Compliance of Infrared Communication Products to IEC 825-1 and CENELEC EN 60825-1

Application Note 1118

Introduction

Products compliant with or merely interoperable under the Infrared Data Association (IrDA) Specifications 1.0 and 1.1 also must be eye safe, and in some geographical regions, compliant with national, regional or international eye safety standards.

It is the responsibility of the final product manufacturer to ensure that the product is eye safe and compliant with applicable safety standards.

Infrared, visible or ultraviolet electromagnetic radiation, in sufficient quantity or concentration, can cause damage to the human eye. Many cases of laser induced eye damage have been documented; in addition, a number of studies have been made of laser induced damage in eyes of animals that have eyes similar to human eyes. From this information, experts world-wide have compiled damage thresholds over a wide wavelength range and for ranges of other appropriate parameters.

Given the damage threshold data, applying a safety factor enables the calculation of a set of Maximum Permissible Exposures (MPEs). For a set of conditions,

the MPE is the maximum electromagnetic radiation exposure that is deemed to be safe.

Given the MPEs, the method of viewing must be considered (with light gathering optical aids, naked eye, diffuse reflection). For each method of viewing, a set of Accessible Emission Levels (AELs) can be calculated. A particular emitter may be safe to view with the naked eye, but not safe if light gathering optical aids may be used. This application note concerns itself only with the AEL classification, and not MPE.

To date, while light emitting diodes (LEDs) have not been found to be the cause of any eye damage, increases in LED efficiency and power indicate that eventually they may be able to do so. Therefore, the International Electrotechnical Commission (IEC), through its Technical Committee 76, Laser Equipment (TC 76) has included LEDs in its basic laser safety standard, IEC 825-1 (Nov. 1993). While the IEC is a voluntary standards organization, its standards may be adopted as national standards. Specifically, the European Committee for Electrotechnical Standardization (CENELEC) has

adopted IEC 825-1 as EN 60825-1 (1994), which has been issued as national standards by the member European countries. In those countries, compliance of LED products is required.

Thus, any product that employs LEDs is subject to IEC 825-1 in CENELEC countries.

Components are not subject to the standards. Citing IEC 825-1:1993, section 1:

"However, laser products which are sold to other manufacturers for use as components of any system for subsequent sale are not subject to IEC 825-1, since the final product will itself be subject to this standard. "Throughout this part 1 light emitting diodes (LED) are included whenever the word 'laser' is used."

Thus, final products must be classified. What does classification mean? Simply, if your product is Class 1, you are not required to label the product, and must only declare the classification in the product information. Above Class 1, external warning labels with a hazard symbol and an explanatory warning label are also required.

Calculations of eye safety exposure limits are presented below. Next, measurement procedures are presented, followed by requirements on published information and labeling, then by information on HP products regarding compliance with IEC 825-1. This is followed by a section containing information about the IEC and CENELEC, including contact information.

Steps to Determine Classification of Systems

1. Given MPE based upon IEC 825-1, calculate the AEL Class 1 limit based upon wavelength, apparent source size, pulse duty factor, and exposure duration. AEL Class 1 limits have been calculated for IrDA systems emitting short infrared pulses, and for systems emitting infrared light continuously. (See the AEL Class 1 Radiant Intensity Limit chart).
2. Measure the actual AEL of the system.
3. Compare the AEL of the system with the AEL Class 1 limit for both pulsed emission and for continuous emission.
4. Consider operating conditions which may cause a single fault condition. If a single fault condition can cause increased emission, make sure that the AEL classification takes this into account.

Definition of Terms

MPE = Maximum Permissible Exposure. MPE is approximately 1/10th of the level of electromagnetic radiation exposure which will cause damage in 50% of human eyes.
AEL = Accessible Emission Level. AEL represents the amount of

electromagnetic emission that is accessible by a human eye. AEL class limits are usually expressed in Watts or Joules. AEL is dependent on the system's light output power, wavelength, apparent source size, and pulse or exposure duration.

Wavelength (λ) = Wavelength of the source at which the peak light intensity occurs (875 nm for typical IrDA systems). If more than one peak occurs in the emission spectrum, then the lowest peak wavelength should be chosen for λ.

Apparent source size (s) = as stated in IEC 825-1, the size of the real or virtual object that forms the smallest possible retinal image. The apparent source size, s, is then defined as the diameter of a circular aperture at the source, containing (1 - 1/e) or approximately 63.2% of the source's total emitted optical power (e~2.71828). See Figure 1.

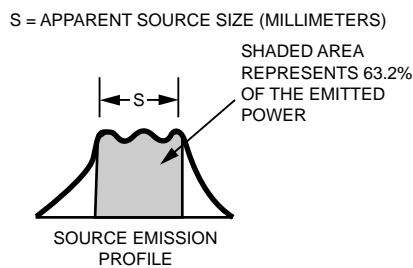S = APPARENT SOURCE SIZE (MILLIMETERS)

Figure 1.

Apparent source angular subtense (α) = The angle subtended by the apparent source, measured at a distance of 100 mm from the source. α is the angle subtended that completely contains the apparent source size, at a distance of 100 mm from the source. For apparent source size $s \leq 10$ mm, then $\alpha \cong 10 \times s$ (milliradians), where s is expressed in millimeters. See Figure 2.

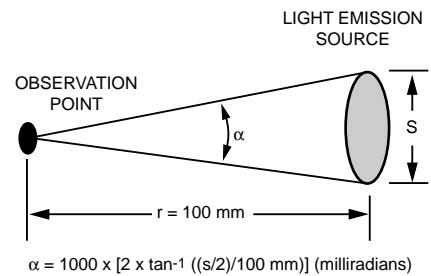$\alpha = 1000 \times [2 \times \tan^{-1}((s/2)/100 \text{ mm})]$ (milliradians)

Figure 2.

Aperture Diameter (d) = The diameter of the measurement aperture used to measure AEL from the system source. The aperture diameter can be set at 7 mm, and the measurement distance, r, is then calculated. Alternatively, the measurement distance, r, can be set at 100 mm, and the aperture diameter calculated. The calculations are based on apparent source size, s, and the fixed parameter d or r. See the measurement section for further details.

Measurement Distance (r) = The distance from the system source to the measurement aperture during the AEL measurement. See Aperture Diameter definition for details on calculation or setting of the correct measurement distance, r.

Exposure duration (t) = The total amount of time the human eye is exposed to the light emission, expressed in seconds, for sources continuously emitting light. t is taken to be 100 seconds, unless a different value can be justified.

Pulse duration (p) = The time the source emits light in pulsed form. p is measured as the time between the leading and trailing edges of the pulse, at the 50% of peak amplitude level. If the pulse duration is greater than 0.25 seconds, then the source output is considered continuous (non-

pulsed). IrDA data rates of 9.6-115.2 kbits/second use modulation where p = (3/16)(1/bit rate). IrDA data rates of 0.576, 1.152 Mbits/second use modulation where p = (1/4)(1/bit rate). The IrDA data rate of 4.0 Mbits/second uses modulation where p = 125 ns.

Number of pulses (N) = The number of pulses in the exposure duration.

Source Intensity (IE) = The output power of the source expressed as an intensity in milliwatts per steradian (mW/sr). See the measurement section for conversion of power to power per solid angle in mW/sr.

Single Fault Condition = A fault condition caused by failure of a single portion of the system. The single failure could be in software, firmware, or hardware. If any single fault could cause the infrared emission to increase, then the AEL classification must be made for this case.

AEL (Accessible Emission Level) Class Limit Calculation

AEL class limits are calculated using the formulas in IEC 825-1 and EN 60825-1, Tables 1 - 4, and Notes to tables 1 - 4. The parameters of concern are wavelength (λ, in nm), apparent source angular subtense (α, in milliradians), exposure and pulse duration (t and p, in seconds), and the number of pulses in the exposure duration (N, dimensionless).

The amount of hazardous exposure to the human eye depends upon the quantity of emission that gets absorbed by the eye, the extent to which that absorption is spread across the eye tissue, and the total amount of exposure time (t). The quantity of emission absorbed depends upon emission wavelength (λ) and intensity (IE). The extent to which the absorption is spread across the eye tissue depends upon the apparent source angular subtense (α).

The procedure for calculating the AEL Class limit is as follows:
1. Measure the apparent source size, s. See the measurements section for measuring apparent source size.
2. Calculate the angular subtense, α, of the system's source.
3. Calculate the AEL Class limit.

For source wavelength λ = 700-1050 nm, the AEL **Class 1 limit** is calculated as:
Limit = [0.0007 $t^{0.75}$ C_4 C_6 Joules] [1000 / t] milliwatts

t = exposure duration in seconds
$C_4 = 10^{[0.002 (\lambda - 700)]}$
$C_6 = 1$ for $\alpha < \alpha_{min}$
$C_6 = \alpha/\alpha_{min}$ for $\alpha_{min} < \alpha < \alpha_{max}$

$C_6 = 100/\alpha_{min}$ for $\alpha > \alpha_{max}$

where $\alpha = 1000 \times [2 \times \tan^{-1}((s/2)/100 \text{ mm})]$ (milliradians)
s = apparent source size (millimeters)

The angular subtense parameter α_{max} is defined as 100 milliradians. α_{max} = 100 mr is taken as the largest reasonable subtense which can be sharply focused by a human eye.

α_{min} is the apparent source angular subtense above which the source is considered an extended source. Because of eye movement, this is a function of time.

α_{min} = 1.5 milliradians for
t < 0.7 seconds

= 2.0 $t^{0.75}$ milliradians for
0.7 seconds < t
< 10 seconds

= 11.0 milliradians for
t > 10 seconds

The AEL **Class 3A limit** is 5 times the Class 1 limit.

Based upon the formulation, examples of the AEL **Class 1 limit** calculation are shown in the AEL Limit Calculation Table 1 below.

The above calculations for AEL Class Limits are easily applied to

Table 1. AEL Limit Calculations (Wavelength λ = 870 in all cases)

Exposure Duration (t) (seconds)	Apparent Source Size (s) (millimeters)	Angular Subtense (α) (milliradians)	AEL Class 1 Limit (milliwatts)
10.0	2.0	20.0	1.566
100.0	2.0	20.0	0.880
10.0	3.0	30.0	2.349
100.0	3.0	30.0	1.321

single pulse exposures of duration t. The AEL Class Limits can be applied to a source emitting a train of pulses. Adjustment of the AEL Class Limit or adjustment of the source's measured power can be done to account for emission of a pulse train rather than a single pulse. The adjustments for sources emitting a train of pulses are described in the Classification of an Infrared System section.

Measurement of the System's AEL

Classification of the system cannot be done based solely on theoretical calculations of emission parameters and AEL. The following parameters need to be measured to classify the system:

1. Source Wavelength (λ)
2. Apparent Source Size (s)
3. Source's accessible output power or energy (AEL)
4. Ranges of variation in the above three parameters

The AEL parameter can be measured on typical systems and under typical use conditions. The ranges of variation in parameters 1, 2, and 3 can then be used to define the AEL distribution for the system over variations in material and operating conditions. The ranges of variation in parameters 1, 2, and 3 should be measured for the range of allowed process variation in the source material (radiation pattern variability, source light output variation), and for the range of allowed variation in the operating conditions of the system (source drive current, temperature) .

The supplier of the infrared source should have measured data for 1, 2, and 4 above. The supplier of the infrared source should also have measured data for the source's

intensity variation, which can be used to determine the variation in parameter 3. The system designer can then measure item 3 on a typical system to complete the measurements.

Wavelength:
The supplier of the source's emitter should provide a distribution of light versus wavelength based upon measured data. The lowest peak wavelength allowed by the source's process variation should be used to calculate the AEL Class limit (870 nm for most IrDA sources).

Apparent Source Size:
The apparent source size is how large the source appears (not the actual size of the emitter chip or the molded lens diameter). One method to determine apparent source size is to form an image of the source with a relay lens, as shown below. By placing the emitter at a distance of twice the focal length of the lens, an image of size equal to the source will form at the same distance on the

other side of the lens. The image can then be scanned with a small photodiode or with a CCD camera system to determine the distribution of emitted light. See Figure 3.

The apparent source size is deemed to be the diameter of a circular aperture containing approximately 63.2% of the total emitted light. The distribution of emitted light can be numerically integrated to determine the apparent source size. The numerical integration can be expressed by the double integral over a circular aperture, using the angular variable θ, and the radial variable r. The apparent source size s is twice r*, where r* is the aperture radius which defines the circle containing 63.2% of the total emitted radiation.

Source's Accessible Output Power AEL:
Measurements of source output power must be made at the correct distance, r, and with the correct aperture diameter, d. Under the new amendment to IEC 825-1 (and
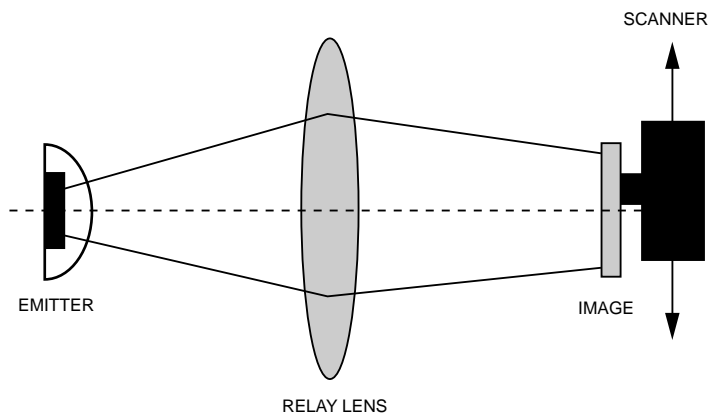
Figure 3.

Equation

$$0.632 = \int_0^{r^*} \int_0^{2\pi} f(r,\theta)\, r\, dr\, d\theta \Big/ \int_0^{r_{max}} \int_0^{2\pi} f(r,\theta)\, r\, dr\, d\theta$$

CENELEC EN60825-1) the conditions for measuring output power, source to measurement aperture distance, r, and aperture diameter, d, are functions of apparent source size, s.

The measurement distance, r, and measurement aperture diameter, d, are derived from apparent source size, s, as shown in Table 2.

A fixed aperture of 7.0 mm can be easier to implement, and then adjust the measurement distance according to the calculation. Whether the aperture is fixed at 7.0 mm or the distance is fixed at 100 mm, only light output power passing through the aperture is measured for comparison to the AEL Class limits.

Source output power can be derived from measured photocurrent resulting from light collected on a calibrated photodiode detector. Measured photocurrent in amps can be converted to detected power in watts, using the calibration factor in amps/watt.

Once the source output power in watts has been determined, it can be compared with the AEL Class limits for classification.

Conversion from watts to watts/steradian:
Sometimes it is convenient to express both the AEL Class limit and the measured AEL of the system in terms of watts/steradian. System source radiant intensity is often specified in milliwatts per steradian.

Apparent source angular subtense, α, is the 2-dimensional angle subtended by the source's radiated light image at a distance of 100 mm. A 3-dimensional angle (solid angle)

Table 2.

Aperture Diameter (d)	Measurement Distance (r)
Fixed at 7.0 millimeters	$100 \, (s / 10 + 0.0046)^{0.5}$ millimeters
$7 \, (s / 10 + 0.0046)^{-0.5}$ millimeters	Fixed at 100 millimeters
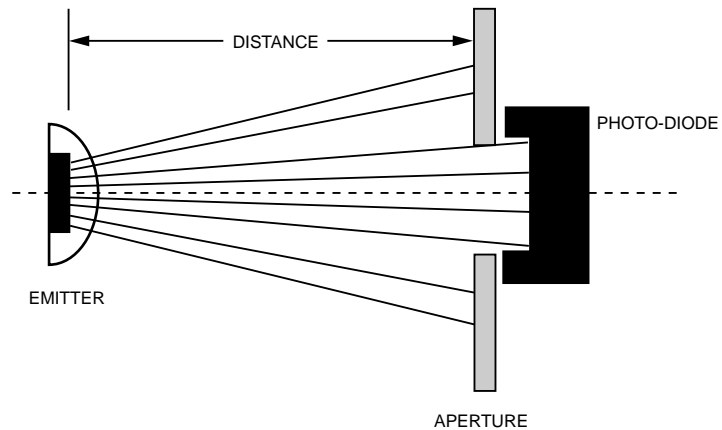
Figure 4.

subtended by the source's radiated light image can be expressed in units of steradians. A hemisphere (1/2 of a sphere) subtends a solid angle of 2π steradians. The solid angle, Ω, subtended by a cone of full angle, θ, is given by:
$$\Omega = 2\pi \, [1 - \cos(\theta/2)]$$

Given the measurement distance, r, and the aperture diameter, d, the solid angle given by:

$$\Omega = 2\pi \, (1 - \cos \, [\tan^{-1}(d/2r)])$$

The measured AEL and AEL Class limits can now be expressed in milliwatts/steradian:

AEL (milliwatts/steradian) = AEL (milliwatts) / Ω (steradians)

Given the measurement distance, r, and the aperture diameter, d, the AEL is:

AEL (mW/sr) = AEL (mW)/ $[2\pi \, (1 - \cos \, [\tan^{-1}(d/2r)])]$

Limits for Pulsed Sources:
For pulsed applications, specific aspects of the system's AEL must be compared against the AEL Class limits to determine classification. For a given AEL Class, the following three requirements must be met in order to gain classification at that class level.

1. The exposure from any single pulse within a pulse train shall not exceed the AEL Class Limit for a single pulse.

2. The average power for a pulse train of duration t shall not exceed the power corresponding to the AEL Class Limits given in Tables 1, 2, 3 and 4, respectively for a single pulse of duration t.

3. The exposure from any single pulse within a pulse train shall not exceed the AEL Class Limit for a single pulse multiplied by the correction factor C5:

   AEL_{train} = (AEL_{single} Class Limit) x C5,

   C5 is only applicable to pulse durations shorter than 0.25 seconds,

AELtrain = AEL for any single pulse in the pulse train,

AELsingle Class Limit = AEL Class Limit for a single pulse,

$C5 = N^{-1/4}$,

N = number of pulses in the pulse train during the appli-cable time base

To date, all IrDA compliant applications have been constrained by the average power limit. For relatively low energy pulses of reasonable average duty factor, the single pulse and pulse train limits have proven to be higher than the average power limit. Therefore, this document will be limited to average power calculations. It is recommended that all three cases be considered for any new application.

Classification of an Infrared System

The following procedure is recommended for classification of an infrared system:

1. Measure the Apparent Source Size, s, of your system's infrared transmitter.
2. Calculate the AEL Class limit in milliwatts or milliwatts/steradian for continuous exposure. Use the minimum peak wavelength of your system (870 nm for example).
3. Calculate appropriate AEL Class limits for continuous emission, and for a pulse train, given a pulse duty cycle.
4. Determine the appropriate measurement distance, r, and aperture diameter, d, for measurement of the AEL of your system.
5. Measure the AEL through an aperture of diameter = d of your system's infrared transmitter, given the measurement distance = r. Convert the measured AEL to milliwatts or milliwatts/steradian.
6. Using the maximum variation in source intensity from process variation and application drive current tolerance, calculate the maximum AEL of your system. The maximum variation in source intensity can be applied to the measured typical AEL of your system.
7. Consider whether a single fault in the system could cause increased infrared emission. If so, then the system's AEL classification must be based on the increased emission case.
8. Given the minimum apparent source size, s, and the system's maximum AEL, determine whether your system can be classified as AEL Class 1 or Class 3A. Compare the measured AEL with the calculated AEL Class 1 limit.

Examples of Classification:
AEL Classification Example. See Table 3.

Figure 5 shows the AEL Class 1 limit (cw) and Peak Power limit (3/16 or 1/4 duty factor) given:
• Wavelength λ = 870 nm
• Aperture Diameter d = 7 mm
• Exposure Duration t = 100 s

Single fault operation:
Infrared sources normally used only in pulsed mode can often have AEL's close to or exceeding their AEL Class 1 limit when emitting continuously for a time duration, t.
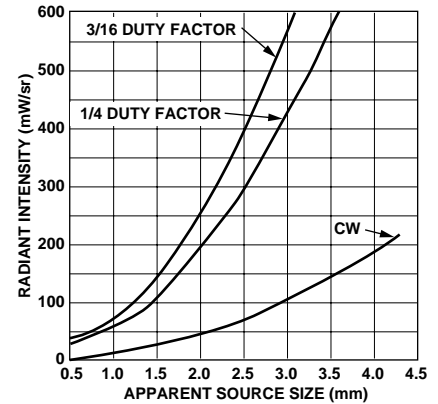

Figure 5. Apparent Source Size vs. Radiant Intensity.

Table 3. AEL Classification Examples.
(Wavelength λ = 870 nm, Aperture Diameter d = 7 mm, Exposure Duration t = 100 s, for all examples)

Apparent Source Size (s) (mm)	Measurement Distance (r) (mm) (See Table 2)	Solid Angle (Ω) (sr)	AEL Class 1 Limit (mW)	AEL Class 1 Limit (mW/sr)	AEL Class 1 Limit of Peak Power for a 25% duty factor pulse train (mW/sr)
2.0	45.2	0.0187	0.88	47.1	188.2
3.0	55.2	0.0126	1.32	104.8	419.2
3.3	57.8	0.0115	1.45	126.6	506.5
4.0	63.6	0.00949	1.76	185.5	741.8

The continuous emission case occurs when faults in the system have biased the source to continuously emitted infrared light.

Infrared systems could also experience faults which may cause an increase in source drive current and so an increase in AEL. Such faults could cause the system to increase the exposure risk and therefore change classification.

In order to protect against exposure to infrared light in the case of such faults, an analysis of the emitter module and its operating environment must be done. The analysis should identify possible faults that can affect the output power or energy. IEC 825-1, Section 8.1, states:

"Tests during operation shall be used to determine the classification of the product. Tests during operation, maintenance and service shall also be used as appropriate to determine the requirements for safety interlocks, labels and information for the user. Such tests shall be made under each and every reasonably foreseeable single fault condition."

Thus, any fault, which, by itself, can increase the optical output should be considered. A judgment must be made of the "reasonableness" of the fault. If a particular fault is extremely unlikely, it can be neglected, if the low likelihood can be justified. The effect of any reasonable fault must be quantified, either by experiment, or by calculation based on experimental information.

The AEL classification must be determined under the worst single fault condition.

Required Information:
Citing IEC 825-1, section 5.8:
"Each laser [or LED] product (except those of Class 1) shall be described on the explanatory label (Figure 15) by a statement of the maximum output of laser radiation, the pulse duration (if appropriate) and the emitted wavelength(s). The name and publication date of the standard to which the product was classified shall be included on the explanatory label or elsewhere in close proximity on the product."

In addition: from section 6.2:
"Manufacturers of laser products shall provide or cause to be provided:
a) In all catalogues, specification sheets and descriptive brochures, the safety classification of each laser product shall be stated."

In summary:
1. For AEL Class 1, labels are not required, but the classification must be declared in the product literature.
2. For AEL Class 3A (Class 2 only applies to sources of visible radiation), labels (warning symbol and explanatory label) are required, as well as information in the product literature.

Application Information for Hewlett-Packard Infrared Transceivers and Emitters

AEL classification is only relevant to an assembled electronic system. Hewlett-Packard infrared components can be the main contributor to classification calculations and measured data in a given system. Other contributors would be the drive and bias circuitry for the transceiver or emitter, and any optical media placed in front of the transceiver or emitter.

AEL classification calculations and measurements have been performed on Hewlett-Packard infrared components under specific drive conditions, and specific viewing conditions. These calculations and measurments can be used as a reference in designing a system. The AEL of the final system can be similar to the reference AEL classification if certain drive circuitry and optical port design guidelines are followed. However, the final system AEL classification should always be completed through calculation and measurement as a final check.

HSDL-1000, HSDL-1001
The apparent source size, s, of the HSDL-1000 and HSDL-1001 infrared transceivers has been measured as viewed through the transceiver package lens. The measured size, s, has been used to calculate an AEL Class limit, treating the bare transceiver as a complete system. Using measurements and allowed process distribution data for the HSDL-1000 and HSDL-1001, maximum AEL levels have been calculated based upon a range of transmitter drive conditions.

Shown in Tables 4 and 5 are the results of the AEL class limit calculation, and the AEL level calculations. Note that these values are only valid for the listed operating conditions, and for the condition of viewing the transceiver with no optical media between the viewer and the transceiver package.

The HSDL-1000 and HSDL-1001

Table 4. HSDL-1000, -1001 Operating Conditions.

Ambient Temperature	0 - 70°C
LED Current	250 - 500 mA (Pulsed Mode Only)
Optical Interface	None
Pulse Duty Cycle	25.7% maximum
Pulse Width	90 μs maximum

Table 5. HSDL-1000, -1001 AEL Calculations.

Apparent Source Size	2.25 mm
AEL Class 1 Limit (CW)	59 mW/sr
AEL Class 1 Limit (3/16 duty cycle)	316 mW/sr
Typical Calculated AEL for the operating conditions listed above and for 3/16 duty cycle pulses	150 mW/sr

Table 6. HSDL-1000, -1001 R_{LED} Selection

Maximum V_{CC} (volts)	Minimum Allowed R_{LED} (ohms) (including all tolerances)
5.5 V	5.3
3.3 V	1.0

Table 7. HSDL-1100 Operating Conditions

Ambient Temperature	0 - 70°C
LED Current	400 - 600 mA (Pulsed Mode Only)
Optical Interface	None
Pulse Duty Cycle	25.7% maximum
Pulse Width	90 μs maximum

Table 8. HSDL-1100 AEL Calculations

Apparent Source Size	3.0 mm
AEL Class 1 Limit (CW)	105 mW/sr
AEL Class 1 Limit (3/16 duty cycle)	559 mW/sr
AEL Class 1 Limit (25% duty cycle)	419 mW/sr
Typical Calculated AEL for the operating conditions listed above	300 mW/sr

should never be used in the continuous emission mode (as outlined in their respective datasheets). The system designer should make sure that no single system fault could cause the HSDL-1000 or HSDL-1001 transceiver to operate in the continuous emission mode.

The system designer should choose V_{CC}, R_{LED}, and the optical interface so as to preserve the operating conditions outlined above. V_{CC} and R_{LED} should be chosen so that $I_{LED} \leq 500$ mA in pulse amplitude. The minimum R_{LED} allowed, including all tolerances on its value in ohms, is shown in Table 6 for a given supply voltage V_{CC}.

The optical interface should be designed so as not to alter the radiation pattern of the transmitted light.

HSDL-1100
The apparent source size, s, of the HSDL-1100 infrared transceiver has been measured as viewed through the transceiver package lens. The measured size, s, has been used to calculate an AEL Class limit, treating the bare transceiver as a complete system. Using measurements and allowed process distribution data for the HSDL-1100 maximum AEL levels have been calculated based upon a range of transmitter drive conditions.

Shown in Tables 7 and 8 are the results of the AEL class limit calculation, and the AEL level calculations. Note that these values are only valid for the listed operating conditions, and for the condition of viewing the transceiver with no optical media between the viewer and the transceiver package.

The HSDL-1100 should never be used in the continuous emission mode (as outlined in their respective datasheets). The system designer should make sure that no single system fault could cause the HSDL-1100 transceiver to operate in the continuous emission mode.

The system designer should choose V_{CC}, R_{LED}, and the optical interface so as to preserve the operating conditions outlined above. V_{CC} and R_{LED} should be chosen as follows in order to keep $I_{LED} \leq 600$ mA in pulse amplitude. The minimum R_{LED} allowed, including all tolerances on its value in ohms, is shown in table 9 for a given supply voltage V_{CC}.

The optical interface should be designed so as not to alter the radiation pattern of the transmitted light.

System Recommendations for Achieving AEL Class 1

Cosmetic Window:
Many infrared systems place a cosmetic window in front of the lens of the infrared source. The window should not be used to focus the light emitted from the infrared source. If focusing is desired, then special attention to the changes in apparent source size, and AEL levels need to be made.

Drive Circuitry:
The infrared transmitter should be driven and biased to achieve the desired link distance, using the lowest emitter current I_{LED} possible. I_{LED} should certainly not exceed the recommended operating conditions shown in the respective datasheet.

Table 9. HSDL-1100 R_{LED} Selection

Maximum V_{CC} (volts)	Minimum Allowed R_{LED} (ohms) (including all tolerances)
5.25 V	4.46

The infrared transmitter's drive circuitry, including the voltage supply and bias resistor, should be chosen to minimize variation in the infrared source's current. The emitter current I_{LED} is usually biased at the minimum recommended in the application to achieve a specified radiant intensity (IE). Variation in I_{LED} due to voltage supply and resistor tolerances can give unnecessary variation in radiant intensity. The variation in radiant intensity could cause the source's AEL to exceed the Class 1 limit.

AC coupling of the transmitter's drive circuitry should be considered in order to keep upstream software or hardware issues from biasing the infrared emitter in continuous emission mode.

Involved Standards Organizations

IEC:
The International Electrotechnical Commission, founded in 1906, has its headquarters in Geneva, Switzerland. It is an international voluntary standards organization whose object "... is to promote international cooperation on all questions of standardization and related matters in the fields of electrical and electronic engineering and thus to promote international understanding." (IEC Statutes - Article 2). In addition to

the information below, the IEC may be contacted and perhaps documents may be procured through one's national committee.

Contacting information:

IEC Central Bureau
3, rue de Varembe
P.O. Box 131
Geneva, Switzerland

41 22 919 02 11 - telephone
41 22 919 03 00 - fax

http://www.iec.ch/
world wide web address

CENELEC:
The European Committee for Electrotechnical Standardization, founded in 1973, has its headquarters in Brussels, Belgium. It is "...a non-profit -making organization under Belgian law to help create an electrotechnical marketplace in Europe that is open to non-European suppliers..." (CENELEC 1995 Catalog). Contacting information:

CENELEC
Rue de Strassart 35
B-1050
Brussels, Belgium

32 2 519 68 71 - telephone
32 2 519 69 19 - fax

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Data Subject to Change