SP-1550M Camera User Guide

For Model
SP-1550M Phosphor Coated CCD Camera

For Use with the LBA-PC Laser Beam Propagation Analyzer

Camera Version 2.0

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Safety

Optical Radiation Hazards

Use of this instrument may require the operator to work within the optical path of lasers. Exposure to radiation from these lasers may be sufficient to warrant the use of protective equipment.

Unless the laser's optical path is enclosed, the operator should be protected against accidental exposure. Exposure to personnel other than the operator must also be considered. Hazards include direct beam exposure and reflected radiation.

When working with an unenclosed beam path, it is advisable to do so while the laser is powered down or at reduced power levels. Whenever there is a risk for dangerous exposure, protective eye shields and clothing should be worn.

1.1 Specifications

Model SP-1550M	EIA	CCIR
Pick Up Device	½" CCD Image Sensor	
Effective Pixels	768 (H) x 494 (V)	752 (H) x 582 (V)
LBA-PC Digitized Pixels	640 (H) x 480 (V)	756 (H) x 572 (V)
Cell Size	8.4 µm (H) x 9.8 µm (V)	8.6 µm (H) x 8.3 µm (V)
Sensor Dimensions	6.45 mm x 4.84 mm	
LBA-PC Digitized Area	6.2 mm x 4.7 mm	
Lens Mount	CS Mount	
Sync System	Internal Crystal Control	
Scanning System	2:1 Interlace, Interline transfer, Field Integration Mode Only	
Video Out	1.0 V (p-p) 75 Ω	
Video Format	RS-170	
Minimum Illumination	0.0001 lx. F1.4	
Full Signal Illumination	.3 µW/cm2 @ 980nm	
Camera S/N Ratio	58 dB @ Gamma=1	
Shutter Speed	See Table 3	
Power Consumption	DC+12V ±10%	
Power Supply	1.32 W	
Operating Humidity	Less than 95% RH (without condensation)	
Operating Temperature	-10°C to +40°C	
Storage Humidity	Less than 95% RH (without condensation)	
Storage Temperature	-30°C to +70°C	
Dimensions	35.5 x 40 x 63 (mm)	
Weight	98 g	

Specifications subject to change without notice.

1.2 Physical Dimensions

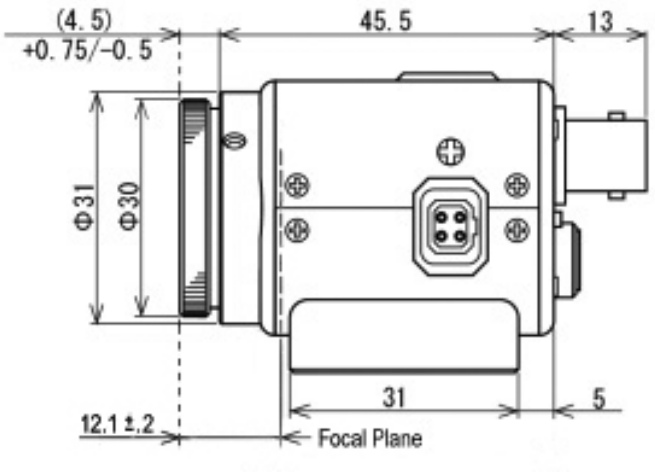

Figure 1 – Profile Dimensions

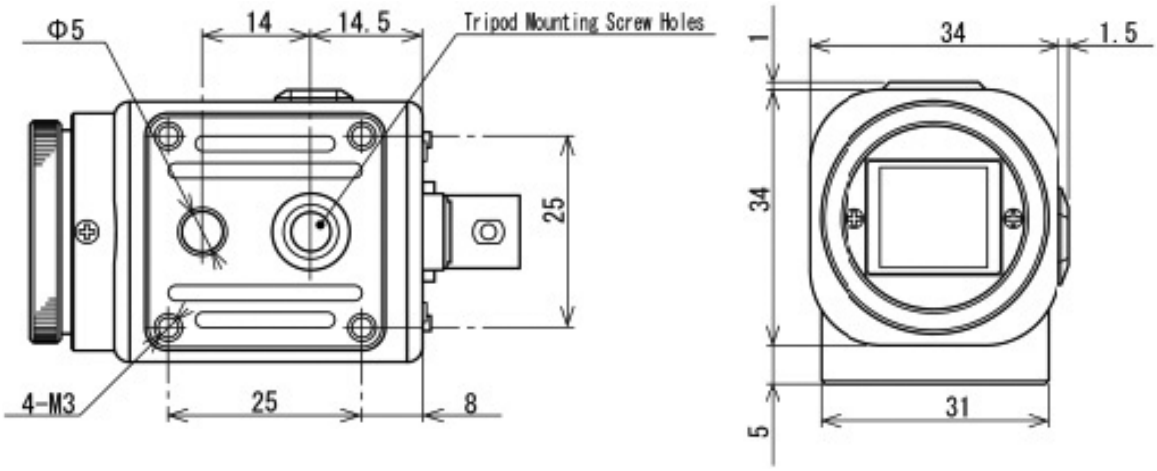

Figure 2 – Bottom and Face Dimensions

1.3 Parts Description

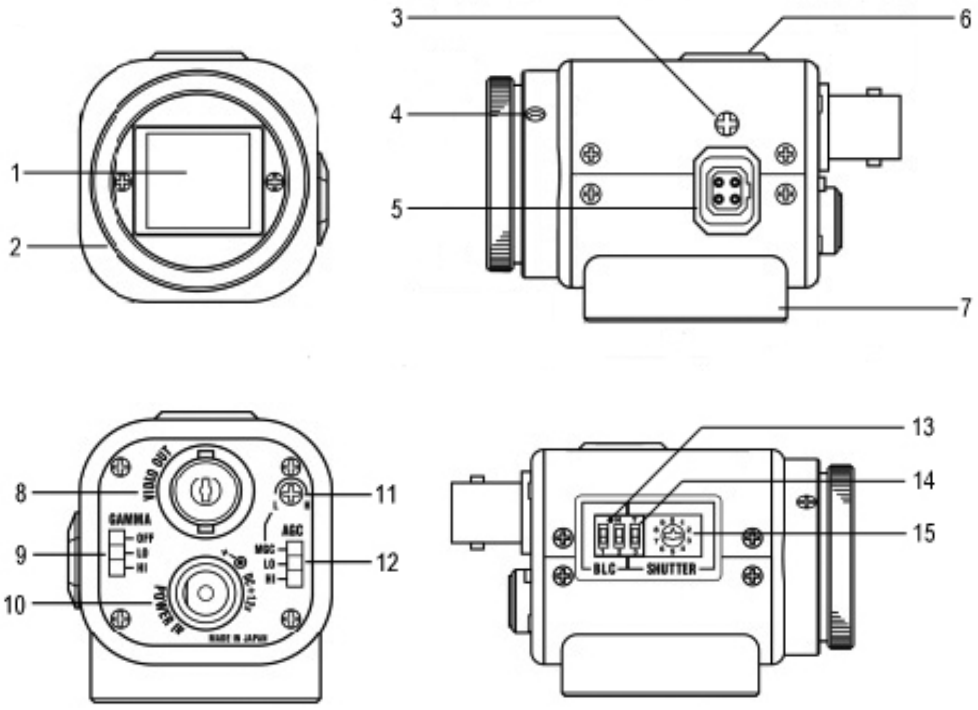

Figure 3 – SP-1550M Parts Description

1. Phosphor coated CCD front face
   - CAUTION: Windowless detector
2. Lens mount
   - CS mount
3. Iris level volume
   - Not used
4. Focusing adjustment screws
   - 3 hex. Adjustment screws placed at 120° intervals for fine-focusing
5. Auto-Iris socket
   - Not used
6. Mounting screw holes
   - ¼"-20 threads, 4.5 ±0.2mm
7. Camera base
   - Mounting screw hole and four M3 size holes
8. Video Out (BNC)
   - Composite video signal output
9. Gamma correction switch
   - Three selectable values: 1.0, 0.45, and .35
10. Power in
    - Connect the DC plug power adapter
11. MGC volume adjusting
    - Manual gain control
12. AGC/MBC selection switch
    - Set AGC HI, LOW or MGC
13. Back light compensation switch
14. Electronic shutter On/Off switch
15. AE mode control
    - 10 position shutter speed

1.4 General Information

The Spiricon SP-1550M IR camera consists of a CCD focal plane array coated with a phosphor that emits visible radiation when illuminated with infrared radiation in the 1460 nm to 1625 nm wavelength range. The camera is thus modified for use when viewing IR emitting telecom devices and IR lasers in the above spectral range.

The camera focal plane array functions from 190 nm to 1310 nm. However, in the 190 nm to 1000 nm region the SP-1550M has scatter form the phosphor, and the transmission of UV through the phosphor coating has not been tested. Spiricon's SP-980M camera is a better choice to supplement the SP-1550M at short wavelengths. At wavelengths from 1000 nm to 1310 nm, both the SP-980M and the SP-1550M cameras exhibit significant blooming, and the COHU 4812 camera is recommended.

The camera has an adjustable CS lens mount that places the focal plane 12.1 mm from the camera front surface when the adjustment ring is fully CW. For C mount lenses for imaging applications, a 5mm adapter ring is provided to achieve proper focus.

1.5 Windowless Detector

CAUTION: The focal plane array of the SP-1550M has no protective window. Do not allow any physical object to come in contact with the focal plane array, as damage will certainly occur. Be especially careful when measuring fibers and other high divergence devices that will be placed close to the detector. See Figure 1 for the dimension to the detector plane.

Regular measurement of devices inserted into the camera housing should have mechanical protection so that the device cannot reach the detector.

1.6 Camera Non-linearity

The response of the phosphor on the SP-1550M camera to infrared radiation is not linear with respect to intensity. Because the generation of visible photons is essentially a two-photon for one-photon process, the probability of the interaction occurring increases roughly as the square of the input IR intensity. Thus, the camera output follows the measured curve shown in Figure 4 below.

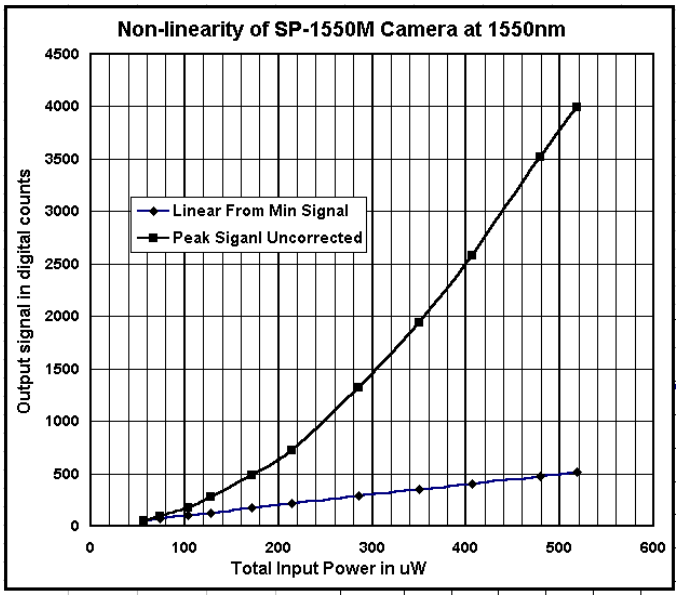

Figure 4 – Non-linearity of SP-1550M Camera

The camera output in digital counts on a 12-bit A/D converter is plotted against total input power in µW. A linear line is shown for illustration starting from just above the noise level of the camera, with the camera output rising much faster as the power is increased.

1.7 Non-linear Correction

Spiricon engineers have corrected the non-linearity in Spiricon's LBA-PC series beam analyzers by setting the "gamma" of the camera to 1.95 in the camera menu. Figure 5 shows the measured response with the correction algorithm in use. A linear line starting at saturation, the linear corrected response, and the uncorrected non-linear response are plotted together.

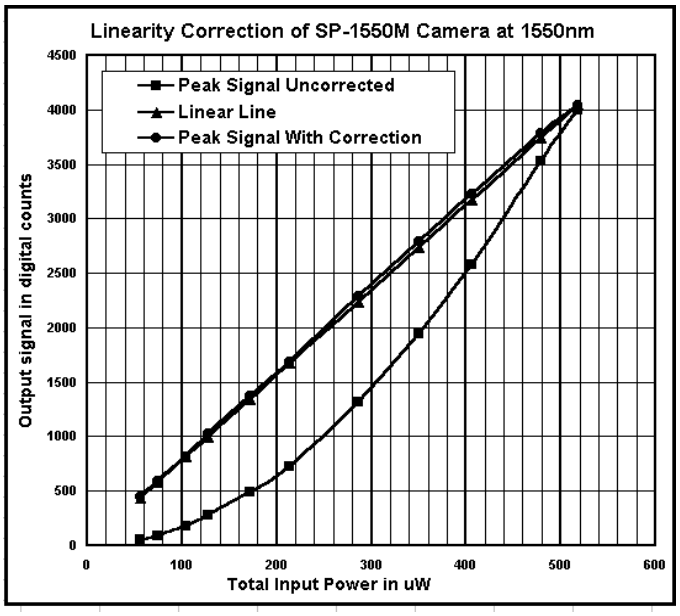

Figure 5 – Linearity of SP-1550M with Correction

1.8 Non-linearity Affects Laser Beam Measurements

If the camera response is left uncorrected, it will be impossible to make accurate laser beam spatial measurements using standard techniques. Beam width, centroid, total energy, peak fluence, and power in a bucket values will all be distorted. The low intensity wings of a beam will fall off faster in the output of the camera than will the intensity input, so that beams with sloping edges will have widths measured much smaller than actual. Figure 6 illustrates measured beam widths with and without the correction algorithm. In this case the beam measurement without correction is about 33% too small. A simple width correction factor cannot be used because every beam has a different slope to the edges. However, Spiricon's correction algorithm enables the Laser Beam Analyzer to measure the correct width. This has been verified with correlation to other IR cameras with linear response.

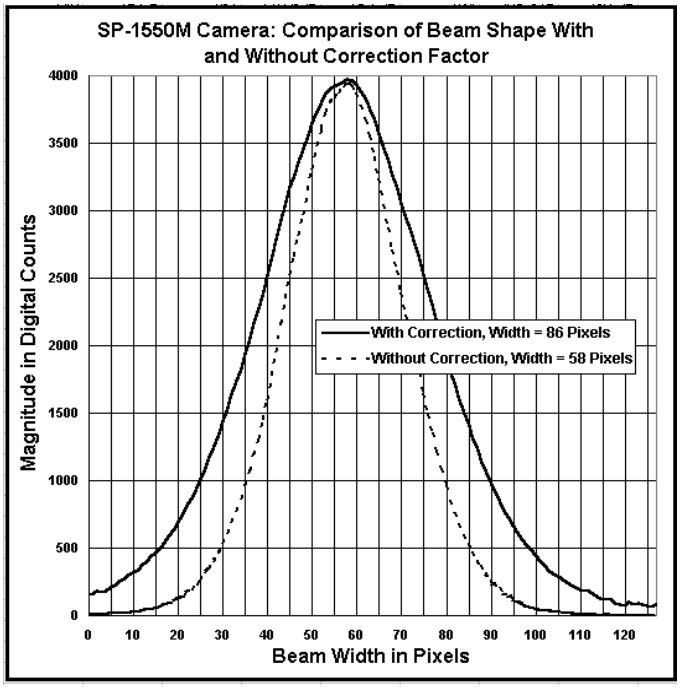

Figure 6 – Measured Beam Width of SP-1550M With and Without Correction

Figure 7 and Figure 8 present the beam profiles of the two beams used in the creation of Figure 6. As seen below, the beam without the correction algorithm appears much smaller than actual.

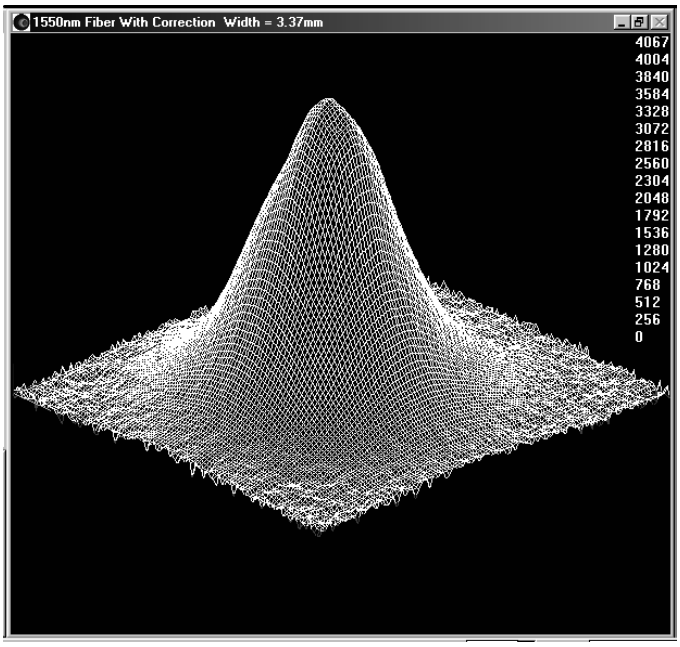

Figure 7 – Fiber Output With Camera Correction

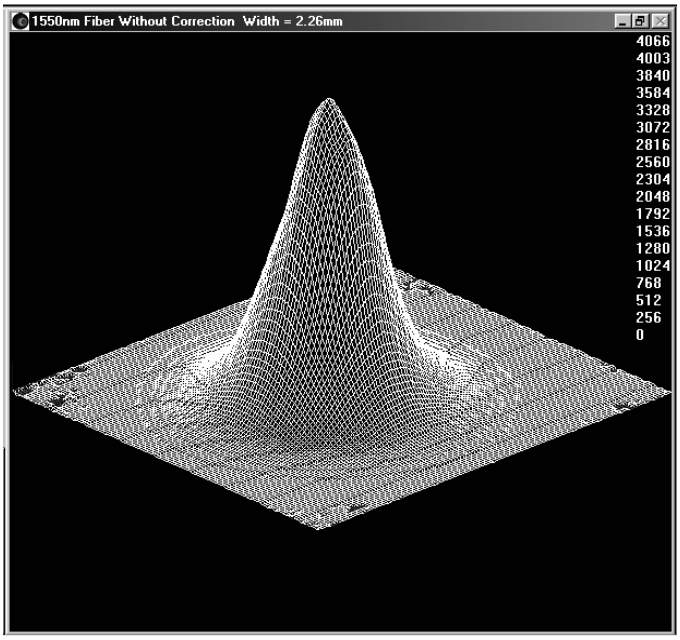

Figure 8 – Fiber Output Without Camera Correction

1.9 Non-linearity Correction Effect on Noise

The non-linearity of the SP-1550M camera can be understood by observing that whenever the input radiation is reduced by one-half, the camera output signal is reduced by a factor of 4. Thus, the correction algorithm will increase the gain of the signals at low levels. One consequence is that camera effective noise is also increased. Table 1 depicts the effect on Signal-to-Noise ratio by using the correction algorithm.

Table 1 – SP-1550M Camera S/N for Various Conditions

Without Linearity Correction	58 dB
With Linearity Correction	30 dB
With Linearity Correction & 3X3 Convolution	38 dB
With Linearity Correction & 16 Frame Averaging or Summing	42 dB
With Linearity Correction & 16 Frame Averaging or Summing & 3X3 Convolution	50 dB

These results suggest some methods that can be used to improve this situation:

- "Convolution" is a technique that averages the signals in a small matrix of pixels, 3 X 3 in the case shown, but gives heavier emphasis to the center pixel so that little resolution is lost. As seen, the noise is reduced by 8 dB, or about a factor of 3 using this technique.
- Because Spiricon's LBA-PC series Laser Beam Analyzers have Ultracal, the camera baseline is set so accurately that frame summing or averaging does not induce a baseline offset. This allows additional noise reduction by this method. Summing or averaging 16 frames occurs in about 1/2 second so response time is still good. The combination of convolution and averaging can increase signal-to-noise ratio by about 20 dB or a factor or 10.

In an imaging mode where quantitative measurements are not needed, it might be better to use the camera with the correction algorithm turned off to yield cleaner visual images. This is done by setting "gamma" to 1.0 in the LBA-PC **Camera** menu.

1.10 Beam Width Accuracy vs. Intensity

The phosphor coating exhibits an extinction phenomenon as the incident power falls below a certain minimum value. As a result, beam width calculations will start to shrink as peak fluence drops relative to the dynamic range of the camera. Figure 9 demonstrates how keeping the peak fluence above 50% of the camera dynamic range keeps this effect to a minimum.

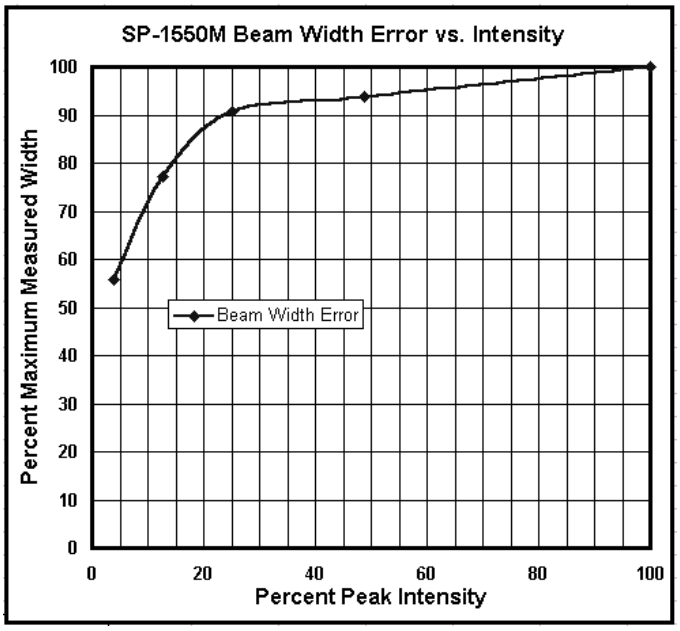

Figure 9 – SP-1550M Beam Width Error vs. Percent Peak Intensity

Note that width calculations fall off rapidly below 25% of peak fluence.

IMPORTANT: *Remember to perform an Ultracal just prior to making any critical measurements. This will reduce any effects of camera baseline drift.*

1.11 Wavelength Response

The anti-Stokes up-conversion efficiency is very wavelength dependent. Figure 10 shows the typical spectral response curve of a new high response coating. As seen, we have calibrated the response from 1527 nm to 1605 nm. We have extrapolated the shorter wavelength region by comparing our measured response to data published over the entire range.

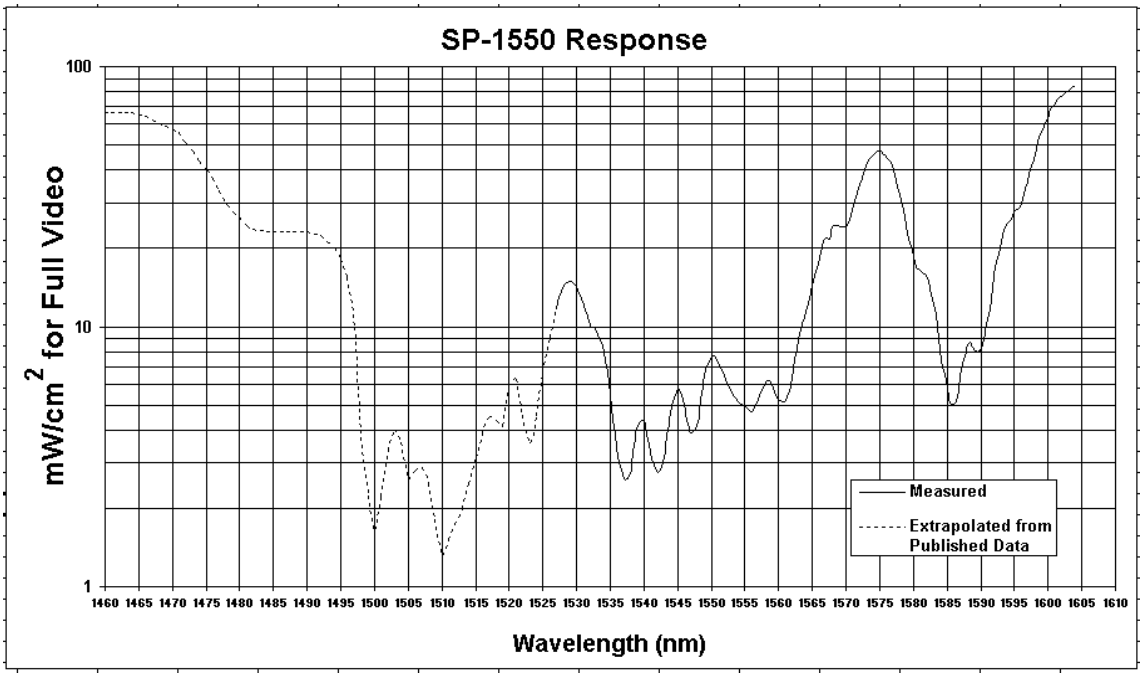

Figure 10 – Signal Required vs. Wavelength to Achieve Camera Full Signal Illumination by Anti-Stokes Up Conversion Material

1.12 Camera Switch Settings

All setup switches are located on the exterior of the camera (see Figure 3). Before performing any measurements with LBA-PC, verify the camera's switch settings conform to the settings described below.

1.12.1 Back Light Dip Switches

The only operational setting for use with LBA-PC is the default (off).

Table 2 – Back Light Settings

SW 1	SW 2	Area Illumination
OFF	**OFF**	**DEFAULT (OFF) Required for use with LBA-PC**
OFF	ON	DO NOT USE
ON	OFF	DO NOT USE
ON	ON	DO NOT USE

1.12.2 Electronic Shutter Settings

The electronic shutter can be used to attenuate the camera signal when the input power saturates the electronics and when it is not possible to use other means of reducing the input power level. Move the AE Mode control dial to one of the 8 valid positions.

Table 3 – Electronic Shutter Settings

No.	Mode	Shutter Speeds (Sec)	
		NTSC	PAL
0	FL	1/100	1/120
1	ES	1/250	
2	ES	1/500	
3	ES	1/1000	
4	ES	1/2000	
5	ES	1/5000	
6	ES	1/10,000	
7	ES	1/100,000	
8	EI: OFF	DO NOT USE	
9	EI: FL	DO NOT USE	

1.12.3 Gamma Correction Switch

The only operational setting for use with LBA-PC is the default (off).

Table 4 – Gamma Correction Settings

MODE	Gamma	Effect
OFF	**1.0**	**OFF Required for image processing via LBA-PC**
LO	0.45	DO NOT USE
HI	0.35	DO NOT USE

1.12.4 Gain Control Switch

The only operational setting for use with LBA-PC is at Manual Gain Control (MGC).

Table 5 – Gain Control Settings

MODE	Range	Effect
MGC	**5~60 dB**	**Manual Gain Control required for image processing via LBA-PC.**
AGC	5~60 dB	DO NOT USE
AGC LO	5~32 dB	DO NOT USE

1.12.5 Manual Gain Control Potentiometer

Set the MGC potentiometer to full counter-clockwise for minimum gain and the highest signal-to-noise ratio.

1.12.6 Auto-Iris Lens Pin Configuration and Level Adjustment

The Auto-Iris lens feature is not utilized by LBA-PC.

1.13 Common Accessories

Two convenient accessories are often used with the SP-1550M camera:

- SP-1550M Silicon Window Kit, which consists of a silicon window, AR coated for 1 µm to 2.5 µm, for blocking ambient visible room light from the detector. It screws into the CS mount on the camera housing.
- SP-1550M Fiber Optic Connector Kit, which consists of a fiber optic connector mounted on a holder which screws into the CS mount on the camera housing. You will need to specify a connector style.

Contact the Sales Department for part numbers.