About IrDA

IrDA–Compatible Data Transmission
IrDA–Standard – Physical Layer

Table of Contents

Document Number 82500
05.01

Introduction: Paving the Way to a Wireless Information Environment

The world of information processing is constantly striving to create ever more powerful tools to produce, retrieve, present and transmit information. The hardware and software needed regardless of how highly sophisticated it may be has to provide a user-friendly interface. The interface to the user should appear simple, self explanatory, efficient and of course wireless. Wireless communication and wireless control of any equipment is the cornerstone of appeal to the user. **I**nfra**r**ed (IR) communication is the most cost efficient approach to provide a cordless user interface. Moreover, it is reliable, short ranged, already available, and as natural as sun light. It is now accepted that IR communication technology will have a big future in **P**ersonal **A**rea **N**etworks (PANs). The market growth since 1996 has been tremendous. The first applications started in small Personal Digital Assistants (PDAs), desk top and notebook PCs. In only 2 years, these pioneer applications reached a deep market penetration. Dongles are widely available to interface with Local Area Networks (LANs) or to retrofit PCs, printers, etc. New ideas and applications relate to digital cameras, toys, wrist watches and set top boxes. The building blocks to form your individual PAN are now ubiquitous. And the IrDA standards have helped to make this happen.

IR communication started in Europe, actually in Germany, as far back as 1974. The remote control of TV sets via infrared transmission conquered the world within 10 years. Today, besides TV sets, VCRs and audio equipment, nearly every product of consumer electronics is controlled via IR communication. In addition to this, IR technology has spread to the development of car keys and automobile immobilizing systems.

Vishay Telefunken has been a major supplier of infrared communication devices from the beginning. Vishay Telefunken is the world's leading supplier of infrared receivers, which integrate a photo pin diode and an elaborate amplifier IC, and is a leading supplier of optimized IR emitters or transmitters. The technological basis of infrared transmission links is wide spread.

Highly efficient emitters are based on III–V compound semiconductors. An optimized layer structure is needed, made from several compositions, mostly of the mixed compound (GaAl)As. The active layer is part of a pn junction and embedded into a double–hetero structure. By varying the GaAlAs composition, the energy band gap can be adjusted within a wide range to meet specific design requirements. The required structure is produced by liquid phase epitaxy. Vishay Telefunken is an experienced specialist in this technology, not only capable of achieving leading edge results, but also providing large production capacity.

Detectors are photo pin diodes made from Si with low capacitance and high dynamic sensitivity at long IR wave lengths. The bipolar production process of these devices has to be capable of achieving unwanted impurity levels below 10^{11} cm^{-3}.

The integrated first signal processing stage is a dedicated circuit. Vishay Telefunken's development effort for IrDA–compatible receiver circuits is based on its long standing experience with remote controls. These circuits are produced by Vishay Telefunken in very large quantities exceeding 100 million units per year. They use sophisticated gain control which compensates for adverse ambient light environments. This circuit principle is also incorporated into the new IrDA amplifiers.

Last but not least, our design capabilities for package and lens are used to create optimized IrDA–suitable devices. Vishay Telefunken has the knowledge and the experience needed to develop and produce dedicated opto electronic packages.

The standardization effort of IrDA and the technological leadership of Vishay Telefunken, as well as its commitment to cordless IR communication are corner stones of our business strategy. They can be fruitfully combined to contribute to the bright future of IR data communication.

IrDA–Compatible Data Transmission

What is IrDA ?

IrDA is the abbreviation for the **I**nfra**r**ed **D**ata **A**ssociation, a non–profit organization for setting standards in IR serial computer connections. The following is an original excerpt from the IrDA Web site (http://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, half–duplex, 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 a voting membership of more than 160 corporate members 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 computer and peripheral devices without the use of cables. IrDA connectivity is being incorporated into most notebook PCs to bring the most cost–effective and easy to use support available for wireless technologies.

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. This extension will require an add–in card to retrofit existing PCs with high speed IR, and a synchronous communications controller or equivalent.

In 1995, several market leaders announced or released products with IR features based on IrDA standards. These products include components, adapters, printers, PCs, PDAs, notebook computers, LAN access, and software applications. In November 1995, the Microsoft Corporation announced it had added support for IrDA connectivity to the Microsoft Windows 95 operating system, enabling low–cost wireless connectivity between Windows 95 based PCs and peripheral devices.

IrDA's interoperable infrared serial data link features low power consumption with data speeds up to 4 Mbit/s, allowing a cordless 'walk–up–to' data transfer in a simple, yet compelling way. Applications are in both consumer and commercial markets with a universal data connection relevant in the use of docking and input units, printers, telephones, desktop/ laptop PCs, network nodes, ATMs, and handheld mobile peers (PDA meets PDA). Yesterday's systems with IR capabilities such as Newton, Omnibook, Wizard and Zoomer are not easily compatible with each other or other complementary devices. 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 non–interfering and interoperable.

The IrDA – Standard

The current IrDA physical layer standard is the version 1.3 (2001, March). Version 1.4 is expected soon and will additionally include the 16 Mbit/s standard which is currently covered by a different document. Version 1.4 will replace version 1.3. The versions 1.0 to 1.2 are also obsolete versions and today only describe historial steps of the IrDA – development.

How IrDA Transmission Works

The transmission in an IrDA–compatible mode (sometimes called SIR for serial IR) uses, in the simplest case, the RS232 port, a built–in standard of all compatible PCs. With a simple interface, shortening the bit length to a maximum of 3/16 of its original length for power–saving requirements, an infrared emitting diode is driven to transmit an optical signal to the receiver.

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 figure 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.

Higher speeds require special interfaces which operate at 1.152 Mbit/s and use a similar pulse–shortening process as in the RS232–related mode, but with a pulse reduction to ¼ of the original pulse length. The fastest data rate supported by IrDA is 4.0 Mbit/s (often called FIR), operating with 125–ns pulses in a 4–PPM (PPM = **P**ulse–**P**osition **M**odulation) mode. The typical interfaces for the various modes are shown in figure 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. For higher speeds, a higher output intensity of 100 W/sr minimum is used. The sensitivity thresholds are 40 mW/m^2 and 100 mW/m^2 for SIR and FIR respectively.

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

An additional IrDA standard was generated in 1997 (voted Feb. 1998) for Control applications, the so–called IrControl standard. This standard is using the IEC1603–1 subcarrier frequency allocation with a carrier at 1500 kHz. The transmission capacity is 72 kbit/s. This system has still some compatibility problems with the SIR/FIR IrDA Standard. One of the disadvantages is that the detector circuitry is different from the other, base–band system. Therefore, integrating both into one application is expensive. Using IrControl and SIR/FIR in one application would imply that two IR hardware channels must be built–in. The Very Fast IR (VFIR, min. 16 Mbit/s transfer rate over more than 1 m) was established in 1999. Transceivers, I/OS and applications are expected in 2001.

What do I need to enable IrDA Transmission ?

The simplest way of optical interfacing in the SIR mode is shown in figure 1. For pulse shaping and recovery, the Vishay Telefunken devices TOIM3000 or TOIM3232 are recommended. The front end including transmitter and receiver should be realized for example by the integrated transceiver module TFDS4500 or other devices of the 4000 series. The TFDS4500 can also be directly connected to Super I/Os®. 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.

For the high–speed mode, the TFDS6000 or other devices from the 6000 series are recommended to be operated with NSC’s or SMC’s IrDA–compatible Super I/O® circuits. Circuit proposals for the various modes can be found in our application section. A block diagram is shown in Figure 2.

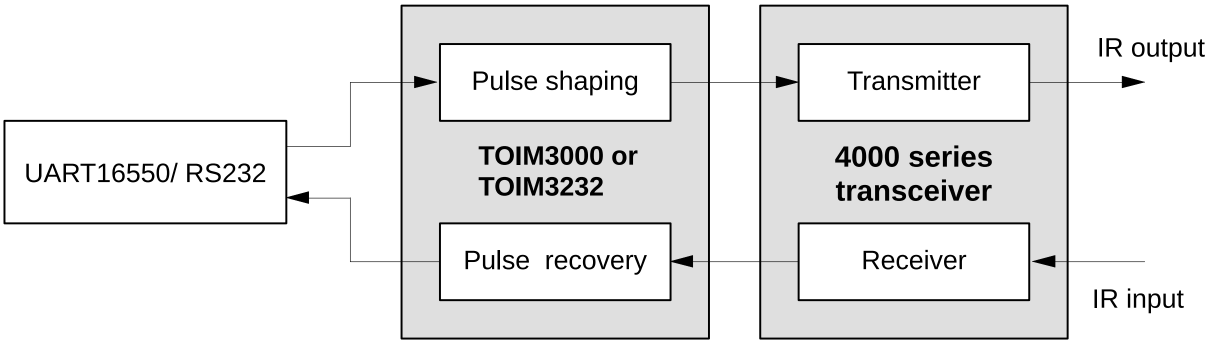


Figure 1. Block diagram of one end of the overall SIR link

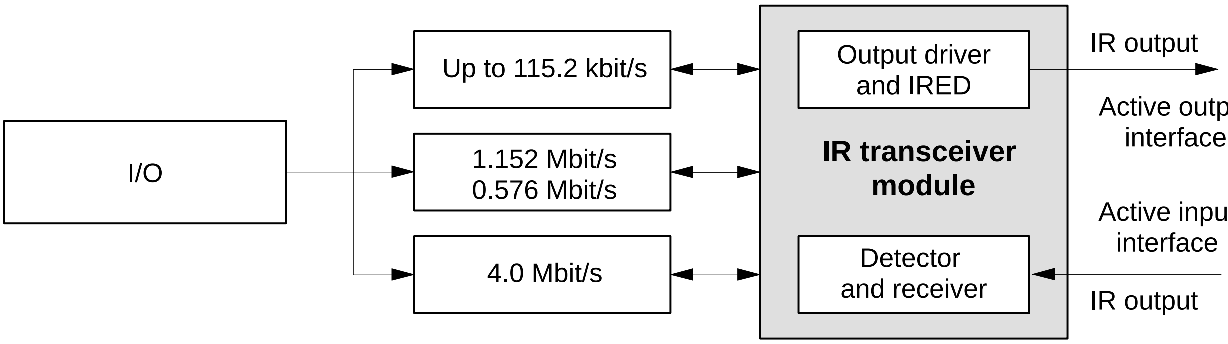


Figure 2. Block diagram of one end of the link for signaling rates up to 4.0 Mbit/s

The IrDA standard documentation can be found on the IrDA web site http://www.irda.org. The documents which are public and can be downloaded are shown in table 1.

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 Telefunken.

Table 1.

Standards available for public access and download on *www.irda.org*	**File size [kbyte]**			
ircomm10.pdf	346	Version 1.0	November 07, 1995	
Irda_ControlV1p0E.zip containing	543			
IrDACErrata_Oct99.pdf	158	”Last Modified”	October 26, 1999	
IrDA_Control_V1p0.pdf	464	”Final 1.0”	June 30, 1998	
IrDA_Dongle_V1p2.pdf	85	Version 1.2	April 26, 1999	
IrJetSendAppNoteV1.1.pdf	55	Version 1.1	November 1999	
IrLAP11.pdf	383	Version 1.1	June 16, 1996	
IrLMP11.pdf	451	Version 1.1	January 23, 1996	
IrMC_v1p1Specs&Errata001024.zip	2486			
IrOBEX12.pdf	327	Version 1.2	March 18, 1999	
IrPHY_1p3.PDF	247	Version 1.3	October 15, 1998	
IrPHYTestMeasurement.pdf	152	Version 1.0	January 16, 1998	
irpnp1_1.pdf	80	Version 1.1	January 08, 1996	
IrTran–P_10.pdf	240	Version 1.0	October 1997	
irwwfinaldocuments.zip	1369	Version 1.0	December 1999	collection of IrWW docs
jetsendappnote.pdf	91	Version 1.0	January 2000	
jetsendpointandshoot.pdf	50	Version 1.0	January 2000	
litever10.pdf	121	Version 1.0	November 07, 1996	
Point and Shoot V1p1.pdf	147	Version 1.1	March 20, 2000	
protocol.doc	58		October 1995	
serialinterface.pdf	134	Version 1.0	January 12, 2000	
Tinytp11.pdf	82	Version 1.1	October 20, 1996	
VFIR_IrLAP Errata to V1p1.pdf	30	Version 1.1	January 05, 1999	
VFIR_IrPHY_Errata to 1.pdf	140	Version 1.3	January 08, 1999	

IrDA–Standard – Physical Layer

Specification

In SIR mode, the data is represented by optical pulses between 1.6 µs and 3/16 of the bit length of the RS232 data pulse in SIR mode. Pulse–length reduction is also applied in the higher frequency modes. The limits of the standards are shown in tables 2 and 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 figure 3). Data from the optical interface standard are documented in tables 2 to 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 to at least 1 meter. The second, referred to as the Low Power Option, has a shorter operating range, and is only defined up to 115.2 kbit/s. There are three possible links (see Table 2 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.

Table 2. Link Distance Specifications

	Low Power - Low Power	Standard - Low Power	Standard - Standard
Link Distance Lower Limit, meters	0	0	0
Minimum Link Distance Upper Limit, meters	0.2	0.3	1.0

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 3.

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.

For 0.576 Mbit/s and 1.152 Mbit/s, the maximum and minimum pulse durations are the nominal 25% of the bit duration plus 5% (tolerance) and minus 8% (tolerance) of the bit duration.

For 4.0 Mbit/s, the maximum and minimum single pulse durations are the nominal 25% of the symbol duration plus and minus a tolerance of 2% of the symbol duration. For 4.0 Mbit/s, the maximum and minimum double pulse durations are 50% of the symbol plus and minus a tolerance of 2% of the symbol duration. Double pulses may occur whenever two adjacent chips require a pulse.

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

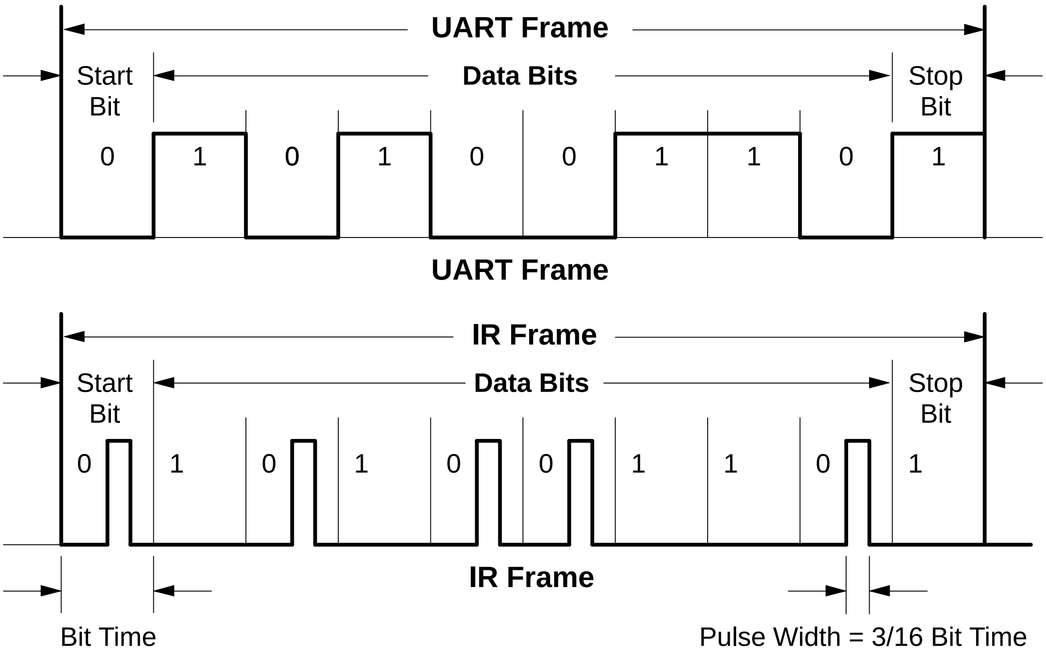
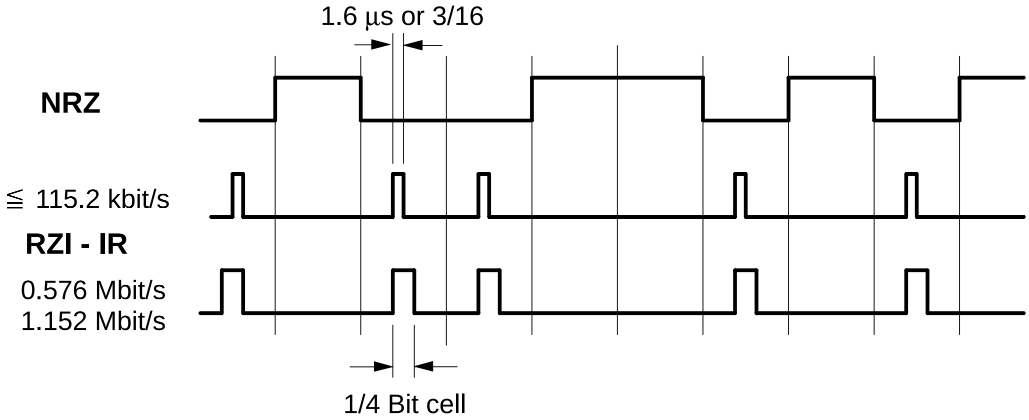
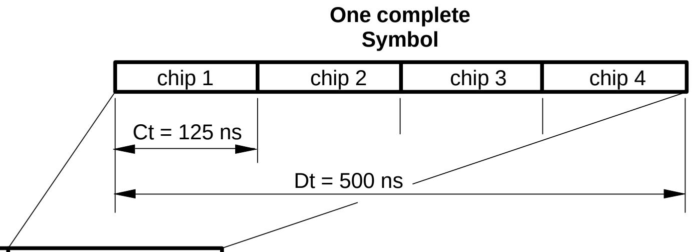


Table 3. Signaling rate and pulse–duration specification

Signaling Rate	Modulation	Rate Tolerance % of Rate	Pulse Duration Minimum	Pulse Duration Nominal	Pulse Duration Maximum
2.4 kbit/s	RZI*)	±0.87	1.41 µs	78.13 µs	88.55 µs
9.6 kbit/s	RZI*)	±0.87	1.41 µs	19.53 µs	22.13 µs
19.2 kbit/s	RZI*)	±0.87	1.41 µs	9.77 µs	11.07 µs
38.4 kbit/s	RZI*)	±0.87	1.41 µs	4.88 µs	5.96 µs
57.6 kbit/s	RZI*)	±0.87	1.41 µs	3.26 µs	4.34 µs
115.2 kbit/s	RZI*)	±0.87	1.41 µs	1.63 µs	2.23 µs
0.576 Mbit/s	RZI*)	±0.1	295.2 ns	434.0 ns	520.8 ns
1.152 Mbit/s	RZI*)	±0.1	147.6 ns	217.0 ns	260.4 ns
4.0 Mbit/s Single pulse Double pulse	 4 PPM 4 PPM	 ±0.01 ±0.01	 115.0 ns 240.0 ns	 125.0 ns 250.0 ns	 135.0 ns 260.0 ns
16 Mbit/s	HHH (1.13)	±0.01	38.3 ns	41.7 ns	45.0 ns

*) RZI = **R**eturn to **Z**ero **I**nverted





Data Bit Pair (DBD)	4PPM Data Symbol (DD)
00	1000
01	0100
10	0010
11	0001

Active Output Interface

At the active output interface, an infrared signal is emitted. The specified active output interface parameters in table 4 are defined in the physical layer specification of the IrDA standard. The complete standard is available from IrDA

Table 4. 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	Std	–	500*)
		Low Power	–	28.8
Minimum intensity in angular range, mW/sr	115.2 kbit/s and below	Std	40	–
		Low Power	3.6	–
	Above 115.2 kbit/s	Std	100	–
		Low Power	9	–
Half angle, degrees	All	Both	± 15	± 30
Signaling rate (also called clock accuracy)	All	Both	See table 3	See table 3
Rise time t_r 10% to 90%, fall time t_f 90% to 10%, ns	115.2 kbit/s and below	Both	–	600
	115.2 kbit/s to 4.0Mbit/s		–	40
	16 Mbit/s		–	19
Pulse duration	All	Both	See table 3	See table 3
Optical overshoot, %	All	Both	–	25
Edge Jitter, % of nominal pulse duration	115.2 kbit/s and below	Both	–	± 6.5
Edge Jitter, relative to reference clock, % of nominal duration	0.576 and 1.152 Mbit/s	Both	–	± 2.9
Edge Jitter % of nominal chip duration	4.0 Mbit/s	Both	–	± 4.0
	16.0 Mbit/s	Std	–	± 4.0

*) For a given transmitter implementation, the IEC 60825–1 AEL Class 1 limit may be less than this. See section 2.4 above and Appendix A.

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 figure 3, the tolerance field of an infrared transmitter's emission is shown. A typical farfield characteristic of a transmitter is also shown in this figure.

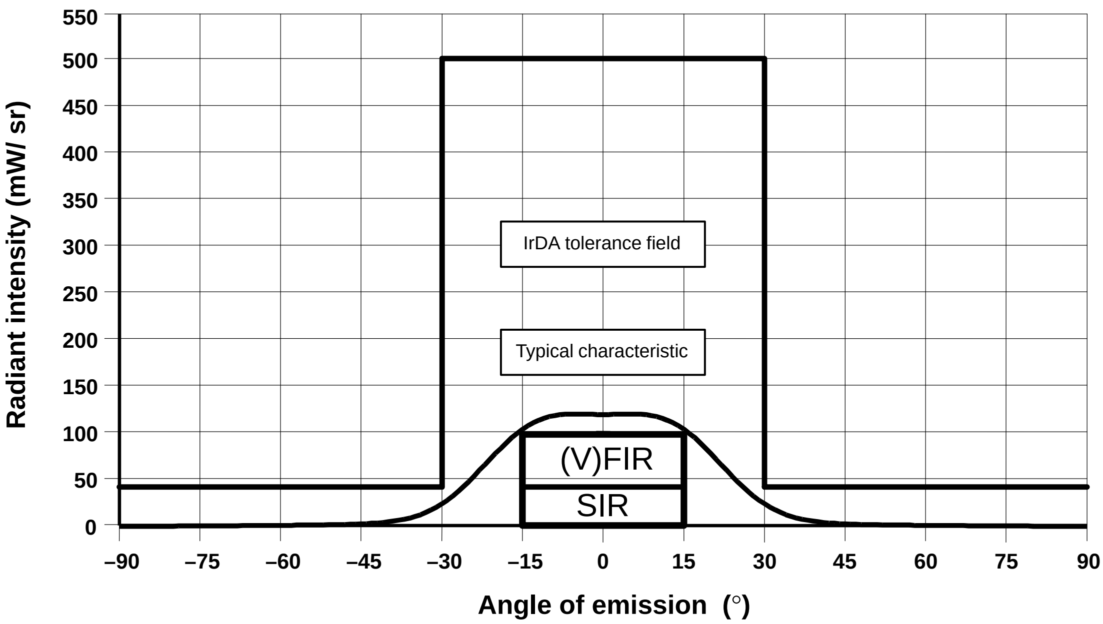


Figure 3. Tolerance field of angular emission

Active Input Interface

If a suitable infrared optical signal impinges on the active input interface, the signal is detected, conditioned by the receiver circuitry, and transmitted to the IR receive decoder.

Table 5. Active input specifications

Specification	Data Rates	Type	Min.	Max.
Maximum irradiance in angular range, mW/sr	All	Both	–	500
Minimum irradiance in angular range, mW/sr	115.2 kbit/s and below	Low Power	9.0	–
		Std	4.0	–
	Above 115.2 kbit/s.	Low Power	22.5	–
		Std	10.0	–
Half angle, degrees	All	Both	± 15	–
Receiver latency allowance, ms	4.0 kbit/s & below	Std	–	10
		Low Power	–	0.5
	16.0 Mbit/s	Both	–	0.10

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, $\mu W/m^2$

– Half–angle, degrees

– 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 also must 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.

Figure 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. For rates up to and including 1.152 Mbit/s, the conditioning signal should include maximum length sequences of ”0”s (light) permitted for this equipment. For 4.0 Mbit/s 4 PPM operation, various data strings should be used; the latency may be pattern dependent. 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 figure 5, since the actual specified value is dependent upon the data rate, SIR or FIR.

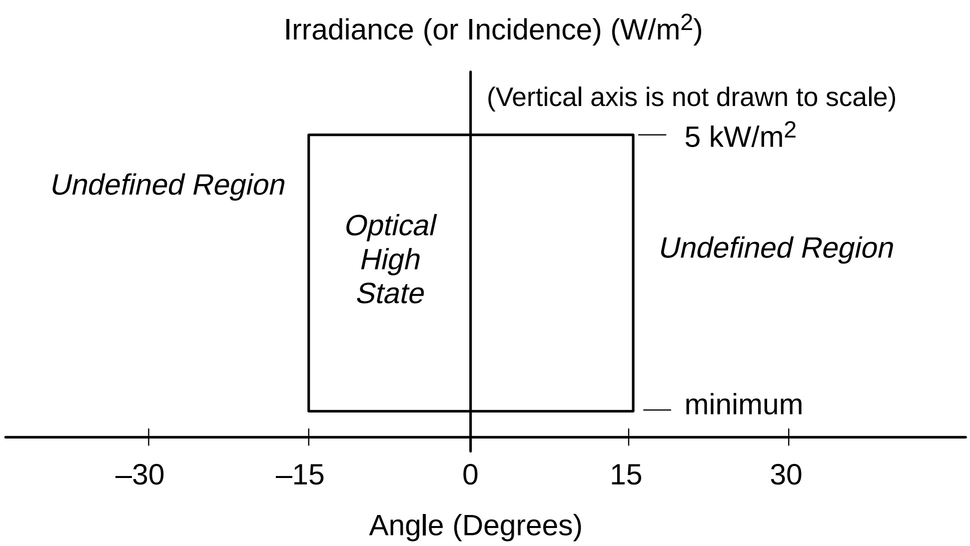


Figure 4. Optical High State Acceptable Range

Test Conditions

(ref: IrDa Physical Layer specification)

Appendix A. Test Methods

Note– A.1 is Normative unless otherwise noted. The rest of Appendix A and all of Appendix B are Informative, not Normative {i.e. it does not contain requirements, but is for information only}. Examples of measurement test circuits and calibration are provided in IrDA Serial Infrared Physical Layer Measurement Guidelines.

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 1kHz 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 kilolux 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 $\mu W/cm^2$ (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 lux maximum
  This is produced with general service, tungsten filament, gas–filled, inside–frosted lamps in the 60 Watt to 150 Watt range to generate 1000 lux 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 to 3050 degrees Kelvin range and a spectral peak in the 850 nm to 1050 nm range.
- Fluorescent Lighting: 1000 lux 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 $\mu W/cm^2$ minimum and 0.3 $\mu W/cm^2$ 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.

Transmission Distance

From figure 5, 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.

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

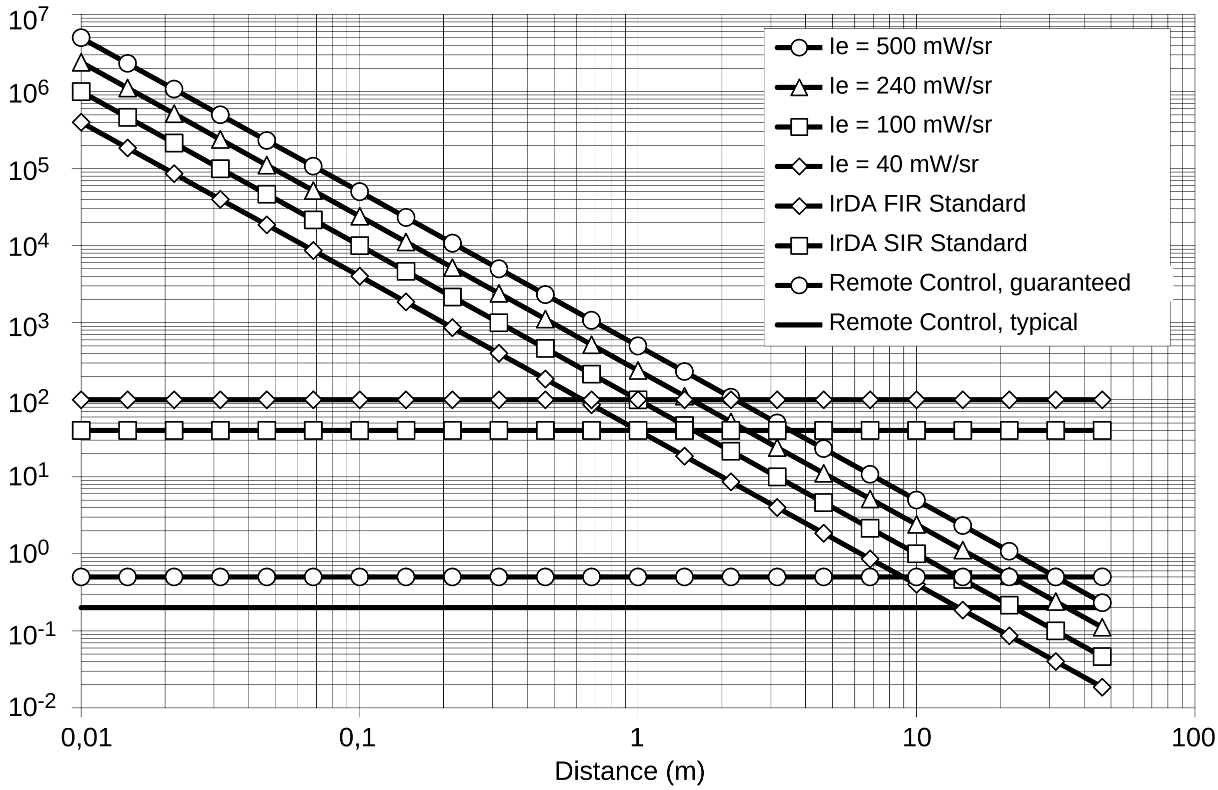


Figure 5. IrDA transmission distance

The Future of the IrDA Standard – Physical Layer

It is Vishay Telefunken‘s policy to support the further development of the standard and not to support hardware developments in order to short cut any standardization efforts. It is firmly believed that this is in the best interest of the future of the IR communication market and all industrial participants in it.

Vishay Telefunken is actively involved in the further development of the standard and will use its influence to reach most beneficial rules for practical operation.

The Future of the Technology

The future of the IrDA standard is not limited by the technology. The technology of IREDs implemented in the transceiver is capable of a bit rate of up to 30 Mbit/s. Even higher bit rates can be achieved in the future with little technological measures. Laser technologies are available for bit rates in the 100 Mbit/s range. Similarly, the band–width of the detecting pin diode can be increased beyond the requirements of the existing IrDA standards.

Technologies Integrated Circuits

Depending on the requirements of the specific device Vishay Telefunken is using bipolar, BICMOS, or CMOS technologies. The ASICs built into the hybrid integrated front end transceiver modules for the 4000 series use bipolar technology, whereas the 5000 and 6000 series rely on CMOS and BICMOS technologies, respectively.

Emitters

Any reliable supplier of advanced IR transceivers must have control over the next generation IR technology. Vishay Telefunken is an acknowledged leader in IR technology for IR emitters as well as detectors.

IR technology for emitters is based on the ternary III–V material system (GaAl)As. The emitter diodes are double hetero structures optimized for high efficiency and low forward voltage. In addition the bandwidth needed for the IR transmission must be designed into the emitter diodes. All three features are important for IR data communication: high efficiency saves battery power through a low forward current to reach the emission intensity requested, e.g. by the IrDA standards.

The importance of a low forward voltage is not so easy to understand. The first reason why a low forward voltage is important is the temperature coefficient of efficiency: efficiency decreases with temperature, therefore thermal heating of the emitter diode must be minimized. Thermal heating cannot be neglected because the current needed to reach 100 mW/sr in the $\pm 15°$ cone for example is typically 350 mA. The trend to decrease package size and therefore lens size tends to increase the required current. The second reason why a low forward voltage is important is the increasing popularity of 3 V applications. It is not trivial to achieve low enough forward voltages. The pn junction voltage of a diode emitting in the IrDA defined wavelength range is by physical law fixed at about 1.3 V, the switching transistor of an IR transceiver needs typically 0.6 V, therefore in an application with a weakened Li ion battery running at 2.7 V only 0.8 V are available for the ohmic voltage drop of the emitter diode and the current limiting resistor. At 0.35 A this means an ohmic resistance of the diode plus the current limiting external resistor of only about 2.3 Ohm!

Bandwidth is no problem at the present 4 Mbit/s requirement. Even the upcoming 16Mbit/s standard can be satisfied with the existing technology.

Figure 6 shows a typical double heterostructure diode for IrDA applications. It is a 4–layer structure grown by liquid phase epitaxy. The layers are all made of ternary material (GaAl)As grown on a binary GaAs substrate. The band gap of GaAs is smaller than that of the ternary material. Therefore, the radiation emitted in this part of the structure is absorbed in the GaAs substrate. To avoid this detrimental effect the substrate is chemically removed. The active layer is sandwiched between higher band gap cladding layers in order to prevent injected carriers from diffusing away from the pn junction region. The doping level in the active layer controls the bandwidth which will be achieved. The internal optoelectronic efficiency of the heterostructure is close to 100%. However, because of the high refractive index of the material, the reflection at the surface of the material is high and the escape efficiency of the radiation is low. To improve escape efficiency the surface is roughened and the metallic contacts are optimized not only for low resistivity, but also for high optical reflectivity. The cladding layers have to be transparent and must be optimized for the highest possible conductivity.

Our diodes optimized for IrDA 1.2 applications achieve about 50 mW at a forward current of 100 mA or 170 mW at 350 mA. At a forward current of 550 mA, which is the thermally limited maximum current at a duty cycle of 25%, the forward voltage is below 2.1 V. The pulse rise and fall times are about 30 ns. This is a combination of excellent values unsurpassed in the industry.

Future higher bandwidth systems need faster emitters. In the Vishay Telefunken development lab rise times of around 5 ns have already been achieved. The challenge here is to minimize the unavoidable drop of the efficiency when going to higher bandwidth.

Detectors

The Si detector diodes used in IR transceivers interface with a mixed signal ASIC built into the transceiver. The ASIC amplifies the signal of the diode and transforms it into a digital output signal. The user of an IR transceiver therefore has no direct interface with the diode. He can only evaluate the combined performance of the diode and the ASIC. Nevertheless a few remarks with respect to the trade–offs involved in the development of these detectors could be helpful.

The diodes used are photo pin diodes. Photons of higher energy than the band gap of Si are absorbed in the material and create a pair of charge carriers: electrons and holes. Charge carriers created in the electric field of the space charge region of the pn junction are quickly separated and driven to the n or p–side depending on the sign of the charge. In contrast, carriers created in the neutral material can move only by diffusion and produce a relatively slow signal in the range up to microseconds.

The designer of a suitable pin diode will take care to see that most, if not all radiation is absorbed in the space charge region. In this case clean signals without a slow tail are provided to the amplifier facilitating signal processing. However, especially in a 3 V application, it is not easy to meet this goal because the space charge region decreases like the square root of the voltage across the pn junction.

The design of our pin diodes is optimized in the sense of avoiding slow tails of the signal, caused by diffusing carriers, as much as possible. This means that the absorption length at the IrDA defined wavelengths between 850 nm and 900 nm is roughly the same as the width of the space charge region. The resistivity of the quasi intrinsic material has been pushed up beyond 1000 Ohmcm, resulting in a space charge region of about 30 µm at 5 V.

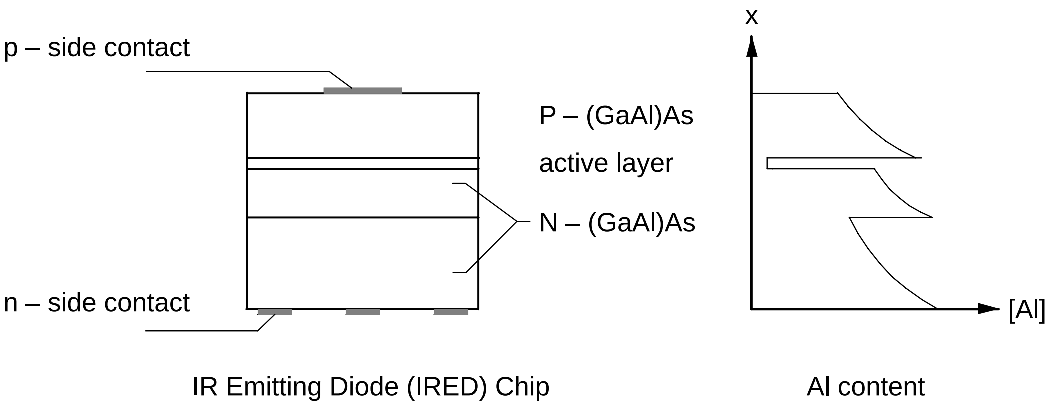


Figure 6. Typical double heterostructure diode for IrDA applications