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Infrared Transceiver Distance and Power Consumption Tradeoffs

Application Note 1113

Introduction

The distance of an infrared link is based upon the transmitter intensity and the receiver sensitivity of the transceivers. Changes in transmitter intensity for both sides of the communication link can be used to increase link distance. If link distance is expendable, then transmitter intensity can be reduced in order to reduce power consumption. At some Infrared Data Association (IrDA) data rates, the duty cycle of the data may be chosen in order to reduce power consumption during transmission.

Increasing Link Distance

If an infrared receiver's sensitivity is left unchanged, then the transmitter intensity must be increased on both sides of the communication link to achieve increased link distance. If the transmitter intensity is increased for only one of the transceivers (A), then the other transceiver's (B) signal will not be correctly received by (A) at the increased distances.

An infrared transceiver's transmission distance increases as the square root of the increase in transmitted intensity.

$(D_2 / D_1) = (IE_2 / IE_1)^{0.5}$

where:

D_2 = transmission distance after transmitter intensity increase

D_1 = original transmission distance

IE_2 = transmitter intensity after increase

IE_1 = original transmitter intensity

For Hewlett-Packard's infrared transceivers, transmitter intensity is based linearly upon emitter current for emitter currents $\geq$ 10mA. The table below shows examples of increased link distance based upon increases in emitter current. For information on selecting the proper LED pull-up resistor R_{LED} to obtain a specific emitter current, see the Emitter Current Reduction section at the end of this application note.

Table 1.

Peak Emitter Current (mA)	Pulse Duty Cycle (%)	Average Emitter Current (mA)	Minimum Transmitter Intensity (mW/sr)	Transmission Distance (meters)
240	18.75	45.00	40	1.0 *
350	18.75	65.63	56	1.21
500	18.75	93.75	80	1.44
350	9.2	32.2	56	1.21
500	9.2	46.0	80	1.44
1000	9.2	92.0	160	2.04

* The transmission distance is 1.0 meters for an IrDA link with receiver sensitivity of 4.0 μW/cm^2.

Note: Refer to Hewlett-Packard's infrared transceiver datasheets for the emitter current (ILED) required to obtain a minimum transmitter intensity (IE). The absolute maximum ratings in the datasheets must be followed in order to guarantee the long term performance of the transceivers.

At the IrDA data rates of 9.6-115.2 kbits/s, the duty cycle of the transmitted pulses can be adjusted to reduce the average emitter current. The IrDA specifications allow pulse widths as small as 1.6 µs for the 9.6-115.2 kbits/s data rates. The average emitter current can be kept under the datasheet absolute maximum average emitter current (ILED) by minimizing the duty cycle of the transmitted pulses.

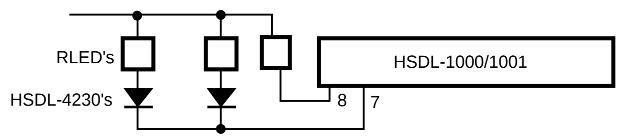
The duty cycle of the transmitted pulses is set by the infrared modulation circuitry contained on an I/O chip, EnDec chip, or IR Controller chip. The HSDL-7001 EnDec and the HSDL-7002 IR Controller allow for 1.6 µs pulse widths at all data rates 9.6-115.2 kbits/s.

Increasing Link Distance

Implementation with Hewlett-Packard Products

Implementation using HSDL-1000 or HSDL-1001 infrared transceivers, can use additional discrete emitters such as the HSDL-4220 and HSDL-4230 in parallel with the transceiver's emitter in order to achieve greater transmission distance. The HSDL-1000 and HSDL-1001 have both the emitter cathode and anode pins available for connection. The emitter's driver in the transceiver is capable of driving up to 5 Amps in peak pulsed total emitter current (pulse width ≤ 100 µs and duty cycle ≤ 25%). If more than 5 Amps of peak pulsed current is needed, then an external bipolar common emitter transistor, or FET transistor is necessary to drive the extra emitters.

For data rates and modulation meeting a pulse width ≤ 2 µs and duty cycle ≤ 10% requirement, the emitter currents of the HSDL-1000, HSDL-1001, HSDL-4220, and HSDL-4230 can be as high as 1.0 Amps peak pulsed amplitude. IrDA allows use of 1.6 µs pulse widths at each of the data rates from 9.6 kb/s to 115.2 kb/s. At data rates at or below 57.6 kb/s, the duty cycle while using 1.6 µs pulse widths will be < 10%. Examples of implementations meeting the pulse width ≤ 2 µs and duty cycle ≤ 10% requirement are shown in table 2 below.



This Diagram Demonstrates the Connection of discrete emitters in parallel with the transceiver;s emitter.

Table 2.

HSDL-1000/1001 Emitter Current (mA)	Number of HSDL-4230 Emitters in parallel Biased at 1.0 Amp Peak Pulsed Amplitude	Minimum Total Transmitted Intensity IE (mW/sr)	Typical Total Transmitted Intensity IE (mW/sr)	Minimum Transmission Distance (meters)	Typical Transmission Distance (meters)
1000	1	840	1710	4.58	6.53
1000	2	1540	3060	6.20	8.75
1000	3	2240	4410	7.48	10.50
1000	4	2940	5760	8.57	12.00

Table 3.

HSDL-1000/1001 Emitter Current (mA)	Number of HSDL-4230 Emitters in parallel Biased at 500 mA Peak Pulsed Amplitude	Minimum Total Transmitted Intensity IE (mW/sr)	Typical Total Transmitted Intensity IE (mW/sr)	Minimum Transmission Distance (meters)	Typical Transmission Distance (meters)
500	1	420	855	3.24	4.62
500	2	770	1530	4.39	6.18
500	3	1120	2205	5.29	7.42
500	4	1470	2880	6.06	8.48
500	5	1827	3555	6.76	9.43

The HSDL-4230 is chosen for increased transmission distance because of its narrower viewing angle, which projects a greater portion of light on axis.

For the data rates that do not meet the pulse width ≤ 2 µs and duty cycle ≤ 10% requirement, the HSDL-1000/1001 transceiver and HSDL-4220/4230 discrete emitters are limited to peak pulsed current amplitudes ≤ 500 mA. Examples of implementations at these emitter currents are shown in table 3 below. Note that 1 transceiver and 9 discrete emitters can be driven at 500 mA peak pulsed current each, from the transceiver internal driver, before the 5.0 Amp maximum of the transceiver internal driver is exceeded.

Reducing Power Consumption

The infrared transceiver's emitter current (ILED) can account for most of the transceiver's power consumption during an infrared conversation. A transceiver's average emitter current can be reduced either by adjusting the duty cycle of the transmitted pulses, or by reducing the peak emitter current during transmission. Reduction of the peak emitter current will result in a decrease in transmission distance of the transceiver.

Duty Cycle Adjustment (9.6-115.2 kbits/s)

Average transmit power can be reduced, without sacrificing link distance, at some Infrared Data Association (IrDA) data rates by reducing the duty cycle of transmitted pulses. Duty cycle is the pulse width divided by the pulse period. Decreasing the pulse width for a given data rate will reduce the duty cycle. Typically, Infrared Data Association (IrDA) links use 3/16 duty cycle modulation and demodulation. IrDA specifications allow data rates of 9.6-115.2 kpulses/second to use pulses of 1.6 µs in width. At the data rate of 115.2 kpulses/s, 1.6 µs pulses is equivalent to 3/16th duty cycle. At data rates lower than 115.2 kpulses/s, using 1.6 µs pulses will decrease the duty cycle below 3/16.

Average transmit power depends directly upon the average emitter current (ILED) of the transceiver. Average emitter current is equal to the peak emitter current multiplied by the duty cycle of the transmitted pulses. The HSDL-1001 requires 240 mA of peak LED current to transmit at least 44 mW/sr (T_A = 0-70°C). At 3/16th duty cycle, 240 mA of peak LED current is equivalent to 45 mA of average current.

The duty cycle of the transmitted pulses is set by the infrared modulation circuitry contained on an I/O chip, EnDec chip, or IR Controller chip. The HSDL-7001 EnDec and the HSDL-7002 IR Controller allow for 1.6 µs pulse widths at all data rates 9.6-115.2 kbits/s.

Table 4. Examples of the reduction in transmission distance based upon a reduction in peak emitter current:

Peak Emitter Current (mA)	Transmitter Intensity (IE) (mW/sr)	Transmission Distance (meters)
240	40	1.0 *
120	20	0.71
60	10	0.5
30	5	0.35
15	2.5	0.25
7	1.17	0.17

* The transmission distance is 1.0 meters for an IrDA link with receiver sensitivity of 4.0 µW/cm^2.

Table 5. Examples of average LED current calculations based upon peak LED current and pulse duty cycle:

Peak LED Current (mA)	Data Rate (kbits/s)	Pulse Width (µs)	Pulse Duty Cycle (%)	Average LED Current (mA)
240	115.2	1.6	18.75	45.0
240	57.6	1.6	9.22	22.1
240	9.6	1.6	1.54	3.70

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Emitter Current Reduction

If usage model for the communication link allows for minimum link distances of less than 1 meter, then peak transmit power can be reduced at the cost of transmission distance. Decreasing emitter current (ILED) and therefore transmitter intensity (IE), will decrease the peak transmit power. The resulting decrease in transmission distance will depend upon the decrease in transmitter intensity:

$(D_2 / D_1) = (IE_2 / IE_1)^{0.5}$
where:
D_2 = transmission distance after transmitter intensity decrease
D_1 = original transmission distance
IE_2 = transmitter intensity after decrease
IE_1 = original transmitter intensity

Emitter Current Reduction

The emitter current of Hewlett-Packard's transceivers can be reduced by raising the value of the LED pull-up resistor R_{LED} from its recommended value in the datasheet. The model used to calculate emitter current for a given R_{LED} is shown below. V_X includes the LED forward voltage and the saturation voltage of the LED drive transistor. R_X includes the LED bulk resistance and the collector resistance of the LED drive transistor.

During signal transmission, the pulse waveform at VLEDA can be observed with an oscilloscope, in order to measure the actual peak emitter current ILED. The observed pulse amplitude (volts) divided by R_{LED} is equal to the peak emitter current.

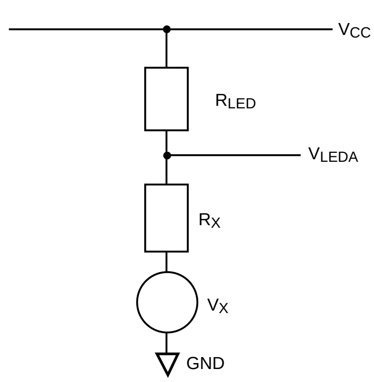
Table 6. Example calculations for some of Hewlett-Packard's infrared transceivers. Note that Vcc examples are for the lowest Vcc in a typical supply range (3.0 V is used for the 3-3.6 V range, 4.5 V is used for the 4.5-5.5 V range, and 4.75 V is used for the 4.75-5.25 V range). This will guarantee a minimum peak emitter current shown in the table below for that supply range.

V_{CC} (volts)	R_{LED} (ohms)	Peak Emitter Current ILED (mA)	
		HSDL-1001	HSDL-1100
3.0	3.3	246	—
3.0	10	113	—
3.0	20	65.2	—
3.0	200	7.2	—
4.5	9.1	252	—
4.5	20	129	—
4.5	100	28.9	—
4.5	410	7.2	—
4.75	4.7	—	409
4.75	10	—	242
4.75	100	—	31.2
4.75	440	—	7.2

Note: If the actual resistor has a % tolerance, then the maximum resistance should be used in the calculation in order to guarantee a minimum peak emitter current in the application.

Table 7. Values of R_X and V_X for some of Hewlett-Packard's infrared transceivers.

Parameter	HSDL-1001	HSDL-1100
V_X@ILED ≥ 100 mA	1.6	1.6
V_X@ILED ≤ 100 mA	1.54	1.54
R_X	2.4	3.0



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