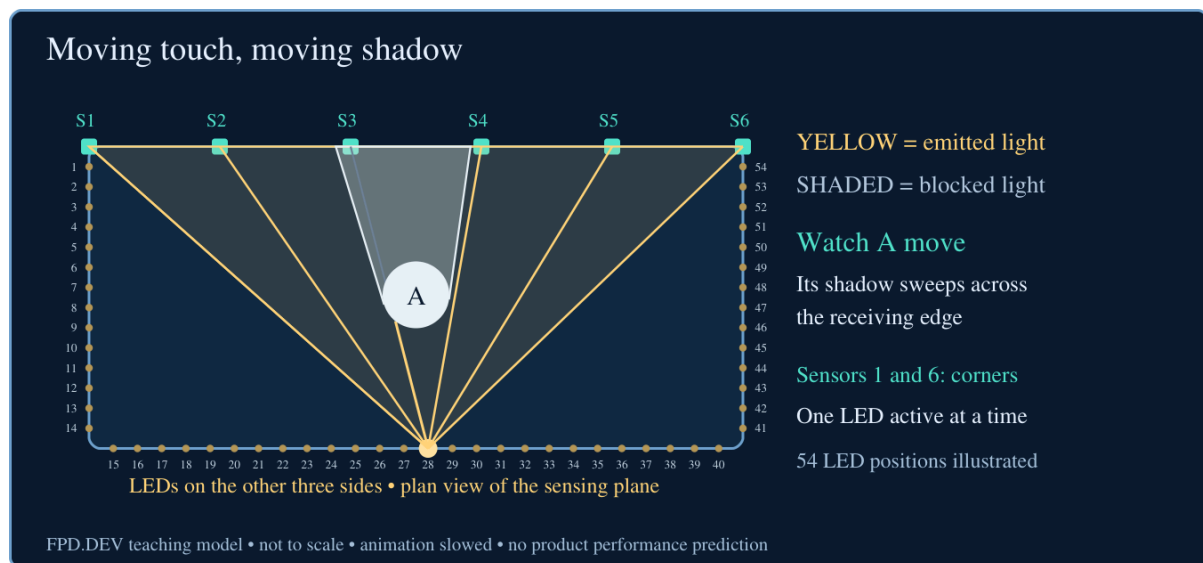


## Chapter 7 - Optical sensing and ShadowSense

Chapter handout | LED illumination

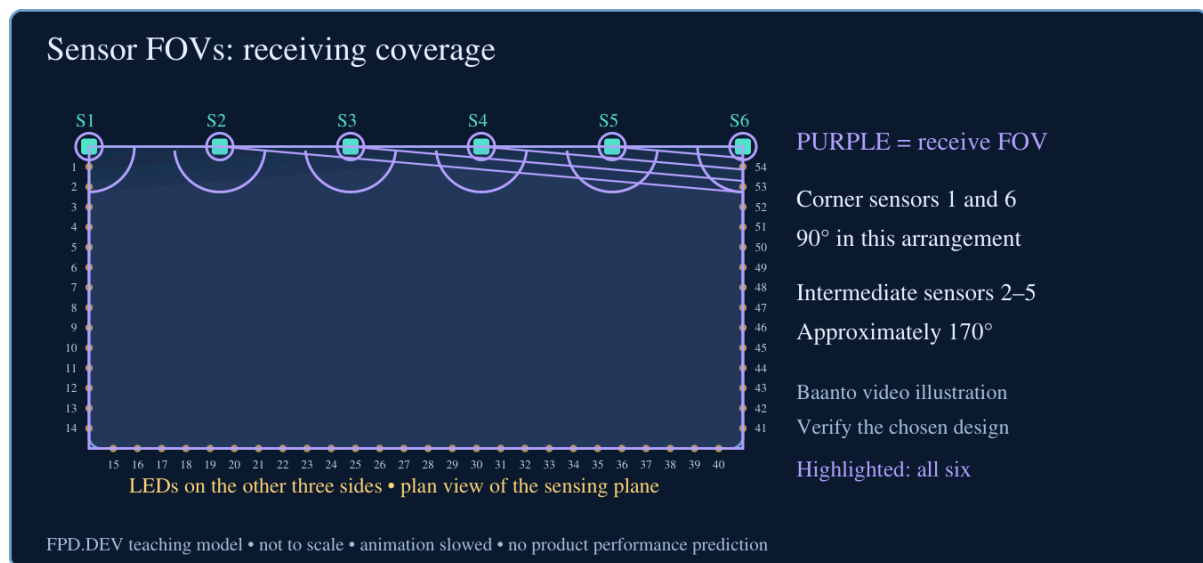


### LED illumination

**IR emitters line three sides of the frame; six sensors are shown along the fourth.** Sensors 1 and 6 sit at the top corners, with four intermediate sensors. The count and placement are design-specific. The teaching graphics show 54 LED positions around three sides; this illustrative count and pitch are not a frame specification. Yellow light fans originate at an active LED. A touch interrupts some of those paths, changing the light reaching the sensors. As the touch moves, its shaded shadow changes direction and shifts along the receiving edge.

## Chapter 7 - Optical sensing and ShadowSense

Chapter handout | Receiving fields of view



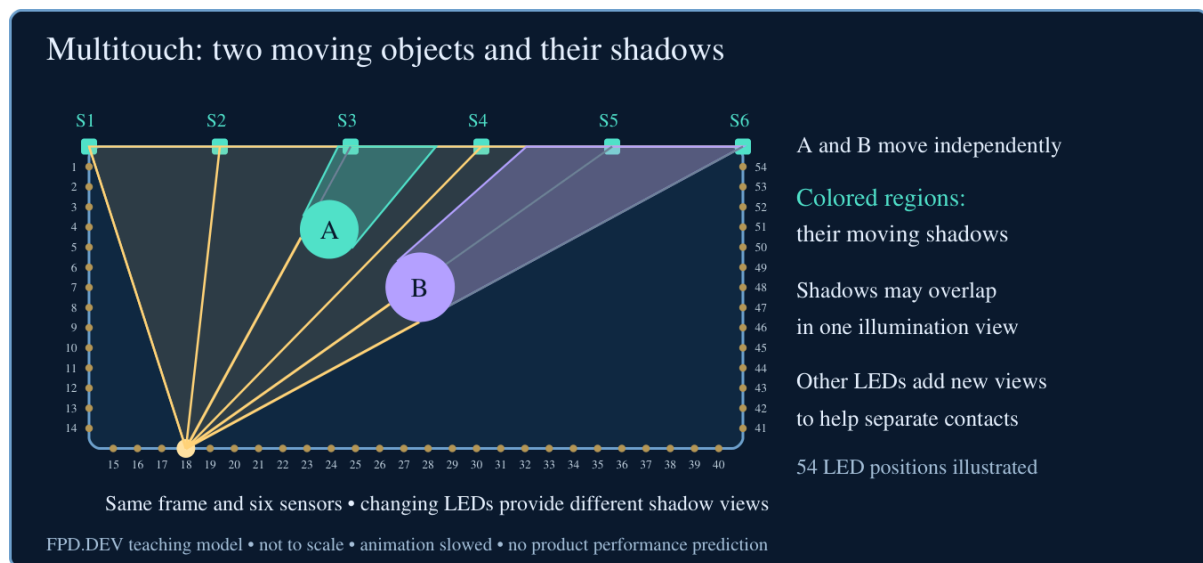
### Receiving fields of view

**A sensor field of view (FOV) describes where it can receive light.** The separate purple diagram shows receiving coverage, not emitted beams. Baanto's illustrated arrangement labels the two corner sensors 90 degrees and intermediate sensors approximately 170 degrees. These values describe that arrangement, not a universal specification for every ShadowSense sensor or frame. The graphic is a plan view of coverage within the sensing plane; vertical acceptance is not shown.

Several observations of the same object provide geometric constraints. A shadow direction is a measurement within a sensor's FOV, not its entire FOV. Combining usable observations helps locate contacts, including when one view is obstructed.

## Chapter 7 - Optical sensing and ShadowSense

Chapter handout | What is distinctive about ShadowSense



### What is distinctive about ShadowSense

ShadowSense uses analog optical sensors to measure light and shadow directions. It does not need a camera image of the hand. Combining observations from several sensors allows the controller to estimate the touch position.

Shadow geometry and density can also help classify objects and reject some unwanted contacts, depending on configuration and conditions. Camera-based optical touch belongs to the broader optical family but uses image features or silhouettes instead.

#### Direct sunlight is a practical differentiator

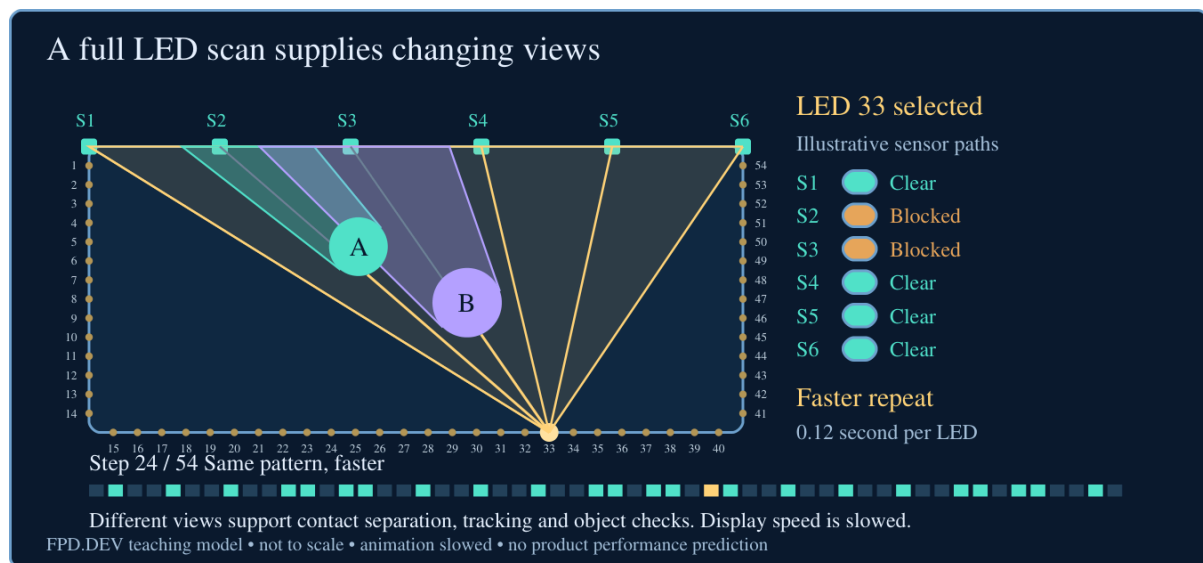
ShadowSense is designed for strong ambient-light rejection. Baanto specifies operation up to full sunlight at 10,000 foot-candles (about 108,000 lux) for ShadowSense Pro. This makes it a useful option where high ambient light overwhelms conventional IR touch frames, causing missed or false touches. It does not mean every IR frame fails outdoors.

Compare the intended assemblies under the same solar exposure, incidence angles, temperatures and contamination conditions. A lux value alone does not describe the infrared loading at the receiver; sunlight tolerance and screen readability are separate requirements.

The adjacent multitouch animation uses the same frame geometry. Objects A and B move independently; their shadows can overlap under one emitter and separate under another. The shading illustrates blocked illumination. It is not a camera image or a simulation of the proprietary contact-tracking algorithm.

## Chapter 7 - Optical sensing and ShadowSense

Chapter handout | Pulse, observe, advance



### Pulse, observe, advance

Baanto describes sequential LED polling: select an emitter, collect sensor observations, then move to the next emitter. The sensor data can therefore be associated with a known light-source position. The animation first shows six slow examples, then visits all 54 illustrated LEDs in a dispersed pattern at 0.45 second per LED, followed by a faster pass at 0.12 second per LED. Each selected emitter changes the shadow geometry. Six path indicators show direct emitter-to-sensor paths as clear, near a contact edge or blocked. These are simplified geometric states, not measured analog values. The pattern, LED count and display speeds are teaching choices, not asserted Baanto firmware behavior. Channel conversion order remains unspecified.

LED selection is also distinct from modulation within an illumination interval. Baanto's 2021 explanation describes a **2 MHz optical carrier** and tuned analog receivers. Detecting that modulation helps distinguish the intended illumination from ambient light. It does not mean two million touch reports per second.

## Chapter 7 - Optical sensing and ShadowSense

Chapter handout | Up to 10,000 per second: define the rate

### Four rates: define what is being counted

|                    |                                                                                                                       |
|--------------------|-----------------------------------------------------------------------------------------------------------------------|
| 1 Optical carrier  | 2 MHz in Baanto's 2021 description<br>Modulation within illumination                                                  |
| 2 Acquisition step | ASSUME up to 10,000 steps/s<br>At upper rate: 100 $\mu$ s/step (illustrative)                                         |
| 3 Complete scan    | 100 steps $\rightarrow$ up to 100 scans/s<br>10 ms at upper rate; before added overhead                               |
| 4 Host report      | Contact extraction $\rightarrow$ tracking $\rightarrow$ USB HID<br>Report rate and latency need separate verification |

Historical "up to 10,000 FPS" claim  $\neq$  a verified rate for every current product.

FPD.DEV teaching model • not to scale • animation slowed • no product performance prediction

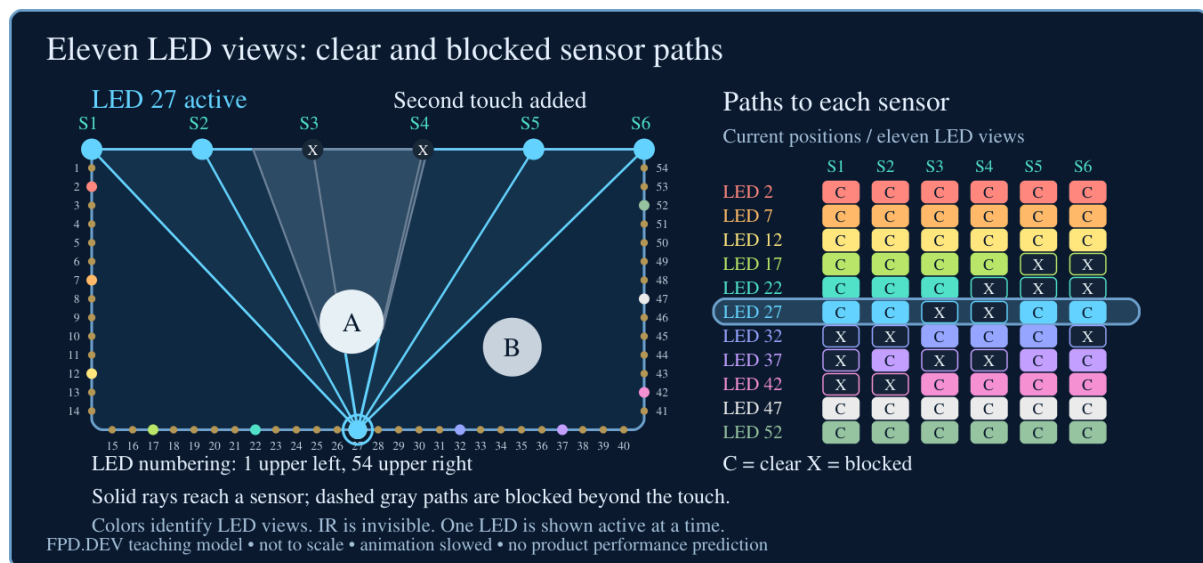
## Up to 10,000 per second: define the rate

Baanto's 2010 announcement advertised **up to 10,000 FPS** at technology level. It does not specify the channel schedule needed to interpret that as a present-day product scan rate. Do not relabel it as a verified 10 kHz sensor clock. In the teaching example, we **assume** up to 10,000 LED-step acquisitions per second: at that upper rate, one step every 100 microseconds. If a complete scan used 100 sequential steps, that would be 10 milliseconds per scan, or 100 scans per second, before additional overhead. The 100-step count is illustrative.

For comparison, Baanto's latency report measured a 10.86 ms polling period for its tested SDW656 configuration (about 92 cycles per second). Full-scan rate, end-to-end latency and USB HID report rate must be specified and verified separately for the intended hardware and firmware. A faster clock alone is not evidence of lower system latency.

## Chapter 7 - Optical sensing and ShadowSense

Chapter handout | Richer observations support multitouch



### Richer observations support multitouch

One blocked optical path gives limited information. Repeating measurements with different emitter positions and several directional sensors adds independent views. Analog response carries more information than a single touched/not-touched bit: angle, signal level and changes relative to an unobstructed baseline can constrain position and object characteristics.

The teaching map compares LEDs 2, 7, 12, 17, 22, 27, 32, 37, 42, 47 and 52 using their actual illustrated frame numbers. LED 1 is at the upper left, numbering runs down the left edge and across the bottom, then up the right edge to LED 54. Each of the eleven selected LEDs has a distinct identifying color. The animation starts with one stationary contact, moves it, then adds a second contact. One LED is shown active at a time. Its solid colored rays reach sensors S1 through S6 wherever unobstructed. Dashed gray segments indicate blocked paths beyond the contact. Map cells show **C for clear** or **X for blocked** at the current contact positions. Colors identify the emitter, not the wavelength or response magnitude. The map is a geometric teaching snapshot, not measured analog data or Baanto's proprietary format. Receiver FOV limits and unavailable observations require separate treatment in a real design.

With two touches, shadows can overlap in one view and separate in another. The controller can combine consistent evidence to form two contact candidates, then associate candidates over time to maintain contact IDs. The moving A and B markers illustrate the resulting tracks; this teaching animation does not implement or validate the supplier's tracking algorithm.

A high acquisition rate can provide more timely observations and opportunities for filtering. **Multitouch also requires adequate geometry, signal-to-noise ratio and processing.** It is not guaranteed by 10,000 acquisitions per second. Sensor bandwidth, settling, averaging, processing time and the host interface all affect the useful result. Ask for supported touch count, minimum separation, response time and behavior under occlusion in the final assembly.

ShadowSense is a Baanto International Ltd. trademark; technology and related IP belong to Baanto.

## Chapter 7 - Optical sensing and ShadowSense

### Custom frames and integration

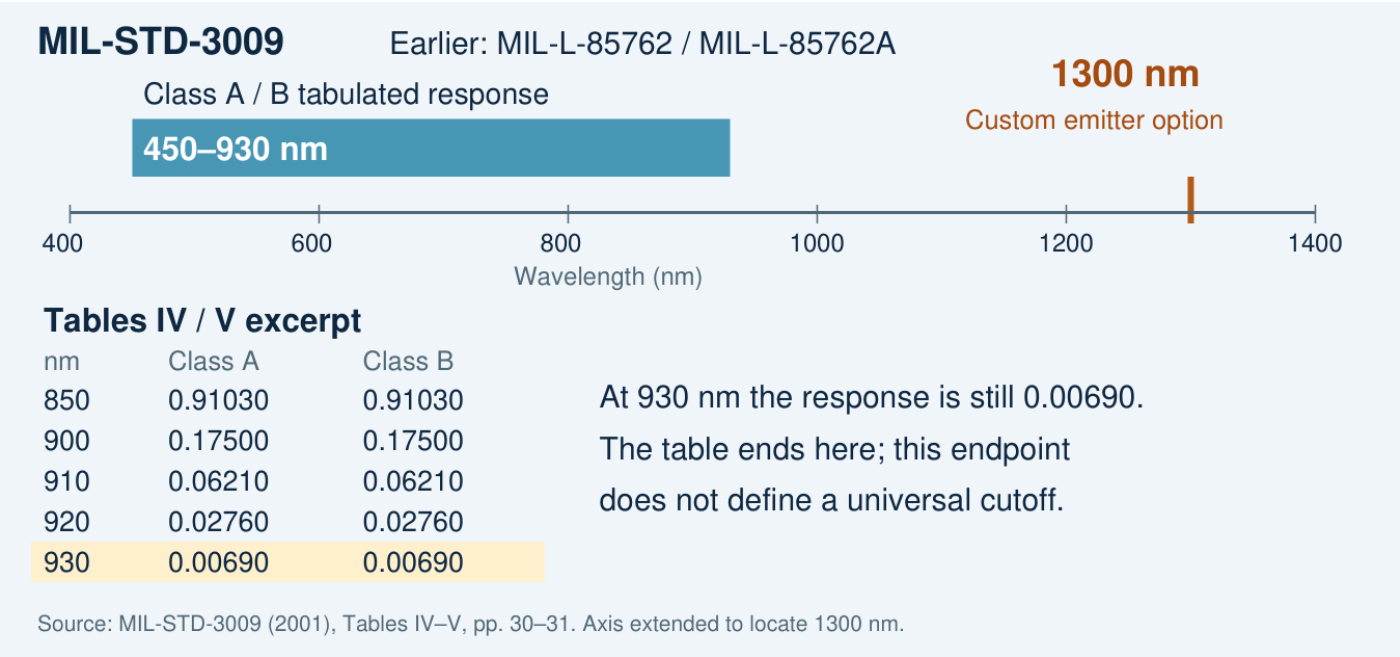
Changing the aspect ratio can change line-of-sight geometry, sensor distribution, mechanical tolerances and electronics placement. A narrow panoramic display is not merely a scaled standard monitor. Ask for coverage at corners and edges and for the smallest detectable object under specified conditions.

FPD.DEV's touch-development work includes direct Baanto coordination. A custom program still needs design-specific agreement on frame geometry, electronics, firmware, host interface and acceptance evidence.

Evaluate occlusion, cleaning, water, ambient light and infrared coexistence using the final assembly. Retain raw diagnostics where available so a failed interaction can be traced to sensing, tracking or application handling.

Custom NVIS illumination uses nominal 1300 nm LEDs, matched receivers and optical windows. The following page explains the wavelength choice and relevant standards.

# Chapter 7 - Optical sensing and ShadowSense



## 1300 nm and NVIS compatibility

**1300 nm lies beyond the response band of conventional image-intensifier goggles.** Match the receiver and optical window, check the full emitted spectrum and verify compatibility with the specified goggles. SWIR cameras can detect 1300 nm.

MIL-STD-3009 follows MIL-L-85762 and MIL-L-85762A. Tables IV and V cover 450-930 nm. Their final response value is nonzero: **930 nm is the end of the tabulation, not a universal cutoff.** Wavelength selection alone does not establish compliance.

Use the applicable project edition. The complete source tables follow in the supporting material. NVIS is pronounced **en-viss**. The 1300 nm option is a custom design discussion, not a specification for every ShadowSense frame.

# Chapter 7 - Optical sensing and ShadowSense

Chapter handout | Apply the idea and explore further

## Apply the idea and explore further

### Why does up to 10,000 acquisitions per second not necessarily mean the same number of complete touch reports?

An acquisition can be only one illumination step or channel observation. A complete scan may require many steps, followed by contact extraction, tracking and host reporting. In our hypothetical 100-step example, 10,000 step acquisitions per second yields at most 100 full scans per second before extra overhead. Define the rate boundary and verify the actual implementation.

### Sources for this chapter

**S09** Baanto - ShadowSense operating principle

[Open publisher source](#)

**S10** Elo - Optical camera touch (legacy Elo implementation)

[Open publisher source](#)

**S28** Baanto - Custom ShadowSense NVIS hardware announcement (2021)

[Open publisher source](#)

**S29** Baanto - ShadowSense Pro - full-sunlight ambient-light specification

[Open publisher source](#)

**S33** Baanto - ShadowSense features and official demonstration videos

[Open publisher source](#)

**S35** Baanto / Sharp NEC - ShadowSense Dashboard User Guide, Rev 2.5 (2017), section 3: sensors on one edge and LEDs on the other three

[Open publisher source](#)

**S36** Baanto - 2010 SID announcement: historical technology claim of up to 10,000 FPS

[Open publisher source](#)

**S37** Baanto - ShadowSense Performance Report: Latency, pp. 4 and 6; sequential LED polling and SDW656 example

[Open publisher source](#)

**S38** Baanto - ShadowSense vs. Ambient Lighting, 26 October 2021: 2 MHz modulation and tuned receivers

[Open publisher source](#)

**S39** Baanto - ShadowSense - A next-generation IR-based technology; FOV arrangement shown in user-supplied video screenshot

[Open publisher source](#)

**MIL-STD-3009****TABLE IV. Relative spectral response of Class A NVIS ( $G_A(\lambda)$ ).**

| Wavelength (nm) | Relative Response | Wavelength (nm) | Relative Response |
|-----------------|-------------------|-----------------|-------------------|
| 450             | 1.0000E-04        | 690             | 9.3790E-01        |
| 455             | 1.1250E-04        | 695             | 9.4480E-01        |
| 460             | 1.2500E-04        | 700             | 9.5170E-01        |
| 465             | 1.3750E-04        | 705             | 9.5860E-01        |
| 470             | 1.5000E-04        | 710             | 9.6550E-01        |
| 475             | 1.6172E-04        | 715             | 9.7304E-01        |
| 480             | 1.7500E-04        | 720             | 9.7930E-01        |
| 485             | 1.9375E-04        | 725             | 9.8020E-01        |
| 490             | 2.1250E-04        | 730             | 9.8280E-01        |
| 495             | 2.2266E-04        | 735             | 9.8838E-01        |
| 500             | 2.3750E-04        | 740             | 9.9310E-01        |
| 505             | 2.7656E-04        | 745             | 9.9719E-01        |
| 510             | 3.1250E-04        | 750             | 1.0000E+00        |
| 515             | 3.4297E-04        | 755             | 1.0000E+00        |
| 520             | 3.7500E-04        | 760             | 1.0000E+00        |
| 525             | 4.1875E-04        | 765             | 1.0000E+00        |
| 530             | 4.6250E-04        | 770             | 1.0000E+00        |
| 535             | 5.0703E-04        | 775             | 9.9814E-01        |
| 540             | 5.5000E-04        | 780             | 9.9660E-01        |
| 545             | 5.8359E-04        | 785             | 9.9543E-01        |
| 550             | 6.2500E-04        | 790             | 9.9450E-01        |
| 555             | 7.0000E-04        | 795             | 9.9380E-01        |
| 560             | 7.7500E-04        | 800             | 9.9310E-01        |
| 565             | 8.5000E-04        | 805             | 9.8620E-01        |
| 570             | 9.2500E-04        | 810             | 9.7930E-01        |
| 575             | 1.4525E-03        | 815             | 9.7283E-01        |
| 580             | 1.9800E-03        | 820             | 9.6550E-01        |
| 585             | 4.7175E-03        | 825             | 9.5515E-01        |
| 590             | 7.8000E-03        | 830             | 9.4480E-01        |
| 595             | 1.1400E-02        | 835             | 9.3402E-01        |
| 600             | 1.5000E-02        | 840             | 9.2410E-01        |
| 605             | 2.6263E-02        | 845             | 9.1720E-01        |
| 610             | 5.2000E-02        | 850             | 9.1030E-01        |
| 615             | 8.8388E-02        | 855             | 8.6334E-01        |
| 620             | 1.7500E-01        | 860             | 8.0000E-01        |
| 625             | 4.3288E-01        | 865             | 7.2848E-01        |
| 630             | 6.1380E-01        | 870             | 6.5520E-01        |
| 635             | 6.7756E-01        | 875             | 5.8016E-01        |
| 640             | 7.4480E-01        | 880             | 5.0340E-01        |
| 645             | 8.2458E-01        | 885             | 4.2523E-01        |
| 650             | 8.8970E-01        | 890             | 3.4480E-01        |
| 655             | 8.9654E-01        | 895             | 2.5704E-01        |
| 660             | 9.0340E-01        | 900             | 1.7500E-01        |
| 665             | 9.1051E-01        | 905             | 1.1009E-01        |
| 670             | 9.1720E-01        | 910             | 6.2100E-02        |
| 675             | 9.2241E-01        | 915             | 4.3125E-02        |
| 680             | 9.2760E-01        | 920             | 2.7600E-02        |
| 685             | 9.3254E-01        | 925             | 1.5525E-02        |
|                 |                   | 930             | 6.9000E-03        |

**MIL-STD-3009****TABLE V. Relative spectral response of Class B NVIS ( $G_B(\lambda)$ ).**

| Wavelength (nm) | Relative Response | Wavelength (nm) | Relative Response |
|-----------------|-------------------|-----------------|-------------------|
| 450             | 1.0000E-05        | 690             | 9.3790E-01        |
| 455             | 1.1250E-05        | 695             | 9.4480E-01        |
| 460             | 1.2500E-05        | 700             | 9.5170E-01        |
| 465             | 1.3750E-05        | 705             | 9.5860E-01        |
| 470             | 1.5000E-05        | 710             | 9.6550E-01        |
| 475             | 1.6172E-05        | 715             | 9.7304E-01        |
| 480             | 1.7500E-05        | 720             | 9.7300E-01        |
| 485             | 1.9375E-05        | 725             | 9.8020E-01        |
| 490             | 2.1250E-05        | 730             | 9.8280E-01        |
| 495             | 2.2266E-05        | 735             | 9.8838E-01        |
| 500             | 2.3750E-05        | 740             | 9.9310E-01        |
| 505             | 2.7657E-05        | 745             | 9.9719E-01        |
| 510             | 3.1250E-05        | 750             | 1.0000E+00        |
| 515             | 3.4297E-05        | 755             | 1.0000E+00        |
| 520             | 3.7500E-05        | 760             | 1.0000E+00        |
| 525             | 4.1875E-05        | 765             | 1.0000E+00        |
| 530             | 4.6250E-05        | 770             | 1.0000E+00        |
| 535             | 5.0703E-05        | 775             | 9.9814E-01        |
| 540             | 5.5000E-05        | 780             | 9.9660E-01        |
| 545             | 5.8359E-05        | 785             | 9.5430E-01        |
| 550             | 6.2500E-05        | 790             | 9.9450E-01        |
| 555             | 7.0000E-05        | 795             | 9.9830E-01        |
| 560             | 7.7500E-05        | 800             | 9.9310E-01        |
| 565             | 8.5000E-05        | 805             | 9.8620E-01        |
| 570             | 9.2500E-05        | 810             | 9.7930E-01        |
| 575             | 9.7688E-05        | 815             | 9.7283E-01        |
| 580             | 1.1000E-04        | 820             | 9.6550E-01        |
| 585             | 1.2566E-04        | 825             | 9.5515E-01        |
| 590             | 1.8200E-04        | 830             | 9.4480E-01        |
| 595             | 2.6581E-04        | 835             | 9.3402E-01        |
| 600             | 5.2500E-04        | 840             | 9.2410E-01        |
| 605             | 1.0183E-03        | 845             | 9.1720E-01        |
| 610             | 2.0000E-03        | 850             | 9.1030E-01        |
| 615             | 3.4569E-03        | 855             | 8.6334E-01        |
| 620             | 6.2500E-03        | 860             | 8.0000E-01        |
| 625             | 9.0935E-03        | 865             | 7.2848E-01        |
| 630             | 1.8414E-02        | 870             | 6.5520E-01        |
| 635             | 4.6447E-02        | 875             | 5.8016E-01        |
| 640             | 7.4480E-02        | 880             | 5.0340E-01        |
| 645             | 2.0949E-01        | 885             | 4.2523E-01        |
| 650             | 4.0037E-01        | 890             | 3.4480E-01        |
| 655             | 6.7139E-01        | 895             | 2.5704E-01        |
| 660             | 9.0340E-01        | 900             | 1.7500E-01        |
| 665             | 9.1073E-01        | 905             | 1.1009E-01        |
| 670             | 9.1720E-01        | 910             | 6.2100E-02        |
| 675             | 9.2741E-01        | 915             | 4.3125E-02        |
| 680             | 9.2760E-01        | 920             | 2.7600E-02        |
| 685             | 9.3254E-01        | 925             | 1.5525E-02        |
|                 |                   | 930             | 6.9000E-03        |