Infrared Data Communication According to IrDA® Standard

WHAT IS IrDA?

IrDA is the abbreviation for the Infrared Data Association, a non-profit organization for setting standards in IR serial computer connections. The following is an original excerpt from the IrDA web site (www.irda.org).

EXECUTIVE SUMMARY

IrDA was established in 1993 to set and support hardware and software standards which create infrared communications links. The association's charter is to create an interoperable, low cost, low power, halfduplex, serial data interconnection standard that supports a walk-up, point-to-point user model that is adaptable to a wide range of applications and devices. IrDA standards support a broad range of computing, communications, and consumer devices. International in scope, IrDA is a non-profit corporation headquartered in Walnut Creek, California, and led by a board of directors which represents voting membership worldwide. As a leading high technology standards association, IrDA is committed to developing and promoting infrared standards for the hardware, software, systems, components, peripherals, communications, and consumer markets.

INDUSTRY OVERVIEW

Infrared (IR) communications is based on technology which is similar to the remote control devices such as TV and entertainment remote controls used in most homes today. IR offers a convenient, inexpensive and reliable way to connect devices without the use of cables.

There are few US, European, or other international regulatory constraints.

Manufacturers can ship IrDA-enabled products globally without any constraints, and IrDA functional devices can be used by international travellers wherever they are, and interference problems are minimal.

Standards for IR communications have been developed by IrDA. In September 1993, IrDA determined the basis for the IrDA SIR data link standards. In June 1994, IrDA published the IrDA standards which includes serial infrared (SIR) link specification, link access protocol (IrLAP) specification, and link management protocol (IrLMP) specification. IrDA released extensions to SIR standard including 4 Mbit/s in October 1995. The IrDA standard specification has been expanded to include high speed extensions of 1.152 Mbit/s and 4.0 Mbit/s.

IrDA is the response in which many segments of the industry have committed themselves to realizing the opportunity of a general standard providing data links which are noninterfering and interoperable.

THE IrDA STANDARD

The current IrDA physical layer standard is version 1.4 and includes all changes and add-ons up to VFIR with 16 Mbit/s. Version 1.4 replaced version 1.3 which is obsolete as are all former versions from 1.0 to 1.2. Referring to these versions currently can describe only historical steps of the IrDA development.

The mentioned high speed extensions FIR, VFIR beyond 115.2 kbit/s will not be discussed in the following, since they are not supported by Vishay transceivers anymore.

HOW IrDA TRANSMISSION WORKS

The transmission in an IrDA-compatible mode (sometimes called SIR for serial IR) uses, in the simplest case, an USB to UART interface, or a microcontroler with a serial port.

An additional encoder / decoder module connected between UART interface and transceiver is used to reduce the bit length to a maximum of 3/16 of its original length, for power saving requirements. The optical signal is transmitted by the infrared emitting diode of one transceiver to the receiving part of the second transceiver.

This type of transmission covers the data range up to 115.2 kbit/s which is the maximum data rate supported by standard UARTs (see Fig. 1). The minimum demand for transmission speed for IrDA is only 9600 bit/s. All transmissions must be started at this frequency to enable compatibility. Higher speeds are a matter of negotiation of the ports after establishing the links.

The typical interfaces for the various modes are shown in Fig. 2. In the following chapter "IrDA Standard - Physical Layer", the definitions of the IrDA standard are given.

Optical output power and receiver sensitivity are set to a level where a point-and-shoot activity (± 15°) is sufficient for point-to-point communication, but prevents the pollution of the ambient by straying needless power. Transmission over a distance of at least 1 m is ensured. The detector front end receives the transmitted signal, re-shapes the signal and feeds it to the port. The system works in a half-duplex mode that allows only one transmission direction to be active at any given time.

For frequencies up to 115.2 kbit/s, the minimum output intensity is defined with 40 mW/sr.

The wavelength chosen for the standard is between 850 nm and 900 nm.

WHAT DO I NEED TO ENABLE IrDA TRANSMISSION?

The simplest way of optical interfacing in the SIR mode is shown in Fig. 1. For pulse shaping and recovery, an encoder / decoder device, such as Texas Instruments TIR1000, is recommended. The front end including transmitter and receiver should be realized for example by the integrated transceiver module TFDU4101 or any other Vishay transceiver model.

A transimpedance amplifier is used in the receiver for input amplification. Its output signal is fed to the comparator input, whose reference level is adjusted to efficiently suppress noise and interferences from the ambient.

Additionally, the digital pulse-shaping circuit must be inserted for shortening the pulse to be emitted to 1.6 µs (i.e., 3/16 of the bit length at 115 kbit/s) and pulse recovery of the detected signal to comply with the IrDA standard. Only the active low bits (0) are transmitted.

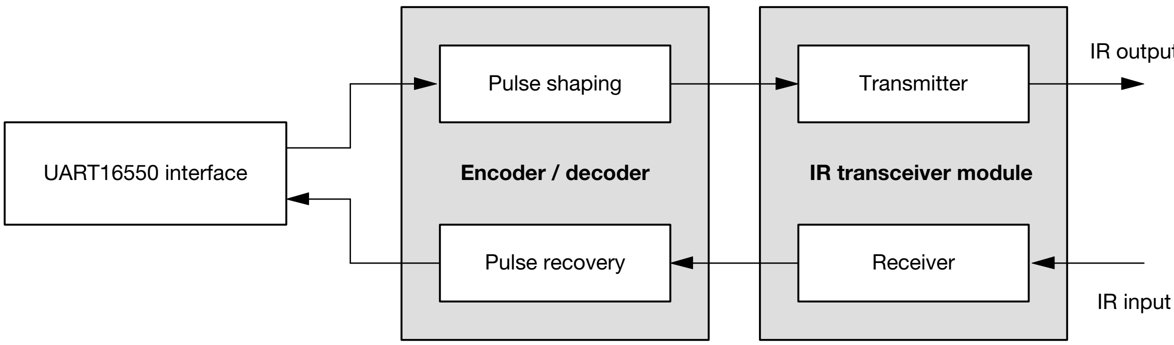

Fig. 1 - Block Diagram of One End of the Overall SIR Link

The IrDA standard documentation can be found on the IrDA web site www.irda.org. The documents which are public and can be downloaded are shown on the next page.

The physical layer is responsible for the definition of hardware transceivers for the data transmission. The physical layer is therefore discussed in the following chapters which define the properties of the front end devices manufactured by Vishay Semiconductors.

STANDARDS AVAILABLE FOR PUBLIC ACCESS AND DOWNLOAD ON www.irda.org

Standards, specifications, and guidelines are available under www.irda.org/standards/specifications.asp

The following documents describe the IrDA standards:

IrDA Serial Infrared Physical Layer Link Specification IrPHY 1.4 (www.irda.org/standards/pubs/IrPHY_1p4.pdf)

IrDA Serial Infrared Link Access Protocol (IrLAP)

IrDA Serial Infrared Link Management Protocol (IrLMP)

IrDA Tiny TP

IrDA Point and Shoot Profile

Test Specification

Other available documents

IrDA Adapter Application Profile and Test Specification

IrDA Infrared Communications Protocol (IrCOMM 1.0)

IrDA Infrared LAN Access Extensions for Link Management Protocol (IrLAN 1.0)

IrDA Minimal IrDA Protocol Implementation (IrLite)

IrDA Plug & Play Extensions to IrLMP 1.0

IrDA Infrared Mobile Communications (IrMC)

IrDA Infrared Transfer Picture Specifications (IrTranP)

Serial Interface for Transceivers

IrDA Point and Shoot

IrDA Point and Shoot Application Profile

IrDA Point and Shoot Test Specification

SPECIFICATION

In SIR mode, the data is represented by optical pulses between 1.6 μs and 3/16 of the bit length of the UART data pulse in SIR mode. The limits of the standards are shown in Table 1 and Table 3. The optical radiant intensity and detector sensitivity are adjusted to guarantee a point-to-point transmission in a cone of ± 15° over a distance of at least 1 m. The radiant intensity and the sensitivity of the front end can be increased to ensure a transmission over 3 m (see Fig. 3). Data from the optical interface standard are documented in Table 2 to Table 4.

MEDIA INTERFACE SPECIFICATION

Overall Links

There are two different sets of transmitter / receiver specifications. The first, referred to as standard, is for a link which operates from 0 m to at least 1 m. The second, referred to as the low power option, has a shorter operating range of 0.2 m, if two low power transceivers are used. There are three possible links (see Table 1 below): low power option to low power option, standard to low power option; standard to standard. The distance is measured between the optical reference surfaces.The bit error ratio (BER) shall be no greater than 10^{-8}. The link shall operate and meet the BER specification over its range.

Signaling Rate and Pulse Duration

An IrDA serial infrared interface must operate at 9.6 kbit/s. Additional allowable rates listed below are optional. Signaling rate and pulse duration specifications are shown in Table 2.

For all signaling rates up to and including 115.2 kbit/s the minimum pulse duration is the same (the specification allows both a 3/16 of bit duration pulse and a minimum pulse duration for the 115.2 kbit/s signal (1.63 μs minus the 0.22 μs tolerance). The maximum pulse duration is 3/16 of the bit duration, plus the greater of the tolerance of 2.5 % of the bit duration, or 0.60 μs.

The link must meet the BER specification over the link length range and meet the optical pulse constraints.

TABLE 1 - LINK DISTANCE SPECIFICATIONS

	LOW POWER TO LOW POWER	STANDARD TO LOW POWER	STANDARD TO STANDARD
Link distance lower limit (m)	0	0	0
Minimum link distance upper limit (m)	0.2	0.3	1.0

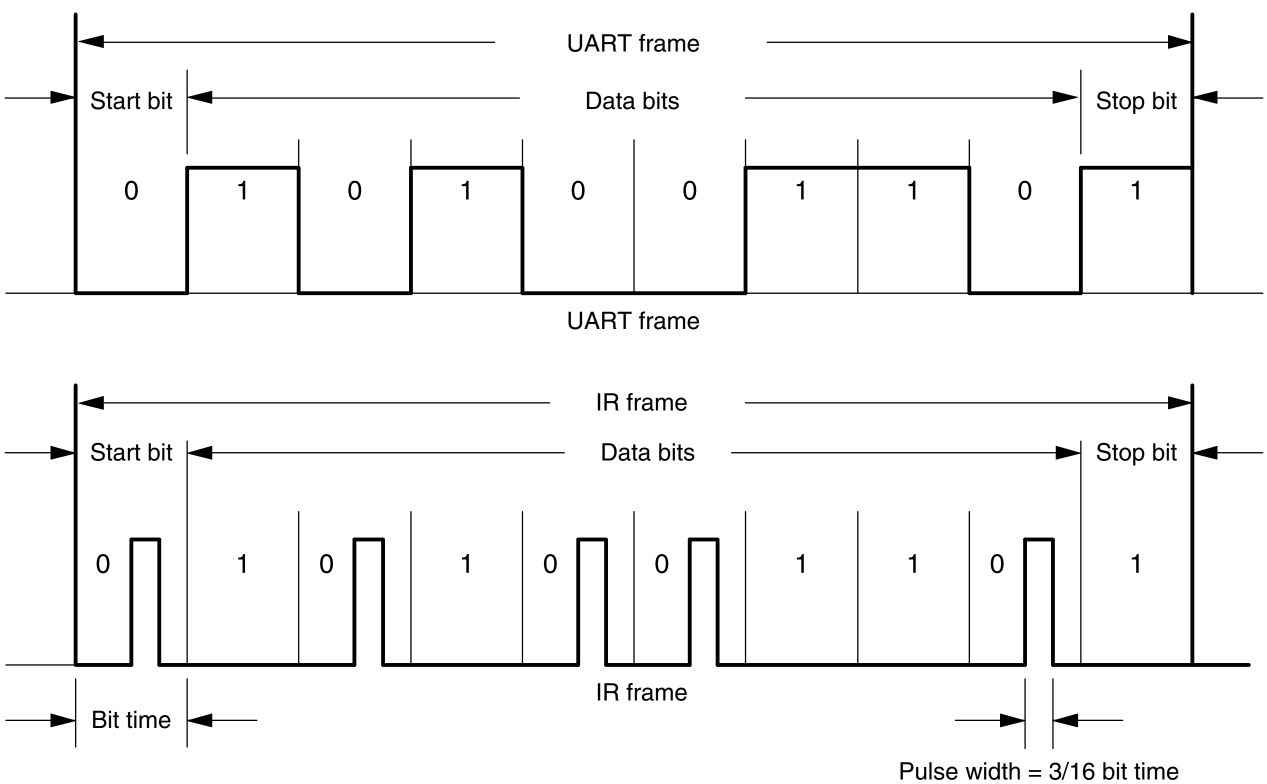

Fig. 2

TABLE 2 - SIGNALING RATE AND PULSE-DURATION SPECIFICATION					
SIGNALING RATE	MODULATION	RATE TOLERANCE % OF RATE	PULSE DURATION MINIMUM	PULSE DURATION NOMINAL	PULSE DURATION MAXIMAL
2.4 kbit/s	RZI [(1)]	± 0.87	1.41 µs	78.13 µs	88.55 µs
9.6 kbit/s	RZI [(1)]	± 0.87	1.41 µs	19.53 µs	22.13 µs
19.2 kbit/s	RZI [(1)]	± 0.87	1.41 µs	9.77 µs	11.07 µs
38.4 kbit/s	RZI [(1)]	± 0.87	1.41 µs	4.88 µs	5.96 µs
57.6 kbit/s	RZI [(1)]	± 0.87	1.41 µs	3.26 µs	4.34 µs
115.2 kbit/s	RZI [(1)]	± 0.87	1.41 µs	1.63 µs	2.23 µs

Note

(1) RZI = return to zero inverted

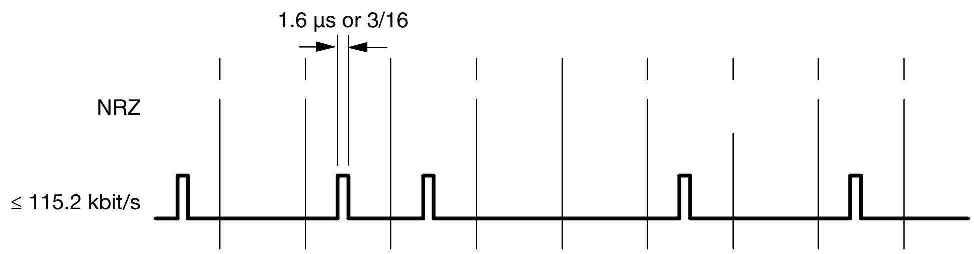

Fig. 3

ACTIVE OUTPUT INTERFACE

The active output interface (IRLED) emits an infrared signal. Key parameters for this interface, defined by IrDA physical layer specification are shown in Table 3. A complete specification is available from IrDA.

TABLE 3 - ACTIVE OUTPUT SPECIFICATION				
SPECIFICATION	DATA RATES	TYPE	MINIMUM	MAXIMUM
Peak wavelength, λ_p (µm)	All	Both	0.85	0.90
Maximum intensity in angular range (mW/sr)	All	Standard	-	500
		Low power	-	500
Minimum intensity in angular range (mW/sr)	115.2 kbit/s and below	Standard	40	-
		Low power	3.6	-
	Above 115.2 kbit/s	Standard	100	-
		Low power	9	-
Half angle (°)	All	Both	± 15	± 30
Signaling rate (also called clock accuracy)	All	Both	See Table 2	
Rise time t_r, 10 % to 90 %, fall time t_f, 90 % to 10 %, ns	115.2 kbit/s and below	Both	-	600
Pulse duration	All	Both	See Table 2	
Optical overshoot (%)	All	Both	-	25
Edge jitter (% of nominal pulse duration)	115.2 kbit/s and below	Both	-	± 6.5

TOLERANCE FIELD OF ANGULAR EMISSION

The optical radiant intensity is limited to a maximum of 500 mW/sr and an angle of ± 30° to enable the independent operation of more than one system in a room. In Fig. 4, the tolerance field of an infrared transmitter's emission is shown. A typical far field characteristic of a transmitter is also shown in this figure.

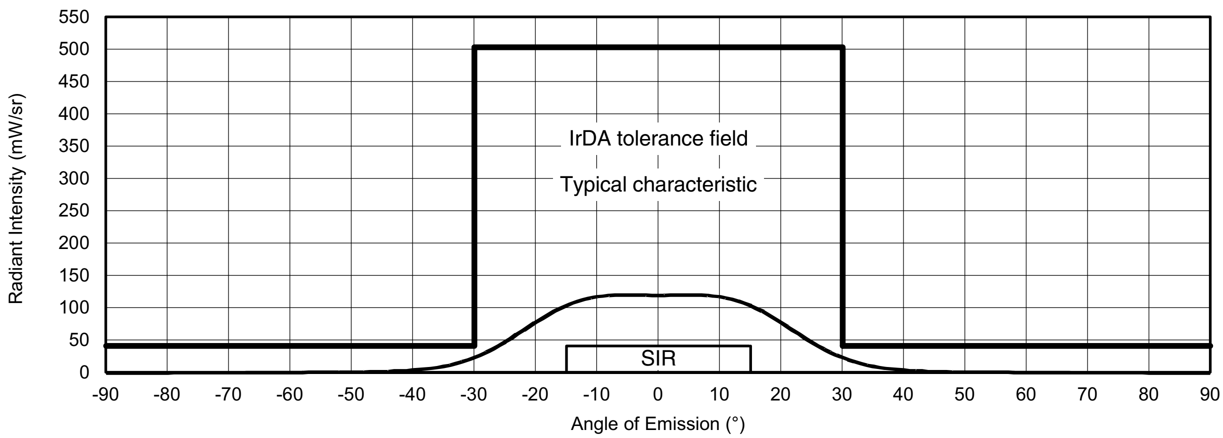

Fig. 4 - Tolerance Field of Angular Emission

ACTIVE INPUT INTERFACE

When a infrared optical signal impinges on the active input interface (PIN photodiode), the signal is detected, conditioned by the receiver circuitry, and transmitted to the IR receive decoder.

TABLE 4 - ACTIVE INPUT SPECIFICATION

SPECIFICATION	DATA RATES	TYPE	MINIMUM	MAXIMUM
Maximum irradiance in angular range (mW/m^2)	All	Both	-	500
Minimum irradiance in angular range (mW/m^2)	115.2 kbit/s and below	Standard	4.0	-
		Low power	9.0	-
Half angle (°)	All	Both	15	-
Receiver latency allowance (ms)	All	Standard	-	10
		Low power	-	0.5

ACTIVE INPUT SPECIFICATION

The following five specifications form a set which can be measured concurrently:

- Maximum irradiance in angular range (mW/m^2)
- Minimum irradiance in angular range (mW/m^2)
- Half-angle (°)
- Bit error ratio (BER)
- Receiver latency allowance (ms)

These measurements require an optical power source and means to measure angles and BERs. Since the optical power source must provide the specified characteristics of the active output, calibration and control of this source can use the same equipment as that required to measure the intensity and timing characteristics. BER measurements require some method to determine errors in the received and decoded signal. The latency test requires exercise of the node's transmitter to condition the receiver.

Definitions of the reference point etc., are the same as for the active output interface optical power measurements except that the test head is now an optical power source with the in-band characteristics (peak wavelength, rise and fall times, pulse duration, signaling rate and jitter) of the Active output interface. The optical power source must also be able to provide the maximum power levels listed in the active output specifications. It is expected that the minimum levels can be attained by appropriately spacing the optical source from the reference point.

Fig. 4 illustrates the region over which the optical high state is defined. The receiver is operated throughout this region and BER measurements are made to verify the maximum and minimum requirements. The ambient conditions of A.1 apply during BER tests; BER measurements can be done with worst case signal patterns. Unless otherwise known, the test signal pattern should include maximum length sequences of “1”s (no light) to test noise and ambient, and maximum length sequences of “0”s (light) to test for latency and other overload conditions.

Latency is tested at the minimum irradiance in angular range conditions. The receiver is conditioned by the exercise of its associated transmitter. The receiver is operated with the minimum irradiance levels and BER measurements are made after the specified latency period for this equipment to verify irradiance, half angle, BER and latency requirements. The minimum allowable intensity value is indicated by “minimum” in Fig. 5.

LOW POWER STANDARD AND FULL RANGE OPERATION

The message that a low power device must be a special design is often propagated, but is incorrect. Full standard devices can be operated easily with reduced IRED drive current to fulfill the low power specification. However, devices specially designed for low power applications with low profile package are not able to cover the full standard because of limited efficiency and little drive current capability.

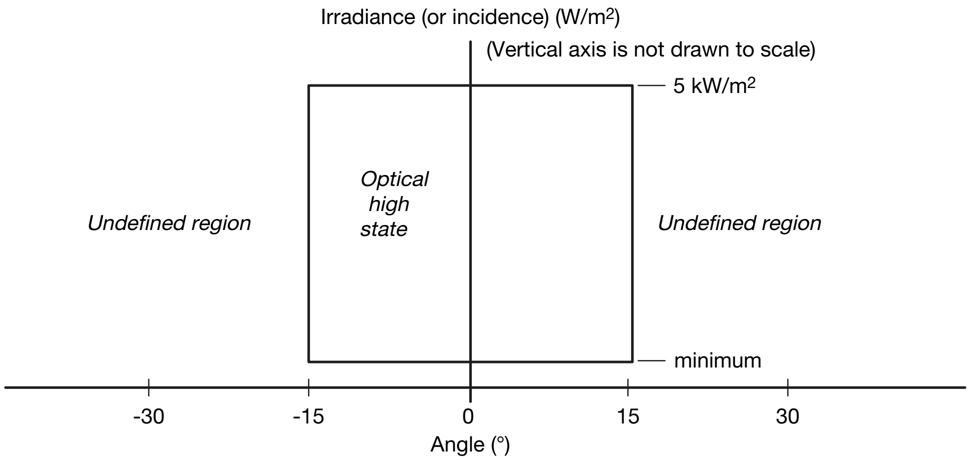

Fig. 5 - Optical High State Acceptable Range

TRANSMISSION DISTANCE

From Fig. 6, the transmission distance as a function of the sensitivity (necessary irradiance on the detector) can be read. For example: sensitivity given as a minimum irradiance on the detector of 40 mW/m^2, combined with an intensity of 40 mW/sr, results in a transmission distance of 1 m. A combination of a detector with a minimum irradiance of 10 mW/m^2 and an emitter with 250 mW/sr can transmit over almost five meters. Vishay Semiconductor transceivers work well with standard remote control receivers and can therefore be operated as remote control transmitters.

The physical layer properties of the devices are defined under ambient conditions listed in an appendix which has been reprinted in the following chapters.

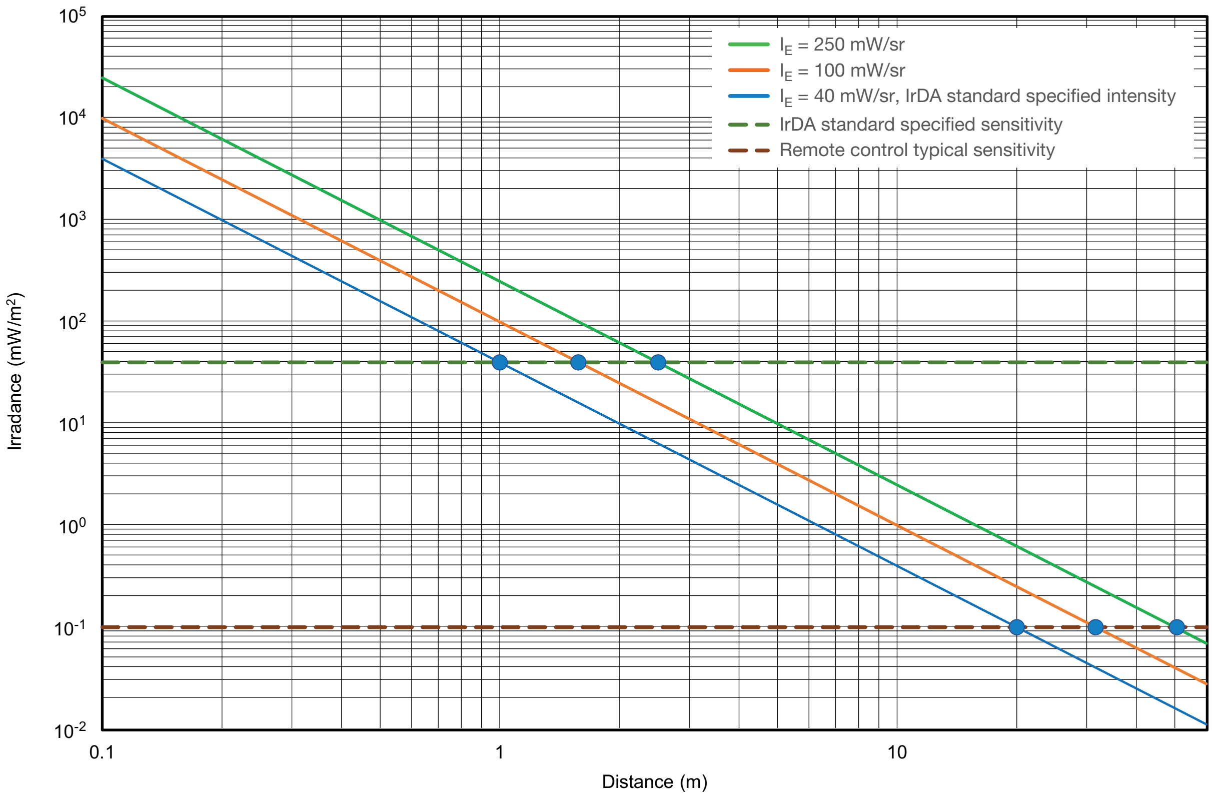

Fig. 6 - IrDA and Remote Control Maximum Transmission Distance,
for Remote Control Receivers Operating With IrDA Transmitters a Sensitivity of 0.1 mW/m^2 can be Assumed

APPENDIX A. - TEST METHODS

Note

- A.1 is normative unless otherwise noted

A.1. Background Light and Electromagnetic Field

There are four ambient interference conditions in which the receiver is to operate correctly. The conditions are to be applied separately:

- **Electromagnetic Field:** 3 V/m maximum (refer to IEC 61000-4-3. test level 2 for details) (for devices that intend to connect with or operate in the vicinity of a mobile phone or pager, a field of 30 V/m with frequency ranges from 800 MHz to 690 MHz and 1.4 GHz to 2.0 GHz including 80 % amplitude modulation with a 1 kHz sine wave is recommended. Refer to IEC 61000-4-3 test level 4 for details. The 30 V/m condition is a recommendation; 3 V/m is the normative condition)
- **Sunlight:** 10 klx maximum at the optical port. This is simulated with an IR source having a peak wavelength within the range 850 nm to 900 nm and a spectral width less than 50 nm biased to provide 490 μW/cm^2 (with no modulation) at the optical port. The light source faces the optical port. This simulates sunlight within the IrDA spectral range. The effect of longer wavelength radiation is covered by the incandescent condition.
- **Incandescent Lighting:** 1000 lx maximum. This is produced with general service, tungsten filament, gas-filled, inside-frosted lamps in the 60 W to 150 W range to generate 1000 lx over the horizontal surface on which the equipment under test rests. The light sources are above the test area. The source is expected to have a filament temperature in the 2700 °K to 3050 °K range and a spectral peak in the 850 nm to 1050 nm range.
- **Fluorescent Lighting:** 1000 lx maximum This is simulated with an IR source having a peak wavelength within the range 850 nm to 900 nm and a spectral width of less than 50 nm biased and modulated to provide an optical square wave signal (0 μW/cm^2 minimum and 0.3 μW/cm^2 peak amplitude with 10 % to 90 % rise and fall times less than or equal to 100 ns) over the horizontal surface on which the equipment under test rests. The light sources are above the test area. The frequency of the optical signal is swept over the frequency range from 20 kHz to 200 kHz. Due to the variety of fluorescent lamps and the range of IR emissions, this condition is not expected to cover all circumstances. It will provide a common basis for IrDA operation.