

For Sharp Products: RY5AR01/AT01/BD01/AR021

Sharp Electronics Corporation, Microelectronics Group, RF Products Marketing Group, 206-834-2500

OVERVIEW

Infra-Red Data Transmission (IRDT) and reception capabilities offer great potential to eliminate or reduce the number of wires and interconnecting cables required for data transfer. Applications such as a wireless mouse reduce the clutter associated with a desktop computer. Palmtop and laptop computers benefit from their small size and light weight. In this environment, bulky connectors add to the size and weight of the unit.

IRDT also has potential for many other applications in industry where data must be transferred: palmtop-palmtop data transfer, remote unit data down-load at the end of the day, computer tablets, barcode readers, data logging equipment and more. Any data transfer application where a mechanical connector interface is impractical is a potential application for IRDT.

RY5 SERIES

The SHARP RY5 series Infra-Red Data Communications products provide small size, low-power serial data transmission. Current technology provides a data transfer rate of 38,400 bits-per-second (bps) at a distance of 1 meter. All RY5 series devices are TTL/CMOS compatible, operate from a 5 V source, and are readily interfaced with existing digital circuitry. A 500 kHz Amplitude Shift Keying (ASK) modulation process combined with an envelope detector insures reliable recovery of transmitted data and significantly reduces the possibility of interference from other IR sources. IR devices inherently demonstrate a high resistance to EMI noise.

Four products are currently available in the RY5 series: RY5AR01 IR Data Receiver, RY5AT01 IR Data Transmitter, RY5BD01 Bidirectional Data Transceiver, and the RY5AR021 enhanced range IR Data Receiver.

General Specifications

RY5 series units have the characteristics shown in Table 1.

Table 1. Operating Characteristics

Transmission Wavelength	900 to 1,050 nanometers
Modulation Frequency	500 kHz \pm 50 kHz
Modulation Process	Amplitude Shift Keying
Range	1 meter (3 meters for RY5AR021)
Data Rate	38,400 bits-per-second
Supply Voltage	5 VDC \pm 0.3 V

RY5AR01 IR Data Receiver

The RY5AR01 IR Data Receiver is designed for reception of Amplitude-Shift-Keying (ASK) format serial data. The unit is composed of a photodiode, amplifier chain, bandpass filter, detector, and hysteresis comparator.

The photodiode is the detector for the IR signal. The recovered signal is amplified through a chain of five amplifiers. An internal AGC and limit stage is used to prevent saturation of the amplifier chain if a strong signal is present. A bandpass filter is incorporated to select the desired signal source as the primary input recovered by the receiver system. The transmitter module provides a 500 kHz modulation source that receives gating information from the transmitting data signal. The receiver will respond to this modulation source and reject signals without the 500 kHz signal. The detector responds to the presence of a correctly modulated IR source and drives the hysteresis comparator to provide an inverted TTL/CMOS compatible output.

The receiver external interface is composed of three pins in a shrouded connector block. The pins are power, ground, and an inverted sense output signal.

RY5AT01 IR Data Transmitter

The RY5AT01 IR Data Transmitter is designed for transmission of 500 kHz ASK-modulated serial data. The unit is composed of an input buffer, a 500 kHz modulator, and the output IR LED. The application of a positive logic '1' (+5 V) to the input enables the 500 kHz modulation at the IR output. A logic '0' (0 V) disables the output. As serial data is applied to the input, the output is gated to correspond to the data stream. Observe correct data protocols for the transmission and reception of serial data to insure correct recovery of the transmitted data. The transmitter external interface is composed of three pins extending flat in the plane of the circuit board. Power, ground, and a signal input are provided.

RY5BD01 IR Bidirectional Data Unit

The RY5BD01 IR Bidirectional Data Unit is designed for transmission and reception of 500 kHz ASK-modulated serial data. This unit incorporates all of the features of the RY5AR01 IR Data Receiver. The transmitting LEDs are the only portion of the RY5AT01 transmitter in this package. The 500 kHz modulation source and input buffer must be incorporated external to the unit. All other data transmission characteristics are the same. Refer to RY5BD01 on page 4.

RY5AR021 Three-Meter IR Data Receiver

The RY5AR021 is an enhanced-range version of the RY5AR01 IR Data Receiver. It has identical electrical characteristics with the exception of the enhanced range. The mechanical package has been changed to incorporate two photodetectors. This unit is used in conjunction with the standard RY5AT01 one-meter transmitter to provide a total three-meter effective operating range. If additional transmission distance is required, a discrete transmitter unit should be developed and used with the RY5AR021. A discrete transmitter implementation will allow for additional transmitting diodes to increase the total radiated signal. Refer to Figure 7.

CIRCUIT APPLICATION

RY5AR01

The RY5AR01 IR Data Receiver is a compact, lightweight unit designed for reception of Amplitude-Shift-Keying (ASK) format serial data. The unit is composed of a photodiode, amplifier chain, bandpass filter, detector, and hysteresis comparator (Figure 1).

The photodiode is the detector for the IR signal. Even though the received IR energy is in the 900-1,050 nanometer range, consideration should be given to reducing the amount of light received from ambient or local light sources. Light sources such as the sun, halogen, and tungsten lamps have a fairly high IR output over a broad frequency range. Reception of broadband light sources by the photodiode detector will tend to raise the internal noise level and reduce the overall sensitivity of the receiver circuits. One easy way to test for the amount of background light interference is with an IR transparent window. Refer to the *IR Window* section. If high ambient IR levels are expected, consideration should be given to the incorporation of an IR filter in the system design.

The recovered signal is amplified through a chain of five amplifiers. An internal AGC and limit stage is used to prevent saturation of the amplifier chain if a strong signal is present. A signal that is at the low end of the receiver sensitivity will be amplified to a usable level. A bandpass filter is incorporated to select the desired signal source as the primary input recovered by the receiver system. The bandpass characteristic suppresses signals in the 38 kHz modulation band used by many in-home consumer products such as television receivers and VCRs. In addition, many new inverter-supply fluorescent fixtures for commercial and in-home application use power sources driven in the 20 kHz to 38 kHz region. The light sources can generate background noise that in some circumstances will raise the overall noise and interference levels in a room.

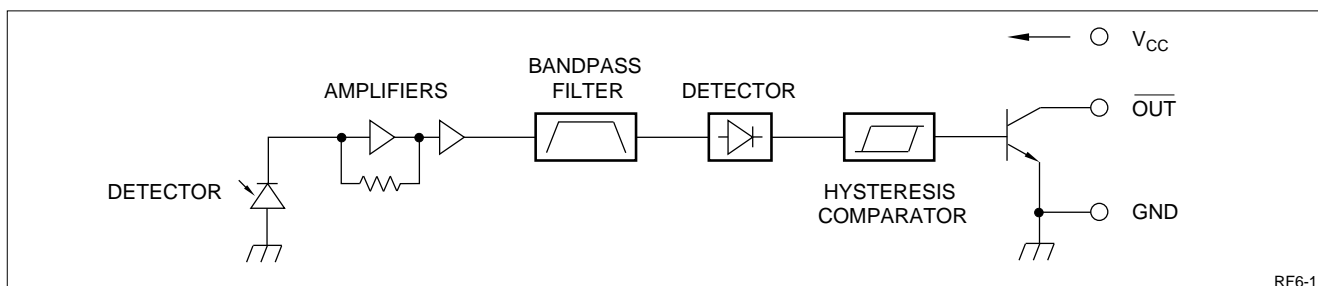


Figure 1. RY5AR01 Block Diagram

The receiver will respond to the 500 kHz transmitter signal source and reject signals without the 500 kHz modulation. For example, an IR signal source in the 900-1,050 nanometer band with 38 kHz modulation will be rejected, and the receive unit will not generate an output.

The detector stage is an envelope detector which responds to the presence of a correctly modulated signal. The detector output feeds the hysteresis comparator which provides a TTL/CMOS compatible output. A positive-going signal that exceeds the upper comparator threshold will set the comparator, and a negative-going signal that exceeds the lower threshold will reset the comparator. Hysteresis minimizes the probability of receiving incorrect information. [1] The comparator output is the logical complement of the received signal. For a logical '1' at the transmitter, a logic '0' is presented at the output of the receiver. The data receiver has an open-collector output that can be used with signals that do not exceed +10 V. A 33 kΩ pull-up resistor from V_{CC} is recommended in a normal +5 V system architecture. The nominal design current for the output is 150 μA. Do not exceed 200 μA. The receiver external interface is composed of three pins in a shrouded connector block; power, ground, and the inverted sense output signal. (See Figure 2.)

Information about where to obtain matching connectors is included in the *References* section.

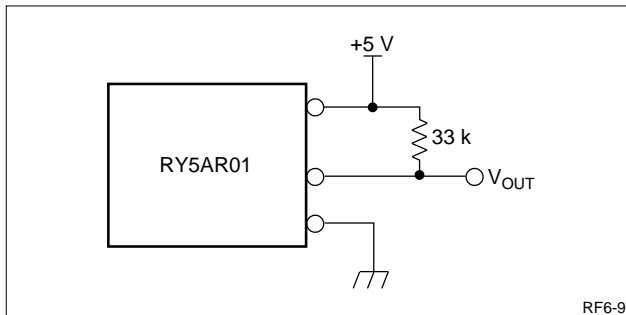


Figure 2. RY5AR01 Output Configuration

IR Window

A convenient source of IR transparent material is to use a piece of color film. Obtain a roll of color print film with an ASA rating of 100. Pull the film out of the can until the end is reached and expose the film to sunlight for several seconds. Roll the film back into the can and have it processed. Explain to your photo shop what you are doing so that they will correctly process the film and not try to make prints. The processed film material will provide a good IR test filter. [2] Double layers of the processed film material will be difficult to see through, yet will remain transparent to most IR wavelengths.

RY5AT01

The RY5AT01 IR Data Transmitter is a compact, lightweight unit designed for transmission of 500 kHz ASK-modulated serial data. The unit is composed of an input buffer, a 500 kHz modulator, and the output IR LED (Figure 3).

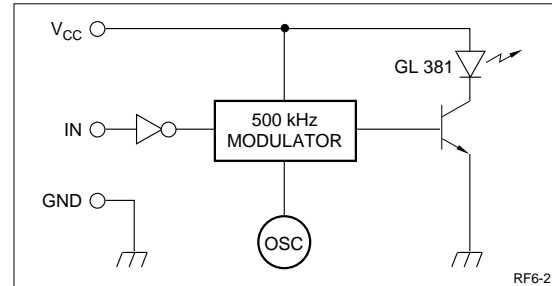


Figure 3. RY5AT01 Block Diagram

The application of a positive logic '1' (+5 V) to the input inverting buffer enables the 500 kHz modulation at the IR output. A logic '0' (0 V) disables the output. Serial data at the input creates a corresponding modulated output. Observing correct data protocols for transmission and reception of serial data will insure correct recovery of the transmitted data. Half-duplex protocols will provide high reliability data transmission. Full-duplex operation is difficult in the IR environment due to local echo at each end of the transmission system, and from reflective objects in short-range line-of-sight. Half-duplex operation can achieve high transfer rates and low error rates when packet transfer and error checking are employed.

The transmitter external interface is composed of three pins extending flat in the plane of the circuit board. Power, ground, and a signal input are provided.

Amplitude Shift Keying

The 500 kHz modulator runs continuously and is enabled by the input signal. The modulation process is Amplitude-Shift-Keying (ASK) (Figure 4). In this application, ASK essentially refers to the presence or absence of a modulated carrier. [3] In transferring data files, 'mark' and 'space' correspond to logic '1' and '0' respectively. [4] With a logic '1' (mark) applied at the input, a modulated signal will be gated to the output IR LED. With a logic '0' (space) at the input, no signal will be sent. In this condition, the IR carrier will not be transmitted. The time period of a logic '1' data bit is filled in with the 500 kHz modulation frequency. The envelope detector at the receiver will respond to the presence of the modulation envelope. The rising and falling edges of the envelope will drive the hysteresis comparator to generate the recovered output. Probability data for the correct transmission and recovery

of ASK data is available in reference 1. With correct application of these modules, error rates of $10e^{-07}$ can be demonstrated.

R5BD01

The R5BD01 IR Bidirectional Data Unit is a compact unit designed for transmission and reception of 500 kHz ASK-modulated serial data. This unit incorporates all of the features of the R5AR01 IR Data Receiver. The transmitting LEDs are the only portion of the R5AT01 transmitter in this package. The 500 kHz modulation source and input buffer are added in external supporting hardware for the unit. (See Figures 5 and 7).

The R5BD01 unit is designed for mounting on the surface of a circuit board. Consider a reflector as an easy method for conducting the IR energy to and from the unit. This will allow for direct mounting of the module without a separate circuit board mounted perpendicular to a normal backplane or motherboard (Figure 6). The mirror surface should be mounted as close as possible to the LEDs and photodiode.

Reflector Material

A recommended material for use as the reflector is 'PET' (Polyethylene Terephthalate) with 'Al' layer by evaporative deposition. This material is essentially a Polyethylene substrate with a reflective layer and should be available as an off-the-shelf item. Or, a similar material with a highly reflective surface should suffice.

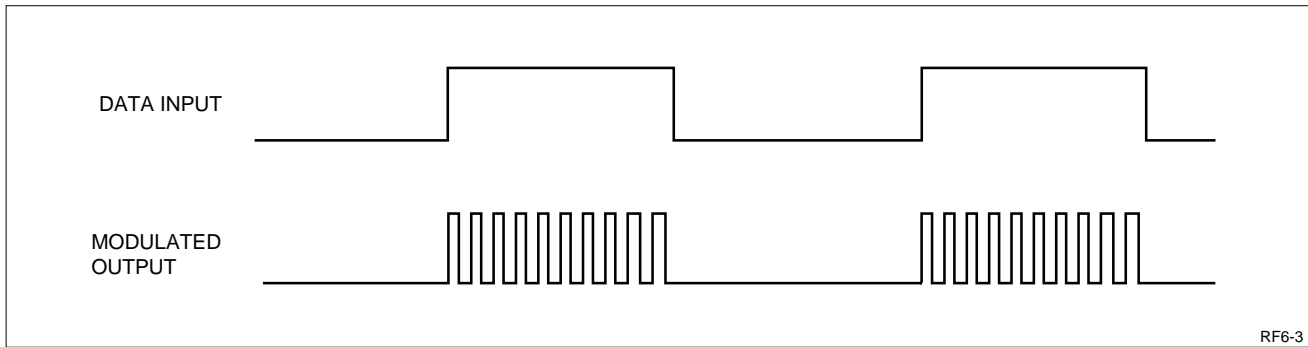


Figure 4. ASK Modulation Diagram

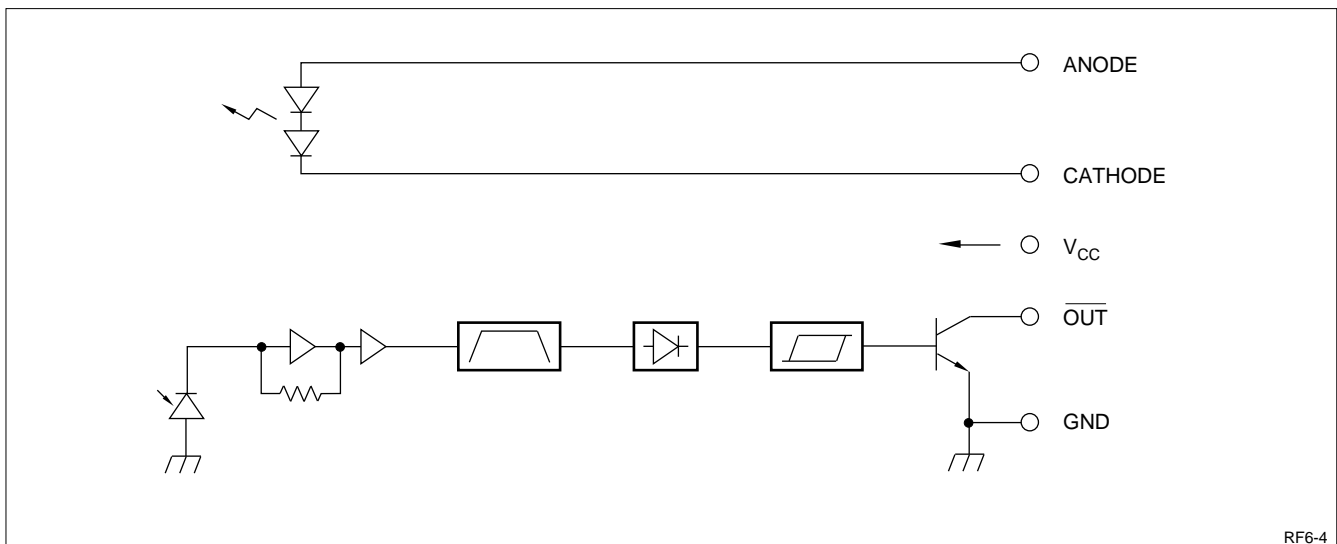


Figure 5. R5BD01 Block Diagram

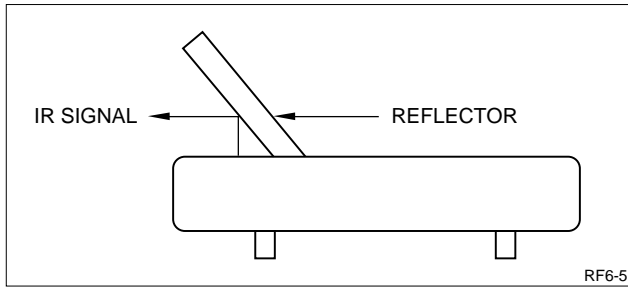


Figure 6. RY5BD01 With Reflector

Modulator Circuit

The RY5BD01 does not include a 500 kHz modulator circuit in order to keep the package size small. A modulator circuit of some type is required to provide the modulation signal and drive the IR LEDs. One possible circuit is shown in Figure 7. The ceramic resonator and CMOS inverters comprise the 500 kHz oscillator. The transistor arrangement is the LED driver network. The limit resistor controls the LED forward current at different duty cycle rates. The ceramic resonator in the oscillator has been chosen for the good frequency stability offered.

Try to maintain the 500 kHz modulation frequency within ± 25 kHz of the fundamental. This will guarantee dependable signal recovery over temperature and other operating environment changes. The diagram in Figure 7 shows a low-cost, reliable, low gate-count

design, but not the lowest possible gate-count. Other modulator schemes can be devised. The primary considerations should be frequency stability, and for a logic '1' (+5 V) at the Signal Input, the LEDs are enabled to provide an IR output. If a 500 kHz sub-multiple of a microprocessor clock is available, as shown in Figure 8, then it may be used as the modulation signal source. In that case, it would be applied to the second NAND gate input in place of the clock signal.

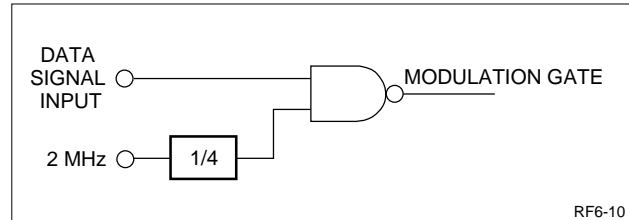


Figure 8. 500 kHz Modulation Source

A stable RC oscillator comprised of CMOS gates is described in National Semiconductor® Application Note 118⁵. This circuit can be used to provide a 500 kHz source when no other methods are desired. (See Figure 9.)

The frequency of operation is described by the expression $f = 1/[2C(0.405 R_{EQ} + 0.693 R1)]$. R_{EQ} is the parallel combination of R1 and R2.

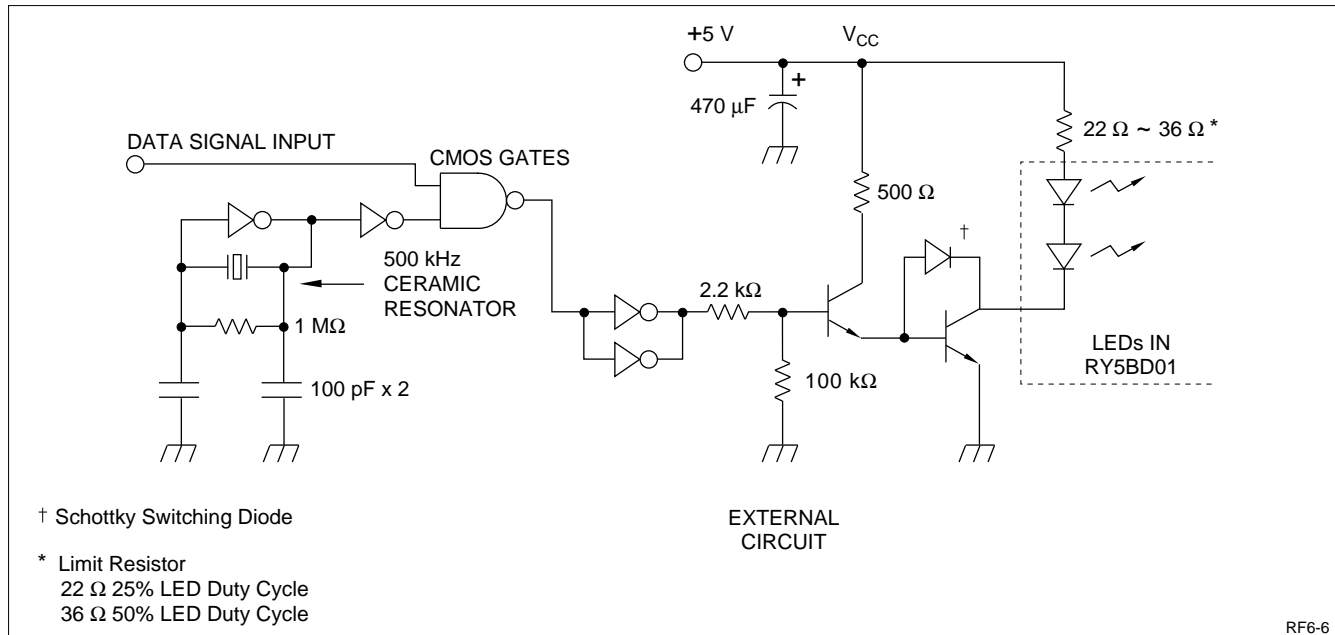


Figure 7. Sample 500 kHz Modulator Circuit

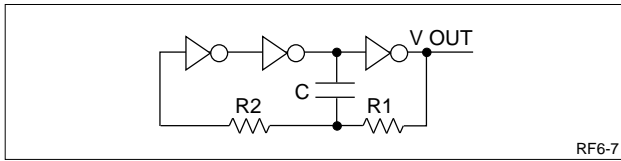


Figure 9. Three-Gate Oscillator

Insure that the correct line-driver connections are made from the MAX233 device to the RS-232 port and to the TTL/CMOS interfaces. Short connection lengths from the MAX223 chips and the RY5AT01 and RY5AR01 modules are possible without additional power supply decoupling. If the run lengths are more than 3 inches, consider additional power supply decoupling if your system environment is noisy.

SAMPLE SYSTEM

A sample RS-232 connection using two RY5AT01 IR Transmitters and two RY5AR01 IR Receivers is shown in Figure 10. Standard RS-232 pin assignments are assumed here. This example employs the use of MAXIM⁶ MAX233 RS-232 Drivers/Receivers, which may be operated from +5 VDC without any additional external components. This configuration duplicates a standard RS-232 connection for two-way data transfer.

For full-duplex operation, isolate the co-located transmitter and receiver pairs from direct viewing by each other. A simple divider plate or other physical separation will suffice. When fully isolated, full-duplex operation may be achieved. Without separation, a local echo will be generated at each end of the transmitting system. In this normal operating environment, half-duplex operation is standard, and depending on the setup, the system software must strip the echo characters from the received data.

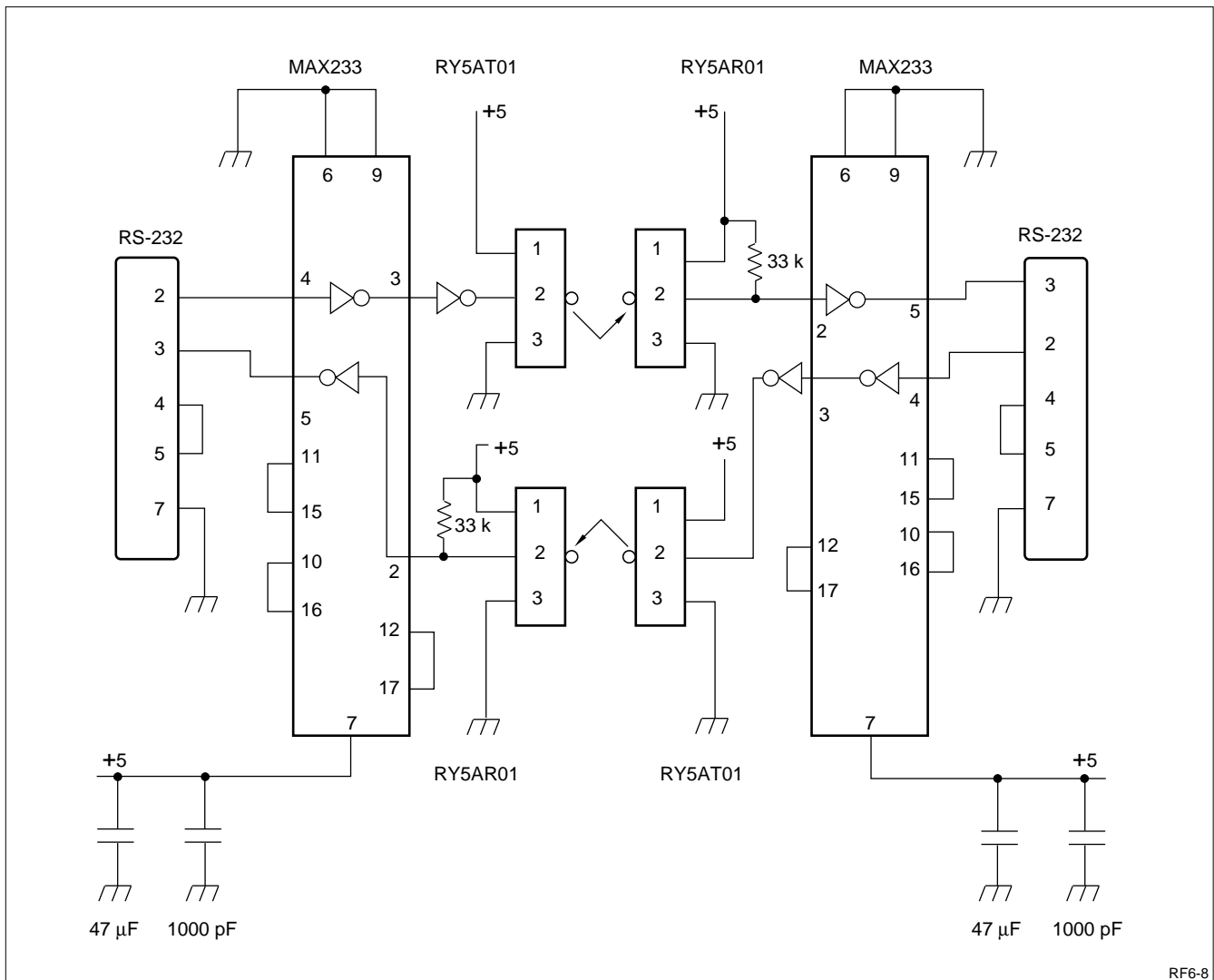


Figure 10. Bidirectional System Diagram

Currently, the RY5BD01 bidirectional data unit will support half-duplex operation only, due to the transmitter and receiver devices being co-located on the module. High data transfer rates may be accomplished by the use of direction control routines in the supervisory software in your final system. System test with a modem software package may appear to demonstrate full-duplex operation when echo canceling is chosen as a set-up parameter. Half-duplex operation will be more reliable and provide an overall lower error rate. Data transfer protocols that use a packet format that are not dependent on simultaneous bidirectional handshakes will operate most effectively.

Most commercially available communications software packages for Personal Computers (PCs) may be used to test the IR link. Data rates up to 38,400 bits-per-second work with minimal data errors, if recommended system parameters are not exceeded. Check your computer system data transfer specifications to determine if higher data rates can be supported without errors. Direct communication between the two modules is a first step in demonstrating the operation of the IR link.

Another method is to prepare a test file for evaluating the serial connection. Prepare the file prior to the test. After configuring the port setup in the software, select 'file transfer.' Use a file transfer protocol without error correction to demonstrate a one-way data file transfer, with or without handshake. Check for file transfer errors. If present, check for system parameters that have been violated, such as range. Bidirectional capabilities may be tested by selecting a protocol that employs echo canceling, half-duplex handshake, or packet transfer methods. The file may be tested for data errors by using comparison routines that are part of the PC system programs.

Manufacturing Considerations

Several considerations should be kept in mind for best overall system results: the ground plane of the circuit board on which the RY5AR01 or RY5BD01 is mounted should be extended under the area of the photodiode. Including ground plane under as much of the units as possible will be of additional help. The receiver circuits and photodiode are susceptible to Electro-Magnetic Interference, and additional ground plane helps reduce the unit sensitivity. In the same context, the mounting tabs of the metal enclosures should also be soldered to plated-through holes that are tied to the ground plane.

Efficient mounting of the RY5BD01 requires the relief of several areas on the circuit board. Figure 11 provides information on the areas that need to be removed.

All of the RY5-series parts should be hand-mounted and soldered. These devices are not suitable for IR process systems used in Surface-Mount Technology

production lines. The high IR temperatures beyond 100°C will soften the material in the IR photodiode and LEDs, distorting the optical characteristics. Under circumstances where due caution is exercised, the RY5AR01, RY5AR021, and RY5AT01 may be processed on a flow-solder system as long as the components do not heat soak to a 100°C level, and solder will not wick to the underside of the modules. Short temperature transitions on the leads for less than five seconds should not harm the devices if the above stated considerations are kept in mind.

Figure 11 shows a drawing of the circuit board locations of mechanical features of the RY5BD01. Specific dimensions for locating the circuit board contacts for soldering to the board are shown. The dimensions of areas that should be cut away from the board to allow flush mounting of the unit are also shown as circular, oval and square shaded areas. The small shaded racetrack designs are for the mounting tabs to be soldered to the circuit board.

Figures 12 through 15 show characteristic data of the GL381 IR LED and PD410PI Photodiode. These two components are often used as reference components for tests of IR data communication links. The GL381, or an equivalent is used in the RY5AT01. The PD410PI or an equivalent is used in the RY5AR01 and the RY5BD01. Complete information is available in the *SHARP Optoelectronics Data Book 1991/1992*.

REFERENCES

- [1] *Reference Data For Radio Engineers*, Howard Sams & Co., 1975, Ch. 23.
- [2] Lance Kempler, Sharp Electronics, Opto-Electronics Field Applications Engineer, Camas, WA
- [3] *Reference Data for Radio Engineers*, Howard Sams & Co., 1975, Ch. 23.
- [4] *RS-232 Simplified*, Byron W. Putnam, Prentice-Hall, 1987.
- [5] *National Semiconductor, CMOS Logic Databook*, AN-118, National Semiconductor Corporation, 2900 Semiconductor Drive, P.O. Box 58090, Santa Clara, California 95052-8090, 408-721-5000.
- [6] *MAXIM Integrated Products*, 120 San Gabriel Drive, Sunnyvale, California 94086, 408-737-7600.
- [7] Matching Connectors for RY5AR01: J.S.T. Corporation, 1200 Business Center Drive, Suite #400, Mt. Prospect, Illinois 60056, 708-803-3300, facsimile 708-803-4918. Crimp style connector: Part number PHR-3; matching contact Part number SPH-002T-P05S. IDC style connector Part Number 03KR-8M for 28 gauge wire; 03KR-6S for 26 gauge wire.

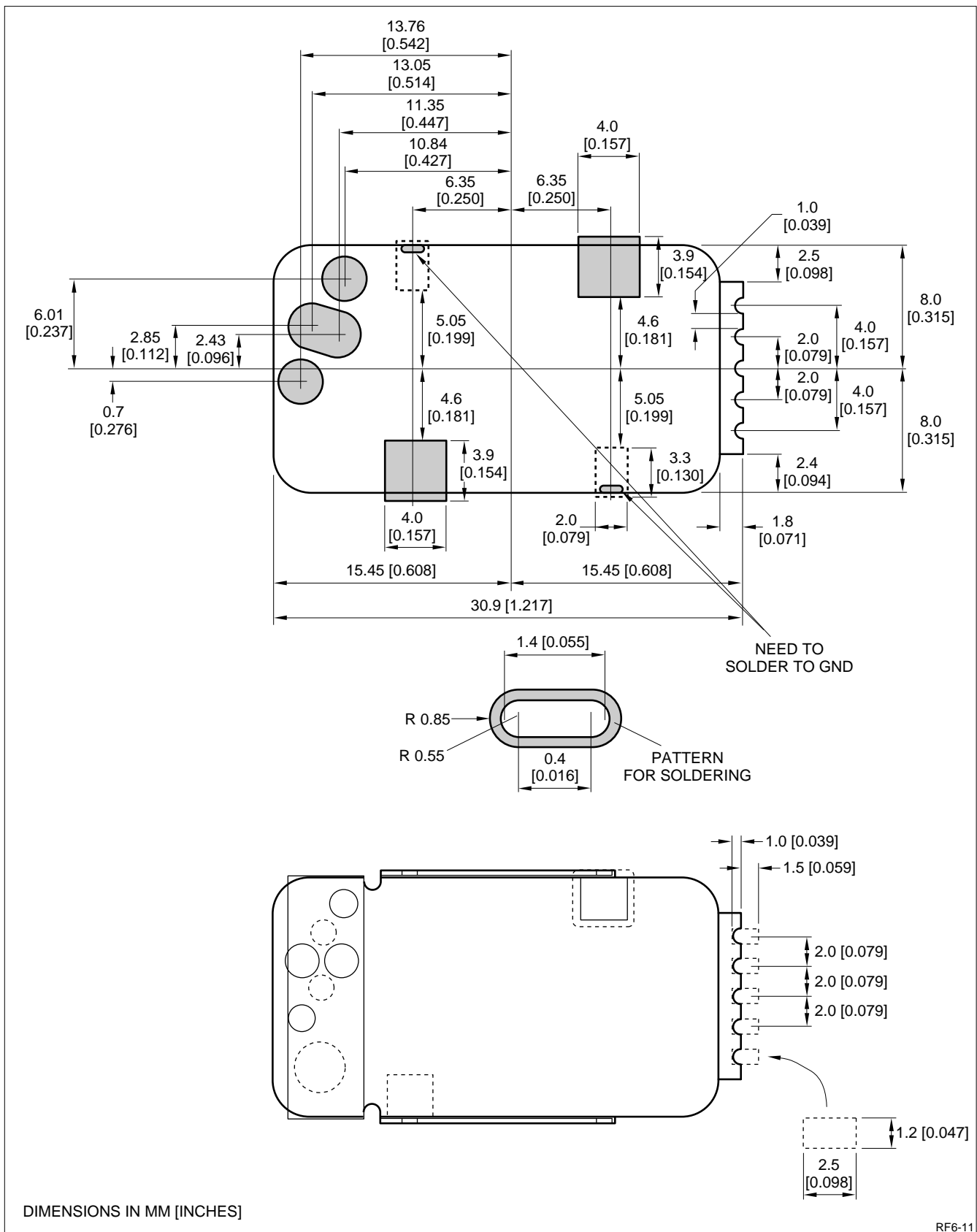


Figure 11. RY5BD01 Mounting and Soldering Details

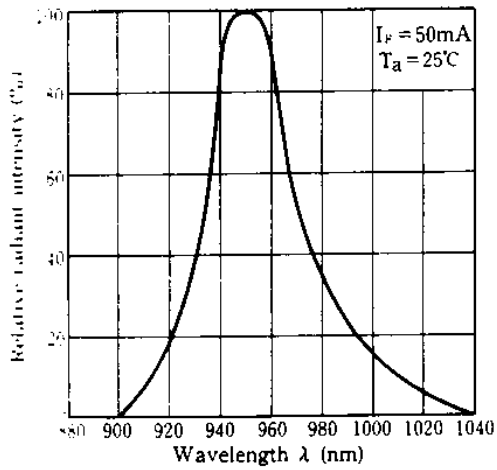


Figure 12. Spectral Distribution
GL381

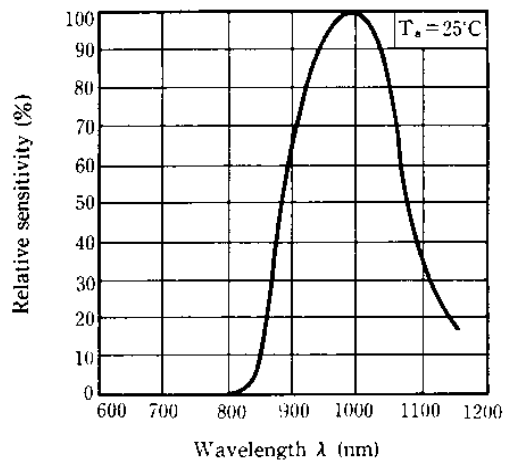


Figure 14. Spectral Sensitivity
PD410PI

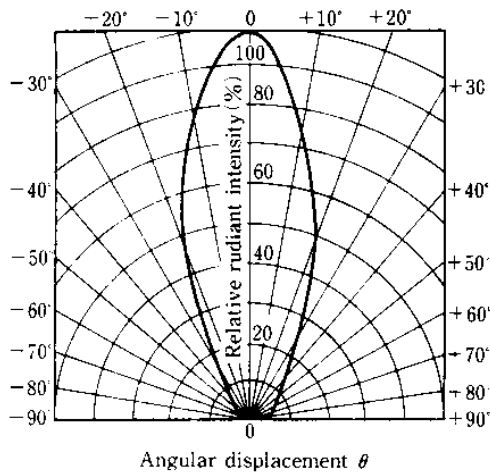


Figure 13. Radiation Diagram
GL381

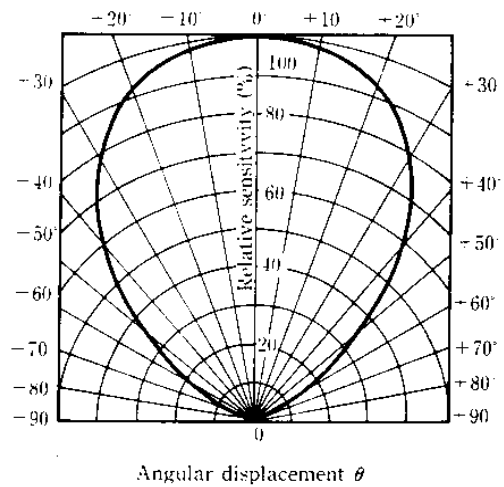


Figure 15. Sensitivity Diagram
PD410PI

NOTES

NOTES

LIFE SUPPORT POLICY

SHARP components should not be used in medical devices with life support functions or in safety equipment (or similiar applications where component failure would result in loss of life or physical harm) without the written approval of an officer of the Sharp Corporation.

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SHARP**NORTH AMERICA**

SHARP Electronics Corporation
Microelectronics Group
5700 NW Pacific Rim Blvd., M/S 20
Camas, WA 98607, U.S.A.
Phone: (360) 834-2500
Telex: 49608472 (SHARPCAM)
Facsimile: (360) 834-8903

EUROPE

SHARP Electronics (Europe) GmbH
Microelectronics Division
Sonninstraße 3
20097 Hamburg, Germany
Phone: (49) 40 2376-2286
Telex: 2161867 (HEEG D)
Facsimile: (49) 40 2376-2232

ASIA

SHARP Corporation
Integrated Circuits Group
1, 2613-banchi, Ichinomoto-cho
Tenri-shi, Nara Pref. 632, Japan
Phone: (07436) 5-1321
Telex: LABOMETA-B J63428
Facsimile: (07436) 5-1532