Intel® RealSense™ Camera SR300

Embedded Coded Light 3D Imaging System with Full High Definition Color Camera

Product Datasheet

Intel Production Part Numbers: MM#943228, H89061-XXX†

†(X) Numeric characters representing configuration or programmed firmware at manufacturing

June 2016

Revision 1.0

Document: 334531-001

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Revision History

Revision	Description	Date
1.0	• Initial Release	May 2016

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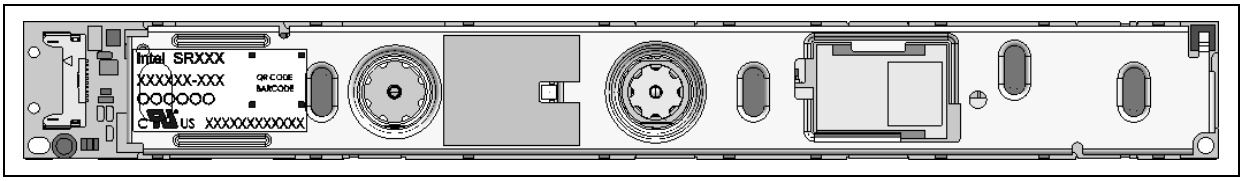
1 Description and Features



SR300 Description

The Intel® RealSense™ Camera SR300 is a subassembly product that implements a short range, coded light 3D imaging system.

The small size of the SR300 subassembly provides system integrators flexibility to design into a wide range of products.

The broad range of 3D mode configurations and synchronization capabilities of the SR300 enable the product to be an optimal solution for 3D imaging applications.

Features

- Onboard Imaging ASIC
- Depth Capture from 0.2 to 1.5m(1)
- Infrared (IR) Laser Projector System
- Synchronized Depth, Color, Infrared Video
- Texture Mapping of Depth to Color
- Depth Unprojection to World Coordinates
- Up to 60FPS Depth at 640x480 (VGA)
- Up to 30FPS Color at 1920x1080 (FHD)
- Up to 200FPS Infrared at 640x480 (VGA)
- 110mm Width x 12.6mm Height
- 4.1mm Maximum Thickness (3.8 – 4.1mm)
- Green Activity LED
- Class 1 Laser Compliant
- Skype* 2.0

(1) *Software may optimize within this range.*

Applications(1)

- Face Analytics and Tracking
- Scanning and Mapping
- Scene Segmentation
- Hand and Finger Tracking
- Augmented Reality

(1) *Additional software must be installed to enable these applications.*

Minimum System Requirements

- 6th Generation Intel® Core™ i3 Processor(1)
- Windows* 10 Desktop (64bit)
- 8GB Disk Storage Space(1)
- 4GB Memory(1)
- USB3
- SR300 Interconnect Cable(2)

(1) *Additional CPU performance, memory and disk space may be required for certain applications. Please refer to application requirements.*

(2) *Provided by the system integrator. Cable design is specific to system definition and meets SR300 cable design specifications.*

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2 Overview

2.1 Components

Table 2-1: Component Descriptions

COMPONENT	DESCRIPTION
Imaging ASIC	USB3 only, primary interface to subassembly components
Infrared Camera	640x480 (VGA) monochromatic infrared sensor
Color Camera	1920x1080 (FHD) chromatic sensor with discrete ISP
Infrared Projector	Class 1 laser compliant coded light infrared projector system
Activity LED	Green LED, illuminates when transmitting video over USB3
Cable Receptacle	10pin connector to system cable assembly
Alignment Holes	Round and oval holes to secure placement via system alignment pins
Label	Manufacture and product identifier information
Adhesive Liner	Thermal connection to the system

Figure 2-1: Component Locations (Front View)

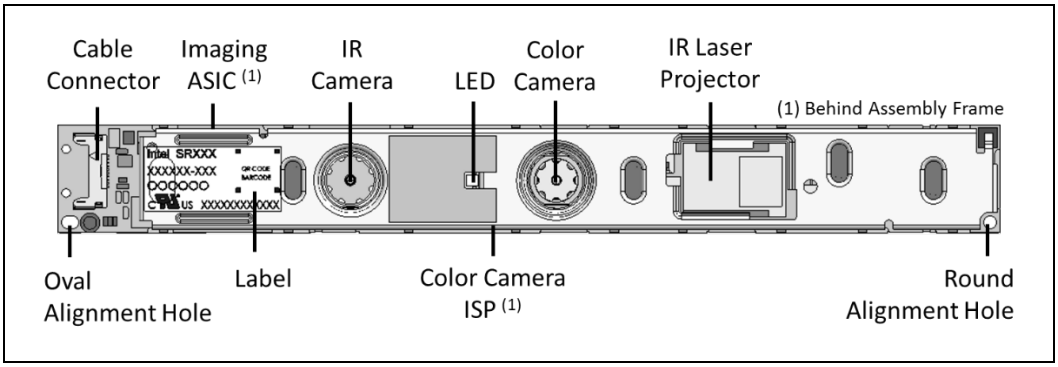
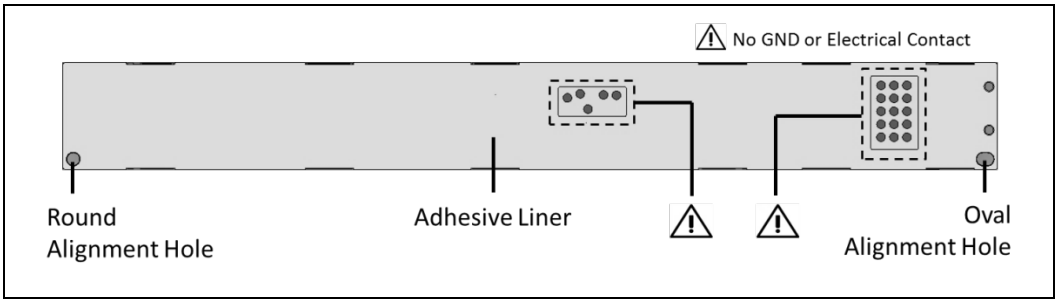


Figure 2-2: Component Locations (Rear View)



2.2 Storage and Operating Conditions

Table 2-2: Storage and Operating Conditions

CONDITION	DESCRIPTION	MIN	MAX	UNIT
Storage (Still Air), Not Operating	Temperature (Sustained, Controlled)(1)	0	40	°C
	Temperature (Short Exposure)(2)	-30	65	°C
	Humidity, Non-Condensing	90% RH, 30°C		
Operating(3) (Still Air)	Temperature	0	35	°C

NOTES:
(1) Controlled conditions should be used for long term storage of product.
(2) Short exposure represents temporary max limits acceptable for transportation conditions.
(3) Component case temperature limits must be met for all operating temperatures.

2.3 Handling Conditions

The SR300 has limited ESD protection built into the subassembly.

Figure 2-3: Electrostatic Discharge Caution

To provide a consistent ESD protection level during SR300 system assembly and rework, it is recommended that the JEDEC JESD625-A requirements standard be incorporated into the ESD environment controls.

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3 Component Specification

Table 3-1: Infrared and Color Camera Properties

PARAMETER	INFRARED CAMERA	COLOR CAMERA
Active Pixels	640x480	1920x1080
Sensor Aspect Ratio	4:3	16:9
Vertical Field of View	55° +/-2°	41.5° +/-2°
Horizontal Field of View	71.5° +/-2°	68° +/-2°
Diagonal Field of View	88° +/-3°	75.2° +/-4°
Inclination	+/-1° Yaw/Pitch Tilt	+/-1° Yaw/Pitch Tilt

Table 3-2: Infrared Projector Parameters

PARAMETER	DESCRIPTION
Projector	Coded Light
Laser Wavelength	860nm Nominal
Laser Compliance	Class 1, IEC 60825-1:2014 Ed 3
Vertical Field of Projection	60° +/-4°
Horizontal Field of Projection	72.5° +/-2°
Inclination	5°+/-2° Yaw Tilt (Towards IR Camera)

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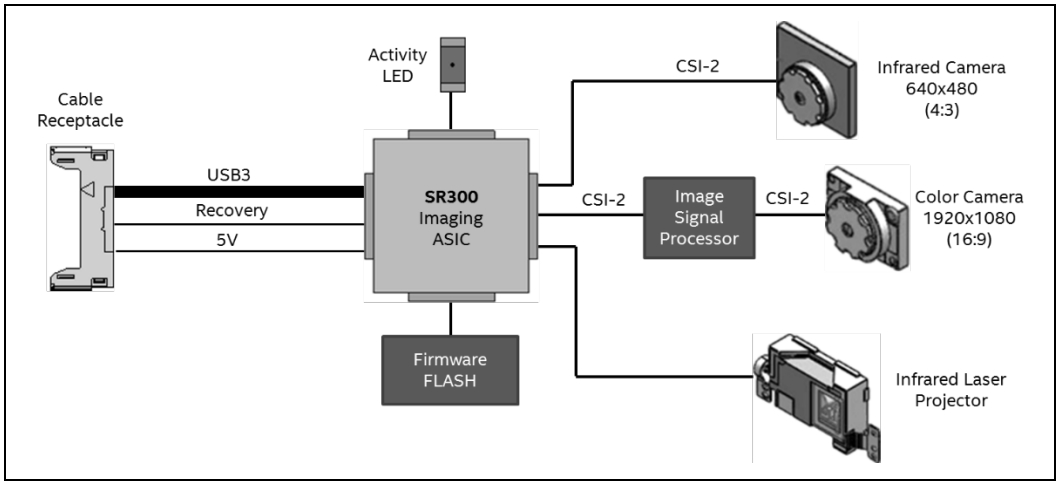
4 Functional Specification

4.1 Embedded 3D Imaging System

The IR projector and IR camera operate in tandem using coded light patterns to produce a 2D array of monochromatic pixel values. These values are processed by the imaging ASIC to generate depth and/or infrared video frames which are transmitted to the client system via USB3.

The color camera consists of a chromatic sensor and an image signal processor which captures and processes chromatic pixel values. These values generate color video frames which are transmitted to the imaging ASIC and then transmitted to the client system via USB3. The color camera can function independently from the infrared camera or function synchronously to create color + infrared + depth video frames.

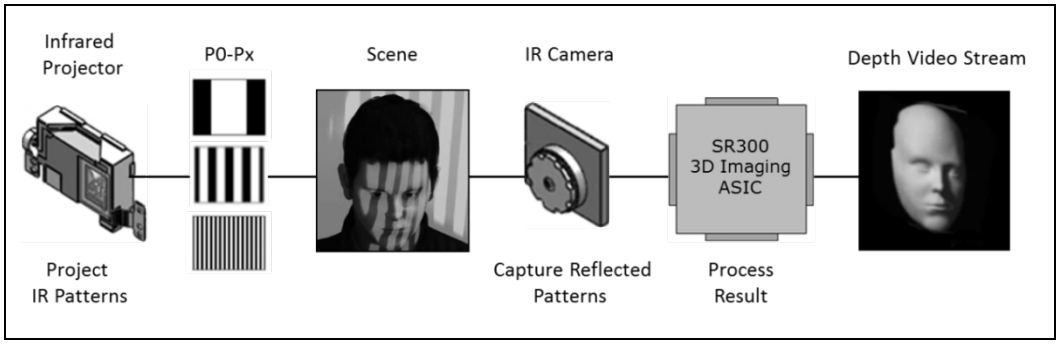
Figure 4-1: Embedded 3D Imaging System



4.1.1 Depth Video Data Capture Flow

To generate a depth frame, the IR projector illuminates the scene with a set of predefined, increasing spatial frequency coded IR vertical bar patterns. These patterns are warped by the scene, reflected back and captured by the IR camera. The IR camera pixel values are then processed by the imaging ASIC to generate a depth frame. Subsequent depth frames create a video stream that is transmitted to the client system.

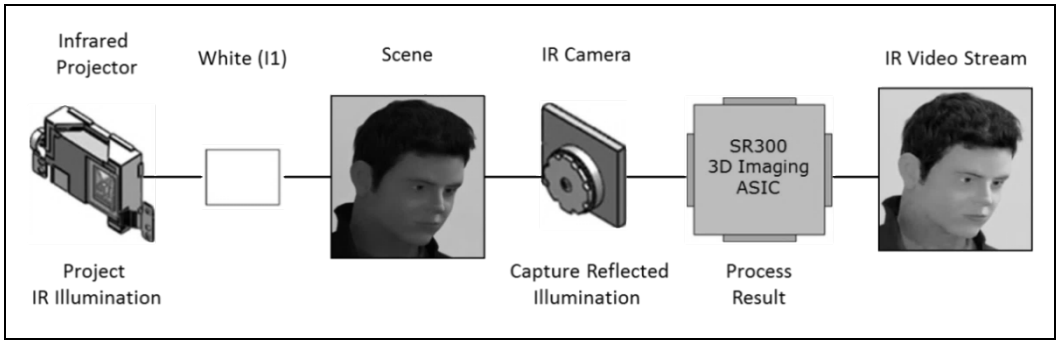
Figure 4-2: Depth Video Data Flow



4.1.2 Infrared Video Data Capture Flow

To generate an IR frame, the IR projector illuminates the scene with a white (I1) pattern. This pattern is reflected by the scene and captured by the IR camera. The IR camera pixel values are processed by the imaging ASIC to generate an IR frame. Subsequent IR frames create a video stream that is transmitted to the client system.

Figure 4-3: IR Video Data Flow



4.2 Camera Video Stream Formats

Table 4-1: Depth and Infrared Data Formats

FORMAT	KEY	TYPE	DESCRIPTION
Depth(1)	Z	16b UINT	Depth format equating to the 1/8mm sub-pixel distance from the SR300 subassembly planar surface to the object.
Depth(1)	Z	32b FLOAT	Depth format equating to the absolute distance (mm) from the SR300 subassembly planar surface to the object.
Infrared	I	10b UINT	IR format which equates to illuminating scene with a fully illuminated I1 pattern.
Texture(2)	U,V	32b FLOAT	Surface map calculated by client software to project depth video pixel values onto the color video pixels.
Vertices(2)	X,Y	32b FLOAT	Surface map calculated by client software to un-project each depth video pixel value into world coordinate space.
Confidence(2)	C	4b UINT	Provides a per pixel confidence value, 0xF equals high confidence and 0x0 represents low confidence.

(1) The effective range of the camera is up to 1.5m, but the 16b UINT depth format is interpolated over an 8m range (or 1/8mm sub-pixel resolution).

(2) The SR300 uses client software to process the UV and XY surface maps as well as the Z FLOAT and C UINT formats. The UV and XY maps are calculated based on the calibration coefficients stored on the SR300. Confidence is sent as 4 bits within a single byte.

All video stream formats are transmitted as 16b aligned formats from the camera.

Table 4-2: Depth and Infrared Video Stream Configurations

FORMAT	DEPTH	INFRARED	TEXTURE	VERTICES	CONFIDENCE
Z	16b/32b				
I		16b			
ZI	16b/32b	16b			
ZC	16b/32b				8b(C)
ZUV	16b/32b		32b+32b		
ZIUV(1)	16b/32b	16b	32b+32b		
ZXY	16b/32b			32b+32b	
ZIXY(1)	16b/32b	16b		32b+32b	
ZIUVXY(1)	16b/32b	16b	32b+32b	32b+32b	

(1) For these modes, the, the Infrared data can be replaced with Confidence map data. Infrared and Confidence cannot be transmitted simultaneously for a given configuration.

4.3 Camera Video Stream Modes

Table 4-3: Depth Modes, Nominal Frame Rates

FORMAT	RESOLUTION	RATIO	FRAME PER SECOND		
			60	30	10
Depth (Z)	640x480 (VGA)(1)	4:3	●	●	●
Depth (Z)	640x480 (VGA)	4:3	●	●	●

(1) Enabled automatically based on MvR exposure setting less than or equal to 8. This format will provide interpolated HVGA as VGA.

Table 4-4: Color Modes, Nominal Frame Rates

FORMAT	RESOLUTION	RATIO	FRAME PER SECOND		
			60	30	10
YUY2 (YUV 4:2:2)	1920x1080 (1080P FHD)	16:9		●	●
YUY2 (YUV 4:2:2)	1280x720 (720P HD)	16:9	●	●	●
YUY2 (YUV 4:2:2)	960x540 (540P)	16:9	●	●	●
YUY2 (YUV 4:2:2)	848x480 (480P)	16:9	●	●	●
YUY2 (YUV 4:2:2)	640x480 (VGA)	4:3	●	●	●
YUY2 (YUV 4:2:2)	640x360 (360P)	16:9	●	●	●
YUY2 (YUV 4:2:2)	424x240 (240P)	16:9	●	●	●
YUY2 (YUV 4:2:2)	320x240 (QVGA)	4:3	●	●	●
YUY2 (YUV 4:2:2)	320x180 (180P)	16:9	●	●	●

Table 4-5: Infrared Modes, Nominal Frame Rates

FORMAT	RESOLUTION	RATIO	FRAME PER SECOND			
			200	120	60	30
IR (I1)	640x480 (VGA)	4:3	●	●	●	●

All frame rates are expressed as nominal. Effective frame rates can vary depending on the exposure settings of the camera. Camera settings that increase the exposure time can decrease the effective frame rate.

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5 Firmware Update

5.1 Update

During a firmware update, the firmware utility will issue a device firmware update command to the SR300. The SR300 will then reset into firmware update mode. The firmware utility uses a single binary file to maintain the firmware image and is executed during the DCM system software installation. The firmware utility compares the firmware version installed on the camera to the firmware version file to be updated. Based on the comparison, the firmware utility will downgrade, upgrade, or skip if the versions match.

The firmware version programmed by the firmware utility is tightly coupled with the DCM runtime version. This is why the firmware utility is bundled with the DCM system software installer and should not be decoupled. If there is a mismatch between firmware and DCM versions, features can cease to function or unknown behaviors can occur.

5.1.1 Update Limits

The firmware update engine does not allow infinite update cycles between older and current versions of firmware. The engine will establish a baseline version of firmware based on the latest firmware version installed. The engine will allow a return to a previous version or baseline version of firmware up to 20 times. After the 20th update, the engine will only allow an update to a firmware revision higher than the baseline version.

5.2 Recovery

A read only boot sector is built into firmware which enables basic operation regardless of the integrity of the operation instructions region. This ensures the SR300 can function in the case of firmware not be written properly. When a firmware recovery is required, the firmware utility will communicate with the recovery driver to set the interrupt pin low and reset the SR300 in recovery mode.

Recovery is only supported if the system BIOS implements the INT33A3 HID device and methods for interrupt and power control. The recovery driver installation and recovery functions will FAIL if not implemented.

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6 Client Software

The SR300 requires the Depth Camera Manager (DCM) software for Windows* to be installed on the client system to enable all capabilities. The DCM provides camera access to RealSense™ SDK application through the SDK runtimes as well as access to standard camera applications. The DCM allows multiple applications to access the camera simultaneously as well as provide firmware update and recover capabilities through the DCM installer. The DCM should be installed before any RealSense™ applications or RealSense™ SDK runtimes are installed.

To ensure the camera implements current functions and property values ranges, install the latest DCM and firmware version.
https://software.intel.com/en-us/intel-realsense-sdk/download

6.1 Depth Camera Functions

Table 6-1: Depth Properties

PROPERTY	DESCRIPTION	AUTO
DEPTH_PROJECTOR_POWER	Set the power output level of the projector.	•
DEPTH_ACCURACY	Set the number of patterns projected per frame.	
DEPTH_FILTER_OPTION	Set the filter to apply to each depth frame.	
DEPTH_MOTION_RANGE	Set the exposure time for each pattern.	•
DEPTH_CONFIDENCE	Set the threshold between valid and invalid values.	
DEPTH_PRIVACY	Replace depth stream with static privacy image.	
DEPTH_PRESET	Set depth setting preset based on specific usage.	

Table 6-2: Depth Property Values

PROPERTY	VALUE RANGE	DEFAULT
DEPTH_PROJECTOR_POWER	0 - 16 (see projector settings)	16
DEPTH_ACCURACY(1)	1 (max) – 3 (min)	1
DEPTH_FILTER_OPTION	0 – 7 (see filter settings)	5
DEPTH_MOTION_RANGE(2)	0 (motion) – 220 (range)	9
DEPTH_CONFIDENCE	0 (min) – 15 (max)	3
DEPTH_PRIVACY	0 (disabled) – 1 (enabled)	0
DEPTH_PRESET(3)	0 – 9 (see preset settings)	N/A

(1) Accuracy values of 2 and 3 will produce the same result as both settings generate same number of patterns.

PROPERTY	VALUE RANGE	DEFAULT
(2) When accuracy is set to 1 (max), each increase in MvR increments total depth frame exposure by approximately 1.0ms. (3) No preset is enabled by default, start up is based on the default settings of the individual depth properties.		

6.1.1 Projector Power Settings

Table 6-3: Depth Projector Power

PROPERTY	DESCRIPTION	VALUE
PROJECTOR_DISABLED	Projector is shut down.	0
PROJECTOR_AUTO	Control power based on infrared camera.	1
PROJECTOR_ENABLE(1)	Projector operating at maximum power.	2-16
(1) Projector values between 2-16 enables projector at max power. Any value within this range will produce the same result.		

6.1.2 Filter Option Settings

Table 6-4: Filter Properties

PROPERTY	DESCRIPTION	RANGE(1)	VALUE
FILTER_SKELETON	High fidelity pixels only.	up to 4m	0
FILTER_RAW	Raw image with no processing.	up to 4m	1
FILTER_RAW_GRADIENT	Raw image with gradient filter applied.	up to 4m	2
FILTER_SCANNING	Very low smoothing, close range scans.	up to 2m	3
FILTER_LOW_SMOOTH	Low smoothing, high sharpness.	up to 2m	4
FILTER_MED_SMOOTH	Moderate smoothing and sharpness.	up to 2m	5
FILTER_MOTION	High smoothing, object motion.	up to 4m	6
FILTER_BLOB	High smoothing, long range blob.	up to 4m	7
(1) Specifies filter range and not optimized camera range. For depth camera settings which enable objects to be seen further than the optimized camera range, the applicable filter range may apply.			

6.1.3 Preset Settings

Presets configure the SR300 depth settings to Intel recommended values based on a predefined usage. Depth settings can be set to these values individually, but using presets provides a more convenient mechanism.

Table 6-5: Presets

PRESET	DESCRIPTION
PRESET_SHORT_RANGE	Objects are near the camera.
PRESET_MID_RANGE	Objects are in middle of range of camera.
PRESET_LONG_RANGE	Objects are far from the camera.
PRESET_SEGMENTATION	Removing background from foreground.
PRESET_GESTURE	Hand tracking and finger tracking.
PRESET_CURSOR_MODE	Use hand/finger as single cursor point for navigation.
PRESET_SCANNING	Object scanning.
PRESET_FACE_ANALYTICS	Face tracking and mapping.
PRESET_FACE_LOGIN	User authentication.
PRESET_IR_ONLY	Generic usage of infrared camera modes.

Table 6-6: Preset Setting Values

PRESET	AR	MVR	ACCURACY	CONF	FILTER
PRESET_SHORT_RANGE	ON	AUTO	1	1	5
PRESET_MID_RANGE	ON	AUTO	1	1	5
PRESET_LONG_RANGE	OFF	AUTO	1	0	7
PRESET_SEGMENTATION	OFF	22	1	2	6
PRESET_GESTURE	ON	AUTO	1	3	6
PRESET_CURSOR_MODE	ON	AUTO	1	1	6
PRESET_SCANNING	OFF	9	1	1	3
PRESET_FACE_ANALYTICS	OFF	22	1	1	5
PRESET_FACE_LOGIN	ON	AUTO	N/A	N/A	N/A
PRESET_IR_ONLY	ON	AUTO	N/A	N/A	N/A

6.1.4 Auto Range (AR)

The SR300 supports the ability to dynamically adjust the projector power and infrared camera exposure based on the scene. This feature is functional for VGA modes only.

Table 6-7: Auto Range

DEPTH CONTROL	SETTING
DEPTH_MOTION_RANGE	AUTO
DEPTH_PROJECTOR_POWER	AUTO

6.2 Color Camera Functions

6.2.1 Standard Functions

Table 6-8: Standard Color Properties

PROPERTY	DESCRIPTION	AUTO
COLOR_EXPOSURE	Manual setting when auto exposure is disabled.	•
COLOR_BRIGHTNESS	Sets brightness when auto-exposure is enabled.	
COLOR_CONTRAST	Sets contrast based on the brightness of the scene.	
COLOR_SATURATION	Sets saturation adjustment applied to the frame.	
COLOR_HUE	Sets hue adjustment applied to the frame.	
COLOR_GAMMA	Sets gamma correction applied to the frame.	
COLOR_WHITE_BALANCE	Manual setting when auto white balance is disabled.	•
COLOR_SHARPNESS	Sets sharpening adjustment applied to the frame.	
COLOR_BACK_LIGHT_COMP	Sets weight amount based on scene brightness.	
COLOR_GAIN	Sets gain level when auto-exposure is disabled.	

Table 6-9: Standard Color Property Values

PROPERTY	RANGE	DEFAULT
COLOR_EXPOSURE	-8 (min) – 0 (max)	AUTO
COLOR_BRIGHTNESS	0 (min) – 255 (max)	0
COLOR_CONTRAST	-0 (min) – 100 (max)	50
COLOR_SATURATION	0 (min) – 100 (max)	64
COLOR_HUE	-180 (min) – 180 (max)	0
COLOR_GAMMA	100 (min) – 500 (max)	300
COLOR_WHITE_BALANCE	2800 (min) – 6500 (max)	AUTO
COLOR_SHARPNESS	0 (min) – 100 (max)	50
COLOR_BACK_LIGHT_COMP	0 (min) - 4 (max)	0
COLOR_GAIN	0 (min) – 128 (max)	64

6.2.2 Extended Functions

There is no native UVC support for these functions. These extended functions can only be accessed through client software installed on top of UVC driver.

Table 6-10: Standard Color Properties

PROPERTY	DESCRIPTION	AUTO
COLOR_PWR_LINE_FREQ	Flicker avoidance based on power line frequency	•
COLOR_EXP_PRIORITY	Set FPS to be static regardless of lighting condition.	

Table 6-11: Extended Color Property Values

PROPERTY	RANGE	DEFAULT
COLOR_PWR_LINE_FREQ	OFF/50Hz/60Hz/AUTO	AUTO
COLOR_EXP_PRIORITY	0 (enable) – 1 (disable)	0

6.3 Control Persistence

The SR300 firmware and DCM provide persistence function based on the control requested and if a client application is running or not. Persistence ensures that the color and depth settings programmed before SR300 power was removed will be the same after SR300 power is restored. The SR300 enables color setting persistence by default.

Table 6-12: Control Persistence

CONTROL	COMPONENT	PERSISTENCE
Color Settings	Firmware	Settings persisted even when power is removed.
Depth Settings	DCM	Persist when client running before system standby.

If a client application requires specific color and depth settings these should be verified and programmed each time the application is executed.

6.4 Privacy

Privacy can be enabled by client software individually for the depth and color endpoints. When enabled, the depth or color video frame data is replaced by the SR300 firmware with a custom image. The depth privacy image is used for the infrared privacy image.

Figure 6-1: Privacy Image Output

PRIVACY DISABLED	PRIVACY ENABLED
	

The custom privacy image will be scaled based on the resolution set for the depth and color video streams. The privacy images are compressed as RLE (run-length encoding) and stored in firmware based on set quantization level.

Table 6-13: Customized Privacy Images

FEATURE	FORMAT	RESOLUTION
Color Privacy Image	RLE (Greyscale)	360P (16:9) and VGA (4:3)
Depth Privacy Image	RLE (Greyscale)	QVGA (4:3)

Depth and color privacy controls are separated for usages in which privacy control for an application using color can be enabled without sacrificing usages which require only depth.

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7 System Interoperability

7.1 USB Composite Device

The SR300 imaging ASIC is a USB3 composite device which exposes all hardware endpoints to the operating system. The imaging ASIC is a bulk device and transmits depth and color videos streams in data bursts rather than as constant video streams.

Table 7-1: USB Composite Device Hardware ID

HARDWARE ID	BITS	VALUE
Vendor ID	[15:0]	0x8086
Device ID	[15:0]	0x0AA5
Revision ID	[15:12]	Firmware Major Version
	[11:4]	Firmware Minor Version
	[3:0]	Firmware Sub-Minor Version

7.1.1 Device Endpoints

Table 7-2: USB Composite Device Endpoints

ENDPOINT	RUNTIME	FW UPDATE
USB Composite Device	●	
Intel® RealSense™ Camera SR300 RGB	●	
Intel® RealSense™ Camera SR300 Depth	●	
Intel® RealSense™ Camera SR300	●	
Intel® RealSense™ Camera SR300 Device		●

7.1.2 System Endpoints

Table 7-3: System Device Endpoints

ENDPOINT	RUNTIME	FW UPDATE
ACPI Intel® RealSense™ Camera (SR300)	●	●

The platform endpoint is required to support SR300 recovery. If the FW becomes corrupted this is the only mechanism to update.

7.1.3 Typical Power Consumption

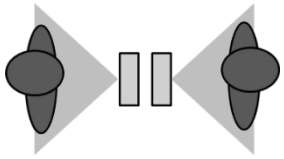
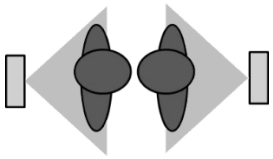
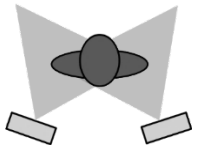
Table 7-4: Typical Power Consumption

DEPTH MODE	INFRARED MODE	COLOR MODE	POWER	UNIT
OFF	OFF	OFF	20	mW
OFF	OFF	1080P, 30FPS	650	mW
OFF	VGA, 30FPS	OFF	980	mW
VGA, 30FPS	VGA, 30FPS	OFF	1150	mW
VGA, 60FPS	VGA, 60FPS	OFF	1450	mW
VGA, 60FPS	VGA, 60FPS	1080P, 30FPS	1800	mW

7.2 Infrared Projector Interference

Interference can occur if the SR300 is capturing infrared patterns projected from multiple infrared projectors simultaneously. Low interference assumes a user is in front of each SR300 and comfortably spaced apart.

Figure 7-1: Interference

NO INTERFERENCE	LOW INTERFERENCE	HIGH INTERFERENCE
		

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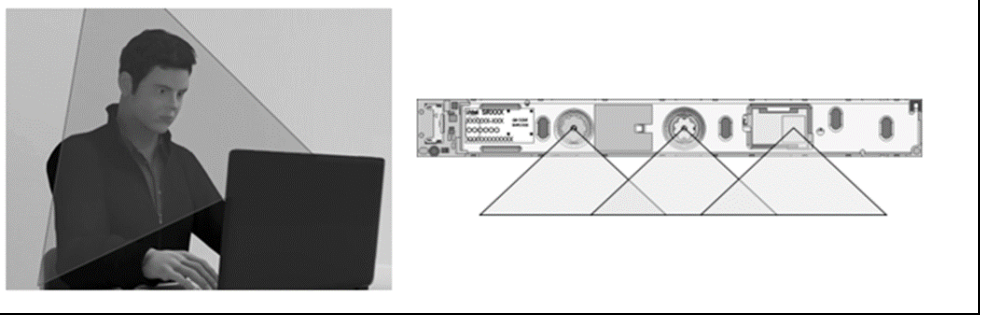
8 System Integration

The small size of the SR300 subassembly provides system integrators flexibility to design into a wide range of products.

Figure 8-1: Front Facing Camera Placement



8.1 Placement

The placement of the SR300 within the system should ensure the visibility of the user or target is maximized. If the system is intended to be designed for face based applications, the SR300 should be placed so that the intended location of the user's face is centered with respect to the SR300 module.

For some designs a rotational placement within the system may be required. The optimal rotational angles are dependent on the product height, component field of views, and target usage. The optical interaction between the IR projector, IR camera, and display glass should be evaluated to ensure depth quality or field of view is not impacted. Rotational angles will also have an impact on the through-hole design.

Table 8-1: Rotational Angles Relative to Glass

ROTATION	MIN	MAX	UNIT
Pitch	-30	30	degrees
Roll(1)	-180	180	degrees
Yaw(2)	0	0	degrees

(1) Client software that requires location descriptor of rotation must align to physical value.

(2) A yaw rotation can create projector reflections into the IR sensor which can lead to unwanted artifacts in the image.

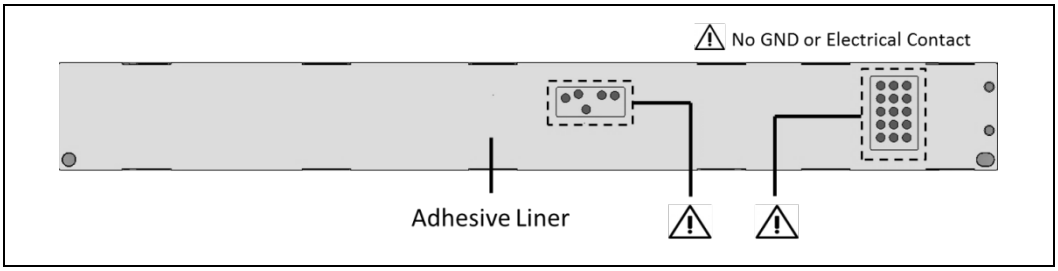
Some applications may have very specific requirements for SR300 placement. If a system is intended to be compliant to those requirements, refer to those respective specifications.

8.2 Grounding

Testing should be performed to quantify the level of grounding required. It is recommended that there be at least two ground contact points to the system.

- It is not recommended that the adhesive liner be used as primary grounding to avoid accidently grounding the test points.
- The assembly frame can be used as the primary ground contact point to the system.
- Openings at the system for each of the SR300 components should be as small as possible.

Figure 8-2: No Ground or Electrical Contact

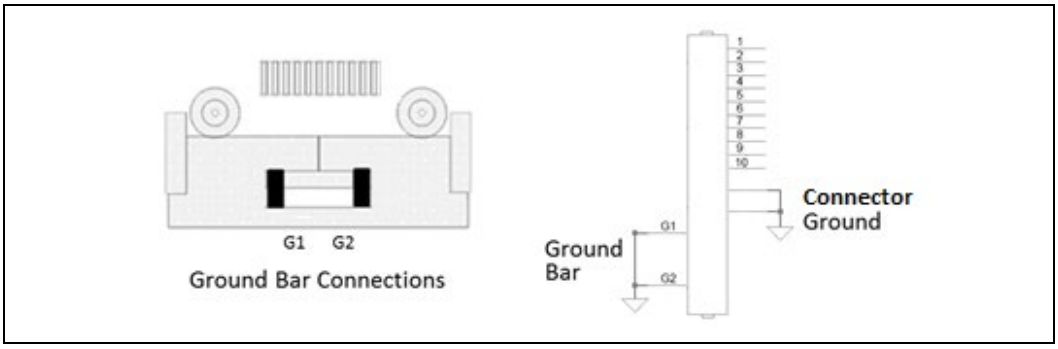


Placement and assembly of any EMI gaskets on the assembly frame must not cause SR300 camera component occlusions. Grounding material must not make contact with any non-GND subassembly components, pads, or signals.

8.2.1 Motherboard Receptacle

It is recommended that the motherboard receptacle by grounded as well as ground bar pads implemented.

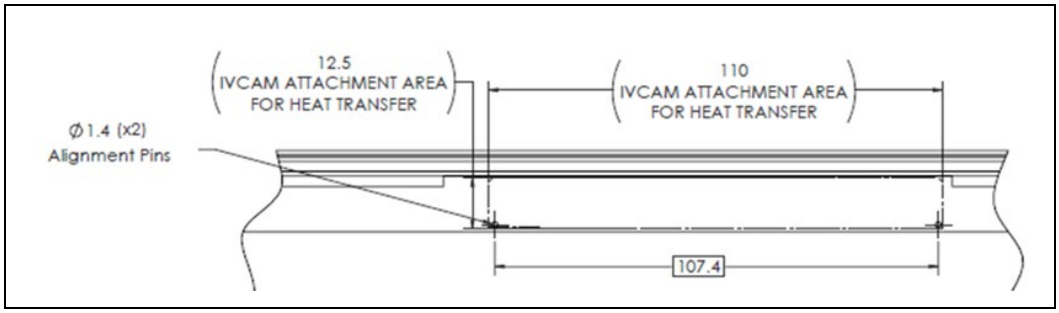
Figure 8-3: Receptacle Ground Bar Motherboard Connections



8.3 Attachment and Alignment

The SR300 aligns to the system chassis by two 1.4 ± 0.05mm alignment pins separated by 107.4 ± 0.1mm. The SR300 consists of two corresponding alignment holes to ensure the subassembly cannot rotate after being assembled into the system.

Figure 8-4: Attachment Area and Alignment Pins

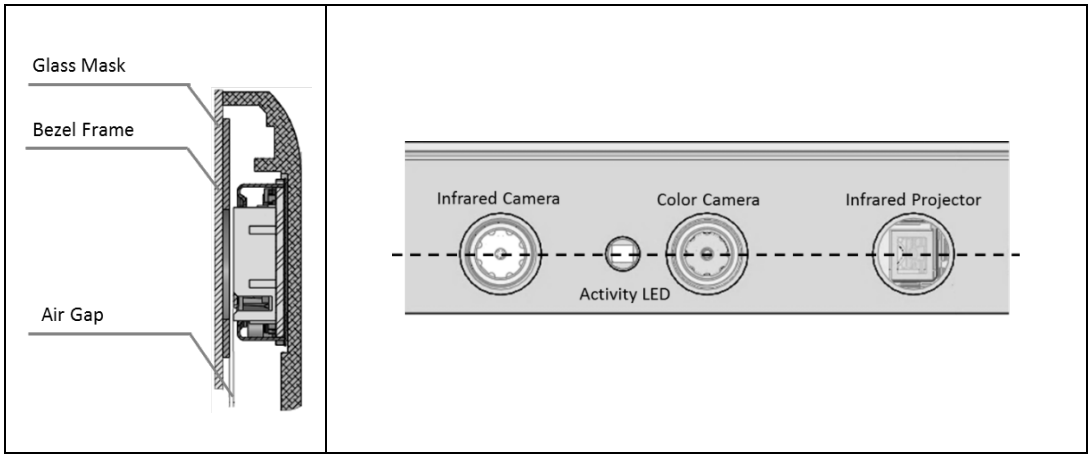


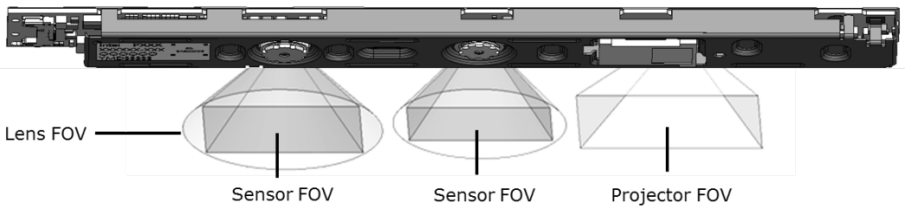
One alignment hole is a 1.5 ± 0.05mm round for securing placement and one hole is a 1.5 ± 0.05mm oval for accommodating manufacturing tolerances.

8.4 System Through-Holes

The system design through-holes should be designed to accommodate the maximum component field of view tolerances. The sensor field of view specifications are defined for the cameras and should be used for the through-hole evaluation.

Figure 8-5: Through-Hole Design Considerations





A system CAD evaluation should be completed with the SR300 CAD to validate that the dimensions of the system through-holes are sized to not intersect the sensor and projector FOV parts.

8.4.1 Cover Material Transmission

The SR300 components must be covered to minimize dust and humidity. The cover material stack-up used must provide acceptable transmission based on the component wavelengths, intended usage, and expected image quality for the system.

Table 8-2: Component Transmission

COMPONENT	WAVELENGTH	UNIT
Color Camera	Visible Spectrum	nm
Infrared Projector	860 @ 92% Transmission	nm
Infrared Sensor	860 @ 92% Transmission	nm

Glass or transparent layers covering the laser projector and infrared sensor must have a uniform thickness and no perceivable curving or bending to minimize the distortion of the transmitted and reflected patterns.

8.5 Thermals

The system thermal design must ensure the SR300 component case temperature and system skin temperature limits are not exceeded for max operating conditions.

Table 8-3: Power and TDP at Max Operating Mode

COMPONENT	POWER(1)	TDP(2)	UNIT
All Components	2300W	2200	mW

(1) The values were measured with an ambient light of 200 Lux and with a white screen 20 cm in front of the camera filling the cameras FOV.

(2) The IR projector and activity LED TDP is lower than power due to a percentage of energy dissipated as photonic emissions rather than heat.

Figure 8-6: Thermocouple Test Locations

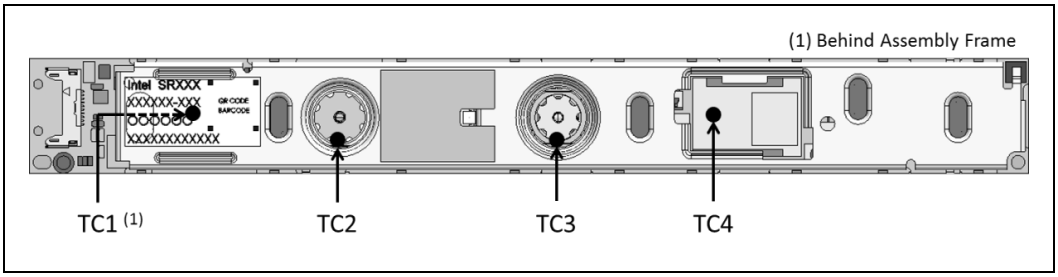


Table 8-4: Case Temperature Limits (Still Air)

LOCATION	COMPONENT	CASE TEMPERATURE LIMIT (T_{CASE})			UNIT
		MIN	TYPICAL(1)	MAX, 35°C T_A	
TC1	Imaging ASIC	0	N/A	85	°C
TC2	Infrared Camera	0	50	60(2)	°C
TC3	Color Camera	0	50	60(2)	°C
TC4	Infrared Projector	0	50	60(2)	°C

(1) Typical represents the recommended TCase temperature limit for standard runtime scenarios at 25°C TA (temperature ambient).

(2) 60°C for the camera and projector components is worst case and must not be designed for typical operation. The camera sensor noise above the max temperature will exceed acceptable limits for image quality.

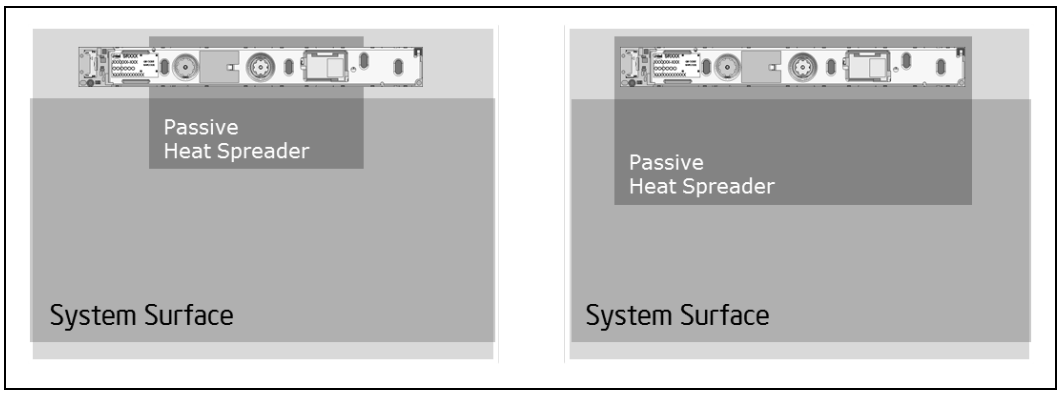
8.5.1 Thermal Interface Material (TIM)

It is recommended that either the 3M 8805 or 3M 9882 thermal-only conductive adhesive strip be used to attach the module to the system chassis. To maximize heat transfer, the TIM area should be maximized as much as possible to cover the area of the SR300 adhesive liner.

8.5.2 Passive Heat Spreader

To minimize the need or size for an internal passive heat spreader, it is recommended that a metal chassis material with a thermal conductance greater than 20 [W/mK] and an effective thermal resistance of less than 8 [K/W] be used. If a plastic chassis material is used, this will generally require a passive heat spreader solution.

Figure 8-7: Passive Heat Spreader



8.6 Electrical

To support the bandwidth required by the camera video stream modes, a USB3 interface is required. To ensure the best of quality of service, the SR300 must be connected to a dedicated USB3 root port within the client system.

To support all operating modes, the SR300 requires a controllable 5V ± 5% power resource. The system design must accommodate for voltage drops within the topology to ensure the minimum input voltage is met for V_{DD}. The controllable power resource should be driven by a core power rail.

To support firmware recovery, a 3.3V controllable interrupt must be connected to the SR300 INT pin.

Table 8-5: Electrical Characteristics

PARAMETER		MIN	NOM	MAX	UNIT
V_{DD}	Supply Voltage	4.5	5	5.5	V
I_{DD}	Supply Current	N/A	0.6(1)	N/A	A
INT V_{IH}	Input High Voltage(2)	2.0	3.3	3.6	V
INT V_{IL}	Input Low Voltage(2)	0	0	0.8	V
INT	Pull Up Resistance	20	N/A	60	kΩ

(1) The SR300 power resource should be capable of supplying at least 2.5W through a 5V nominal power source. The SR300 implements two 5V pins with a rated current of 0.3A for each pin.

(2) Voltage is as measured by SR300 ASIC pin.

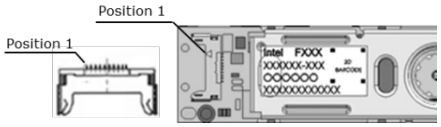
8.6.1 Receptacle

Table 8-6: Receptacle Pin Out

POSITION	NAME	TYPE	DESCRIPTION
1	GND	-	Ground
2	$USB3\_SS_{TX-}$	OUT	USB3 Transmitter Negative
3	$USB3\_SS_{TX+}$	OUT	USB3 Transmitter Positive
4	GND	-	Ground
5	$USB3\_SS_{RX-}$	IN	USB3 Receiver Negative
6	$USB3\_SS_{RX+}$	IN	USB3 Receiver Positive
7	GND	-	Ground
8	INT	IN	Firmware Recovery Interrupt
9	VDD	-	Supply Voltage, Connect to 5V
10	VDD	-	Supply Voltage, Connect to 5V

The system USB3 transmit signals must be connected to the imaging module USB3 receive signals. The system USB3 receive signals must be connected to the imaging module USB3 transmit signals.

Table 8-7: Receptacle Characteristic

PROPERTY	DESCRIPTION	DIAGRAM
Shell Finish	Tin (Sn)	
Lock	Yes	
Ground Bar	Yes	
Alignment Boss	No	
Part Number	IPEX 20347-310E-12R	

8.6.2 High Speed Cable Assembly

The high speed cable assembly is developed and procured by the system integrator. The cable assembly design is specific to the system definition and must meet SR300 cable assembly design specification.

Table 8-8: Plug Characteristics

PROPERTY	DESCRIPTION	DIAGRAM
Shell Finish	Tin (Sn)	
Friction Lock	Yes	
Ground Bar	Yes	
Plug Part Number	IPEX 2047-0103	
Housing Part Number	IPEX 20346-010T-31	

The cable should not be connected/disconnected from the SR300 more than 10 times.

Table 8-9: Cable Assembly Specification

PROPERTY	DESCRIPTION
Cable Length	508mm ± 10mm (~20 inches)
Controlled Impedance	50Ω ± 10%
Max Insertion Loss	7.5dB at 2.5Ghz
Cable Shielding	Each plug connected to the receptacle shield and GND bar.
Minimum Gauge	40 AWG for micro-coax, 36 AWG for wire.

Deviation from these properties is allowed, but the compatibility with the SR300 receptacle must be maintained. Longer cable lengths is allowed, but signal integrity should be evaluated by the system integrator.

Table 8-10: Cable Assembly Interconnect Properties

POS	SR300	SYSTEM	AWG	INTERCONNECT DESCRIPTION
1	GND	GND	40	50Ω micro-coax, shield soldered to GND bar.
2	USB3_TXN	USB3_RXN	40	50Ω micro-coax, shield soldered to GND bar.
3	USB3_TXP	USB3_RXP	40	50Ω micro-coax, shield soldered to GND bar.
4	GND	GND	40	50Ω micro-coax, shield soldered to GND bar.
5	USB3_RXN	USB3_TXN	40	50Ω micro-coax, shield soldered to GND bar.
6	USB3_RXP	USB3_TXP	40	50Ω micro-coax, shield soldered to GND bar.
7	GND	GND	36	UL 10064 Wire (Rated at least 0.3A.)
8	INT	INT	36	UL 10064 Wire
9	VDD	5V	36	UL 10064 Wire (Rated at least 0.3A.)
10	VDD	5V	36	UL 10064 Wire (Rated at least 0.3A.)

8.6.3 System Receptacle

Table 8-11: System Receptacle Properties

PIN	WIRE DESCRIPTION
Differential Impedance	75 to 105Ω (USB3 Signals)
Rise Time	50ps (20% - 80%)
Max Cross Talk	-34dB up to 2.5GHz.
Current Rating	0.3A ± 5%
Shielding	Metal shielding, connected to GND plane.
Grounding	Two ground bar connections in addition to the connector GND.

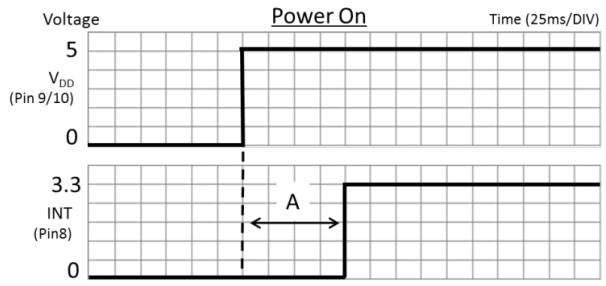
8.7 Power Sequence Timings

Table 8-12: Power Sequence

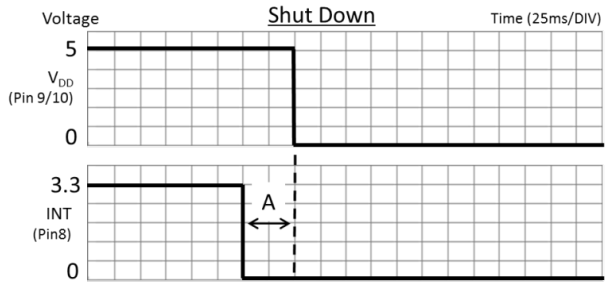
SYSTEM STATE	SR300 STATE	VDD	INT
S0	Runtime	5V	3.3V
S0	Recovery	5V	0V
S3/S4/S5	Shut Down	0V	0V

Due to internal capacitance, a 200ms minimum delay is required to discharge the SR300 before power is restored. The SR300 interrupt must be set LOW anytime power is removed.

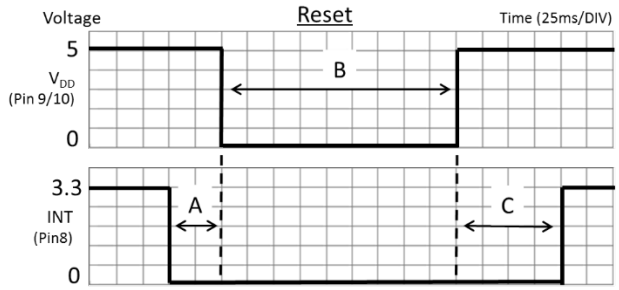
Table 8-13: Power Sequence Timings



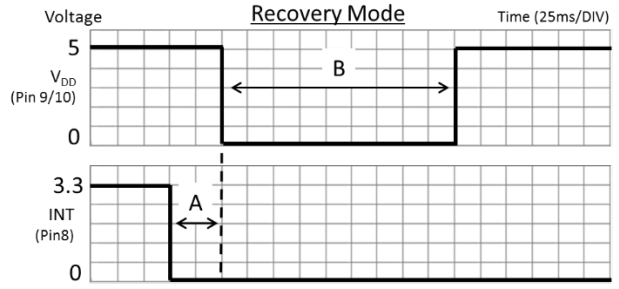
	MIN	MAX	UNIT
A	0	100	ms



	MIN	MAX	UNIT
A	0	50	ms



	MIN	MAX	UNIT
A	0	50	ms
B	200	N/A	ms
C	0	100	ms



	MIN	MAX	UNIT
A	0	50	ms
B	200	N/A	ms

8.8 Acoustics

System elements in contact with the SR300 can cause acoustics generated by the SR300 to be transferred and amplified. To minimize this effect, the following considerations are recommended.

- The only chassis contact with the module is the adhesive liner to the adhesive TIM and SR300 alignment holes to the chassis alignment pins.
- Any chassis element around the module (metal/plastic), or any gaskets from the glass/bezel should be spaced at least 50-300um from the module.
- Avoid any hard connection between the camera module assembly frame and the chassis (plastic frame/glass).
- Maintain a minimum air-gap of 50-300um.

Acoustic measurements should be taken with SR300 integrated into the system. Measurements are not intended to be taken with respect to standalone module.

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9 System BIOS

The BIOS must map the integrated USB3 port to the SR300 and report the location for each camera. The BIOS must declare the SR300 power resource methods and creates an interface to directly control the power resource and interrupt pin through a GPIO.

9.1 UPC (USB Port Capabilities)

The USB3 port in the USB port allocation must be a non-companion port.

Table 9-1: UPC Elements

ELEMENT	TYPE	DESCRIPTION	VALUE
Port Is Connectable	Integer (BYTE)	Yes	0xFF
Port Connector Type	Integer (BYTE)	Fixed	0xFF
Reserved 0	Integer	N/A	0x00000000
Reserved 1	Integer	N/A	0x00000000

Table 9-2: UPC Return Package Values

```
Name(_UPC, Package()) {

    0xFF,             // Port is Connectable and Internal
    0xFF,             // Connector is Proprietary and Fixed
    0x00000000,       // Reserved 0, must be zero
    0x00000000})      // Reserved 1, must be zero
}
```

9.2 PLD (Physical Device Location)

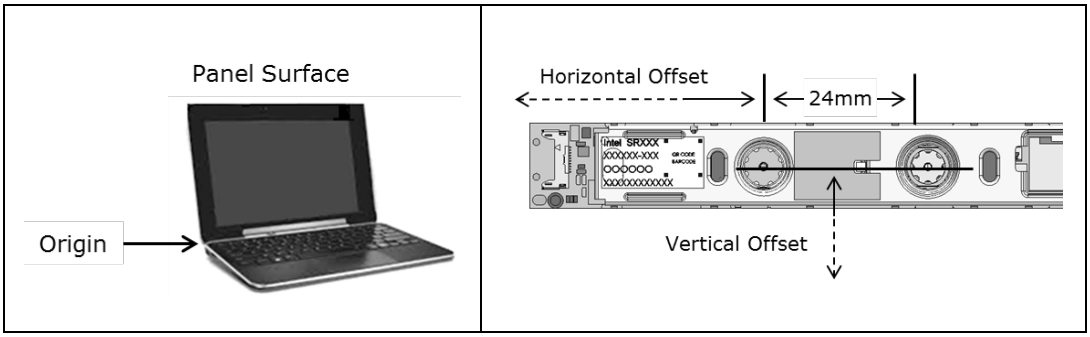
An independent _PLD table must be mapped to each camera's address. The address (_ADR) for the color camera (offset 0x0) and infrared camera (offset 0x2) are dependent on the USB port that the SR300 is mapped.

For example, if the SR300 was mapped to USB port 15 (0x0F), the color camera _ADR value is 0x0F and infrared camera _ADR value is 0x11. The UVC OS Address property can be used to verify this value.

Table 9-3: PLD Elements

ELEMENT	BITS	DESCRIPTION	VALUE
Revision	[6:0]	Current	2
Color	[7]	Ignore	0
User Visible	[64]	Integrated	0
Panel Surface	[69:67]	Front Surface	4
Vertical Position	[71:70]	Upper	0
Horizontal Position	[73:72]	Center	1
Group Position	[94:87]	Non-Companion USB3 Port	Unique Port Value
Rotation	[118:115]	Default Orientation, No Rotation	0
Vertical Offset	[143:128]	Offset from Panel Surface Origin	System Specific
Horizontal Offset	[159:144]	Offset from Panel Surface Origin	System Specific

Figure 9-1: PLD System Design Considerations



9.3 Recovery Device Interface

INT33A3 is the unique HID identifier for the SR300 recovery device interface. This device is a fixed platform device, independent from the SR300 device state, and is always exposed.

9.3.1 DSM (Device Specific Method)

The recovery device interface must implement methods to control the INT_GPIO and VDD_GPIO directly. These methods are used by the firmware utility to configure the SR300 into recovery mode. VDD_GPIO and INT_GPIO system design locations are defined by the integrator and abstracted through a write to GPIO (WTGP) function.

Table 9-4: Recovery Device Method Arguments

ARGUMENT	DESCRIPTION	VALUE
Arg0	Unique Function Identifier	F5CF0FF7-5D60-4842-82C0-FA1A61D873F2
Arg1	Integer Revision Level	0
Arg2	Integer Function Index	0: QUERY, 1: INT_GPIO, 2: VDD_GPIO
Arg3	Package Parameters	0: Disable, 1: Enable

9.4 Power Resource

The BIOS needs to specify the serialized power resource methods for enabling and disabling VDD_GPIO based on the OSPM policies.

Table 9-5: Power Resource Methods

OBJECT	DESCRIPTION
_OFF	Disable the power resource.
_ON	Enable the power resource.
_STA	Evaluate enable/disable state of the power resource.

Adding the serialized statement ensure that multiple operations are not attempted concurrently.

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10 System Assembly and Rework

The system assembly and rework flows are specific to the recommended 3M 8805 and 3M 9882 thermal conductive strip.

ATTENTION
OBSERVE PRECAUTIONS FOR HANDLING
ELECTROSTATIC DISCHARGE
SENSITIVE DEVICES

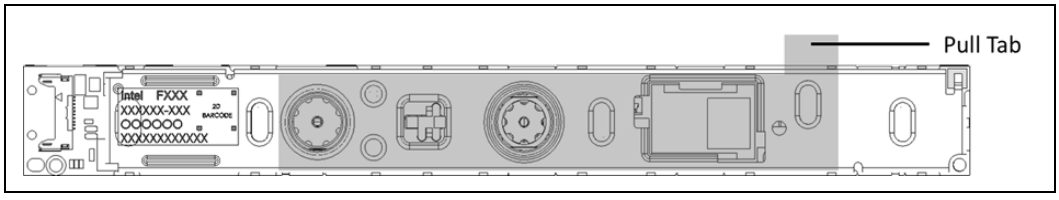
10.1 System Assembly

The SR300 system assembly flow for the adhesive thermal conductive strip is as follows:

1. Clean the imaging module attachment area and system chassis attachment area with isopropyl alcohol (IPA).
2. Once both attachment areas are dry, release one side of the adhesive strip and place securely on the system chassis attachment area(1). Ensure flush attachment, no wrinkles or bubbles.
3. Release second side of adhesive strip.
4. Attach the SR300 adhesive liner area to the adhesive strip on the system chassis attachment area, use alignment pins as guides. The external force applied to the SR300 assembly frame should not exceed 180N or 20 PSI. Refer to the TIM strip bonding force specification for minimum force requried.
5. Remove the plastic protective liner from the SR300 using the pull tab. Verify no excess charge has accumulated around the components.

(1) *Refer to the application pressure guidelines of the adhesive strip to ensure proper "flexible to rigid" surface connection of the imaging module to the system.*

Figure 10-1: Plastic Protective Liner

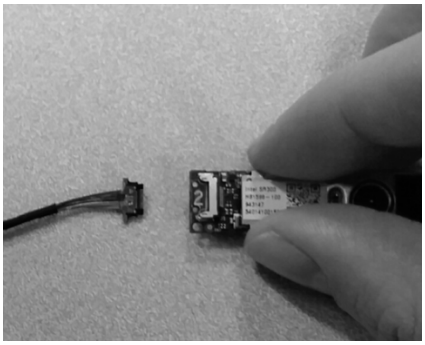
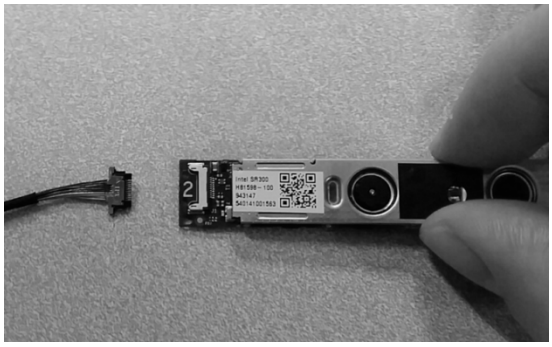


If the plastic protective liner is not removed, this will cause significant impact to SR300 image quality and performance.

10.1.1 Attaching Cable Assembly

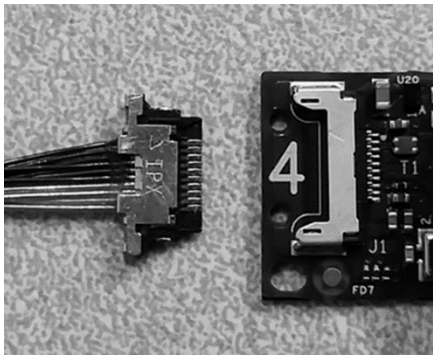
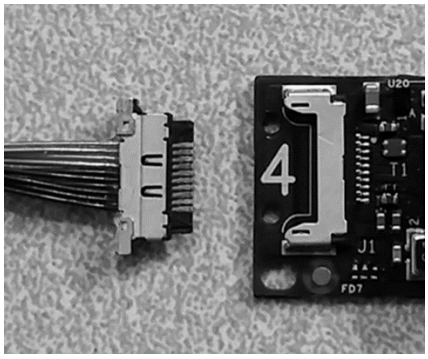
The top and bottom area near the label should be used to grasp the module when attaching the cable assembly. This will prevent stress and the possibility of module bending or cracking.

Figure 10-2: Attaching Cable Assembly

CORRECT	NOT CORRECT
	

Ensure the plug of the cable assembly is orientated correctly before connecting to the module receptacle. Check with your cable assembly provider.

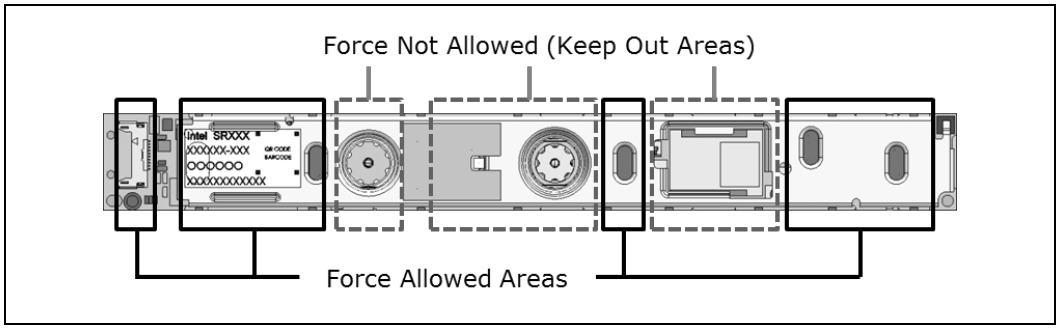
Figure 10-3: Cable Plug Orientation

CORRECT	NOT CORRECT
	

10.1.2 Pressure Force Allowed Areas

Care must be taken to ensure that no force is applied to the optical components, including camera sensors, projector and activity LED areas.

Figure 10-4: Pressure Force Allowed Areas



10.2 Removal and Replace

The SR300 removal and rework flow for the recommended adhesive thermal-electrical conductive strip is as follows:

1. Release SR300 from its place in the system form factor.
2. Release adhesive strip from its place in the system chassis.
3. Repeat the SR300 system assembly flow.

Based on the 3M 8805 and 3M 9882 adhesive strip bonding force specification, the force required to remove the SR300 may cause structural damage to the unit. The cable should not be connected/disconnected from the SR300 more than 10 times.

10.3 Cleaning

If the window of the IR projector accumulates dust or oils, gently wipe the window with a lint free cloth. If dust or oils are still present, dampen the lint free cloth with a couple drops of isopropyl alcohol (IPA) and gently wipe the window again. Care should be taken in the amount of pressure used and to avoid any scratching of the IR projector window surface.

Do not apply isopropyl alcohol to the window surface directly.

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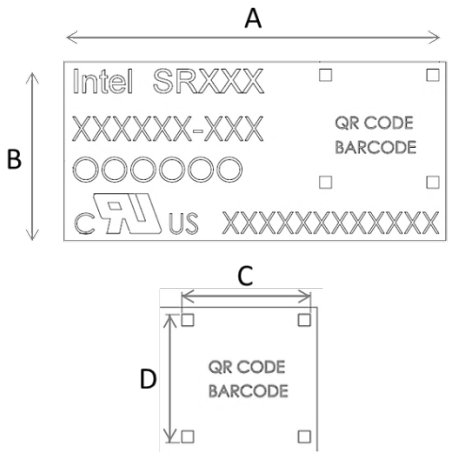
11 Labeling

The SR300 label is located on the front side of the module.

Figure 11-1: Product Labeling



	DIMENSION	VALUE	UNIT
A	Label Width	7.0	mm
B	Label Height	7.0	mm
C	Scan Code Width	3.5	mm
D	Scan Code Height	3.5	mm

Scan Code Format
XXXXXXXXXXXXOOOOOOXXXXXX-XXX

Table 11-1: Scan Code Fields

GROUP	FIELD	DESCRIPTION	TYPE
Company	Intel	Manufacturer	Static
Model Number	SR300	Camera Model Number	Static
Product Assembly Number	XXXXXX	Product Identifier Code	Static
	-XXX	Manufacture Configuration Code	Dynamic
	OOOOOO	Product Material Code	Static
Serial Number	XXXXXXXXXXX	Manufacture Unit Code	Dynamic

Table 11-2: Product Code Details

PRODUCT IDENTIFIER CODE	PRODUCT MATERIAL CODE
H89061	943228

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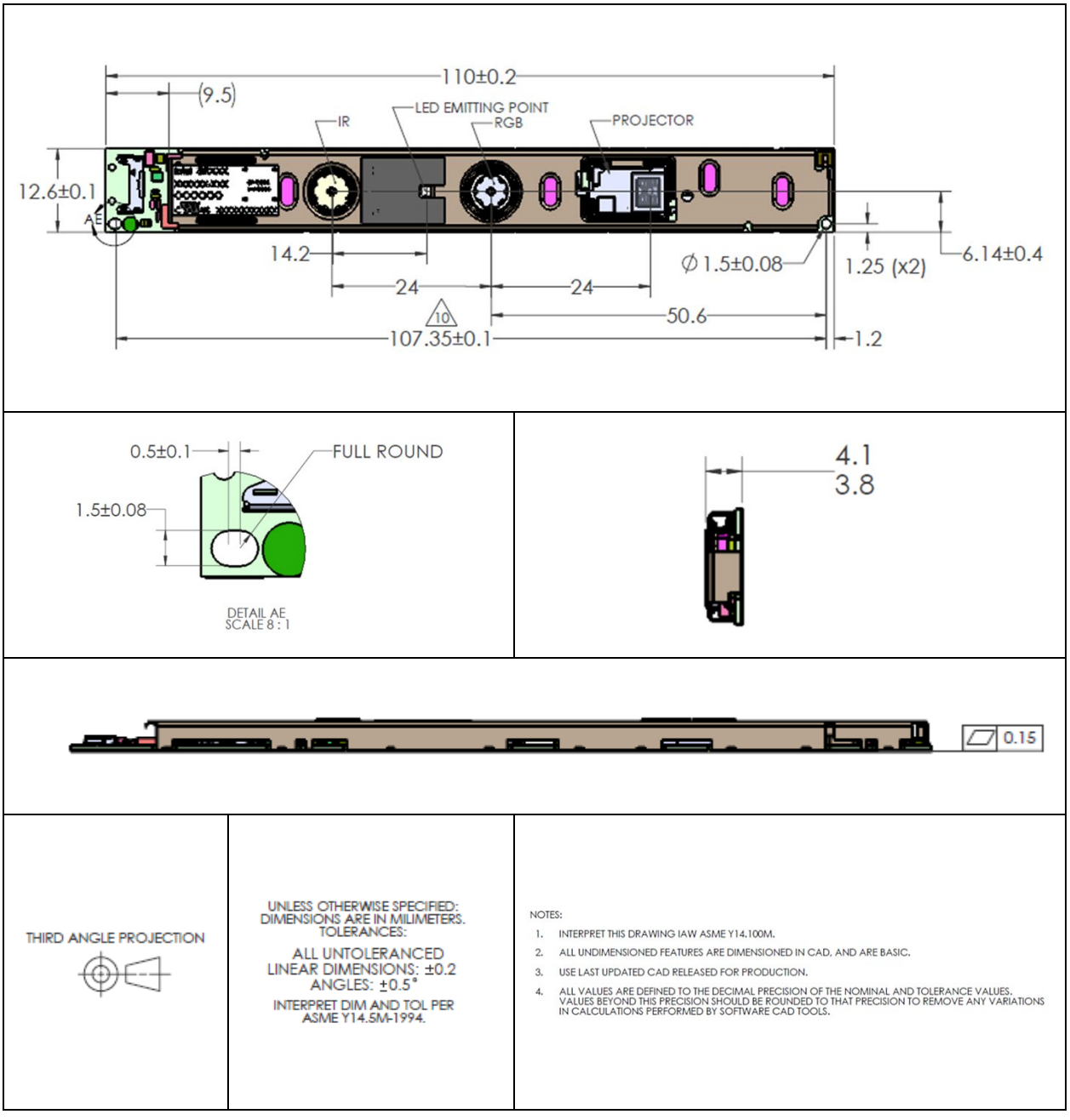
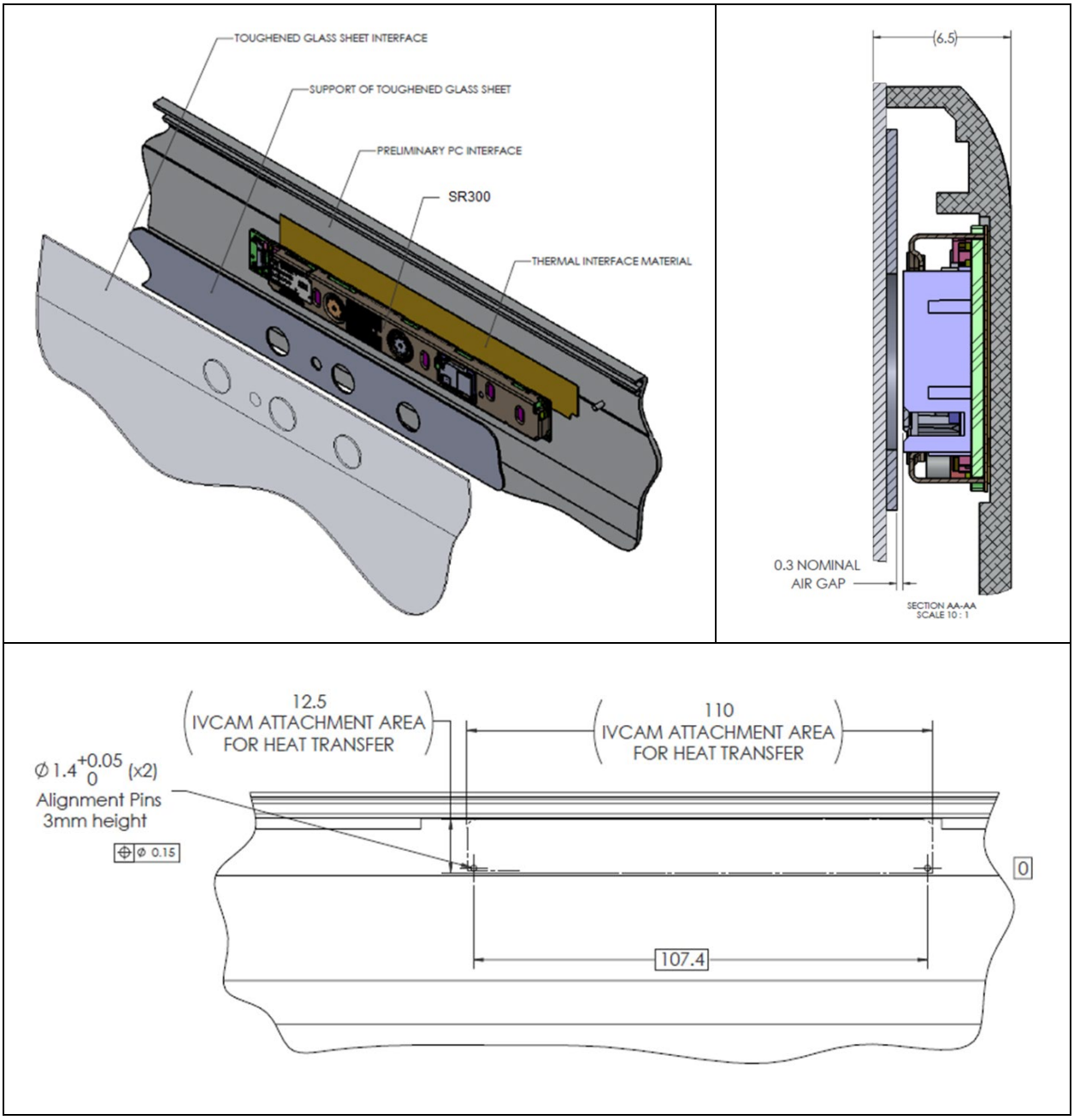
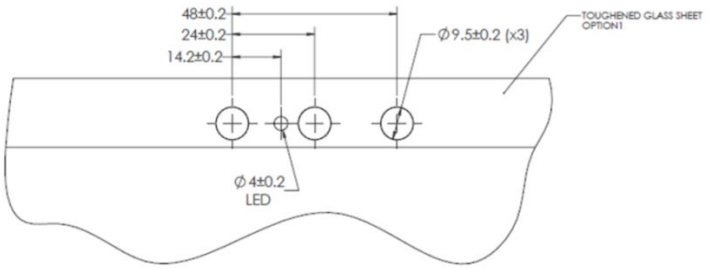
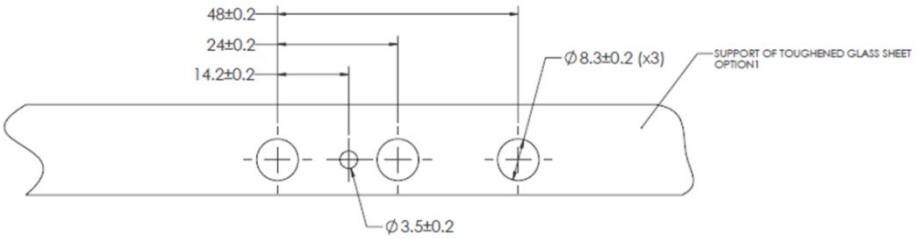
12 Mechanical Drawing



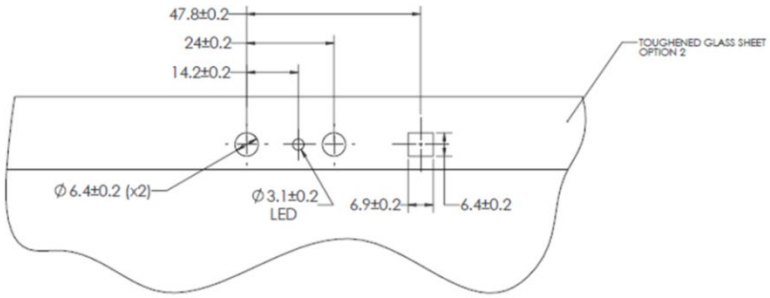

TOUGHENED GLASS SHEET INTERFACE
SUPPORT OF TOUGHENED GLASS SHEET
PRELIMINARY PC INTERFACE
SR300
THERMAL INTERFACE MATERIAL
(6.5)
0.3 NOMINAL
AIR GAP
SECTION AA-AA
SCALE 10 : 1
12.5
IVCAM ATTACHMENT AREA
FOR HEAT TRANSFER
110
IVCAM ATTACHMENT AREA
FOR HEAT TRANSFER
Ø 1.4 +0.05 0 (x2)
Alignment Pins
3mm height
Ø 0.15
0
107.4

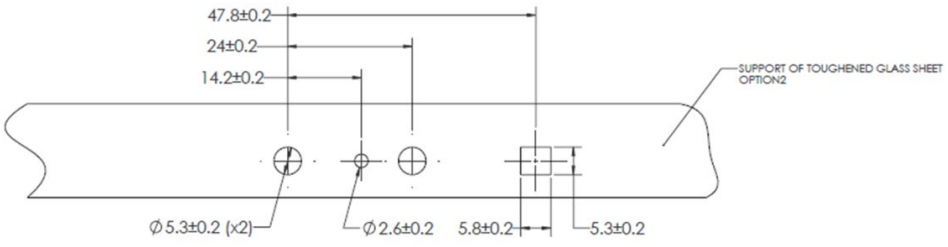
EXAMPLE 1 THROUGH-HOLE DESIGN





EXAMPLE 2 THROUGH-HOLE DESIGN





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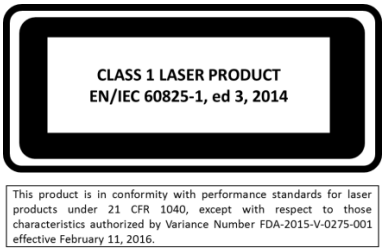
13 Regulatory Compliance

System integrators should refer to their respective regulatory and compliance owner to finalize regulatory requirements for a specific geography.

This product is in conformity with performance standards for laser products under 21 CFR 1040, except with respect to those characteristics authorized by Variance Number FDA-2015-V-0275-001 effective February 11, 2016. This product is classified as Class 1 under IEC 60825-1 edition 3, 2014, internationally. The use of the edition 3 for classification also in the US is allowed by the terms of the aforementioned US FDA CDRH variance at the time of manufacture.



Caution--use of controls or adjustments or performance of procedures other than those specified herein may result in hazardous radiation exposure.

Manufactured by Intel Corporation
2200 Mission College Blvd., Santa Clara, CA 95054
Model Number: SR300

U.S. FDA accession number is **1420377-001**.

There are no service/maintenance, modification, or disassembly procedures for SR300 and infrared projector. The system integrator must either notify Intel or return modules before any failure analysis is performed.

- Do not attempt to open any portion of this laser product.
- There are no user serviceable parts with this laser product.
- Modification or service of the SR300, specifically the infrared projector, may cause the emissions to exceed Class 1.

This device is EU RoHS 2 (Directive 2011/65/EU) compliant and low halogen (PCB). For additional details please download the SR300 Material Declaration Data Sheet.

www.ul.com/database

NWGQ2.E139761

NWGQ8.E139761
The Intel(R) RealSense(TM) Camera / SR300, has passed the USB-IF Test Procedure for USB 3.1 Gen 1 products.

http://www.usb.org/kcompliance/view/
TID: 310000184

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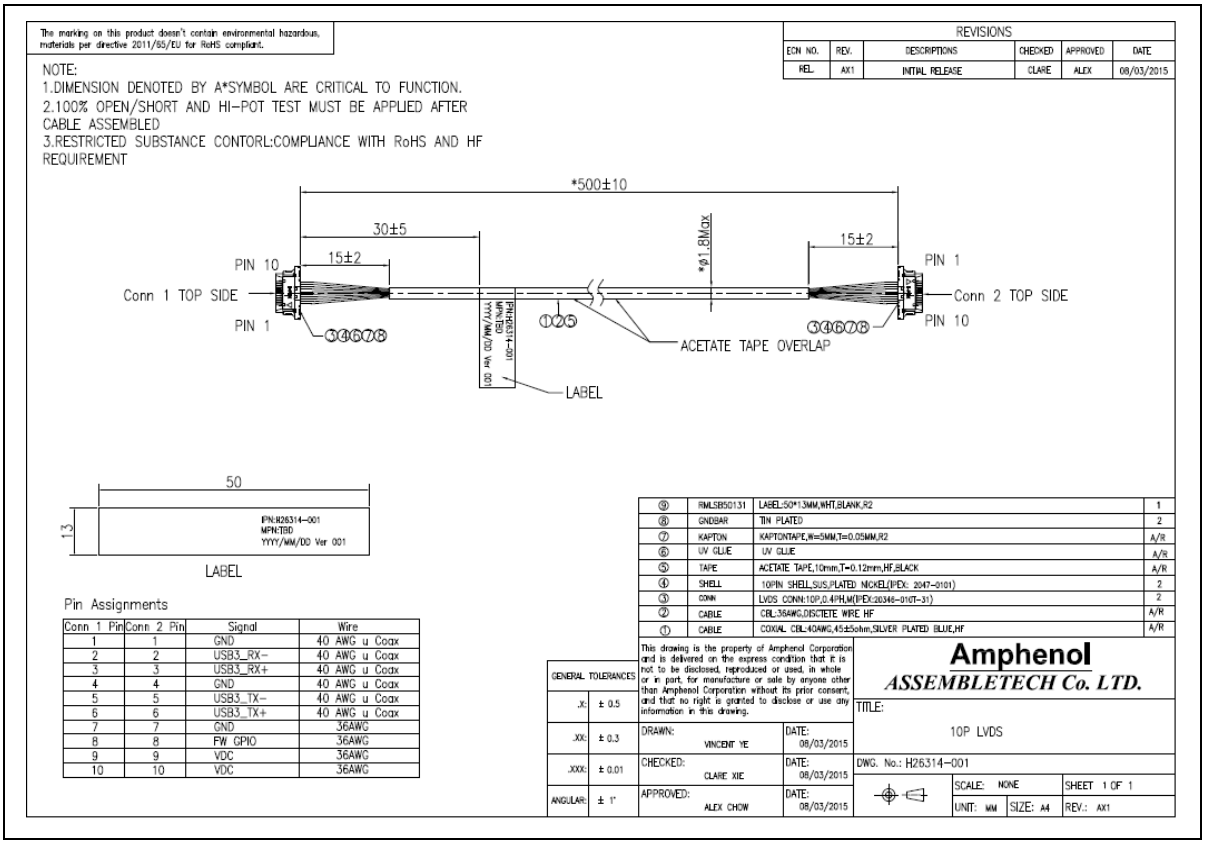
14 SR300 Cable Drawings

The interconnect cable can be used to connect the SR300 to the motherboard receptacle or to the receptacle on the USB adapter card.

Table 14-1: Cable Ordering Logistics

VENDOR	PART NUMBER	LENGTH	REVISION	SALES CONTACT
Amphenol	H26311-001	100mm	AX1	**Bruce Motavaf** AGIS - Sales Engineer Amphenol bruce.motavaf@amphenol-gis.com 408.799.6060
Amphenol	H26312-001	150mm	AX1	
Amphenol	H26313-001	300mm	AX1	
Amphenol	H26314-001	500mm	AX1	

Figure 14-1: Cable Mechanical Drawing



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15 SR300 USB Adapter

The SR300 is designed to be integrated into a client system as a subassembly component through an internal interconnecting cable. If a system configuration requires the SR300 to be connected through a standard USB connection, an adapter is required to convert the SR300 receptacle connection to a standard USB plug.

Figure 15-1: SR300 Adapter 3D

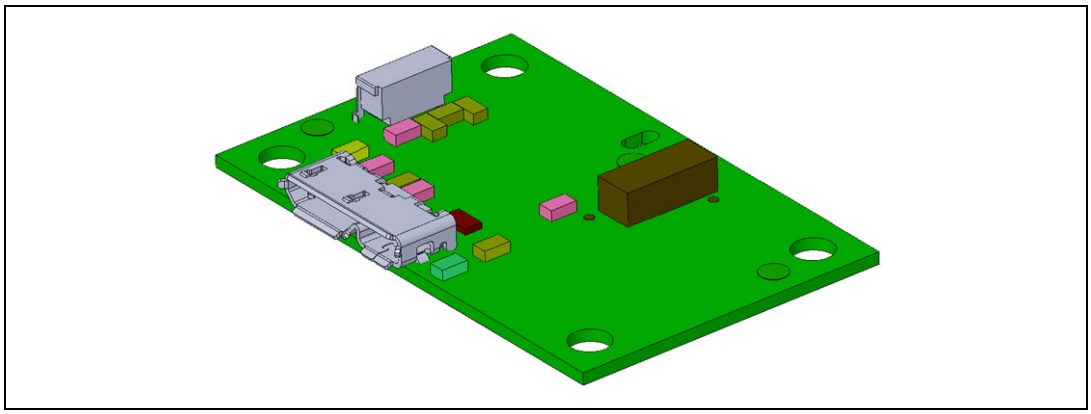


Table 15-1: Mechanical Dimensions

DIMENSION	NOMINAL	UNIT
Width	28(1)	mm
Height	41(2)	mm
Depth	5.3(3)	mm

(1) Measured from USB micro-B receptacle edge to PCB edge.
(2) Measured from PCB edge to PCB edge.
(3) Measured from SR300 cable receptacle edge to toggle switch edge.

Intel provides an adapter design schematic for reference purposes only. This adapter board design converts the SR300 receptacle connection to a standard USB3 micro-B receptacle on a single subassembly. A 10 pin cable with an SR300 plug on either end is required to connect the SR300 to this adapter board. A standard USB3 micro-B to USB3 type-A cable is required to connect the adapter board to a standard USB3 external port.

The USB test adapter design is for reference purposes only. Intel disclaims all express and implied warranties, including without limitation, the implied warranties of merchantability, fitness for a particular purpose, and non-infringement, as well as any warranty arising from course of performance, course of dealing, or usage in trade.

15.1 Design Reference

Figure 15-2: SR300 Adapter 2D

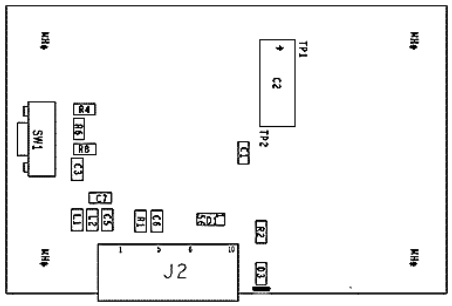
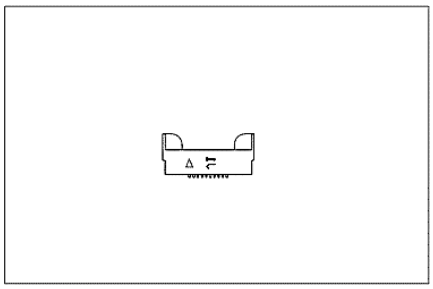
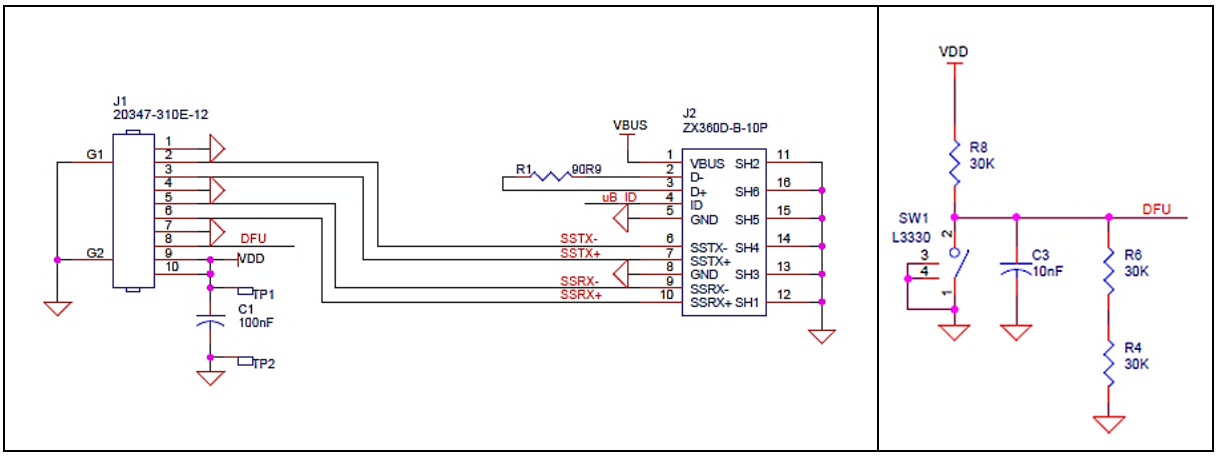
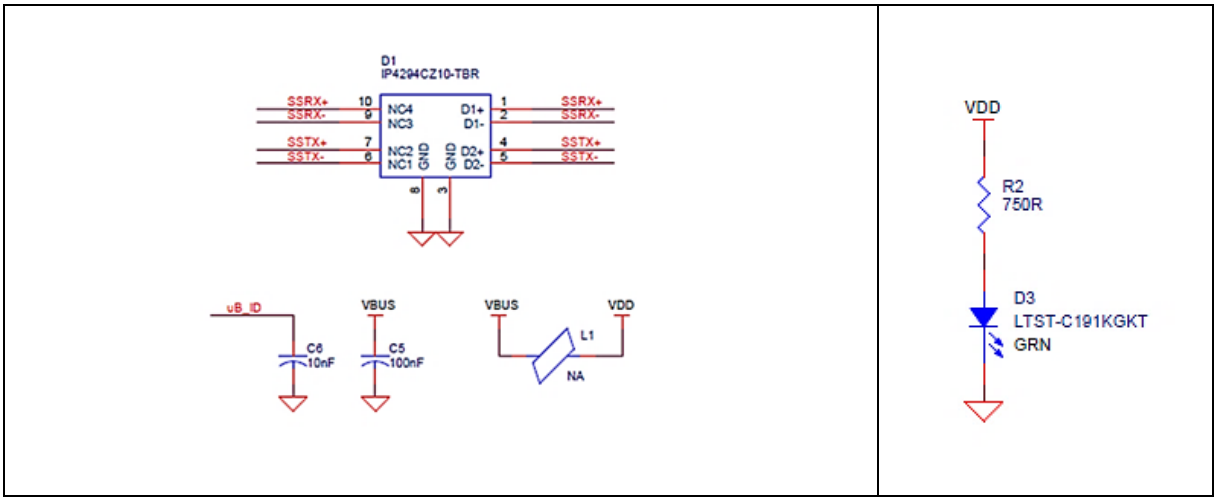
PC002708 TOP VIEW	PC002708 BOTTOM VIEW
	

Table 15-2: USB Test Adapter Designator Description

DESIGNATOR	DESCRIPTION
J1	Receptacle SR300 cable connection.
J2	Receptacle for USB3 micro-B cable connection.
SW1	Toggles the INT pin from HIGH to LOW.
D1	ESD Diode Pack
D3	VDD Green LED Indicator

Figure 15-3: SR300 USB Adapter Schematics




D1
IP4294CZ10-TBR
SSRX+
SSRX-
SSTX+
SSTX-
NC4
NC3
NC2
NC1
GND
D1+
D1-
D2+
D2-
uB_ID
VBUS
C6
10nF
C5
100nF
L1
NA
VDD
R2
750R
D3
LTST-C191KGKT
GRN

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16 Schematic Checklist

The following checklist should be compared to the motherboard design.

Table 16-1: Motherboard Connector Signals

CONNECTOR	MOTHERBOARD	REQUIRED	√
Pin 1	Routed to GND	Y	
Pin 2	Routed to USB3_RXN	Y	
Pin 3	Routed to USB3_RXP	Y	
Pin 4	Routed to GND	Y	
Pin 5	Routed to USB3_TXN	Y	
Pin 6	Routed to USB3_TXP	Y	
Pin 7	Routed to GND	Y	
Pin 8	Routed to RECOVERY 3.3V GPIO	Y	
Pin 9	Routed to 5V Supply	Y	
Pin 10	Routed to 5V Supply	Y	
Connector	Routed to GND	Y	
Connector	Routed to GND	Y	
Ground Bar	Routed to GND	Y	
Ground Bar	Routed to GND	Y	

Table 16-2: USB_RX Motherboard Signals

SIGNAL	MOTHERBOARD	REQUIRED	√
Pin 2	ESD protection diode connected to GND.	Optional	
Pin 3	ESD protection diode connected to GND.	Optional	

Table 16-3: USB_TX Motherboard Signals

SIGNAL	MOTHERBOARD	REQUIRED	√
Pin 5	Inline 80ohm choke placed close to connector.	Y	
Pin 5	Inline 0.1uF AC capacitor placed close to the connector.	Y	
Pin 5	ESD protection diode connected to GND.	Optional	
Pin 6	Inline 80ohm choke placed closed to connector.	Y	
Pin 6	Inline 0.1uF AC capacitor placed close to the connector.	Y	
Pin 6	ESD protection diode connected to GND.	Optional	

Table 16-4: Power Signals

SIGNAL	MOTHERBOARD	REQUIRED	√
Pin 9/10	Series components rated for at least 1A.	Y	
Pin 9/10	Independent 5V controllable FET	Y	
Pin 9/10	Routed 5V FET control GPIO	Y	

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