System Solution Guide

Machine Vision

Updated: MAR-2024

Industry	Industrial – Industrial Automation, Collaborative Robots (Cobots), Automated Guided Vehicles (AGV) and Autonomous Mobile Robots (AMR)
Applications	Machine vision is used in many sectors of industries for numerous applications. In the manufacturing sector, it's utilized for tasks like the final examination of sub-assemblies and inspecting parts for potential manufacturing defects. In the realm of automation, machine vision is instrumental in guiding robots. Additionally, it's used to verify data matrix codes, check food packs, and read bar codes.

System Purpose

Machine vision operates by utilizing cameras to gather visual data from the environment. This data is then processed through a mix of hardware and software, transforming it into a format suitable for a range of applications. Specialized optics are frequently employed in machine vision technology to capture images, allowing specific aspects of the image to be processed, analyzed, and quantified. This application could examine a specific feature of a component being produced on a production line. It could assess whether the component satisfies the product quality standards and, if it falls short, the component could be discarded. Machine vision systems utilize digital sensors that are safeguarded within industrial cameras equipped with specialized optics. These sensors capture images, allowing computer hardware and software to subsequently process, analyze, and measure different attributes to facilitate decision-making.

In addition to quality control in manufacturing, machine vision systems have a multitude of other applications. They can be used in traffic management systems to monitor and control traffic flow, enhancing safety and efficiency on the roads. In the medical field, machine vision can assist in diagnostic procedures, enabling precise image analysis for early disease detection. In agriculture, these systems can monitor crop health and automate harvesting processes.

Furthermore, in the retail industry, machine vision can facilitate automated checkout systems, improving customer experience and operational efficiency. Thus, the versatility of machine vision systems extends their utility across various sectors, making them an integral part of modern technology.

System Purpose – Different Vision Systems

The system can be used to inspect a wide range of products, including food, beverages, pharmaceuticals, and electronics. The system uses a variety of machine vision techniques, including image recognition, optical character recognition (OCR), and object detection, to identify and classify defects, also it can be used to measure the size and shape of objects, and to track and trace products throughout the production process. The machine vision system can help to improve product quality, reduce costs, and ensure product safety. By identifying and correcting defects early in the production process, the system can help to prevent recalls and returns.

Damages & Defects: The system can be used to identify a variety of damages and defects, such as holes, voids, damaged edges, artwork defects, bent dip tubes, damaged or absent closures, and damaged or vacant spray triggers.

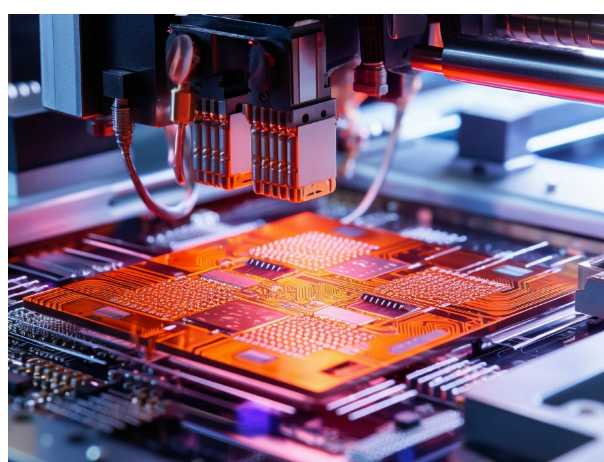
Characters & Codes: The system can be used to identify and verify characters and codes, such as dot matrix and non-dot print, OCR and OCV, lot, date, and bar codes, 1D and 2D bar codes (QR codes and custom artwork), and track and trace capabilities.

Seal Integrity Inspections: The system can be used to inspect seal integrity for product in seal inspections.

Alignment & Positioning: The system can be used to ensure that products are aligned and positioned correctly, such as graphic position and alignment, and cover and container match.

Match & Verification: The system can be used to match and verify products, such as ensuring lid and label artwork match, and spray trigger or cap orientation.

Filling & Orientation: The system can be used to inspect the filling and orientation of products, such as bottle presence and orientation before filling.

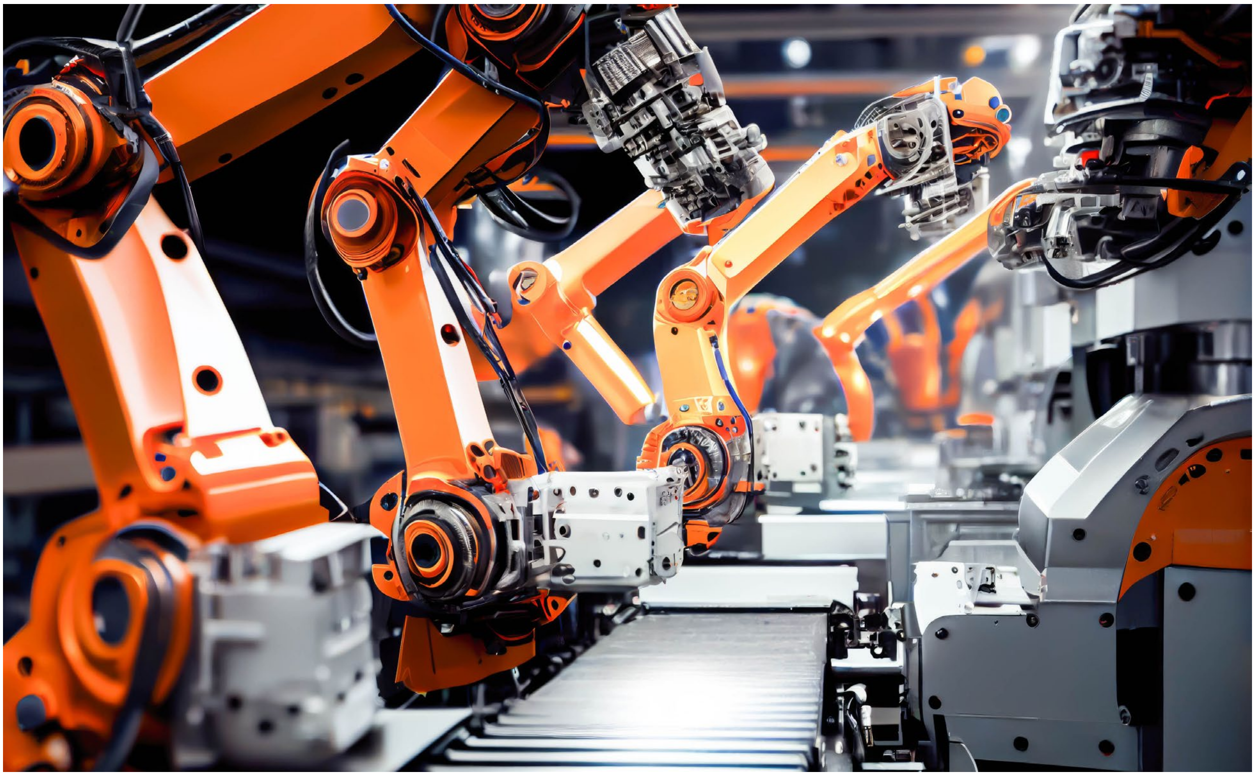


Market Information & Trend

According to a report by Expert Market Research, the global machine vision market size reached a value of around USD 10.88 billion in 2023. The market is projected to grow at a CAGR of 7.90% between 2024 and 2032, reaching a value of nearly USD 21.51 billion by 2032.

The adoption and implementation of advanced technologies following innovations like Industry 4.0 and the Industrial Internet of things (IIoT) as one of the major trends fueling the machine vision market growth. The digital transformation of various industrial sectors, coupled with the growing integration of advanced technologies such as analytics, the internet of things (IoT), machine learning, cloud computing, and AI, is also driving the adoption of machine vision. The increasing focus on the development of smart factories equipped with computer vision-enabled equipment, embedded software, advanced sensors, and robotics, to drive real-time decision-making, productivity, and automation is bolstering the market for machine vision. However, this advanced equipment comes with a high initial cost and requires investment in frequent maintenance activities, which can hamper the market growth.

Machine vision applications are gaining popularity because of their low hardware cost and availability of fast processors, along with complete, scalable software that provide all elements required for deploying and developing machine vision systems.



Market Information & Trend

The machine vision market in the Asia Pacific region is significantly influenced by the rapid growth of industrial sectors such as automotive, packaging, pharmaceuticals, and other industrial applications. With the ongoing industrialization in the region, there is a notable increase in investments towards advanced technologies in various industrial sectors, which is expected to create expansion opportunities for the machine vision market. Additionally, the strong growth of the electronics, semiconductors, and automotive sectors in countries like China, India, South Korea, and Japan further contributes to the market's lucrative growth prospects.

Since its humble beginnings in the 1950s, machine vision has made remarkable progress. Machine vision's journey is deeply intertwined with the evolution of camera sensors. Early CCDs offered high quality but lacked speed and resolution. As CMOS sensors emerged, affordability and speed increased, paving the way for multi-megapixel sensors and specialized options like infrared and hyperspectral. The deep learning boom saw sensors integrate seamlessly with AI, enabling real-time object detection and scene understanding. This trend continues with advancements in 3D imaging, edge computing, and cutting-edge sensor technologies, promising a future where machines 'see' the world with ever-increasing accuracy and intelligence, shaping an automated and insightful world around us.

Advancements in artificial intelligence and deep learning

The continuous advancements in artificial intelligence (AI) and deep learning have greatly improved the capabilities of machine vision systems. AI algorithms, specifically deep learning techniques like convolutional neural networks (CNNs), have revolutionized the fields of image processing and pattern recognition. These systems, which can learn from vast amounts of data, are now capable of accurately identifying and categorizing objects, faces, and scenes. This progress has led to significant improvements in areas such as facial recognition, autonomous vehicles, medical imaging, and security surveillance. As AI continues to evolve, machine vision is expected to become more sophisticated, adaptable, and capable of handling increasingly complex visual tasks. This will undoubtedly drive further growth and innovation in the field of machine vision.

Source: Machine Vision Market Report by Product (Vision Systems, Cameras, and Others)

System Implementation

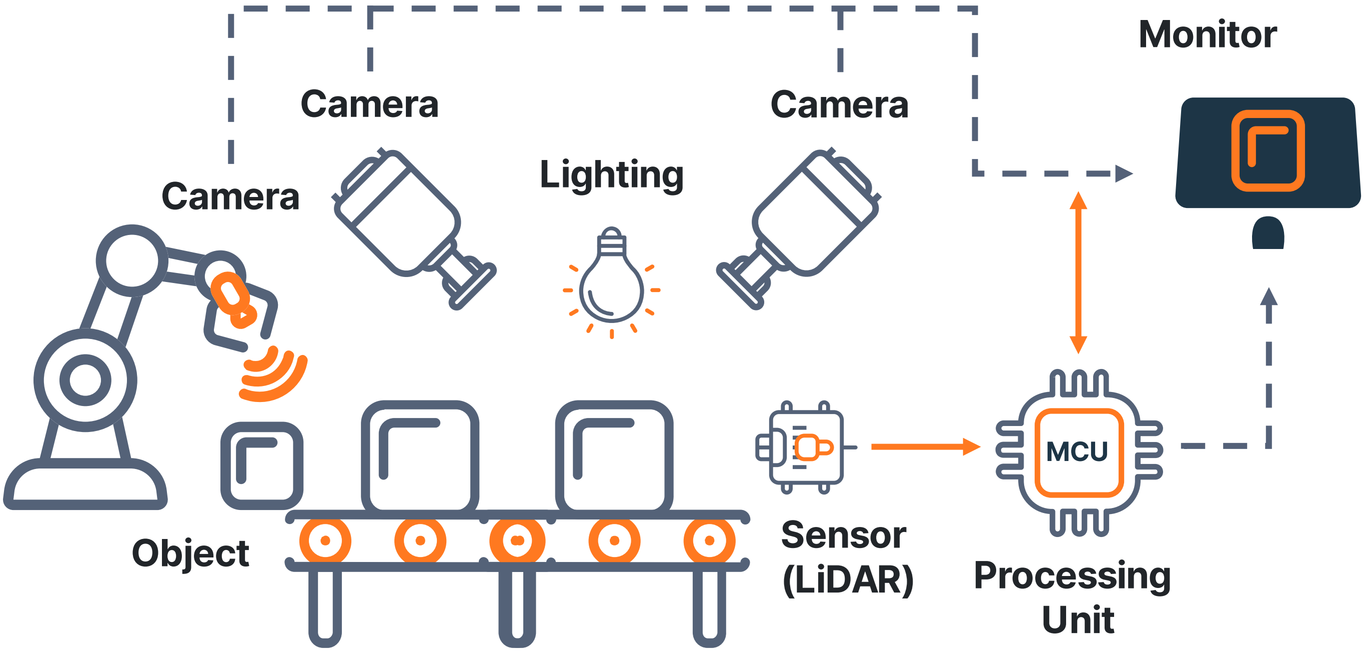


Figure 1: General System diagram for Machine Vision

Machine vision is used in industries for the analysis of electronic components, identification of signatures, recognition of objects and patterns, and inspection of materials. It helps in the automation of different processes and detects faults by image processing. Machine vision has become popular as it reduces the manual work and enhances the accuracy in product manufacturing.

The following system diagram shows the machine vision implementation in a factory environment in which an object is being inspected. This section explains the different parts or modules of the machine vision system. Majority of the factory inspection systems have similar modules in use with some minor variations.

Camera Module: The camera module encompasses lens and image sensors and are used to take pictures of an object to analyze later. The lens design is based on the lighting conditions and the characteristics of the object to choose the lens focal length, aperture range. The image sensor, located on the image plane at the back of the lens, is responsible for the information photoelectric conversion.

Image Processor: The digital data coming from the camera module can be analyzed by using image processing algorithms. These are the main steps in image processing in machine vision:

- Pre-processing: Pre-processing consists of noise removal and contrast enhancing.
- Color Pipeline:
  - Color Interpolation, Color Balancing, Aperture Correction
- Image Recognition:
  - Segmentation: A threshold is applied, and the edges of the image is determined in this process.
  - Feature Extraction: Size, color, length, shape or combination of these features can be extracted in this process.

Processing Unit: A processing unit with built-in software is required to process images, detect, measure, compare etc. to confirm if a quality-criteria has been met or to system provide type verification or robot control to another control

System Implementation

Light Module: Lighting is one of the most challenging aspects of a vision system. Incorrect or inadequate lighting of an object or scene can dramatically increase error rates in vision system. Yet, the proper lighting for an application depends strongly on the task to be accomplished.

Sensor: A machine vision system, generally, incorporates Optical, Magnetic, LiDAR, Ultrasonic and Light sensors which are the part of the detection system. The sensors detect if there any defects in the final products. Depending upon the setup they can also trigger image acquisition and processing and some form of actuators to sort, route or reject defective parts. Choosing between a monochrome and color sensor depends on how you prioritize color information and light sensitivity. Color sensors capture a natural image with red, green, and blue channels, making them ideal for situations where identifying objects by color is essential. However, they struggle in low light because a color filter array (CFA) blocks some light to capture color data. Conversely, monochrome sensors ditch the CFA, capturing all incoming light in shades of gray. This makes them much more sensitive in low light conditions and potentially faster to process.

Display: The primary function of the display module in machine vision is to display the processed image or video data in a clear and intuitive manner. In machine vision systems, a display module serves as a crucial component for visualizing and interpreting the captured images or video data. It provides a direct visual representation of the processed information, allowing users to assess the quality of the data, identify potential defects, and make informed decisions based on the analyzed images.

Things to Consider when choosing and setting up machine vision solutions:

To select the right machine vision solution, it is necessary to evaluate the machine vision stages individually.

Image capture - The purpose of the machine vision system should be well defined from the beginning. For example, consider the image capture/camera module. This system must be equipped with high pixel quality cameras with fast frame rates and short exposure times. On the other hand, if products are to be evaluated according to their temperatures, an infrared camera must be used at that point. In short, the right equipment will depend on the use case.

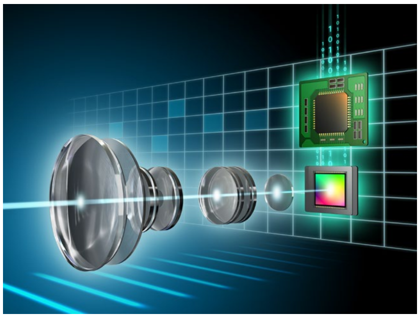
Image processing/recognition - It is important to choose the correct image processing or image recognition software and to integrate this software to the system used in image capture. Image processing software will run on a hardware which will determine the image processing speed. The necessary speed will depend on the use case and optimizing for the right speed would optimize hardware costs.

System action - The software that enables image processing and analysis must be well integrated with the system that takes an action. Integration costs need to be considered while considering total cost of ownership of the machine vision system.

System Description

Image Sensors

Physical Parameters:



Resolution: The amount of information per frame or an image is the product of horizontal pixel count x by vertical pixel count y. Machine vision applications does not require extremely high resolution like a consumer camera. Too much resolution needs more sensors and more image processor's bandwidth which leads to unnecessary higher system cost. A user must choose resolution as per the relative objects to scan and the amount of light provided on the object.

Optical format: Match the lens' projection of focused light onto the sensor's array of pixels, to cover the sensor (and make use of its resolution).

Aspect ratio: Whether 1:1, 3:2, or some other ratio, the optimal arrangement should correspond to the layout of the target's field of view, so as not to buy more resolution than is needed for your application.

Frame rate: If your target is moving quickly, you'll need enough images per second to "freeze" the motion and to keep up with the physical space you are imaging. But as with resolution, one needs just enough speed to solve the problem.

Dynamic Range (DR): Factors such as Full Well Capacity and Read Noise determine DR, which is the ratio of maximum signal to the minimum. The greater the DR, the better the sensor can capture the range of bright to dark gradations from the application scene.

Competitive Advantages

onsemi's image sensors outperform the competition in terms of dynamic range under harsh lighting conditions. Thanks to the whole-pixel architecture, the sensors retain far more detail in all lighting conditions, even in low light. Scalable families reduce system development cost and time.

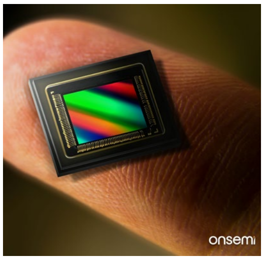
Figure 2: onsemi benefits in image quality

System Description

Image Sensors

Optical parameters: While some seemingly-color applications can in fact be solved more easily and cost-effectively with monochrome, in either case each silicon-based pixel converts light (photons) into charge (electrons). Each pixel well has a maximum volume of charge it can handle before saturating. After each exposure, the degree of charge in each pixel correlates to the amount of light that impinged on that pixel.

Rolling vs. Global shutter: Most current sensors support global shutter, where all pixel rows are exposed at once, eliminating motion-induced blur. But the on-sensor electronics to achieve global shutter have certain costs associated, so for some applications it can still make sense to use rolling shutter sensors.



Pixel Size: A larger physical pixel will admit more photons than a small one. Generally, large pixels are preferred. However, that requires the expense of more silicon to support the resolution for a desired x by y array and requires bigger optical systems with higher costs for the BOM. On the other hand, very small pixel requires a challenging design of the optical path to achieve a good optical resolution.

Output modes: While each sensor typically has a “standard” intended output, at full resolution, many sensors offer additional switchable outputs modes like Region of Interest (ROI), binning, or decimation. Such modes typically read out a defined subset of the pixels, at a higher frame rate, which can allow the same sensor and camera to serve two or more purposes. Example of binning would be a microscopy application whereby a binned image at high speed would be used to locate a target blob in a large field, then switch to full-resolution for a high-quality detail image.

Image Sensor Features - Global vs Rolling Shutter

Optical sensors be used for depth sensing, orientation in the environment and interaction. It is the only sensorics solution which can detect colors. Image sensors with global shutter store the pixel data in whole image at the same time, they do not have motion artifacts, therefore they are useful when moving around. Rolling shutter sensors have higher dynamic range so they can work better in worse lightning conditions.

Global Shutter Efficiency (GSE)

Global shutter offers advantages in capturing scenes with motion and offers other benefits for developers and manufacturers.

Minimize motion artifacts: This is a key benefit of global shutters. Because they capture the entire image at once, they avoid the distortion and artifacts that can plague rolling shutter images, especially when capturing fast moving objects.

Benefits:

- Statistics engines for each ROI
- Control & adaptation to dynamic lighting conditions
- Precision lighting & ISP synchronization
- Easy development of imaging system leads to short time-to-market

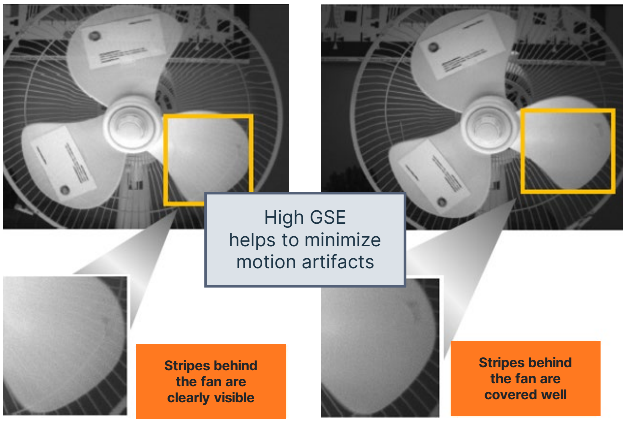


Figure 3: Global Shutter Efficiency comparison example

Solution Overview

Depth Sensing – Lidar

LiDAR (Light Detection and Ranging) plays a crucial role in many machine vision solutions, offering distinct advantages over traditional cameras. It can be used for Single point, 2D or 3D monitoring. LiDAR uses laser, from which short pulse is transmitted. This pulse reflects off objects, returns to photodetector and measure distance based on the transmit time. This process is repeated in order to get accurate representation of the surrounding area. LiDAR can be used in all light conditions due to using infrared light transmitter.

3D Mapping: LiDAR sensors emit laser pulses and measure the time it takes for them to bounce back, creating a highly accurate 3D map of the environment.

Robust Operation: LiDAR functions well in various lighting conditions, including darkness, smoke, and fog, where cameras would struggle.

Accuracy: LiDAR measurements are highly accurate, especially for longer distances, exceeding the capabilities of most cameras.

Fast Output: Fast Output is unique feature to **onsemi** SiPM sensors, which can achieve short pulse width and fastest signal rise time. It can be used for ultra-fast timing and for higher count rate.

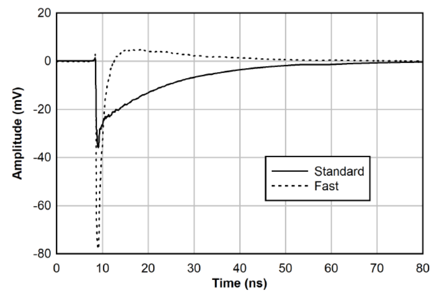
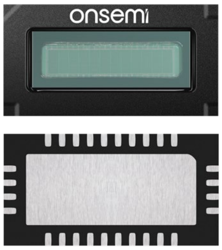


Figure 4: Unique Fast Output mode of **onsemi's** SiPMs

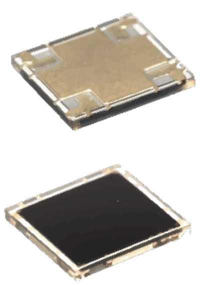
ArrayRDM-0112A20

- 12 SiPM pixel array, common anode
- No fast output
- 20x20 µm microcell active area
- PDE @ 905nm 16%
- Microlens technology for maximum optical efficiency
- Recommended V_{op} 30V



MicroFC-100

- 1x1 mm SiPM for single point or 2D LiDAR
- Standard and **Fast Output**
- Highest sensitivity in visible range
- PDE @ 420nm >18% - depends on microcell size
- Recommended V_{op} <30V
- 10,20 or 35 µm microcell size



The block diagram - Industrial LiDAR

- The laser is typically pulsed, so the power supply needs to have a fast response and good transient recovery.
- The SiPM/SPAD sensor operates in Geiger mode where it benefits from higher sensitivity and gain. A boost converter is required to bias the device at 25V to 30V. The SiPM can be biased positively or negatively, see Biasing and Readout of ON Semiconductor SiPM Sensors for more details.
- The transmitter and receiver have optical or mechanical interface to direct/sweep the energy across a field of view (FOV).
- The signal from sensor requires amplification and signal discrimination (comparator).

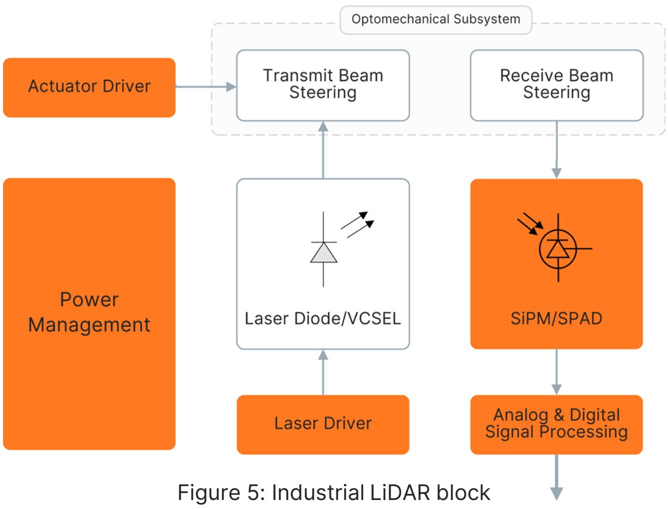


Figure 5: Industrial LiDAR block diagram using onsemi parts

System Implementation

Autonomous Sensor Modality - Depth Sensing Table Comparison

In industrial machine vision, choosing the right sensor depends on the specific task.

- Image sensors excel at detailed visual analysis with high angular resolution and object edge detection, but struggle with depth perception and low-light environments.
- Lidar shines in 3D applications with excellent depth resolution and range but lacks color recognition and velocity detection.
- Ultrasonic sensors offer exceptional low-light performance and close-range depth accuracy. However, they can have limited angular resolution and object detail detection.

Ultimately, the best sensor balances the application's needs with the technology's strengths and limitations. For intricate object inspection, image sensors reign supreme. For precise 3D scanning/navigation, lidar takes the lead. In order to achieve almost perfect and simple obstacle detection in low-light conditions, ultrasonic sensors are the right choice.

Table 1. Different Machine Vision Sensing Comparison

Parameter	LiDAR	Imaging	Ultrasonic
Angular Resolution	+++	+++	+
Depth Resolution	+++	++	+++
Velocity	++	+	+
Depth Range	+++	++	++
Object Edge Detection	+++	+++	++
Color Recognition	+	+++	+
Low-Light Performance	+++	++	+++

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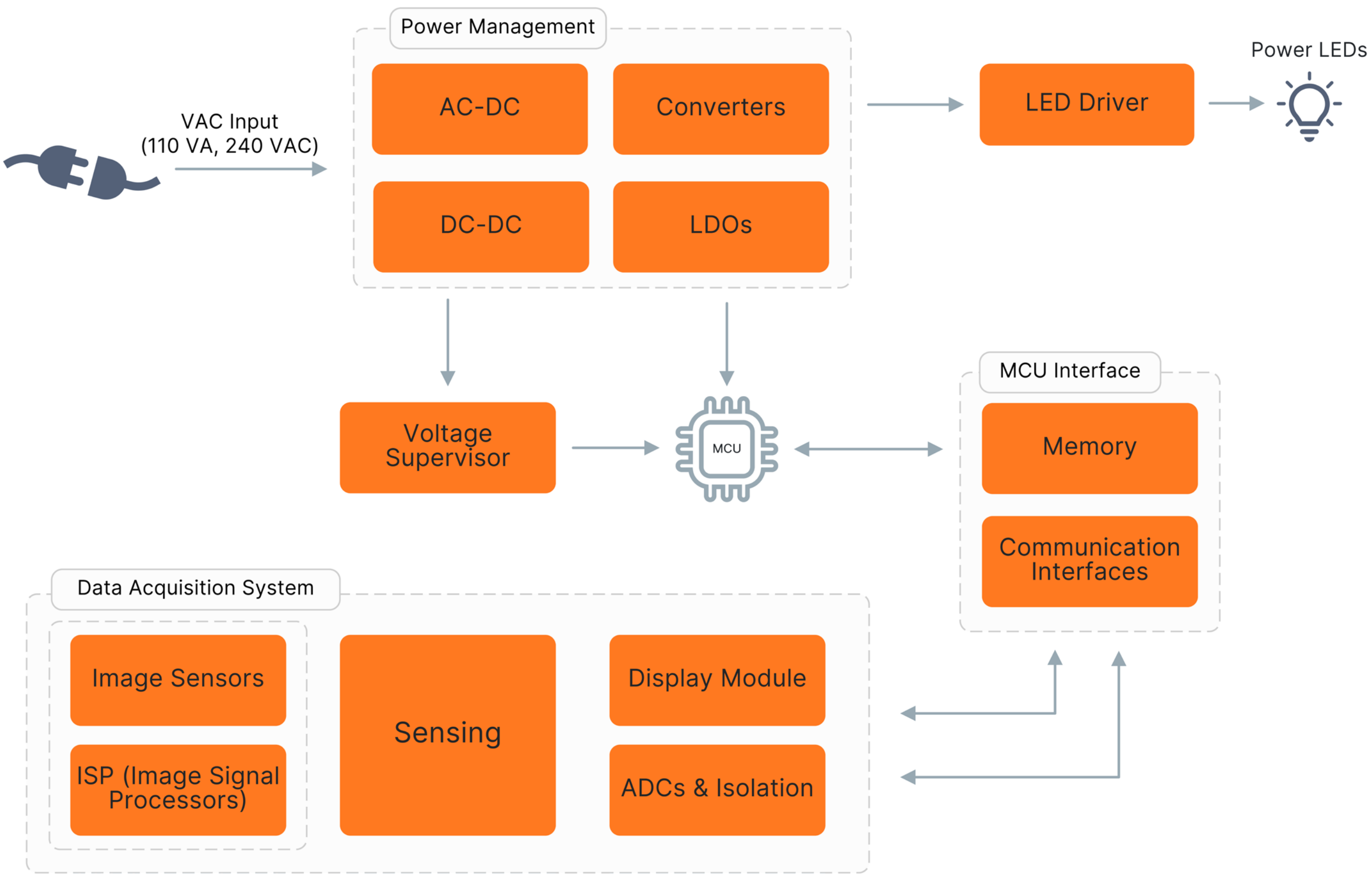
Solution Overview

Machine Vision – Block Diagram

- Block diagram below represents Machine Vision solution recommended by **onsemi**.
- Majority of the functional block devices can be sourced by the **onsemi** solutions as shown in the following device tables.



[Find Interactive Block Diagram on the Web]

Solution Overview – Product Benefits

Data Acquisition Sytem – Image Sensors

PYTHON Family

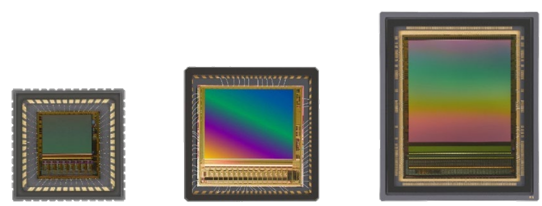
The PYTHON family of Global Shutter image sensors is a product line optimized for the most typical Machine Vision applications including inspection, tracking, measuring and a lot more. This family consists out of 8 resolutions based on a 4.5 or 4.8um pixels having resolutions starting at VGA up to 25 Megapixels featuring frame rates varying between >800fps and 80 fps depending on the resolution. All PYTHON devices have the unique feature of quadratic speed increase, in which the frame rate increases as function of both vertical and horizontal dimensions of the Region of Interest read out. PYTHONs are available as mono, color and NIR enhanced versions while speed and quality grade options are available for selected resolutions.

Key Features

- 8 resolutions covering a broad range of applications
- All PYTHON family members feature the quadratic speed increase in case of ROI read out (frame rate increases also in case *x* or the *y* of the window is reduced)
- Advanced Global Shutter CMOS design
- High performance, low noise, ~ 60 dB DR

A fast and versatile family of Global Shutter Image sensors

- Various resolutions and speed grades providing a cost-efficient imaging solution
- Square and rectangular aspect ratios to maximize the use of the available FOV



Hyperlux SG Family

The Hyperlux SG is a versatile camera that can be used for a variety of purposes, including AR/VR, machine vision, barcode scanning, and device inspection. It has a number of features that make it well-suited for these applications, including a global shutter sensor that minimizes motion artifacts, programmable regions of interest (ROIs), auto-exposure and control to adapt to dynamic lighting, trigger and strobe controls for precision active illumination, and low-power operation for battery-powered devices. More sensors with outstanding features are coming this year.

Range of small devices for portable and fixed function devices

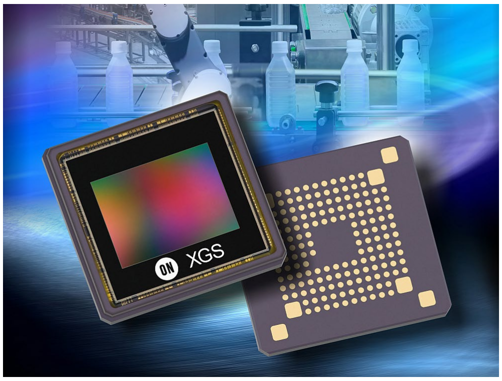
- ARX383 - VGA, 1/8” at 120 fps

Features and Benefits

- High global shutter efficiency for motion
- On-board AE for variable lighting
- Small form factor
- Programmable ROIs
- Trigger Mode and Strobe Controls

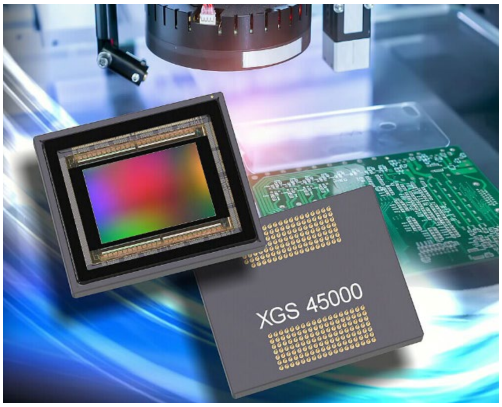
Solution Overview – Product Benefits

Data Acquisition Sytem – Image Sensors



XGS family

onsemi's image sensor family, also known as the XGS, combines high performance with compact pixels and low power consumption. It offers a variety of resolutions, ranging from 2.3 to 45 Megapixels, making it suitable for a wide range of applications. The sensors also feature a global shutter design, which means that all pixels capture light at the same time, reducing distortion and rolling shutter effects. Additionally, the sensors are available in both monochrome and color options.



Key features:

- Excellent image quality, artifact/pattern free raw images
- Outstanding power efficiency (2x lower than competing parts)
- High performance, low noise 3.2 µm pixel
- Very good size – resolution combinations
- Up to 16MP (1:1) in 29 x 29 mm cameras
- 4k/8k video @ 120/60 fps (12-bit) (XGS8000 / XGS45000)

XGS Development Support Tools

XGS X-Celerator

- Interface to standard FPGA eval environments
- Compatible with the ANSI / VITA 57.1 FMC standard
- Facilitates camera design and reduces TTM
- All collateral available on: X-Celerator
- Available for XGS 5000/12000/16000/45000

XGS X-Cube

- XGS sensor board (color or mono), FPGA board to convert to MIPI output
- Flex cable to IAS module for Demo 3 / DevWare interface
- Facilitates camera design and reduces TTM
- Available for XGS 5000/12000

Solution Overview – Product Benefits

Global Shutter Image Sensor Families – Key Parameters Overview

Table 2. Python image sensor family comparison

Python	PYTHON 480	PYTHON 300	PYTHON 500	PYTHON 1300	PYTHON 2000	PYTHON 5000	PYTHON 16K	PYTHON 25K
Resolution (x,y)	800 x 600	640 x 480	800 x 600	1280 x 1024	1920 x 1200	2592 x 2048	4096 x 4096	5120 x 5120
Resolution (Mp)	0.5	0.3	0.5	1.3	2.3	5.3	16.8	26.2
Imaging Diagonal (mm)	4.8	3.8	4.8	7.9	10.9	15.9	26.1	32.6
Optical Format	1/3.3”	1/4”	1/3.3”	1/2”	2/3”	1”	APS-C	APS-H
Max Frame Rate (10 bit)	120	815	545	210	225	100	120	80
Pixel Size (µm)	4.8	4.8			4.8		4.5	
Dynamic Range (dB)	60	60			60		59	
HDR (dB)	N/A	Up to 90 (multiple slope)			Up to 90 (multiple slope)		N/A	
SNR_{max} (dB)	40	40			40		41	
CFA Options	Mono, Color	Mono, Color, Extended NIR			Mono, Color, Extended NIR		Mono, Color, Extended NIR	

Table 3. XGS image sensor family comparison

XGS	XGS 5000	XGS 8000	XGS 9400	XGS 12000	XGS 16000	XGS 32000	XGS 45000
Resolution (x,y)	2592 x 2048	4096 x 2160	3072 x 3072	4096 x 3072	4000 x 4000	6580 x 4935	8192 x 5460
Resolution (Mp)	5.3	8.8	9.4	12.6	16.0	32.5	45
Imaging Diagonal (mm)	10.6	14.8	13.9	16.4	18,1	24.9 mm	31.6 mm
Optical Format	2/3	1/1.1	1/1.2	1	1.1”	Super 35mm	Super 35mm
Max Frame Rate (12 bit)	132 & 43	128 & 80	90 & 56	90 & 28	65 & 42 & 21	35 & 53	47 & 30 & 15
CRA Options	0/4.7 degree	0/7.3 degree	0 degree	0/7.3 degree	0 degree	10 degree	10 degree
CFA Options	Mono, Color	Mono, Color	Mono, Color	Mono, Color	Mono, Color	Mono, Color	Mono, Color

Recommended Products

Suggested Block	Part Number	Description
Image Sensing		
Image Processor	AP1302	Image Signal Processor, 13 MP, Frame Rate 30 (fps), interlaced High Dynamic Range (iHDR) operations
Image Sensors	AR0234CS	CMOS Digital Image Sensor with Global Shutter 1/2.6-inch 2.3 MP
	AR0331	CMOS Image Sensor, 3 MP, 1/3"
	ARX383CS	CMOS Digital Image Sensor with Global Shutter 1/8-inch 0.3 MP
	AR0522	CMOS Image Sensor, 5.1 MP, 1/2.5", Near Infra-Red Enhancement
	AR0821CS	CMOS Digital Image Sensor with Rolling Shutter 8.3 MP, 1/1.7", embedded HDR (eHDR)
	AR0822	CMOS Image Sensor, 4K/ 8 MP, 1/1.8", embedded HDR (eHDR)
	AR0830	CMOS Digital Image Sensor, 8.3 MP, Rolling Shutter, Hyperlux™ LP, 1/2.9", enhanced Dynamic Range (eDR)
	AR2020	CMOS Digital Image Sensor, 20 MP, Rolling Shutter, Hyperlux™ LP, 1/8", enhanced Dynamic Range (eDR)
	PYTHON480	CMOS Image Sensor, Global Shutter, 0.48 MP, SVGA, 1/3.6"
	PYTHON1300	CMOS Image Sensor, 1.3 MP (SXGA), Global Shutter, 1/2"
	PYTHON5000	CMOS Image Sensor, 5.3 MP, Global Shutter, 1"
	PYTHON25K	CMOS Image Sensor, 26.2 MP, Global Shutter
	XGS5000	CMOS Image Sensor, 5.3 MP, Global Shutter, 2/3"
	XGS12000	CMOS Image Sensor, 12.6 MP, Global Shutter, 1"
	XGS16000	CMOS Image Sensor, 16 MP, Global Shutter, 1.1"
	XGS20000	CMOS Image Sensor, 20.2 Mp, Global Shutter, 1.3"
	XGS32000	CMOS Image Sensor, 32.5 Mp, Global Shutter, Super 35 mm optical format, up to 80 fps
	XGS45000	CMOS Image Sensor, 44.7 Mp, Global Shutter, Super 35 mm optical format, up to 48 fps
	Application Recommended Image Sensors	
Depth Sensing		
LiDAR	ARRAYRDM-0112A20-QFN	NIR-enhanced LiDAR, monolithic, 1 × 12 array of SiPM pixels, NIR wavelengths of 905/940nm
	ARRAYRDM-0116B10-DBR	NIR-enhanced LiDAR, monolithic 1 × 16 array of SiPM pixels, NIR wavelengths of 905/940nm
	C-SERIES	Silicon Photomultiplier Sensors, C-Series (SiPM), C-Series available in 1 mm, 3 mm and 6 mm sizes

Complementary Products

Suggested Block	Part Number	Description
AC-DC / DC-DC Power Management		
AC-DC Power Management (up to 20W)	NCP1077	High Voltage Switching Regulator for Offline SMPS
	NCP431	Voltage Reference, Low Cathode Current, Programmable, Shunt Regulator
	NRVBA2H100N	Schottky Power Rectifier, Surface Mount, 2.0 A, 100 V
	NRVUA160V	Power Rectifier, Ultra-Fast Recovery, 1 A, 600 V
AC-DC Power Management (up to 60W)	NCP1253	PWM Controller, Current Mode, for Offline Power Supplies
	NTBL125N60S5H	MOSFET - Power, N-Channel, SUPERFET® V, FAST, 600 V, 22 A, 125 mΩ, TOLL
	FOD817	4-Pin DIP Phototransistor Optocouplers
	NCP431	Voltage Reference, Low Cathode Current, Programmable, Shunt Regulator
	NRVTS2H60ESF	Trench Schottky Rectifier, Very Low Leakage 2A, 60V
	NRTS8100PFS	8 A, 100 V Trench Schottky Rectifier in TO-277 package
	NRVUA160V	Power Rectifier, Ultra-Fast Recovery, 1 A, 600 V
DC-DC Power Management	FAN65005A	Synchronous PWM Buck Regulator, High Performance, Voltage Mode, 65 V, 8 A
	FAN65004B	Synchronous PWM Buck Regulator, High Performance, Voltage Mode, 65 V, 6 A
	FAN65008B	Synchronous PWM Buck Regulator, High Performance, Voltage Mode, 65 V, 10 A
	Application Recommeded DC/DC Buck	
Power Management (Low Voltage)	NCP5252	Synchronous Buck Regulator, Integrated, 2.0 A, 1.0 MHz, with Light Load Efficiency
	NCV891330	3 A, 2 MHz Low-Iq Dual-Mode Step-Down Regulator
	NCV890430	Automotive 0.6 A 2 MHz 100% Duty Cycle Step-Down Synchronous Regulator
	NCP6324	Synchronous Buck Converter, 3 MHz, 2.0 A
	Application Recommended Converters	
	NCP189	LDO, 500mA, Low noise, High Accuracy with Power-Good amd Vout Controlled slew rate
	NCP164	300mA LDO Regulator, Ultra-Low Noise, High PSRR with Power Good
	Application Recommended Power Supply - AC/DC & DC/DC conversion ICs and LDOs	

Complementary Products

Suggested Block	Part Number	Description
Voltage Supervisor	NCP308	Voltage Supervisor, Ultra Low Quiescent Current, Programmable Delay Time
	NCV308	Low Quiescent Current, Programmable Delay Time Supervisory Circuit
	NCV303LSN	Voltage Detector Series with Programmable Delay - Auto Rated
	NCV301LSN	Voltage Detector Series - Auto Rated
LED Drivers	NCL35076	Wide Analog Dimming CCM Buck Controller
	NCP3066	Buck / Boost / Inverting Regulator, Switching, Constant Current, 1.5 A, for HB-LEDs with Enable
	NCV78723	High Efficiency Buck Dual LED Driver with Integrated Current Sensing for Automotive Front Lighting
ADCs & Isolation		
ADCs	NCD98011	12-Bit Low Power SAR ADC Signed Output
	NCD98010	12-Bit Low Power SAR ADC Unsigned Output
Isolators	NCID9411	High Speed Quad-Channel Digital Isolator
	NCID9311	High Speed 3-Channel Digital Isolator
	NCID9211	High Speed Dual-Channel, Bi-Directional Ceramic Digital Isolator
	NCID9200	High Speed Dual-Channel, Ceramic Digital Isolator
	Application Recommended Digital Isolators	
Display Module		
LED Driver	CAT4004A	LED Driver, 4-Channel, with 32 Dimming Levels and Reset
	CAT4104	LED Driver, 4-Channels, 700 mA
	FAN5624	Linear LED Driver, 4-channel, with Single-wire Digital Interface
DC-DC LED Driver	CAT3224	LED Driver, Charge Pump, 2-Channel
	CAT3626	LED Driver, Charge Pump, 6-Channel, I2C Interface
	Application Recommended DC-DC LED Drivers	
Linear LED Driver	LM321	Operation Amplifier, Single-Channel
	NCS21911	Precision Operational Amplifier, 2 MHz Bandwidth, Low Noise, Zero-Drift, 25 μV Offset
	NCS20071	Operational Amplifier, Wide supply range, 3 MHz CMOS Op-Amp
	KDT00030	Phototransistor Photo Detector

Complementary Products

Suggested Block	Part Number	Description
Memory		
EEPROMs	CAT24C04	EEPROM Serial 4-Kb I2C
	CAT24C512	EEPROM Serial 512-Kb I2C
	CAT25040	EEPROM Serial 4-Kb SPI
	CAT25512	EEPROM Serial 512-Kb SPI
	CAT24M01	EEPROM Serial 1-Mb I2C
	Application Recommended EEPROMs	
SRAM Memory	N64S830HA	Serial SRAM Memory, 64-kb, 3.0 V
	N25S818HA	Serial SRAM Memory, 256-kb, 1.8 V
	N25S830HA	Serial SRAM Memory, 256-kb, 3.0 V
	N01S818HA	Serial SRAM Memory, Ultra-Low-Power, 1 Mb, 1.7 - 2.2 V
Flash Memory	LE25U20AMB	Serial Flash Memory, 2 Mb (256k x 8)
	LE25U20AQG	Serial Flash Memory, 2 Mb (256K x 8)
	LE25U40CMC	Serial Flash Memory, 4 Mb (512K x 8)
	LE25U40PCMC	Serial Flash Memory, 4 Mb (512K x 8)
	LE25S161	Serial Flash Memory, 16 Mb (2048K x 8)
Clock Buffer	NL17SZ17	Single Non-Inverting Buffer with Schmitt Trigger Output
	NLSF3T125	Quad Bus Buffer with 3-state Control Inputs
Communication Interfaces		
Ethernet Controller	NCN26010	Ethernet Controller, 10 Mb/s, Single-Pair, MAC + PHY, 802.3cg, 10BASE−T1S Compliant
SPI	NLSX5004	Level Translator, 4-Bit, 100 Mbps, Configurable Dual-Supply
I2C	NLA9306	Dual Bidirectional I2C Bus and SMBus Voltage Level Translator
	FXL2T245	Low Voltage Dual Supply2-Bit Signal Translator with Configurable Voltage Supplies and Signal Levels and 3-STATE Output
Interfaces Protections		
SPI	ESD7504	ESD Protection, USB3.0 ESD Protection Array
	ESD7004	ESD Protection Diode with Low Capacitance
I2C	ESD7462	Ultra-Low Capacitance ESD Protection
	ESD7205	Low Capacitance ESD Protection Diodes for High Speed Data Lines
GPIO	ESD7551	ESD Protection, Micro−Packaged Diodes
	ESD7571	Micro−Packaged Diodes for ESD Protection

Complementary Products

Suggested Block	Part Number	Description
Sensing		
Ultrasonic Sensor	NCV75215DB001R2G	Ultrasonic Parking Distance Measurement ASSP
	NRVTSAF260E	Very Low Forward Voltage Trench-based Schottky Rectifier
LiDAR	NCP81074	Small, High Speed Low Side MOSFET Driver with 10A sink/source capability
	NVRGS055N06CL	Single N-Channel Logic Level Power MOSFET 60 V, 5.11 A, 51 mΩ, Small Signal
	NRVB120VLSF	1.0 A, 20 V, Schottky Power Rectifier, Surface Mount
	BAS16H	100 V Switching Diode
	BC856BW	PNP Bipolar Transistor
	NCV2903	Comparator, Dual, Low Offset Voltage
	BAT54T	200 mA, 30 V, Schottky Barrier Diode
	BC817-40W	45 V, 0.5 A, General Purpose NPN Transistor
	NSVF4015SG4	RF Transistor for Low Noise Amplifier
	NBA3N012C	3.3 V Automotive Grade LVDS Line Receiver
Current Sense Amplifiers	NCS214R	Current Sense Amplifier, 26V, Low-/High-Side Voltage Out, Bidirectional Current Shunt Monitor
	NCS210R	Current Sense Amplifier, 26V, Low-/High-Side Voltage Out, Bidirectional Current Shunt Monitor
	NCS20072	Operational Amplifier, Wide supply range, 3 MHz CMOS Op-Amp
	NCS21674	Current-Shunt Monitors, 40 V Common Mode, Unidirectional, Dual Channel
	Application Recommended Currnet Sense Operation Amplifiers	
Voltage Sense	NCS333	Low Power, Zero-Drift Operational Amplifier with 10 µV Offset
	NCS4333	Operational Amplifier, 30 µV Offset, 0.07 µV/°C, Low Power, Zero-Drift
	NCS21804	Precision Operational Amplifier, 10µV, Zero-Drift, 1.8V to 5.5V Supply, 1.5 MHz
	NCS21914	Precision Quad Operational Amplifier, 2 MHz Bandwidth, Low Noise, Zero-Drift, 25 µV Offset
	Application Recommended Voltage Sense Operation Amplifiers	
Temperature Sense	N34TS108	Low-Voltage Digital Temperature Sensor
	NCT375	Digital Temperature Sensor with 2-wire Interface and SMBus Time-Out

Development Tools and Resources

Image Sensor Development Software - DevWareX

DevWareX is an extremely versatile and powerful tool that allows you to program the imager, display and evaluate images using Demo3 Kit. **onsemi's** sensor demonstration software, enables you to display and work with images from your sensor. Software suite is designed for development and evaluation purposes with **onsemi** image sensor products. DevWareX is a versatile tool for developers working with **onsemi** image sensors, allowing them to program, visualize, and assess the performance of their imaging applications.

A Primer Training video can be found here.

onsemi DevWareX

Functionalities:

Programming the imager: DevWareX allows you to configure and control the behavior of the image sensor, including settings like exposure, gain, and white balance.

Displaying images: The software can display the images captured by the sensor in real-time, enabling you to visualize the results of your configuration changes.

Evaluating images: DevWareX provides tools to analyze the captured images, such as measuring image quality metrics like signal-to-noise ratio and dynamic range.

Compatibility: It works with various **onsemi** products, including image sensors (Hyperlux & XGS image sensor families), system-on-chips (SoCs), and companion chips, in a plug-and-play manner. This is the cross-platform version, compatible with Windows, MacOS, and Ubuntu.

DevWareX

Try free Image Sensor development software.
For more information, visit the onsemi website.

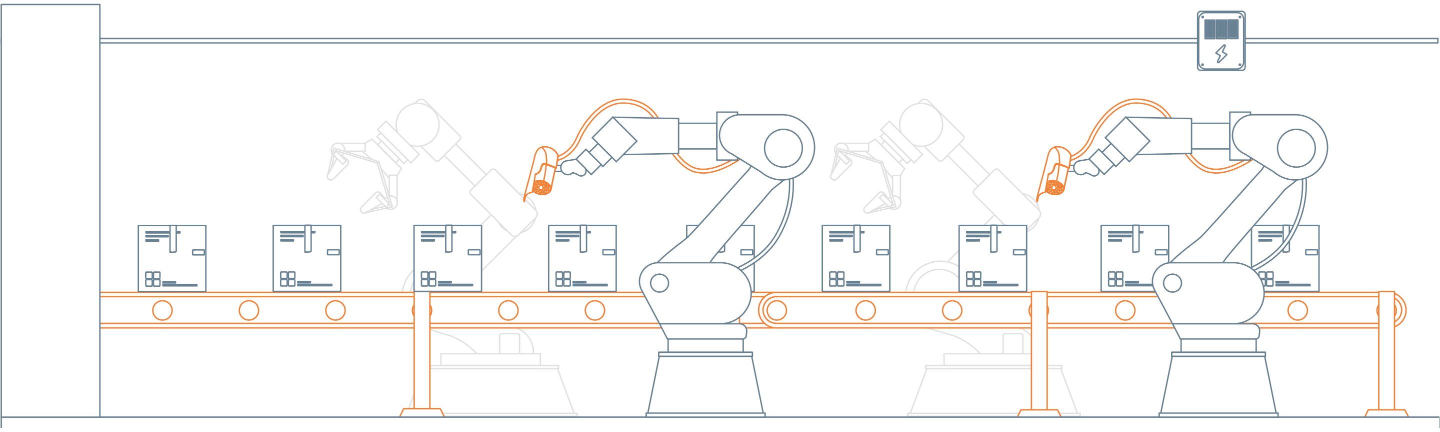
Download

Evaluation Boards

Type	Description and Link
Evaluation Board	**DEMO3 Board** - AGB1N0CS-GEVK
Evaluation Board	XCEL-NOIX1SE012KBL-GEVK
Evaluation Board	XCEL-NOIX0SN045KBG-GEVK
Evaluation Board	XCUBE-NOIX1SE012KBL-GEVK
Evaluation Board	NOIX1SE012KBLFB-GEVB
Evaluation Board	X-Celerator XGS 5000 Mono Developer Kit

Technical Documents

Type	Description and Link
Whitepaper	How Imaging Technologies are Enabling Industry 4.0
Whitepaper	What Issues Drive Image Sensor Choice for ITS and other Machine Vision Applications?
Whitepaper	Direct Time–of–Flight Depth Sensing Reference Designs
Application Note	Optimizing the LiDAR Signal Chain, Application Note Sensors and Integrated Processing from **onsemi** and LeddarTech
Application Note	Introduction to the Silicon Photomultiplier (SiPM)
Application Note	Direct Time-of-Flight Ranging with the SiPM based Gen1 LiDAR Demonstrator
Application Note	Gen1 Ranging Demonstrator Description
Application Note	Performance Measurement and Model Validation of the **onsemi** or Gen3 Scanning LiDAR Demonstrator
Application Note	Factory Automation Lens Options
Other Documents	PRISM Module User Guide
Other Documents	Understanding Challenges in Powering High Resolution, High Frame Rate CMOS Image Sensors
Other Documents	Image Sensor ISO Management



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