SOFRADIR-EC

Night Vision Imaging

HOW NIGHT VISION WORKS

EVERYTHING YOU'VE ALWAYS WANTED TO KNOW

Image intensifiers are sophisticated electro-optical devices that amplify low-light images. They have been popularized primarily by their use in night vision applications (both military and commercial). If you have seen the familiar green tint images in movies and television news coverage, you are seeing the output of an image intensifier being photographed or video-taped.

Law Enforcement

Military

Nature

Miscellaneous

Edition: 12-17

HOW NIGHT VISION WORKS

EVERYTHING YOU'VE ALWAYS WANTED TO KNOW

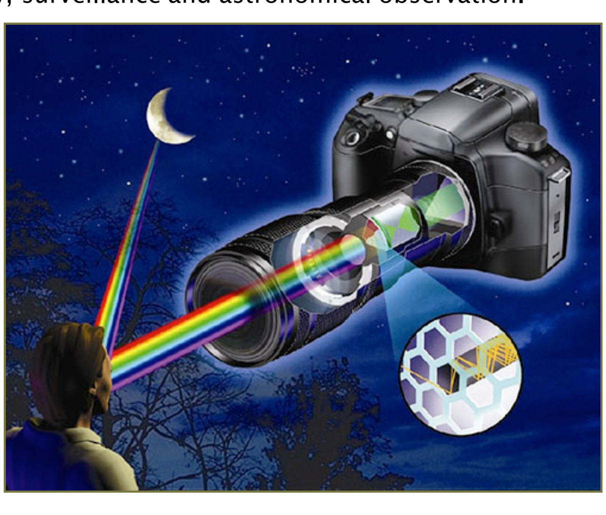
"Night Vision" as referenced here is that technology that provides us with the miracle of vision in total darkness and the improvement of vision in low light environments.

This technology is an amalgam of several different methods each having its own advantages and disadvantages. The most common methods as described below are Low-Light Imaging, Thermal Imaging and Near-infrared Illumination. The most common applications include night driving or flying, night security and surveillance, wildlife observation, sleep lab monitoring and search and rescue. A wide range of night vision products are available to suit the various requirements that may exist for these applications.

Low-Light Imaging

Today, the most popular and well known method of performing night vision is based on the use of image intensifiers. Image intensifiers are commonly used in night vision goggles and night scopes. More recently, on-chip gain multiplication CCD cameras have become popularized for performing low-light security, surveillance and astronomical observation.

Image Intensifiers



HOW THEY WORK: This method of night vision amplifies the available light to achieve better vision. An objective lens focuses available light (photons) on the photocathode of an image intensifier. The light energy causes electrons to be released from the cathode which are accelerated by an electric field to increase their speed (energy level). These electrons enter holes in a microchannel plate and bounce off the internal specially-coated walls which generate more electrons as the electrons bounce through. This creates a denser "cloud" of electrons representing an intensified version of the original image.

The final stage of the image intensifier involves electrons hitting a phosphor screen. The energy of the electrons makes the phosphor glow. The visual light shows the desired view to the user or to an attached photographic camera or video device. A green phosphor is used in these applications because the human eye can differentiate more shades of green than any other color, allowing for greater differentiation of objects in the picture.

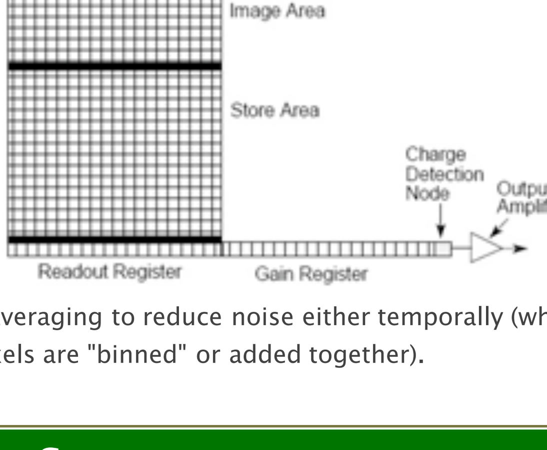
All image intensifiers operate in the above fashion. Technological differences over the past 40 years have resulted in substantial improvement to the performance of these devices. The different paradigms of technology have been commonly identified by distinct generations of image intensifiers. Intensified camera systems usually incorporate an image intensifier to create a brighter image of the low-light scene which is then viewed by a traditional camera.

Image Intensifiers	
Advantages	**Disadvantages**
• Excellent low-light level sensitivity. • Enhanced visible imaging yields the best possible. recognition and identification performance. • High resolution. • Low power and cost. • Ability to identify people.	• Because they are based on amplification methods, some light is required. This method is not useful when there is essentially no light. • Inferior daytime performance when compared to daylight-only methods. • Possibility of blooming and damage when observing bright sources under low-light conditions.

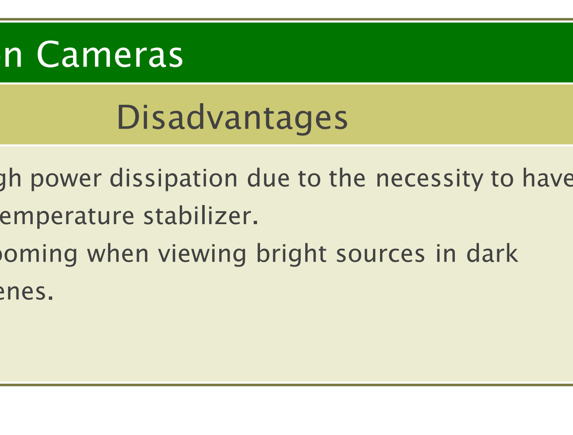
Image Intensifier Based Products:

- Intensified Nikon dSLR Cameras
- Intensified Canon dSLR Cameras
- Intensified Professional News Cameras
- Intensified Pro-consumer Camcorders
- Intensified Removable Lens Camcorders
- Intensified C-Mount CCD Cameras
- Night Vision Pocketscopes

On-Chip Gain Multiplication Cameras



HOW THEY WORK: In order to overcome some of the disadvantages of image intensifiers, CCD image detector manufacturers have substantially improved the sensitivity of certain CCD detectors by incorporating an on-chip multiplication gain technology to multiply photon-generated charge above the detector's noise levels. The multiplication gain takes place after photons have been detected in the device's active area but before one of the detector's primary noise sources (e.g. readout noise). In a new multiplication register, electrons are accelerated from pixel-to-pixel by applying high CCD clock voltages. As a result, secondary electrons are generated via an impact-ionization process. Gain can be controlled by varying the clock voltages.



Because the signal boost occurs before the charge reaches the on-chip readout amplifier and gets added to the primary noise source, the signal-to-noise ratio for this device is significantly improved over standard CCD cameras and yields low-light imaging performance far superior than traditional CCD cameras. However, since the CCD temperature also affects the on-chip gain multiplication (lower temperatures yield higher gain) and because other noise sources exist that occur before the multiplication (i.e. dark noise), it is prudent in these systems to temperature stabilize these detectors at temperatures about of below room temperature.

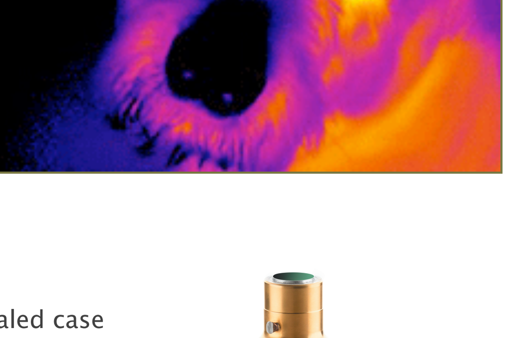
Another method for improving a CCD camera's sensitivity is to perform averaging to reduce noise either temporally (where sequential video frames are averaged) or spatially (where neighboring pixels are "binned" or added together).

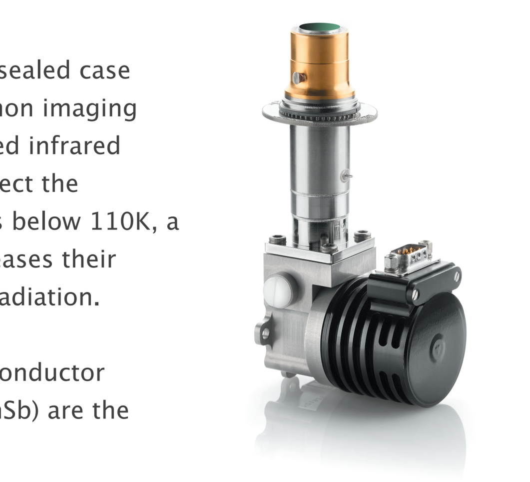
On-chip Gain Multiplication Cameras	
Advantages	**Disadvantages**
• High sensitivity in low-light. • Reduced likelihood of damage to the imaging detector due to viewing bright sources. • High speed imagin capability. • Good daytime imaging performance.	• High power dissipation due to the necessity to have a temperature stabilizer. • Blooming when viewing bright sources in dark scenes.

On-Chip Gain Multiplication Camera-Based Products:

- Day/night surveillance camera
- Frame-averaged and binned low-light CCD camera

Thermal Imaging

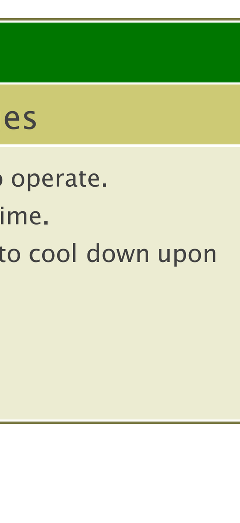




Different from low-light imaging methods of night vision (which require some ambient light in order to produce an image), thermal imaging night vision methods do not require any ambient light at all. They operate on the principal that all objects emit infrared energy as a function of their temperature. In general, the hotter an object is, the more radiation it emits. A thermal imager is a product that collects the infrared radiation from objects in the scene and creates an electronic image. Since they do not rely on reflected ambient light, thermal imagers are entirely ambient light-level independent. In addition, they also are able to penetrate obscurants such as smoke, fog and haze. There are two types of thermal imaging detectors: cooled and uncooled. Cooled detector infrared cameras require cryogenic cooling to very cold temperatures (below 200K). Uncooled detector infrared cameras are normally either temperature stabilized (at room temperatures) or entirely unstabilized.

Thermal images are normally black and white in nature, where black objects are cold and white objects are hot. Some thermal cameras show images in color. This false color is an excellent way of better distinguishing between objects at different temperatures.

Cooled-detector Infrared Cameras



HOW THEY WORK: Cooled infrared detectors are typically housed in a vacuum-sealed case and cryogenically cooled. The detector designs are similar to other more common imaging detectors and use semiconductor materials. However, it is the effect of absorbed infrared energy that causes changes to detector carrier concentrations which in turn affect the detector's electrical properties. Cooling the detectors (typically to temperatures below 110K, a value much lower than the temperature of objects being detected) greatly increases their sensitivity. Without cooling, the detectors would be flooded by their own self-radiation.

Materials used for infrared detection include a wide range of narrow gap semiconductor devices, where mercury cadmium telluride (HgCdTe) and indium antimonide (InSb) are the most common.

Cooled-detector Thermal Imaging Cameras	
Advantages	**Disadvantages**
• The highest possible thermal sensitivity. • Able to detect people and vehicles at great distances. • Not affected by bright light sources. • Able to perform high speed infrared imaging. • Able to perform multi-spectral infrared imaging.	• Expensive to purchase and to operate. • Limited cooler operating lifetime. • May require several minutes to cool down upon initiation. • Bulky

Cooled-Detector Infrared Cameras

- Short-wave Infrared Cameras
- Mid-wave Infrared Cameras
- Long-wave Infrared Cameras
- Multi-spectral Infrared Cameras

Uncooled-detector Cameras

HOW THEY WORK: Unlike the cryogenically cooled detectors described above, uncooled infrared detectors operate at or near room temperature rather than being cooled to extremely low temperatures by bulky and expensive cryogenic coolers. When infrared radiation from night-time scenes are focused onto uncooled detectors, the heat absorbed causes changes to the electrical properties of the detector material. These changes are then compared to baseline values and a thermal image is created. Despite lower image quality than cooled detectors, uncooled detector technology makes infrared cameras smaller and less costly and opens many viable commercial applications.

Uncooled detectors are mostly based on materials that change their electrical properties due to pyroelectric (capacitive) effects or microbolometer (resistive) effects.

Uncooled-detector Thermal Imaging Cameras	
Advantages	**Disadvantages**
• Relatively inexpensive compared to other thermal imaging technologies. • High contrast in most night-time scenarios. • Easily detects people and vehicles. • Not affected by bright light sources . • Higher reliability than cooled detector thermal imagers .	• Less sensitive than cooled detector thermal imagers. • Cannot be used for multispectral or high-speed infrared applications .

Uncooled-Detector Thermal Imaging Products:

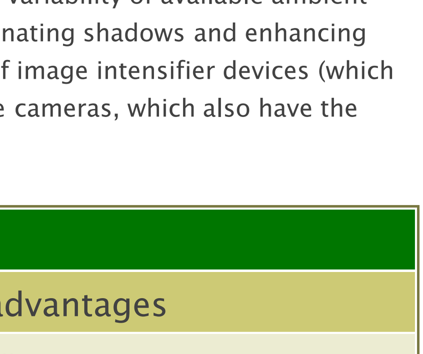
- Uncooled thermal imaging camera (fixed mount)
- Uncooled thermal imaging camera (portable)

Near Infrared Illumination

A popular and sometimes inexpensive method for performing night vision is by near infrared illumination. In this method, a device that is sensitive to invisible near infrared radiation is used in conjunction with an infrared illuminator. The Sony Night Shot camcorder popularized this method. Because of the IR sensitivity of the camcorder's CCD detector and since Sony installed an infrared light source in the camcorder, infrared illumination was available to augment otherwise low-light video scenes and produce reasonable image quality in low-light situations.

The method of near-infrared illumination has been used in a variety of night vision applications including perimeter protection where, by integrating with video motion detection and intelligent scene analysis devices, a reliable low-light video security system can be developed.

IR Illumination



HOW THEY WORK: Several different near infrared illumination devices are available today, including:

- Filtered incandescent lamps: A standard high power lamp that is covered by an infrared filter designed to pass the lamp's near infrared radiation and block the visible light component. These devices typically need good heat transfer properties since the intense visible light is internally absorbed and dissipated as heat.
- LED type illuminators: These illuminators utilize an array of standard infrared emitting LEDs.
- Laser type: The most efficient infrared illuminator, these devices are based on an infrared laser diode that emits near infrared energy.

Near infrared illuminators are typically available in a range of wavelengths (e.g. 730nm, 830nm, 920nm). Providing supplemental infrared illumination of an appropriate wavelength not only eliminates the variability of available ambient light, but also allows the observer to illuminate only specific areas of interest while eliminating shadows and enhancing image contrast. The supplemental near infrared lighting not only improves the quality of image intensifier devices (which have both a visible and a near-infrared response), but also permits the use of solid state cameras, which also have the ability to convert near infrared images to visible.

IR Illumination	
Advantages	**Disadvantages**
• Lowest cost compared to other night vision technologies. • Eliminate shadows and reveal identifying lettering, numbers and objects. Can also be used to perform facial identification. • Able to perform high-speed video capture (such as reading license plates of moving vehicles). • IR illuminators can see through night-time fog, mist, rain and snowfall as well as windows. • Eliminates the variability of ambient light.	• Users of infrared illuminators can be detected by others that have near-infrared viewing devices.

IR Illumination Products:

- Wide area infrared laser illuminator
- Portable Laser illuminator

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