PAJ7025R2: Multiple Objects Tracking Sensor Module

General Description

PAJ7025R2 is a Multiple Objects Tracking (MOT) module which integrates a high quality CMOS image sensor, image processor and Digital Signal Processor (DSP).

Upon grayscale image is captured, the PAJ7025R2 immediately process and produce relevant output information. The output information consist of object area, object center coordinate, 4-way object boundary, average/maximum object brightness, object radius, object range, and aspect ratio. The communication interface is through SPI.

The tracking object(s) could be supported through a direct Infra-Red (IR) light source or indirect with passive IR reflector light source.

Key Features

- color type: black and white
- Array size: 98 x 98
- Pixel size: 11 x 11 µm
- Pixel depth: 8 bits
- Scan mode: progressive
- Shutter Type: Global Shutter
- System clock: 10 MHz ± 3% @ 25 °C (internal clock)
- Programmable Gain setting: 2 to 8 X
- Programmable exposure duration
- Support 4 types of output format
- Frame subtraction function
- Support two operation mode: STREAM mode and Frame On Demand (FOD) mode

Applications

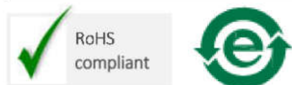
- Direct Pointing Device
- Whiteboard Interactive Pen
- Robot Positioning System
- Interactive Toys Application

Key Parameters

Parameter	Value
Lens FOV (Diagonal degree)	52.2 °
Target object tracking Wavelength	850 nm
Tracking object number	Up to 16
Object center coordinate resolution	Up to 4095 x 4095
Frame rate	Up to 200 fps
Interface	4-Wire SPI
SPI Clock	Up to 14 MHz
Supply Voltage	2.0 to 3.6 V
Power consumption	Operation: 6 mA Power-Down: 14 µA

Ordering Information

Part Number	Description	Package Type	Packing Type	MOQ
PAJ7025R2	MOT Sensor Module	Module-20 pins	Tray	900



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1.0 Introduction

1.1 Overview

PAJ7025R2 is a Multiple Objects Tracking (MOT) module which integrates a high quality CMOS image sensor, image processor and Digital Signal Processor (DSP).

Upon greyscale image is captured, the PAJ7025R2 immediately process and produce relevant output information. The output information consist of object area, object center coordinate, 4-way object boundary, average/maximum object brightness, object radius, object range, and aspect ratio. The communication interface is through SPI.

The tracking object(s) could be supported through a direct Infra-Red (IR) light source or indirect with passive IR reflector light source.

Note: Throughout this document PAJ7025R2 is referred as the Module.

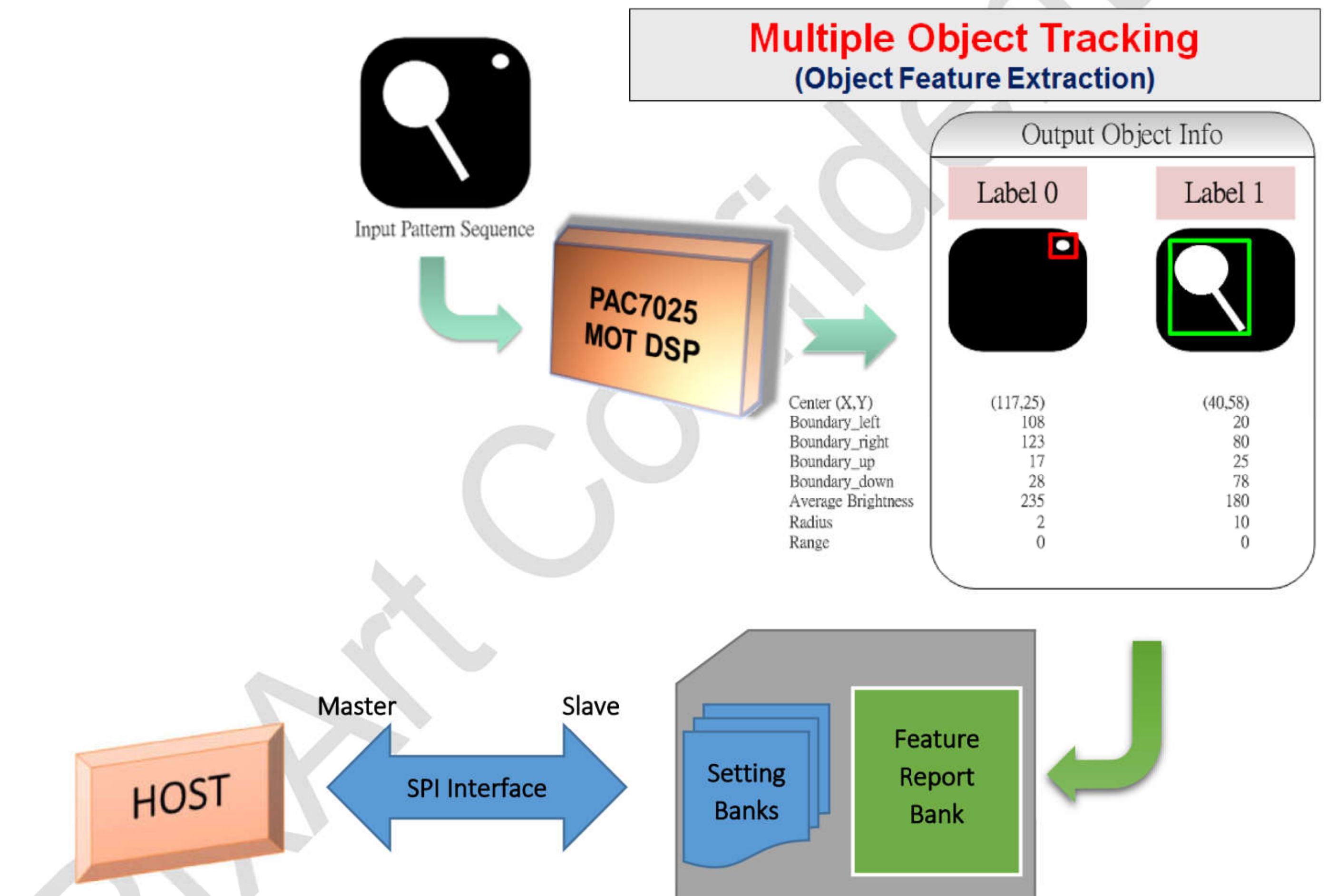

Figure 1. System Blocks

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1.2 Block Diagram

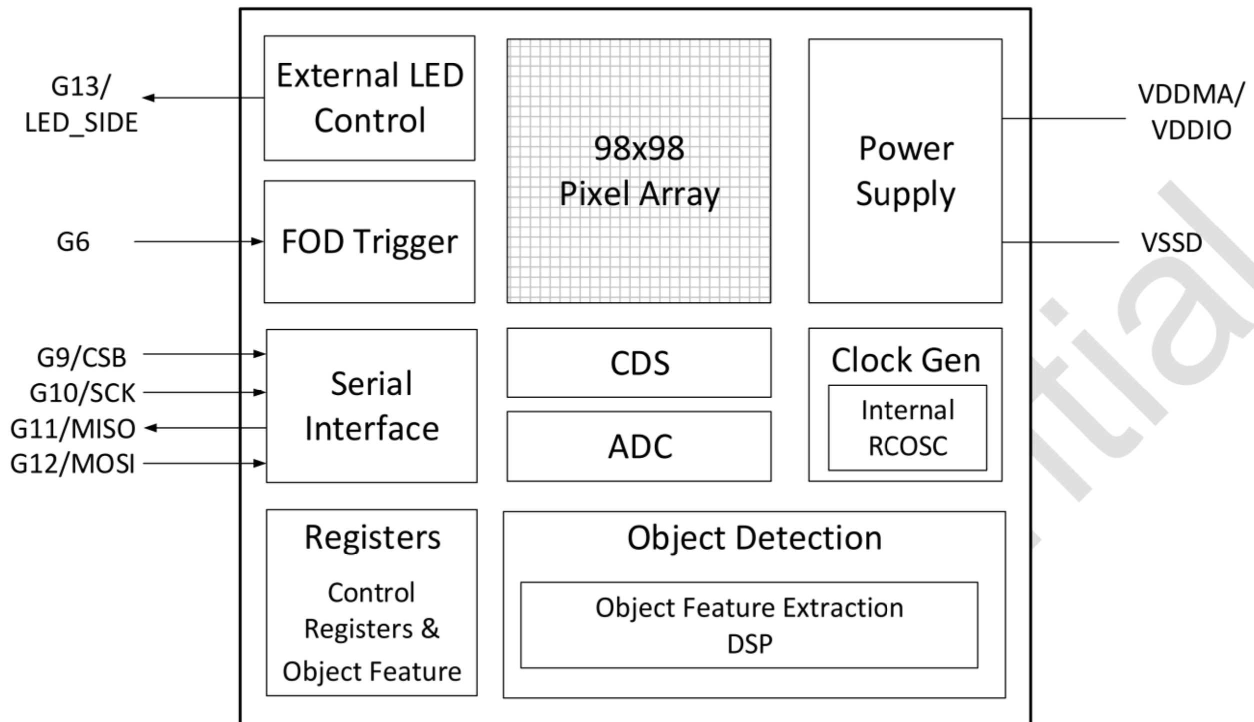

Figure 2. Sensor Architecture Block Diagram

- Sensor color type: black and white
- Pixel size: 11 x 11 um
- Number of array elements: 98 x 98
- Pixel depth: 8 bits
- Scan mode: progressive
- Shutter Type: Global Shutter
- Programmable object center coordinate resolution: up to 4095 x 4095
- Object number: up to 16
- System clock (internal clock): 10 MHz ± 3% at 25°C
- Interface: SPI (up to 14 MHz (bits/sec))
- Programmable frame rate control: 10 to 200 fps
- Programmable Gain setting: 2 to 8 X
- Programmable exposure duration
- Support frame subtraction feature
- Support two operation modes: STREAM and FOD
- Suitable wavelength of tracking target: infrared ray 850 nm LED
- Support 4 type of output format. Output Object features: Object center coordinate, object area, object boundary, object brightness, object radius, object range, and aspect ratio

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1.3 Terminology

Term	Description
MOT	Multiple Objects Tracking
CMOS	Complementary Metal-Oxide-Semiconductor
DSP	Digital Signal Processor
SPI	Serial Peripheral Interface
IR	Infrared
LED	Light-Emitting Diode
FOD	Frame On Demand
CDS	Correlated Double Sampling
ADC	Analog-to-Digital Converter
FPS	Frame Per Second
FOV	Field Of View
I/O	Input/Output
GPIO	General Purpose Input/Output
DC	Direct Current
Fno	F number
SMT	Surface-Mount Technology
CPOL	Clock Polarity Control Bit
CPHA	Clock Phase Control Bit
Cmd_thd	brightness threshold definition
Cmd_nthd	noise threshold definition
Cmd_oalb	Object Area Low Bound definition
Cmd_oahb	Object Area High Bound definition
OP_mode	Operation mode
LSB	Least Significant Bit
PCB	Printed-Circuit Board
ESD	Electrostatic discharge

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1.4 Pin Assignment and Signal Description

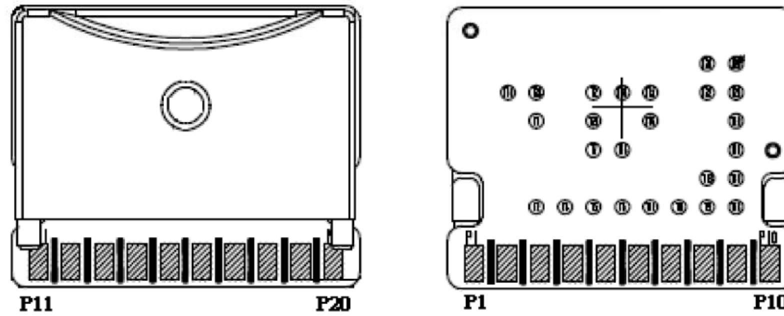

Figure 3. Module Pinout Configuration (Top and Bottom View)

Table 1. Signal Pins Description

Pin No.	Signal Name	Type	Description	Notes
1	G0	NC	No connection	Please leave it as floating.
2	G1	NC	No connection	Please leave it as floating.
3	G2	NC	No connection	Please leave it as floating.
4	G3	NC	No connection	Please leave it as floating.
5	G4	NC	No connection	Please leave it as floating.
6	G5	NC	No connection	Please leave it as floating.
7	G6	I/O	G6 or FOD_TRI	In Tri-state after initial setting. Can be programmed as FOD_TRI input pin when FOD mode is enabled.
8	G7	NC	No connection	Please leave it as floating.
9	G8	Output	G8 or VSYNC	In Tri-state after initial setting. Can be programmed as VSYNC output pin via register.
10	G9/CSB	Input	SPI Chip Select pin	Active low.
11	G10/SCK	Input	SCK: Serial Clock	
12	G11/MISO	Output	Master Input/Slave Output	Serial Data Output in Slave Mode.
13	G12/MOSI	Input	Master Output/ Slave Input	Serial Data Input in Slave Mode.
14	VSSD	Ground	Ground	This pin must be connected to ground.
15	CP_1	NC	No connection	Please leave it as floating.
16	CP_2	NC	No connection	Please leave it as floating.
17	VDDMA	Power	Main Power supply	2.0 to 3.6 V.
18	G14/LED_FRT	NC	No connection	Please leave it as floating.
19	G13/LED_SIDE	Output	G13 or LED Sync Control	In Tri-state after initial setting. Can be programmed as LED output pin via register.
20	VSSD_LED	Ground	Ground for IR LED	This pin must be connected to ground.

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2.0 Operating Specifications

2.1 Absolute Maximum Ratings

Table 2. Absolute Maximum Ratings

Parameters	Symbol	Min.	Max.	Unit	Notes
Storage temperature	T_{STG}	-25	80	°C	
Lead Solder Temperature	T_{SOLDER}	-	300	°C	Lead free. Refer to Section 4.3.1 for detail
HBM (Human Body mode)	ESD	-	2000	V	
MM (Machine mode)		-	200		
I/O power & Analog power DC External Power Input	VDDMA	-0.3	3.96	V	
DC input voltage	V_{IN}	-0.3	VDDMA+0.3	V	All I/O signal pin

Notes:

1. The above Maximum Ratings are the guaranteed parameters that Module expect to be functional as per intended design.
2. Exposure to these conditions or beyond those indicated may adversely affect device reliability and unexpected or premature functional failure.

2.2 Recommended Operating Conditions

Table 3. Recommended Operating Conditions

Description	Symbol	Min.	Typ.	Max.	Unit	Notes
Ambient Temperature	T_A	0	-	40	°C	
Input Power Supply	VDDMA	2.0	2.8	3.6	V	

2.3 DC Characteristics

Table 4. DC Electrical Specifications

Parameters	Symbol	Min.	Typ.	Max.	Unit	Conditions
Supply Current	I_{DD}	2	6	10	mA	Operation state, STREAM mode. At 25°C, VDDMA=3.6 V, 200 ± 3% fps.
Power-down current		5	14	60	µA	At 25°C, VDDMA=3.6 V
Input High Voltage	V_{IH}	0.7 x VDDMA	-	-	V	
Input Low Voltage	V_{IL}	-	-	0.3 x VDDMA	V	
Output Low Voltage	V_{OH}	-	-	0.1 x VDDMA	V	See Note
Output High Voltage	V_{IL}	0.9 x VDDMA	-	-	V	See Note

Note: All the GPIO maximum sinking/driving current is 4 mA, Capacitance load spec. =100 pF at maximum clock frequency = 14 MHz ± 1.5%.

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2.4 AC Characteristics

Table 5. AC Electrical Specifications

Parameters	Symbol	Min.	Typ.	Max.	Unit	Conditions
Ready to Operation (STREAM mode)	t_{RTO}	-	-	2	frame	After all power rails reach steady level, switch to STREAM mode to get first valid output
Power-Down to Operation (STREAM mode)	t_{PTO}	-	-	2	frame	From Power-Down state to Operation state to get first valid output
Operation to Power-Down	t_{PD}	-	-	13	µs	From Operation state to Power-Down state, confirm that the system has entered power down state
Power Down (wake up) to Operation (SPI Interface Ready)	t_{PTO_WAKE}	-	-	1	ms	Time require to ensure SPI interface is ready upon receiving wake up command

Note: All the parameters are tested under operating conditions: VDDMA = 2.8 V and T_A = 25 °C.

2.5 Filter Specification

The Module has integrated IR Pass filter for IR application, the IR filter spectrum response profile as shown below.

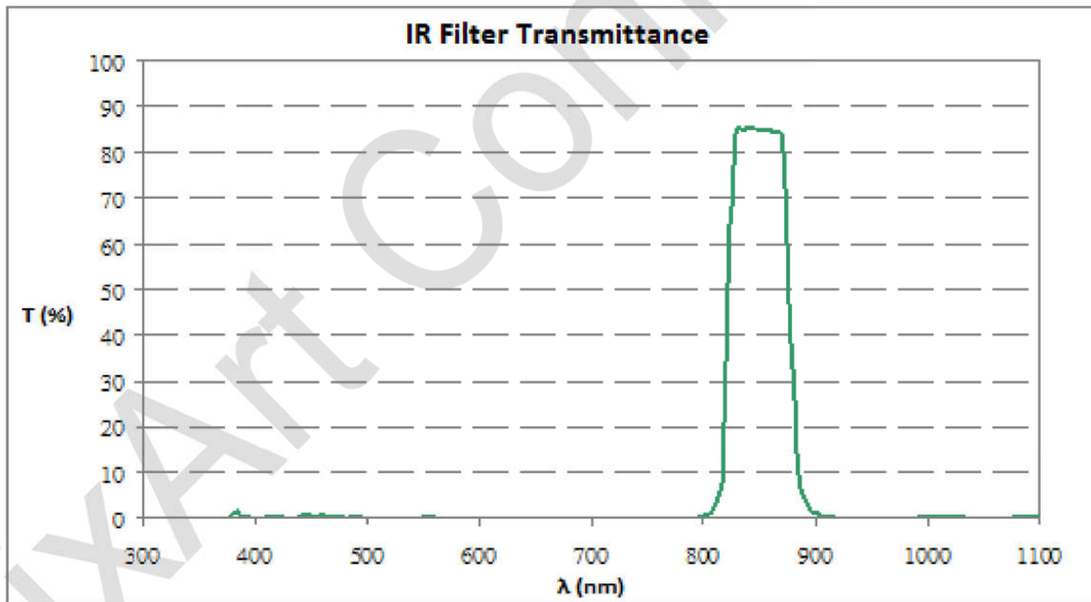

Figure 4. IR Filter Spectrum Response

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2.6 Optical Specifications

Table 6. Optical Specifications

Parameter		Specification		Unit	Notes
Effective Focal Length		1.484307	±5 %	mm	
Fno		1.838227	±5 %	mm	F number
Image Circle		1.658		mm	
Back Focal Length		0.975		mm	
Distortion		<2.8		%	
Relative Illumination		>60		%	
Chief Ray Angle		15.5		Degree	
Component		1P		-	
Image Area		1.524		mm	
Sensor Pixel Size		11x11		μm	
Sensor Pixel Resolution		98 x 98		pixel	
Angle Field of View	Diagonal	52.2	±5 %	Degree	Y = 0.762 mm
	Vertical	38.3	±5 %	Degree	Y = 0.539 mm
	Horizontal	38.3	±5 %	Degree	Y = 0.539 mm

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3.0 Mechanical Specifications

3.1 Mechanical Dimension

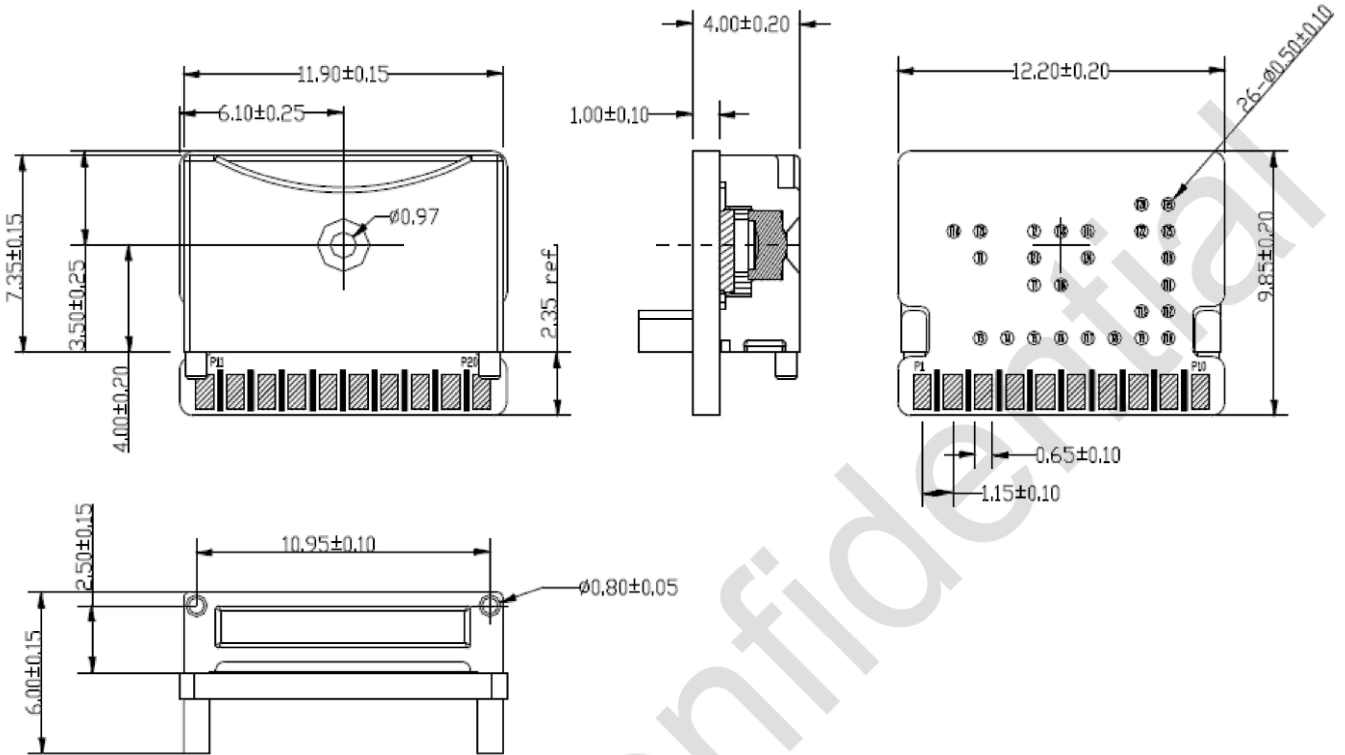

Figure 5. Module Outline Drawing

3.2 Package Marking Identification

Refer to Figure 6 for the code marking location on the chip package.

Table 7. Code Identification

Laser Mark	Description
XXXXXX (LINE A)	PXI Date code
XXXXXX (LINE B)	Assembly Supplier_Sublot Trace Code

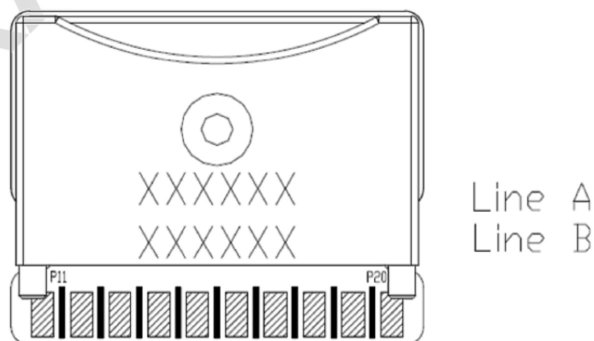

Figure 6 Package Marking Outline

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3.3 Packing Information

Module orientation is identify based on the chamfer corner of chip tray.

However, the tray serial number is located on the right side of tray.

Figure 7. Module Orientation

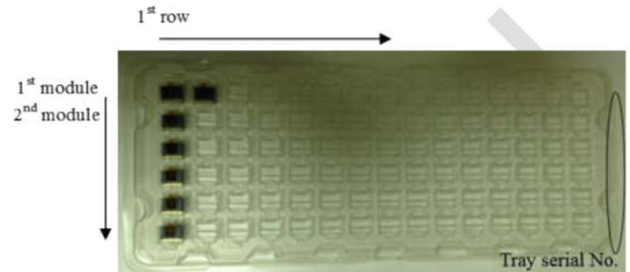

Figure 8. Module Tray Order

A stack of 10 trays (Top tray + 10 Chip Tray + Bottom Tray) is refer as a bunch

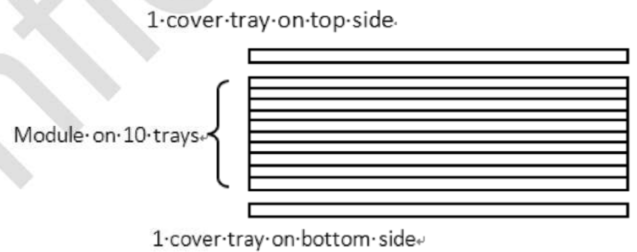

Figure 9. A bunch and Stack Definition

Pack one bunch of tray into one moisture proof bag.

Figure 10. Bunch & Moisture Proof bag

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Pack one bag into an inner packing box

Figure 11. Bag & Inner Packing Box

Figure 12. Inner Packing Box

A group of six inner sub-packed box pack into one big outer packing box. The maximum capacity of one outer packing box as below:

One outer packing box	**5400 units**
Remark	90ea per tray x 10 tray per inner box x 6 inner box per outer box

Note: The module cannot not be guaranteed to operate per intended design if the module work beyond specified operating temperature (>80°C/hr).

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4.0 Design References

4.1 General Reference Schematics

4.1.1 Reference Circuit for STREAM mode

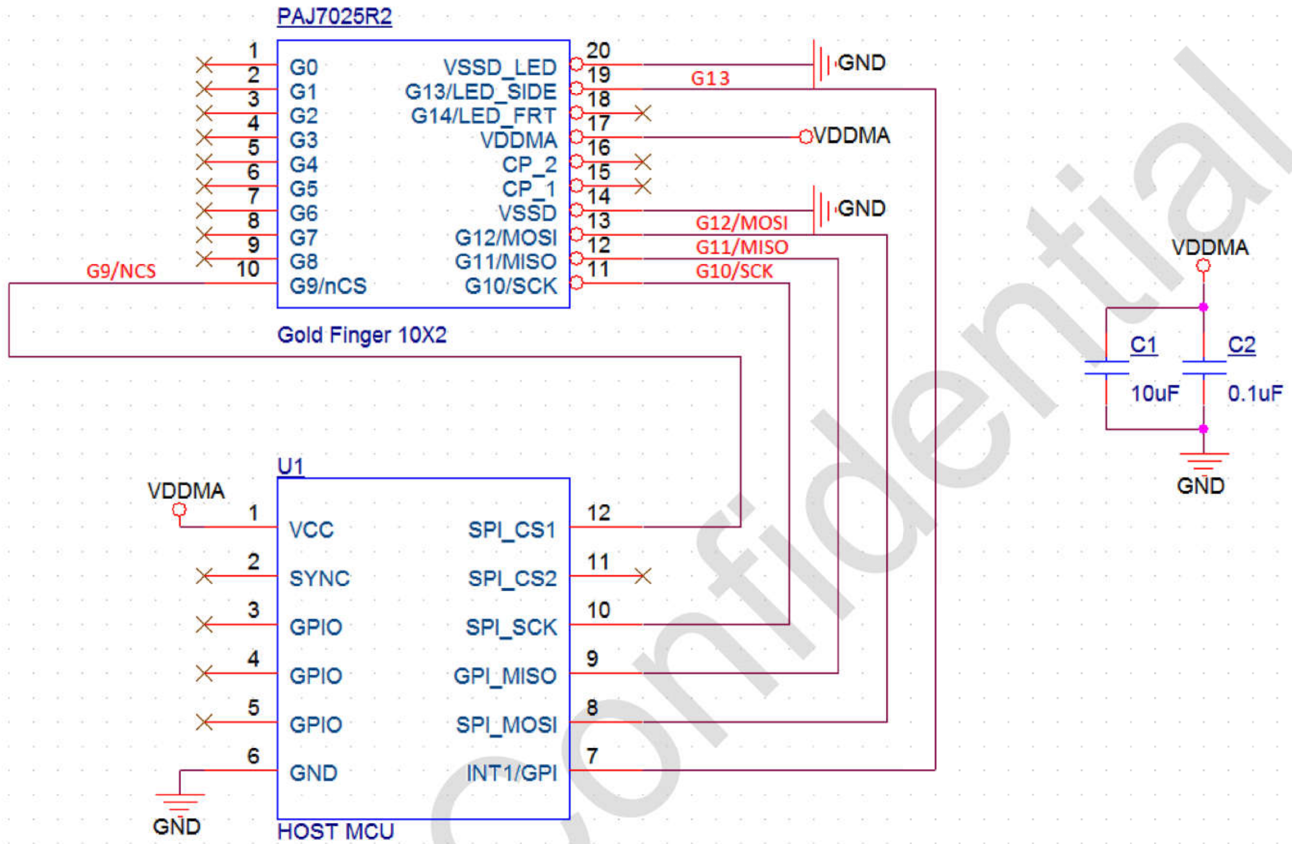

Figure 13. Application Circuit for STREAM Mode

Notes:

1. VDDMA: 2.0 to 3.6 V
2. Place C1 and C2 as close as possible to the module pinouts.
3. The G13 connection is optional for exposure signal output. Refer to Section 7.7.3 for detail.

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4.1.2 Reference Circuit for FOD mode

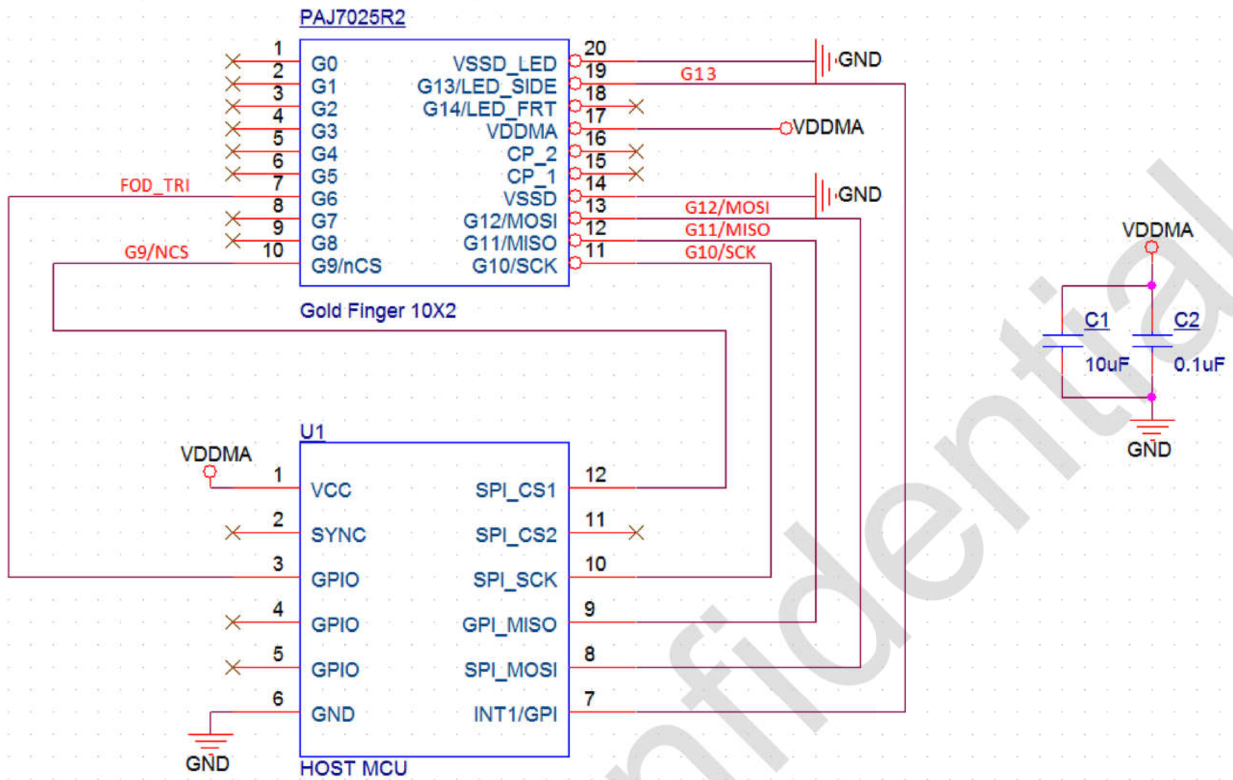

Figure 14. Application Circuit for FOD Mode

Notes:

1. VDDMA: 2.0 to 3.6 V.
2. Place C1 and C2 as close as possible to the module pinouts.
3. The Module starts capture image when FOD_TRI input is triggered. Refer to Section 7.2.3 for detail.
4. The G13 connection is optional for exposure signal output. Refer Section 7.7.3 for detail.

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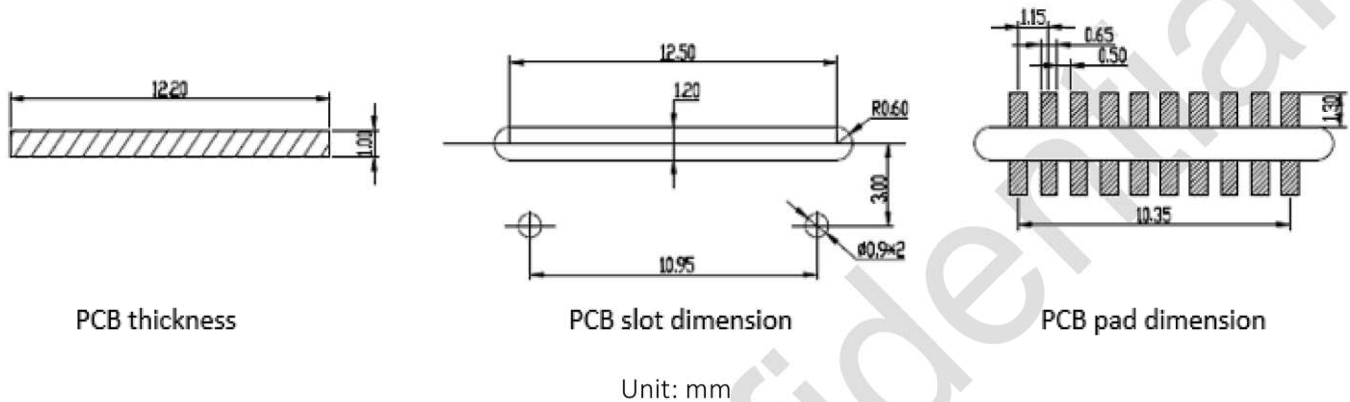
4.2 PCB Layout Design Guide

4.2.1 Design Rules

The Module pinout is designed to be a gold finger, which facilitates setting up the Module on PCB main board. For PCB and layout footprint design, please refer to the following section.

4.2.2 Recommended PCB Footprint



Unit: mm

Figure 15. The Module PCB Design Guideline

The recommended PCB thickness is 1mm. If the PCB is too thick, it will easily cause poor soldering between the gold finger and the pad on the PCB.

4.3 Assembly Guide

4.3.1 Soldering Guide

Manual soldering is recommended to prevent damage of the module casing. The guidance of the manual solder as follow:

1. Temperature ≈ 300 °C (Recommended 30W solder iron) with solder duration 2sec or less
2. Alternatively, temperature <260 °C with solder duration ± 10sec for volume production.

Disclaimer: The Module casing is not suitable for SMT solder IR reflow process. Do not risk the module from being damaged or prematurely malfunction.

4.3.2 Module Assembly Guide

The Module need to be placed as well as held firmly with PCB before Soldering. However, the Module placement need to place one sided abutment of the PCB opening slot.

Note: It is important to ensure proper alignment mentioned in order to minimize assembly error.

4.3.3 ESD Precaution

As the chip is sensitive device, an ESD awareness is required to prevent from premature damage during handling of the chip.

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