HP 48 I/O
Technical Interfacing Guide

HP 48 I/0 Technical Interfacing Guide

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Introduction

This document gives HP 48 hardware information required to connect serial devices to the wired (serial) I/O port or to communicate with the HP 48 via the 2-way infrared (IR) I/O port. It also gives some considerations for I/O software on devices connected to the HP 48. The serial I/O port is a full-duplex UART with RS-232 compatible signal level shifting. The IR I/O port uses an infrared receiver circuit for input and an LED for output, giving a half-duplex IR UART. For both serial and IR ports, incoming bytes are received in the interrupt system (when the port is open) up to the 255 byte limit of the input buffer.

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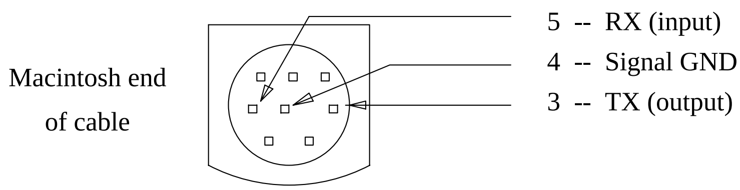
Wired Serial I/O Hardware

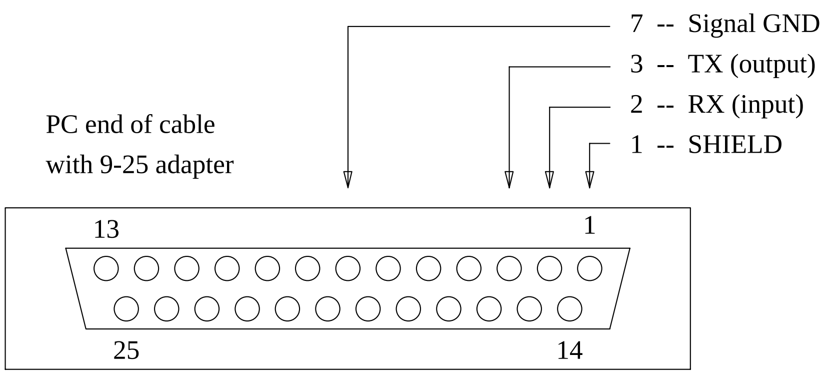
The serial I/O port allows full-duplex communication between systems at 1200, 2400, 4800, or 9600 baud over wires with RS-232 compatible signal levels. Available parity settings are: none, odd, even, mark, or space. Parity checking of received bytes may be disabled while still transmitting with parity. XON/XOFF handshaking can be used on either or both transmit and receive. The serial I/O port is divided into separate receive and transmit sections which share a baud-rate generator and an interrupt mechanism. Both the receiver and transmitter sections are double-buffered to maximize the throughput of the serial channel.

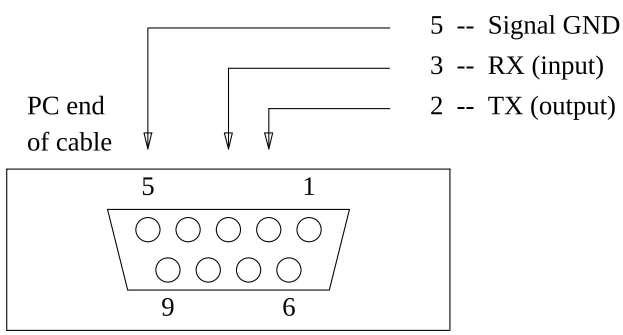
Cable Wiring

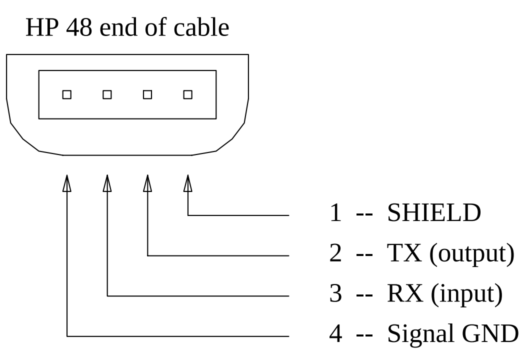
The pin definitions for the HP 82208A (IBM) and 82209A (Macintosh) serial cables for the HP 48 are shown on the next page, including the 25 pin end of the 9-25 pin adapter. All signals are labeled from the HP 48's point of view.

HP 48 I/O Cable Pinouts









Notes:

1. Output = from HP 48
2. Input = to HP 48

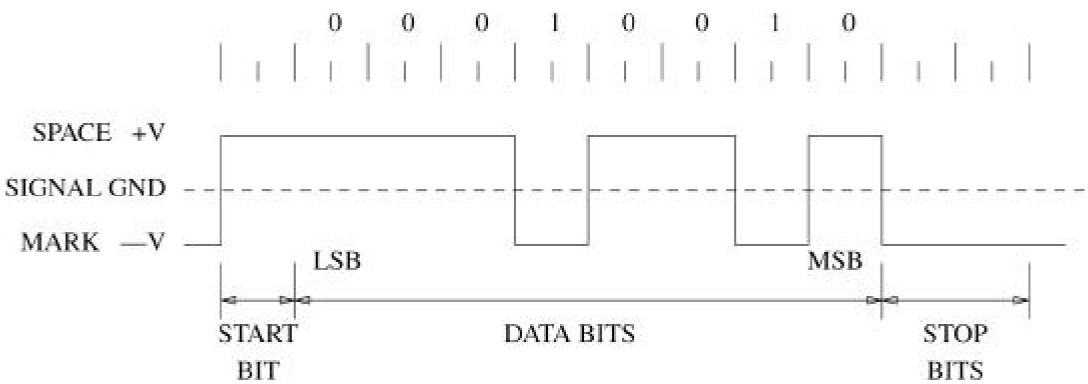
Serial Format

A frame of serial data consists of a start bit, eight data bits, and at least one stop bit. The start bit is equivalent to a "0" data bit and a stop bit is equivalent to a "1" data bit. The data bits are sent least-significant-bit first. The HP 48 transmitter sends slightly more than 2 stop bits with every frame. The HP 48 receiver requires at least 1 stop bit for proper frame synchronization.

A mark condition or "1" data bit on the serial line corresponds to a negative voltage. A space condition or "0" data bit corresponds to a positive voltage. An idle condition corresponds to zero voltage. The line is held in this low power (idle) state when the port is closed. When the port is open, the line is normally held in the mark condition. When data is to be transmitted it must start in the mark condition. When the line is to be returned to the idle condition it must pass through the mark condition first.

A break condition is when the line is held in the space condition for at least one entire frame. A break should not start in the middle of a character.

Example: an 'H' (48 hex)



Serial Electrical Specifications

The following table gives the serial port electrical operating specifications. The TX output voltage swing is measured at the end of a 1-meter cable with the specified load, where the 500 pF includes distributed capacitance in the cable.

Signal	Description	Min	Typ	Max	Units
TX	Output voltage swing. Load: 3 kΩ min, 500 pF max	+/-3.0	3.5		
	Bit width tolerance			2.5	%
RX	Input + operating range	1.0		15.0	V
	Input – operating range	-15.0		.03	V
	Input impedance	5.0		7.0	kΩ
	Bit width tolerance			2.5	%
All	Absolute maximum voltage			+/-25	V

Serial UART Operation

Receiver Operation

The port must be open to receive data. HP 48 Kermit I/O functions, XMIT, and SRECV all open the port automatically if it is closed. The following description of the HP 48 receiver is offered as a model for the receiver on an external device communicating with the 48.

All bit timing is relative to the leading-edge of the start bit. The resolution of this timing is 16 times the baud setting. The data on the RX pin is shifted into a shift register at the center of the bit time. When the RX pin goes to the space condition (indicating the start of a frame) the receive clock starts. If the RX pin remains in the space condition for at least half of a bit time, the start bit is considered valid and the receive shift register is enabled. If the RX pin returns to mark condition before a half bit time elapses, the receive clock is stopped and the frame is aborted.

When the shift register has shifted in a start bit, eight data bits, and a stop bit, it transfers the eight data bits to the receive buffer register (RBR), sets the receive buffer full flag (RBF), and reinitializes the shift register. If the RBF flag was already set, the receive error (RER) flag is set to indicate an overrun. If the stop bit was not a "1" (mark condition), the RER flag is set to indicate a framing error. Then the receiver returns to its idle state of waiting for a valid start bit. Another incoming frame may be received while software is responding to the RBF condition.

The HP 48 software reads the byte out of the RBR and places the byte in a 255 byte input buffer. All parity checking is done in software when the bytes are read out of this input buffer.

Interpretation of Break Condition

A break condition on the line will be interpreted as a valid start bit followed by eight zero data-bits and at least one "0" (invalid) stop-bit. Thus a break condition will result in a null byte in RBR and setting RER and RBF. The start bit filter will prevent an extended break condition from being interpreted as additional characters until the line returns to the mark condition.

Transmitter Operation

When the port is closed, the transmit voltage level shifter is turned off to save power. The TX pin is shorted to signal ground to send a line idle condition. When the port is opened, the transmit level shifter is enabled and the TX pin goes to the mark condition. For each byte of data, the transmitter sends 2 stop bits, 1 start bit, and 8 data bits plus 3/16 bit internal clocking delay for a total of 1.375 bits per frame. Therefore the maximum transmission rate is:

Baud setting/11.375 (844 characters/second at 9600 baud)

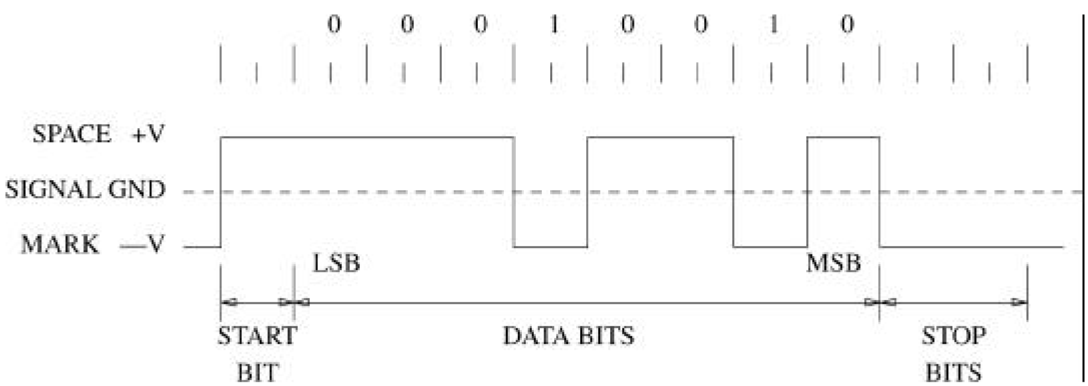
Infrared I/O Hardware

The IR port allows half-duplex communication between systems at 2400 baud using pulses of infrared light instead of wires. Full-duplex is not used due to the need to suppress reflections.

IR Format

The format for IR transmission is similar to serial transmission except that a pulse of infrared light of 52 \(*ms duration (nominal) is used to transmit a zero-bit. The absence of a pulse indicates a one-bit or idle condition. Note that if the pulses are stretched out to fill a bit time this becomes very similar to the serial signal.

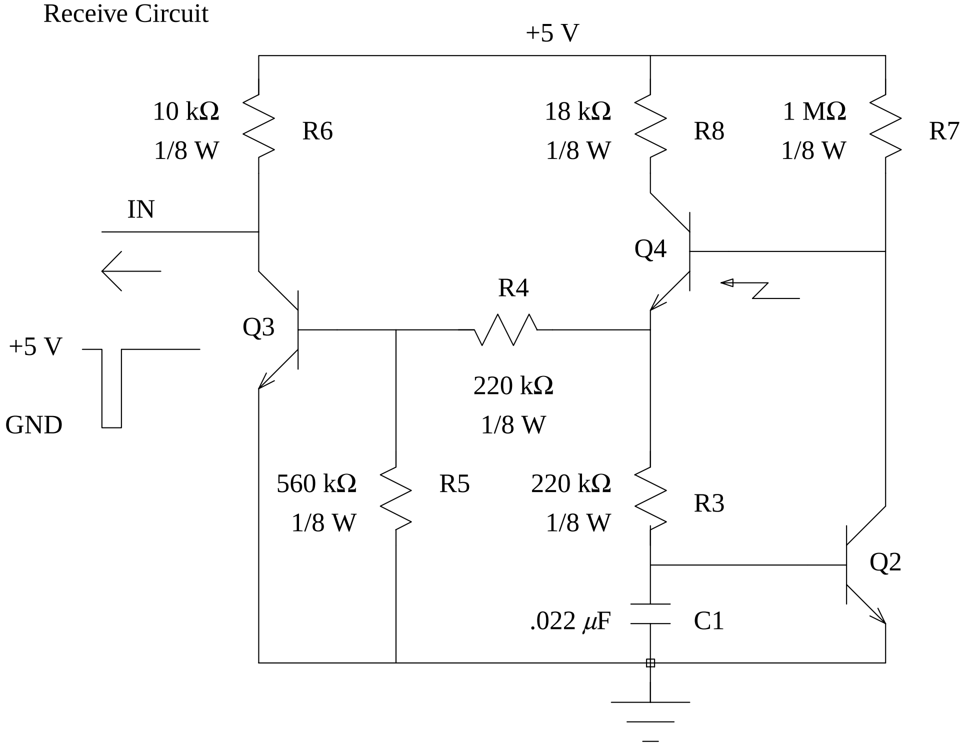
Example: an 'H' (48 hex)



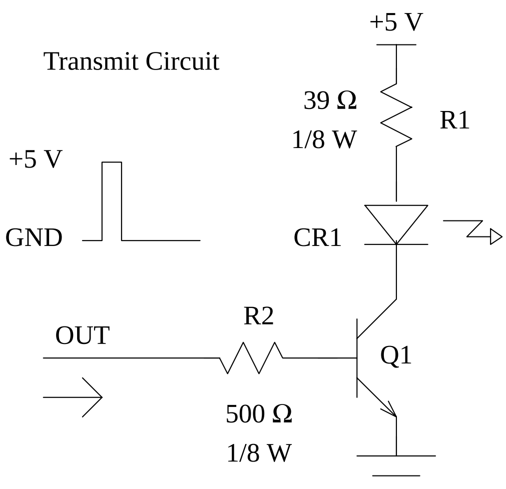
Transmit and Receive Circuits

The first circuit shown below detects incoming IR pulses and produces the signal shown at the left, labeled "IN." The second circuit generates the IR output given the signal shown at the left, labeled "OUT."

Receive Circuit



Transmit Circuit



Q1,Q2,Q3: 2N3904

Q4: EG&G VATEC VTT 9112

CR1: NEC SE303A

or

HP HEMP-3301 (narrower beam)

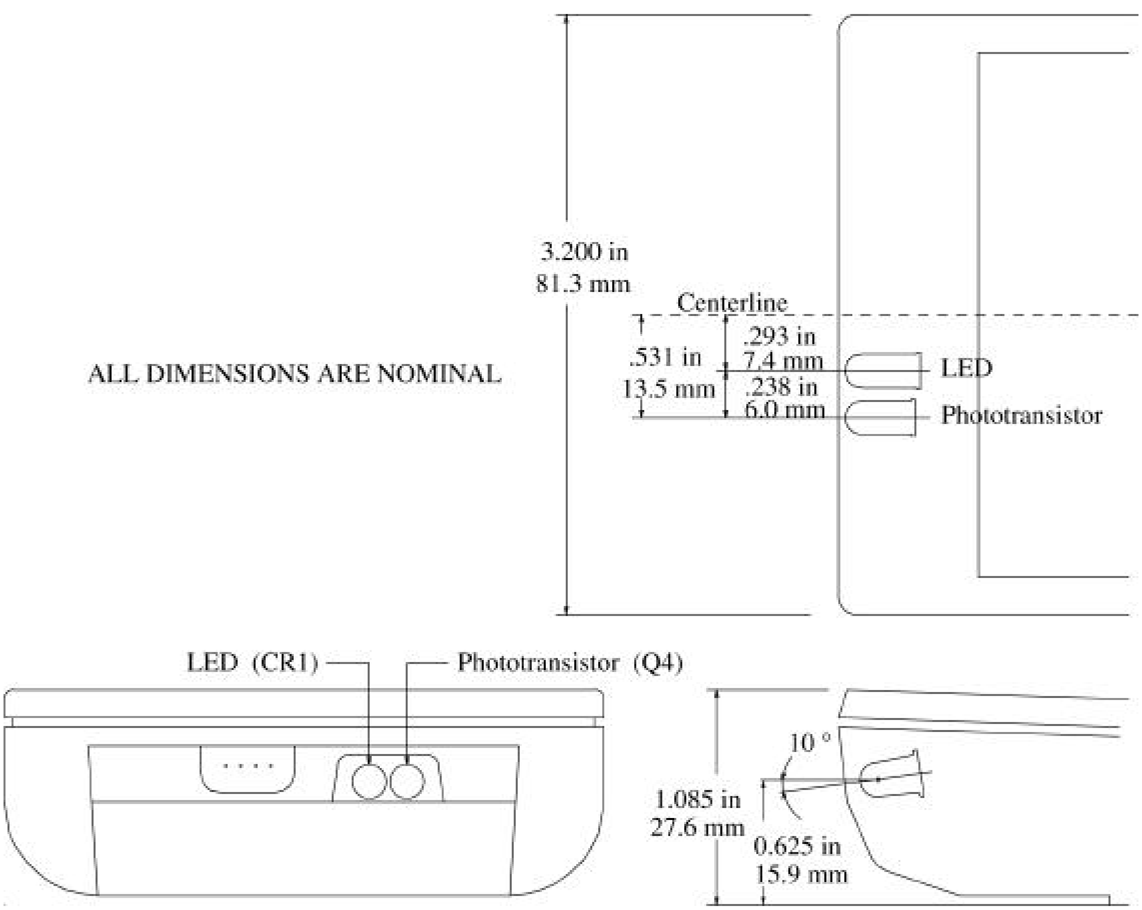
R1-R8: 5%

IR Specifications

Description	Min	Typ	Max	Units
Wavelength		940		nm
Distance from transmitter to receiver			2.0	in
Half-intensity beam width	+/-20	+/-30		°
Receiver pulse width	40	52	80	µs
Transmitter pulse width	46.8	52	57.2	µs
Baud	2340	2400	2460	bit/s

1. Half intensity beam width is measured from the emitter's centerline to where the radiant intensity is half of the on-axis value.

2. The IR transparent material used in the HP 48 card port cover is GE ML4309-21051 IR TRANSPARENT FCR POLYCARBONATE.



IR UART Operation

The IR UART uses the transmit and receive circuits for IR output and input as described below.

Receiver Operation

The port must be open to receive data. HP 48 Kermit I/O functions, XMIT, and SRECV all open the port automatically if it is closed. The following description of the HP 48 IR receiver is offered as a model for the receiver on an external device communicating with the 48.

IR pulses from the receive circuit's "IN" signal are used to set a latch whose output is called IRE (IR Event). The receiver starts by waiting for a valid start bit. An incoming pulse of IR will start the receiver clock, which shifts IRE into a shift register after half of a bit time and then clears IRE for the next bit. Because this method stretches the pulses, any pulse of light that is long enough to set IRE will be considered a valid start bit.

The remaining bits are shifted in the same fashion as described above for the wired UART including checking for framing and overrun errors and using RBR and RBF. As in the serial port, all bit timing is relative to the leading edge of the start bit and has $1/16^{th}$ bit resolution.

Due to the probability that reflections from the transmitter will be received and interpreted by the receiver, the receiver data is ignored (by disabling receiver interrupts) while transmitting.

The serial port cannot be used while doing IR I/O. Its RX pin will be ignored by the UART.

Transmitter Operation

The port must be open to transmit data. HP 48 Kermit I/O functions, XMIT, and SRECV all open the port automatically if it is closed. The output of the UART is modulated as shown under "IR Format" and sent to the output circuit.

The serial port cannot be used while doing IR I/O. Its TX pin will be held in the mark condition and breaks (SBRK command) will not be sent to the TX pin but will instead generate a series of IR pulses.

Kermit File Transfer

Kermit file transfer is preferable to unformatted I/O since it can detect errors and correct them by retransmitting bad packets. The Kermit you use should be set to use type 3 (CRC) checksums for IR I/O since the error rate is higher than for wired I/O. If you use your Kermit in server mode the HP 48 will use "I" packets to request type 3 checksums.

The HP 48 Kermit does not use XON/XOFF handshaking since Kermit packets are small enough that additional handshaking should not be necessary. Your Kermit must have an input buffer which can hold at least 14 bytes in order to receive an "S" or "I" from the HP 48, although a larger buffer is clearly desirable for more efficient transfers. The input buffer must also be large enough to receive the largest "F" (filename) packet that will be sent.

Non-Kermit I/O

General Considerations

The HP 48 can receive a maximum of 255 bytes in a continuous stream, so to transfer more than this you should use XON/XOFF handshaking or some higher level protocol which breaks the data stream into pieces smaller than this. Data sent to the HP 48 should have inter-frame gaps that are less than 4 frame times or greater than 4 frame times plus 5 ms. Inter-frame gaps of between 4 frame times and 4 frame times plus 5 ms should be avoided since they may cause UART overruns on the HP 48. Be sure the clock is not ticking in the HP 48 display since clock ticks, alarms coming due, or other timer interrupts extend the 5 ms to a much longer time, so they can cause UART overruns. For the same reason, no keys should be pressed while doing I/O (unless the intent of the key press is to abort the I/O). You must allow enough time for the HP 48 to read data out of its receive buffer (using SRECV) before sending more data or the 255 byte receive buffer will be overflowed.

Use of some sort of checksum is recommended, especially for IR I/O which is sensitive to noise. Garbage characters (most commonly FF bytes) can be received between transmissions since a single IR or electrical noise pulse acts as a start bit.

Special Considerations for IR

Since IR from the transmitter can reflect back into the receiver, the receiver should be ignored while transmitting and carefully cleaned up after the transmitting is done. If your IR receive circuit is feeding a UART, you should wait for at least a half bit time after the stop bit from the last byte transmitted to be sure that the reflected byte has been received before clearing the UART's receive buffer as well as any framing or overrun errors. At this point the receive circuit will be ready to receive valid data, although (as noted above) this "valid data" can contain garbage characters due to IR or electrical noise pulses. Be sure to use some reliable error detection technique if data integrity is important!

Because IR I/O is half duplex (due to reflections), XON/XOFF handshaking is not possible.