Symbols and Terminology

A **Anode**, anode terminal

A **Ampere**, SI unit of electrical current

A **Radiant sensitive area**, that area which is radiant sensitive for a specified range

a **Distance**, e.g. between the emitter (source) and the detector

B **Base**, base terminal

BER **Bit Error Rate**

bit/s **Data rate or signaling rate**
1000 bit/s = 1 kbit/s, 10^6 bit/s = 1 Mbit/s

C **Capacitance,** unit: F (farad) = C/V

C **Coulomb,** C = s x A

C **Cathode**, cathode terminal

C **Collector**, collector terminal

°C **Degree Celsius,** Celsius temperature, symbol t, and is defined by the quantity equation $t = T - T_0$. The unit of Celsius temperature is the degree Celsius, symbol °C. The numerical value of a Celsius temperature t expressed in degrees Celsius is given by t/°C = T/K - 273.15
It follows from the definition of t that the degree Celsius is equal in magnitude to the Kelvin, which in turn implies that the numerical value of a given temperature difference or temperature interval whose value is expressed in the unit degree Celsius (°C) is equal to the numerical value of the same difference or interval when its value is expressed in the unit Kelvin (K).

C_{CEO} **Collector emitter capacitance,** Capacitance between the collector and the emitter with open base

cd **Candela,** SI unit of luminous intensity. The candela is the luminous intensity, in a given direction, of a source that emits monochromatic radiation of frequency 540 Hz x 1012 Hz and that has a radiant intensity in that direction of 1/683 W per steradian. (16th General Conference of Weights and Measures, 1979), 1 cd = 1 lm · sr^{-1}

C_D **Diode capacitance,** total capacitance effective between the diode terminals due to case, junction and parasitic capacitances

Cj **Junction capacitance,** capacitance due to a p-n junction of a diode, decreases with increasing reverse voltage

d **Apparent (of virtual) source size** (of an emitter), the measured diameter of an optical source used to calculate the eye safety laser class of the source. See IEC 60825-1 and EN ISO 11146-1

D* **Detectivity** $\sqrt{A}/NEP$

E **Emitter,** Emitter terminal (phototransistor)

E_A **Illumination at standard illuminant A**, according to DIN 5033 and IEC 306-1, illumination emitted from a tungsten filament lamp with a color temperature T_f = 2855.6 K, which is equivalent to standard illuminant A, unit: lx (Lux) or klx

$E_{A\,amb}$ **Ambient illumination** at standard illuminant A

echo-off Unprecise term to describe the behavior of the output of IrDA® transceivers during transmission. “Echo-off” means that by blocking the receiver the output RXD is quiet during transmission

echo-on Unprecise term to describe the behavior of the output of IrDA® transceivers during transmission. “Echo-on” means that the receiver output RXD is active but often undefined during transmission. For correct data reception after transmission the receiver channel must be cleared during the latency period

E_e, E **Irradiance** (at a point of a surface), quotient of the radiant flux $d\Phi_e$ incident on an element of the surface containing the point, by the area dA of that element. Equivalent definition. Integral, taken over the hemisphere visible from the given point, of the expression $L_e \cdot \cos\theta \cdot d\Omega$, where L_e is the radiance at the given point in the various directions of the incident elementary beams of solid angle $d\Omega$, and θ is the angle between any of these beams and the normal to the surface at the given point

$$E_e = \frac{d\Phi_e}{dA} = \int_{2\pi sr} (L_e \cdot \cos\theta \cdot d\Omega)$$

unit: W · m^{-2}

E_v, E **Illuminance** (at a point of a surface), quotient of the luminous flux $d\Phi_v$ incident on an element of the surface containing the point, by the area dA of that element. Equivalent definition. Integral, taken over the hemisphere visible from the givenpoint, of the expression $L_v \cdot \cos\theta \cdot d\Omega$, where L_v is the luminance at the given point in the various directions of the incident elementary beams of solid angle $d\Omega$, and θ is the angle between any of these beams and the normal to the surface at the given point

$$E_v = \frac{d\Phi_v}{dA} = \int_{2\pi sr} (L_v \cdot \cos\theta \cdot d\Omega)$$

unit: lx = lm · m^{-2}

F **Farad,** unit: F = C/V

f **Frequency,** unit: s^{-1}, Hz (Hertz)

f_c, f_{cd} **Cut-off frequency** - detector devices, the frequency at which, for constant signal modulation depth of the input radiant power, the demodulated signal power has decreased to ½ of its low frequency value. Example: The incident radiation generates a photocurrent or a photo voltage 0.707 times the value of radiation at f = 1 kHz
(3 dB signal drop, other references may occur as e.g. 6 dB or 10 dB)

f_s **Switching frequency**

FIR **Fast infrared,** as SIR, data rate 4 Mbit/s

I_a **Light current,** general: current which flows through a device due to irradiation/illumination

I_B **Base current**

I_{BM} **Base peak current**

I_C **Collector current**

I_{ca} **Collector light current,** collector current under irradiation. Collector current which flows at a specified illumination/irradiation

I_{CEO} **Collector dark current, with open base,** collector emitter dark current. For radiant sensitive devices with open base and without illumination/radiation (E = 0)

I_{CM} **Repetitive peak collector current**

idle Mode of operation where the device (e.g. a transceiver) is fully operational and expecting to receive a signal for operation e.g in case of a transceiver waiting to receive an optical input or to send an optical output as response to an applied electrical signal.

I_e, I **Radiant intensity** (of a source, in a given direction), quotient of the radiant flux d Φ_e leaving the source and propagated in the element of solid angle dΩ containing the given direction, by the element of solid angle.
$I_e = d\Phi_e/d\Omega$, unit: $W \cdot sr^{-1}$
Note: The radiant intensity I_e of emitters is typically measured with an angle < 0.01 sr on mechanical axis or off-axis in the maximum of the irradiation pattern.

I_F **Continuous forward current,** the current flowing through a diode in the forward direction

I_{FAV} **Average (mean) forward current**

I_{FM} **Peak forward current**

I_{FSM} **Surge forward current**

I_k **Short-circuit current,** that value of the current which flows when a photovoltaic cell or a photodiode is short circuited ($R_L << R_i$) at its terminals

I_o **DC output current**

I_{ph} **Photocurrent,** that part of the output current of a photoelectric detector, which is caused by incident radiation.

I_R **Reverse current, leakage current,** current which flows through a reverse biased semiconductor p-n-junction

IR **Abbreviation for infrared**

I_{ra} **Reverse current under irradiation,** reverse light current which flows due to a specified irradiation/illumination in a photoelectric device
$I_{ra} = I_{ro} + I_{ph}$

IrDA® **Infrared Data Association,** no profit organization generating infrared data communication standards

IRED **Infrared emitting diode,** solid state device embodying a p-n junction, emitting infrared radiation when excited by an electric current. See also LED: solid state device embodying a p-n junction, emitting optical radiation when excited by an electric current.

I_{ro} **Reverse dark current, dark current,** reverse current flowing through a photoelectric device in the absence of irradiation

IRPHY Version 1.0, **SIR IrDA®, data communication specification** covering data rates from 2.4 kbit/s to 115.2 kbit/s and a guaranteed operating range more than one meter in a cone of ± 15°

IRPHY Version 1.1, MIR and FIR were implemented in the IrDA® standard with the version 1.1, replacing version 1.0

IRPHY Version 1.2, added the SIR low power standard to the IrDA® standard, replacing version 1.1. The SIR low power standard describes a current saving implementation with reduced range (min. 20 cm to other low power devices and min. 30 cm to full range devices).

IRPHY Version 1.3, extended the low power option to the higher bit rates of MIR and FIR replacing version 1.2.

IRPHY Version 1.4, VFIR was added, replacing version 1.3

I_{SB} **Quiescent current**

I_{SD} **Supply current in dark ambient**

I_{SH} **Supply current in bright ambient**

I_v, I **Luminous intensity** (of a source, in a given direction), quotient of the luminous flux dΦ_v leaving the source and propagated in the element of solid angle dΩ containing the given direction, by the element of solid angle. $I_e = d\Phi_v/d\Omega$, unit: $cd \cdot sr^{-1}$
Note: The luminous intensity I_v of emitters is typically measured with an angle < 0.01 sr on mechanical axis or off-axis in the maximum of the irradiation pattern.

K **luminous efficacy** of radiation, quotient of the luminous flux Φ_v by the corresponding radiant flux Φ_e: $K = \Phi_v / \Phi_e$, unit: $lm \cdot W^{-1}$
Note: When applied to monochromatic radiations, the maximum value of K(λ) is denoted by the symbol K_m.
$K_m = 683\ lm \cdot W^{-1}$ for $\nu_m = 540 \times 10^{12}$ Hz
($\lambda_m \approx 555$ nm) for photopic vision.
$K'_m = 1700\ lm \cdot W^{-1}$ for $\lambda'_m \approx 507$ nm for scotopic vision. For other wavelengths :
$K(\lambda) = K_m V(\lambda)$ and $K'(\lambda) = K'_m V'(\lambda)$

K **Kelvin,** SI unit of thermodynamic temperature, is the fraction 1/273.15 of the thermodynamic temperature of the triple point of water (13th CGPM (1967), Resolution 4). The unit Kelvin and its symbol K should be used to express an interval or a difference of temperature.
Note: In addition to the thermodynamic

temperature (symbol T), expressed in Kelvins, use is also made of Celsius temperature (symbol t) defined by the equation t = T - T_0, where T_0 = 273.15 K by definition. To express Celsius temperature, the unit “degree Celsius”, which is equal to the unit “Kelvin” is used; in this case, “degree Celsius” is a special name used in place of “Kelvin”. An interval or difference of Celsius temperature can, however, be expressed in Kelvins as well as in degrees Celsius.

Latency **Receiver latency allowance** (in ms or µs) is the maximum time after a node ceases transmitting before the node’s receiving recovers its specified sensitivity

LED and IRED

Light **E**mitting **D**iode, LED: solid state device embodying a p-n junction, emitting optical radiation when excited by an electric current. The term LED is correct only for visible radiation, because light is defined as visible radiation (see Radiation and Light). For infrared emitting diodes the term IRED is the correct term. Nevertheless it is common but not correct to use "LED" also for IREDs.

L_e; L **Radiance** (in a given direction, at a given point of a real or imaginary surface).

Quantity defined by the formula

$$L_e = \frac{d\Phi_v}{dA \cdot \cos\theta \cdot d\Omega} \quad ,$$

where $d\Phi_e$ is the radiant flux transmitted by an elementary beam passing through the given point and propagating in the solid angle dΩ containing the given direction; dA is the area of a section of that beam containing the given point; θ is the angle between the normal to that section and the direction of the beam, unit: $W \cdot m^{-2} \cdot sr^{-1}$

lm **Lumen,** unit for luminous flux

lx **Lux,** unit for illuminance

m **Meter,** SI unit of length

M_e; M **Radiant exitance** (at a point of a surface) - Quotient of the radiant flux $d\Phi_e$ leaving an element of the surface containing the point, by the area dA of that element. Equivalent definition. Integral, taken over the hemisphere visible from the given point, of the expression $L_e \cdot \cos\theta \cdot d\Omega$, where L_e is the radiance at the given point in the various directions of the emitted elementary beams of solid angle dΩ, and θ is the angle between any of these beams and the normal to the surface at the given point.

$$M_e = \frac{d\Phi_e}{dA} = \int_{2\pi sr} L_e \cdot \cos\theta \cdot d\Omega$$

unit: $W \cdot m^{-2}$

MIR **Medium speed IR,** as SIR, with the data rate 576 kbit/s to 1152 kbit/s

Mode Electrical input or output port of a transceiver device to set the receiver bandwidth

N.A. **Numerical Aperture,** N.A. = sin α/2

Term used for the characteristic of sensitivity or intensity angles of fiber optics and objectives

NEP **Noise equivalent power**

P_{tot} **Total power dissipation**

P_v **Power dissipation, general**

Radiation and Light

Visible radiation, any optical radiation capable of causing a visual sensation directly.

Note: There are no precise limits for the spectral range of visible radiation since they depend upon the amount of radiant power reaching the retina and the responsivity of the observer. The lower limit is generally taken between 360 nm and 400 nm and the upper limit between 760 nm and 830 nm.

Radiation and Light

Optical radiation, electromagnetic radiation at wavelengths between the region of transition to X-rays (λ = 1 nm) and the region of transition to radio waves (λ = 1 mm)

Radiation and Light IR

Infrared radiation, optical radiation for which the wavelengths are longer than those for visible radiation.

Note: For infrared radiation, the range between 780 nm and 1 mm is commonly sub-divided into:

IR-A 780 nm to 1400 nm

IR-B 1.4 µm to 3 µm

IR-C 3 µm to 1 mm

R_D **Dark resistance**

R_F **Feedback resistor**

R_i **Internal resistance**

R_{is} **Isolation resistance**

R_L **Load resistance**

R_S **Serial resistance**

R_{sh} **Shunt resistance,** the shunt resistance of a detector diode is the dynamic resistance of the diode at zero bias. Typically it is measured at a voltage of 10 mV forward or reverse, or peak-to-peak

R_{thJA} **Thermal resistance,** junction to ambient

R_{thJC} **Thermal resistance,** junction to case

RXD **Electrical data output** port of a transceiver device

s **Second,** SI-unit of time 1 h = 60 min = 3600 s

S **Absolute sensitivity**

Ratio of the output value Y of a radiant-sensitive device to the input value X of a physical quantity: S = Y/X, units: e.g. A/lx, A/W, A/(W/m^2)

s(λ_p) **Spectral sensitivity** at a wavelength λ_p

$s(\lambda)$ **Absolute spectral sensitivity** at a wavelength λ, the ratio of the output quantity y to the radiant input quantity x in the range of wavelengths
λ to $\lambda + \Delta\lambda$
$s(\lambda) = dy(\lambda)/dx(\lambda)$
E.g., the radiant power $\Phi_e(\lambda)$ at a specified wavelength λ falls on the radiationsensitive area of a detector and generates a photocurrent $I_{ph} \cdot s(\lambda)$ is the ratio between the generated photocurrent Iph and the radiant power $\Phi_e(\lambda)$ which falls on the detector. $s(\lambda) = I_{ph} / \Phi_e(\lambda)$, unit: A/W

$s(\lambda)_{rel}$ **Spectral sensitivity, relative,** ratio of the spectral sensitivity $s(\lambda)$ at any considered wavelength to the spectral sensitivity $s(\lambda_0)$ at a certain wavelength λ_0 taken as a reference
$s(\lambda)_{rel} = s(\lambda)/s(\lambda_0)$

$s(\lambda_0)$ **Spectral sensitivity** at a reference wavelength λ_0

SC Electrical input port of a transceiver device to set the receiver sensitivity

SD Electrical input port of a transceiver device to shut down the transceiver

Shutdown
Mode of operation where a device is switched to a sleep mode (shut down) by an external signal or after a quiescent period keeping some functions alive to be prepared for a fast transition to operating mode. Might be in some cases identical with “standby”

SIR **Serial Infrared,** term used by IrDA® to describe infrared data transmission up to and including 115.2 kbit/s. SIR IrDA® data communication covers 2.4 kbit/s to 115.2 kbit/s, equivalent to the basic serial infrared standard introduced with the physical layer version IrPhy version 1.0

Split power supply
Term for using **separated power supplies** for different functions in transceivers. Receiver circuits need well-controlled supply voltages. IRED drivers do not need a controlled supply voltage but need much higher currents. Therefore it safes cost not to control the IRED current supply and have a separated supply. For that some modified design rules have to be taken into account for designing the ASIC. This is used in nearly all Vishay transceivers and is described in US-Patent no. 6,157,476

sr **Steradian** (sr), SI unit of solid angle Ω. Solid angle that, having its vertex at the centre of a sphere, cuts off an area of the surface of the sphere equal to that of a square with sides of length equal to the radius of the sphere. (ISO, 31/1-2.1, 1978)
Example: The unity solid angle, in terms of geometry, is the angle subtended at the center of a sphere by an area on its surface numerically equal to the square of the radius (see figures below). Other than the figures might suggest, the shape of the area does not matter at all. Any shape on the surface of the sphere that holds the same area will define a solid angle of the same size. The unit of the solid angle is the **steradian (sr)**. Mathematically, the solid angle is dimensionless, but for practical reasons, the steradian is assigned.

Standby
Mode of operation where a device is prepared to be quickly switched into an idle or operating mode by an external signal.

T **Period of time** (duration)

T **Temperature,** 0 K = - 273.15 °C, unit: K (Kelvin)

t **Temperature,** °C (degree Celsius). Instead of t sometimes T is used not to mix up temperature T with time t

t **Time**

T_{amb} **Ambient temperature,** if self-heating is significant: temperature of the surrounding air below the device, under conditions of thermal equilibrium. If self-heating is insignificant: air temperature in the surroundings of the device

T_{amb} **Ambient temperature range,** as an absolute maximum rating: the maximum permissible ambient temperature range

T_C **Temperature coefficient,** the ratio of the relative change of an electrical quantity to the change in temperature (ΔT) which causes it under otherwise constant operating conditions

T_C **Colour temperature** (BE), the temperature of a Planckian radiator whose radiation has the same chromaticity as that of a given stimulus, unit: K
Note: The **reciprocal colour temperature** is also used, unit K^{-1} (BE).

T_{case} **Case temperature,** the temperature measured at a specified point on the case of a semiconductor device. Unless otherwise stated, this temperature is given as the temperature of the mounting base for devices with metal can

t_d **Delay time**

t_f **Fall time,** the time interval between the upper specified value and the lower specified value on the trailing edge of the pulse.
Note: It is common to use a 90 % value of the signal for the upper specified value and a 10 % value for the lower specified value.

T_j **Junction temperature,** the spatial mean value of the temperature during operation. In the case of phototransistors, it is mainly the temperature of the collector junction because its inherent temperature is the maximum.

t_{off} **Turn-off time,** the time interval between the upper specified value on the trailing edge of the applied input pulse and the lower specified value an the trailing edge of the output pulse. $t_{off} = t_{d(off)} + t_f$

t_{on} **Turn-on time,** the time interval between the lower specified value on the trailing edge of the applied input pulse and the upper specified value an the trailing edge of the output pulse. $t_{on} = t_{d(on)} + t_f$

t_p **Pulse duration,** the time interval between the specified value on the leading edge of the pulse and the specified value an the trailing edge of the output pulse.
Note: In most cases the specified value is 50 % of the signal

t_{pi} **Input pulse duration**

t_{po} **Output pulse duration**

t_r **Rise time,** the time interval between the lower specified value and the upper specified value on the trailing edge of the pulse.
Note: It is common to use a 90 % value of the signal for the upper specified value and a 10 % value for the lower specified value t_s storage time

t_s **Storage time**

T_{sd} **Soldering temperature,** maximum allowable temperature for soldering with a specified distance from the case and its duration

T_{stg} **Storage temperature range,** the temperature range at which the device may be stored or transported without any applied voltage

TXD Electrical data input port of a transceiver device

V **Volt**

$V(\lambda)$ **Standard luminous efficiency function** for photopic vision (relative human eye sensitivity)

$V(\lambda)$, $V'(\lambda)$
Spectral luminous efficiency (of a monochromatic radiation of wavelength λ); $V(\lambda)$ for photopic vision; $V'(\lambda)$ for scotopic vision).
Ratio of the radiant flux at wavelength λ_m to that at wavelength λ such that both radiations produce equally intense luminous sensations under specified photometric conditions and λ_m is chosen so that the maximum value of this ratio is equal to 1

V_{BEO} **Base emitter voltage, open collector**

$V_{(BR)}$ **Breakdown voltage,** reverse voltage at which a small increase in voltage results in a sharp rise of reverse current. It is given in technical data sheets for a specified current

$V_{(BR)}$ **CEO Collector emitter breakdown voltage, open base**

$V_{(BR)EBO}$ **Emitter base breakdown voltage, open collector**

$V_{(BR)ECO}$ **Emitter collector breakdown voltage, open base**

V_{CBO} **Collector-base voltage, open emitter,** generally, reverse biasing is carried out by applying a voltage to any of two terminals of a transistor in such a way that one of the junctions operates in reverse direction, whereas the third terminal (second junction) is specified separately.

V_{CC} **Supply voltage (positive)**

V_{CE} **Collector emitter voltage**

V_{CEO} **Collector emitter voltage, open base** ($I_B = 0$)

V_{CEsat} **Collector emitter saturation voltage,** the saturation voltage is the DC voltage between collector and emitter for specified (saturation) conditions, i.e., I_C and E_V (E_e or I_B), whereas the operating point is within the saturation region.

V_{dd} **Supply voltage (positive)**

V_{EBO} **Emitter base voltage, open collector**

V_{ECO} **Emitter collector voltage, open base**

V_F **Forward voltage**, the voltage across the diode terminals which results from the flow of current in the forward direction

VFIR As SIR, data rate 16 Mbit/s

V_{logic} **Reference voltage** for digital data communication ports

V_{no} **Signal-to-noise ratio**

V_O **Output voltage**

ΔV_O **Output voltage change** (differential output voltage)

V_{OC} **Open circuit voltage,** the voltage measured between the photovoltaic cell or photodiode terminals at a specified irradiance/illuminance (high impedance voltmeter!)

V_{OH} **Output voltage high**

V_{OL} **Output voltage low**

V_{ph} **Photovoltage,** the voltage generated between the photovoltaic cell or photodiode terminals due to irradiation/ illumination

V_R **Reverse voltage** (of a junction), applied voltage such that the current flows in the reverse direction

V_R **Reverse (breakdown) voltage,** the voltage drop which results from the flow of a defined reverse current

V_S **Supply voltage**

V_{ss} (Most negative) **supply voltage** (in most cases: ground)

$\pm \varphi_{1/2}$ **Angle of half transmission distance**

η **Quantum efficiency**

$\theta_{1/2}$; $\pm \varphi = \alpha/2$
Half-intensity angle, in a radiation diagram, the angle within which the radiant (or luminous) intensity is greater than or equal to half of the maximum intensity.
Note: IEC 60747-5-1 is using $\theta_{1/2}$. In Vishay datasheets mostly $\pm \varphi = \alpha/2$ is used

$\theta_{1/2}$; $\pm \varphi = \alpha/2$
Half-sensitivity angle, in a sensitivity diagram, the angle within which the sensitivity is greater than or equal to half of the maximum sensitivity.
Note: IEC 60747-5-1 is using $\theta_{1/2}$. In Vishay datasheets mostly $\pm \varphi = \alpha/2$ is used

Ω **Solid angle,** see sr, steradian for IEC 60050(845)-definition. The space enclosed by rays, which emerge from a single point and lead to all the points of a closed curve. If it is assumed that the apex of the cone formed in this way is the center of a sphere with radius r and that the cone intersects with the surface of the sphere, then the size of the surface area (A) of the sphere subtending the cone is a measure of the solid angle Ω. $\Omega = A/r^2$. The full sphere is equivalent to 4πsr. A cone with an angle of $\alpha/2$ forms a solid angle of $\Omega = 2\,\pi(1 - \cos\,\alpha/2) = 4\,\pi\,\sin^2\,\alpha/4$, unit: sr

λ_m **Wavelength** of the maximum of the spectral luminous efficiency function $V(\lambda)$

$\Delta\lambda$ **Range of spectral bandwidth (50 %),** the range of wavelengths where the spectral sensitivity or spectral emission remains within 50 % of the maximum value

Φ_e; Φ; P
Radiant flux; radiant power, power emitted, transmitted or received in the form of radiation.
unit: W, W = Watt

Φ_v; Φ; **Luminous flux,** quantity derived from radiant flux Φ_e by evaluating the radiation according to its action upon the CIE standard photometric observer. For photopic vision

$$\Phi_v = K_m \int_0^{\infty} \frac{d\Phi_e\lambda}{d\lambda} \cdot V(\lambda) d\lambda,$$

where $\frac{d\Phi_e\lambda}{d\lambda}$ is the spectral distribution of the radiant flux and $V(\lambda)$ is the spectral luminous efficiency, unit : lm, lm: lumen, K_m = 683 lm/W:
Note: For the values of K_m (photopic vision) and K'm (scotopic vision), see IEC 60050 (845-01-56).

λ **Wavelength,** general

λ_c **Centroid wavelength,** centroid wavelength λ_c of a spectral distribution, which is calculated as "centre of gravity wavelength" according to

$$\lambda_c = \int_{\lambda_1}^{\lambda_2} \lambda \cdot S_X(\lambda) d\lambda / \int_{\lambda_1}^{\lambda_2} S_X \cdot (\lambda) d\lambda$$

λ_D **Dominant wavelength**

λ_p **Wavelength** of peak sensitivity or peak emission

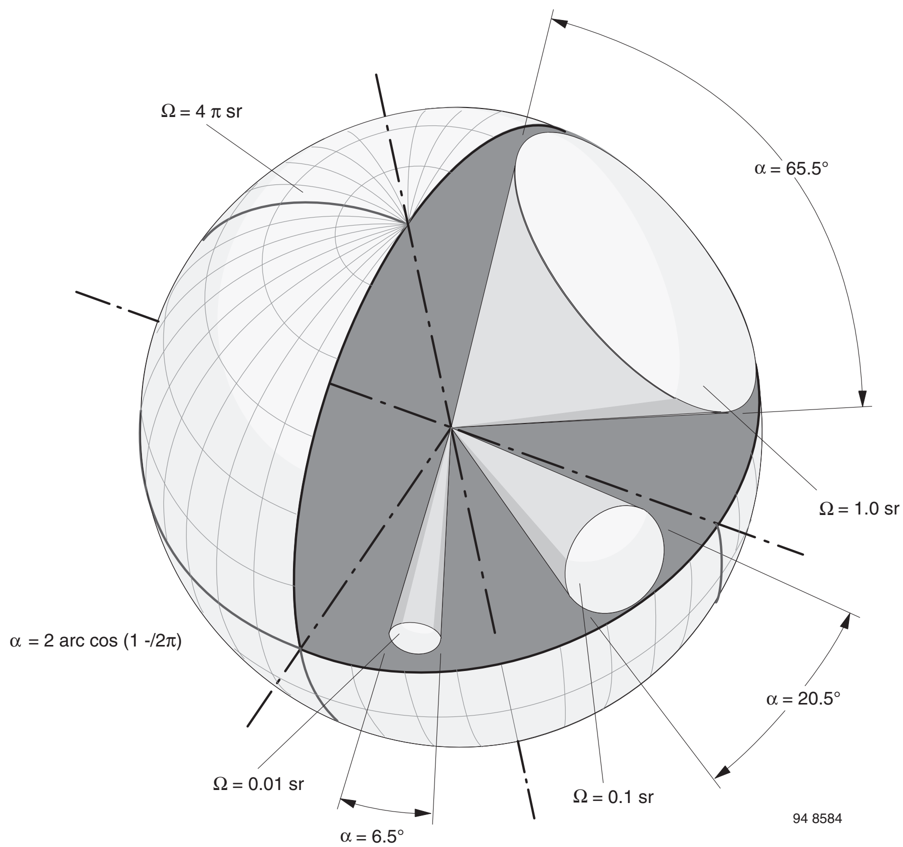

Fig. 1

DEFINITIONS

Databook Nomenclature

The nomenclature, symbols, abbreviations and terms inside the Vishay Semiconductors data book is based on ISO and IEC standards.

The special optoelectronic terms and definitions are referring to the IEC Multilingual Dictionary (Electricity, Electronics and Telecommunications), Fourth edition (2001-01), IEC 50 (Now: IEC 60050). The references are taken from the current editions of IEC 60050 (845), IEC 60747-5-1 and IEC 60747-5-2. Measurement conditions are based on IEC and other international standards and especially guided by IEC 60747-5-3.

Editorial notes: Due to typographical limitations variables cannot be printed in an italics format, which is usually mandatory. Our booklet in general is using American spelling. International standards are written in UK English. Definitions are copied without changes from the original text. Therefore these may contain British spelling.

Radiant and Luminous Quantities and Their Units

These two kinds of quantities have the same basic symbols, identified respectively, where necessary, by the subscript e (energy) or v (visual), e.g. Φ_e, Φ_v. See note.

Note: Photopic and scotopic quantities. Luminous (photometric) quantities are of two kinds, those used for photopic vision and those used for scotopic vision. The wording of the definitions in the two cases being almost identical, a single definition is generally sufficient with the appropriate adjective, photopic or scotopic added where necessary.

The symbols for scotopic quantities are prime (Φ'_v, I'_v, etc), but the units are the same in both cases.

In general, optical radiation is measured in radiometric units. Luminous (photometric) units are used when optical radiation is weighted by the sensitivity of the human eye, correctly spoken, by the CIE standard photometric observer (Ideal observer having a relative spectral responsivity curve that conforms to the V(λ) function for photopic vision or to the V'(λ) function for scotopic vision, and that complies with the summation law implied in the definition of luminous flux).

Note: With a given spectral distribution of a radiometric quantity the equivalent photometric quantity can be evaluated. However, from photometric units without knowing the radiometric spectral distribution in general one cannot recover the radiometric quantities.

Radiometric Terms, Quantities and Units

The radiometric terms are used to describe the quantities of optical radiation.

The relevant radiometric units are:

TABLE 1 - RADIOMETRIC QUANTITIES AND UNITS

RADIOMETRIC TERM	SYMBOL	UNIT	REFERENCE
Radiant power, radiant flux	Φ_e	W	IEC 50 (845-01-24)
Radiant intensity	I_e	W/sr	IEC 50 (845-01-30)
Irradiance	E_e	W/m^2	IEC 50 (845-01-37)
Radiant exitance	M_e	W/m^2	IEC 50 (845-01-47)
Radiance	L_e	$W/(sr \cdot m^2)$	IEC 50 (845-01-34)

Photometric Terms, Quantities and Units

The photometric terms are used to describe the quantities of optical radiation in the wavelength range of visible radiation (generally assumed as the range from 380 nm to 780 nm). The relevant photometric terms are:

TABLE 2 - PHOTOMETRIC QUANTITIES AND UNITS

PHOTOMETRIC TERM	EQUIVALENT RADIOMETRIC TERM	SYMBOL	UNIT	REFERENCE
Luminous power or luminous flux	Radiant power or radiant flux Φ_e	Φ_v	lm	Φ_v: IEC 50 (845-01-25) lm: IEC 50 (845-01-51)
Luminous intensity	Radiant intensity I_e	I_v	lm/sr = cd	I_v: IEC 50 (845-01-31) cd: IEC 50 (845-01-50)
Illuminance	Irradiance E_e	E_v	lm/m^2 = lx (lux)	E_v: IEC 50 (845-01-38) lx: IEC 50 (845-01-52)
Luminous exitance	Radiant exitance M_e	M_v	lm/m^2	IEC 50 (845-01-48)
Luminance	Radiance L_e	L_v	cd/m^2	IEC 50 (845-01-35)

Photometric units are derived from the radiometric units by weighting them with a wavelength dependent standardized human eye sensitivity V(λ) - function, the so-called CIE-standard photometric observer. There are different functions for photopic vision (V(λ)) and scotopic vision (V'(λ)).

In the following is shown, how the luminous flux is derived from the radiant power and its spectral distribution. The equivalent other photometric terms can be derived from the radiometric terms in the same way.

Relation between distance r, irradiance (illuminance) E_e (E_V) and intensity I_e (I_V)

The relation between intensity of a source and the resulting irradiance in the distance r is given by the basic square root rule law.

An emitted intensity I_e generates in a distance r the irradiance $E_e = I_e/r^2$.

This relationship is not valid under near field conditions and should be used not below a distance d smaller than 5 times the emitter source diameter.

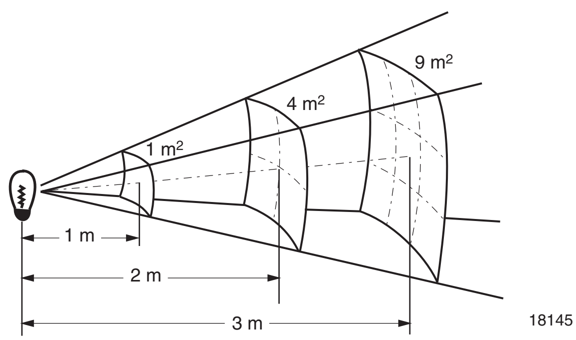

Fig. 2

Using a single radiation point source, one gets the following relation between the parameter E_e, Φ_e, r:

$$E_e = \frac{d\Phi_e}{dA}\left[\frac{W}{m^2}\right]$$

use

$$I_e = \frac{d\Phi}{d\Omega}, \quad \Omega = \frac{A}{r^2} \quad \text{and get}$$

$$E_e = \frac{d\Phi_e}{dA} = I_e\frac{d\Omega}{dA} = \frac{I_e}{r^2}\left[\frac{W}{m^2}\right]$$

Examples

1. Calculate the irradiance with given intensity and distance r: Transceivers with specified intensity of I_e = 100 mW/sr will generate in a distance of 1m an irradiance of $E_e = 100/1^2$ = 100 mW/m². In a distance of 10 m the irradiance would be $E_e = 100/10^2$ = 1 mW/m².
2. Calculate the range of a system with given intensity and irradiance threshold. When the receiver is specified with a sensitivity threshold irradiance E_e = 20 mW/m², the transmitter with an intensity I_e = 120 mW/sr the resulting range can be calculated as

$$r = \sqrt{\frac{I_e}{E_e}} = \sqrt{\frac{120}{20}} = \sqrt{6} = 2.45 \text{ m}$$