Operating Instructions for

ISSI

Series LM2X, LM2X-DM, LM2X-DMHP
and

LM2X-DMHP-RGB LED Modules

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Rev. 1

Caution

This LED illuminator is manufactured with very high power LEDs. Please be aware that eye damage can occur if the user stares into the LED illuminator at a close range. The same precautions should be followed with this LED illuminator as with any high intensity light source.

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I. Description of LED Illuminators

The Series LM2X illuminator is a very compact, high-output device that is capable of operating in a constant-light-output mode (DC) or gated on and off by an external signal with either DC levels or high power level with reduced duty factors.

The LED illuminator is usually purchased with one of the two drive modules available. These modules are standardized to permit the operator who wishes to change operating modes from DC to high power pulse in the field with a simple change of drive modules.

The change simply requires a replacement of the rear drive module with the proper drive module and connection of the appropriate power supply. The rear modules are interchangeable on all the LM2X illuminators, with exception of the RGB driver module.

The LM2X illuminator consists of a LED module and one of two drive modules. The LM2X-DM drive module has a three-position locking switch for changing from continuous to dc pulsed operation. The center position is off condition. The dc pulsed operation allows the operator to turn on the LED with a TTL signal at the BNC connector. This drive module uses a 24 vdc power supply.

The LM2X high power pulsed illuminator has the same front LED module, but the LM2X-DMHP drive module is a high power pulser that uses a 48 vdc power supply. The LM2X high power pulsed illuminator is capable of generating light output that is five (5) times greater peak intensity than the continuous-output illuminator. To achieve that output level the duty factor must be limited to 5%, and the maximum pulse width must be <3 ms. The LM2X has a built in safety circuit to protect the illuminator if these limits are exceeded. This module has one BNC to facilitate pulsing.

The Series LM2X-DMHP-RGB series has the same duty-factor and pulse-width limitations as the LM2X illuminator but operates at three output wavelengths (red, green and blue). Each color is independently controlled with a TTL input signal. The RGB drive module also has the safety circuit for duty-factor protection.

II. Specifications

LM2X w/LM2X-DM

Standard output wavelengths	400nm & 460 nm
Optical output power dc	> 3 W
DC pulsed -rise time	<10 µsec
-fall time	150 µsec
Divergence-full angle	100 degrees
Power-supply voltage	24 vdc/2.5 A

LM2X w/LM2X-DMHP

Optical output power	>1.0 watts @ 5% duty factor
Pulsed -rise time	< 100 nsec
-fall time	< 100 nsec
Maximum pulse width	1.5 milliseconds
Power- supply voltage	48 vdc/ 2.7 A

LM2X-DMHP-RGB

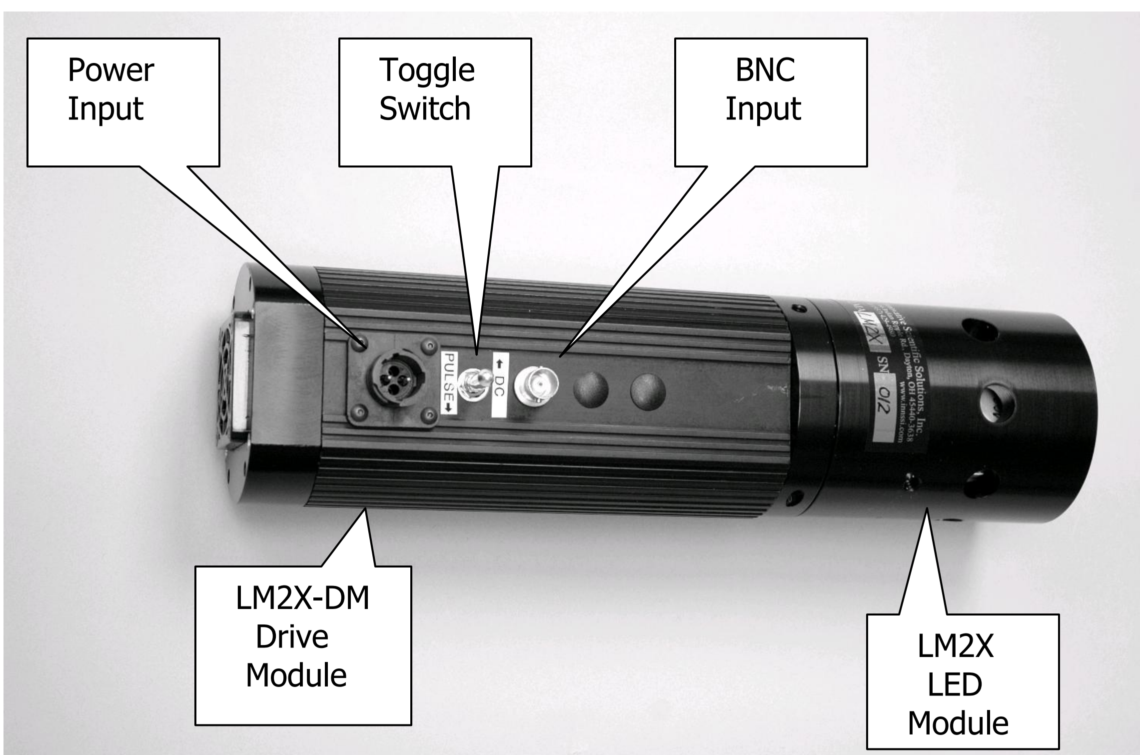
Wavelengths	- red	625 nm
	- green	530 nm
	- blue	460 nm
Pulsed	-rise time	< 50 nsec
	-fall time	< 50 nsec
Minimum pulse width		140 nsec
Power-supply voltage		48 vdc/ 1.25A

III. Operating Instructions

These led illuminators are extremely easy to use. There are only two parts to the light source. They consist of the led main body, driver module with power supply. The cable from the power supply is connected to the driver/led assembly and the power supply is plugged into a power source. The led illuminator is ready for operation.

Series LM2X w/ LM2X-DM

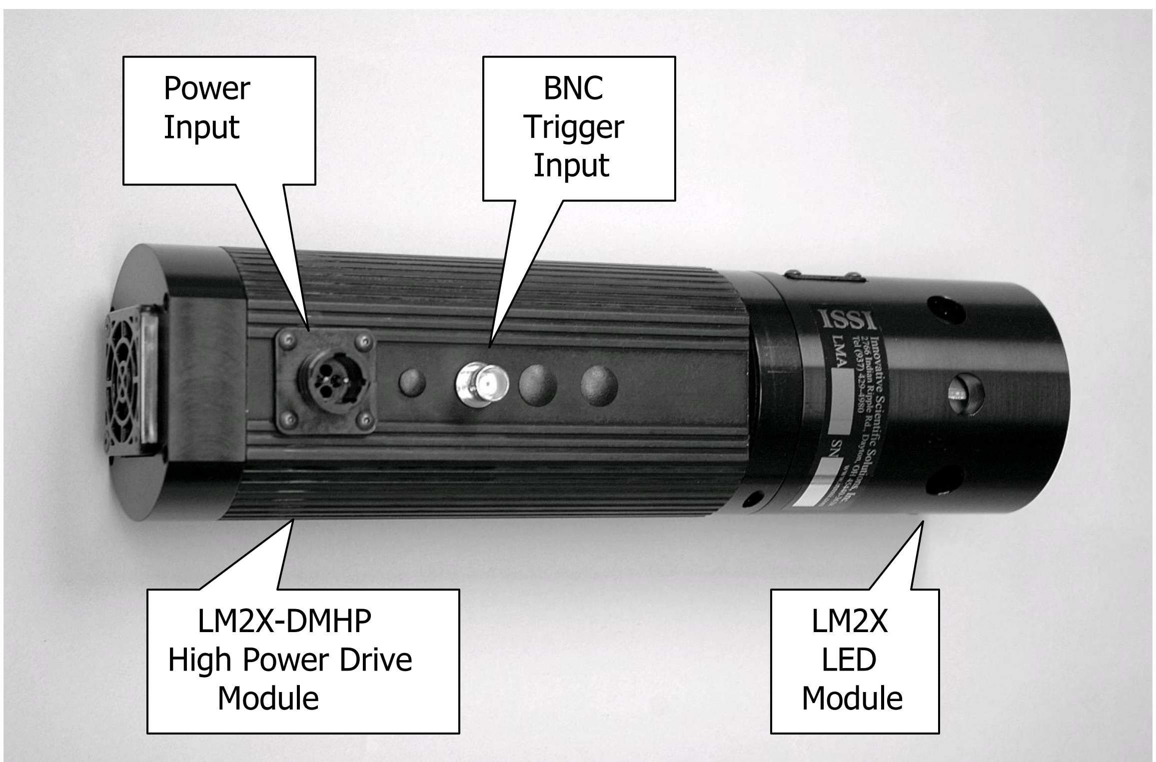
If the LM2X-DM is being used the power supply will be a 24 vdc / 2.5 A model. The drive module will have one three position switch on the rear housing. This switch is in the off position when it is perpendicular to the housing. To actuate the switch, lift and move to either side depending on which mode of operation you wish to use. One position is the continuous dc output mode and the other position is the pulsed dc mode which requires a +5 vdc level to be introduced into the BNC connector next to the switch. Once the switch is in the correct position it will fall into a locked positions when released. To move the switch, it needs to be pulled up to release the locking mechanism before moving to the new position.



Series LM2X w/ LM2X-DMHP

The LM2X-DMHP uses a power supply that is 48-vdc/2.7-A model. The plugs for the two driver modules are keyed such that the power supplies are not interchangeable.

The high power pulser has only one BNC connector, which is used to apply the TTL (5 vdc) signal to the illuminator. The output occurs with a +5 vdc pulse application. The drive module has a built-in safety circuit to prevent the user from exceeding the 5% duty factor and to limit the maximum pulse width to about 1.5 ms. The LED illuminator will cease to produce light output if either of these limitations is exceeded. Once the limit has been reached, the safety circuit is tripped; this circuit can be reset by reducing the input pulse width or repetition rate.

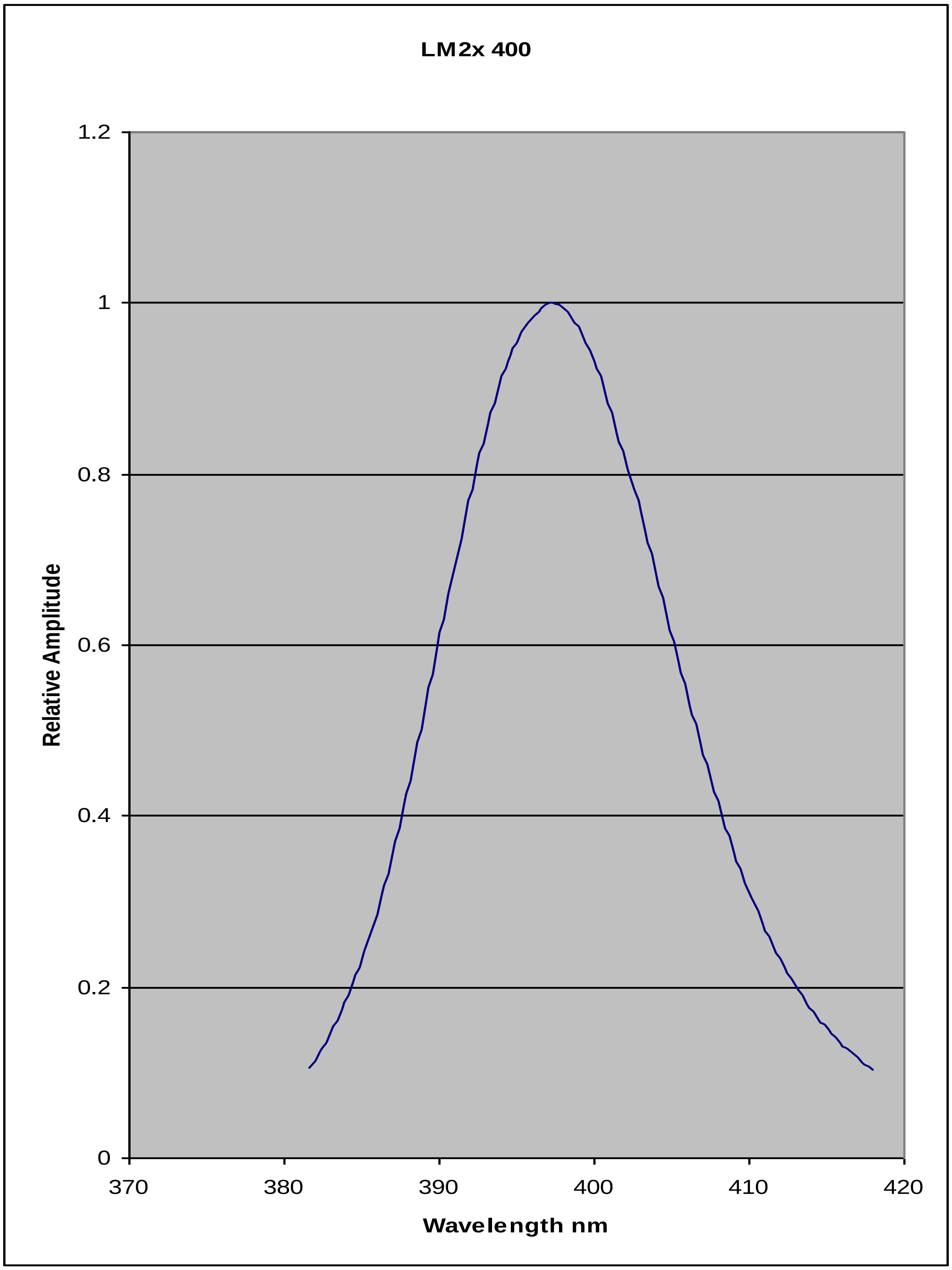


Series LM2X-DMHP-RGB

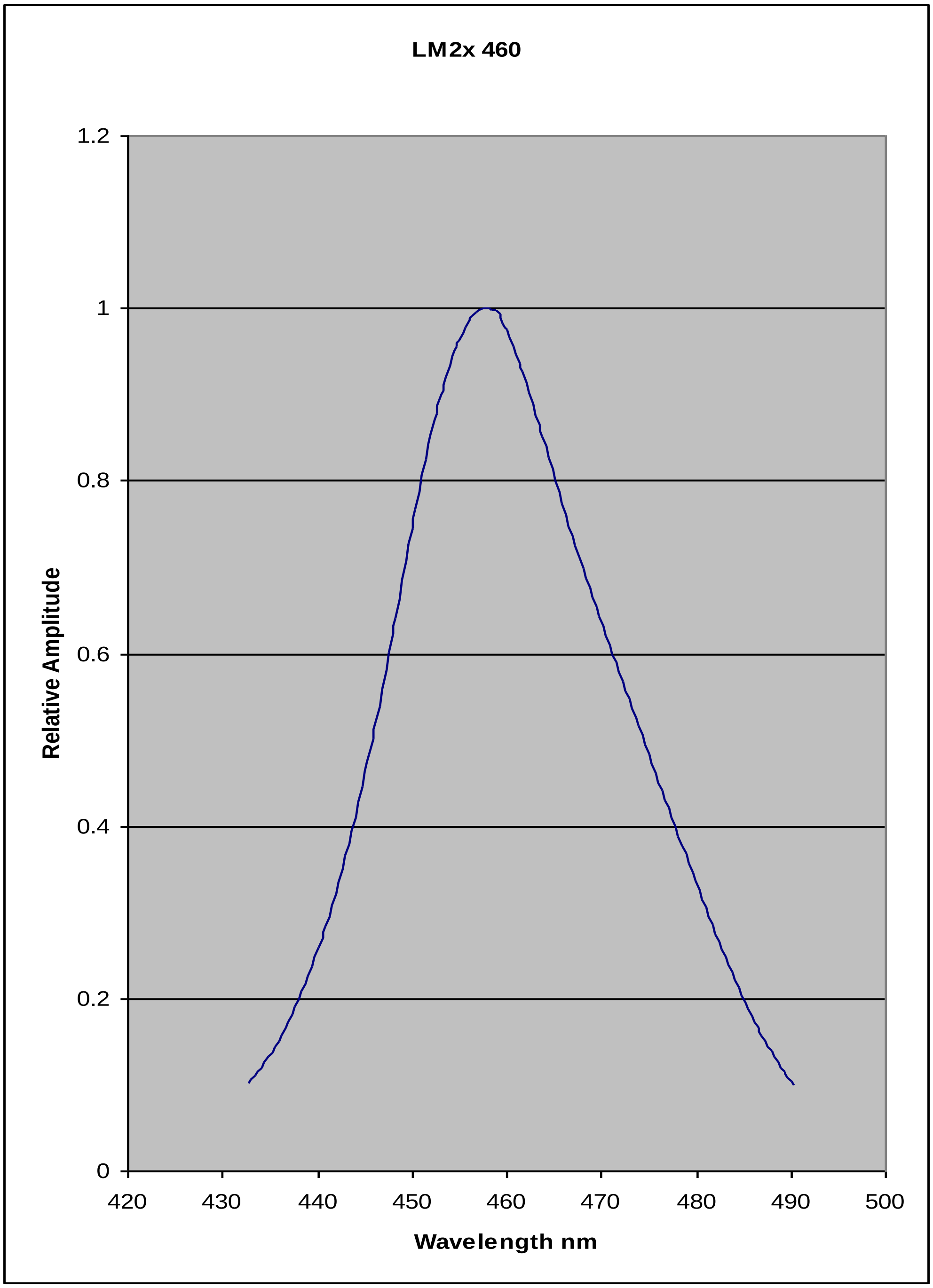
This illuminator has a different front module to accommodate a different type of LED having outputs at three distinct wavelengths. The driver module has been modified from the standard driver to allow three individual trigger inputs. The three LEDS can be triggered in any order in relation to each other with a TTL (+5 vdc) input signal.

This illuminator also has the safety circuit installed to protect the leds from excessive duty factor and/or pulse width. Because of the type of LEDs that are employed, this unit has a minimum pulse width of 140 nsec. The three BNC connectors are marked with the corresponding LED color.

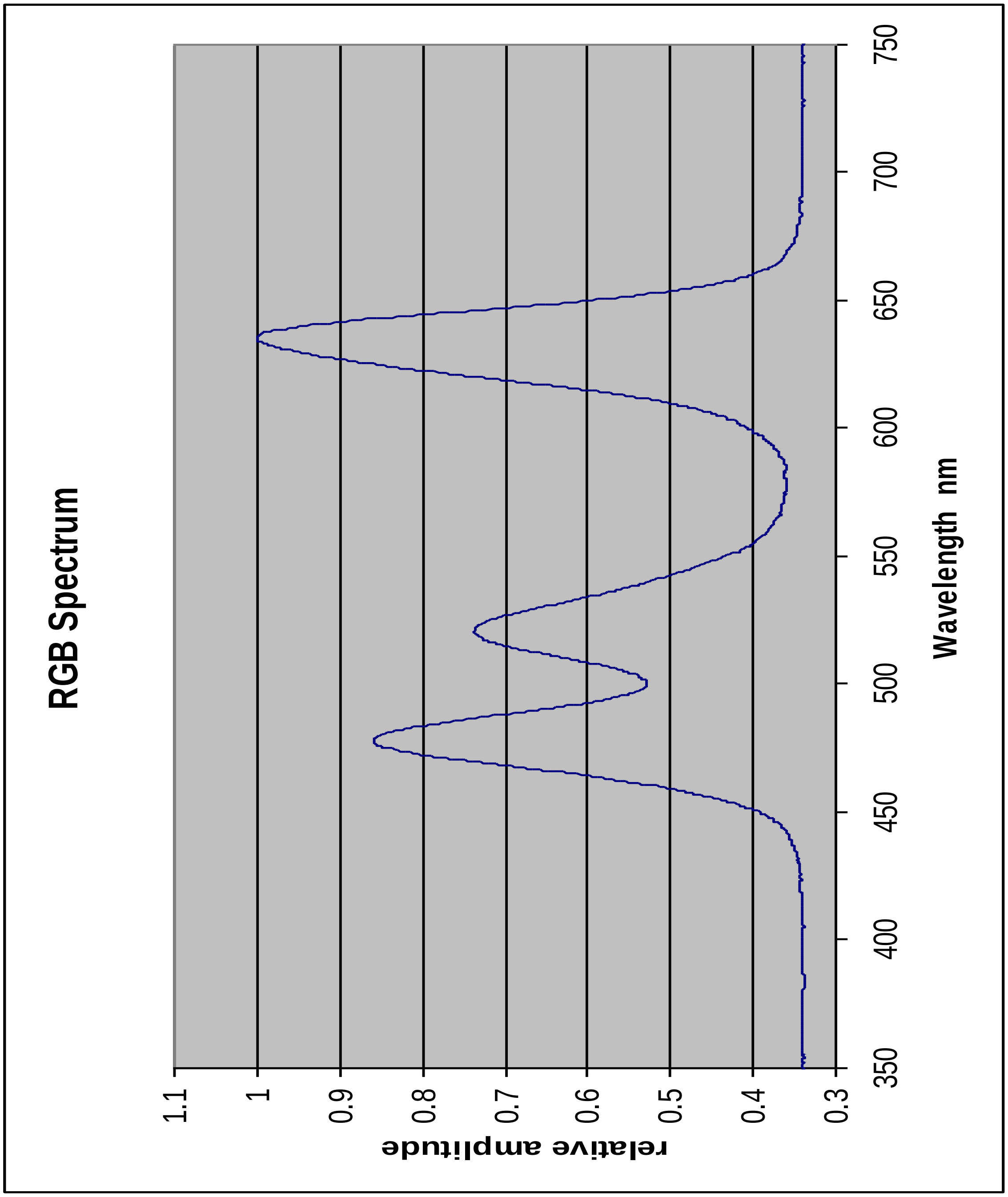
IV. Typical Waveform



Typical waveform of an LM2X 400



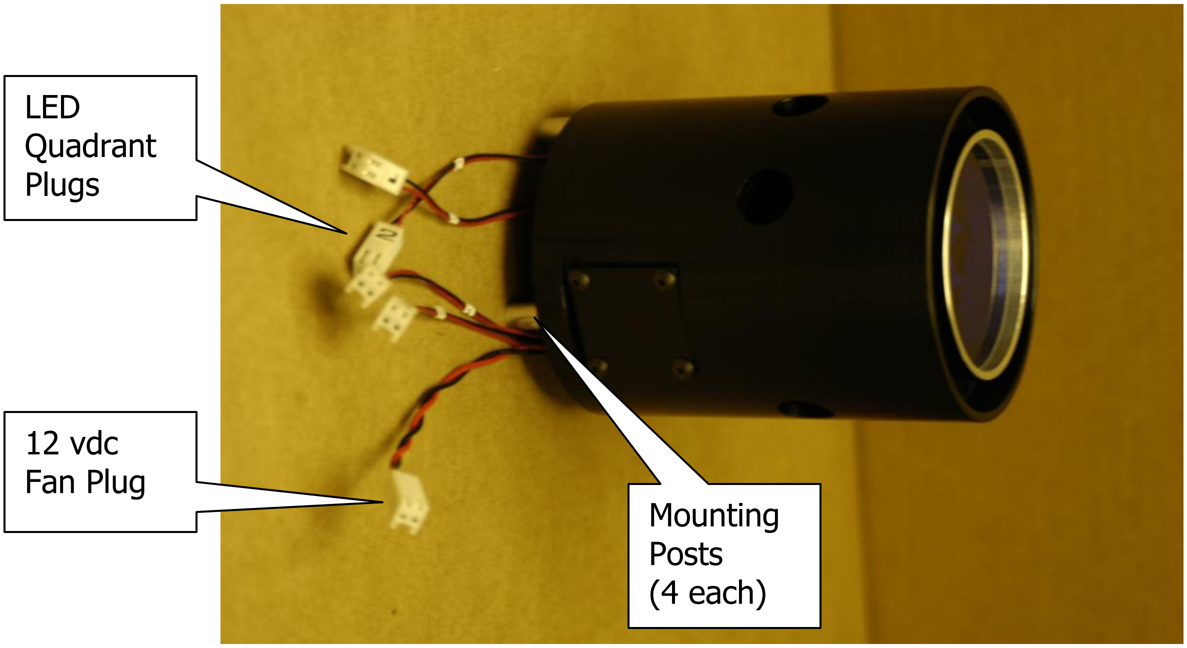
Typical waveform of an LM2X 460



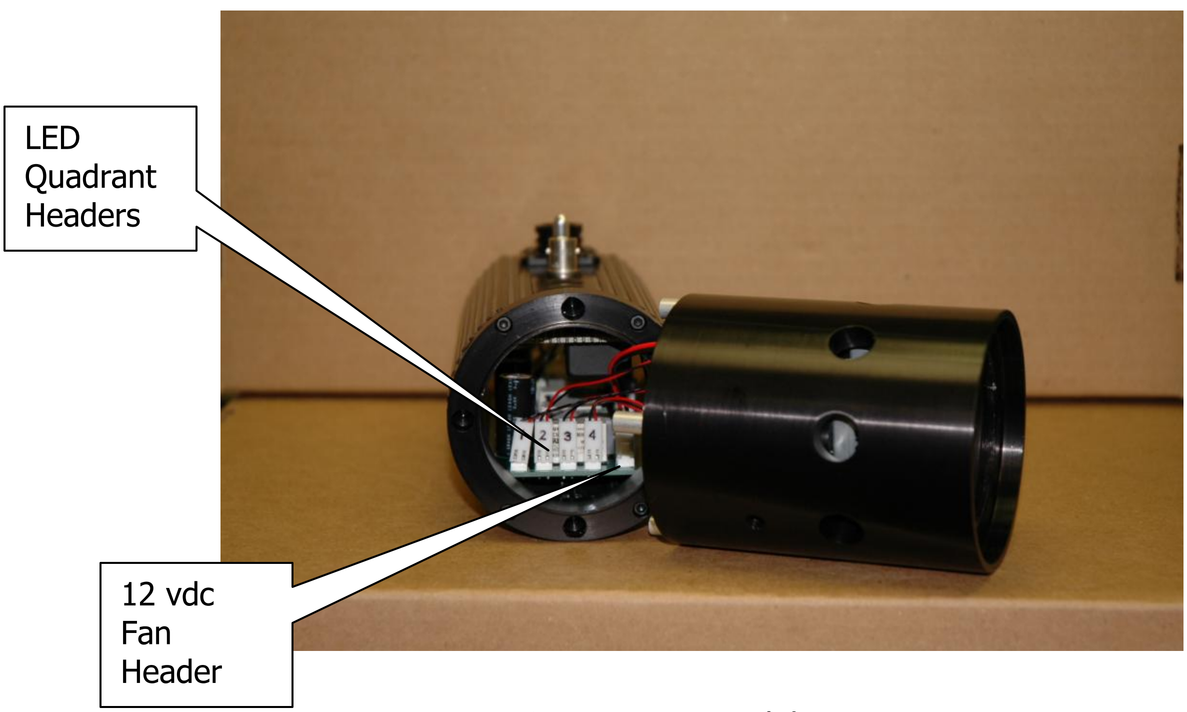
Typical waveform of an LM2X-DMHP-RGB

IV. Module Changing Instructions

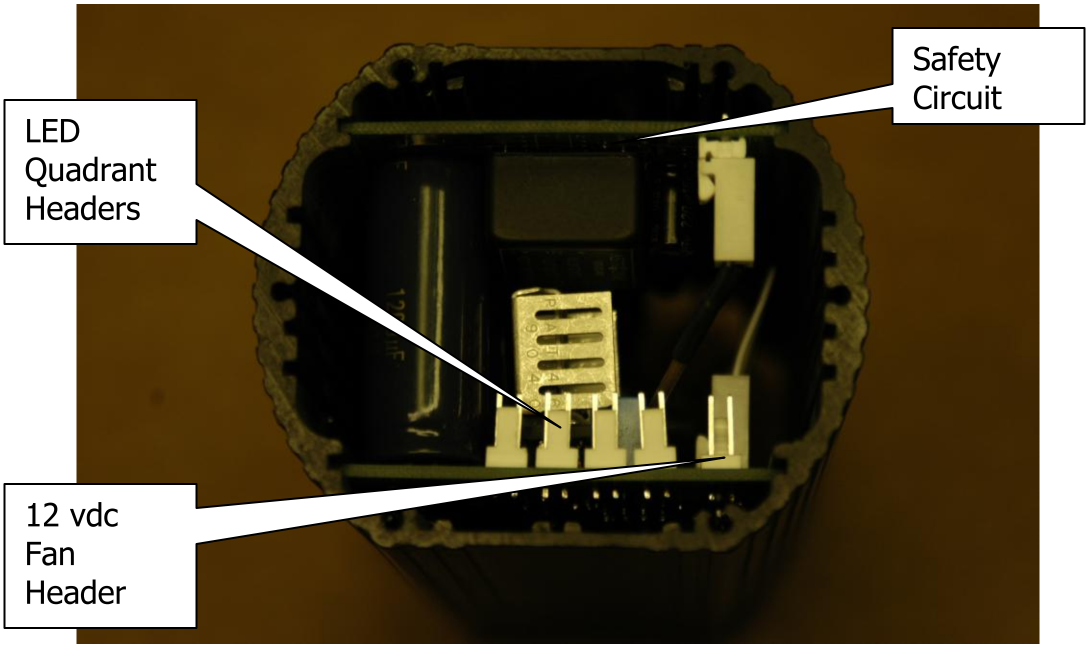
The LM2X LED module has four Led quadrant plugs and a 12 vdc fan plug. These are matched to corresponding headers on each of the drive modules.



LM2X LED Module



LM2X-DM Drive Module



LM2X-DMHP Drive Module

To change drive modules all that needs to be done is to loosen the two socket head set screws that are tightened on the mounting posts and slide off which ever module that is currently connected. Remove the four led quadrant plugs as well as the 12 vdc plug. Connect the quadrant plugs and the 12 vdc fan plug of the new driver module and slide the led module onto the posts and tighten the two set screws onto the mounting posts.

Install the proper power supply for the module in use. The power supplies are keyed so that they cannot be used on the wrong drive module.

The LED illuminator is now ready for use.

As always observe the proper safety measures when using high power light sources.

V. Safety Notices

Safe Operating Procedures for the LM2X-400

The data and recommendations contained in this document are based on "Recommended Practice for Photobiological Safety for Lamps & Lamp Systems – General Requirements", published by the American National Standard and prepared by the IESNA Committee. (ANSI/IESNA RP-27.1-96) This document is a general guide; the user of the LM2X-400 LED assumes all responsibility for the safe use and operation of the device. **The overall recommendation is that the use of safety goggles is recommended to prevent the possibility of damage to the eyes.** The safe working distance, defined as the distance at which continuous exposure to the lamp will not exceed the recommended danger level, for a singe lamp is 13-cm. Note that the use of multiple lamps will increase this distance.

Exposure Limits for LM2X-400 LED

Personnel working with or in the vicinity of the LM2X-400 LED should not be exposed to levels exceeding the following limits.

Ultraviolet Exposure Limits

Exposure limits for ultraviolet extend from 200-nm to 400-nm, just on the boundary of the operation of this lamp. The peak region for UV hazard is centered near 270-nm, a region where this lamp has no content. The spectral content of a LM2X-400 LED is shown in Figure 1. The peak wavelength is near 397-nm and the FWHM is approximately 20-nm. The distribution of radiation at a distance of 76-cm (30-inches) is shown in Figure 2 and the radiation along the centerline as a function of distance is shown in Figure 3. The Effective Ultraviolet Irradiance is calculated using the spectra in Figure 1 and:

$$E_S = \sum_{200}^{400} E_\lambda \bullet S(\lambda) \bullet \Delta\lambda \qquad (1)$$

E_S is the Effective Ultraviolet Irradiance in W•cm^{-2}
E_λ is the Spectral Irradiance in W•cm^{-2}•nm^{-1}
S(λ) is the hazard weighting function (Table 2, ANSI/IESNA RP-27.1-96)
Δλ is the bandwidth in nm

The permissible time per day for exposure to ultraviolet radiation upon the unprotected eye or skin is computed using:

$$t(\max) = \frac{0.003}{E_S} \qquad (2)$$

The spectral irradiance at the exit plane of the LM2X was measured as 32-mW•cm^{-2}. To simplify the analysis, all radiation from the lamp is assumed to be at 395-nm and therefore, the value of S(λ) at 395-nm (from Table 2 ANSI/IESNA

RP-27.1-96) is 0.000036. Using this information and equation 1, a value for E_S of ($1.2\ 10^{-6}$) is computed. Using this result and equation 2, the maximum exposure time per day is ~43 minuets. Note that this assumes the user has placed his/her skin or eye at the exit plane of the lamp. To determine safe operation, the peak irradiance as a function of working distance is plotted in Figure 3. This plot was converted to maximum exposure time as a function of distance as demonstrated above using, equation 1, and equation 2. The maximum exposure time for a single lamp as a function of distance is plotted in Figure 4 (black circles). From this figure, **the recommended safe operating distance for ultraviolet exposure for the LM2X-400 lamp is 13-cm.** Note that the use of multiple lamps will increase the spectral irradiance at a given distance and thus decrease the maximum allowable exposure time at that distance. Plots of the maximum exposure time as a function of distance for multiple lamps are also included in Figure 4. **Regardless of the operating conditions, the use of UV safety glasses is recommended.**

Light and Near Infrared Radiation Exposure Limits

Exposure limits for ultraviolet extend from 400-nm to 1400-nm. These limits apply for exposure within any 8-hour period.

Retinal Thermal Hazard Exposure Limit

To protect against retinal thermal injury, the integrated spectral radiance of the light source, L_R, weighted by the burn hazard weighting function R(λ) (From Table 3, ANSI/IESNA Rp-27.1-96) should not exceed levels defined by:

$$L_R = \sum_{400}^{1400} L_\lambda \bullet R(\lambda) \bullet \Delta\lambda \leq \frac{5}{\alpha t^{0.25}} \tag{4}$$

L_R is the burn hazard weighted radiance of the light source in $W\bullet cm^{-2}\bullet sr^{-1}$.
L_λ is the spectral radiance in $W\bullet cm^{-2}\bullet sr^{-1}\bullet nm^{-1}$.
R(λ) is the burn hazard weighting function (Table 3, ANSI/IESNA RP-27.1-96)
Δλ is the bandwidth in nm.
α is the angular subtense of the source in radians defined b the 50 percent peak radiance points.

If the calculation of α exceeds 0.1 radian, use 0.1 radian in equation 4. No criteria for thermal hazard are relevant for exposure durations longer than 10 seconds, because while thermal injury is the dominant injury mechanism to 10 seconds, photochemical mechanisms predominate for exposure durations longer than 10 s. Finally, note that the burn hazard is minimal at 400-nm and peaks near 440-nm.

For this calculation we have used the *worst case* model of an exposure of 10 seconds and α of 0.1 radian. The half maximum in Figure 1 is near 415-nm, we will simply use a burn hazard function of 10 for all wavelengths to predict the maximum burn hazard. With these assumptions, LR equals 1.9 while the lower limit on LR is 28.1. From this we conclude that **the LM2X poses no burn hazard**.

Retinal Blue Light Hazard Exposure Limit

To protect against retinal photochemical injury from chronic blue-light exposure, the integrated spectral radiance of the light source weighted against the blue-light hazard function (Table 3, ANSI/IESNA RP-27.1-96) should not exceed levels defined by:

$$(L_B \bullet t) = \sum_{400}^{700} L_\lambda \bullet B(\lambda) \bullet t \bullet \Delta\lambda \leq 100 \qquad (\text{for t} \leq 10^4) \tag{5a}$$

$$L_B = \sum_{400}^{700} L_\lambda \bullet B(\lambda) \bullet \Delta\lambda \leq 0.1 \qquad (\text{for t} \geq 10^4) \tag{5b}$$

L_B is the blue light weighted radiance in W•cm^{-2}•sr^{-1}.
L_λ is the spectral radiance in W•cm^{-2}•sr^{-1}•nm^{-1}.
B(λ) is the blue light hazard weighting function (Table 3, ANSI/IESNA RP-27.1-96)
Δλ is the bandwidth in nm.
t is the exposure duration in seconds.

For a weighted source exceeding 10-mW•cm^{-2}•sr^{-1}, the maximum possible exposure duration, t(max), is

$$\text{t}(\text{max}) = \frac{100}{L_B} \tag{6}$$

The spectral radiance at the exit plane of the LM2X was measured to be 32-mW•cm^{-2}•sr^{-1}. Since this exceeds the 10-mW•cm^{-2}•sr^{-1} limit equation 6 is used to compute t(max). Again, a *worst case* estimate is made by assuming that all radiation form the LM2X is at 435-nm, the peak sensitivity for blue light hazard (Note from Figure 1 that the LM2X has little content beyond 415-nm). Making these assumptions yields a maximum exposure duration of 3125 seconds (52 min.). Again, this estimate assumes that the user has placed his/her eye at the exit plane of the lamp. A careful integration of equation 5b using Figure 1 and the data from Table 3 of ANSI/IESNA RP-27.1-96 yields a limit on the maximum exposure time of 4 hours. Finally, using the peak radiance as a function of distance from Figure 3, a curve for the maximum exposure time for blue light hazard as a function of distance is produced. These curves are very similar to Figure 4 however; the limits are less restrictive than those for UV hazard. The recommended safe operating distance for Blue Light Hazard for the LM2X-400 lamp is 5-cm. Note that the limit for UV exposure in the preceding section is more restrictive and therefore this limit is followed. **The recommended safe operating distance for Blue Light Hazard for the LM2X-400 lamp is 13-cm.**

Infrared Radiation Hazard Exposure Limit

To avoid thermal injury of the cornea and possible delayed effects upon the lens of the eye, ocular exposure to infrared radiation, E_{IR}, over the range 770-nm to 3000-nm should be limited to 0.01 W•cm^{-2} for periods exceeding 1000 seconds. This can be expressed as:

$$E_{IR} = \sum_{770}^{3000} E_\lambda \bullet \Delta\lambda \leq 0.01 \qquad (\text{for t} > 1000) \tag{9a}$$

For exposures of less than 1000 seconds the irradiance limit should be:

$$E_{IR} = \sum_{770}^{3000} E_{\lambda} \bullet \Delta\lambda \leq 1.8 \bullet t^{-0.75} \qquad (\text{for } t < 1000) \qquad (9b)$$

E_{IR} is the ocular exposure to infrared radiation in W•cm^{-2}.
Δλ is the bandwidth in nm.
t is the exposure duration in seconds.
The LM2X-400 has no significant content beyond 450-nm and therefore, **the LM2X-400 does not present an infrared radiation hazard**.

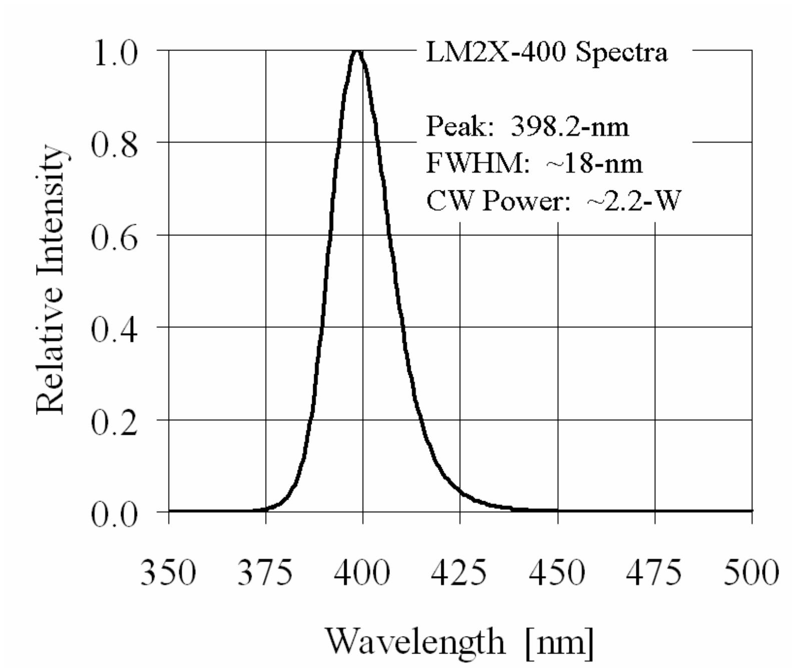


Figure 1: Spectral content of a LM2X-400.

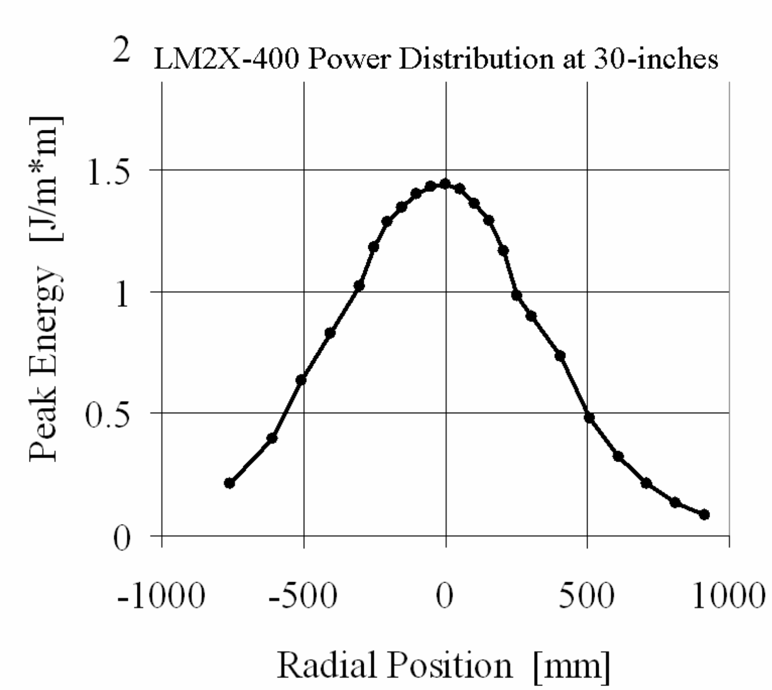


Figure 2: Distribution of radiation at 76-cm (30-inches) for an LM2X-400.

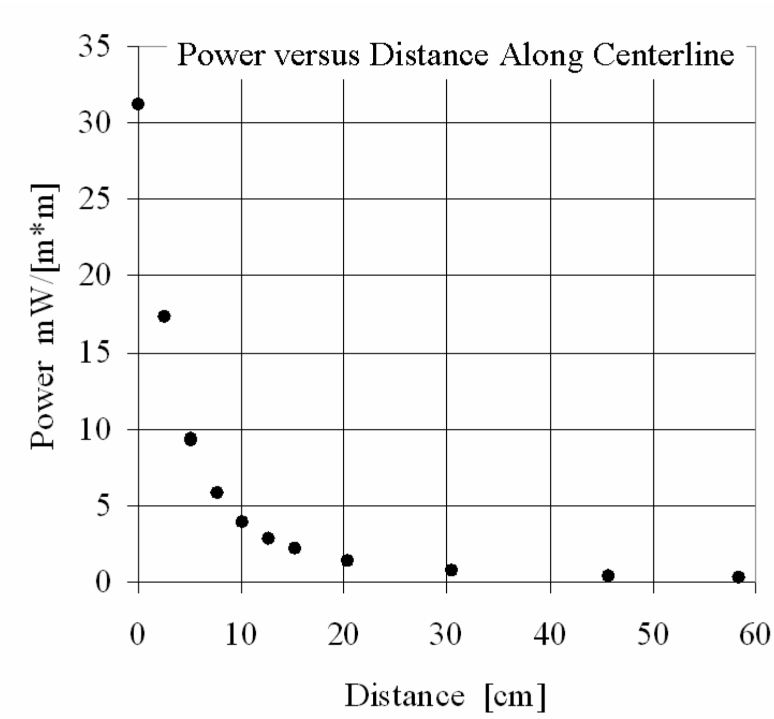


Figure 3: Spectral Irradiance as a function of distance along centerline of an LM2X-400

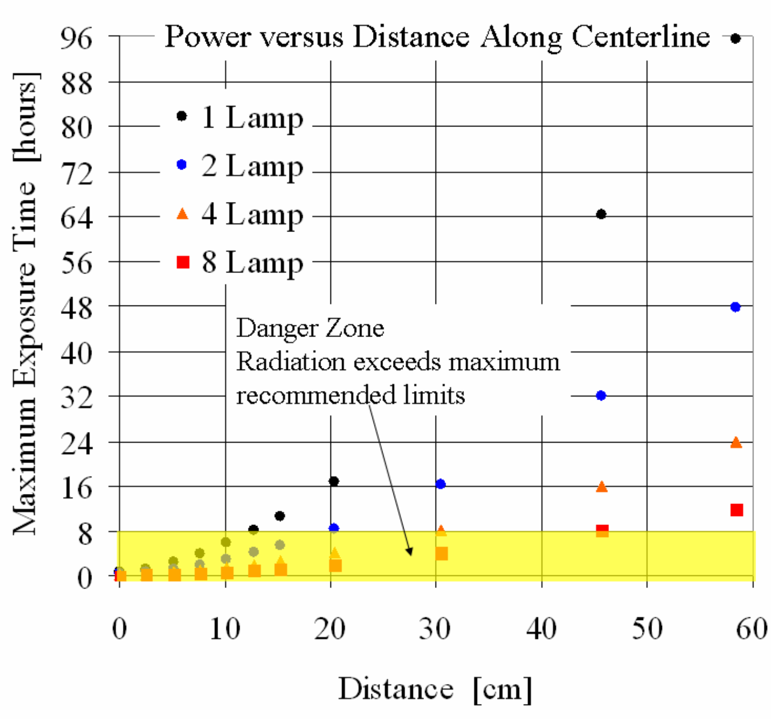


Figure 4: Maximum recommended exposure time limit as a function of distance for an LM2X-400. Note that use of multiple lamps increases the safe working distance.