveform.

3. Abbreviations

Following abbreviations apply to this document:

ASIC	Application-Specific Integrated Circuit
EPD	Electrophoretic Display
GPIO	General Purpose In/Out
IC	Integrated Circuit
L*	Lightness (measure for human perception of lightness, 0<L*<100)
MCU	Microcontroller Unit
PCB	Printed Circuit Board
TBC	To Be Completed

4. Product Description

The EPD module is in this content considered as the complete EPD including pixel electronics and its driving circuitry as shown in Figure 1. In order to drive the EPD pixels, a peripheral driving circuitry is required. The circuit shall be able to receive image-data from a host MCU and translate the data into proper signals to control the pixels on the EPD. The circuitry should be implemented as an application-specific integrated circuit (ASIC) in order to minimize the effective area and power consumption.

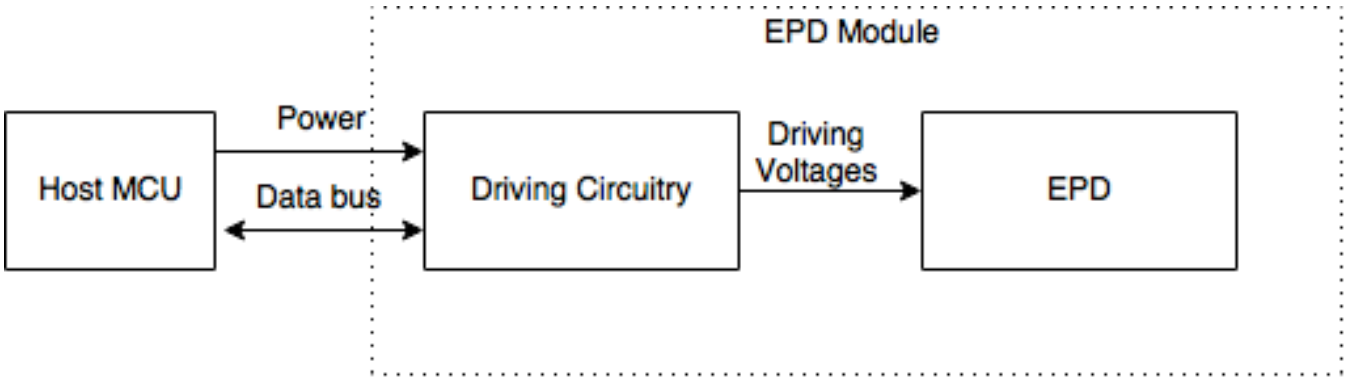

Figure 1: EPD Module Top

4.1 Product Context

The EPD module should be an independent product that interfaces with a variety of host MCUs and display sizes. The idea is to be able to control the EPD with as few external connections and discrete components as possible. Focusing on small size EPDs, more of the electronics can be integrated into a single chip, which lower the cost due to PCB-design and manufacturing as well as it reduces required area and power consumption.

4.2 User Characteristics

The EPD module is to be used as a reference by product designers and engineers that want to implement a small size, low power EPD into a new product.

4.3 Assumptions

It is assumed that the host MCU will provide all necessary signals and power as input to the driving circuitry. Types of MCUs and specific operating system/firmware details are neglected in this document, as the EPD module should be able to be operated by most MCUs that have enough processing capability to operate a traditional flat panel display. It is also assumed that memory for image frames and external components such as sensors and other components not required directly for driving the EPD are considered as peripheral units and are not integrated into the EPD module design.

4.4 Constraints

TBC

4.5 Dependencies

TBC

5. Requirements

5.1 Functional Requirements

Requirement ID	Description	Comments
FR-01	The EPD panel shall be able to be operated by a host MCU with the EPD driving flow chart presented in Figure 2. Communication interface via SPI.	EPD module require setup for input clock, slave-select/chip-enable input, serial data input and a stable input power supply.
FR-02	The EPD panel shall be able to show all kind of images or texts in black and white.	Active matrix black/white EPD
FR-03	The EPD panel shall be able to be operated in a temperature range between 0 and 50°C	
FR-04	The EPD module shall be able to drive an EPD panel with image resolution of 128 x 96 pixels.	128 output source-driver 96 output gate-driver
FR-05	The EPD module shall not consume any power when the EPD panel is in static mode (not updating).	Turn off driving circuitry after image write
FR-06	The EPD panel shall at all times and temperatures provide a white state reflectance above L*=30 during update of image.	Driving voltage (larger than): 5V/100ms.
FR-07	There shall be no visual ghosting-effect/sticking image after an image update.	
FR-08	The EPD panel shall not be able overwrite black pixels with black pixels or white pixels with white pixels.	Need to be able to compare previous image with new image and control the driving waveform in accordance to the specific image patterns.

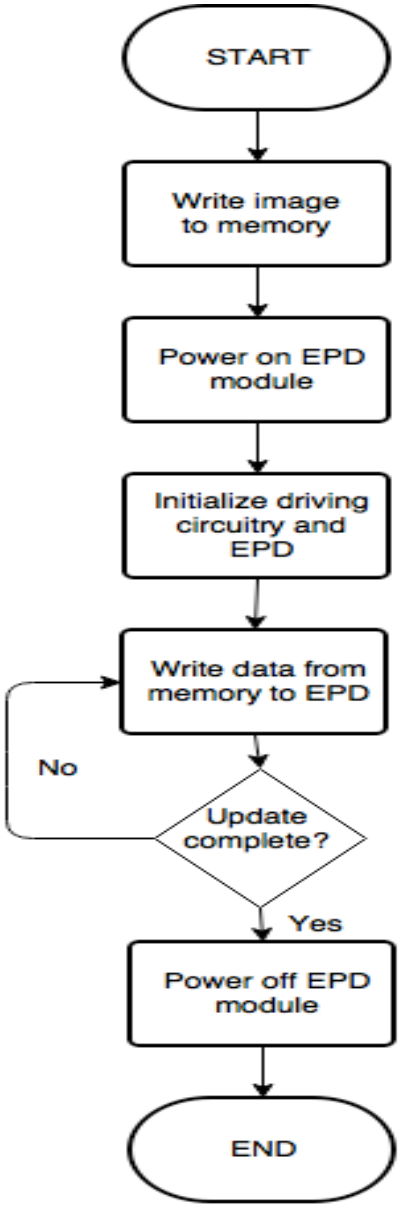

Figure 2: EPD driving flow chart [1]

5.2 Non-functional Requirements

Requirement ID	Description	Comments
NFR-01	Design priorities (most relevant): 1. Low power consumption 2. Miniaturization 3. Cost 4. Performance	
NFR-02	The EPD module should preferably be a single chip designed to be integrated on the EPD panel.	
NFR-03	EPD panel dimension shall be no larger than 40x30mm (30x22mm)	

NFR-04	Input voltage supply of EPD module shall be powered from a GPIO pin at host MCU.	Typically 3.3V or 5V
NFR-05	EPD module shall draw no more than 1mA for less than 500ms or 500µA for less than 1 second at each display update.	At room temperature = 22°C
NFR-06	The EPD module should at all temperatures consume the least possible power without any significant image degradation.	
NFR-07	The clock frequency should be limited to 8MHz.	

5.3 Hardware Requirements

Requirement ID	Description	Comments
HWR-01	The EPD panel shall be a 1-bit active matrix a-Si:H TFT panel with an image resolution of 128 x 96 pixels	Derived from FR-02, FR-04, NFR-01 and NFR-03
HWR-02	A temperature sensor shall be used to measure the temperature.	Derived from FR-03, FR-06 and NFR-06
HWR-03	A memory unit shall be able to store at least two image frames at the same time. With an image resolution of 128 x 96, this translates to a memory larger than 3072 bytes.	Derived from FR-04 and FR-08
HWR-04	EPD module requires a SPI-reciever to receive data from the master (MCU host). EPD module shall be the SPI-slave.	Derived from FR-01
HWR-05	EPD module requires a DC/DC converter to convert input voltage to TFT gates/sources, respectively ±7V and ±2.5V.	Derived from NFR-04 and HWR-01
HWR-06	EPD module requires a regulator to stabilize input voltage ranging from 3V to 5V.	Derived from NFR-04 and HWR-05
HWR-07	EPD module requires a timing controller to decode input serial data into waveforms that control and match inputs to both TFT gates and TFT sources.	Derived from HWR-01

HWR-08	EPD module require a gate driver that converts a low voltage serial waveform from the timing controller into driving voltages that provide all the TFT gates in accordance to the input waveform.	Derived from FR-04, HWR-05 and HWR-07 (Approx. ±5V higher than the source voltages)
HWR-09	EPD module require a source driver that converts a low voltage waveform from the timing controller into driving voltages that provide all the TFT sources in accordance to the input waveform.	Derived from FR-04, HWR-05 and HWR-07 (Approx. ±2.5V)

5.4 Interface Requirements

TBC

5.5 Performance

TBC

REFERENCES

[1] E-paper display COG Driver Interface Timing for 1.44”, 1.9”, 2.6” and 2.7” EPD with G2 COG and Aurora Mb film. Pervasive Displays. Doc.no 4P018-00. Rev. 03. 7/2015.