PDA Reference Design using the Agilent HSDL-3002[1]

Application Note 1315

Introduction

Starting with the late 90s to the rest of the century to date, digital convergence has gained prominence and the ease of use has improved by bringing the convenience within your palm in the form of handheld devices including mobile phones, PDAs, smart phones and PDA phones. Portability is key to the success of these devices and one technology has enabled this and has been successful in gaining large-scale market acceptance. It is infrared technology based on Infrared Data Association (IrDA) standards. This application note provides a reference design on how to incorporate an IrDA transceiver into an embedded device, like a PDA and the associated support available for IrDA from third-party processor manufacturer and Operating Systems. The reference device chosen is the HSDL-3002, which marks the beginning of a new generation of transceiver family from Agilent enabling not only IrDA data transmission but also consumer electronics compliant Remote Control functionality.

IrDA Architecture

Infrared Data Association was founded in 1993 and the objective was to create an interoperable, low-cost infrared data interconnection standard that supported a walk-up, point-to-point user model that is adaptable to a broad range of mobile appliances that need to connect to peripheral devices and hosts.

Over the decade, IrDA has specified and drafted standards to realize the objective. The essential protocol stack comprises of the Physical Layer, IrLAP, IrLMP and IAS. The latest version of the Physical Layer, v1.4, supports data rates up to 16 Mbps and includes standard power and low power options. The physical layer includes the optical transceiver, encoding and decoding and cyclic redundancy checks (CRCs). The encoding and decoding of data bits and CRC are usually implemented in hardware or at lower data rates, it can be implemented in software as well. Most controllers support this in hardware. Currently, the support is available for data rates up to 4 Mbps on most controllers. In case an external implementation is required, Agilent also provides endecs in the form of HSDL700x, which supports data rates up to 115.2 kbps.

There resides a framer between the hardware and the software so as to create a transparency between the two and shield the software of the constantly changing hardware.

The essential protocol stack is comprised of:

1. Physical Layer: This comprises the hardware specifying the optical characteristics of the transceiver, encoding of data and framing for various speeds.

2. IrLAP: This is the Link Access Protocol that provides the basic link layer connection between a pair of IrDA devices. It is based on the HDLC protocol providing functions like connection establishment, data transfer and flow control.

3. IrLMP: The Link Management Protocol sits on top of the IrLAP layer. It provides application and service discovery and multiplexing of application level connections over a single IrLAP connection. This allows services of one device to “talk” with identical services in a peer device without any interference from other services using the same IrLAP connection.

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[1]Patent filed in Singapore and patent pending in other regions

4. IAS: The Information Access Service, as the name indicates, is a "yellow pages" service provided by the host device. This allows devices to discover which services are available on the host device and provides the configuration information necessary to access those services.

The optional protocols are:

5. TinyTP: The Tiny Transport Protocol provides flow control on top of the IrLAP layer. In the event that more than one IrLMP connection is operating over a LAP layer, a deadlock might result. IrDA hence provides this lightweight transport protocol which adds per-channel flow control to overcome this problem.

6. IrOBEX: The Object Exchange Protocol enables the transfer of generic data across devices. It is similar to the role that HTTP serves in the Internet Protocol suite. This enables covering a wide range of data object besides traditional files like pages, phone messages, digital images, electronic business cards and database records.

7. IrCOMM and IrLPT: IrCOMM and IrLPT was developed to emulate existing serial and parallel port emulation targeted at supporting "legacy" applications like printing, file transfer and modem communications.

The IrDA architecture is illustrated in Figure 1.

For more details on the architecture, please refer to the Agilent IrDA Data Link Design Guide or the IrDA web-site at www.irda.org.

Agilent's IrDA Product Offering

Agilent infrared product offerings include a wide range of products and services comprising optical transceivers, endecs, netlists, software solutions and design services. More information can be obtained from www.agilent.com/view/infrared or from your nearest sales representative.

For PDA devices where form factor, data rate, link distance and power consumption are of primary concern, Agilent offers a whole range of transceivers like the HSDL-3201, HSDL-3202, HSDL-3203, HSDL-3208, HSDL-3210, HSDL-3000, HSDL-3002 and HSDL-3310. HSDL-3002 is the latest offering from Agilent, which incorporates a remote-control functionality besides the traditional IrDA data transfer function and is the industry first in doing so. The HSDL-3210 is another industry first offering from Agilent in that it incorporates the new IrDA standard, Serial Transceiver Interface (STC). More information on STC implementation in HSDL-3210 can be obtained from application note AN1170, which can be downloaded from the Agilent website. The ultra small HSDL-3208, an industry first once again, at a height of 1.60 mm is the smallest transceiver in the world.

This note illustrates the reference design based on the HSDL-3002, which is highly recommended for a PDA design due to the added remote control functionality that it enables besides the existing IrDA data transfer. The HSDL-3002 is compliant to the IrDA low power specifications version 1.4. Besides having the capability of extended link distance performance of 50 cm and beyond as opposed to the traditional 20~30 cm link distance, the device also boasts a remote control link distance of typically 6 m. This is made possible by the inclusion of a spectrally suited 940 nm remote control transmitter.

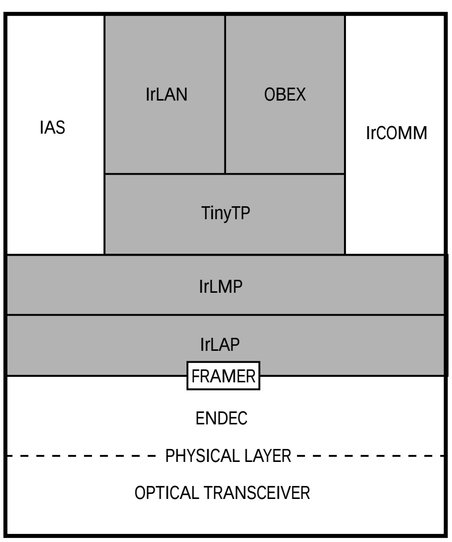


Figure 1. IrDA Protocol Stack

Hardware Reference Design

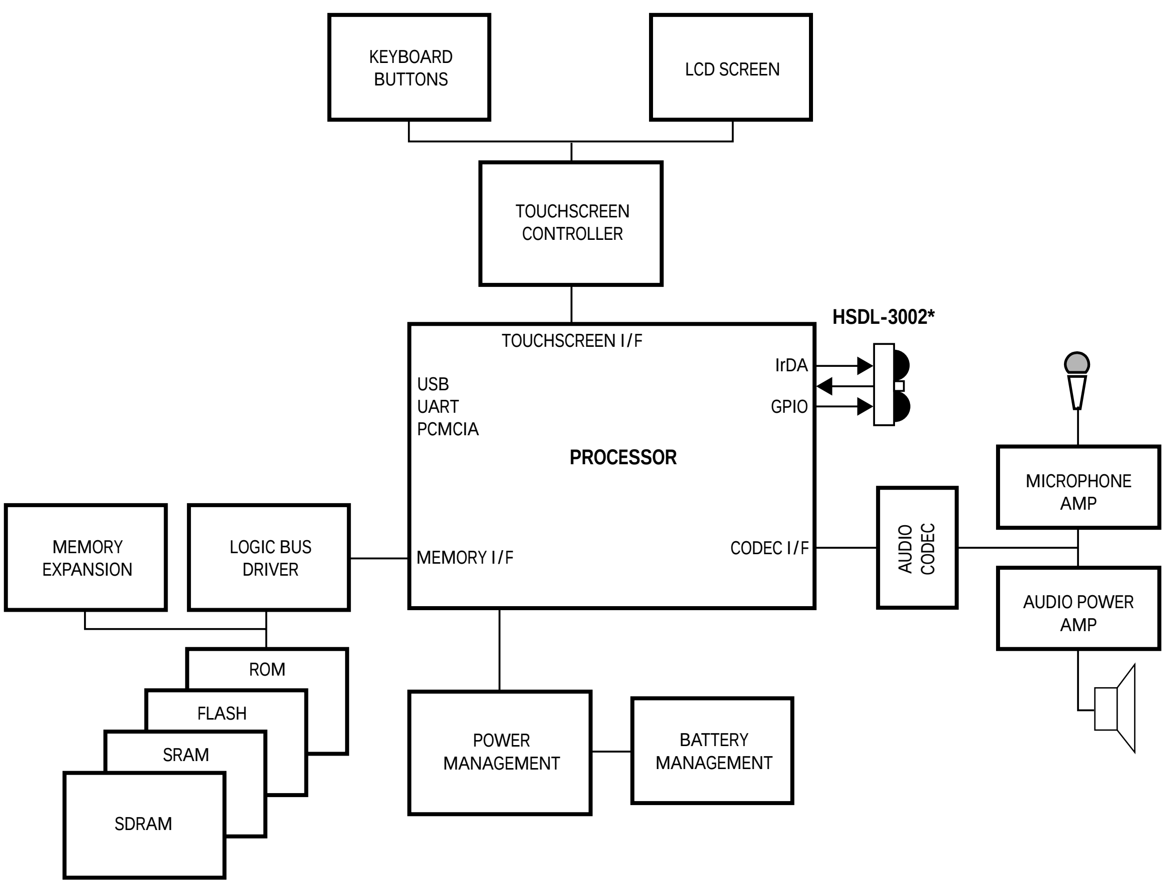
A typical PDA reference architecture is illustrated in Figure 2.

Currently, there are a wide range of ARM and MIPS based processors supporting a wide variety of operating systems based on which a PDA can be designed. The most popular of the operating systems are Palm OS and Windows CE. Almost all processors have built in support for an IR port. This usually takes the form of an UART port supporting IrDA. This does away with the need for an external endec and simplifies the interfacing to a direct connection between the processor and the transceiver. The rest of the section discusses reference interfacing suggestions with two popular processors, Intel StrongARM SA-1110 and Motorola MC68SZ328.

Intel StrongARM SA-1110

The Intel StrongARM SA-1110[1] microprocessor is a highly integrated communication microcontroller incorporating a 32-bit StrongARM RISC processor core which is based on an ARM architecture. The SA-1110 provides support for infrared communication via serial port 2. This is also called the Infrared Communications Port (ICP). The ICP supports both SIR data rates up to 115.2 kbps and FIR data rates up to 4 Mbps. At SIR data rates, also referred to as Low-Speed ICP operation, the data transferred between the ICP's UART engine and TXD_2/RXD_2 pins is modulated/ demodulated according to IrDA SIR standard. A separate engine called the high-speed serial to parallel (HSSP) implements the IrDA FIR standard compliant 4PPM scheme. At FIR data rates, data transferred between the TXD_2/RXD_2 pins and the ICP's HSSP hence is modulated/demodulated in accordance to IrDA physical layer version 1.4 standard. This provides a direct connection to any IrDA compliant infrared transceiver.

Figure 3 illustrates a reference interfacing to implement only IrDA functionality using the HSDL-3002.



*A SWITCHING TRANSISTOR IS REQUIRED TO DRIVE THE 940 nm LED. PLEASE REFER TO FIGURE 4 FOR AN EXAMPLE CONFIGURATION USING THE SWITCHING TRANSISTOR Q1.

Figure 2. PDA Architecture

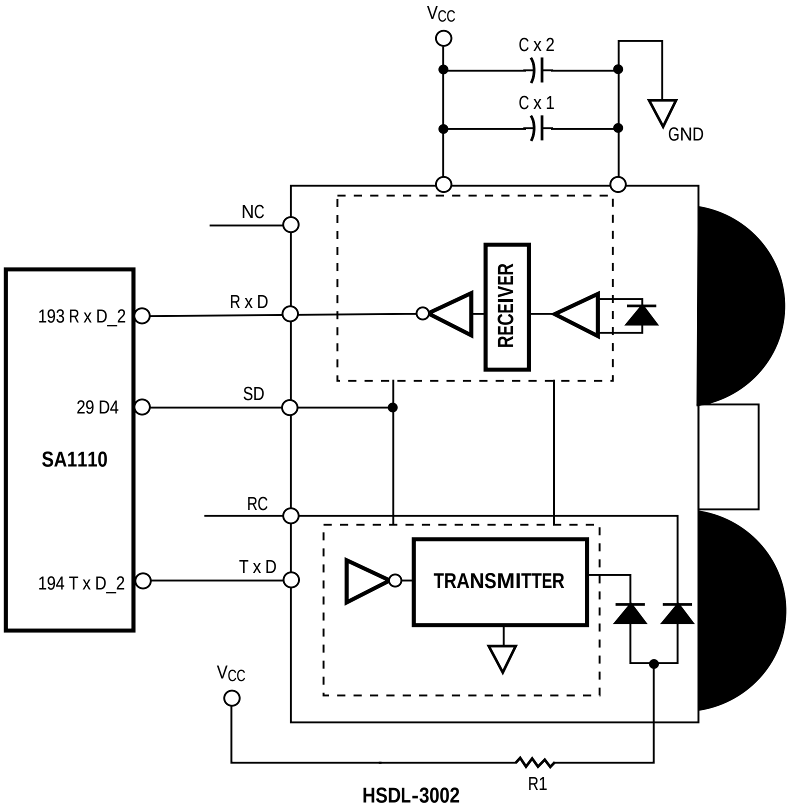


Figure 3. IrDA Mode of Operation

To implement the remote control functionality in HSDL-3002, an additional external switching transistor needs to be used to drive the 940 nm LED. Remote control commands can be sent using one of the available General Purpose IO pins or the UART block with IrDA functionality. It should be observed that although both IrDA data transmission and Remote control transmission is possible simultaneously by the hardware, this should not be done as it would lead to the mixing and corruption of data while being transmitted over free air. The possible configurations are given in the following figures.

In Figure 4, the UART block supporting IrDA is also used for remote control transmission. In remote control mode, the Low-Speed ICP operation will provide

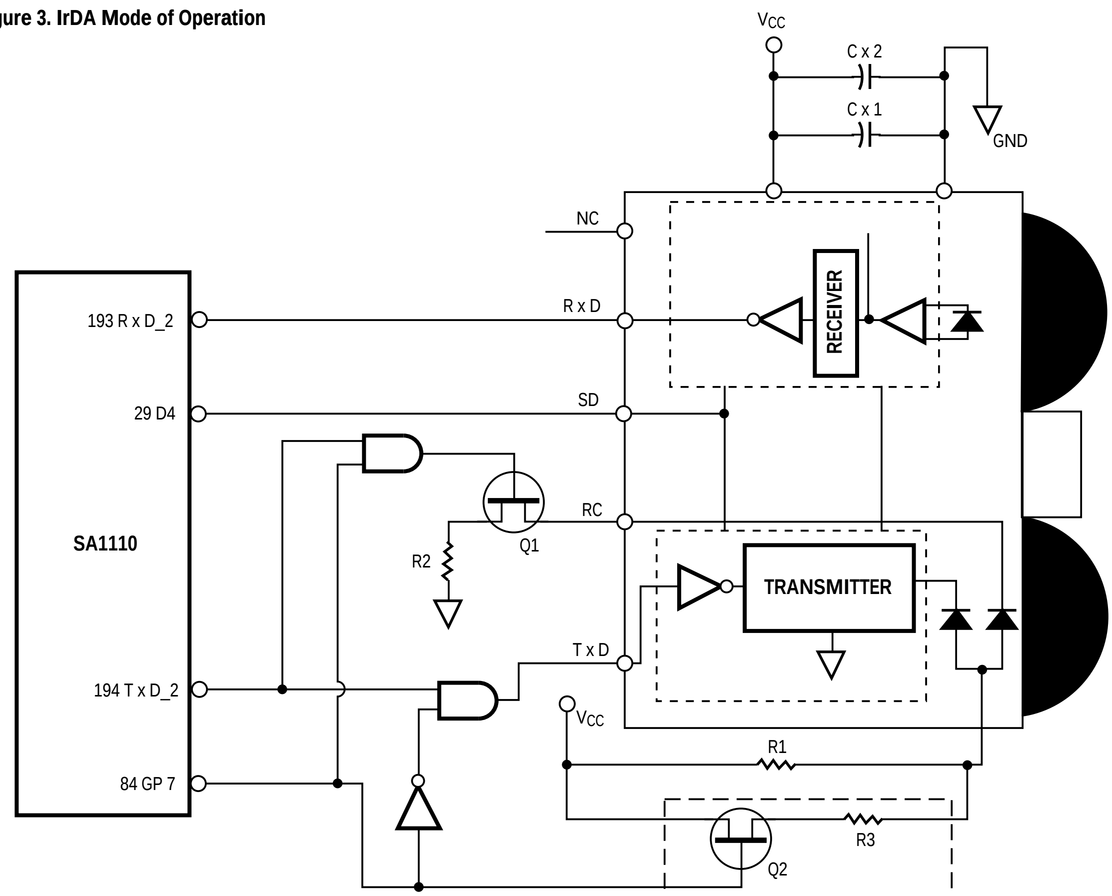


Figure 4. Configuration 1

the necessary modulation for remote control operation. The UART supports data rates of 56.2 bps to 230.4 kbps, inclusive of the IrDA SIR data rates of 2.4 kbps to 115.2 kbps. The UART frequency is programmable by the baud rate divisor. Remote control carrier frequencies are in the range of 30 kHz to 60 kHz (for details of some of the frequently used carrier frequencies, please refer to AN1314). Some common carrier frequencies and the corresponding SA-1110 UART frequency and baud rate divisor are shown in the Table 1.

The transistor Q2 and R3 are optional and give an additional fine tuning capability. The combination is useful when R1 is optimized for low-power IrDA mode and an effective resistance lower than R1 is required for remote control operation. The pin GP7 is used as a remote control select pin. GP7 should be logic 1 for remote control mode and logic 0 during IrDA data transmission.

In Figure 5, the available General Purpose pin GP7 is used for remote control data transmission instead of mode selection as in configuration 1. This would re-

Table 1

Remote Control Carrier Frequency (kHz)	SA-1110 UART Frequency (kHz)	Baud Rate Divisor
30	28.8	8
32, 33	32.9	7
36, 36.7, 38, 39.2, 40	38.4	6
56	57.6	4

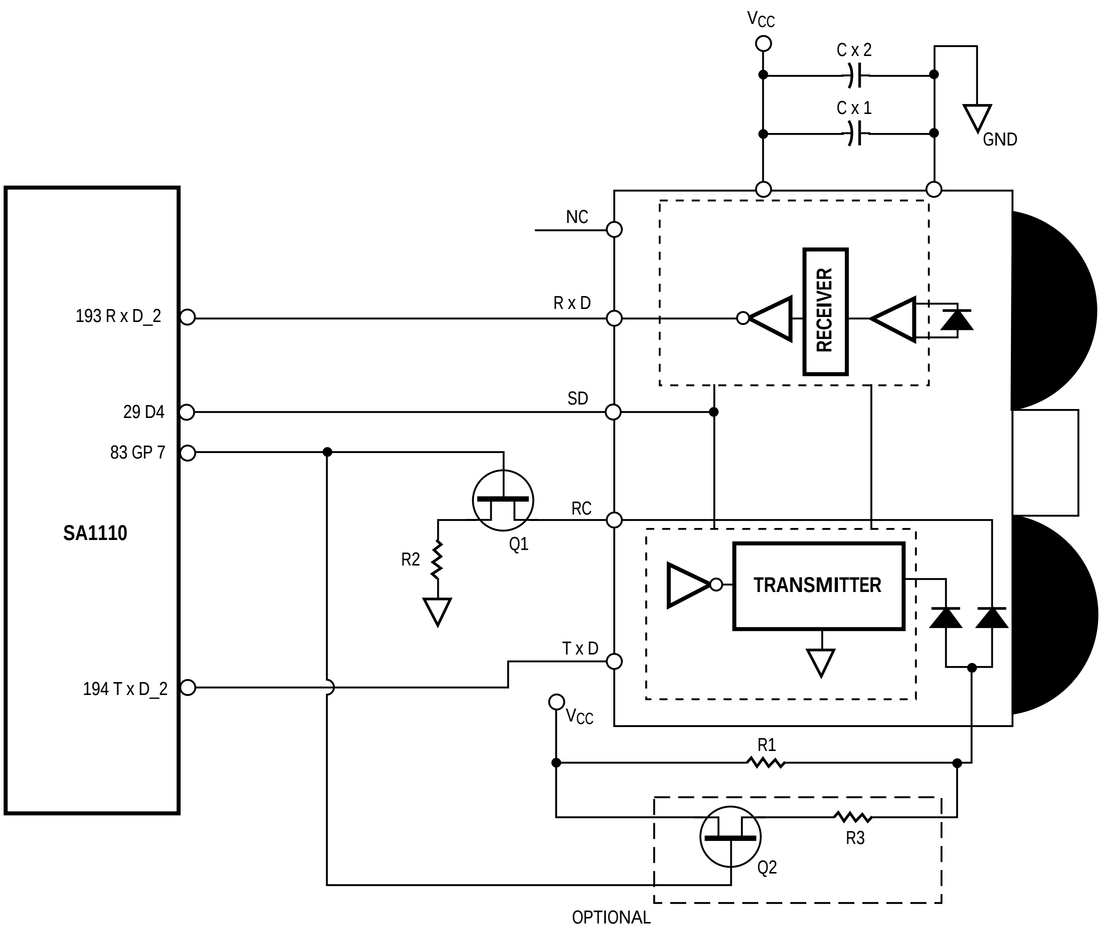


Figure 5. Configuration 2

[2]http://oasis.palm.com/dev/kb/papers/2589.cfm

duce the number of external components required but would be at the expense of increased CPU processing cycles for transmitting data.

Motorola DragonBall

The interfacing for the different configurations using the Motorola DragonBall is very similar to that when using SA-1110, except for the pin-out. The configurations given below, using the MC68SZ328[2], correspond to configuration 1 and configuration 2 described in figure 4 and 5.

The original MC68328 and DragonBall EZ processors had only one UART, which was shared between the serial port and the infrared port. In the PalmOS, "port switching" is used to accomplish switching between the serial and infrared port. This can be done by either using the new serial manager or the old serial manager. This can be accomplished from the following code[2].

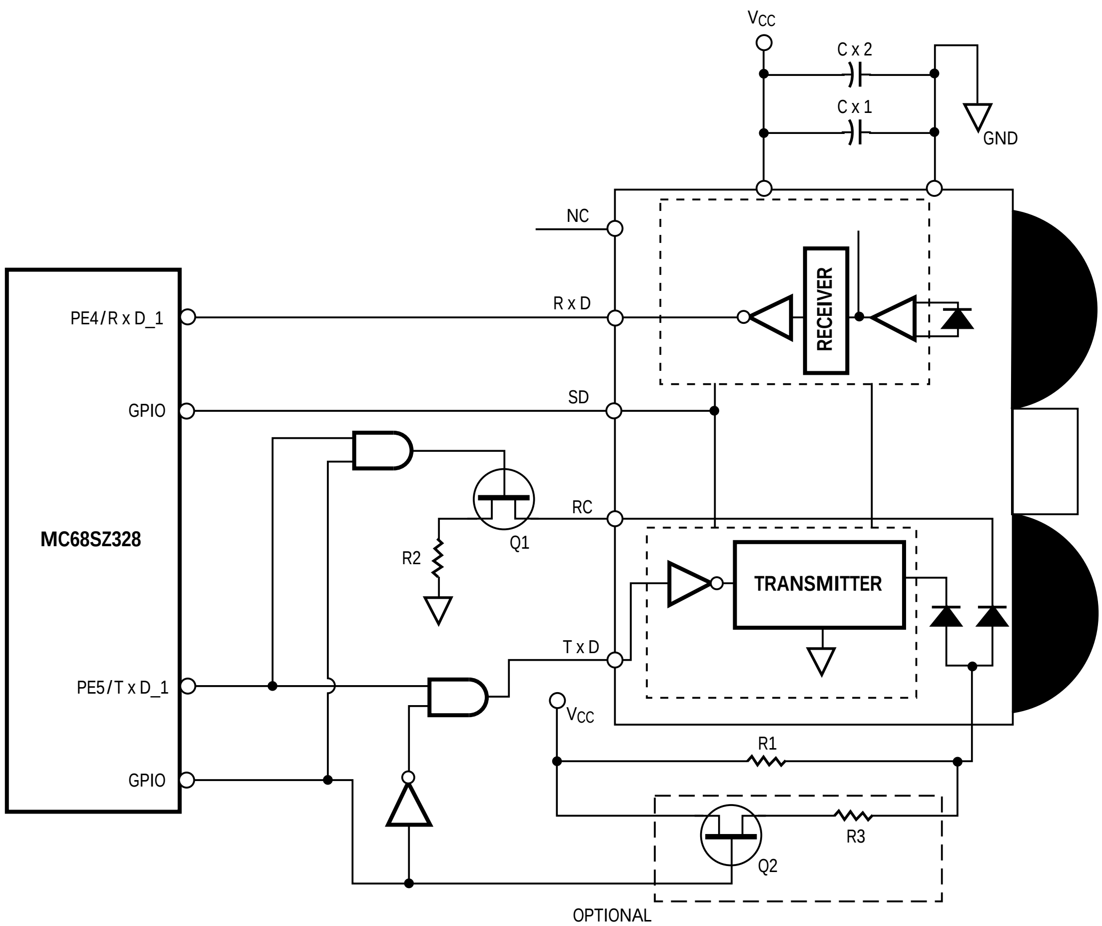


Figure 6. Configuration 1

[2]http://oasis.palm.com/dev/kb/papers/2589.cfm

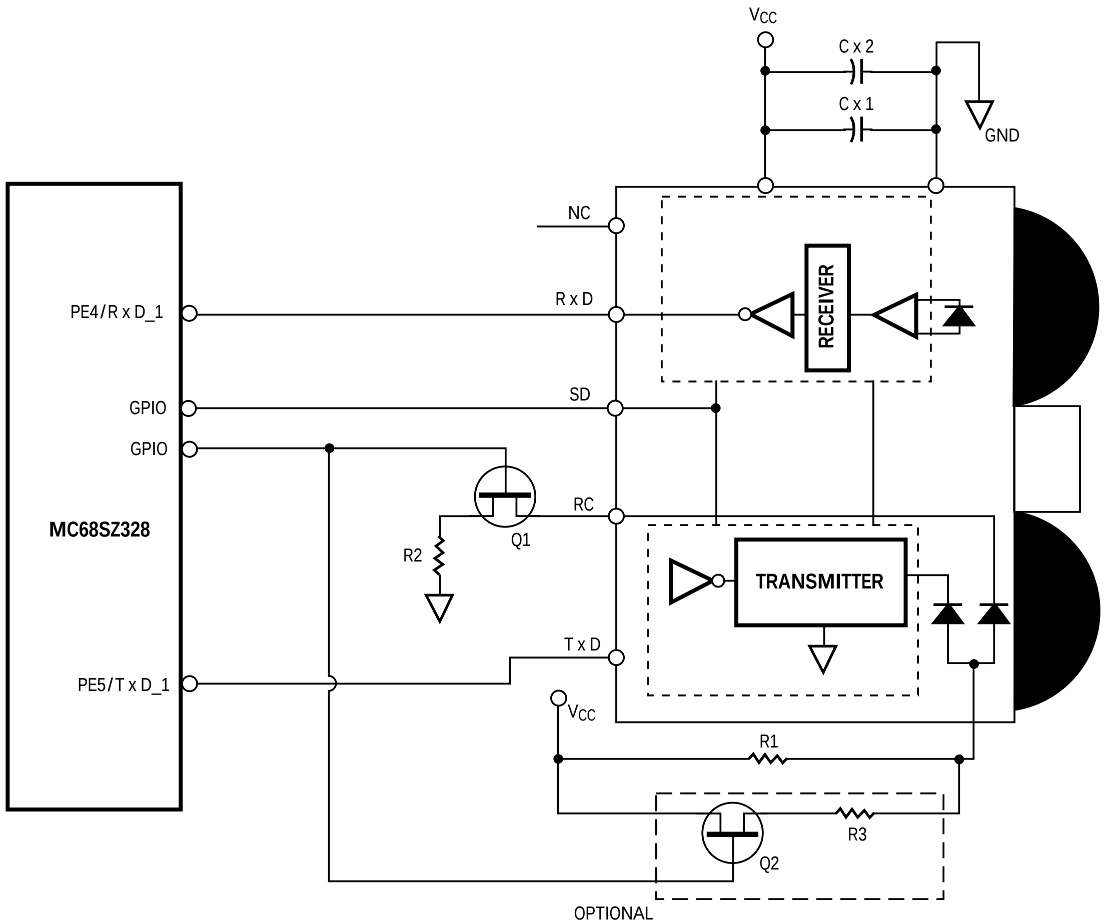


Figure 7. Configuration 2

```
Old Serial Manager:
SysLibFind("Serial Library", &libRef);
SerOpen(libRef, 0, baud);
SerControl(libRef, serCtlIrDAEnable, NULL, 0);

New Serial Manager:
SrmOpen(serPortIrPort, INITIAL_BAUD_RATE, &portID);
    // You can use serPortIrPort or serPortCradlePort on non-VZ devices.
SrmControl(portID, srmCtlIrDAEnable, NULL, 0);
```

On the DragonBall VZ processor, 2 UARTs are used with one UART being dedicated to infrared. Therefore, only the new serial manager needs to be used. The corresponding code[2] to do so is,

```
New Serial Manager:
SrmOpen(serPortIrPort, INITIAL_BAUD_RATE, &portID);
    // You must use serPortIrPort on DragonBall VZ devices.
SrmControl(portID, srmCtlIrDAEnable, NULL, 0);
```

So, your code should look like this:

```
if (PalmOS_version < OS3.3) // The New Serial Manager
                            // was introduced in OS 3.3.
{
    SysLibFind("Serial Library", &libRef);
    SerOpen(libRef, 0, baud);
    SerControl(libRef, serCtlIrDAEnable, NULL, 0);
    // Continue using Ser.... calls to send and receive data.
}
else
{
    SrmOpen(serPortIrPort, INITIAL_BAUD_RATE, &portID);
    SrmControl(portID, srmCtlIrDAEnable, NULL, 0);
    // Continue using Srm.... calls to send and receive data.
}
```

For details refer to, http://oasis.palm.com/dev/kb/papers/2589.cfm.

Choice of components and estimated link distance

For switching transistors Q1, a low R_{ds} (on-resistance) FET is recommended with high enough current driving capability. A recommendation would be the BSH-103 N-Channel MOSFET from Philips Semiconductors. A P-Channel MOSFET like NDS352-P from Fairchild Semiconductors is recommended for switching transistor Q2.

All results presented in the note are based on this transistor. The LED current and LOP values for R1 = 2.2 Ω, R2 = 0 Ω and $V_{cc} = V_{led}$ = 3.0 V is summarized in table 2.

Operating System

The following section briefly covers the support for infrared and the available resources for developing infrared based applications on Windows CE and PalmOS.

Windows CE

The support for infrared as implemented in Windows CE version 1.0 covers all its successors as of this date, including PocketPC and PocketPC2002. The same support for IrDA programming is also available in Windows 2000 and Windows 98. Windows CE offers three modes for implementing IR communications, namely raw infrared (raw IR), IrCOMM and infrared sockets (IrSock).

Table 2. LED current and LOP values for R1 = 2.2 Ω, R2 = 0 Ω and $V_{CC} = V_{led}$ = 3.0 V

LEDs turned on	LED current drawn (mA)			Total LOP	Link Distance
	870 nm LED	940 nm LED	Total	(mW/Sr)	(m)
Only 940 nm	0	440	440	29	5.5
Only 870 nm	400	0	400	45	1.05

Note: The remote control link distance is based on a receiver irradiance of 0.1 μW/cm^2, while the IrDA link distance is based on a receiver irradiance of 4 μW/cm^2.

In the raw IR mode, the IR port is accessed and handled as a serial port with the IR hardware attached. However, no handshaking, collision detection and discovery occurs as in normal IR communication. The port can be controlled using the serial communication APIs.

In the IrCOMM mode, Windows CE transparently uses IrSock to configure an IrCOMM port to meet the IrDA standard. This is not a real device and is a virtual port. The IrCOMM emulates the RS-232 serial ports and the Centronics parallel port. IrCOMM enables legacy applications to continue working using the same APIs as before without knowing that the IrDA stack is being used before the actual data interchange. This allows issues such as signal collision, interruption and discovery to be taken care of, which is critical in infrared wireless communication. While Windows 95 and Windows 98 support IrCOMM, Windows 2000 does not expose the IrCOMM virtual serial ports due to many reasons. However, a subset of the IrCOMM protocol is implemented and exposed through the WinSock API. This needs to be kept in mind when developing applications for the handheld to communicate with the PC.

IrSock is an extension of WinSock made available to implement IrDA compliant infrared applications. The OS supports the essential protocol stacks IrLAP, IrLMP and IAS and the optional layer TinyTP. The application writer is exposed to the TinyTP layer by WinSock. The header file af_irda.h must be included by WinSock applications to support IrDA. The version of af_irda.h that is available with the Windows 2000 IrDA DDK supports all platforms namely, Windows NT, Windows CE and Windows. The header file is also available with the VC++ toolkit of Windows CE and IRD3DDK.

More information can be found from Microsoft website, MSDN and also at the following pages,

http://www.microsoft.com/hwdev/infrared/IrDAapps.htm

http://www.calsoft.co.in/techcenter/windows/irdatips.html

Palm Operating System

The Palm Operating System provides 2 levels of support for infrared communication: Exchange Manager and IR Library.

The exchange manager was developed to provide facility by which Palm OS applications could communicate directly with external devices and data formats without being tied to the HotSync mechanisms and conduits. This provides a high-level interface that handles all communication details transparently. The OS implements IrLAP, IrLMP and Tiny TP as well as the OBEX layer. IrCOMM and IrLAN are currently not supported by the OS (the HotSync Manager uses IrCOMM to sync with a Desktop supporting IrCOMM though). The stack is capable of connection-based or connectionless sessions. The commands are defined in the ExgMgr.h file and is available with the Palm OS SDK.

The IR Library provides a low-level of direct interface to the IR capabilities offered by the OS. The commands in the library can be used by including the irlib.h file. More information can be obtained from the Palm Knowledge Base at http://oasis.palm.com/dev/kb.

PDA Processors Supporting IR

Table 3 provides a list of some commonly available processors being used in PDA devices along with the IrDA data rate and the Operating Systems supported. Please note that the list is not exhaustive and refer to the device manufacturer for details.

Table 3: PDA Processors

Manufacturer	Part Number	Processor Core	Data Rate	Operating System
Achlemy/AMD	AU1000	MIPS CPU core	SIR, MIR[1], FIR	WinCE, Linux, VxWorks
	AU1100	MIPS CPU core	SIR, MIR[1], FIR	WinCE, Linux, VxWorks
	AU1500	MIPS CPU core	UART[2]	WinCE, Linux, VxWorks
Intel	SA-1110	StrongARM	SIR, FIR	WinCE, Linux,
	PXA250	32 bit XScale core CPU	SIR, FIR	WinCE, Linux,
Motorola	MC68EZ328	32 bit 68K core	SIR	Palm, WinCE, PocketPC, Linux, Symbian
	MC68VZ328	32 bit 68K core	SIR	Palm, WinCE, PocketPC, Linux, Symbian
	MC68SZ328	32 bit 68K core	SIR	Palm, WinCE, PocketPC, Linux, Symbian
	MC9328MXI/D	ARM920T Core	SIR	Palm, WinCE, PocketPC, Linux, Symbian
NEC	Vr4121	Vr4120, 64 bit NEC MIPS based	SIR, FIR, MIR	WinCE, PocketPC, Linux
	Vr4122	Vr4120, 64 bit NEC MIPS based	SIR, FIR, MIR	WinCE, PocketPC, Linux
	Vr4131	Vr4130, 64 bit NEC MIPS based	SIR, FIR, MIR	WinCE, PocketPC, Linux
	Vr4181	Vr4110, 64 bit NEC MIPS based	SIR	WinCE, PocketPC, Linux
	Vr4181A	Vr4120, 64 bit NEC MIPS based	SIR	WinCE, PocketPC, Linux
Hitachi	SH7706	SuperH RISC architecture	UART[2]	WinCE, VxWorks, Nucleus+, QNX/Neutrino, OS9, Linux, CMX-RTX
	SH7708	SuperH RISC architecture	UART[2]	WinCE, VxWorks, Nucleus+, QNX/Neutrino, OS9, Linux, CMX-RTX
	SH7709A	SuperH RISC architecture	SIR	WinCE, VxWorks, Nucleus+, QNX/Neutrino, OS9, Linux, CMX-RTX
Texas Instruments	OMAP 1510	TI-enhanced ARM™ 925 + TMS320C55x DSP core	SIR	WinCE, Palm OS, Symbian, Linux, Java(J2ME)
	OMAP 710	TI-enhanced ARM™ 925 + GSM/GPRS digital baseband	SIR	WinCE, Palm OS, Symbian, Linux, Java(J2ME)
	OMAP 310	TI-enhanced ARM™ 925	SIR	WinCE, Palm OS, Symbian, Linux, Java(J2ME)

Note:
[1] MIR data rate of only 1.152 Mbps is supported.
[2]The UART can be interfaced via an external IrDA endec such as the HSDL-700x to the IrDA transceiver.

Hardware Design Consideration

Agilent infrared devices have good PSRR and EM immunity. However, care should be taken while designing the PCB board to reduce the effect of interference from switching circuits, LCD displays and other noise sources. For a good coverage on the above topics and guidelines on board design please refer to application note AN1114 and Agilent Infrared Data Link Design Guide.

Also of importance is the cosmetic window design. Besides aesthetic reasons, care should be taken to meet the viewing angle requirements as stipulated by IrDA and also to reduce interference from ambient light sources. For a detailed coverage on this topic please refer to application note AN1169.

Power budget

Power budgeting becomes critical in handheld devices as maximizing battery life is an important requirement in mobile devices and power budget calculations effect the reliability of the product. In the IrDA mode of operation the maximum allowed peak pulsed current at duty cycle less than 20% (PW≤20 µs) is 500 mA. At a lower duty cycle the peak pulsed current can be relaxed. For duty cycle less than 5%, the maximum peak current that the package can withstand is 600 mA. While the duty cycle of the carrier frequency in remote control application is as high as 50%, the carrier frequency is modulated and is not always pulsed. The modulation is protocol dependent. The following case considers the RC5 protocol, which is illustrated in figure 9.

Every data bit contains 32 pulses at a carrier frequency of 36 kHz. The carrier frequency has a duty cycle of 25%, while the data is pulsed for a duration of 24.9 ms, every 114 ms at a duty cycle of 2.73%. The LED drive capability is determined by the carrier duty cycle while for power budgeting the duty cycle of the data frame needs to be considered. The current drain in µAh and power in mW are estimated as,

Current drain = I (µa) • (total pulse on-time/total bit duration)
Power = V • I • duty cycle

Current drain in the remote control mode, assuming a peak current of 600 mA and V_{CC} = 3 V, is 450 µAh/day. This assumes a usage model of 1 sec continuous button push 100 times a day using the RC-5 protocol. The power consumed is 50 mW.

IrDA duty cycle at SIR data is 18.7%. Based on this, current drain in the IrDA mode, assuming a peak current of 500 mA and V_{CC} = 3 V, is 31.35 µAh/day. This assumes a usage model of sending 20 v-cards of size 866 bytes in a day at a data rate of 115.2 kbps. The power consumed is 280 mW.

Appendix

The following plots can be used to determine the choice of resistor value to obtain the desired LED current, which in turn determines the radiant intensity and link distance. The resistor value R2 was set to 0 while doing these measurements.

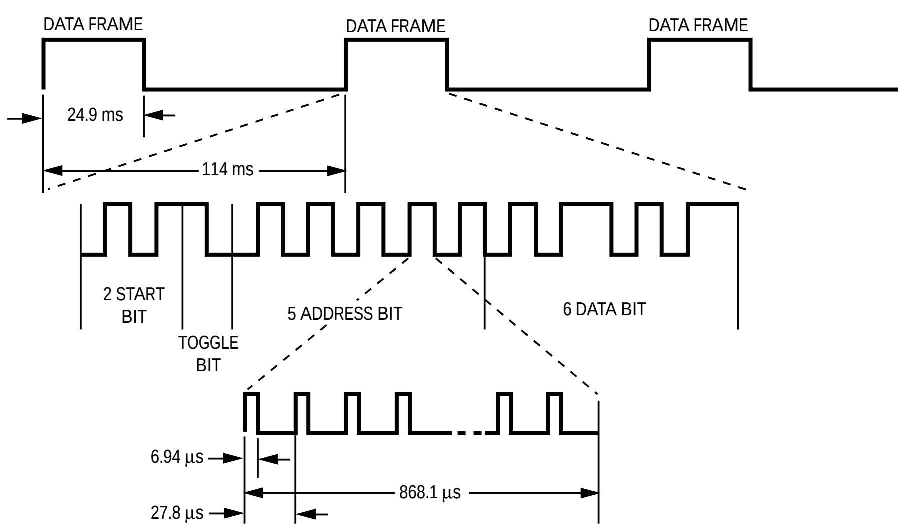


Figure 8. RC5 Protocol

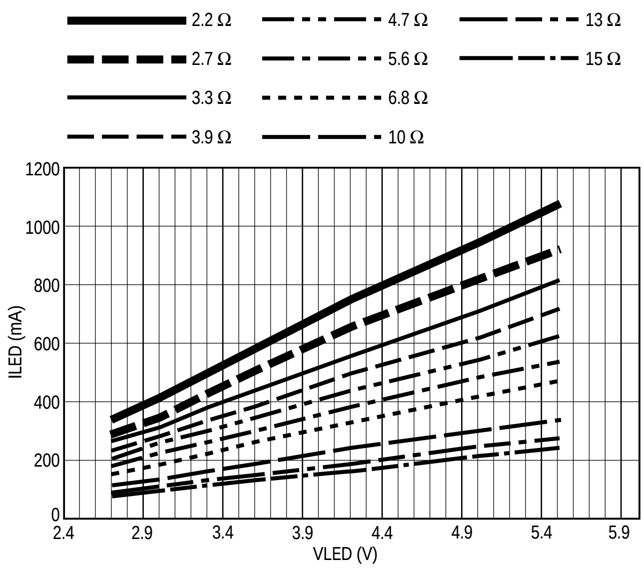


Figure 9. Vled vs. Iled for different resistor values for driving only 870 nm LED (IrDA mode)

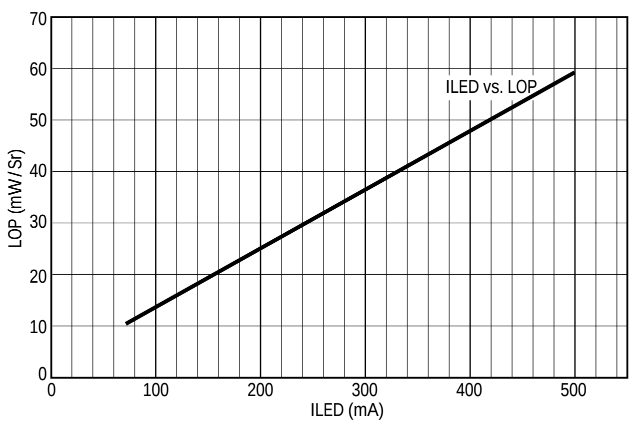


Figure 10. Iled vs. LOP for the 870 nm LED

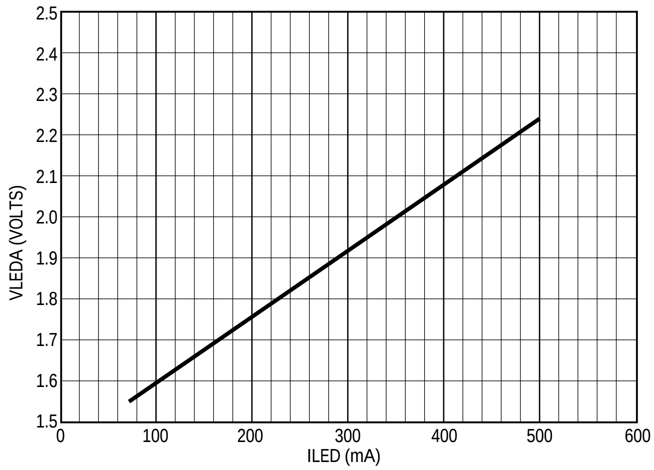


Figure 11. VledA vs. Iled for 870 nm LED

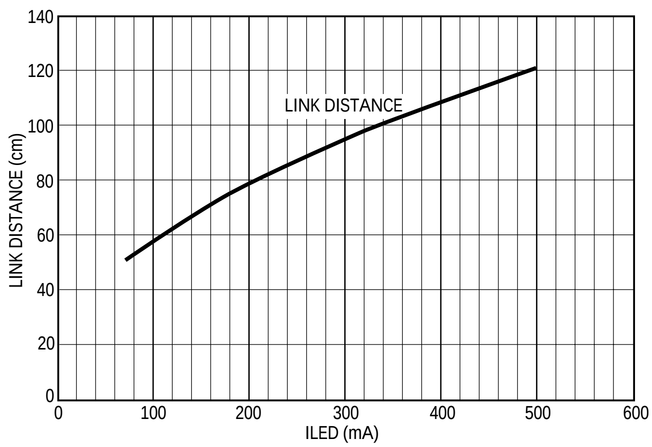


Figure 12. Iled vs. link distance using 870 nm LED for IrDA communication based on detector irradiance of 4μW/cm^2

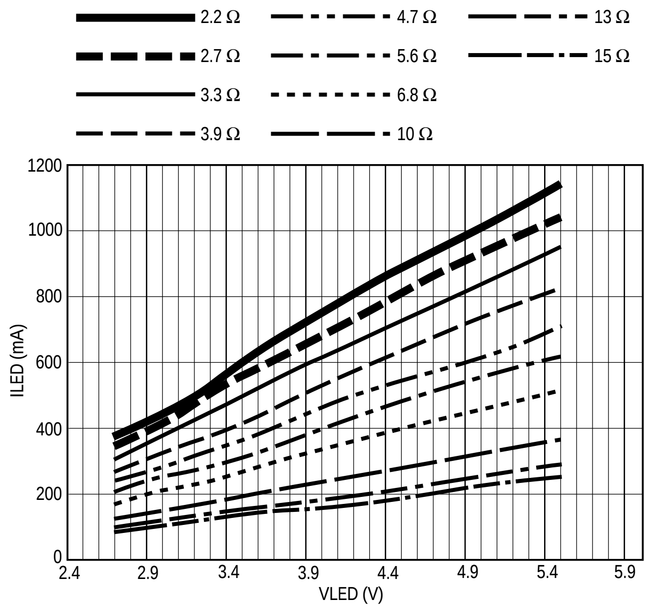


Figure 13. Vled vs. Iled for different resistor values for driving only 940 nm LEDBased on a BSH-103 N-Channel transistor

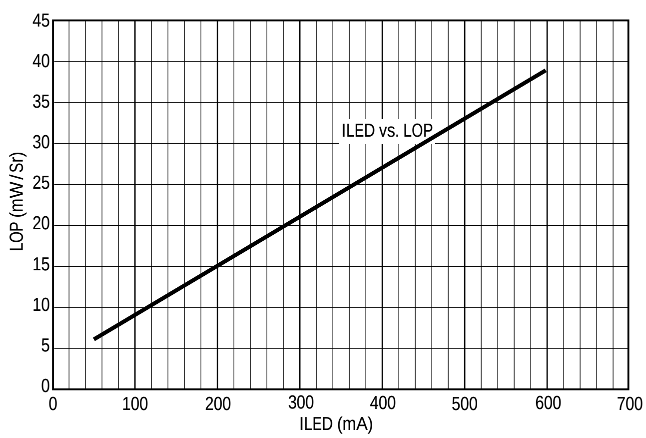


Figure 14. Iled vs. LOP of the 940 nm LED

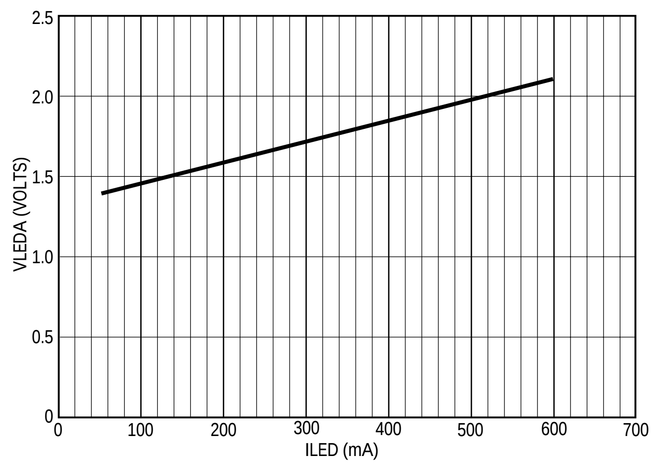


Figure 15. VledA vs. Iled for 940 nm LED

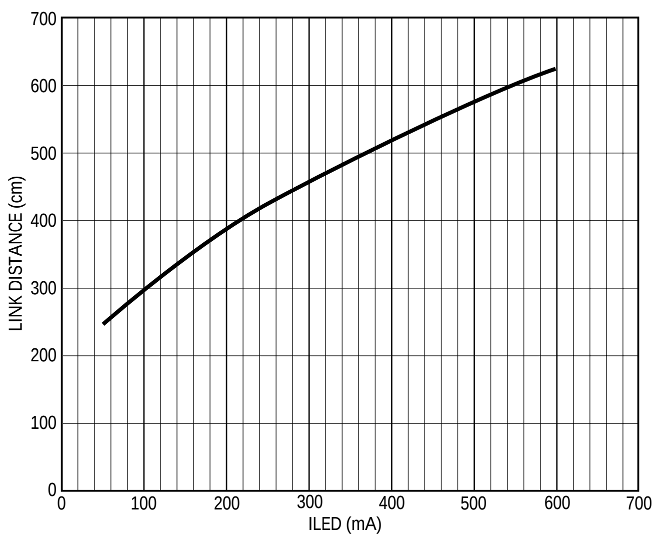


Figure 16. Iled vs. Link distance using only 940 nm LED for remote control based on detector irradiance of 0.100 μW/cm2

References

[1] Intel™ StrongARM SA-1110 Microprocessor, Developer's Manual, October 2001.

[2] MC68SZ328 Integrated Processor, Reference Manual, MC68SZ328RM/D Rev. 1.1, 02/2002.

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Korea: (+65) 6271 2194

Malaysia, Singapore: (+65) 6271 2054

Taiwan: (+65) 6271 2654

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