

# **PIL-IO board notes**

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1. General Description
2. PIL-IO Board Description and Setup
  - PIL-IO board kit
  - PCB layout and bill of material
  - Additional wiring
  - PIL-IO supply and I/O connectors
  - HP-IL cable wiring
  - PIL-IO board basic test
3. PIL-IO Board Usage
  - PILPIO1 device
  - PILSER1 device
4. PIL-IO firmware history

## 1. General Description:

The PIL-IO board provides 4 digital input/output lines and a serial link to the HP-IL loop. It can be driven by any HP-IL controller such as the HP-41C or the HP-71B.

The PIL-IO board is intended to be used by electronic hobbyists.

The PIL-IO board provides 2 HP-IL device functions at the same time:

- a mini HP-IL/GPIO interface with 4 I/O lines,
- a mini HP-IL/serial interface with logic level Rx and Tx lines.

The 4 I/O lines can be used either as inputs or outputs in any combination.

The serial Tx and Rx lines can be used to interface with an other microcontroller using an asynchronous serial communication link (UART).

All the I/O and Rx/Tx lines are 5V logic (TTL/CMOS compatible logic)

The power supply is not included. A 5V supply has to be provided by the user to the board.

The PIL-IO will work with any HP-IL controller such as the HP-41C, HP-71B or HP-75C.

With the HP-41C, OUTA is used to set the 4 I/O lines, by sending a hexa-coded character that is the binary value corresponding to lines 0-3:

For instance "0" OUTA clears all lines 0 to 3,

"2" OUTA sets line 1, and clears lines 0, 2, 3.

INSTAT reads the status of the I/O lines, the result is in flags 0 to 3 and decimal value in X.

With the HP71, the equivalent commands are:

OUTPUT :1,"0" clears all lines 0 to 3,

OUTPUT :1,"2" sets line 1, and clears lines 0, 2, 3.

X=SPOLL(1) read the status of the I/O lines, the result is in the variable X

This document gives the necessary information to connect the board and use it with a HP-41C or HP-71B and their respective HP-IL module.

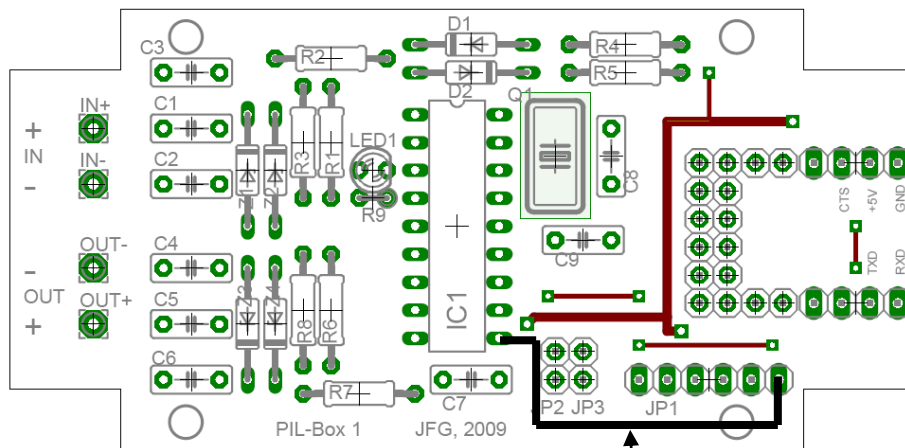
## 2. PIL-IO Board Description and Setup

### PIL-IO board kit



- 1 PCB
- 1 programmed microcontroller PIC 16F628A
- 1 component set:
  - o R1..R9
  - o C1..C9
  - o D1, D2
  - o Z1, Z2, Z3, Z4
  - o LED
  - o Crystal 20 MHz
  - o Zener diode BZX85 5.6V
  - o capacitor 4.7uF 25V
  - o 18 pts socket for the uC
  - o connectors for HP-IL cable (2) with wire terminals (4)
  - o I/O connectors: JP1 6pts , JP2/JP3 2 pts

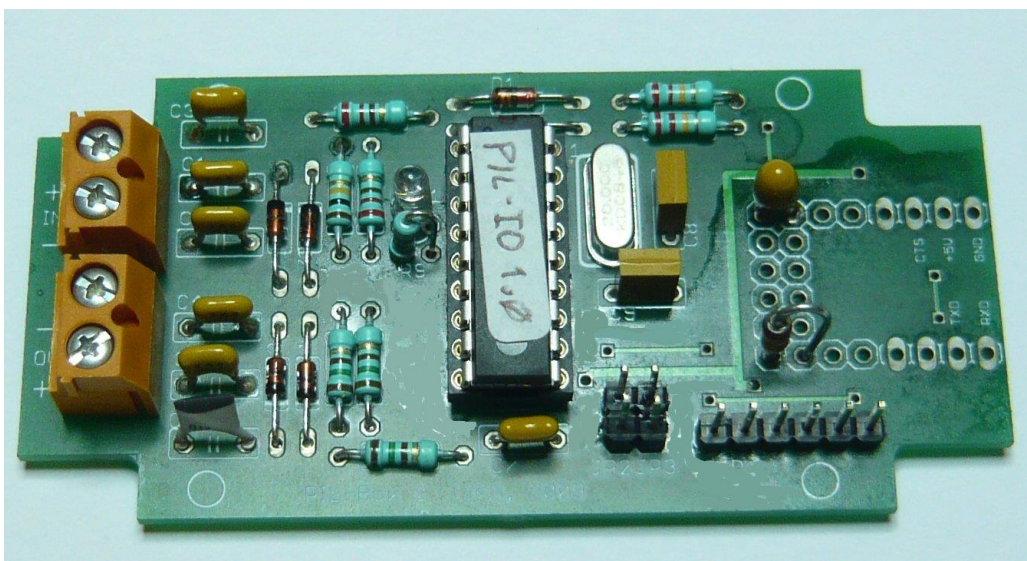
## PCB layout:



Wire to be added

## Bill of Material:

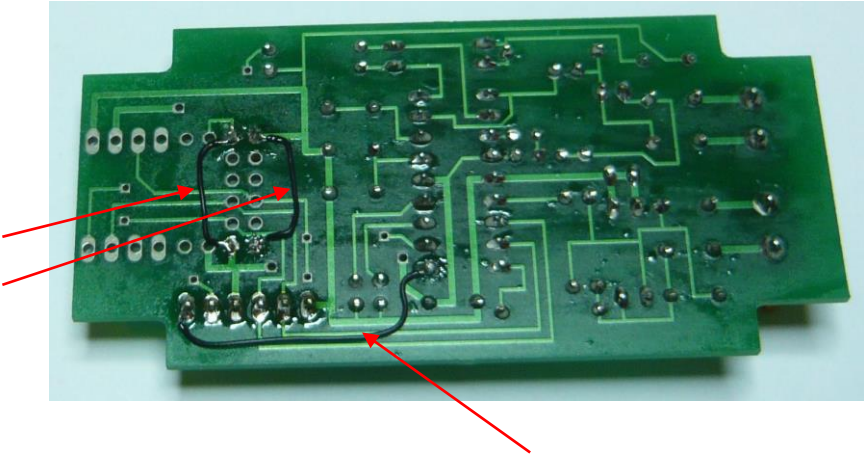
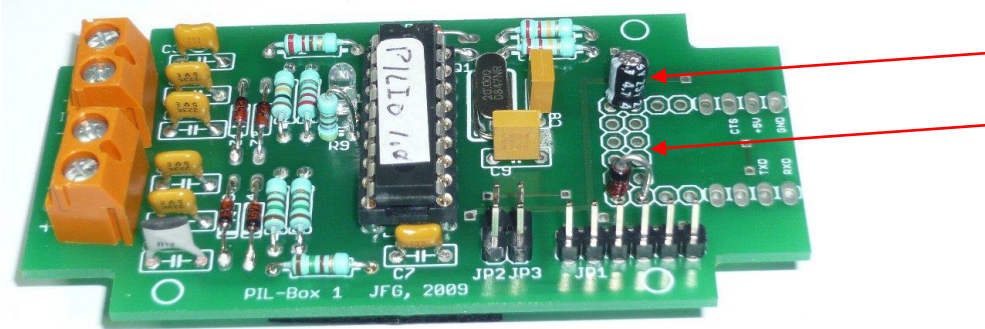
R1, R2:	220 Ohms
R3:	10 kOhms
R4, R5:	22 kOhms
R6, R7, R8:	150 Ohms
R9:	470 Ohms – vertical mounting, used only if LED1 is mounted
C1, C2, C4, C5:	22 nF – 100V rating
C3, C7:	100 nF
C6:	100 pF
C8, C9:	22 pF
D1, D2:	1N4148
Z1, Z2, Z3, Z4:	BZX55-5.1V
LED1:	3mm LED, red (optional) – cathode (shortest lead) towards IC1
Q1:	20 MHz crystal
IC1:	Microchip 16F628A (on socket)



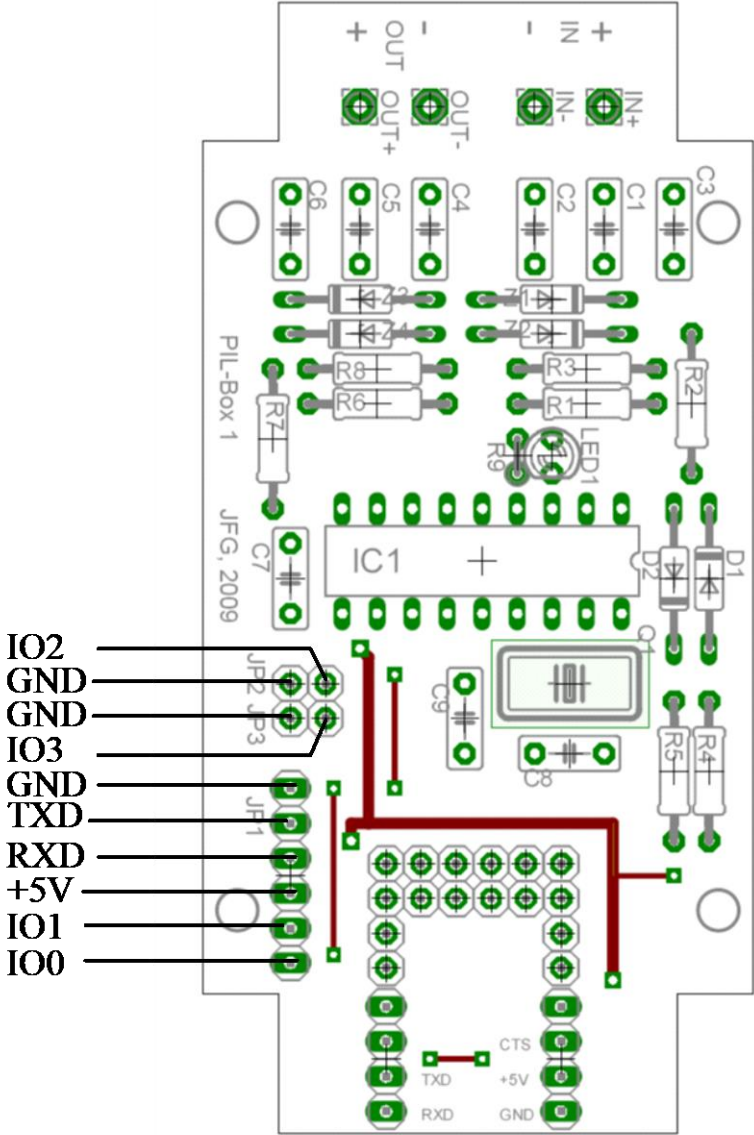
**Additional wiring for the PIL-IO board:**

A wire is need between IC1, pin 10 and JP1, pin 6 (see above).

It is recommended to mount a 4.7 to 10uF capacitor (16V min, preferred tantalium for small size) and a 5.6V Zener diode (BZX85 5.6V) on the supply lines on the board, for proper decoupling and protection against incorrect voltage or polarity. Below is the suggested wiring for these 2 components:



**PIL-IO supply and I/O connectors:**



### HP-IL cable wiring:

The IN and OUT cables must be wired like this:



See the original PIL-Box setup document for more details.

### PIL-IO board basic test:

Apply a 5V supply to the PIL-IO board. The LED should blink 3 times. If yes, the uC is working correctly.

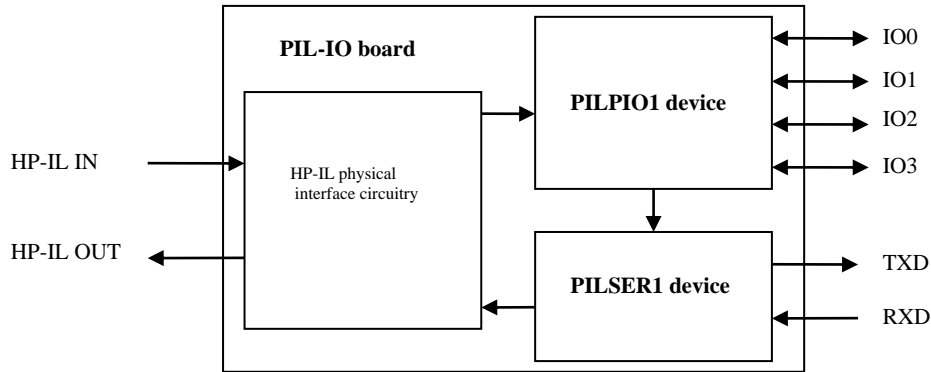
Connect a HP-41C or HP71B to the PIL-IO:

- HP-41C:  
do "PILPIO1" FINDID.  
If the result is 1, then the PIL-IO board is working correctly and the HP-IL cables are correctly wired.
- HP-71B:  
do RESTORE IO, then DEVADDR("PILPIO1")  
If the result is 1, then the PIL-IO board is working correctly and the HP-IL cables are correctly wired.

### 3. PIL-IO Board Usage

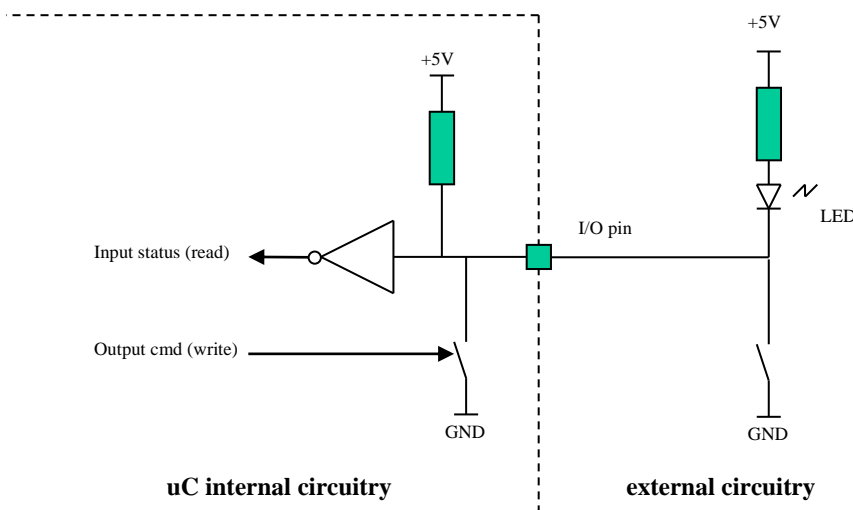
The PIL-IO board provides 2 HP-IL device functions at the same time:

- “PILPIO1”: a mini HP-IL/GPIO interface with 4 I/O lines,
- “PILSER1”: a mini HP-IL/serial interface with logic level Rx and Tx lines.



#### PILPIO1 device:

The 4 I/O lines IO0 to IO3 are used for both input and output. No special configuration is needed. The I/O structure is like this:



Writing a ‘1’ to the output drives the I/O low (closed to ground). An external load connected between the I/O pin and the +5V (such as a LED as indicated) is activated.

Writing a ‘0’ to the output drives the I/O high (pulled up by the internal resistor). The LED is off.

The output drive capability is up to 8.5mA when the I/O is driven low.

The internal pullup resistor provides about 200uA.

To use an I/O as an input, write ‘0’ to the output. With no external signal applied on the I/O pin, the status is 0. If the I/O line is driven low (for instance by an external switch as indicated), then the status is 1.

The inputs are TTL compatible.

See the electrical specification of the PIC16F628A uC on next page for more details.



Sym	Characteristic/Device	Min	Typ†	Max	Unit	Conditions
VIL	<b>Input Low Voltage</b>					
	I/O ports with TTL buffer	VSS	—	0.8	V	VDD = 4.5V to 5.5V otherwise  <b>(Note1)</b>
	_____with Schmitt Trigger input <sup>(4)</sup>	VSS	—	0.15 VDD	V	
	MCLR, RA4/T0CKI, OSC1 (in RC mode)	VSS	—	0.2 VDD	V	
	OSC1 (in HS)	VSS	—	0.3 VDD	V	
	OSC1 (in LP and XT)	VSS	—	0.8	V	
VIH	<b>Input High Voltage</b>					
	I/O ports with TTL buffer	2.0V	—	VDD	V	VDD = 4.5V to 5.5V otherwise  <b>(Note1)</b>
	_____with Schmitt Trigger input <sup>(4)</sup>	.25 VDD + 0.8V	—	VDD	V	
	MCLR RA4/T0CKI	0.8 VDD	—	VDD	V	
	OSC1 (XT and LP)	1.3	—	VDD	V	
	OSC1 (in RC mode)	0.9 VDD	—	VDD	V	
OSC1 (in HS mode)	0.7 VDD	—	VDD	V		
IPURB	PORTB weak pull-up current	50	200	400	µA	VDD = 5.0V, VPIN = VSS
IIL	<b>Input Leakage Current</b> <sup>(2), (3)</sup>					
	I/O ports (Except PORTA)	—	—	±1.0	µA	VSS ≤ VPIN ≤ VDD, pin at high-impedance
	PORTA <sup>(4)</sup>	—	—	±0.5	µA	VSS ≤ VPIN ≤ VDD, pin at high-impedance
	RA4/T0CKI	—	—	±1.0	µA	VSS ≤ VPIN ≤ VDD
	OSC1, MCLR	—	—	±5.0	µA	VSS ≤ VPIN ≤ VDD, XT, HS and LP oscillator configuration
VOL	<b>Output Low Voltage</b>					
	I/O ports <sup>(4)</sup>	—	—	0.6	V	IOL = 8.5 mA, VDD = 4.5 V, -40° to +85°C
		—	—	0.6	V	IOL = 7.0 mA, VDD = 4.5 V, +85° to +125°C
VOH	<b>Output High Voltage</b> <sup>(3)</sup>					
	I/O ports (Except RA4 <sup>(4)</sup> )	VDD - 0.7	—	—	V	IOH = -3.0 mA, VDD = 4.5 V, -40° to +85°C
		VDD - 0.7	—	—	V	IOH = -2.5 mA, VDD = 4.5 V, +85° to +125°C

### PIC16F628A I/O specification.

**I/O state, decimal values read for input, hexa character to be written for output:**

<b>IO0</b>	<b>IO1</b>	<b>IO2</b>	<b>IO3</b>	<b>Decimal</b>	<b>Hexa char.</b>
0	0	0	0	0	“0”
1	0	0	0	1	“1”
0	1	0	0	2	“2”
1	1	0	0	3	“3”
0	0	1	0	4	“4”
1	0	1	0	5	“5”
0	1	1	0	6	“6”
1	1	1	0	7	“7”
0	0	0	1	8	“8”
1	0	0	1	9	“9”
0	1	0	1	10	“A”
1	1	0	1	11	“B”
0	0	1	1	12	“C”
1	0	1	1	13	“D”
0	1	1	1	14	“E”
1	1	1	1	15	“F”

**Programming examples with the HP-41C:**

```
LBL "IOEX1"  
"PILPIO1" FINDID SELECT  
10  
LBL 01  
  "1" OUTA  
  "2" OUTA  
  "4" OUTA  
  "8" OUTA  
  "0" OUTA  
DSE X  
GTO 01
```

This example successively drives the 4 lines IO0 to IO3 low 10 times.

```
LBL "IOEX2"  
"PILPIO1" FINDID SELECT  
"0" OUTA  
LBL 01  
  INSTAT  
  VIEW X  
GTO 01
```

This example continusly reads the I/O status and displays it in flags 0-3 and as a decimal value in X.

**With the Extended I/O module HP82183A:**

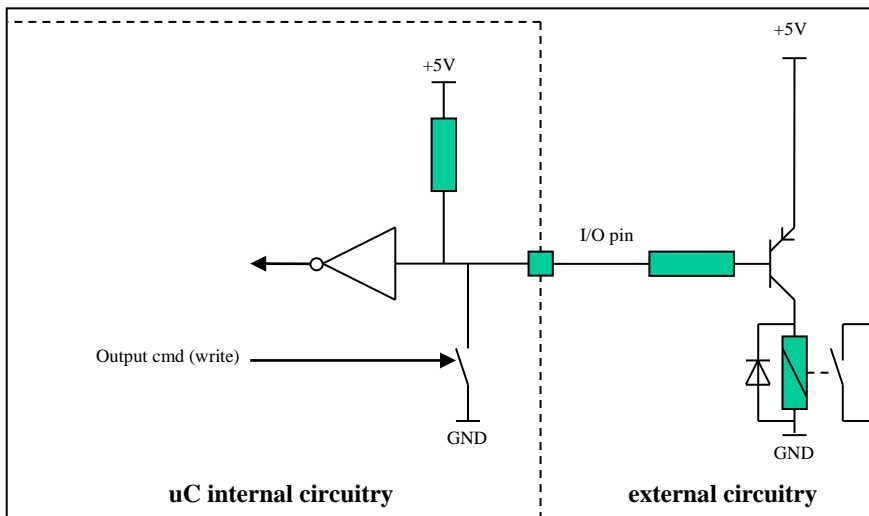
CLRDEV or CLRLOOP: drives all the I/O line to 0 (open).

ID: returns "PILPIO1C". The 'C' character indicates the firmware revision.

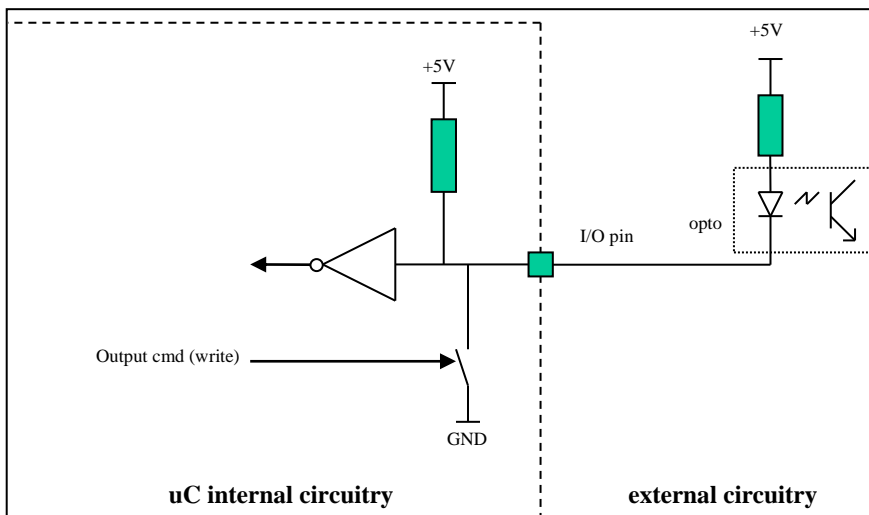
AID: returns 64.

64 FINDAID: finds the PILPIO1 address.

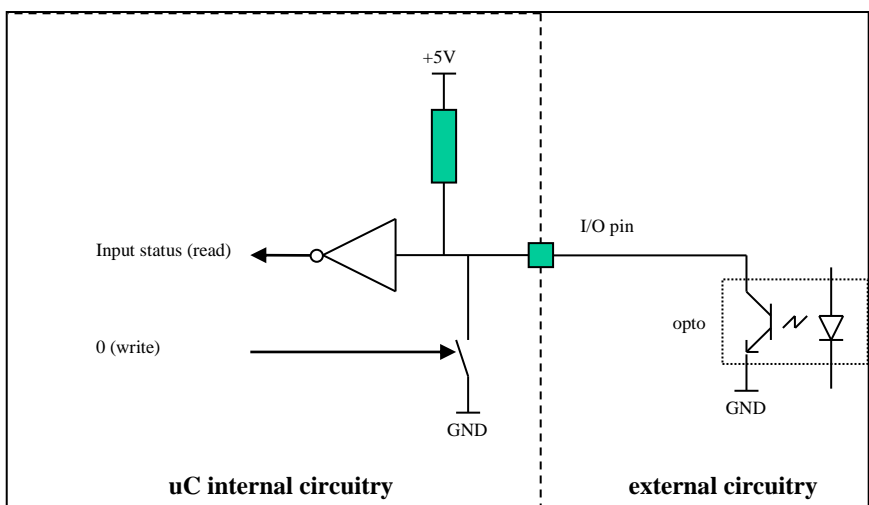
## Application examples:



Driving a relay with an external transistor



Driving an opto-coupler output



Reading an opto-coupler input

### **PILSER1 device:**

The TXD and RXD serial lines are logic +5V CMOS signals, coming from the USART of the PIC16F628A uC. They are NOT at RS232 level.

The primary function of the serial lines is to interface with an external microcontroller to extend the functionalities of the PIL-IO.

### **The USART is programmed as: 9600 bps, 8 bits, 1 start, 1 stop, no parity.**

No software handshake is provided. A hardware handshake mode is available on firmware revision 1.2 and higher, see the section below on firmware revision for details.

There is a 64 bytes input buffer.

A status byte is available. It can be read by the HP-IL controller to get the status of the serial communications (HP-41C: INSTAT function, HP-71B: SPOLL function).

### **Status byte format:**

Bit	Value	Description
0	1	Data available in the receive buffer. Cleared when buffer is empty
1	2	Line-feed (10 decimal) received. Cleared after reading the status byte
2	4	IO0 / CTS input (firmware 1.2 and higher)
3	8	Buffer overflow. Cleared after reading the status byte
4	16	Framing error. Cleared after reading the status byte
5	32	(unused)
6	64	IO2 / Service Request input (firmware 1.2 and higher)

Bit 0 can be used to check if there is some data in the received buffer.

Bit 1 can be used to check if a complete line ending with LF has been received

Bits 3 and 4 are for error checking. Bit 3 is set if more than 64 bytes are received. Bit 4 is set if a character is not correctly received (for instance no stop bit detected), usually meaning that the transmission rate is not consistent between transmitter and receiver.

### **Programming example with the HP-41C:**

```
LBL "IOEX3"  
"PILSER1" FINDID SELECT  
INSTAT INA  
"ABCDEF" OUTA  
INSTAT  
INA
```

This example reads the status byte and input buffer to clear any previous state, sends the string "ABCDEF", then reads the status byte and the input buffer.

If the RXD and TXD lines are connected together (local loopback), then the flags 0 and 1 will be set and the ALPHA register will hold "ABCDEF".

### **With the Extended I/O module HP82183A:**

CLRDEV or CLRLOOP: clears the input buffer and status byte.

ID: returns "PILSER1C". The 'C' character indicates the firmware revision.

AID: returns 66.

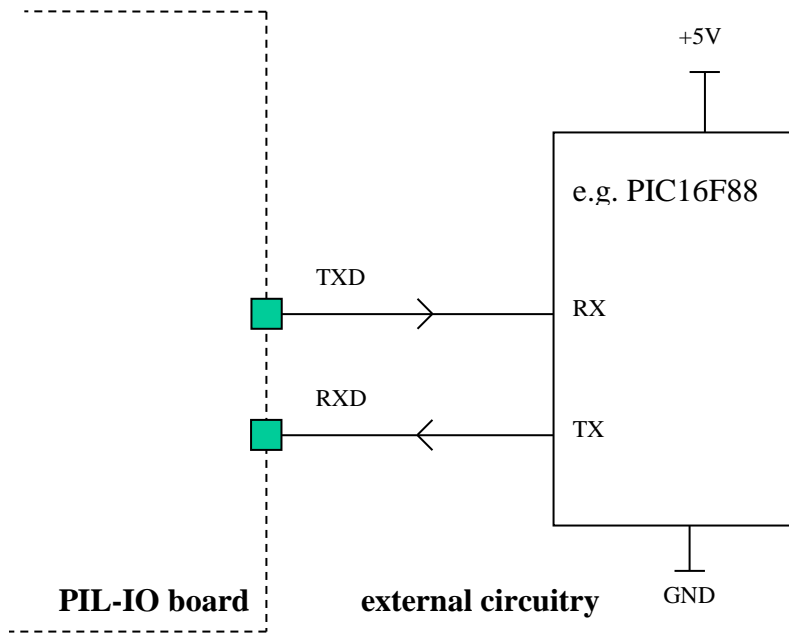
66 FINDAID: finds the PILSER1 address.

The INAN, OUTAN, etc variants can be used for advanced communication management.

**Note:**

If the serial lines are not used, do not leave the RXD line unconnected, for instance put a jumper between RXD and TXD on the connector JP1.

**Application example:**



**Connection between the PIL-IO serial lines and an external circuitry.**

## 4. PIL-IO firmware history

### Firmware versions:

#### Version 1.0:

- Initial version.
- HP-IL Devices IDs: PILPIO1A, PILSER1A.

#### Version 1.1:

- Brownout removed to be compatible with a power supply using 3 AA/AAA batteries.
- Addition of a power down mode: when receiving a HP-IL Loop Power-down command (LPD frame), the PIL-IO goes to sleep mode with a power consumption reduced from 3mA to 0.2 mA (typ). The state of the I/O lines is preserved. No character can be received from the serial line in sleep mode.
- Addition of the trigger function: when receiving a HP-IL Trigger command (GET frame), the line IO3 is pulsed down for 800 us, unless IO3 is already driven low. This provides a certain level of compatibility with HP82166 applications that were using the trigger line.
- HP-IL Devices IDs: PILPIO1B, PILSER1B.

#### Version 1.2:

- Addition of a mode with serial receive/transit handshake signals and Service Request capability (SRQ bit in HP-IL frames). The handshake lines are using the IO0 and IO1 lines and the SRQ input is using the IO2 line. This mode is entered by sending a HP-IL Goto Local command (GTL frame) to the PILSER1 device, and is exited by sending a Goto Local command to the PILPIO1 device See detailed description below.
- Addition of a 16-byte output buffer to optimize the data transfer in handshake mode.
- HP-IL Devices IDs: PILPIO1C, PILSER1C.

**Serial handshake mode with CTS/RTS lines and Service Request input (firmware version 1.2 and later):**

When a HP-IL Goto Local command (GTL frame) is sent to the PILSER1 device, the IO0-IO3 lines are normally no more available to the PILPIO1 device but are assigned to serial handshake functions for the PILSER1 device.

A HP-IL Goto Local command sent to the PILPIO1 device gives the control of the IO0-IO3 lines back to the PILPIO1 device.

In serial handshake mode, the IO0 and IO1 lines are used as handshake lines:

- IO0 is the CTS input: character transmission is enabled only if CTS is active (low level),
- IO1 is the RTS output: when there is less than 48 characters in the input buffer, the RTS output signal is active (low level) to indicate that the PILSER1 device is ready to accept characters. When the input buffer is nearly full (more than 56 characters), the RTS is driven false (high level).

The IO2 line is the SRQ input: when the SRQ line is driven low, a HP-IL Service Request is indicated on each data and identify frames (DSR or ISR frames).

The CTS (IO0) and SRQ (IO2) states are indicated in the PILSER1 status byte in bits 2 and 6 respectively, regardless of the normal I/O or serial handshake mode.

The HP-IL Goto Local command (GTL frame) is sent by the HP-IL LOCAL function of the HP-41C / HP-71B / HP-75C/D.

The HP-IL REMOTE command disables the access to the serial data buffers, and should not be used.

**I/O lines functions:**

Lines	Normal I/O mode (default, or after GTL to PILPIO1)	Serial handshake mode (after GTL to PILSER1)	Serial status bit
IO0	general purpose I/O	Serial CTS input	2
IO1	general purpose I/O	Serial RTS output	-
IO2	general purpose I/O	Service Request input	6
IO3	general purpose I/O / Trigger output	Trigger output	-

