E-PI
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Specification

EPD-Module
Part-No. 70013801

4.0", 115 ppi, single sided driven, B/W

Revision 1.00

E-PI Confidential

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1. Introduction

1.1 Purpose of this document

This document describes the technical specification of the electrophoretic display module, part number 70013801. It defines general characteristics of the display module and the technical information required to integrate the display module into a potential product.

The 70013801 is an active-matrix electrophoretic display (AM EPD), with interface and a reference system design. The 4.0" active area contains 400 x 240 pixels. The module is a TFT-array driving electrophoretic display, with integrated circuits including gate driver, source driver and an integrated EPD-controller. The module can be used e.g. in portable electronic devices.

1.2 Key features of display module

- Consists of an active-matrix electrophoretic display driven chips combining source drivers, gate drivers and an integrated EPD-controller bonded on a COF (COF = chip on film)
- 400 x 240 pixels @ 220 µm pixel pitch
- Supports 16 grey levels
- Incorporates industry-leading bi-stable electrophoretic display technology in pure reflective mode and with ultra-wide viewing angle
- Display surface anti-glare and with hardcoat (2H)
- Low power consumption
- Enables robust product design (glass-free and flexible)

2. Mechanical specification

2.1 Dimensions

Parameter	Value	Unit	Comments
Active area size	4.0	inch	
Active area dimension	88.00 x 52.80	mm	
Active area resolution	400 x 240 115	Pixel ppi	
Active area pixel pitch	220	µm	
Outline length	104.20 ± 0.2	mm	~ 106.70 mm when COF is bent
Outline width	59.80 ± 0.2	mm	
Thickness	0.65 ± 0.1	mm	
FPC length	39.10 ± 0.3	mm	length over display outline
Weight	5	g	typical with liners

Table 1: Mechanical specification

2.2 Outline

The outline of the final product is depicted in Figure 1.

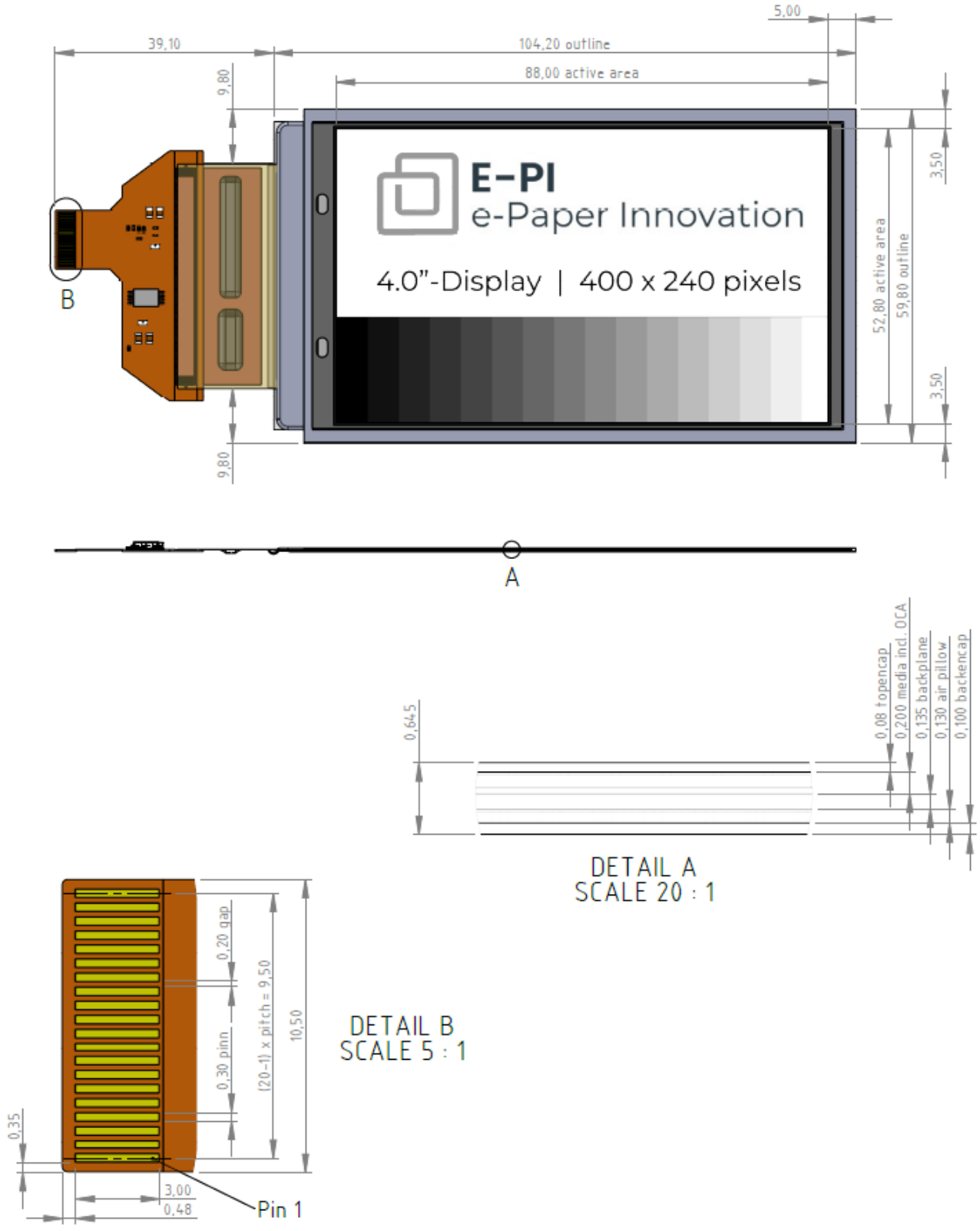

Figure 1: Dimensions of the final product in mm

3. Optical specification

The display supports 16 grey levels. Specific display grey levels are defined using the terminology GLx, where x = 0-15. GL0 corresponds to “black” and GL15 corresponds to “white”.

Grey levels are measured using the L* scale, which is the lightness component of the CIE 1976 CIELUV and CIELAB [2] colour spaces. Measurements in L* can be related to reflectivity using the formula $L^*=116(L/L_w)^{1/3}-16$, where L and Lw are measured in % reflectance and Lw is defined as 100 %. This formula is valid for L* > 16.

Measurements are made with illumination under an angle of 45 degrees, the detection is perpendicular unless otherwise specified, the viewing distance is 30 cm ± 10 cm, the ambient luminance is between 700 and 1000 Lux and ambient environmental conditions are temperature between 20°C and 25°C and humidity between 40%rH and 70%rH.

3.1 Optical requirements

3.1.1 Picture quality

The display will be lineout free; however typical expectations are a pixel yield of > 99.99 %.

3.1.2 Parameters for GL waveforms

Parameter	Description	Min	Typical	Max	Unit
White state	Median GL15	65	70	-	L*
Black state	Median GL0	-	24	28	L*

Table 2: Optical requirements

3.1.3 Display update waveforms

The display module will be supplied with a library of waveforms that are tuned to optimise display performance. The waveform library will be stored into the controller flash memory. Each waveform has an optimum temperature range over which it is valid – it is the responsibility of the display controller in combination with the temperature sensor to ensure that the correct waveform is selected for the current display module temperature.

E-PI will provide several waveforms. The update time is dependent on the waveform design. It might vary based on the number of grey levels and the expected optical performance (contrast, ghosting, etc.), see Table 3.

Waveform	Usage	Grey levels	Ghosting	Update speed
INIT	Recover from unknown state/ start up	white only	low	slow
GC16	Full refresh	16 GL	low	slow
DU	Delta Update; 16GL to Monochrome	16 GL → b/w	high	medium
A2	Fast monochrome updates	b/w → b/w	high	fast

Notes: additional customer specific waveforms are possible on request

Table 3: Waveform types

4. Reliability and other specifications

Parameter	Value	Unit	Comments
Operating Temperature	0 to 50	°C	The operating temperature of 0 to 50 °C is a limitation of the media material
Storage Temperature	-25 to 50	°C	
Operation/Storage humidity	25 to 60	%RH	T ≤ 40°C without dewing
Waterproofing	n/a		The deliverables of this product will not guarantee an IP rating

Note: long-term exposure of stress close to the limits might reduce the overall lifetime

Table 4: Reliability parameters

No.	Test	Condition	Comments
1	High Temperature Operation	T = +60°C, RH = 30 % for 240 hrs	IEC 60 068-2-2Bp
2	Low Temperature Operation	T = 0°C for 240 hrs (RWU-profile)	IEC 60 068-2-2Ab
3	High Temperature Storage	T = +70°C, RH = 23 % for 240 hrs	IEC 60 068-2-2Bp
4	Low Temperature Storage	T = -25°C for 240 hrs	IEC 60 068-2-1Ab
5	High Temperature, High Humidity Operation	T = +40°C, RH = 90 % for 360 hrs (RWU-profile)	IEC 60 068-2-3CA
6	High Temperature, High Humidity Storage	T = +60°C, RH = 90 % for 360hrs	IEC 60 068-2-3CA
7	Thermal Shock	Cycle: [-25°C/30min] → [+70°C/30 min] 100 cycles	IEC 60 068-2-14
8	Real World Use	T = +22°C for 500hrs T = +40°C for 500hrs	RWU-profile
9	Ambient Operation	T = +22°C for 1 Mio updates	1s image updates
10	Electrostatic Effect (nonoperating)	Machine model +/- 250 V, 0 Ω, 200 pF	IEC 62179, IEC 62180

Table 5: Reliability tests; at the end of the test, electrical, mechanical, and optical specifications shall be fulfilled

5. Electrical specification

5.1 Connection of display module

The display module can be contacted via a 20-pin connector e.g. an Omron XF2M2015-1A, back flip FPC dual contact connector.

5.2 Electrical pin-out of display module

Following tables list the pin-out and description of all signals of the display module.

No.	Name	Description
1	MP_VCC_3V3	3V3 power pin
2	MP_VCC_3V3	3V3 power pin
3	MP_I2C_SCL	I2C clock
4	MP_I2C_SDA	I2C data
5	MP_POR_RESET	EPDC power-on reset pin
6	MP_HD/C	Reserved, not used currently
7	MP_SPICS	SPI chip select for EPDC host interface
8	MP_SPIDI	SPI data input for EPDC host interface
9	MP_SPIDO	SPI data output for EPDC host interface
10	MP_SPICLK	SPI clock for EPDC host interface
11	MP_HIRQ	Interrupt line from EPDC
12	MP_CLKI	EPDC clock
13	MP_GND	Ground
14	MP_VGNEG	Negative HV supply for gate driver (-32V typ)
15	MP_VSNEG	Negative HV supply for source driver (-15V typ)
16	MP_GND	Ground
17	MP_VGPOS	Positive HV supply for gate driver (+25V typ)
18	MP_VSPOS	Positive HV supply for source driver (+15V typ)
19	MP_GND	Ground
20	MP_FPCOM_SW	Switched VCOM supply (tuned for each panel, +9V typ)

Table 6: Electrical pin-out

5.3 DC characteristics

Signal	Parameter	Min	Typical	Max	Unit
GND	Signal ground	-	0	-	V
VDD	Logic power supply	3.0	3.3	3.6	V
VGH	HV power supply for gate positive	23	25	27	V
VGL	HV power supply for gate negative	-34	-32	-30	V
VPOS	HV power supply for source positive	14.6	15	15.4	V
VNEG	HV power supply for source negative	-15.4	-15	-14.6	V
VASYM	Asymmetry source (VPOS + VNEG)	-150	0	150	mV
VCOM*	Common voltage	1.0	5.0	9.0	V

* VCOM needs to be tuned for each display module. The correct value is provided as part of the waveform.

Table 7: DC characteristics

5.4 Controller

The display is driven and controlled by an IXYS MXEI2240 gate driver chip and the Epson S1D134541 EPD-controller with source drivers, display engine, display memory, waveform memory, command memory, multi time PROM and temperature sensing system.

Key features are

- Serial Interface (SPI) as host interface
- Transparency write
- Supported data formats: 1bpp, 2bpp, 4bpp, 1 Byte-per-pixel
- 202K Bytes image buffer
- Mirror and rotate mode (Vertical/Horizontal Mirror, 0°/90°/180°/270° Rotate)
- 16K Bytes embedded memory for waveform storage
- 16 or 32 MHz clock input
- Built-in thermistor sensing system (external thermistor)
- I2C serial master
- External gate driver control, type 1
- External power management IC control

Please refer to the EPSON S1D13541 datasheet for full controller specification.

The FPC contain additional components required by the controller and the temperature sensor.

5.5 Display Power Supply System

The display module itself does not contain the power management subsystem required to generate the high voltages driving the display. Reference circuitry can be provided by E-Pi recommending either a Maxim MAX17135 or a TI TPS65185.

6. Handling requirements

The display modules are shipped in appropriate packages. All loose tails must be constrained during shipping.

Keep the EPD-panel/module in the specified environment and original packing boxes when stored to avoid scratching and to keep original performance.

The product is intended to be used around ambient temperature. Please control the temperature to avoid frost or dew on the surface of EPD-panel. Moisture may ingress the EPD-panel and may damage the EPD-panel.

High temperature, high humidity, sunlight, or UV-light may degrade the EPD-panel's performance. Please do not expose the unprotected EPD-panel to high temperature, high humidity, sunlight, or UV-light for long periods of time. Please store the EPD panel in controllable environment of warehouse and in original package, without sunlight, without condensation.

The display module should not be exposed to harmful gases, such as acid and alkali gases, which corrode the electronic components.

Do not disassemble or re-assemble the EPD-panel.

The EPD panel/module is manufactured from fragile materials such as glass and plastic and may be broken or cracked if dropped. Please handle with care. Do not apply force such as bending or twisting to the EPD panel.

Use a soft dry cloth without chemicals for cleaning. Please don't press hard for cleaning because the surface of the protection sheet film is very soft and without hard coating.

Minimise pulling or bending of the FPC and do not use the FPC for pick up. Do not press or pull FPC to ± 90° bending and don't twist FPC and PCB. Keep r ≥ 1mm when bending for assembly.

To avoid scratches, do not stack the EPD-panels/modules.

Do not apply pressure or hit to the EPD-module, IC, FPC and PCB to prevent damage.

Do not touch the FPC lead contacts and IC area to avoid ESD damage.

The display module is an electrostatic discharge (ESD) sensitive device. Ensure that proper ESD-precautions are in place to avoid damage of the display module.

Typical operation conditions in the assembly area are (25 ± 2)°C and 50%RH to 60%RH. Operators should use ionizer fan during assembly. The working area must be connected to ground, the resistance between operator and working area should be less than 5 Ω. Operator should wear PVC or anti-electrostatic gloves. Operators should wear grounding wrist ring and must make sure that grounding is fine. Before working in operation area, please ensure wrist ring and suit is fine by passing a conductive test before operation.

To avoid electrical overstress (EOS) in operation, please

- ensure that power is off before EPD is installed into jig/tag
- ensure that FPC is well connected (no misalign in connector) to avoid a short
- do not remove/uninstall EPD from jig/tag when image is updating,
- switch power off after operation or function test before uninstalling the EPD

EOS or short may damage the IC or the TFT.

7. Safety and flammability requirements

The integrator of this display module into a final product is responsible for ensuring that the relevant safety and flammability requirements are met.

8. Compatible evaluation kits

Do not use any other evaluation kit than the recommended one.