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Streamlining Design-to-Manufacture for Imaging Devices Tutorial

Introduction to onsemi's
Premier Reference Image Sensor Modules (PRISM)

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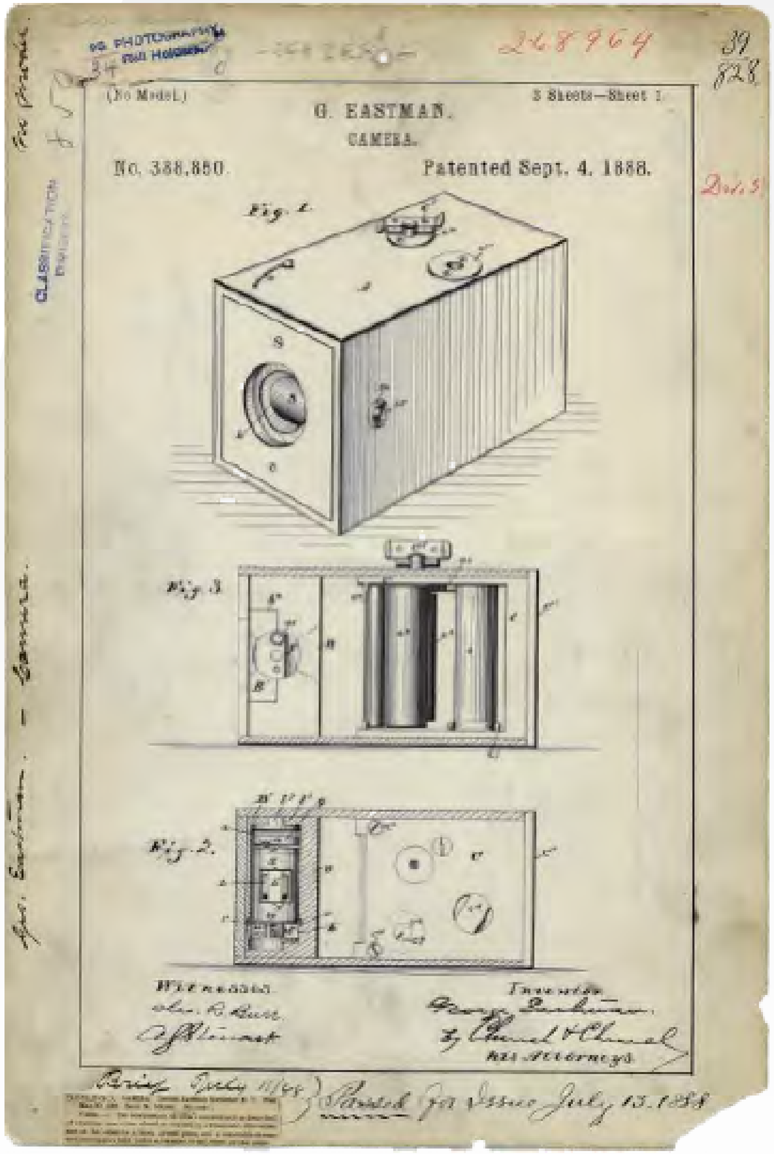
Introduction: Design-to-manufacture

Innovation, despite the word's implication of complete newness, never happens in a vacuum. Innovators are people who try new approaches and they encounter failures, sometimes spectacular ones. Experience informs the product innovator as to the feasibility of approaches tried in the past, and the record of methods and approaches that, either at the outset or over time, failed.

Every great new idea in electronic imaging technology builds on an existing platform. Whether you're new to the art of imaging product manufacturing, or you've had a wealth of experience behind you, what innovation requires from you is a workable foundation from which to start. Sometimes you need such a foundation in order for you to discover what doesn't work. George Eastman, working to innovate the handheld portable Kodak camera he had introduced in 1888, reasonably concluded the barrel shutter he had patented would be impractical to continue manufacturing and supporting in a mass-produced device. It's an insight Eastman probably wished he could have had three years earlier.



Source: US National Archives

Introducing PRISM

Today, it's possible for an imaging platform maker to try an innovative approach without having to reinvent the wheel — or, in Eastman's case instance, the shutter. The Premier Reference Image Sensor Modules (PRISM) platform from onsemi is a pre-optimized subsystem solution whose purpose is to streamline the digital imaging product development process. PRISM provides innovators with low-cost, pre-tuned, optimized, modular components already designed and engineered to work together, presented specifically for the purpose of product prototyping.

The PRISM module

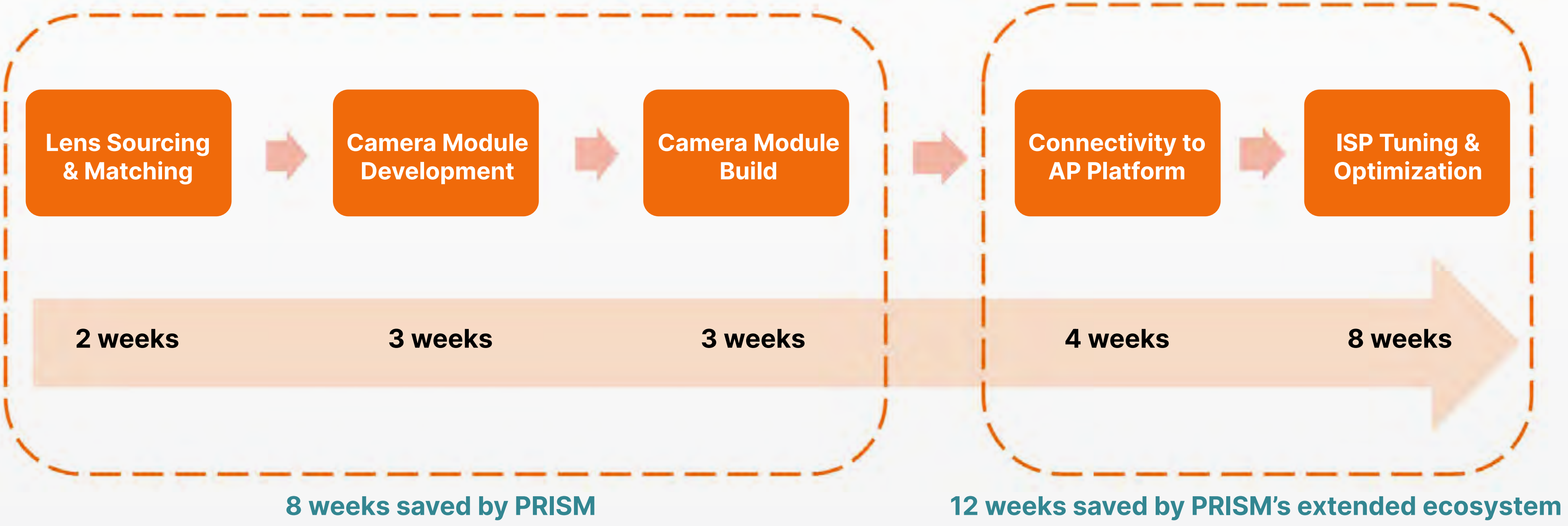
The PRISM module is a high-quality, tested, verified reference module designed to ensure superior imaging capability. It is versatile enough to be used for every industrial and commercial sensor, including during its early customer sampling phases. It accomplishes this by utilizing standardized universal connectors, ensuring flexibility between sensors.

onsemi provides adapters for ensuring imaging components may be seamlessly integrated with the SoC platform. For mass distribution, a component made with PRISM may be easily adapted for onsemi's Image Access System (IAS). This way, components using the PRISM module may be integrated with other hardware adapters and development kits from PRISM ecosystem partners.

PRISM simplifies the imaging product prototyping process, accelerates the design phase, and shortens time-to-market. For the typical image sensing device application that does manage to clear all the hurdles and obstacles and make its way through to production, PRISM is capable of reducing time-to-market by as much as six months.

onsemi **PRISM module** with **AR0830** image sensor

Realizing a new device development process



PRISM accelerates the design cycle and reduces development costs that imaging product designers face when attempting to innovate a prototype for a novel design, or for a radically new imaging application. What too often prevents an imaging application design from moving forward are the technical and architectural details involved with simply finding reasonably representative components of the final design that work together. For any product engineering project that involves optics, getting all the parts to fit into a confined space is not the biggest obstacle. Just as important as power to the operation of any optical device are light, space, and airflow. When you're dealing with these finicky components, you can't afford to get bogged down by a lens that can't adjust itself properly for depth-of-field, a sensor array that can't effectively white-balance, or an interface that won't reliably connect.

The 5 main components of a vision system

A typical vision system consists of many elements including optics (lens), image sensor, sensor interface, image signal processor and application software or artificial intelligent (AI).

1. Optical element (lens)

The purpose of the lens is to focus light into the sensor element. But to do this effectively, the lens needs to be matched perfectly to the optical format of the sensor. The capabilities to obtain and, where applicable, adjust the desired field of view (FOV), depth of field (DOF), and effective sensor resolution, all depend on the device designer's choice of lens.

As with any optical camera, the aperture of the lens has an inverse relationship with DOF, which impacts the perception of FOV. The wider the lens aperture may be, DOF appears shallower and, as a result, FOV may appear narrower. Conversely, with a narrower aperture, DOF appears deeper, making more areas of the picture sharper, and thus FOV may appear wider. However, widening the aperture for deeper DOF typically results in lower resolution. If the image sensor doesn't handle low resolution well enough, a picture that should reveal deeper depth of field may end up blurrier anyway.

2. Image sensor element

The image sensor is a semiconductor device whose task is to photoelectrically convert the image projected onto it by the lens, into digital signals in such a way that it may be reproduced. Its semiconductor incorporates an array of linked capacitors, each of which is photosensitive unit, acting as a pixel.

At the foundation of a CMOS structure is an array of light sensitive elements. Two shift registers emanate pulses that control horizontal and vertical scanning circuits, sequentially addressing each element by row, then column. These circuits enable each row of elements to be reset and then subsequently re-scanned. In-between those two events, the pixels in each row integrate incident light. A shutter mechanism is utilized — either a mechanical one such as a rolling shutter, or an electronic shutter which is often the choice for a progressive-scan camera that eliminates the need for signal interlacing.

Microlens Array
Small lenses that collect and focus light onto light-sensitive areas of the sensor

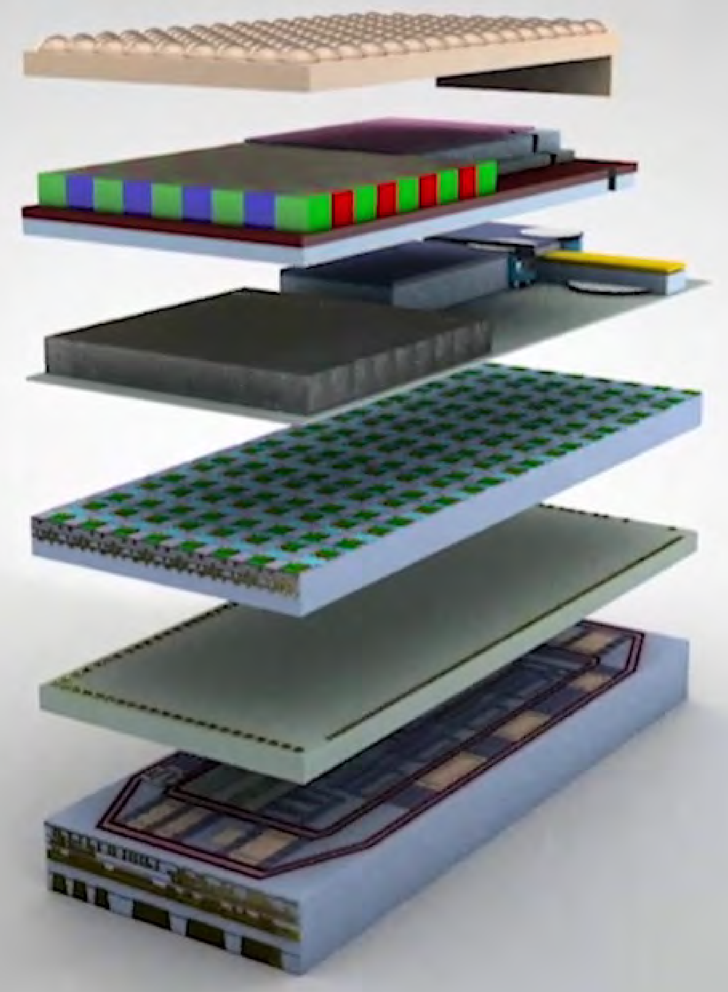
Color Filter Array (CFA)
Mosaic of tiny color filters placed over the pixel sensors of an image sensor to capture color information

Photodiode
Semiconductor that converts light into an electrical current

Pixel Transistors
Transistors provide gain or buffer of electrical charge from photodiode

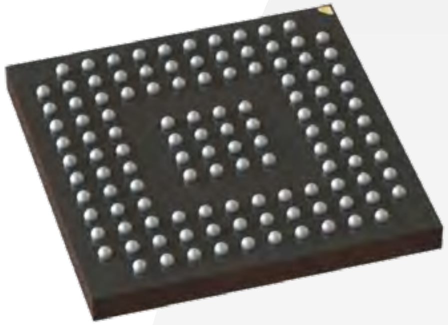
Bond Layer
Connects the Active Pixel Array to the ASIC layer

ASIC
Logic layer for features such as: error correction; memory for multi-exposures; cores for cybersecurity; hardware blocks for functional safety; high speed I/O



3. Image signal processor (ISP)

The image signal processor (ISP) digitally captures the raw data collected by the image sensor, and re-interprets it into a format that's not only practical to use but reasonably free from errors. The tasks an ISP performs typically include demosaicing, noise reduction, color corrections, gamma correction.



onsemi **AP1302**

4. Sensor/processor interface

The physical interface is responsible for ensuring full and unimpeded communication between the image sensor and the image signal processor's SoC (system-on-a-chip). Different industry standards applied to the design and manufacture of these two components typically leads to the development of separate interface standards, for which manufacturers typically count
five or more.

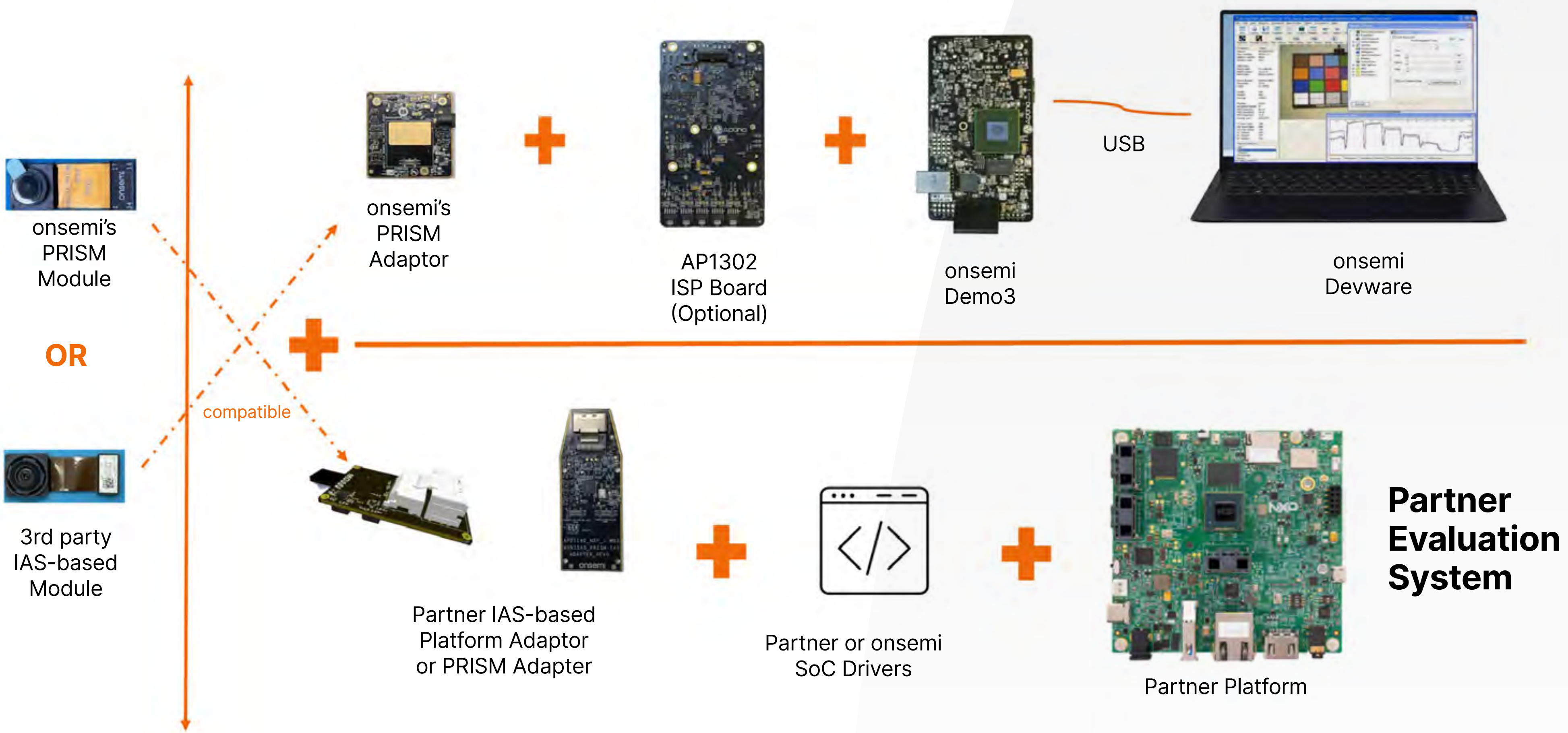
onsemi **PRISM adapter**

5. Application processor (AP)

The AP is the central digital processing unit of an imaging system. This component may also incorporate a graphics processor for rendering images onto a display or screen, as well as a digital signal processor (DSP) for specialized processing functions such as image enhancement and manipulation. The software or firmware the device utilizes to be accessible to the user, is orchestrated by the AP.

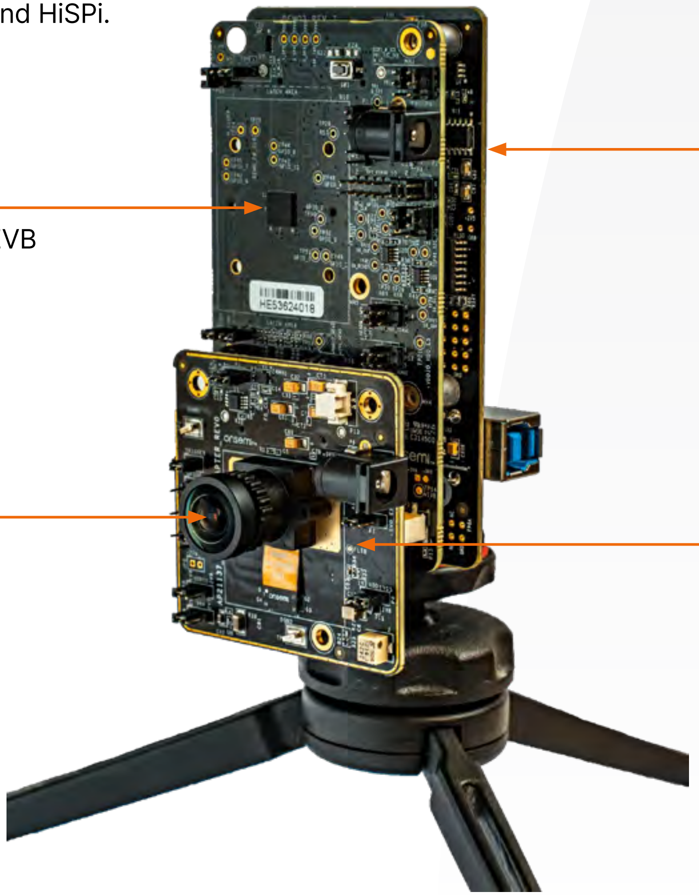
onsemi **Demo3 board**

Start with PRISM



Evaluation kit utilizing PRISM Module + Demo3 + AP1302 + Adapter

With the Demo3 baseboard, a device developer working with PRISM can interface onsemi imaging components with a host PC. It features an FPGA processor, a USB 3.0 controller, an HDMI transmitter supporting MIPI and HiSPi.

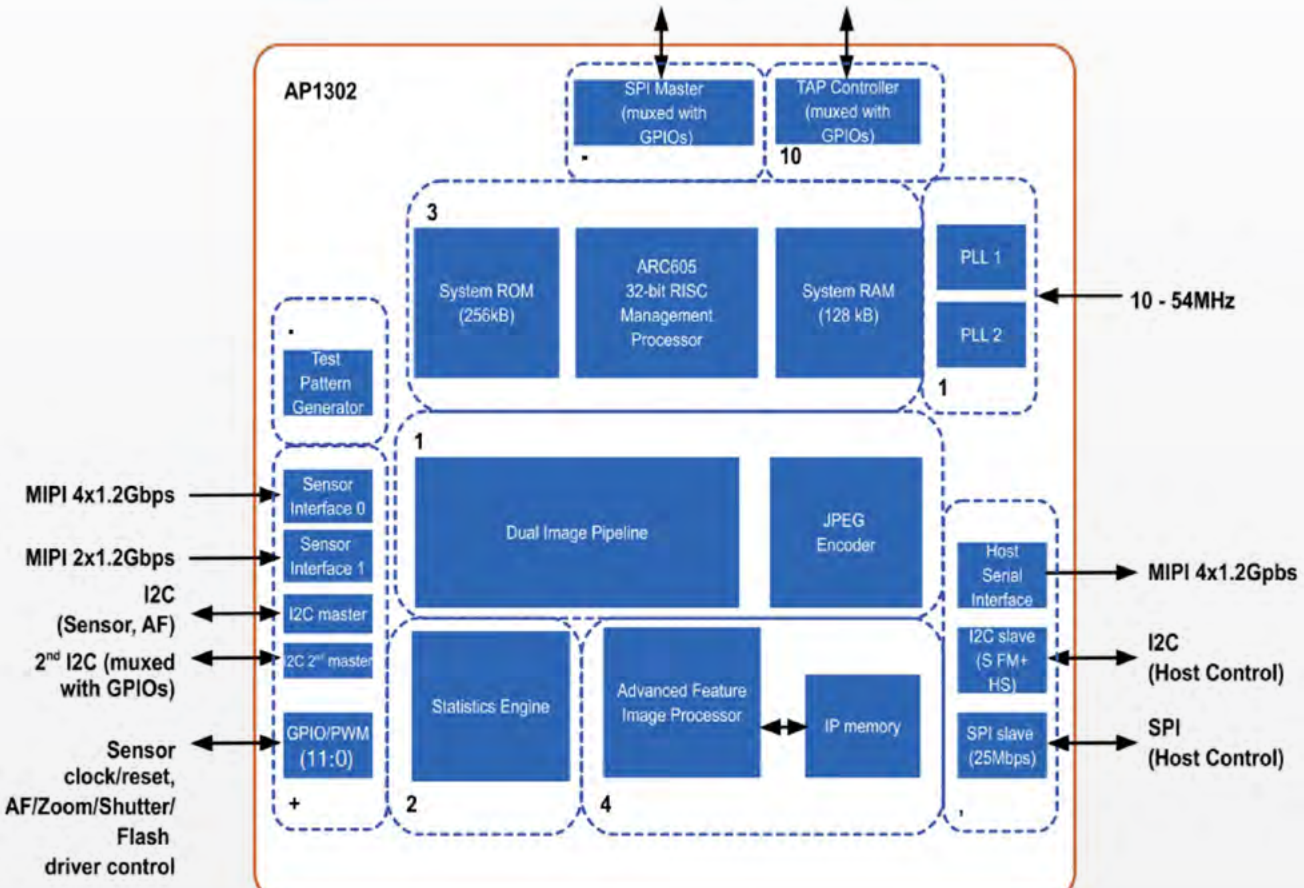


** All PRISM modules are tuned with AP1302*

AP1302 co-processor

The AP1302 is a high–performance, ultra–low power in–line, digital image and video stream processor, supporting image resolutions up to 13 megapixels (4224×3156) and frame rates up to 13 MP at 30 fps.

The AP1302 supports both sub–LVDS (MIPI) sensor (input) and host (output) interface. AP1302 interfaces to CMOS imaging sensors and performs all the necessary operations required to capture state–of–the–art 13 MP images including JPEG compression, capture 1080p video streams, and preview generation. AP1302 is also designed to support onsemi's sensors that provide video interlaced HDR capability, allowing capture of high dynamic range scenes at video recording speed.



Performance test report

The PRISM module is tested and verified with a series of tests to meet performance requirements. A test report can be provided as baseline for customer's design. These tests include:

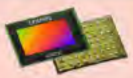
- **Dark testing**, in which the camera modules are completely shrouded in darkness to prevent as much light leakage into the image sensor as possible. Then, inside the shrouded area, unbiased light at calculated frequencies but low amounts is applied, and each pixel is tested to determine whether it can split that light into its four constituent optical planes in equal measure
- **Light testing**, in which ranges of light at various temperatures Kelvin are projected by LED panels, and pixels are tested to determine the temperatures of light recorded within the calculated field of vision
- **Lens shading uniformity**, which evaluates the quality of light emanating from outside the center of the lens to determine the degree to which that light becomes weaker

- **Color uniformity** (also called “MacAdam testing”), in which each pixel is evaluated to determine whether the chromaticity of light captured by the sensors strays outside the boundaries of noticeable variation — boundaries dubbed “MacAdam ellipses”
- **ISO 12233 image testing**, which is an international standard evaluation for whether the frequency responses from pixels in a sensor meet the requirements for certification for the sensor’s stated pixel resolution
- **AP1302 ISP processing**, which utilizes onsemi’s own quality standards to determine the performance of the sensor in conjunction with onsemi’s AP1302 image signal processor
- **Flare testing** (also called “glare testing”), in which the sensor is tested for instances where light has been recorded in any amount, and from any angle, other than the natural focal path from the lens

Hyperlux SG CMOS image sensors

The Hyperlux SG image sensor family has made groundbreaking advances in image sensor technology, some of which can be measured in terms of Global Shutter Efficiency (GSE). Operating at 120 fps, Hyperlux SG sensors employ a global shutter mechanism that is revolutionary for such small components. This shutter enables simultaneous capture of an entire image, ensuring that fast-moving objects remain crisply defined and artifact-free. Consistent pixel size and sensor performance are maintained for all SG form factors.

Hyperlux SG components incorporate an innovative global shutter pixel design optimized for accurate and fast capture of moving scenes at 120 fps, producing clear, low-noise images in both dim and bright lighting conditions. It features auto-exposure control, auto black-level correction, windowing, skipping, and pixel-binning (combining data from four pixels into one). This family of image sensors is exceptionally well-suited for applications including barcode scanning, machine vision for robotics and manufacturing, autonomous mobile guidance, surveillance, and industrial quality control.

Sensor in Module	PRISM Module OPN	CFA	Sensor CRA	Sensor Format	HFOV	F#	Module X (mm)	Module Z (mm)
ARX383 	PRISM1M-ARX383CSSM130110-GEVB 	RGB	28	CSP	43.4	4	6.5	3.83
AR0145 	PRISM1M-AR0145CSSM130110-GEVB 	Mono	28	DIE	70.8	2	8.5	3.94
AR0235 	PRISM1M-AR0235CSSM130110-GEVB 	Mono	28	DIE	134.3	2	17	15.76

Hyperlux LP CMOS image sensors

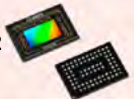
onsemi's Hyperlux LP image sensor family is ideally suited for industrial and commercial cameras where higher resolution is required: for instance, smart doorbells, security cameras, AR/VR applications, and videoconferencing. The LP family's stacked architecture minimizes its footprint, with the smallest component no larger than a grain of rice, making it a critical component for applications where space is a vital resource.

Hyperlux LP-series sensors capture images in either linear mode or Enhanced Dynamic Range (eDR) mode. This enhanced state leverages a non-linear transfer function to enable a higher range of luminosity values to be represented by the same number of luminance bits. They also feature rolling-shutter readout, which increase quantum efficiency and reduce readout noise without introducing distortion.

Sensor in Module	PRISM Module OPN	CFA	Sensor CRA	Sensor Format	HFOV	F#	Module X (mm)	Module Z (mm)
AR0544 	PRISM1M-AR0544CSSC130110-GEVB 	RGB	33	DIE	99.2	2.2	8.5	5.15
AR0830 	PRISM1M-AR0830CSSC130110-GEVB 	RGB	11	CSP	144.2	2.2	15.8	20.36
AR2020 	PRISM1M-AR2020CSSC130110-GEVB 	RGB	13	mPBGA	80	2	17	28.52

Hyperlux LH CMOS image sensors

With the Hyperlux LH image sensor series, onsemi extends the capability of LP sensors with Adaptive Local Tone Mapping (ALTM) — which packs the contents of high dynamic range images into a reduced bit-depth format. Hyperlux LH also incorporates wake-on-motion for vastly improved power savings, plus support for line-interleaved high dynamic range (LI-HDR), eDR, and embedded High Dynamic Range (eHDR) to ensure maximum bit depth with minimum resources. These features make Hyperlux LH ideal for applications such as facial recognition, automotive DVR, and wearable devices.

Sensor in Module	PRISM Module OPN	CFA	Sensor CRA	Sensor Format	HFOV	F#	Module X (mm)	Module Z (mm)
AR0246 	PRISM1M-AR0246NPSC130110-GEVB 	RGB	32	DIE	71.4	2	8.5	3.94
AR0822 	PRISM1M-AR0822NPSC130110-GEVB 	RGB	10	mPBGA	110	2	18	32.6

PRISM connectivity into ecosystem

Processor Partner Platform	PRISM Adaptor (onsemi Part Number)	Note
onsemi Demo3	PRISM1-ADPTR-DM3D1-GEVB	Adaptor to onsemi Baseboard
NIVIDIA Jetson NANO	PRISM1-ADPTR-NVDM1-GEVK	-
NXP i.MX8	PRISM1-ADPTR-NXPM2-GEVK	Adaptor also offered by NXP
NXP i.MX9	PRISM1-ADPTR-NXPM1-GEVK	Adaptor also offered by NXP
Qualcomm RB5	PRISM1-ADPTR-QCMM1-GEVB	-
AMD Kria KV260	N/A	Adaptor built on KV260 EVK (VDD not applied to all sensors)
MediaTek Genio 700	N/A	Adaptor built on Genio 700 EVK
MediaTek Genio 1200	N/A	Adapter built on Genio 1200 EVK
Intel Alder Lake, Raptor lake	contact onsemi	Support upon request
Raspberry PI	PRISM1-ADPTR-NVDM1-GEVK	-

What PRISM offers design engineers

It's the goal of onsemi to shorten the design-to-manufacture process, while simplifying and streamlining it. onsemi's PRISM provides digital imaging product designers and producers pre-tuned solutions that integrate all five of these principal components, optimizing their operations while ensuring full interoperability. The PRISM imaging ecosystem extends beyond onsemi, not only giving device developers options for utilizing third-party components, but also the system development kits and resources needed to develop native software.

PRISM from onsemi gives you the means and the support to build new imaging applications today that are feasible, distinctive, and sellable to manufacturing partners and OEMs. PRISM provides multiple direct and quick paths to manufacturing.

Key Features	Advantages	Benefits
Pre-optimized Optics	Eliminate R&D time in lens sourcing and matching	• Reduce system development cycle time • Avoid system developer getting stuck in image related issues • Allow system developers to focus more on non-image design effort • Quick time to market for system debut • Quick mass production scale-up
Pre-tuned onsemi ISP	Eliminate R&D time in ISP tuning and optimizing	
Commercial form factor	Form factor solution to meet real-world applications	
Accessible to major application processors through onsemi's adaptors	Quick hands-on with major AP platforms for easy program development	
Manufacturable reference	Quick to launch for mass production	

Resources:

- Video: Simplifying Camera Development with Premier Reference Image Sensor Modules
- PRISM Module User Guide
- White Paper: Introducing onsemi's Premier Reference Image Sensor Module (PRISM) Designed to Optimize Camera Development

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Contact onsemi sales channel for:

- PRISM sample
- PRISM design documents:
    - Module Datasheet
    - Module Mechanical Drawing
    - Module Schematics, PCB & BOM
    - Module Gerber
- Sensor ini file for OTPM/EEPROM
- AP1302-calibrated data in XML format
- Validation Report

Visit www.onsemi.com for more information and additional resources.

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