Application Note — IrDA-Compliant Transmitter/Receiver

INTRODUCTION

Sharp is developing IrDA-compatible IR data communication devices for use in computers, personal organizers, printers and other products. Our knowledge in the Optoelectronic technology field has been applied in the development of these devices. This Application Note introduces some of our devices, and shows examples of how to use them.

IrDA (INFRARED DATA ASSOCIATION)

The IrDA is a non-profit organization with the purpose of developing and setting standards in wireless IR communication between information equipment, communication equipment and other products.

The IrDA was founded in 1993 with members from various computer-related companies, including hardware, software, and component manufacturers.

The IrDA 1.0 standard was established in June 1994. The standard document defines the data transmission speed from 2.4 kbps up to 115.2 kbps, and a one meter range. In addition, IrDA 1.1, a high-speed data transmission standard, was established in April 1995.

IrDA 1.0

This system has an emitter and detector pair operating in half duplex mode, providing point-to-point communication. Transmission is specified for a minimum communication distance of 1 m in a circular cone of ±15° from the center of the beam. The communication link is initially negotiated at 2,400 bps with a shift to 115.2 kbps if both sides can operate at this speed.

An example of an IR data communication system implementing IrDA 1.0is shown in Figure 1a. First, the bit length of the data transmitted from the Universal Asynchronous Receiver/Transmitter (UART) is shortened to 3T/16 (T stands for the time length required for 1-bit data transmission) by the modulation circuit. The emitting diode is driven to transmit an optical signal to the receiver. The detector front end will receive the transmitted signal, decode it, and feed it to the receiving UART. Figure 1b shows some examples of the signal waveform.

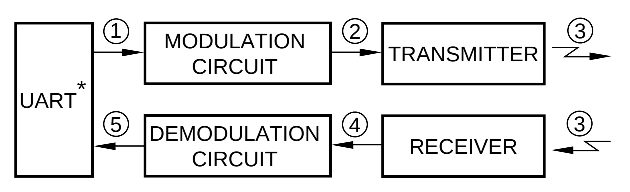
In the IrDA data transmission standard, light emission does not occur when the data has a value of '1' and is emitted when the data value of '0'. Light is emitted for 3/16 of the length of one bit cycle. The use of the 3/16 transmission period contributes to power conservation as there is no need to transmit for the entire period of time. For this reason, this system is suitable for use in portable PCs, PDAs and other portable devices.

IrDA 1.0 STANDARD SPECIFICATION

Figure 1a and 1b show the specification of IrDA 1.0.

Table 1. IrDA Standard

ACTIVE OUTPUT SPECIFICATIONS	MIN.	MAX.	UNITS
Peak Wavelength	0.85	0.90	µm
Intensity in Angular Range	40	500	mW/sr
Half-Angle	±15	±30	degrees
Rise Time and Fall Time (10 – 90%)		0.6	µs
Optical Over Shoot		25	%
Pulse Width (2.4 kbps)	1.41	88.55	µs
Pulse Width (115.2 kbps)	1.41	2.71	µs
Contributed Systematic Jitter		0.2	µs
Incidence in Angular Range	0.004	500	mW/cm^2
Half-Angle	±15		degrees
Receiver Latency Allowance		10	ms



NOTE: * = UART (Universal Asynchronous Receiver/Transmitter)

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Figure 1a. Example of IR Data Communication System

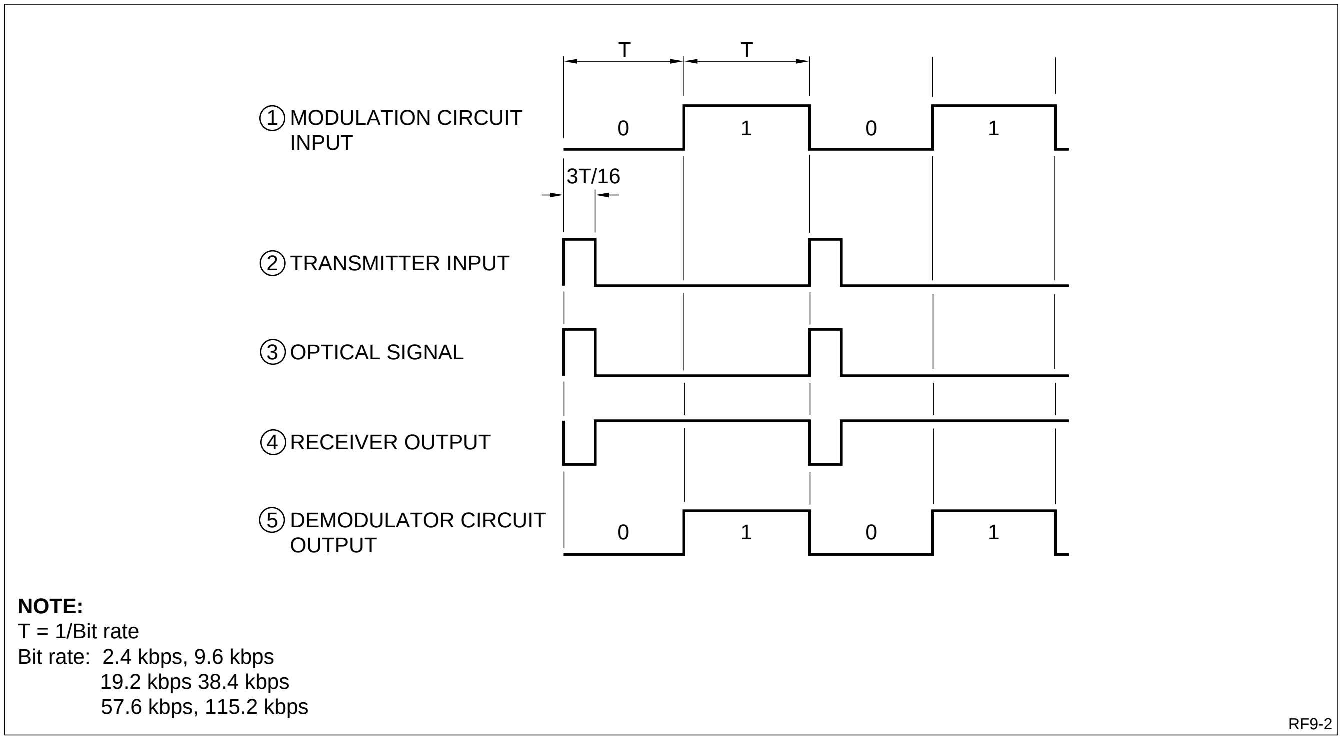


Figure 1b. Example of Waveforms

DIRECTION CHARACTERISTICS OF DETECTOR/EMITTER DEVICE

Figure 2 shows the accepted level, range and angular displacement of radiated power from the emitter, which is listed in Table 2.

Table 2. Emissive Power of the Emitter

ANGLE FORM LIGHT AXIS	EMISSIVE POWER
0° to 10°	40 mW/sr MIN. to 500 mW/sr MAX.
15° to 30°	0 to 500 mW/sr MAX.
30°	40 mW/sr MAX.

Emissive power is the amount of energy which is emitted from IR LED per unit solid angle (1sr) in the direction of the light axis.

The following formula shows the correlation:

$$\text{Emissive Power [mW/sr]} = \frac{\text{Light Power [mW]}}{\text{Solid Angle [sr]}}$$

A solid angle is defined by the following formula, when the area of the light detector S (cm^2), the distance from the detector lens to the light source, L (cm). (Refer to Figure 3.) Incident illuminance at the detection point is variable between 4 µW/cm^2 and 500 mW/cm^2 between 0 to 15° angular displacement as shown in Figure 4.

EMISSIVE POWER, INCIDENT ILLUMINANCE, AND TRANSMISSION DISTANCE

Correlation between emissive power, incident illuminance, and transmission distance is defined as follows:

$$\text{Incident illuminance [mW/cm}^2\text{]} = \frac{\text{Emissive Power [mW/sr]}}{\text{Square of Transmission Distance [cm}^2\text{]}}$$

For example, if the minimum sensitivity of the detector is 4 µW/cm^2 and emissive power of the emitter is 40 mW/sr., transmission distance becomes 1 m. Figure 5 shows this correlation.

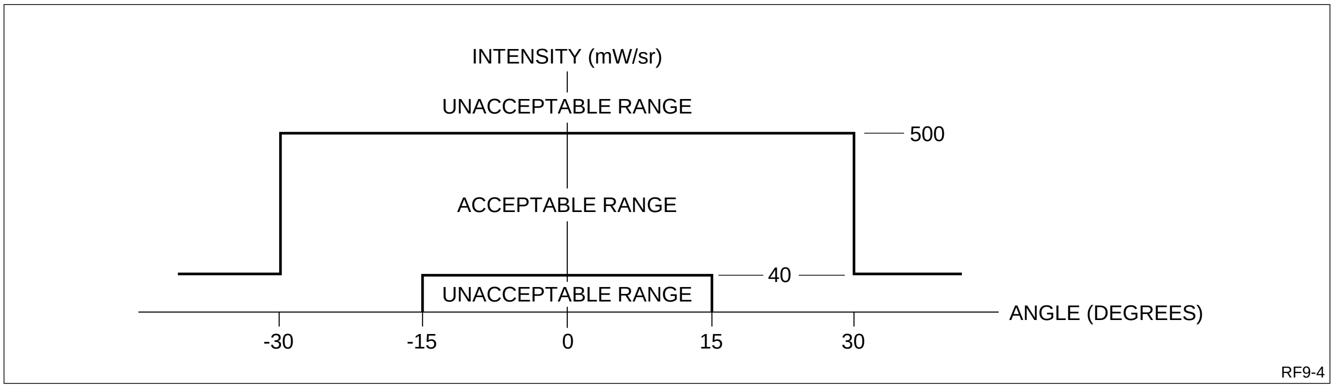
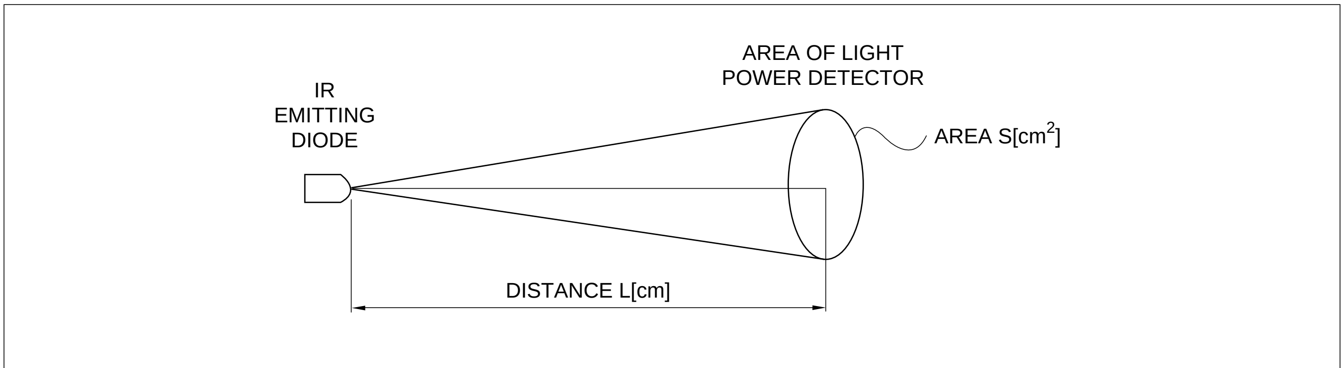
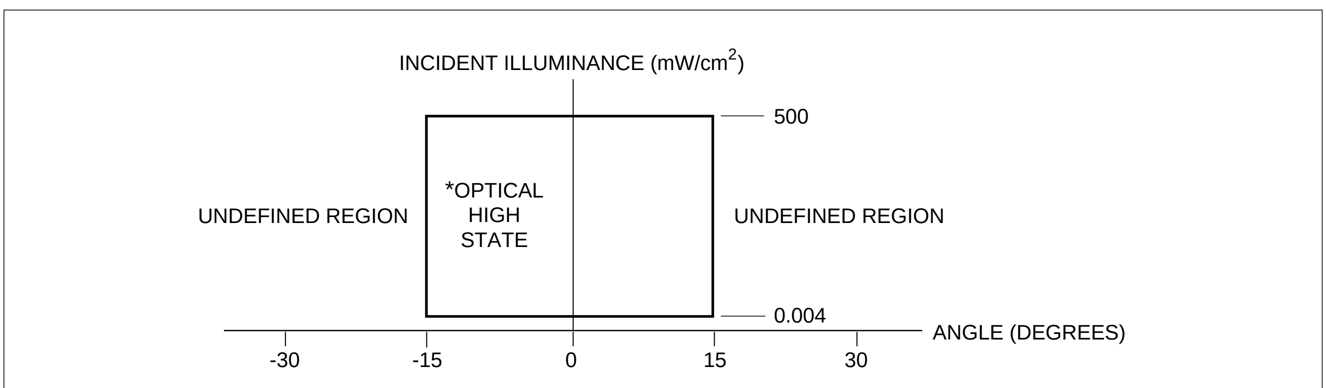


Figure 2. Directivity of Emitter Part



$$\text{SOLID ANGLE [sr]} = \frac{\text{AREA OF LIGHT POWER DETECTOR [cm}^2\text{]}}{\text{(DISTANCE BETWEEN THE EMITTER AND DETECTOR)}^2\ \text{[cm}^2\text{]}}$$

Figure 3. Solid Angle Formula



NOTE: * = The detector outputs '0' (light existence) in the optically High range.

Figure 4. Directivity of Detector Part

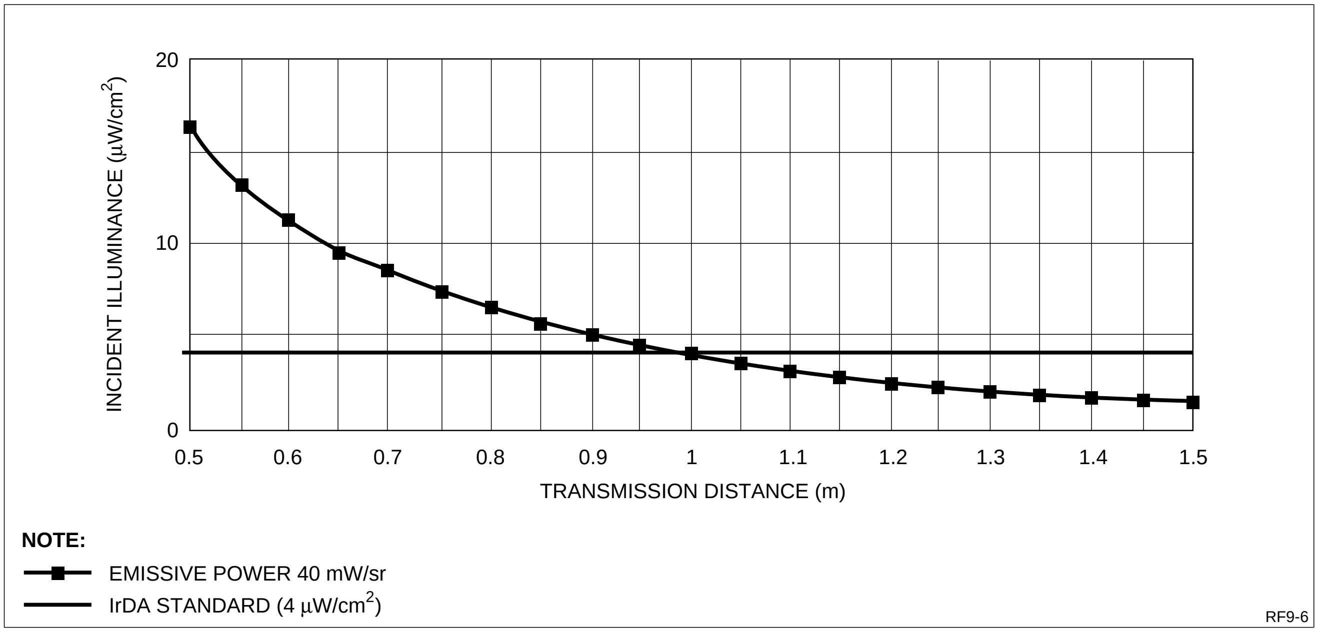


Figure 5. Correlation Between Emissive Power, Incident Illuminance, and Transmission Distance

IrDA 1.1

In April 1995, IrDA adopted the standard specification of high-speed IR data transmission. The IrDA 1.1 specification is a set of extensions to IrDA 1.0 that include all of the requirements as set forth in the IrDA 1.0 document. The data transmission rate of IrDA 1.1 is 9.6 kbps to 115.2 kbps, 1.152 Mbps and 4 Mbps. Link negotiation is retained at the 2,400 bps as required in IrDA 1.0.

Figure 6 shows a comparison of pulse trains at each transmission rate and method. When the rate is 9.6 kbps to 115.2 kbps, the pulse form is the same as IrDA 1.0. When the rate is 1.152 Mbps, the emitter's pulse width becomes T/4 = 217 ns. When the data rate is 4 Mbps, 4 Pulse Position Modulation (PPM) is used. The time-related light pulse conveys a the equivalent a 2-bit signal.

Table 3 shows the primary characteristics of IrDA 1.1.

Table 3. IrDA 1.1 Standard

ACTIVE OUTPUT SPECIFICATIONS	MIN.	MAX.	UNITS
Peak Wavelength	0.85	0.90	μs
Intensity in Angular Range	100	500	mW/sr
Half-Angle	±15	±30	degrees
Rise Time and Fall Time (10 – 90%)		40	ns
4 Mbps Pulse Width	24.5	25.5	% of Period
1.152 Mbps Pulse Width	17	30	% of Period

Table 3. IrDA 1.1 Standard (cont'd)

ACTIVE INPUT SPECIFICATIONS	MIN.	MAX.	UNITS
Incidence in Angular Range	0.01	TBD	mW/cm^2
Half-Angle	±15		degrees

IrDA COMPATIBLE DEVICES

Refer to Table 4.

ARCHITECTURE EXAMPLE OF EMITTER AND DETECTOR CIRCUIT

Figure 7 shows an architecture example of the emitter circuit in which InfraRed LED GL550 is used. For some applications, two LEDs are connected serially to provide the desired amount of radiated power while limiting the amount of drive current to the LED. GL550 is a GaAlAs IR LED and has a peak wavelength of 850 nm to 900 nm, which is appropriate for IrDA 1.0.

PD413PI is a photodiode which conforms to IrDA 1.0 and efficiently converts the light of 850 nm to 900 nm to an electric signal.

GL1F20/GL1F201

GL1F20/GL1F201 is a three-pin device in which the components for the emitter circuit (transistor and LED) are encapsulated in one package. (Refer to Figures 8a and 8b.)

GL1F20 is a 5 V device and has an internal base resistor. GL1F201 will operate from either a 3 V or 5 V power supply, and requires an external base resistor.

Table 4. IrDA Compatible Devices

SPECIFICATION	PHOTODIODE	IR LED	OPIC SENSOR	DRIVER ATTACHED LED
IrDA 1.0 2.4 kbps to 115.2 kbps	PD413PI	GL550, GL551, GL382	IS1U20	GL1F20, GL1F201
IrDA 1.1 9.6 kbps to 115.2 kbps 1.152 Mbps, 4 Mbps	PD414PI	GL551	IS1U30	–

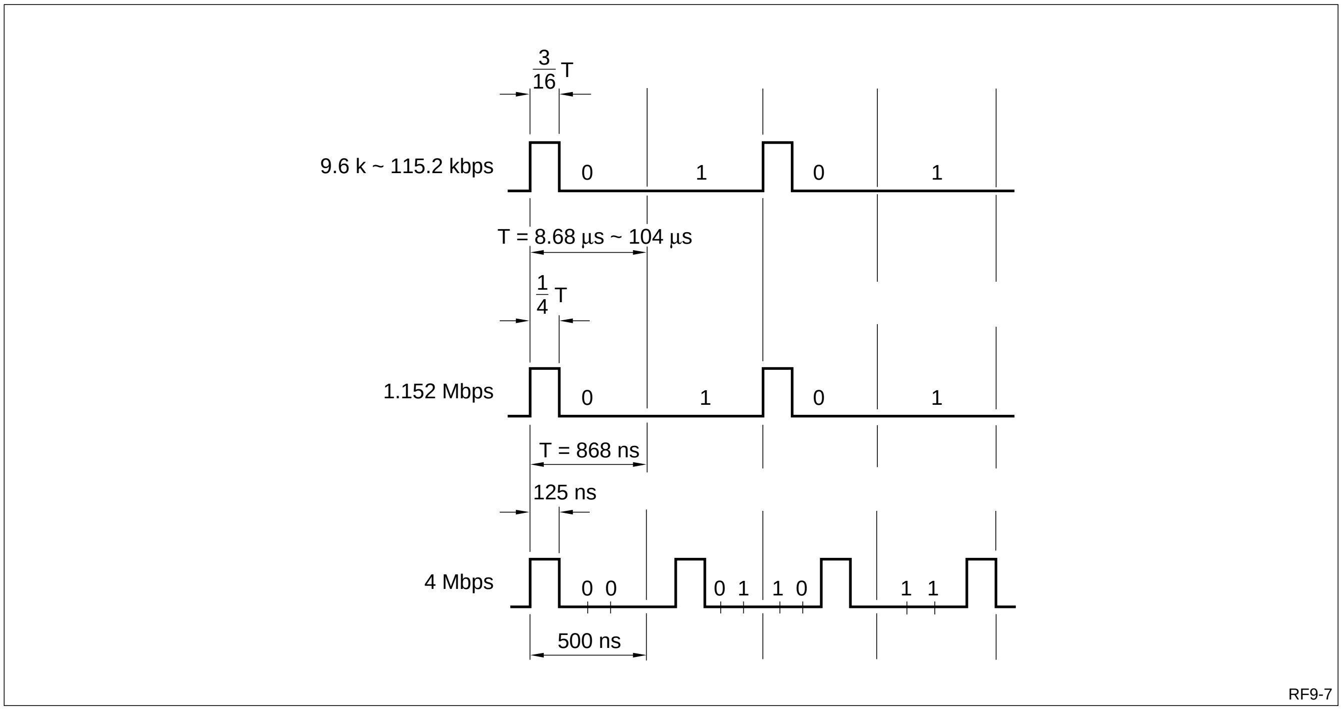


Figure 6. Pulse Form of IrDA 1.1

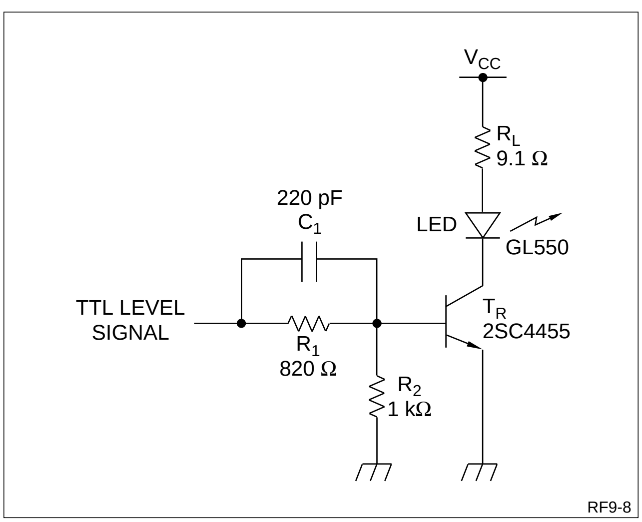


Figure 7. Architecture Example of Emitter Circuit

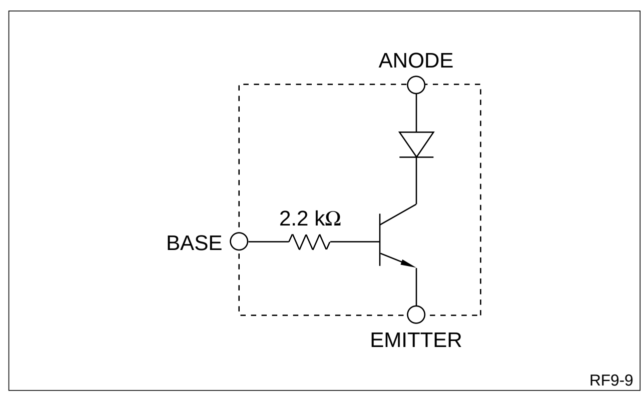


Figure 8a. GL1F20 Internal Circuit

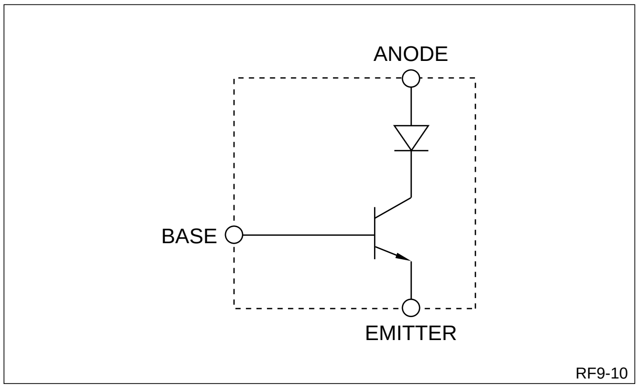


Figure 8b. GL1F201 Internal Circuit

Resistor for LED Current Limitation of GL1F20 and GL1F201

Resistor for LED Current Limitation of GL1F20 and GL1F201. GL1F20/GL1F201 requires an external resistor to limit the LED current. Table 5 shows the resistor value and LED current. Figures 9a and 9b shows the architecture.

Table 5. Example Using the GL1F20

MODEL NO.	POWER SUPPLY VOLTAGE	ATTACHED RESISTOR VALUE [1]	LED CURRENT AMOUNT (TYP.) [2]
GL1F20	5 V	9.1 Ω	290 mA
GL1F201	3 V	2.2 Ω	270 mA

NOTES:
1. Normal resistor value for a light intensity of 40 mW/sr.
2. As the current value changes due to variations of the LED, adjust the resistor value as necessary.

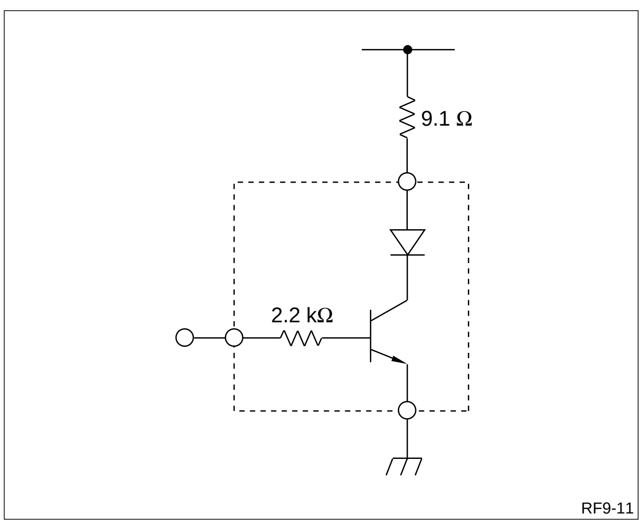


Figure 9a. Architecture Example of the GL1F20

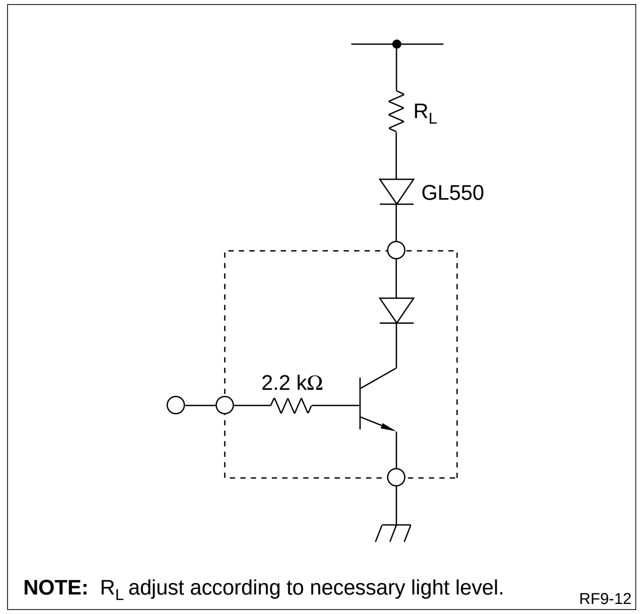


Figure 9b. Architecture Example of Combining Use of GL1F20 and GL550

IS1U20

IS1U20 is an IrDA-compatible receiver in which the components required for the detector circuit (photodiode, amplifier and comparator circuits) are integrated into a single chip thanks to Sharp's own Optical Integrated Circuit (OPIC) technology. This device can be implemented in portable equipment such as PDAs and can be used in both 3 V and 5 V systems. In addition, by optimizing the time constant of the detector, the turn-around time (Receiver Latency Allowance) has been shortened.

As shown in Figure 10, turn-around time is the latency time required to turn around the IR link. The transmitted signal is sent from Port A to Port B, received at Port B, and a response generated and sent back to Port A . This same latency can be measured from Port B to Port A as well. Part of the latency time is attributed to the IR receiver and its response time.

IS1U20 provides efficient reception, shortening the waiting time in half-duplex data. It has a short turn-around time of approximately 30 µs.

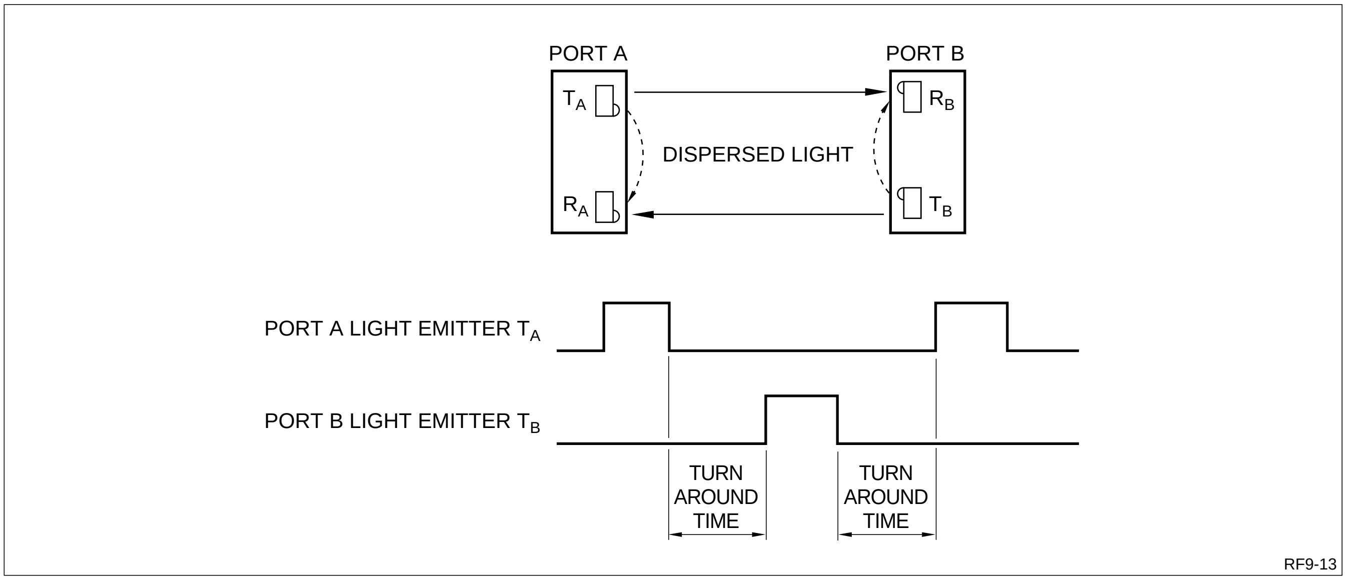


Figure 10. Turn-Around Time

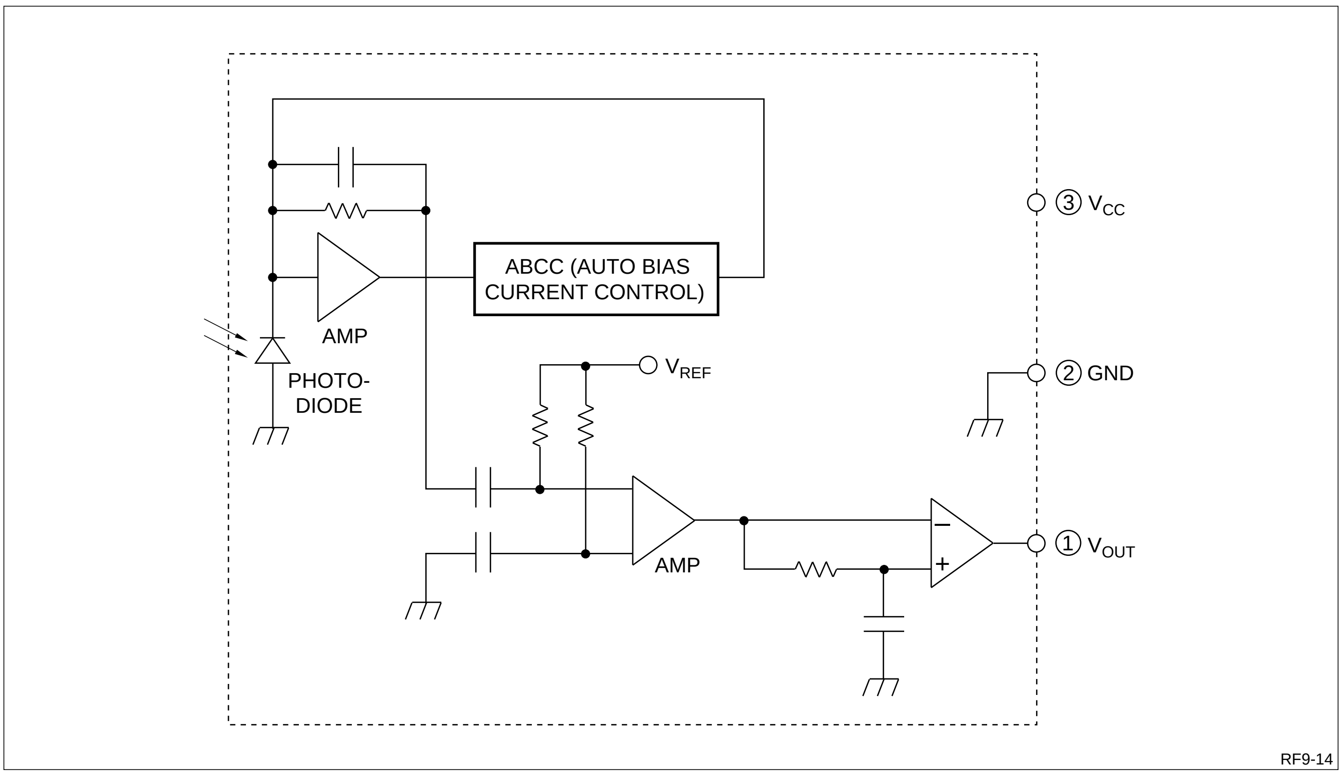


Figure 11. Internal Block Diagram of IS1U20

DERATING THE DISSIPATION CURRENT OF IS1U20

When used in battery-operated systems such as a PDA, an architecture similar to that shown in Figure 12 will minimize dissipation current when the IR interface is not used. An example of an IR interface is shown in

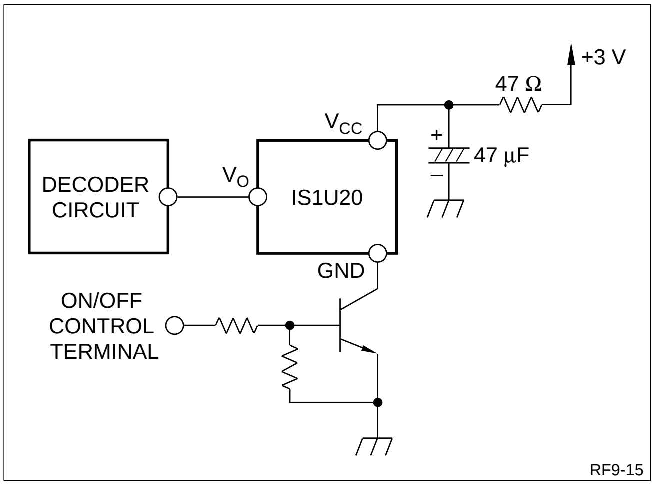


Figure 12. Architecture Example of Dissipation Current

Figure 13, including the UART (16450 or 16550 compatible). In this case, an encoder-decoder circuit is required between emitter and detector circuit. In many cases, the encoder/decoder is available as a single Integrated Circuit (IC).

The encoder circuit feeds 'high' to IRTX for 3/16T length of time when transmitted data, TX, is '0.' And it feeds 'low' to IRTX when the transmitted data, TX, is '1.' (T stands for the cycle of 1-bit of data). The decoder circuit returns the transmitted data into the original form by outputting '0' to Rx for T length of time when the falling-edge signal is sensed at the input to IRRX.

The UART clock frequency of at least 16 times faster than the transmission speed is required to realize this encoding and decoding. The UART can provide this signal at the BAUDOUT terminal. (Refer to Figure 14.) These circuits are generally constructed with gate arrays.

Circuits with a higher level of integration exist, which include the encoder-decoder circuits and the UART. If this kind of LSI is used, design of the encoder-decoder circuit is not required. Depending on the source of components, care should be used in matching the IR transmission and detection components to the encoder-decoder circuits.

Figures 15 and 16 show a circuit example using PC87334/PC87336 (National Semiconductor). Figures 17 and 18 show a circuit example using PD67C665IR/FD37C666IR (Standard Microsystems). Figures 19 and 20 show a circuit example using MC68328 (Motorola). Since these LSIs have encoder and decoder circuits in them, it is possible to connect GL1F20/IS1U20 directly to them.

NOTE: The application circuit shown in Figures 17 through 20 are connection examples of signal lines; operation with the circuit is not guaranteed under all conditions. Figures 21 and 22 show the connection example of two cases: one example using the LT1319 (Linear Technology Co., Ltd.) and the other example using Sharp's IrDA 1.1-compatible OPIC sensor, IS1U30.

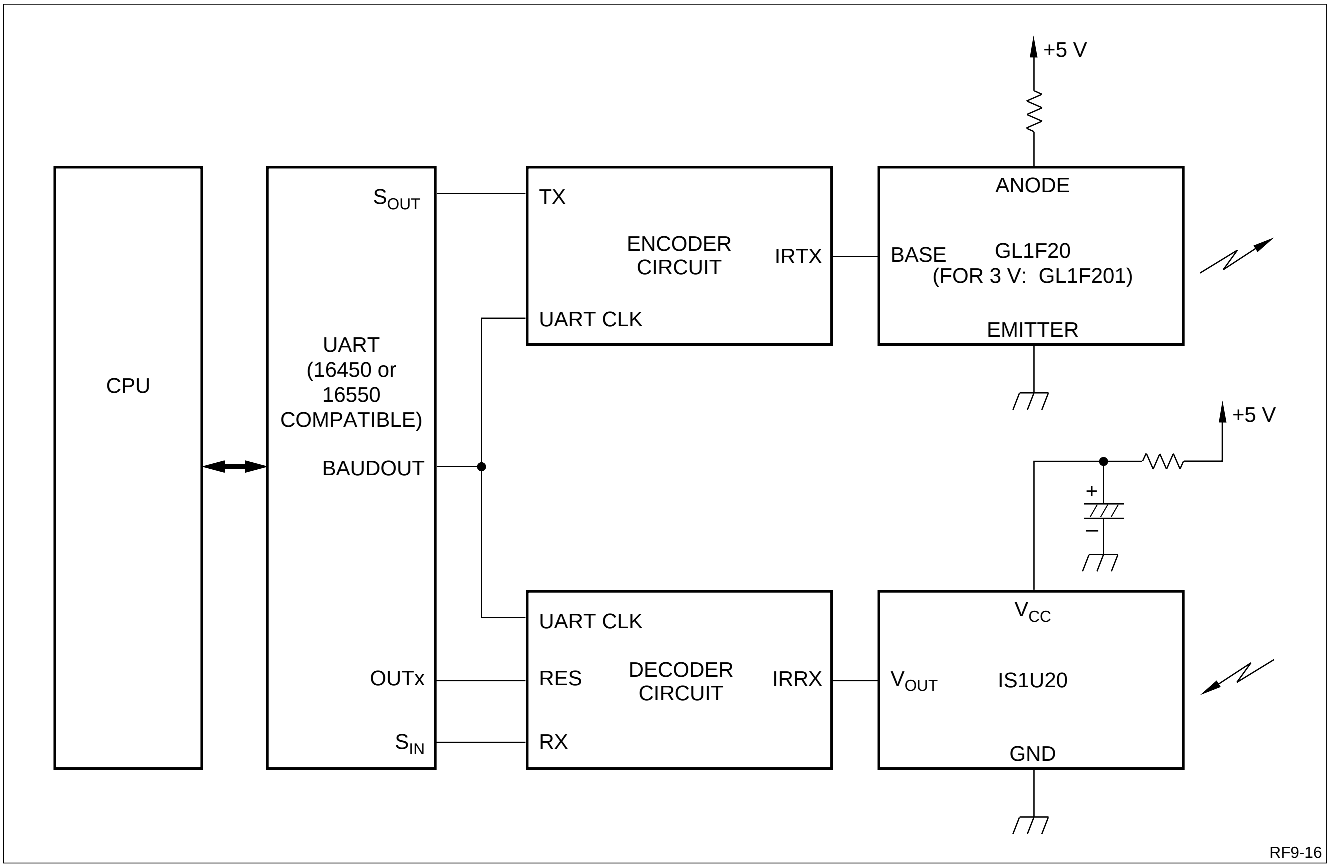


Figure 13. Example of an IrDA System

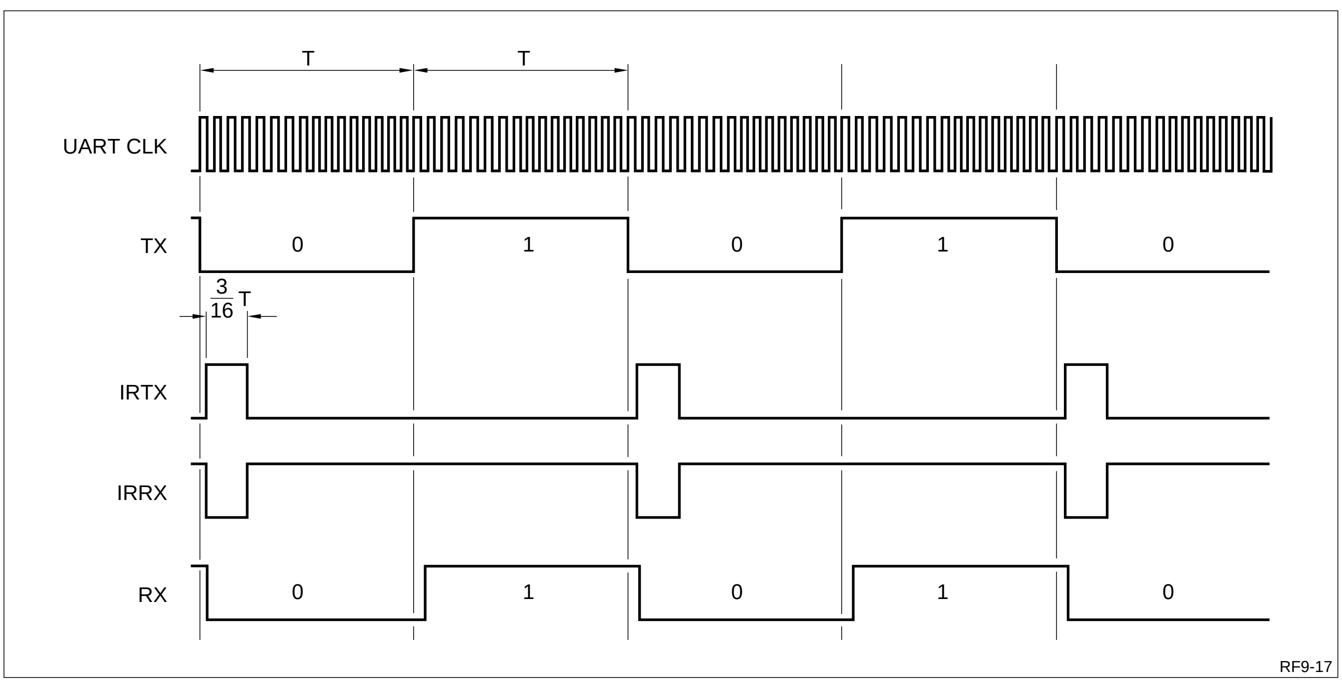


Figure 14. Waveform Example of Modulator/ Demodulator Circuit

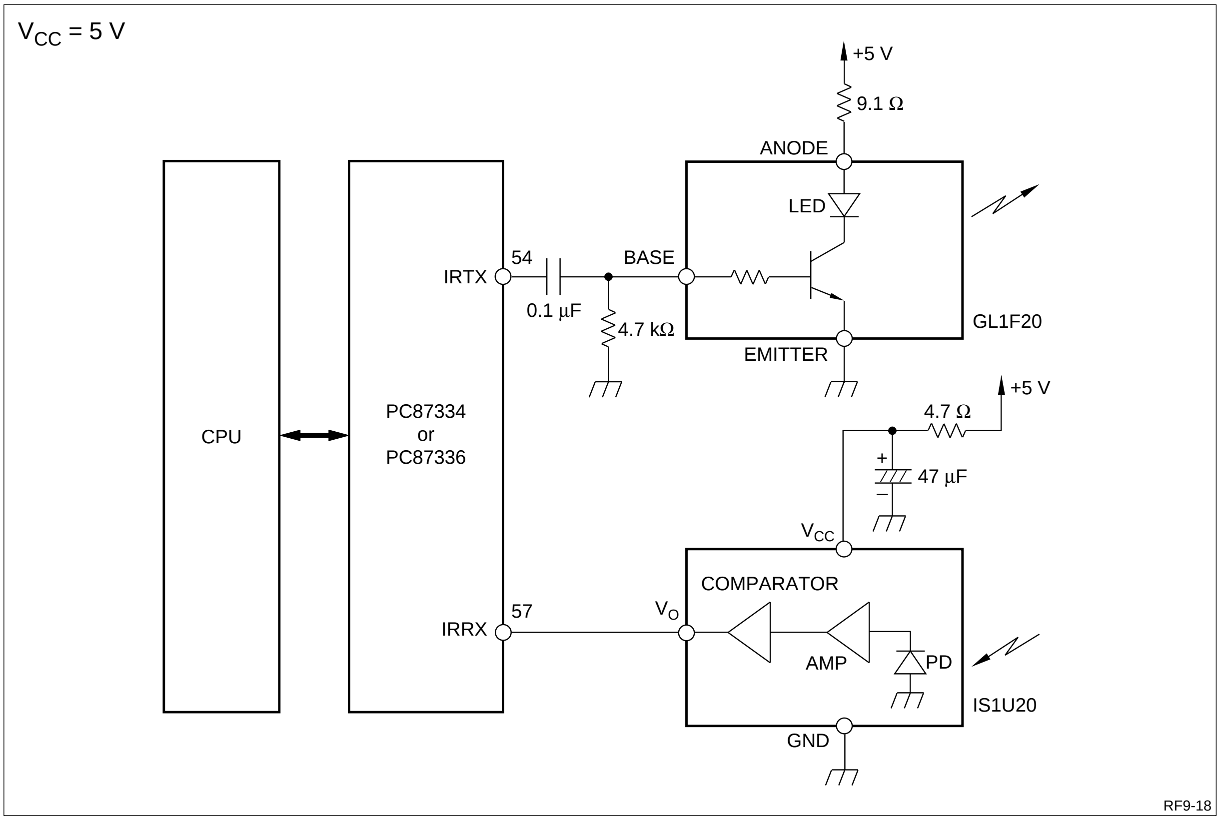


Figure 15. National Semiconductor PC87334/PC87336 Super I/O Application Example (V_{CC} = 5 V)

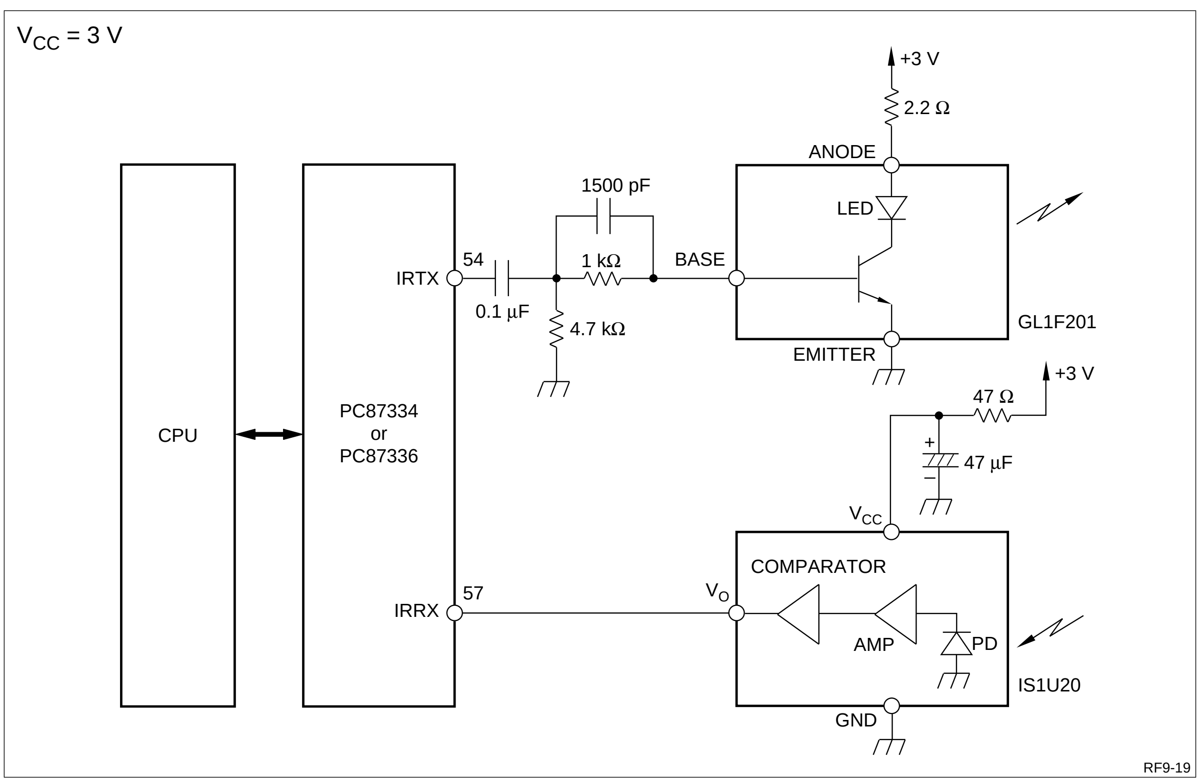


Figure 16. National Semiconductor PC87334/PC87336 Super I/O Application Example (V_{CC} = 3 V)

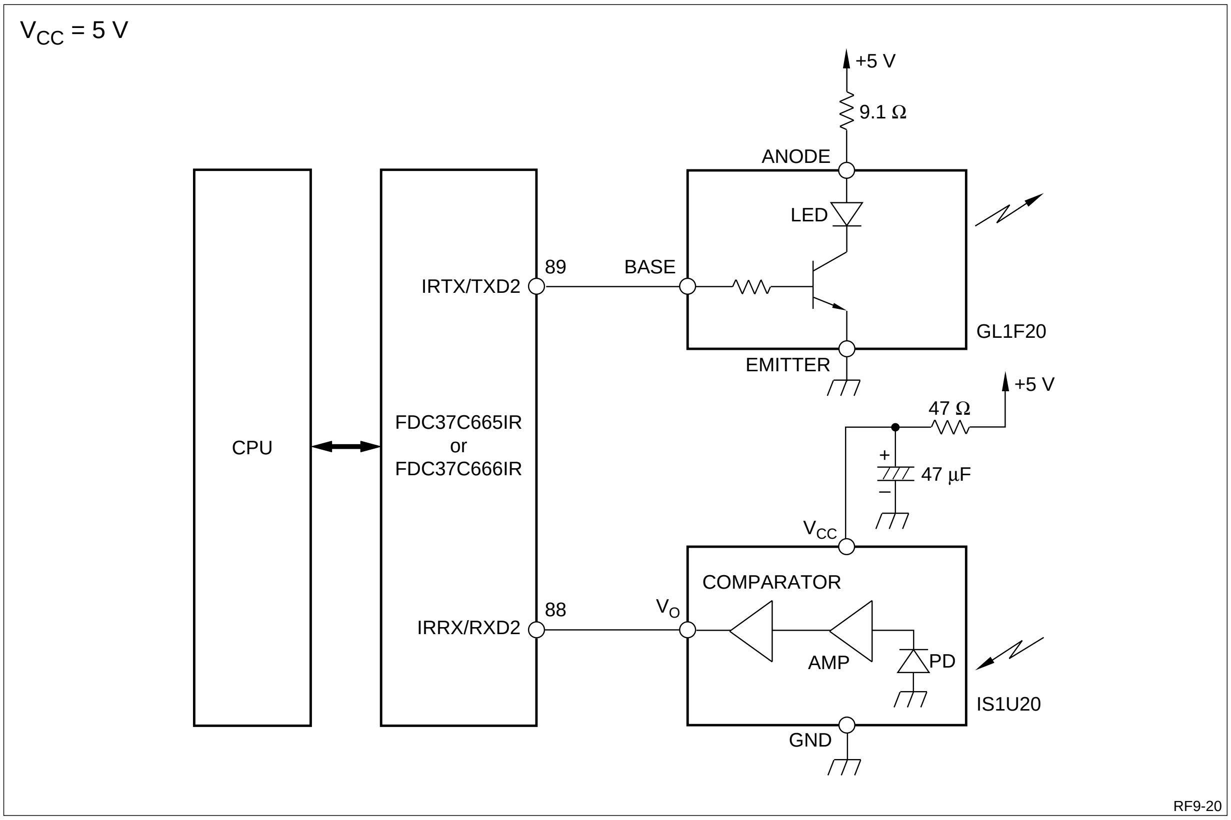


Figure 17. Standard Microsystems FDC37C665IR/FDC37C666IR Super I/O Application Example (V_{CC} = 5 V)

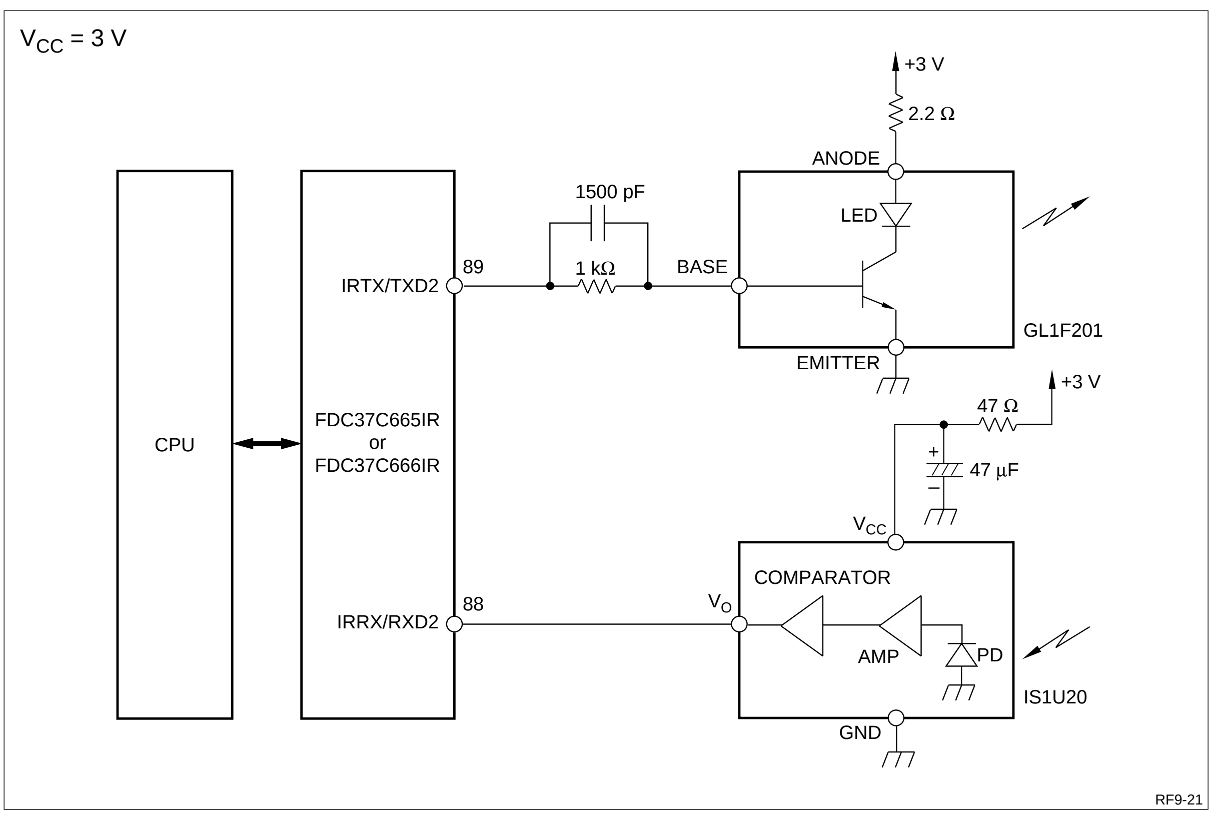


Figure 18. Standard Microsystems FDC37C665IR/FDC37C666IR Super I/O Application Example (V_{CC} = 3 V)

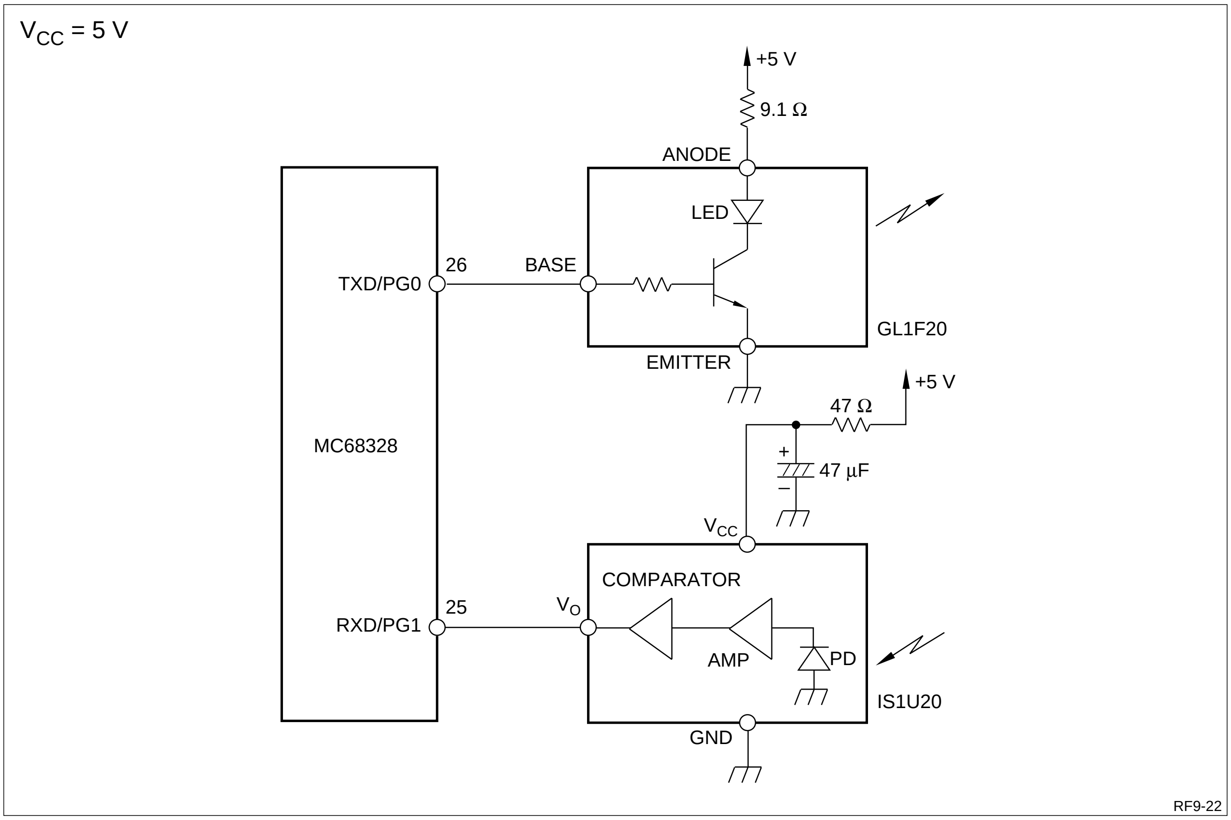


Figure 19. Motorola MC68328 Integrated Processor Application Example (V_{CC} = 5 V)

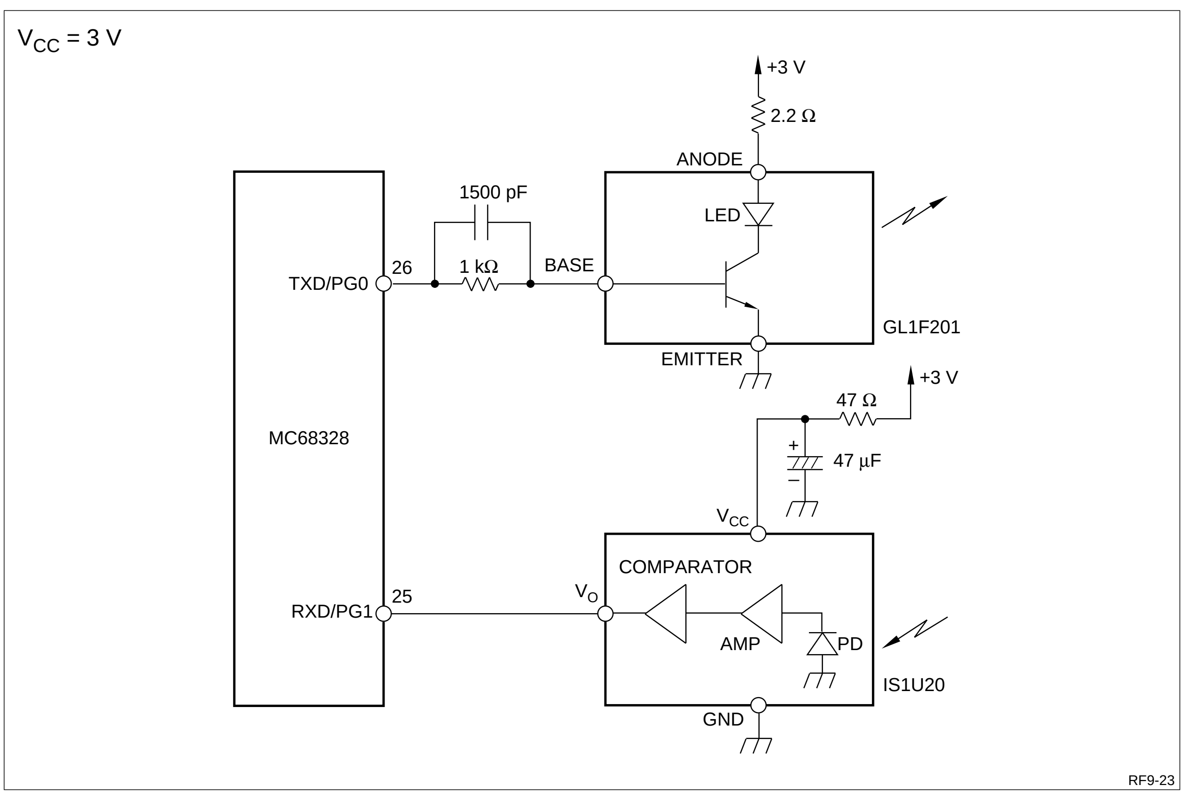


Figure 20. Motorola MC68328 Integrated Processor Application Example (V_{CC} = 3 V)

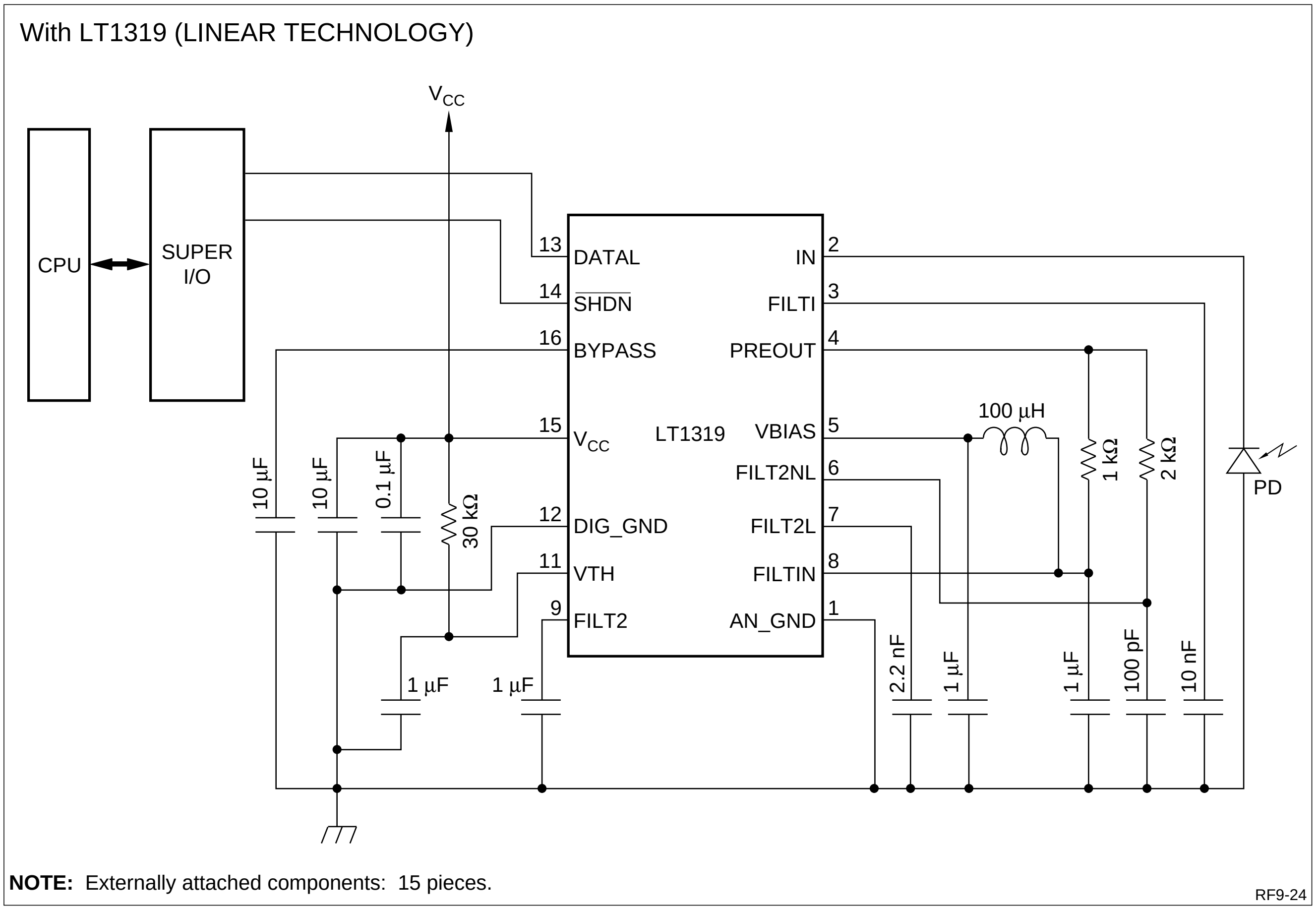


Figure 21. Application Example of IS1U30 With LT1319 (Linear Technology)

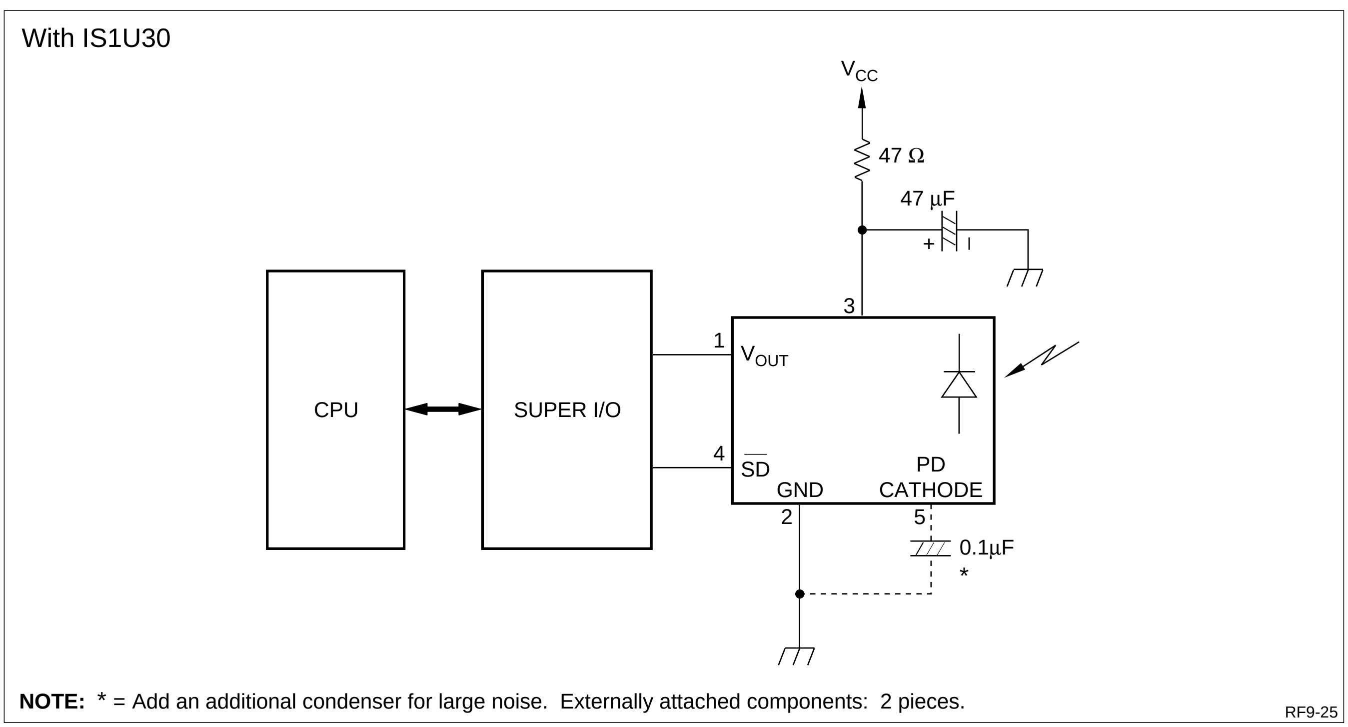


Figure 22. Application Example of IS1U30 With IS1U30