Out-Of-Band countermeasure capabilities of 4G specification Image Tubes

Tactical differences between Gen3 Night Vision equipment and emerging 4G standards

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***Abstract*—Contemporary image intensifier based night vision devices typically provide imaging capabilities over the 500 nm to 900 nm spectral band. Recent technology developments extending this range from approximately 400 nm to 1000 nm have resulted in significant out-of-band performance increases, leaving existing image intensifier based night vision, and digital/thermal based night vision blind to next-generation lasers, illuminators, pointers and beacons.**

Keywords—Out Of Band; OOB; Image Intensifiers; Night Vision; Opto-Electronic Countermeasures; Low-light Albedo; Strobes; Aiming Devices; Illuminators; NIR; SWIR

I. Introduction

Developed in 1934, the tube-based technology behind image intensifiers still forms the backbone of every military night-operations strategy, accounting for well over a million deployed night vision devices. Sitting at the forefront of this technology is Third-Generation (Gen3), or NEA (Negative Electron Affinity) Image Intensifier Tube (IIT) technology, which has remained dominant on the battlefield for three decades. However continued development of Second-Generation (Gen2) IIT technology has recently resulted in new capabilities that, based on the 4G performance specification, not only outperform current third-generation technology, but could be used in ways that render existing Gen3 night vision effectively blind to significant threats on the battlefield.

II. The differences between 4G and Gen3

A. The difference between 4G and Gen3

4G represents a performance specification for any type of image intensifier, while Gen3 represents a technology class within Image Intensifiers. The 4G performance specification requires only four points of conformance;[1]

- Spectral sensitivity from below 400 nm to above 1000 nm
- A minimum figure-of-merit of FOM1800
- High light resolution higher than 57 lp/mm
- Halo size of less than 0.7 mm

Of these requirements, it is the first which represents a significant departure from prior capabilities. Typical Gen3 photocathodes become transparent above 900 nm, with negligible sensitivity above 950 nm.

This means that the newer tubes cannot only image a wider band of spectrum, but can image light that is Out Of Band (OOB) for existing Gen3 night vision.

OOB devices are suited to situations where active illumination is required, and is suitable for applications including covert target indication (pointers), covert target illumination (torches), aiming purposes and identification purposes, such as beacons and strobes.[2]

Intensified OOB applications are unique in that they are very difficult for non-intensified applications to detect, even if they have capability to image the light-source spectral band.

III. Evaluating Out Of Band capabilities of 4G

To test the comparative out-of-band capabilities with active light sources, photographs were taken out of both an INTENS 4G and Gen3 image tube, with similar performance characteristics, fitted to an AN/PVS-14 monocular.

Testing was carried out during part-moon and new-moon events, in dark-skies locations in Western Australia, to ensure conditions under which the image tubes were tested represented realistic conditions that may be encountered by persons operating night vision devices in the field. Field conditions were post-rain and vegetation albedo in the infra-red 700-1300 nm range due to chlorophyll was significant.[3]

The 980 nm band for light sources was chosen with respect to the 4G Quantum Efficiency (QE) and Gen3 QE curves to maximise 4G sensitivity to the band, while minimising Gen3 sensitivity. It is also a recommended band for OOB imaging, and is used by specialist InGaAs imaging equipment.[4]

Finally, a Night Sky Co-efficient was calculated against the QE to predict relative 4G performance variation in the field, as in (1), where CIE-Aλ represents the 2856K illuminant [5], and NSλ represents the night sky brightness spectral distribution.[6]

$$\frac{\left(\left(\int_{360nm}^{1040nm} CIE\text{-}A\lambda(x)\times Gen3QE\lambda(x)\,dx\right)\times\left(\int_{360nm}^{1040nm} NS\lambda(x)\times INTENSQE\lambda(x)\,dx\right)\right)}{\left(\left(\int_{360nm}^{1040nm} CIE\text{-}A\lambda(x)\times INTENSQE\lambda(x)\,dx\right)\times\left(\int_{360nm}^{1040nm} NS\lambda(x)\times Gen3QE\lambda(x)\,dx\right)\right)} \quad (1)$$

Three tests were carried out with 980 nm light; detection of an illuminator, detection of a pointer and detection of a strobe.

IV. Practical Demonstration of the Technology

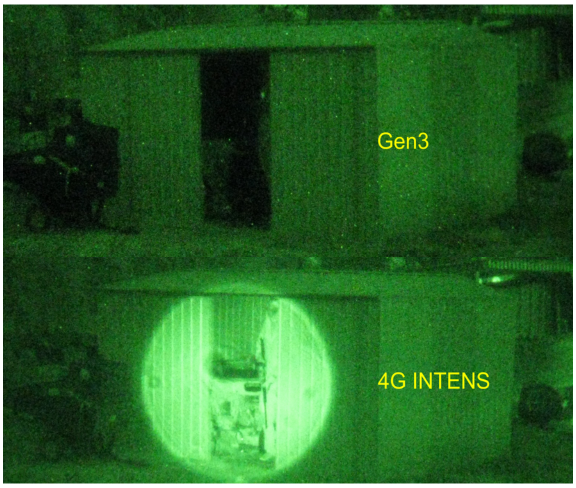

Fig. 1. Active illumination that cannot be seen by Gen3 Night Vision

A. Test 1 - Detection of an illuminator

Under dark-sky conditions, such as would be encountered in the field, an actor was asked to conceal himself in immediate shadows within a small construction, near the opening, holding a rifle prop. Under normal conditions, within full-shadow Night-Level 5 conditions[7], the actor could not be identified and the threat could not be seen. The actor was also equipped with contemporary Gen3 night vision.

The scene was then illuminated with an out-of-band illuminator and photographed and viewed under both Gen3 and 4G systems (Fig.1). The illumination was not detected at all by any external parties with Gen3 equipment, but was bright and well defined to 4G equipped parties, and the threat could be clearly made out at any distance under which it was within the resolution of the night vision device to identify the threat.

The actor was unable to detect the illuminant source until illumination was on-axis. Reflected light from the beam or the source when off-axis was not detected. The illuminator range was approximately 150 m at 10 degrees however could be adjusted for greater range.

B. Test 2 - Detection of a pointer

A laser pointer exhibiting OOB characteristics was tested as a pointing device under partial moonlight. At low power, it was not detectable beyond 15 m with Gen3 equipment, but was clearly visible and useful as an aiming or pointing device beyond 100 m with the 4G equipment.

C. Test 3 - Detection of a strobe

A strobe was tested at various distances to 100 m, next to a non-OOB strobe at the same distance. The Gen3 equipment could detect the non-OOB strobe, but could not effectively detect the OOB strobe at a distance further than 10 m. 4G equipment could detect the strobe at all distances. Testing at distances beyond 100 m was not attempted.

V. On-Axis Detection

On-axis detection of the beam source was also tested, with direct illumination from the light examined through a Gen3 night vision device. Although Gen3 lacks sensitivity to the light, it was still able to detect the *source* when directly on-axis to the full intensity of the beam source at close range. The beam angle was just under 10 degrees at 10 m distance.

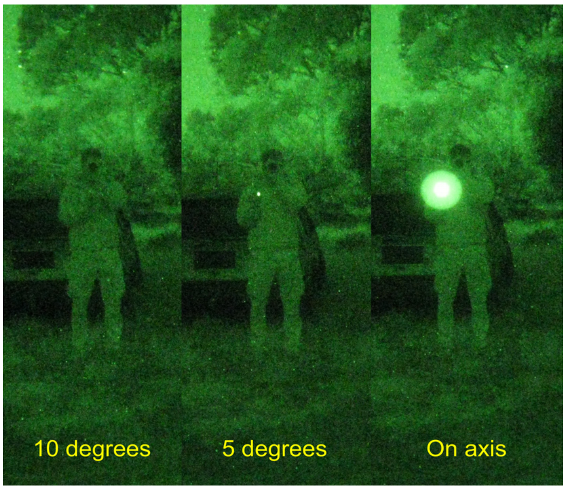

Fig. 2. Off Axis, Near Axis and On-Axis visibility of direct light source.

VI. Relative Performance Levels

The Night Sky Co-efficient calculated for the INTENS tube was 1.097, predicting an in-the-field performance increase of almost 10 % over an equivalent Gen3 tube due to the spectral distribution variation from the 2856K test standard [5].

VII. Outcome of Tests

From the tests performed, it was reasonably confirmed that 4G image tubes can make extensive tactical use of Out Of Band illumination that Gen3 devices cannot effectively detect.

References

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