PMI Feeds, Inc.

LabDiet
THE RICHMOND STANDARD

PMI® Micro-Stabilized Rodent Liquid Diet LD 101/101A*

Description

Diet LD 101A is a dry powder used to prepare a liquid diet for rodents in alcohol studies. The powder is designed to be mixed with alcohol and carbohydrate prior to feeding. When mixed according to instructions, it provides a similar level of nutrition as LD 101.

Diet LD 101 is a dry powder used to prepare a liquid diet formulated for rodents. It is nutritionally balanced with excellent palatability. This diet is especially designed for use as the control diet when LD 101A is being used as the test diet. LD 101 can be used in other applications where solid diets are not appropriate.

Various flavors are available upon request.

Features and Benefits

- Nutritionally-balanced
- Volatile ingredients can be included
- Easily prepared
- Provides stable nutrients
- Shipped in dry form to simplify storage, shipping and stability
- Minimal foaming
- Fully suspended
- Stabilized against microbial growth

Typical Analysis

Crude protein not less than	3.8%
Crude fat not less than	3.9%
Crude fiber not more than	1.0%
Ash not more than	0.4%

Values are based upon the liquid form of the diet when prepared according to directions.

***Diet Preparation Instructions:** To 770 gms. deionized/distilled water, add 230 gms. Micro-Stabilized Rodent Liquid Diet mix (LD 101). Blend vigorously for 15-30 seconds with a mechanical blender until completely suspended. For best results add water to blender before dry mix. See information provided to prepare isocaloric diets with alcohol or other test substances.

Ingredients

Vitamin-free casein, olive oil, maltodextrin, dried corn syrup, soy fiber, corn oil, suspension colloid, safflower oil, L-cystine, DL-methionine, vitamin A acetate, cholecalciferol, DL-alpha tocopheryl acetate, menadione sodium bisulfite (source of vitamin K), fumaric acid, citric acid, propionic acid, ascorbic acid, potassium sorbate, cyanocobalamin, thiamin mononitrate, riboflavin, calcium pantothenate, nicotinic acid, choline chloride, pyridoxine hydrochloride, folic acid, inositol, p-aminobenzoic acid, biotin, calcium acetate, calcium phosphate, potassium phosphate, sodium phosphate, magnesium sulfate, sodium chloride, manganese sulfate, ferrous fumarate, zinc chloride, cupric sulfate, chromium chloride, sodium fluoride, ammonium molybdate, calcium iodate and sodium selenite.

Feeding Directions

Diet consumption will vary according to animal size and sex. An average rat should consume at least 50 grams of diet daily to sustain a creditable average daily weight gain. The growth rate of rats maintained on this diet should be similar to that attained by young rats (55-100 gram) maintained on a good quality, nonpurified rodent diet. Mice should consume at least 20 grams per day.

Allow new animals an adequate period of time to adjust to their surroundings. After they have adjusted, introduce the liquid diet gradually by offering some of the liquid diet while the regular diet is still present. Gradually decrease the amount of regular diet offered while increasing the amount of liquid diet over a 3-5 day period. Additional time for adjustment may be necessary for the ethanol diets.

Prepare the diet as frequently as needed and always **refrigerate** to minimize loss of nutrients. Fresh diet should be prepared at least every **5 days**. Although the diet may be bacteriologically sound for a longer period of time, diet more than **5 days** old may have deteriorated nutritionally. Before using diet which has been prepared on a previous day, check to ensure all of the ingredients are in suspension. Remix if necessary. Additional water may be provided in separate drinking tubes, but may not be consumed.

05/12/95

* Product Code Numbers

LabDiet
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PMI Feeds, Inc.®

PMI® Micro-Stabilized Rodent Liquid Diet LD 101/101A*

Diet Preparation Instructions

PMI® Micro-Stabilized Rodent Liquid Diet (LD 101)

Water (deionized/distilled)........................ 770 grams
Micro-Stabilized Rodent Liquid Diet
mix (LD 101)... 230 grams

Blend vigorously for 15-30 seconds with a mechanical blender until completely suspended. For best results add water to blender first, then add dry mix.

PMI® Micro-Stabilized Alcohol Rodent Liquid Diet (LD 101A)

Diet composition varies according to the amount of alcohol added to maintain an isocaloric diet. The following chart indicates the amounts of deionized/distilled water, PMI® Micro-Stabilized Alcohol Rodent Liquid Diet LD 101A mix (Dry Mix), PMI® Maltodextrin LD 104, and ethanol to be used to make one kilogram of liquid diet.

% Calories from Ethanol	gms. Water	gms. Dry Mix	gms. Maltodextrin	gms. Ethanol
36	810	140	0	50
30	803.7	140	14	42.3
20	792.8	140	39	28.2
10	783	140	63	14.1

Add water to a mechanical blender, then add dry mix and maltodextrin. Blend vigorously for 15 seconds. Add ethanol to the blended mixture and blend for an additional 15 seconds.

For calculation purposes:
- 140 gms. dry Alcohol Rodent Liquid Diet mix = 645 kcal.
- Ethanol = 7.1 kcal/gm
- PMI® Maltodextrin LD 104 = 3.96 kcal/gm

Additional Considerations:
- For best results a mechanical blender should be used for diet preparation; hand blending does not suspend the diet adequately to avoid some settling out of undissolved ingredients.
- Do not over-blend; excessive mechanical blending creates foaming.
- Prepare fresh diet at least every **5 days**. Keep unused portion of diet refrigerated or at room temperature (not to exceed 75°F). Before using diet which has been prepared on a previous day, check the diet to insure all of the ingredients are still in suspension - remix if necessary. Although the diet will remain bacteriologically stable for up to 10 days, product more than **5 days** old should not be used due to changes in the nutritional quality.

* Product Code Numbers

05/12/95

LabDiet
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PMI Feeds, Inc.

PMI® Micro-Stabilized Rodent Liquid Diet LD 101/101A*

Chemical Composition[1]

Nutrients[2]

Protein gm/kg	**38.4**
Arginine gm/kg	1.38
Cystine gm/kg	0.24
Glycine gm/kg	0.76
Histidine gm/kg	1.01
Isoleucine gm/kg	1.88
Leucine gm/kg	3.4
Lysine gm/kg	2.86
Methionine gm/kg	1.21
Phenylalanine gm/kg	1.88
Tyrosine gm/kg	1.99
Threonine gm/kg	1.52
Tryptophan gm/kg	0.43
Valine gm/kg	2.24
Fat gm/kg	**39.6**
Fiber (Crude), gm/kg	**10.0**

Minerals

Calcium mg/kg	1300
Phosphorus (total) mg/kg	1000
Potassium mg/kg	875
Magnesium mg/kg	125
Sulfate mg/kg	500
Sodium mg/kg	323
Chlorine mg/kg	390
Fluorine, mg/kg	0.25
Iron, mg/kg	17.6
Zinc, mg/kg	7.6
Manganese, mg/kg	13.7
Copper, mg/kg	1.5
Chromium, mg/kg	0.6
Iodine, mg/kg	0.05
Molybdenum, mg/kg	0.11
Selenium, mg/kg	0.027

Vitamins

Menadione, mg/kg	0.24
Thiamin mononitrate, mg/kg	1.6
Riboflavin, mg/kg	1.5
Nicotinic acid, mg/kg	7.5
Calcium pantothenate, mg/kg	4.0
Choline, mg/kg	250
Folic Acid, mg/kg	0.5
Pyridoxine hydrochloride, mg/kg	1.75
Biotin, mg/kg	0.05
Inositol, mg/kg	25.0
p-aminobenzoic acid, mg/kg	12.5
B_{12}, mg/kg	0.025
Vitamin A, IU/kg	3000
Vitamin D_3 (added), IU/kg	400
Vitamin E, IU/kg	30
Ascorbic Acid, mg/gm	10.0

***Product Code Numbers**

[1] **Values are based upon the liquid form of the diet when prepared according to directions. Based on the latest ingredient analysis information.**

Energy*

Protein, kcal/kg	164
Fat, kcal/kg	350
Carbohydrates, kcal/kg	486

* Lieber, CS & LM DeCarli (1982) Alcoholism: Clinical and Experimental Research 6: 523-531.
Miller, SS, ME Goldman, CK Erickson & RL Shorey (1980) Psychopharmacology 68: 55-59.

***Energy Levels used (kcal/gm)**
Protein = 4.27; Fat = 8.84; Carbohydrates = 3.96; Ethanol = 7.1. These values are different than the 4, 9, 4 kcal/gm for protein, fat & carbohydrate, respectfully, as generally used.

* 1 kilogram of diet in liquid form, when prepared according to directions, provides 1000 kilocalories (1 kcal per gram).

05/12/95

KODAK MEGAPLUS Camera, Models: ES 1.0 / ES 1.0/10 Bit / ES 1.0/TH

I Optomechanical Specification
II Imaging Performance Specification

REVISION 9.0

TABLE OF CONTENTS

I OPTO-MECHANICAL SPECIFICATION

1) Image sensor

MODEL	Kodak **KAI 1001M** CCD	
TYPE	Front illuminated interline architecture	
PHOTOSENSITIVE AREA	9.1 H by 9.2 V	*mm's*
ASPECT RATIO	1:1	*ratio*
HORIZONTAL PIXELS	1008	*valid pixels*
VERTICAL PIXELS	1018	*valid pixels*
PIXEL DIMENSIONS	9 H by 9 V	*microns*
FILL FACTOR	60	*percent*

DEFECTS refer to PART II, SECTION 7

2) Sensor cover glass

GLASS TYPE	Corning 7059			
REFRACTIVE INDEX	1.5		*@*	*587.6 nm*
THICKNESS	0.76	*mm*	*+/-*	*0.05 mm*
SURFACE FINISH	5	*microns*		
COATING	Anti-reflective	*(both sides)*		*optimized 430-630 nm's*
REAR SURFACE LOCATION	2.5	*mm*		*in front of the sensor plane*

3) Optical window

CLEAR WINDOW

GLASS TYPE	BK7			
REFRACTIVE INDEX	1.52		*@*	*587.6 nm*
DIAMETER	31.7	*mm*	*+/-*	*0.3 mm*
THICKNESS	1.00	*mm*	*+/-*	*0.05 mm*
FLATNESS	0.2	*waves*	*@*	*546.1 nm over 80% of surface*
SURFACE FINISH	60-40	*Scratch and Dig*		
OPTIONAL COATINGS	Wide band hot mirror			

INFRARED FILTER

GLASS TYPE	Schott KG5 filter glass			
REFRACTIVE INDEX	1.51		*@*	*587.6 nm*
DIAMETER	31.7	*mm*	*+/-*	*0.2 mm*
THICKNESS	1.00	*mm*	*+/-*	*0.1 mm*
FLATNESS	2-3	*Waves*	*@*	*546.1 nm*
SURFACE FINISH	60-40	*Scratch and Dig*		
COATING	None			

4) Focal plane shutter

TYPE	fully electronic	
RESOLUTION	0.0000625	*seconds*
CLEAR APERTURE	9.1 H by 9.2 V	*mm's*
EXPOSURE RANGE	0.000125 and up	*seconds*

The shutter may exhibit less than 100% repeatability from frame-to-frame, as well as some spatial nonuniformity of exposure within any single frame. Repeatability and nonuniformity are reported as percent of the mean gray level output.

DEFINITION: Nonuniformity
Defined as the spatial nonuniformity of exposure within any single frame.

DEFINITION: Repeatability
Defined as the variation in the mean signal output level for any single frame compared to any other.

DEFINITION: Lifetime
Defined in terms of either the mean number of continuous shutter operating hours or number of shutter exposure cycles befor complete mechanical failure of the shutter mechanism.

NONUNIFORMITY	100	*percent*	*@ <=0.006 seconds exposure*
REPEATABILITY	NA	*percent*	
LIFETIME	NA	*cycles*	

NOTE: The rated *lifetime* and *repeatability* of camera focal plane shutters applies to mechanical shutters only. *Lifetime* is based on **complete mechanical failure** and does not consider degradation of performance with age. Nonuniformity and repeatability may degrade with age.

Repeatability and nonuniformity of mechanical shutters may degrade with exposure times < 0.050 seconds.

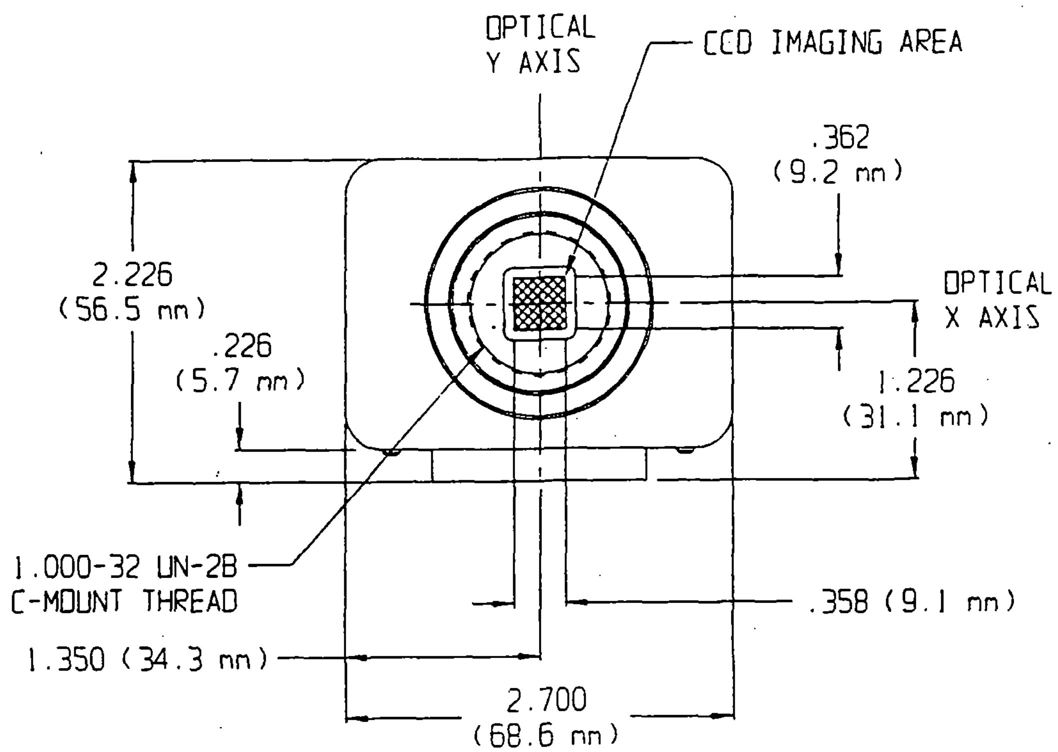
Measurement conditions:
Infrared-filtered Xenon light source
Integrating sphere illuminator
25 ^{o} C ambient operating temperature
Digital video output
Defect concealment disabled
Center and edge of frame ROI image samples

5) Lens interface

TYPE	C mount			
FLANGE FOCAL DISTANCE	17.5	*mm*	*+/-*	*0.05*
NONCOPLANARITY	0	*arc-minutes*	*+/-*	*47.4*
DECENTER	0	*mm*	*+/-*	*0.45*

6) Drawings

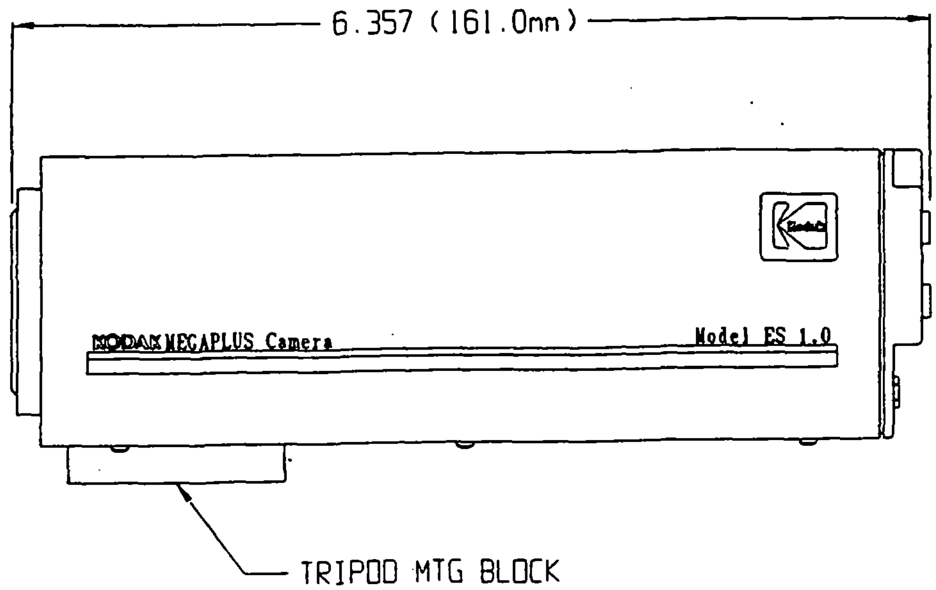
ES 1.0 and ES 1.0/10 BIT



FRONT VIEW

FIGURE 1.1

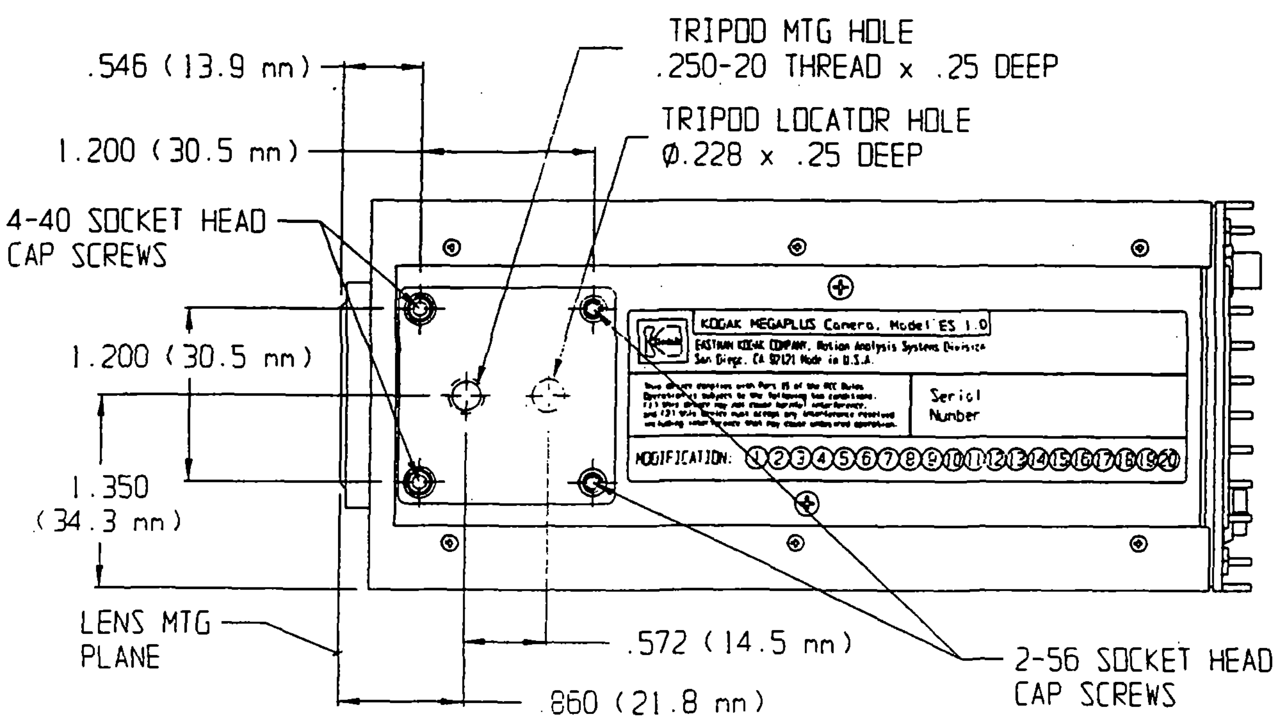
ES 1.0 and ES 1.0/10 BIT



SIDE VIEW

FIGURE 1.2

ES 1.0 and ES 1.0/10 BIT



BOTTOM VIEW

FIGURE 1.3

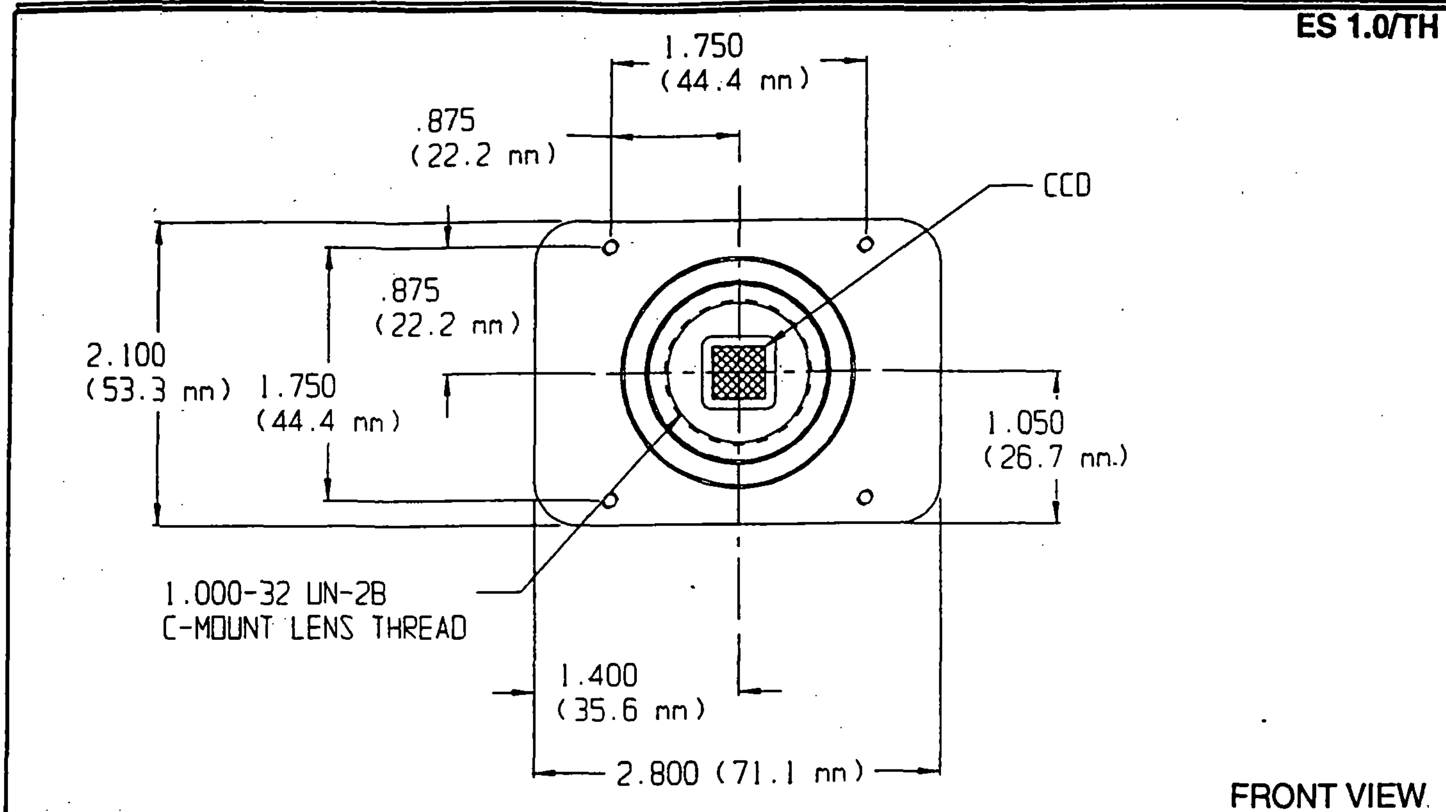


FIGURE 2.1

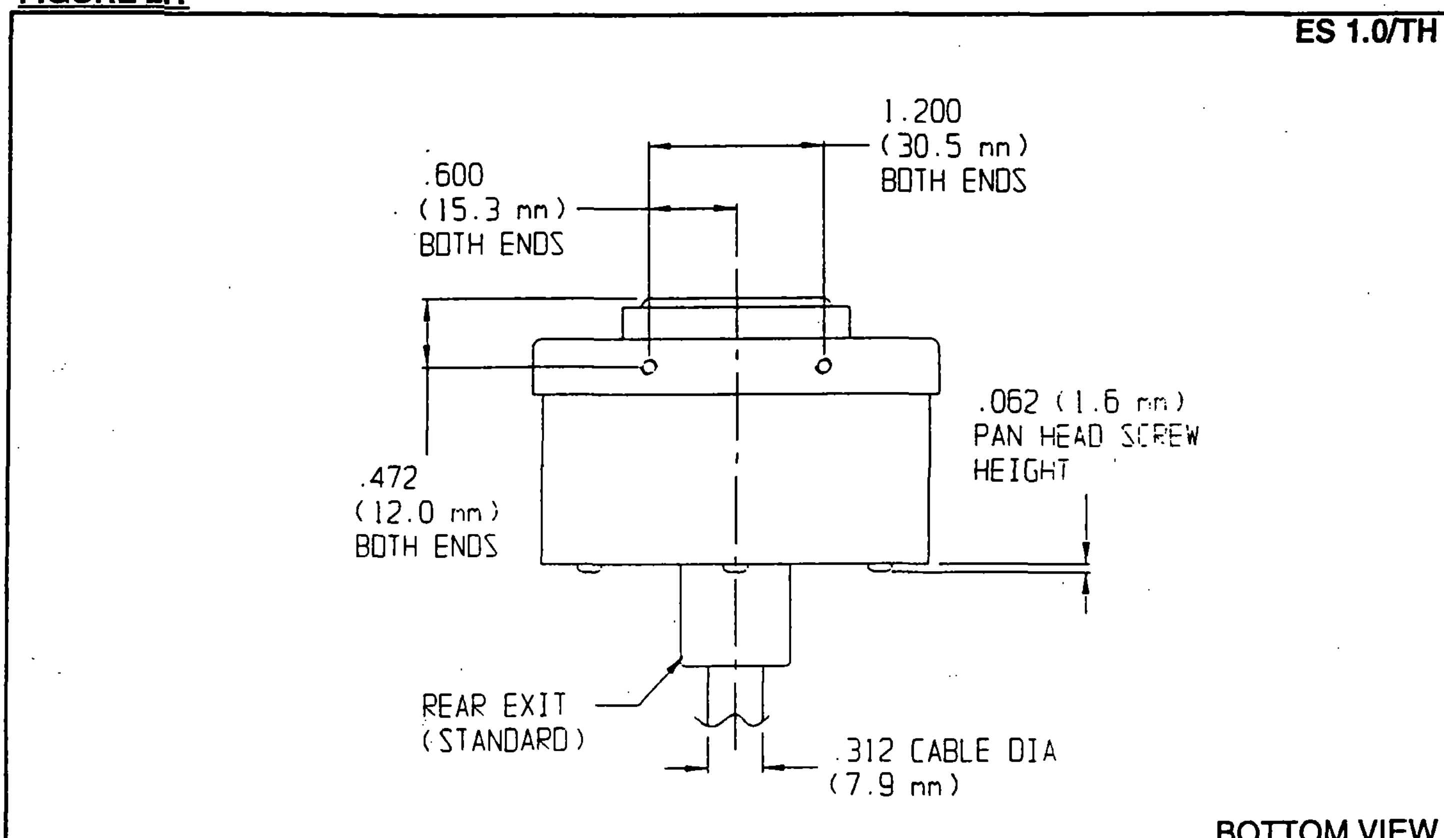
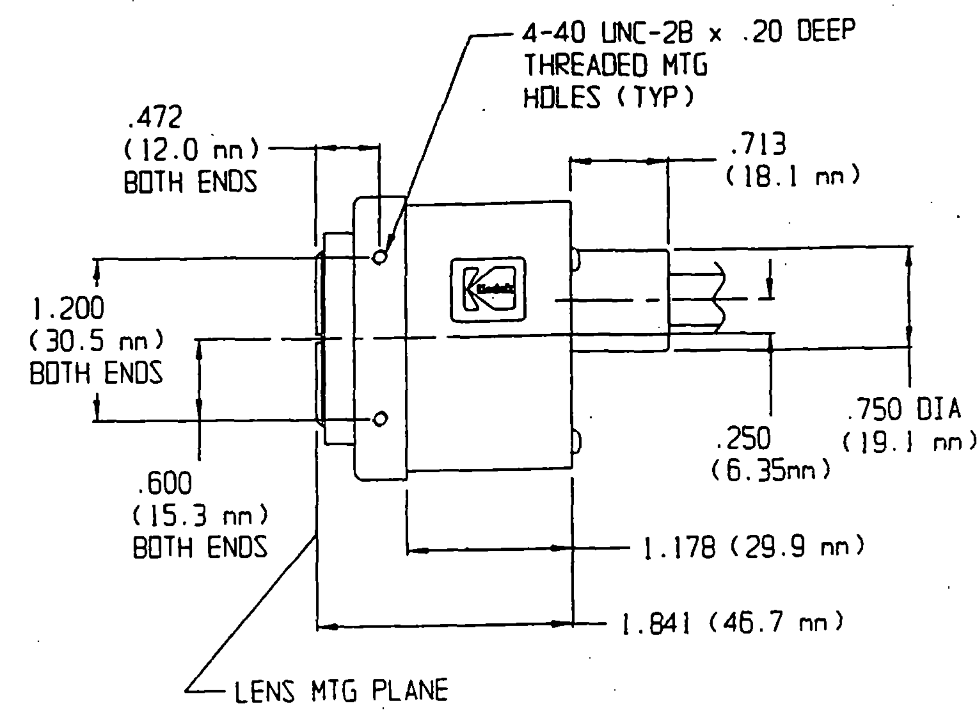


FIGURE 2.2

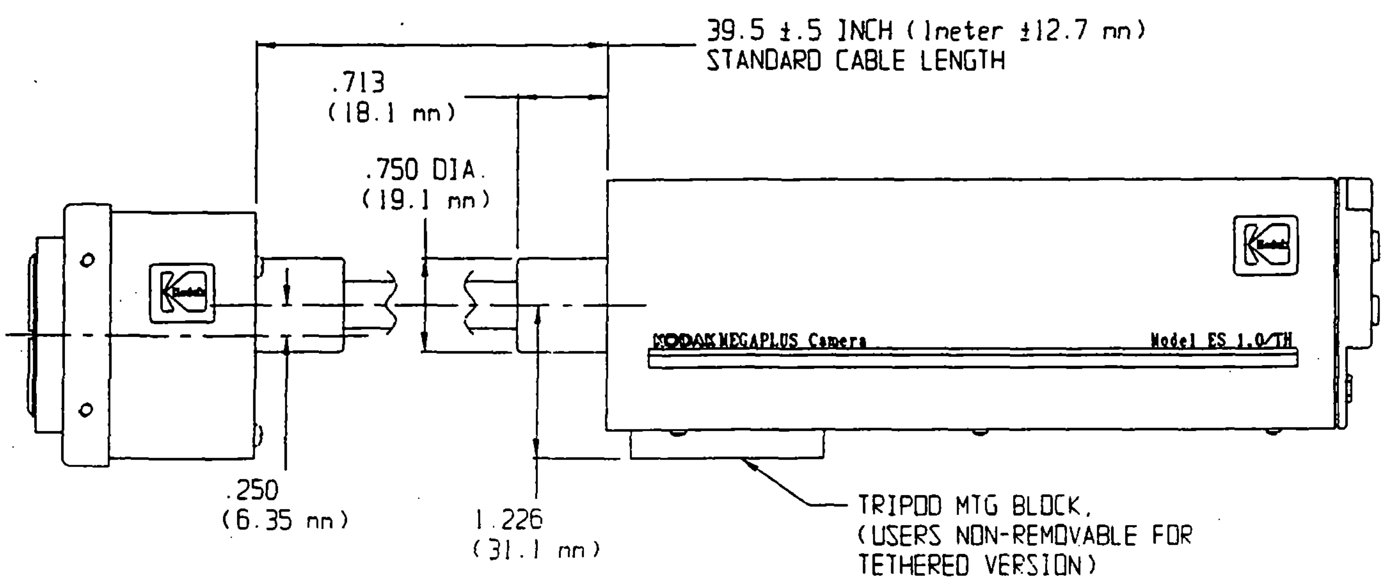
ES 1.0/TH



SIDE VIEW

FIGURE 2.3

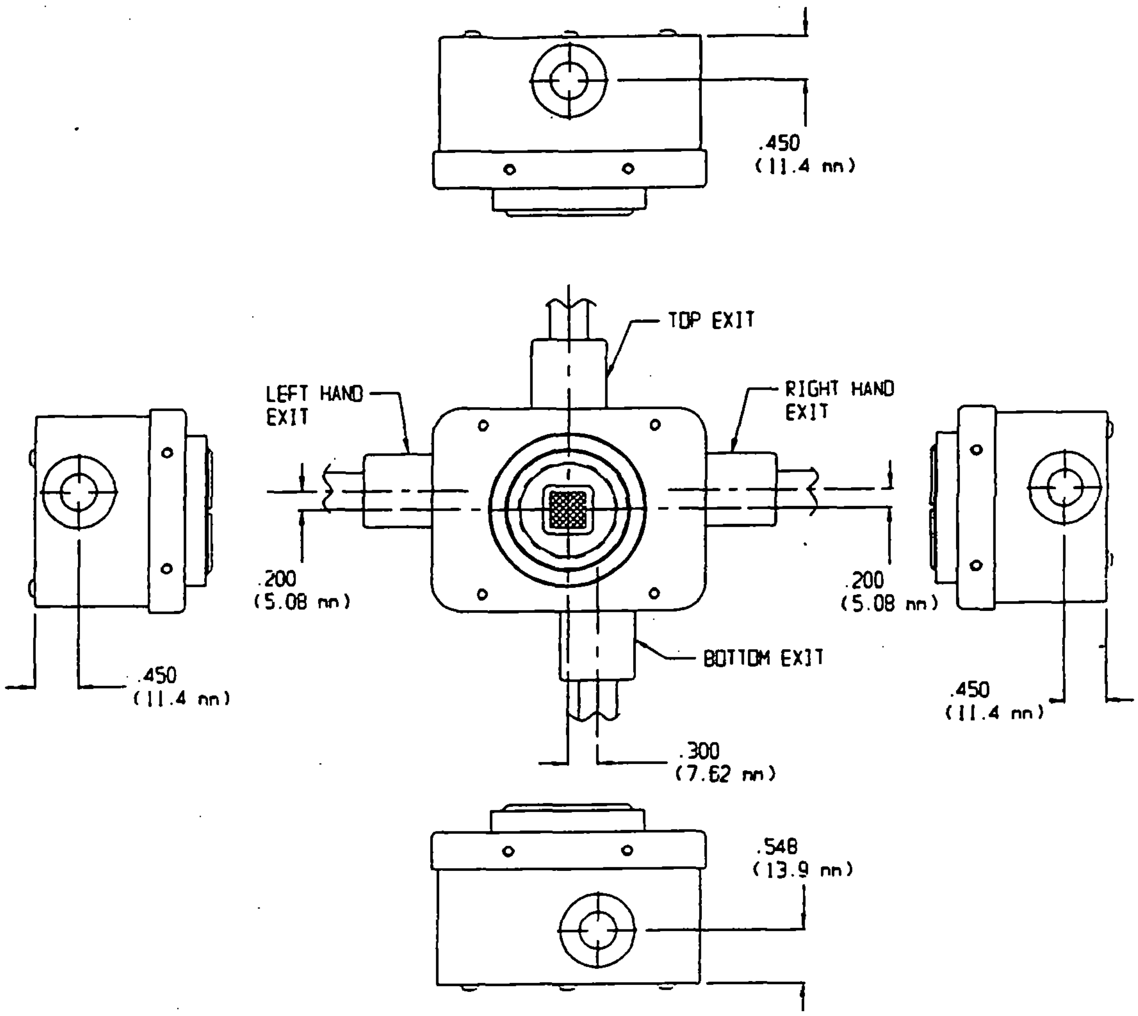
ES 1.0/TH



SIDE VIEW

FIGURE 2.4

ES 1.0/TH



FRONT VIEW

FIGURE 3

II IMAGING PERFORMANCE SPECIFICATION

The performance data contained in this document is presented as "typical" and does not represent a guarantee of any specific performance level. Where noted, some performance data is reported as theoretical.

1) Signal Output

TYPE	*Digital RS 422 Differential*
FORMAT	8 or 10 Bit parallel

FRAME RATE	MINIMUM	MAXIMUM	
Continuous	30	30	*frames/second*
Triggered	0	30	*frames/second*
Controlled	0	30	*frames/second*
Triggered Double Exposure	0	15	*frames/second*

The ES 1.0 internally digitizes video using 10 significant bits of gray scale resolution. The Camera will then output either a the full 10 bit data or a select 8 bit set of the 10 bit internal representation. The ES 1.0 *base model* output is **limited to the select eight ('8') significant bits** of digital video. Invoking the Camera's 'DIGITAL GAIN' command selects the specific 8 bits for output as follows:

10 BIT DIGITAL VIDEO

9	8	7	6	5	4	3	2	1	0
MSB									LSB

		8 BIT Output	**10 BIT Output**
- Command	'DGN 1'	Bits 2-9	Bits 0-9
- Command	'DGN 2'	Bits 1-8	
- Command	'DGN 4'	Bits 0-7	

2) Responsivity and Equivalent ISO speed

DEFINITION: Responsivity
This is defined as the camera's nominal response to light. In other words, the change in the camera's digital video output level, measured in counts, for a given change in illuminance or irradiance delivered to the camera. Radiometric responsivity is the derivative of the GAMMA TRANSFER FUNCTION measured @ 550 nm's. Photopic responsivity is the derivative of the GAMMA TRANSFER FUNCTION measured using a specified broad band illumination.

DEFINITION: Equivalent ISO speed
Equivalent ISO speed is a variation on the ISO photographic speed standard used to specify the 'sensitivity' of many film-based *imaging systems. Equivalent* **ISO speed** = **$78/H_{Sat}$** where H_{Sat} = **focal plane exposure in Lux-seconds** for the maximum **VALID** digital video output count. Refer to **ISO STANDARD #12232, "Photography - Electronic Still Picture Cameras - Determination of ISO Speed"**

Equivalent ISO speed is computed from measured camera photopic responsivity. The computed speed value is rounded *down* to the nearest standard ISO film speed number. For more information on how equivalent ISO speed is determined contact Eastman Kodak Company, Motion Analysis Systems Division.

Nominal photopic and radiometric responsivity, and equivalent ISO speed, as a function of camera gain setting, are reported in the table below. Responsivity measurements discount all dark field and photoresponse nonuniformities, and known sensor defects. Responsivity is measured in *counts per Lux-second* and *counts per uw/cm²-second @ 550 nm's* rounded to the nearest 10 counts. Equivalent ISO speed is reported using the standard ISO film speed scale.

GAIN	PHOTOPIC RESPONSIVITY	RADIOMETRIC RESPONSIVITY (@550 nm's)	EQUIVALENT ISO SPEED
(DGN 'X')	*(8 bit counts/LUX-second)*	*(8 bit counts/uw/cm^2-second)*	*(ISO value)*
DGN 1	**1540**	**5020**	**400**
DGN 2	**3080**	**9660**	**800**
DGN 4	**6150**	**19050**	**1500**
(DGN 'X')	*(10 bit counts/LUX-second)*	*(10 bit counts/uw/cm^2-second)*	*(ISO value)*
DGN 1	**6400**	**20900**	**1500**

NOTES:

Cameras may vary as much as +/- 15% in absolute responsivity to light, though much better consistency is typical. In addition, measurements made of camera responsivity, upon which the above speed figures are based, are only accurate to +/- 10%. Hence, variations in the computed equivalent ISO speed from the above figures may be as much as 25%.

The equivalent ISO speed will vary with changes in the spectral content of the illumination used.

The camera's black level offset is adjustable. Changing the black level offset will change the apparent brightness of a picture. Equivalent ISO speed is computed for a black level offset of '0'.

Measurement conditions:

Infrared-filtered Xenon light source -photopic measures
550 nm single line irradiance (10 nm bandwidth) -radiometric measures

Uncoated clear glass window installed
F11 nonimaging illumination
25 °C ambient operating temperature
Digital video output
Dual channel mode
Defect concealment disabled
0.0325 seconds exposure time
Center of frame ROI image samples
Measured in the plane of the lens mount flange
ISO index checked with standard ISO exposure meter

EG&G Model DR 2550 Radiometer used for illuminance/irradiance measurements

3) Gamma ratio

DEFINITION: Gamma ratio
Defined as the derivative of the best fit line to a 'Log transformed' GAMMA TRANSFER FUNCTION. The GAMMA TRANSFER FUNCTION is 'Log transformed' by applying a $Log_{Base\ 10}$ remapping function to both the X and Y coordinate values of the measured GAMMA TRANSFER FUNCTION. See GAMMA TRANSFER FUNCTION.

Linear GAMMA TRANSFER FUNCTION	=>	OUTPUT = m * (INPUT) +offset m = responsivity, offset = black background level
Gamma ratio	=>	Log[OUTPUT]/Log[m * INPUT] + offset
Log Transformed GAMMA TRANSFER FUNCTION	=>	Log[OUTPUT] = **Gamma ratio** * Log[m * INPUT] +offset
or simply	=>	OUTPUT = m* $INPUT^{Gamma\ ratio}$ +offset

GAIN *(DGN 'X')*	Gamma ratio *(8 bit)*	Gamma ratio *(10 bit)*	
1	1	1	ratio
2	1	-	"
4	1	-	"

4) Dynamic Range

DEFINITION: Dynamic Range
Defined on the PHOTON TRANSFER FUNCTION as the **ratio** between the SQRT[**Y axis coordinate value**] (i.e. signal variance axis) for the lowest **VALID** mean signal output level, to the **X axis coordinate value** (i.e. signal variance axis)for highest **VALID** mean signal output; expressed in Decibels as **20 * LOG_{10}(Ratio)**.

GAIN *(DGN 'X')*	Dynamic Range *(8 bit)*	Dynamic Range *(10 bit)*	
1	56	59	Decibels
2	52	NA	"
4	46	NA	"

5) Maximum Luminous Signal/noise ratio

DEFINITION: Maximum Luminous Signal/noise ratio
Defined on the PHOTON TRANSFER FUNCTION as the **ratio** between the SQRT[**Y axis coordinate value**] (i.e. signal variance axis) for the highest **VALID** mean signal output level (i.e. near A/D saturation), to the **X axis coordinate value** (i.e. mean signal level) for highest **VALID** mean signal output level (i.e. near A/D saturation); expressed in Decibels as **20 * LOG_{10}(Ratio)**.

GAIN *(DGN 'X')*	Maximum Luminous Signal/Noise Ratio *(8 bit)*	Maximum Luminous Signal/Noise Ratio *(10 bit)*	
1	46	46	Decibels
2	42	NA	"
4	39	NA	"

6) Sensor defects and classes

The Camera can be equipped with an image sensor of any of three general quality levels. General sensor quality is specified with regard to the number and location of pixels which exhibit *markedly different output* from their neighbors when operated under conditions specified below. These nonuniformities are called *defects*. Defects can be of the *point*, *cluster*, or *column/row* type.

DEFINITION: Saturation
This is defined as the pixel illumination level wherein no further increase in camera output is possible and either vertical smearing or blooming suppression begin.

DEFINITION: Point defect
An isolated defective pixel.

DEFINITION: Major Defective Pixel
This is defined as a pixel whose signal deviates by more than 7.5% from the mean value of all active pixels in complete darkness, or by more than 15% from the mean value of all active pixels under uniform illumination at 80% of saturation.

DEFINITION: Minor Defective Pixel
This is defined as a pixel whose signal deviates by more than 8 millivolts from the mean value of all pixels in complete darkness.

DEFINITION: Cluster defect
A grouping of 2 to 4 contiguous major defective pixels.

DEFINITION: Column or row defect
A grouping of more than 4 contiguous major defective pixels along a single column or row.

CLASS	Point Defects		Cluster Defects	Column/Row Defects
	MAJOR	MINOR		
CLASS 0	<= 0	<= 50	0	0
CLASS 1	<= 5	<= 50	0	0
CLASS 2	<= 20	<= 100	<= 4	<= 0
CLASS 3	<= 50	<= 400	<= 8	<= 4

OPERATING CONDITIONS:		
Illumination level	80	*% of Saturation*
Sensor operating Temperature	40	*Degrees Celsius*
Exposure time	0.070	*seconds*
Readout time	0.070	*seconds*
Gain	0	*Decibels*

For the Model ES 1.0 cameras, *80%* of saturation is reached when the Camera is illuminated to approximately full scale output (full scale = 255 or 1023 for 8 or 10 bits respectively) for **DGN 1** gain setting.

NOTE: Nonuniformities which represent known sensor defects have been pre-identified using only the above specified sensor operating conditions. The Model ES 1.0 cameras have a typical sensor operating temperature of **40° Celsius**. Higher sensor operating temperature may reveal additional nonuniformities not called out in the defect map which accompanies the Camera. Higher camera gain settings, longer exposure times, and/or higher or lower illumination levels may also in some cases increase the number of dark field nonuniformities or photoresponse nonuniformities that will qualify as defects according to the above defect definitions.

7) Dark field noise and nonuniformities

DEFINITION: Pixel-to-pixel dark field noise
This is a random pixel-to-pixel video output level disparity within a single frame and from frame-to-frame. It is sourced in the Camera's analog channel electronics and individual pixel dark current variations. It increases with increasing gain, exposure time, and increasing ambient operating temperature.

DEFINITION: Pixel-to-pixel dark field nonuniformity
This is a repeatable pixel-to-pixel video output level disparity, observed as a quasi-random noise pattern across a frame. It is sourced in individual pixel dark current variations and increases with increasing gain, increasing exposure time and increasing operating temperature. It is sometimes called fixed pattern noise.

DEFINITION: Dark field Vertical Shading
This is a disparity in the mean video output level along the vertical dimension of a frame as compared to mean level for the frame. The disparity takes the form of a slow change in the mean video output level for adjacent horizontal video lines. Dark field Vertical shading may or may not be repeatable from frame-to-frame. It increases with increasing gain, increasing exposure time, and increasing ambient operating temperature.

DEFINITION: Dark field Horizontal shading [DROOP]
This is a disparity in the mean video output level across the horizontal dimension of a frame as compared to mean level for the frame. The disparity takes the form of a slow change in the mean video output level for adjacent vertical video columns. Dark field Horizontal shading is repeatable from frame-to-frame. It increases with increasing gain, increasing exposure time, and increasing ambient operating temperature.

DEFINITION: Dark field Vertical line nonuniformity
This is a disparity in the mean video output level for single or groups of vertical video columns that takes the form of an abrupt change between immediately adjacent or nearby vertical video columns. It is repeatable from frame to frame and increases with increasing gain, increasing exposure time, and increasing/ ambient operating temperature.

DEFINITION: Dark field Horizontal line nonuniformity
This is a disparity in the mean video output level for single or groups of horizontal video lines that takes the form of an abrupt change between immediately adjacent or nearby horizontal video columns. It is repeatable from frame to frame and increases with increasing gain, increasing exposure time, and increasing/ ambient operating temperature.

Model ES-1.0 images exhibit *dark field noise* sourced in the camera sensor and electronics. The noise is substantially random with an approximately Poisson distribution. It is independent of illumination level and exists even in dark field frames captured with little or no illumination. The observed effect is a variation in any pixel's digital video output count from frame-to-frame. Note that this behavior is not illumination-related *shot noise*.

Camera images also exhibit dark field nonuniformities. The nonuniformities are referred to as *pixel-to-pixel dark field nonuniformity, vertical line nonuniformity, horizontal line nonuniformity, vertical shading,* and *droop*. These nonuniformities are independent of illumination level and exist even in dark field frames captured with little or no illumination.

Reported *dark field noise and nonuniformity* measures discount known sensor defects.

FIGURE 4 reports Model ES 1.0 *pixel-to-pixel dark field noise and nonuniformity* for DGN 1-4 digital gain.

FIGURE 5 reports Model ES 1.0 *pixel-to-pixel dark field noise and nonuniformity* for DGN 1-4 digital gain as function of ambient operating temperature.

Pixel-to-pixel dark field noise and nonuniformity is an average for a 10,000 pixel region in the center of the frame, and is reported as percent RMS. of full scale. Full scale is a digital video output count of 255 or 1023 for 8 and 10 bit output respectively.

Dark field horizontal and *vertical shading*, and *horizontal* and *vertical line nonuniformity* measurements are derived from column or row averages over 200 columns or rows in the center of the frame for the entire vertical or horizontal dimension of the frame, and are reported as percent peak of full scale. Full scale is a digital video output count of 255 or 1023 for 8 and 10 bit output respectively.

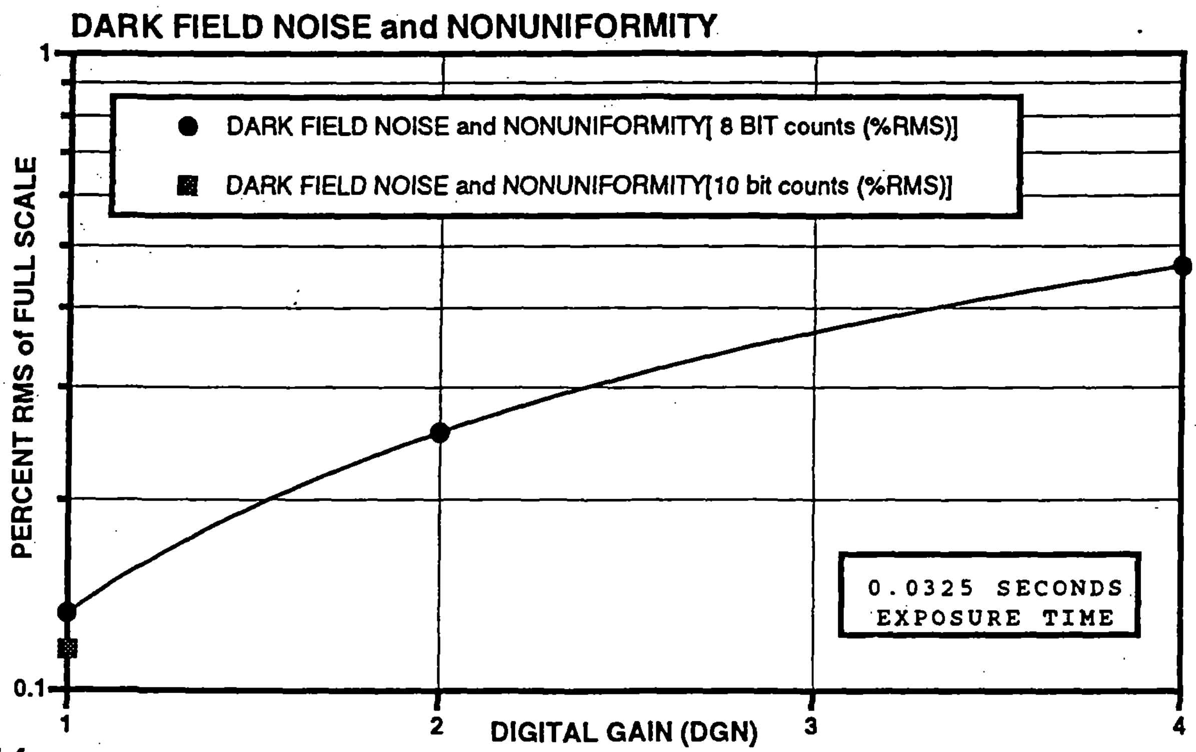


FIGURE 4

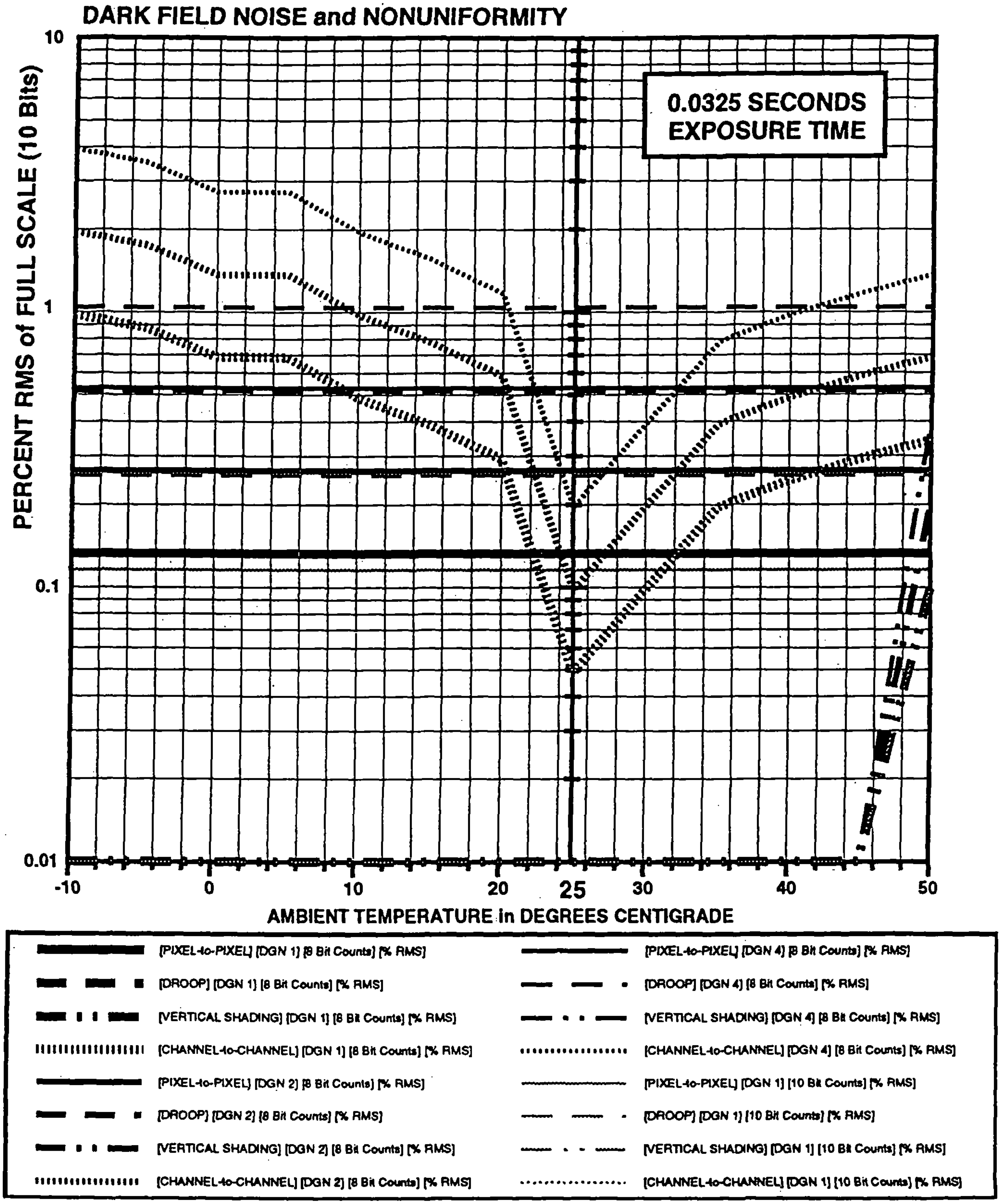

DARK FIELD NOISE and NONUNIFORMITY
0.0325 SECONDS EXPOSURE TIME
PERCENT RMS of FULL SCALE (10 Bits)
10
1
0.1
0.01
-10
0
10
20
25
30
40
50
AMBIENT TEMPERATURE in DEGREES CENTIGRADE
[PIXEL-to-PIXEL] [DGN 1] [8 Bit Counts] [% RMS]
[DROOP] [DGN 1] [8 Bit Counts] [% RMS]
[VERTICAL SHADING] [DGN 1] [8 Bit Counts] [% RMS]
[CHANNEL-to-CHANNEL] [DGN 1] [8 Bit Counts] [% RMS]
[PIXEL-to-PIXEL] [DGN 2] [8 Bit Counts] [% RMS]
[DROOP] [DGN 2] [8 Bit Counts] [% RMS]
[VERTICAL SHADING] [DGN 2] [8 Bit Counts] [% RMS]
[CHANNEL-to-CHANNEL] [DGN 2] [8 Bit Counts] [% RMS]
[PIXEL-to-PIXEL] [DGN 4] [8 Bit Counts] [% RMS]
[DROOP] [DGN 4] [8 Bit Counts] [% RMS]
[VERTICAL SHADING] [DGN 4] [8 Bit Counts] [% RMS]
[CHANNEL-to-CHANNEL] [DGN 4] [8 Bit Counts] [% RMS]
[PIXEL-to-PIXEL] [DGN 1] [10 Bit Counts] [% RMS]
[DROOP] [DGN 1] [10 Bit Counts] [% RMS]
[VERTICAL SHADING] [DGN 1] [10 Bit Counts] [% RMS]
[CHANNEL-to-CHANNEL] [DGN 1] [10 Bit Counts] [% RMS]

FIGURE 5

Measurement conditions:

Complete darkness
0.0325 seconds exposure time
Digital video output
Dual channel mode
Defect concealment disabled
ROI image samples

Column averaging used for droop
Column averaging used for vertical line nonuniformity.

Row averaging used for vertical shading
Row averaging used for horizontal line nonuniformity.

8) <u>Nonlinearity</u>

DEFINITION: Nonlinearity

This is defined as the measure of departure from the camera's theoretical GAMMA TRANSFER FUNCTION. Nonlinearity is computed by applying the camera's inverse theoretical GAMMA TRANSFER FUNCTION to the specified range of X axis coordinate values, and computing the departure of the resultant function from perfect linearity.

GAMMA TRANSFER FUNCTION
The line is defined and fit for the range between the **Y axis coordinate value** (i.e. mean signal output axis) of the lowest **VALID** mean signal output level (darkness), and the **Y axis coordinate value** of the highest **VALID** mean signal output.

PHOTON TRANSFER FUNCTION
The line is defined and fit for the range between the **X axis coordinate value** (i.e. mean signal output axis) for the lowest **VALID** mean signal output level (darkness), and the **Y axis coordinate value** (i.e. noise variance axis) for highest **VALID** mean signal output.

A best fit line to the GAMMA TRANSFER FUNCTION is computed as follows: For the function $y = f(x) = ax+b$, where y and x are output gray level and incident illumination respectively on the camera's gamma curve, a and b are calculated so that the sum of the squares of the errors given by $\Sigma[f(x_i)-y_i]^2$ is minimized. The measure of Nonlinearity may be reported in any or all of three ways.

% RMS. - Expressed as a percent, and defined as the ratio between the average Y axis departure from the theoretical GAMMA TRANSFER FUNCTION and the X axis value for the highest **Valid** mean signal output.

% INTEGRAL - Expressed as a percent, and defined as the ratio between the normalized absolute value sum of all Y axis departures from the theoretical GAMMA TRANSFER FUNCTION and the X axis value for the highest **Valid** mean signal output.

% PEAK DIFFERENTIAL - Expressed as a percent, and defined as the ratio between the maximum Y axis departure between any two adjacent X axis coordinate values from the theoretical GAMMA TRANSFER FUNCTION and the X axis coordinate value for the highest **Valid** signal output.

	GAMMA TRANSFER FUNCTION		PHOTON TRANSFER FUNCTION	
GAIN (DGN 'X')	NONLINEARITY (8 BIT %RMS.)	NONLINEARITY (8 BIT % Integral)	NONLINEARITY (8 BIT %RMS.)	NONLINEARITY (8 BIT % Integral)
DGN 1	0.16	1.5	0.13	0.85
DGN 2	0.24	2.25	0.02	0.02
DGN 4	0.57	5.14	0.04	0.37
GAIN (DGN 'X')	NONLINEARITY (10 BIT %RMS.)	NONLINEARITY (10 BIT % Integral)	NONLINEARITY (10 BIT %RMS.)	NONLINEARITY (10 BIT % Integral)
DGN 1	0.48	17.64	0.01	0.12

NOTES: When imaging with very high illumination levels (> 255 or > 1023 for 8 or 10 bit output) , the slow onset of sensor blooming may give rise to increased nonlinearity.

When imaging with low high illumination levels and very high gain (< 5 counts and 24 dB) , photoelectron traps may also give rise to increased nonlinearity.

Measurement conditions:

Infrared-filtered Xenon light source
F11 nonimaging illumination

Uncoated clear glass window installed
0.0325 seconds exposure time
25 ° C ambient operating temperature
Digital video output
Dual channel mode
Defect concealment disabled
Center of frame ROI image samples

Labsphere Model ISP 4000 Photometer used for relative illuminance measurements.

9) Minimum irradiance and illuminance

DEFINITION: Minimum illumination and Minimum irradiance
Defined on the GAMMA TRANSFER FUNCTION as the **X axis coordinate value** (i.e. illuminance or irradiance level) where for the PHOTON TRANSFER FUNCTION, the [SQRT(**Y axis coordinate value**)] (i.e. signal variance level) and the **X axis coordinate value** (i.e. signal output level) are equal. In other words, the illumination or irradiance level required to produce a mean video level output equal to the RMS. noise.

Minimum irradiance is reported in nanowatts per cm^2 @ 550 nm's. Horizontal and vertical shading, and known sensor defects are not considered.

GAIN *(DGN 'X')*	**Minimum irradiance** *(8 bit)*	**Minimum irradiance** *(10 bit)*	
1	3.3	2.1	*nanowatts per* cm^2 *@550 nm's*
2	2.9	NA	"
4	2.7	NA	"

GAIN *(DGN 'X')*	**Minimum illuminance** *(8 bit)*	**Minimum illuminance** *(10 bit)*	
1	-	-	*millilux for XENON illumination*
2	-	-	"
4	-	-	"

10) Photoresponse nonuniformities

The Model ES 1.0 exhibits nonuniformities arising from illumination of the camera's sensor. Photoresponse nonuniformities occur as *pixel-to-pixel photoresponse nonuniformity, vertical shading, droop, vertical line nonuniformity,* and *horizontal line nonuniformity.*

DEFINITION: Pixel-to-pixel photoresponse nonuniformity
Photo-response non-uniformity arises from variations in individual pixel photo-responsivity. The result is differing video level outputs for pixels that are equally illuminated. The observed effect can be individual pixel-to-pixel variations and/or regional variations across a single frame.

DEFINITION: Bright field Vertical shading
This is a disparity in the mean video output level across the vertical dimension of a frame as compared to mean level for the frame. The disparity takes the form of a slow change in the mean video output level for adjacent horizontal video lines. Bright field Vertical shading is repeatable from frame-to-frame. Bright field Vertical shading is not substantially influenced by gain, exposure time or temperature.

DEFINITION: Bright field Horizontal shading [DROOP]
This is a disparity in the mean video output level across the horizontal dimension of a frame as compared to mean level for the frame. The disparity takes the form of a slow change in the mean video output level for adjacent vertical video columns. Bright field Horizontal shading is uniform across vertical video columns, and is repeatable from frame-to-frame. Bright field Horizontal shading is not substantially influenced by gain, exposure time or temperature.

DEFINITION: Bright field Vertical line nonuniformity
This is a disparity in the mean video output level for single or groups of vertical video columns that takes the form of an abrupt change between immediately adjacent or nearby vertical video columns. It is repeatable from frame to frame and not substantially influenced by increasing gain, increasing exposure time, or increasing ambient operating temperature.

DEFINITION: Bright field Horizontal line nonuniformity
This is a disparity in the mean video output level for single or groups of horizontal video lines that takes the form of an abrupt change between immediately adjacent or nearby horizontal video columns. It is repeatable from frame to frame and not substantially influenced by increasing gain, increasing exposure time, or increasing ambient operating temperature.

FIGURE 6 reports *pixel-to-pixel photoresponse nonuniformity, vertical shading, droop,* and *horizontal line nonuniformity* as a percent of the camera's mean gray level output.

Pixel-to-pixel photoresponse nonuniformity is derived form a multiple frame average. It is an average for a 10,000 pixel region in the center of the frame, and reported as percent RMS. of the mean signal output.

Vertical shading, *droop*, and *horizontal line nonuniformity* are reported as percent peak.

Bright field vertical shading and *droop,* and *vertical* and *horizontal line nonunifomrity* measurements are derived from row or column averages over 200 columns or rows in the center of the frame for the entire vertical or horizontal dimension of the frame, and are reported as percent peak of the mean signal output.

All measures exclude all dark field nonuniformities, exposure nonuniformity, and known sensor defects.

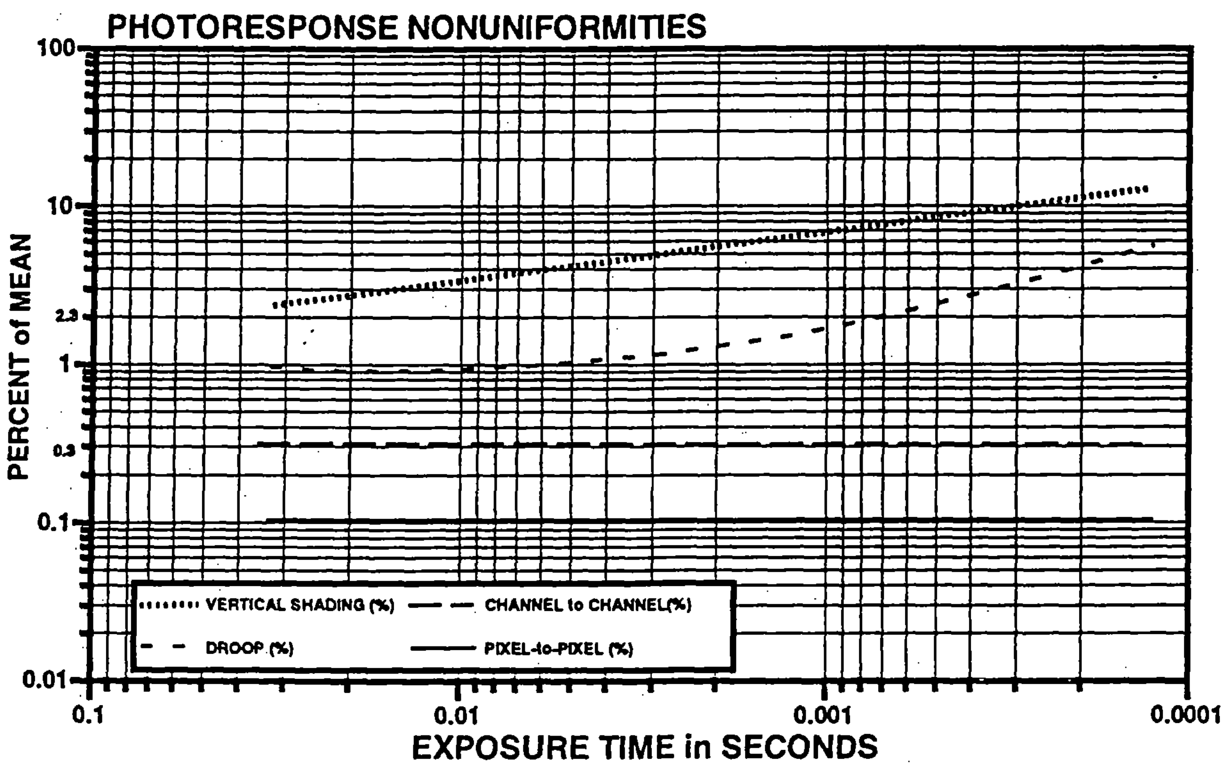


FIGURE 6

NOTES:	For the ES 1.0, Droop may be greater at the DGN 1 setting when operating with exposure times of 10 milliseconds or less.

Measurement conditions:

Infrared-filtered Xenon light source
F11 nonimaging illumination
Uncoated clear glass window installed
0.0325 seconds exposure time
25 ° C ambient operating temperature
Digital video output
Dual channel mode
Defect concealment disabled
Center of frame ROI image samples
Frame averaging used for pixel-to-pixel photoresponse nonuniformity.

Column averaging used for droop and vertical line nonuniformity.

Row averaging used for vertical shading and horizontal line nonuniformity.

11) PHOTON TRANSFER FUNCTION and GAMMA TRANSFER FUNCTION

These are the primary MODEL ES 1.0 transfer functions from which many other reported performance measures are derived.

DEFINITION: PHOTON TRANSFER FUNCTION
Defined as a two dimensional discrete function describing the relationship between the *mean* and the *variance of the random component* of the camera's signal output. The X axis is the camera's *mean signal output* and the Y axis is the *variance of the signal output*.. The function is defined from complete darkness up through clipping of the A/D where the camera's digital output range is exceeded.

DEFINITION: GAMMA TRANSFER FUNCTION
Defined as a two dimensional discrete function describing the relationship between a camera's *mean signal output* and the *illuminance/irradiance*, or *luminous/radiant* energy delivered to the camera. The X axis is the *input irradiance* and the Y axis is the camera's *mean signal output*. The plot is from complete darkness up through clipping of the A/D where the camera's digital output range is exceeded.

DEFINITION: ELECTRONIC GAIN
Defined as the *derivative* of the best fit line to the PHOTON TRANSFER FUNCTION. Reported in counts per photoelectron.

NOTES: The QUANTUM EFFICIENCY computed from the PHOTON TRANSFER FUNCTION is for the complete CAMERA SYSTEM, **not the sensor alone**. It includes other optical losses associated with the sensor cover glass and clear glass window.

FIGURES 7,8,9, and 10 report MODEL ES 1.0 8 and 10 bit PHOTON TRANSFER FUNCTIONS and GAMMA TRANSFER FUNCTIONS for DGN 1,2, and 4 gain settings and exposure time of 0.0325 seconds. Photoresponse and dark field nonuniformity, and black level offset have been subtracted out.

The Model ES 1.0 GAMMA TRANSFER FUNCTIONS are overlaid onto the PHOTON TRANSFER FUNCTIONS. FIGURE 7,8,9, and 10 are four axis plots. The bottom and left axes describe the PHOTON TRANSFER FUNCTIONS. The right and top axes describe the GAMMA TRANSFER FUNCTIONS.

The PHOTON and GAMMA TRANSFER FUNCTIONS for broad band illumination are not reported.

The measurements are an average over a 250,000 pixel region in the center of the frame and exclude dark field nonuniformities, exposure nonuniformity, and known sensor defects.

GAIN *(DGN 'X')*	ELECTRONIC GAIN *(8 bit counts/photoelectron)*	GAIN *(DGN 'X')*	ELECTRONIC GAIN *(10 bit counts/photoelectron)*
DGN 1	**0.006**	DGN 1	**0.023**
DGN 2	**0.012**	DGN 2	NA
DGN 4	**0.026**	DGN 4	NA

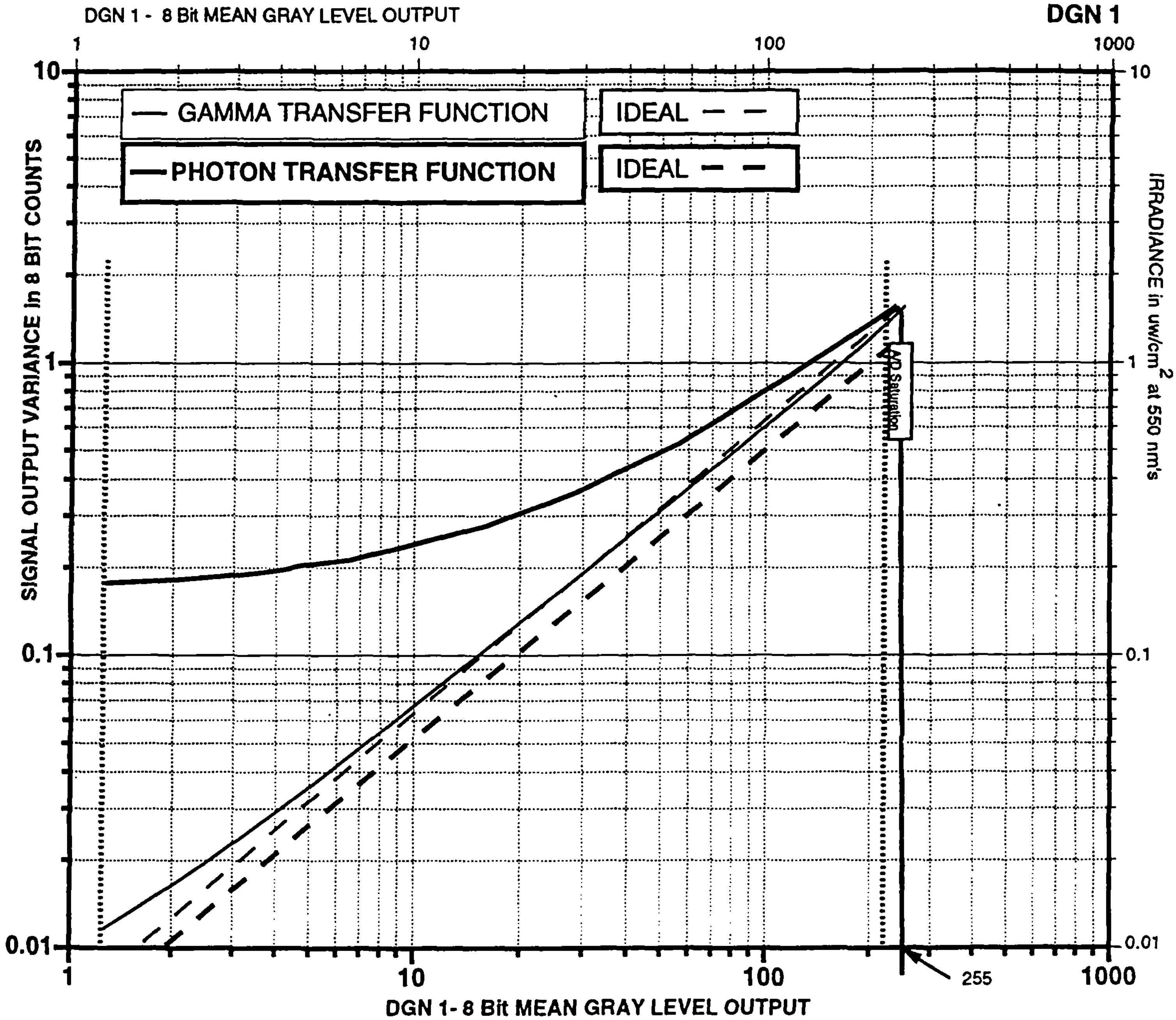

DGN 1 - 8 Bit MEAN GRAY LEVEL OUTPUT
DGN 1
1
10
100
1000
GAMMA TRANSFER FUNCTION
IDEAL
PHOTON TRANSFER FUNCTION
IDEAL
SIGNAL OUTPUT VARIANCE in 8 BIT COUNTS
IRRADIANCE in uw/cm² at 550 nm's
10
1
0.1
0.01
A/D Saturation
255
DGN 1- 8 Bit MEAN GRAY LEVEL OUTPUT

FIGURE 7

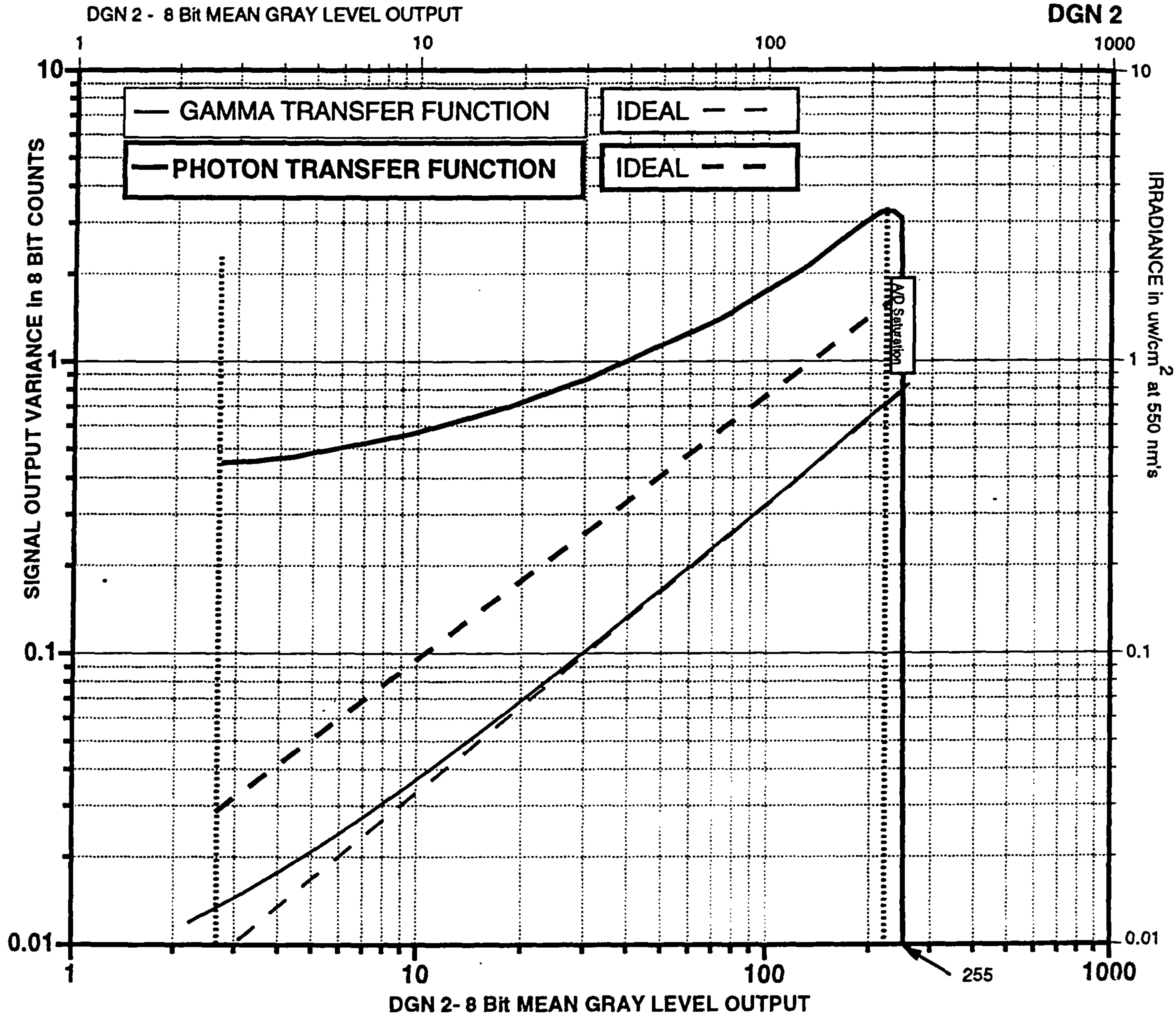

DGN 2 - 8 Bit MEAN GRAY LEVEL OUTPUT
DGN 2
GAMMA TRANSFER FUNCTION
IDEAL
PHOTON TRANSFER FUNCTION
IDEAL
SIGNAL OUTPUT VARIANCE in 8 BIT COUNTS
IRRADIANCE in uw/cm2 at 550 nm's
A/D Saturation
255
DGN 2- 8 Bit MEAN GRAY LEVEL OUTPUT

FIGURE 8

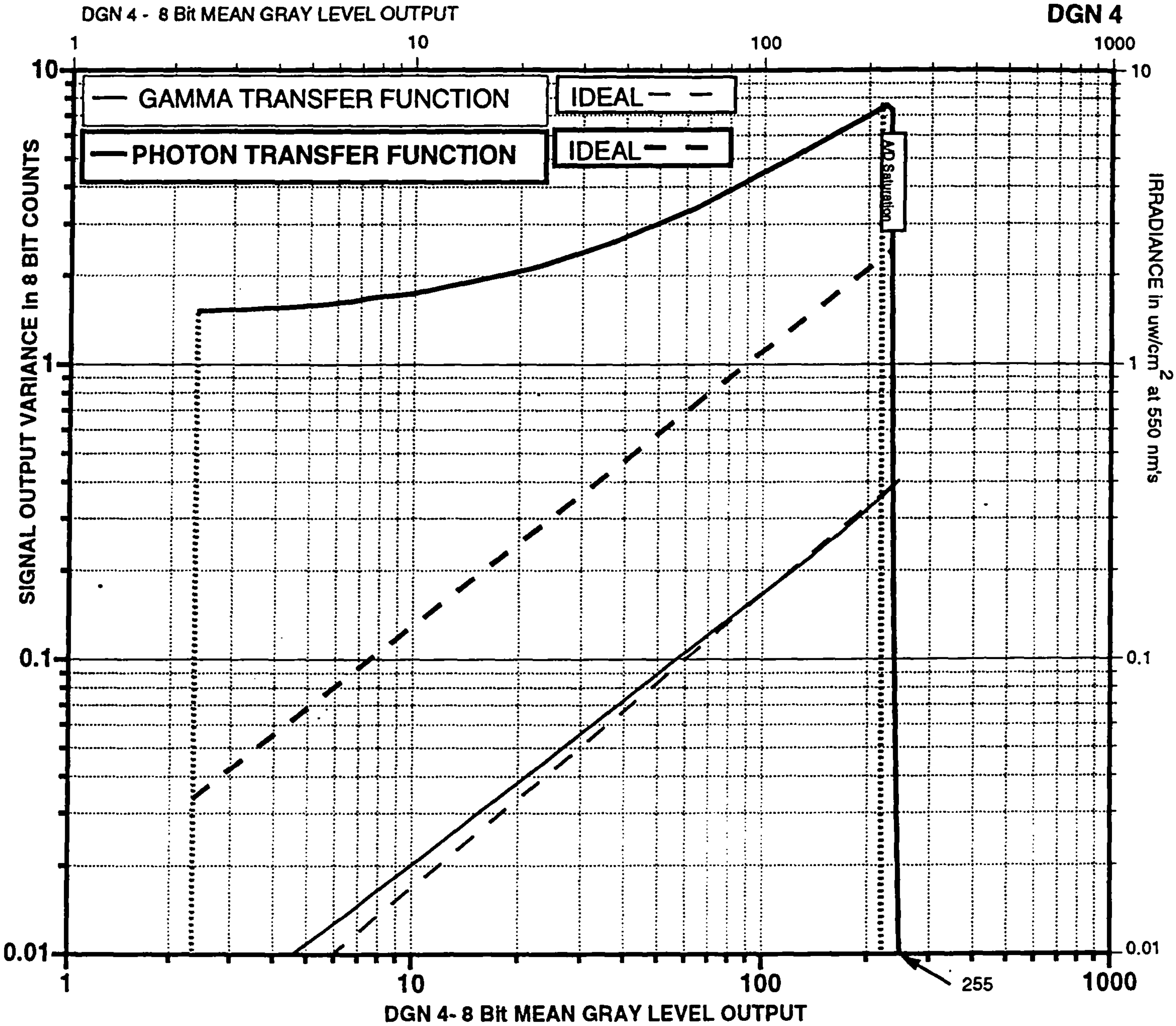

DGN 4 - 8 Bit MEAN GRAY LEVEL OUTPUT
DGN 4
1
10
100
1000
GAMMA TRANSFER FUNCTION
IDEAL
PHOTON TRANSFER FUNCTION
IDEAL
A/D Saturation
SIGNAL OUTPUT VARIANCE in 8 BIT COUNTS
IRRADIANCE in uw/cm2 at 550 nm's
10
1
0.1
0.01
255
DGN 4- 8 Bit MEAN GRAY LEVEL OUTPUT

FIGURE 9

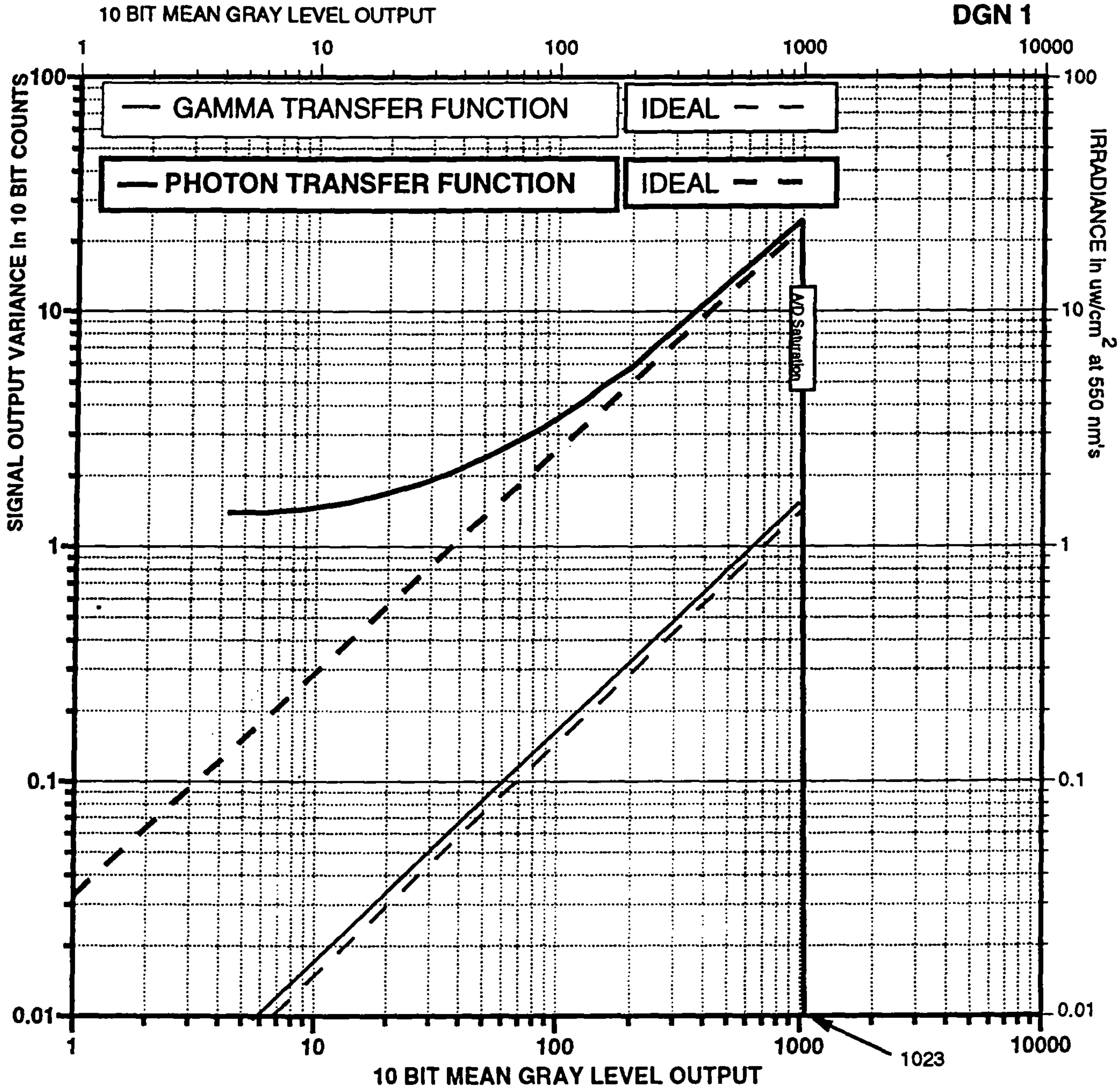

10 BIT MEAN GRAY LEVEL OUTPUT
DGN 1
1
10
100
1000
10000
GAMMA TRANSFER FUNCTION
IDEAL
PHOTON TRANSFER FUNCTION
IDEAL
SIGNAL OUTPUT VARIANCE In 10 BIT COUNTS
100
10
1
0.1
0.01
IRRADIANCE in uw/cm2 at 550 nm's
A/D Saturation
1023
10 BIT MEAN GRAY LEVEL OUTPUT

FIGURE 10

Measurement conditions:

Infrared-filtered Xenon light source
F11 nonimaging irradiance
Irradiance measured at the lens mount flange plane.

Uncoated clear glass window installed
25 ° C ambient operating temperature
0.0325 seconds exposure time
Digital video output
Dual channel mode
Defect concealment disabled
Center of frame ROI image samples

Frame subtraction used to remove photoresponse nonuniformities.

12) MODULATION TRANSFER FUNCTION

DEFINITION: MODULATION TRANSFER FUNCTION
The MODULATION TRANSFER FUNCTION (MTF) is the modulation captured by the camera when imaging sine waves of different spatial frequencies. Sine waves of known modulation are imaged into the Camera and modulation is computed by: **(Max.-Min.)/(Max.+Min.)**, as a function of increasing spatial frequency. The MTF may change with the spectrum of the illumination.

MODULATION TRANSFER FUNCTION (MTF) is reported in FIGURE 11. The measurements are in the center of the frame using optimum target phasing. Horizontal and vertical MTF are nearly equal.

A Nikon 95 mm printing lens was measured for MTF and used to image a sine wave test target into the camera. The lens MTF was then divided out to yield the Camera MTF.

Reported measurements are column averages over approximately 25 rows in the center of the frame. Horizontal and vertical shading, all dark field nonuniformities, and known sensor defects are intentionally avoided.

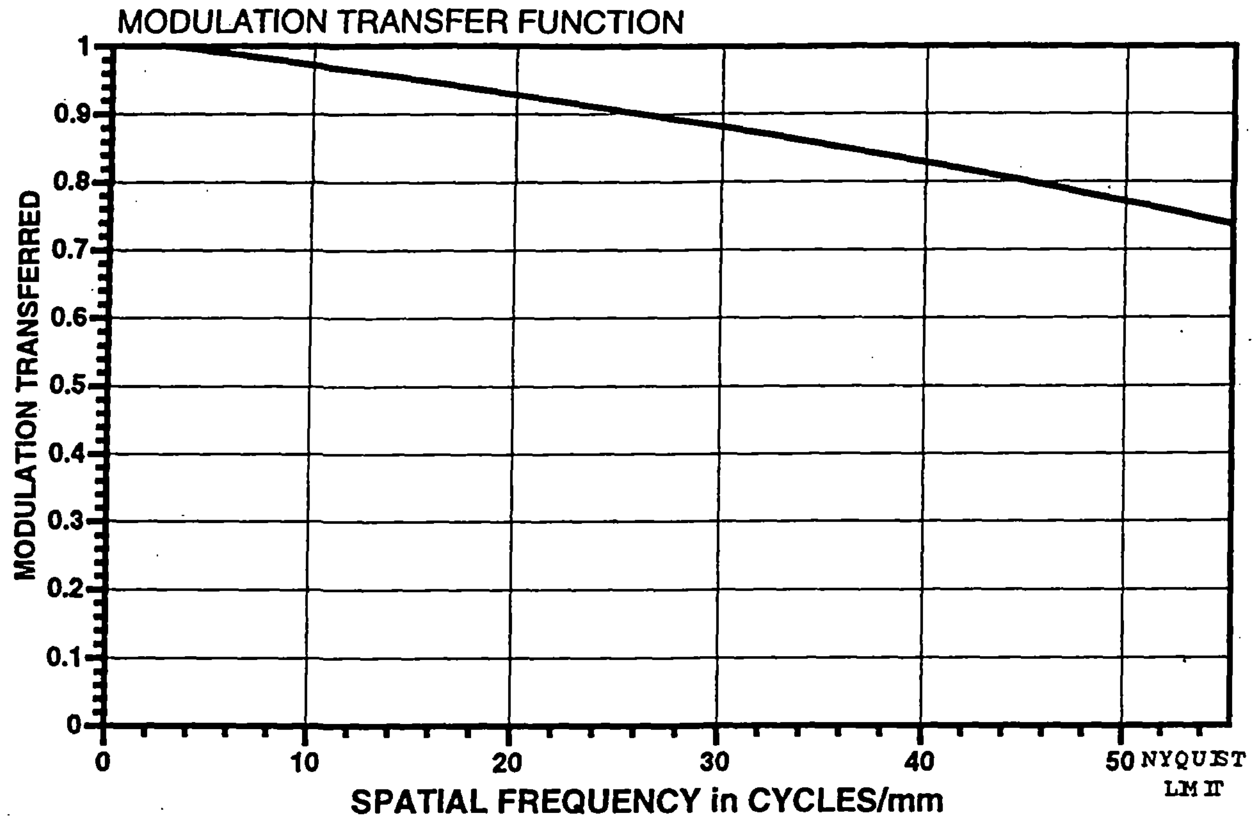


FIGURE 11

NOTES:	Average Camera MTF, (i.e. less than optimum target phasing) will yield lower modulation figures for the higher spatial frequencies. MTF will change with the spectrum of the illumination. MTF drops rapidly during blooming suppression. Effects of transfer efficiency, and crosstalk, and linear smear within the camera sensor result in slight variations in MTF depending upon location within the camera frame. The variations will be most noticeable at higher spatial frequencies using: high camera gain settings and low light levels, or low camera gain settings and high light levels. MTF is measured using 8 bit output.

NOTES:	MTF is measured using DGN 1 gain setting.

Measurement conditions:

Infrared-filtered Xenon light source
Integrating sphere illuminator

Uncoated clear glass window installed
0.0325 seconds exposure time
DGN 1 gain setting
25 ° C ambient operating temperature
Digital video output
Dual channel mode
Defect concealment disabled
Nikon 95 mm printing lens
F 5.6
Center of frame ROI image samples
SINE PATTERNS INC. Sine wave test pattern
2 times target demagnification

13) Limiting Resolution

DEFINITION: CONTRAST TRANSFER FUNCTION
The CONTRAST TRANSFER FUNCTION (MTF) is the contrast captured by the camera when imaging black/white line pairs waves of different spatial frequencies. Black/white line pairs of known contrast are imaged into the Camera and contrast is computed by: **(Max.-Min.)/(Max.+Min.)**, as a function of increasing spatial frequency. The CTF may change with the spectrum of the illumination. The CTF of the imaging lens is compounded into the measure and NOT subtracted out.

DEFINITION: Limiting resolution
The Limiting resolution is the maximum imaged spatial frequency, reported in cycles or TV lines/picture height, wherein the camera can maintain a minimum contrast value of 30%.

Illumination	Gain	Limiting Resolution
	(DGN 'X')	*(cycles/picture height)*
Infrared-filtered Xenon	1	**500**
	(dB)	*(TV lines/picture height)*
Infrared-filtered Xenon	1	-

NOTES: **1 cycle** is equivalent to **2 TV lines** using the SMPTE standard for measurement of resolution. Also, the measured contrast for TV lines will be different (usually higher) than the measured modulation using sine waves.

14) CONTRAST TRANSFER FUNCTION

DEFINITION: CONTRAST TRANSFER FUNCTION
The CONTRAST TRANSFER FUNCTION (MTF) is the contrast captured by the camera when imaging black/white line pairs waves of different spatial frequencies. Black/white line pairs of known contrast are imaged into the Camera and contrast is computed by: **(Max.-Min.)/(Max.+Min.)**, as a function of increasing spatial frequency. The CTF may change with the spectrum of the illumination. The CTF of the imaging lens is compounded into the measure and NOT subtracted out.

The Camera CONTRAST TRANSFER FUNCTION (CTF) is reported in FIGURE 12. The measurements are in the center of the frame using optimum target phasing. Horizontal and vertical CTF are nearly equal.

A Nikon 60 mm AF lens is used to image the line pair test target into the camera. The CTF of the Nikon lens is compounded into the measure and **NOT** divided out.

Reported measurements are column averages over approximately 25 rows in the center of the frame. Horizontal and vertical shading, all dark field nonuniformities, and known sensor defects are intentionally avoided.

NOTES:

Average Camera CTF, (i.e. less than optimum target phasing) will yield lower contrast figures for the higher spatial frequencies.

CTF will change with the spectrum of the illumination.

CTF drops rapidly during blooming suppression.

Effects of transfer efficiency, and crosstalk within the camera sensor result in slight variations in CTF depending upon location within the camera frame. The variations will be most noticeable at higher spatial frequencies using high camera gain settings and low light levels or low camera gain settings and high light levels.

CTF is measured using 8 bit output.

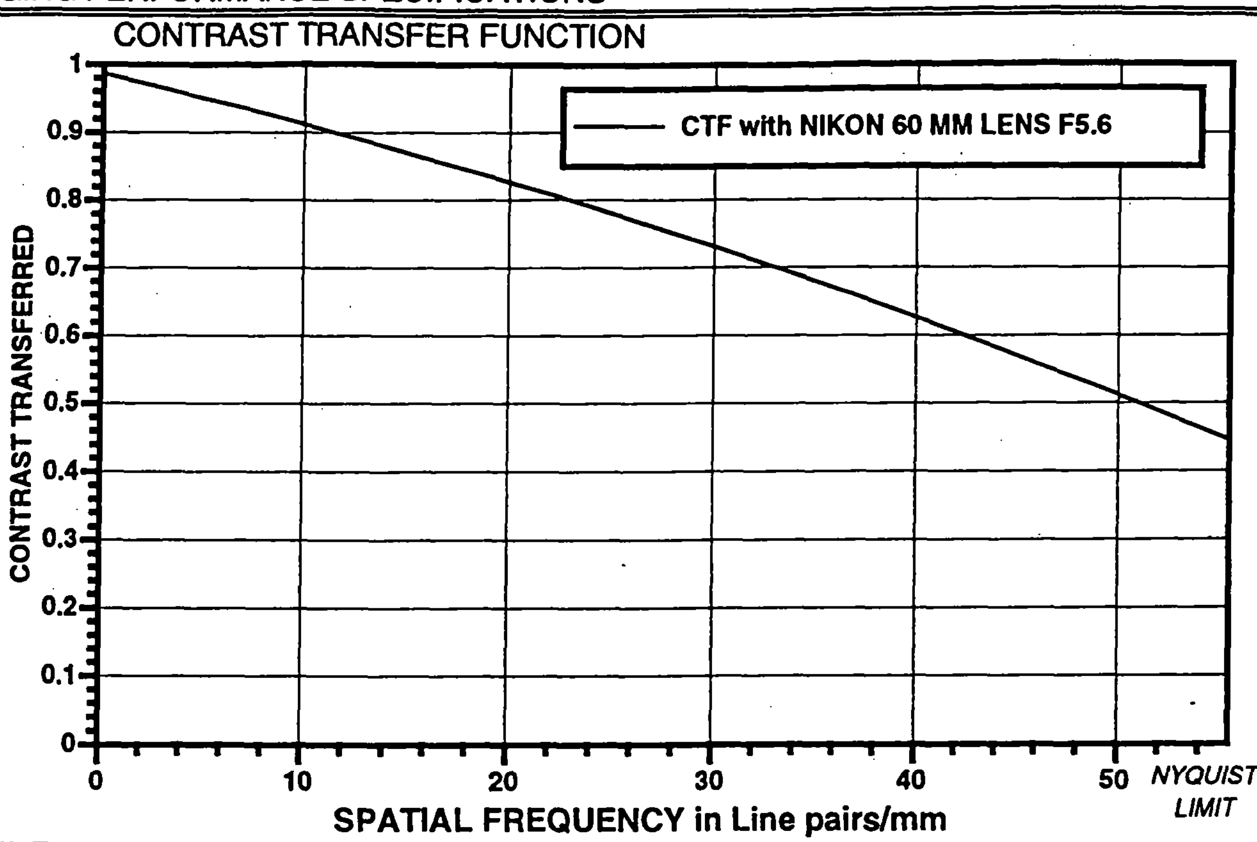


FIGURE 12

Measurement conditions:

Infrared-filtered Xenon light source

Uncoated clear glass window installed
0.0325 seconds exposure time
25 ° C ambient operating temperature
Digital video output
Dual channel mode
Defect concealment disabled
Nikon 60 mm AF lens
F 5.6
Center of frame ROI image samples
NBS type microscopy test target
1 times target demagnification

15) Spectral responsivity

DEFINITION: Spectral responsivity
Spectral responsivity is defined as the Camera's responsivity when imaging with different spectral wavelength bands.

FIGURE 13 reports Model ES 1.0 spectral responsivity in counts per uw/cm^2-second rounded to the nearest 10 counts. Reported responsivity is for the camera exclusive of any filters, and in conjunction with the Schott infrared filter option. When used with lenses or other filters the net spectral response may be different.

SPECTRAL RESPONSIVITY

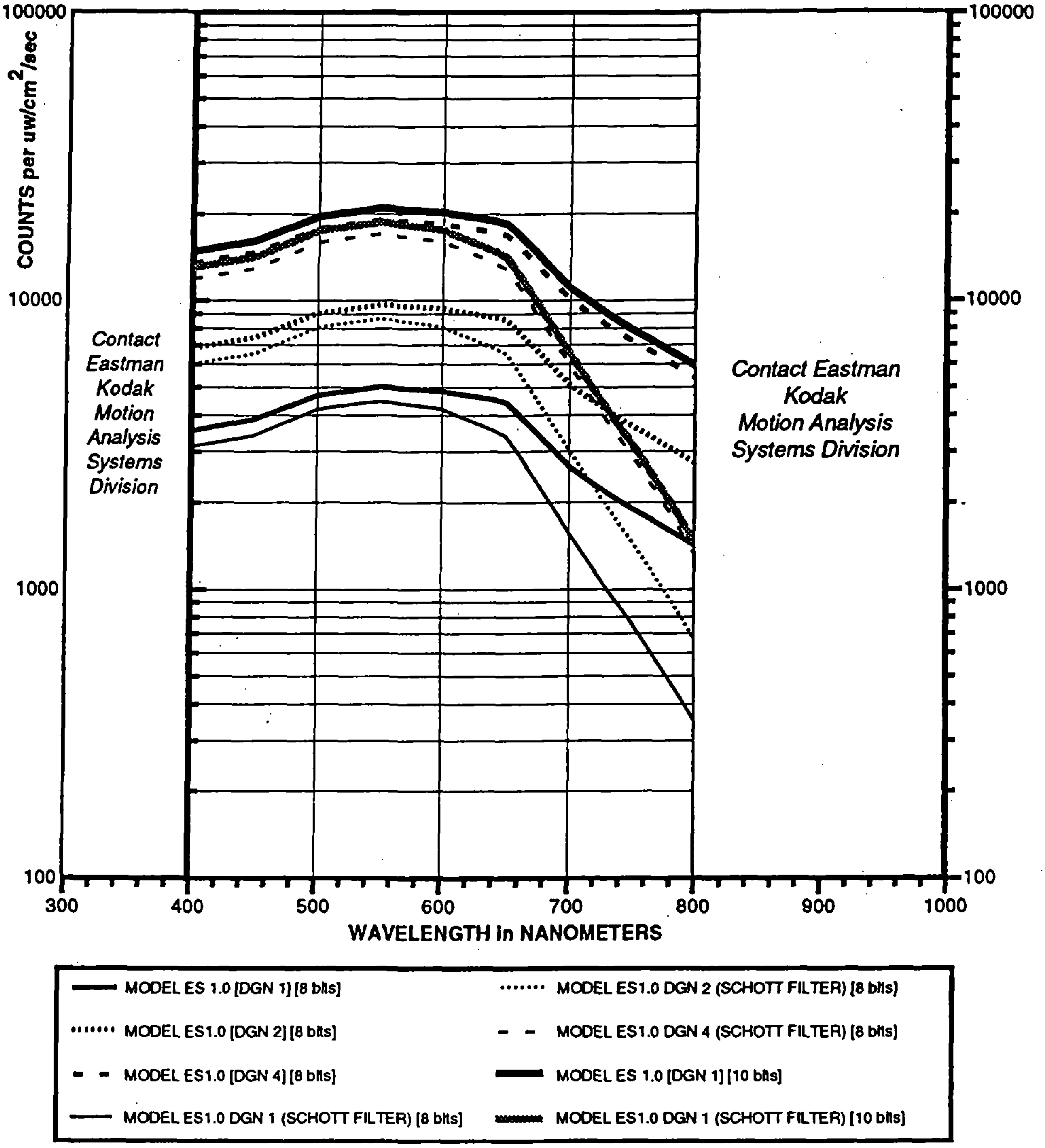


FIGURE 13

SPECTRAL RESPONSIVITY
(counts/uw/cm^2/second)

WAVELENGTH	DGN 1 [8 bits]	DGN 2 [8 bits]	DGN 4 [8 bits]	DGN 1 [10 bits]
400	**3550**	**6820**	**13460**	**14780**
450	**3880**	**7460**	**14710**	**16150**
500	**4690**	**9020**	**17780**	**19530**
550	**5020**	**9650**	**19030**	**20900**
600	**4860**	**9360**	**18450**	**20270**
650	**4450**	**8550**	**16870**	**18530**
700	**2660**	**5120**	**10090**	**11080**
750	**1900**	**3660**	**7210**	**7920**
800	**1420**	**2730**	**5380**	**5910**

WAVELENGTH	DGN 1 [8 bits] SCHOTT	DGN 2 [8 bits] SCHOTT	DGN 4 [8 bits] SCHOTT	DGN 1 [10 bits] SCHOTT
400	**3130**	**6030**	**11880**	**13050**
450	**3400**	**6540**	**12900**	**14170**
500	**4190**	**8070**	**15900**	**17470**
550	**4490**	**8630**	**17020**	**18690**
600	**4210**	**8100**	**15980**	**17550**
650	**3390**	**6510**	**12850**	**14110**
700	**11570**	**3030**	**5970**	**6560**
750	**760**	**1460**	**2880**	**3170**
800	**350**	**670**	**1320**	**1450**

Measurement method: *Monochromator (per Kodak MTD sensor data)*
Measured at the lens mount flange plane

Measurement conditions: *Uncoated clear glass window installed*
25 ° C ambient operating temperature
0.0325 seconds exposure time

Cross-check at 550 nm: *EG&G Model DR 2550 Radiometer*

16) Crosstalk and Smear

DEFINITION: Crosstalk

This is defined as either or both of the following two effects:

1) Photocurrent integration in pixels that at not illuminated, but are nearby to illuminated pixels.

2) Photocurrent integration in pixel transfer registers resulting from light leakage through the sensor substrate. This results in premature blooming at the pixels of entry, along with nonlinear GAMMA TRANSFER FUNCTION behavior and premature blooming at other pixel locations.

Crosstalk increases linearly with increasing exposure time, higher illumination level, and increasing illumination wavelength.

DEFINITION: Smear

This is defined as an apparent linear smear of an imaged object caused by photocurrent integration in transfer registers (effect #2). Smear increases linearly with the luminous exposure time until the entire vertical dimension of the frame is affected.

FIGURES 14 and 15 reports the effect of MODEL ES 1.0 *crosstalk* arising from photocurrent integration in vertical pixel transfer registers. *Crosstalk* is reported as percent of the mean digital video output count. Reported measures are for the **DGN 2** gain setting and the worst case pixel; namely, that pixel whose video output level receives the greatest *crosstalk* contribution from other vertically adjacent pixels.

FIGURE 16 reports MODEL ES 1.0 *smear* resulting from *crosstalk*.

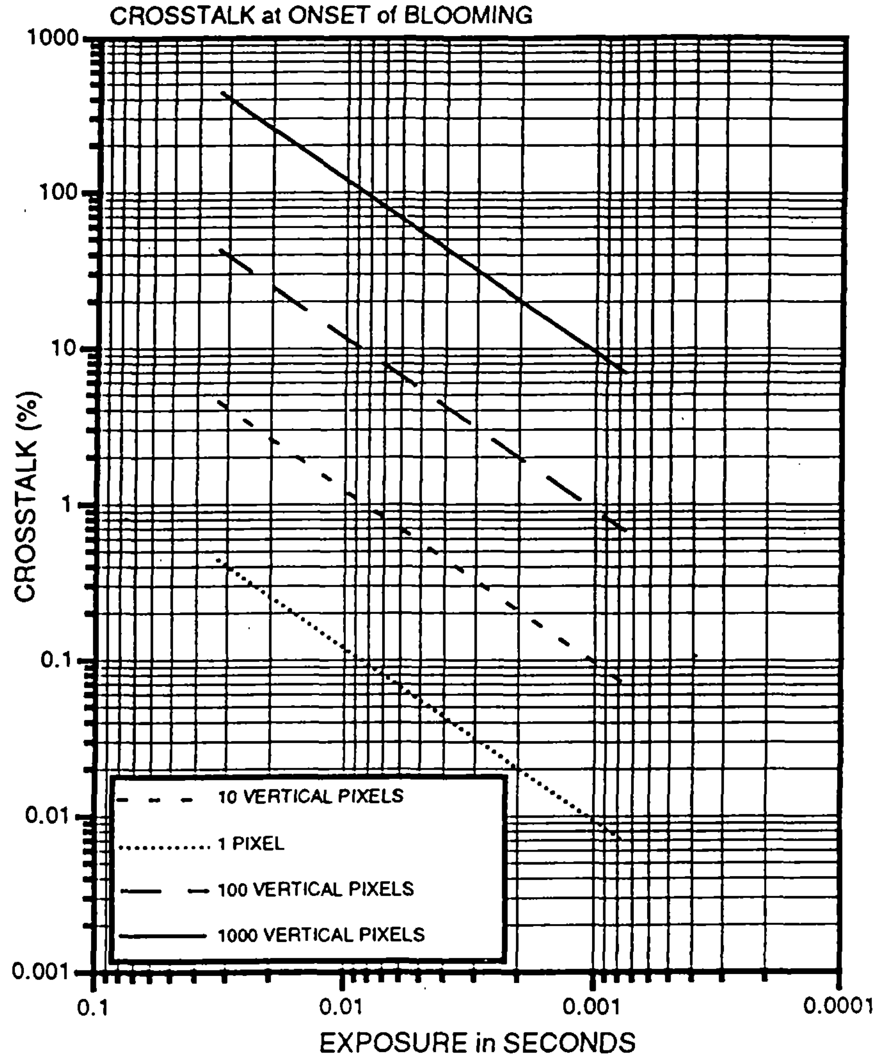


FIGURE 14

NOTES:	The crosstalk may be different for different DGN gain settings.

Measurement conditions:

DGN 2 gain setting
Infrared-filtered Xenon light source
Continuous wave illumination

Uncoated clear glass window installed
25 ^{o} C ambient operating temperature
Center of frame ROI image samples
Digital video output
Dual channel mode
Defect concealment disabled

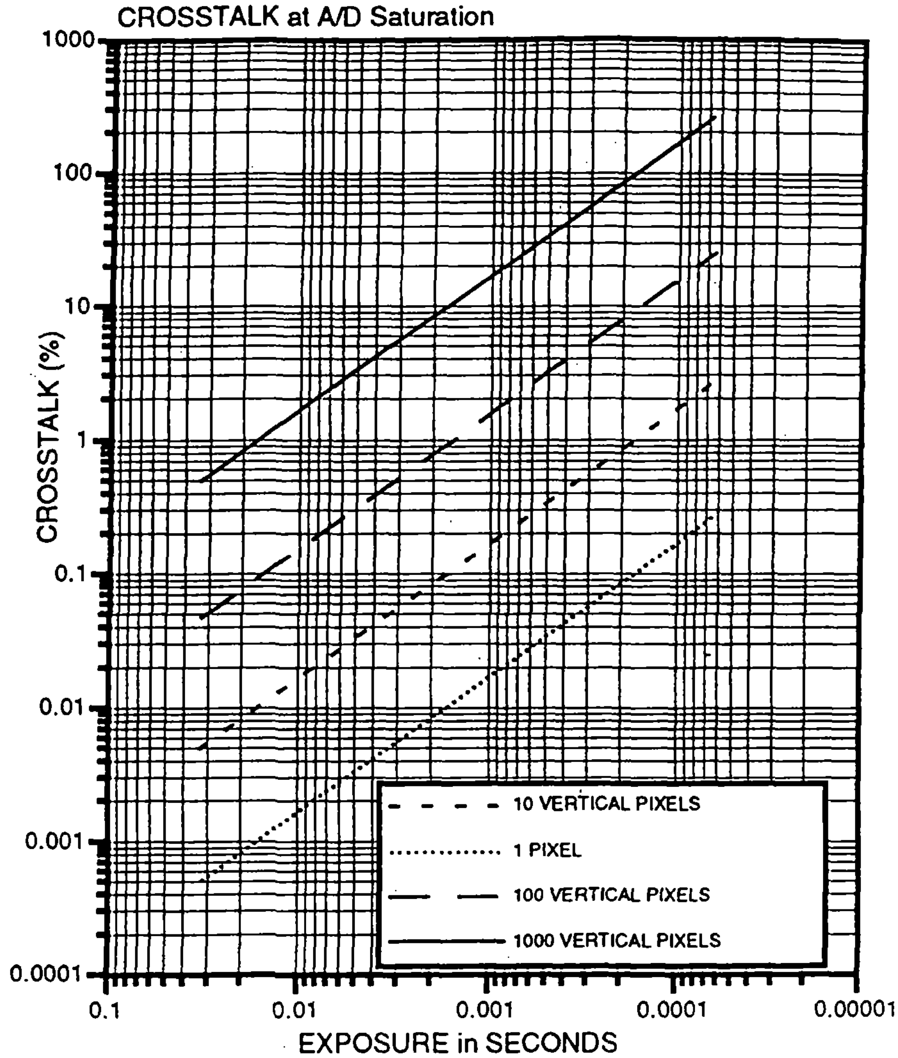


FIGURE 15

NOTES:	The crosstalk may be different for different DGN gain settings.

Measurement conditions:

DGN 2 gain setting
Infrared-filtered Xenon light source
Continuous wave illumination

Uncoated clear glass window installed
25 °C ambient operating temperature
Center of frame ROI image samples
Digital video output
Dual channel mode
Defect concealment disabled

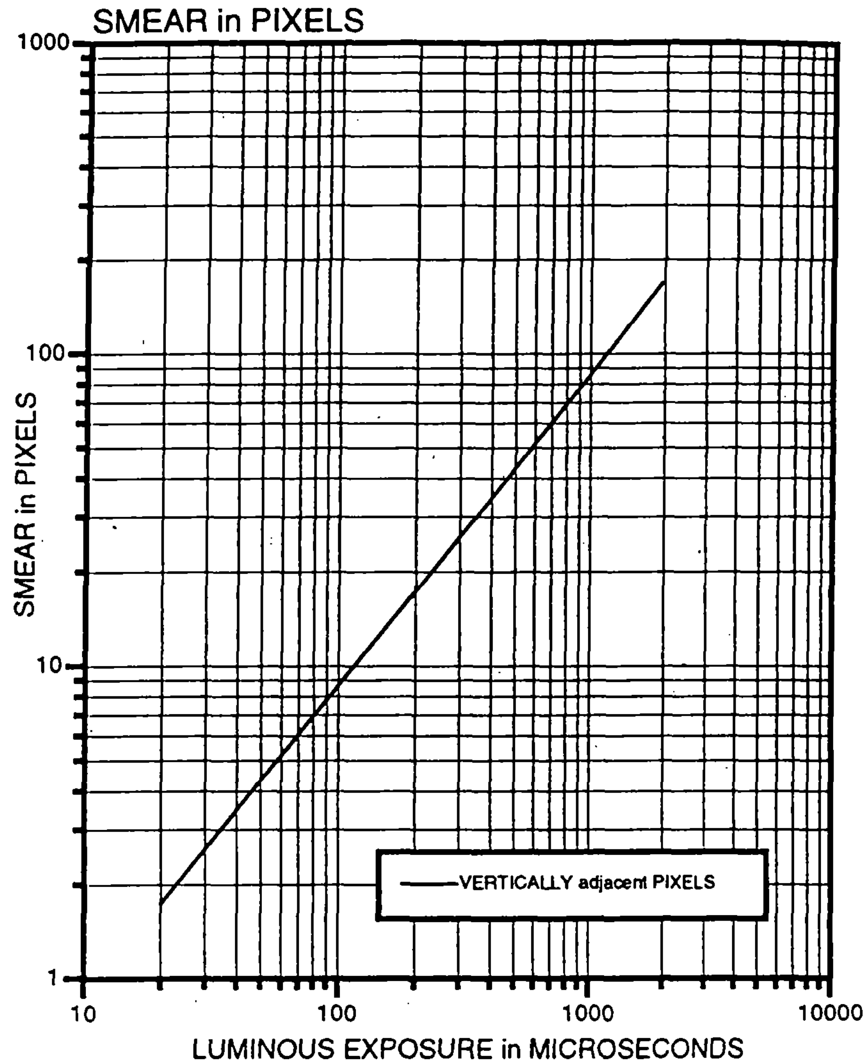


FIGURE 14

Measurement conditions:

Infrared-filtered Xenon light source

Uncoated clear glass window installed
Back illuminated variable height horizontal slit.
25 °C ambient operating temperature
Center of frame ROI image samples
Digital video output
Dual channel mode
Defect concealment disabled

17) Blooming suppression

DEFINITION: Over-illumination
This is defined as an imager illumination level that is higher than the maximum value of the camera's digital count output range. Illumination levels higher than this maximum digital count cannot be 'sensed' by the Camera.

DEFINITION: Blooming
This is defined as a dynamic 'pixel overflow' condition within many sensors, usually caused by over-illumination. Pixels are illuminated beyond their ability to integrate charge, causing charge overflow into adjacent structures. Adjacent structures may be nearby pixels, transfer registers, or other sensor structures. The observed effect is usually a 'growing vertical stripe or bright spot', or other bright and/or distorted/extended image objects that appear to have been imaged abnormally by the camera. The resolution of an imager is reduced rapidly and significantly as blooming begins to occur, and can reach zero depending on the specific region of the camera sensor. An important identifying characteristic of blooming is its rapid spreading across the entire vertical dimension of the frame.

DEFINITION: Blooming suppression factor
This is defined as the camera over-illumination multiplication factor *(x)* wherein the Camera *will not bloom*.

Imager *blooming* is observed as a *growing bright spot* which expands more rapidly in the vertical axis than the horizontal, eventually resulting in a vertical stripe. *Over-illumination* of the camera may produce this condition.

FIGURE 17 reports MODEL ES 1.0 *blooming suppression factor* for the DGN 2 gain setting.

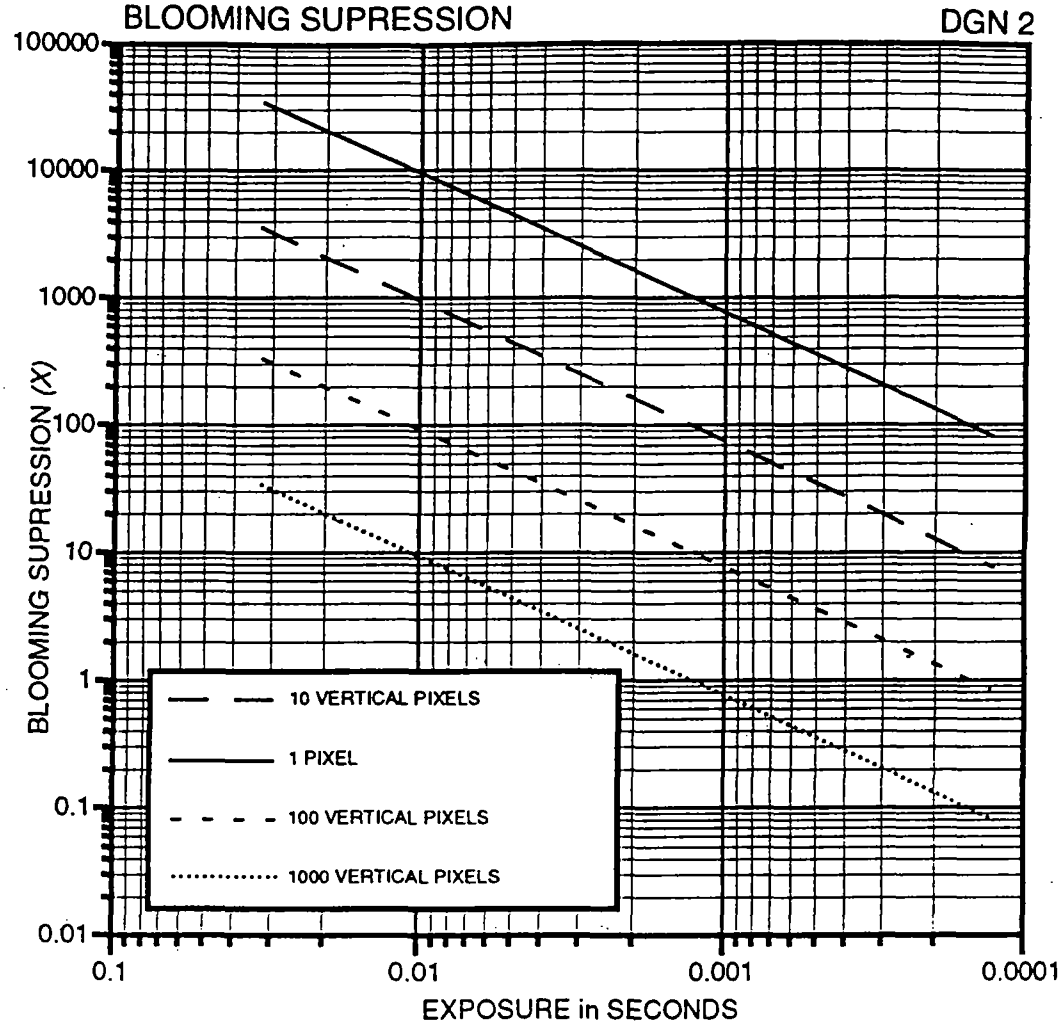


FIGURE 15

NOTES:	The blooming suppression factor may be different for different DGN gain settings.

Measurement conditions:

DGN 2 gain setting
Infrared-filtered Xenon light source
Continuous wave illumination

Uncoated clear glass window installed
25 °C ambient temperature
Center of frame ROI image samples
Digital video output
Dual channel mode
Defect concealment disabled

18) Stray Light

19) Valid signal output and measurement accuracy

DEFINITION: Valid signal output

Valid signal output is defined as that portion of the GAMMA and PHOTON TRANSFER FUNCTIONS where the reported performance figure is determined to be a '99% confident' measure of the camera's performance.

'Confidence' is defined as the standard statistical *99% confidence* measure of a parameter of a population.

The **parameters** for which the *confidence* applies are the reported MEAN and VARIANCE figures of the GAMMA and PHOTON TRANSFER FUNCTIONS.

The **population** for which the *confidence* applies is the population of measures or estimates used in reporting the MEAN and VARIANCE figures of the GAMMA and PHOTON TRANSFER FUNCTIONS.

MEASURE		ACCURACY	UNITS
PHOTON TRANSFER FUNCTION		*+/- 1*	*percent of value*
GAMMA TRANSFER FUNCTION		*+/- 1*	*percent of value*
MODULATION TRANSFER FUNCTION	*Relative*	*+/- 5*	*percent of value*
	Absolute	*+/- 15*	"
CONTRAST TRANSFER FUNCTION	*Relative*	*+/- 5*	*percent of value*
	Absolute	*+/- 15*	"
Responsivity		*+/- 15*	*percent of value*
Gamma ratio		*+/- 1*	*percent of value*
Blooming suppression		*+/- 10*	*percent of value*
Crosstalk		*+/- 10*	*percent of value*
Smear		*+/- 10*	*percent of value*
Nonlinearity		*+/- 1*	*percent of value*
Dynamic range		*+/- 1*	*percent of value*
Dark Field noise and nonuniformity		*+/- 1*	*percent of value*
Maximum Luminous signal/noise ratio		*+/- 1*	*percent of value*
Minimum illuminance and irradiance		*+/- 10*	*percent of value*
Photoresponse nonuniformity		*+/- 1*	*percent of value*
Stray light		-	*percent of value*
Limiting Resolution	*Relative*	*+/- 5*	*percent of value*
	Absolute	*+/- 15*	"
Exposure variability and nonuniformity	*Relative*	*+/- 1*	*percent of value*
	Absolute	*+/- 1*	"
Spectral responsivity	*Consult Eastman Kodak Company Motion Analysis Systems Division*		
Equivalent ISO speed	*Computed from photopic responsivity measure*		

20) Measurement Instrumentation and data reduction tools

INSTRUMENTATION

ILC 300 watt xenon lamp and linear power supply
Oriel cold mirror and liquid light guide
Labsphere 6" integrating sphere with 2 " port
Labsphere 4" integrating sphere with 1 " port
Kodak custom F11 baffle tube
Sine Patterns sine wave target
Melles Griot 10nm band width 550 nm filter
Labsphere model ISP4000 integrating sphere photometer
EG&G Model 2550 Radiometer/photometer
Nikon 95 MM Printing Lens
Nikon 60 mm photographic lens
Precision Digital Images Model AD4 digital frame grabber
Macintosh IIfx computer system

DATA REDUCTION TOOLS

"Image 1.55.3 VDM" image processing software
"Image 1.58 VDM" image processing software
"Deltagraph" data analysis and plotting software
"Statview" statistical data analysis software

NOTES

Redlake / Kodak Megaplus ES 310 Summary

MAX: PCI-1422 img0 684 x 242 Disable serial
Note the use of modified camera file "Redlake ES 310 Modified"
in NI-IMAQ\Data.

Serial communications via COM1
TTermPro: 9600 baud / 8 data / 1 stop / no parity
Configure TTermPro->Terminal for local echo

Issue the following serial commands (followed by ENTER)

IDN? (camera responds with ID string)
VID OF (disable analog video output, unless needed)
BLK ON (block mode)
BST 1 (block start line 1)
BSP 121 (required for 684 W x 242 H frame)
FRS 60 (set camera frame rate to 60 FPS [85 max])
AEX ON (autoexposure mode)

Run the LabVIEW application TCP VIDEO

nframes specifies the size of the circular buffer (200 frames)
initialize "trialname" to an appropriate string identifier

The application will create a folder on the desktop with the name entered in the trialname box. Binary dumps of the circular buffer are named sequentially: 000.vid, 001.vid, . . . and saved to this folder.

Video files can be replayed with the MATLAB application "playback".

From another PC:

telnet
set crlf (terminator sequence CR/LF appended to messages)
set localecho (TCP VIDEO does not echo)
set escape x (if necessary)
open 132.239.185.132 6342

send "s" to write the circular buffer to disk
send "q" to cause TCP VIDEO to exit

Notes

The cable connections are fragile and often result in line dropout.
See additional camera documentation in lab files.