General Overview of IR Transmission in Free Ambient

Free ambient IR data transmission, IR remote control as well as the most optoelectronic sensors and light barrier systems work with a wavelength of between 870 nm and 950 nm. The emitter and detector components are highly efficient in this near IR wavelength band and can be manufactured at low cost.

Data transmission in free space demands high interference immunity of the IR receiving modules. The receiver unit (waiting to receive signals) is loaded with different optical and electromagnetic disturbances, omni-present in the ambient or generated by the electrical appliance itself. All optical sources with an emission spectrum in the reception bandwidth (830 nm - 1100 nm) of the detector can be considered as disturbing sources. These are mainly fluorescent lamps, incandescent lamps and sunlight. Sometimes also plasma displays can produce significant emissions in the optical band of the IR transmission.

The common method of modulation for IR remote control is Pulse Code Modulation (PCM). This way of encoding data allows a wide transmission range because it is carrier based and a receiver with limited bandwidth and good sensitivity is feasible.

As emitter for the IR signal there are various IR emitting diodes with high brightness and efficiency available from Vishay. The IR emitters with a wavelength of 950 nm best match the IR receivers for remote control. The faster IR emitter at 870 nm (e.g. TSHF series) is the optimum light source for the TSOP7000.

The maximum possible transmission distance of an IR remote control system depends on various parameters. Mainly it is the radiant intensity of the emitter (I_e) and the sensitivity of the receiver (E_{emin}). Additionally, the reflective conditions of the test room, the optical transmittance of windows or light guides in front of the receiver and the disturbance conditions influence the choice of distance. Of course, also the minimum possible distance (high irradiance) is an important value for a remote control system. The TSOP IR receiver modules from Vishay will work even at zero distance.

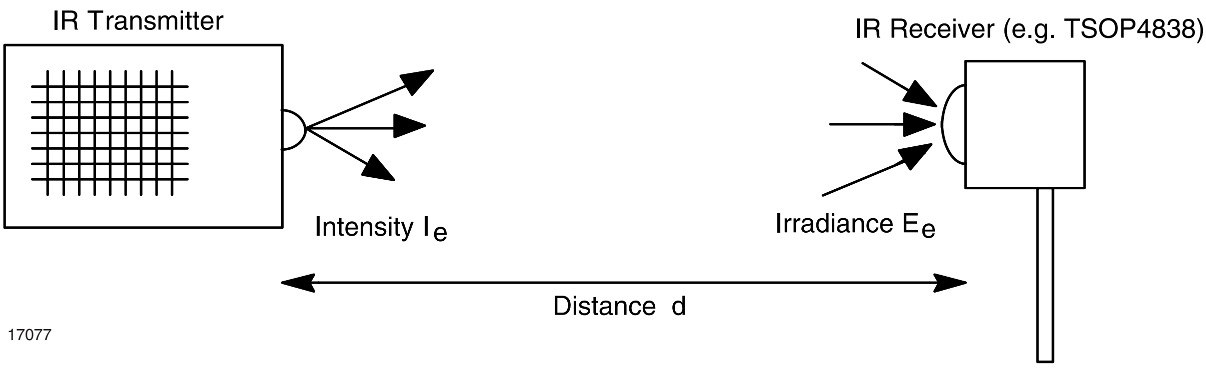

Figure 1. Relevant Values for IR Transmission Distance

Calculating transmission ranges in the simplest case assumes a quadratic expression relationship between distance d and irradiance E_e. Given emitter intensity I_e, the result is

$$d_{max} = \sqrt{\frac{I_e}{E_{emin}}}$$

With known responsivity of the receiver module and known intensity of the transmitter, the transmission range can be calculated with this expression or read from Figure 2 where this quadratic equation for distance is implemented. As a typical threshold of the receiver sensitivity for safe operation, a value of 0.2 mW/m^2 is taken for the necessary irradiance in Figure 2. This is equivalent to the typical specified value of the TSOP48 or TSOP22 series. The maximum sensitivity threshold is specified at 0.4 mW/m^2 for these devices. The typical intensity values of selected emitters are listed in Table 1.

For example, operating a TSAL6200 emitter at 500 mA pulsed forward current leads to an intensity of 300 mW/sr. These data result (in combination with the Vishay receiver module TSOP48xx) in a theoretical transmission range of 39 m (see Figure 2).

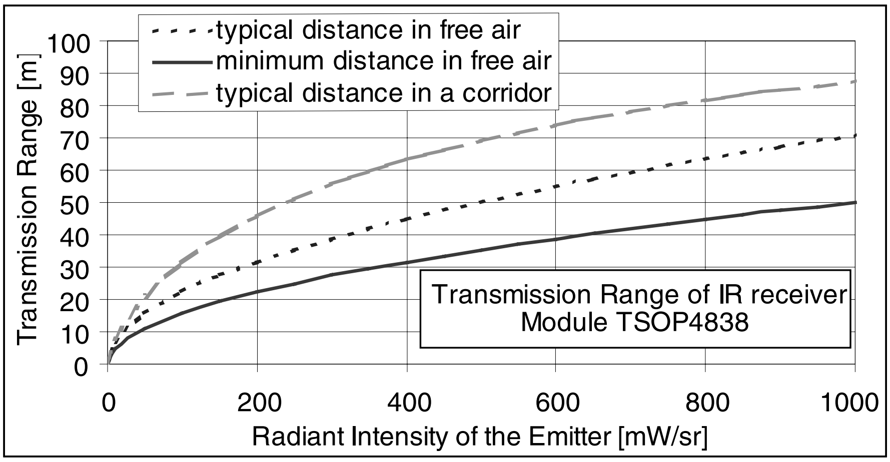

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Figure 2. Maximum Transmission Range with TSOP4838 as a Function of the Radiant Intensity of the Emitter

In practice, it is difficult to achieve the quadratic relationship between irradiance and transmission distance. In most cases the actual distance is longer than calculated by the expression. This means that the example calculated here is the worst case and in reality better transmission ranges are attained. However, in many cases the actual distance is decreased because of dull windows in front of receiver and emitter.

Comparison of remote control systems is often performed in long corridors. As indicated in Figure 2 the transmission range is longer under this test condition because of reflectivity properties of walls, ceiling, etc. In a corridor, the function of the irradiance does not obey the quadratic expression.

The levels for indoor optical power can be estimated by using other approximations. In this case, it is assumed that the whole inner surface of a room is irradiated with the emission of the source. To irradiate the whole surface of a square room (e.g. area = 30 m^2, height = 2.5 m) with an overall irradiance of E_e = 0.4 mW/ m^2, an emitted radiant flux of 50 mW is necessary (surface = 120 m^2, 100 % efficiency). With 80 % reflection loss, about 250 mW emitted radiation will be sufficient for safe reception in the whole room.

250 mW is a value, which can be achieved with an emitter TSAL6400 operating at a peak forward current of 700 mA. Under these conditions, no direct path between emitter and receiver is supposed, but radiation after at least one reflection will reach the detector. This kind of remote control is very convenient for the customer because he can target in any direction of his living room. An IR emitter with wide emitting angle will also support this kind of comfortable remote control.

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Emitter	Package Diameter	Wavelength nm	Radiant Flux I_F = 100 mA mW Typ.	Radiant Intensity I_F = 100 mA mW/sr Typ.	Emission Angle	Remarks
TSAL4400	3 mm	950	35	30	± 25 °	blue resin
TSAL5100	5 mm	950	35	130	± 10 °	Leads with stand off, blue resin
TSAL6100	5 mm	950	35	130	± 10 °	blue resin
TSAL6200	5 mm	950	35	60	± 17 °	blue resin
TSAL7200	5 mm	950	35	60	± 17 °	clear resin
TSAL5300	5 mm	950	35	45	± 22 °	Leads with stand off, blue resin
TSAL7300	5 mm	950	35	45	± 22 °	clear resin
TSAL6400	5 mm	950	35	40	± 25 °	blue resin
TSAL7400	5 mm	950	35	40	± 25 °	clear resin
TSAL7600	5 mm	950	35	35	± 30 °	clear resin
TSML1020	SMD	950	35	35	± 12 °	Clear SMD package with lens
TSML3700	SMD	950	35	7	± 60 °	PL-CC-2 SMD package
TSHF5200	5 mm	870	35	100	± 10 °	clear resin
TSHF5400	5 mm	870	35	40	± 22 °	clear resin
TSMF1020	SMD	870	35	25	± 17 °	Clear SMD package with lens

Table 1: Emitters for TSOP Receiver Modules

All IR emitting diodes with a wavelength of 950 nm mentioned in Table 1 are suitable for the Vishay IR receiver for standard remote control applications (30 kHz … 56 kHz). The rise time and fall time of these IR emitters is about 800 ns.

The IR emitters in Table 1 with a wavelength of 870 nm are faster. The rise time and fall time is 30 ns for these parts. They best match the IR receivers TSOP5700 and TSOP7000 (carrier frequency 455 kHz).