PIL-IO board notes

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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 hobbysts.

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 controler such as the HP-41C, HP-71B or HP-75C.

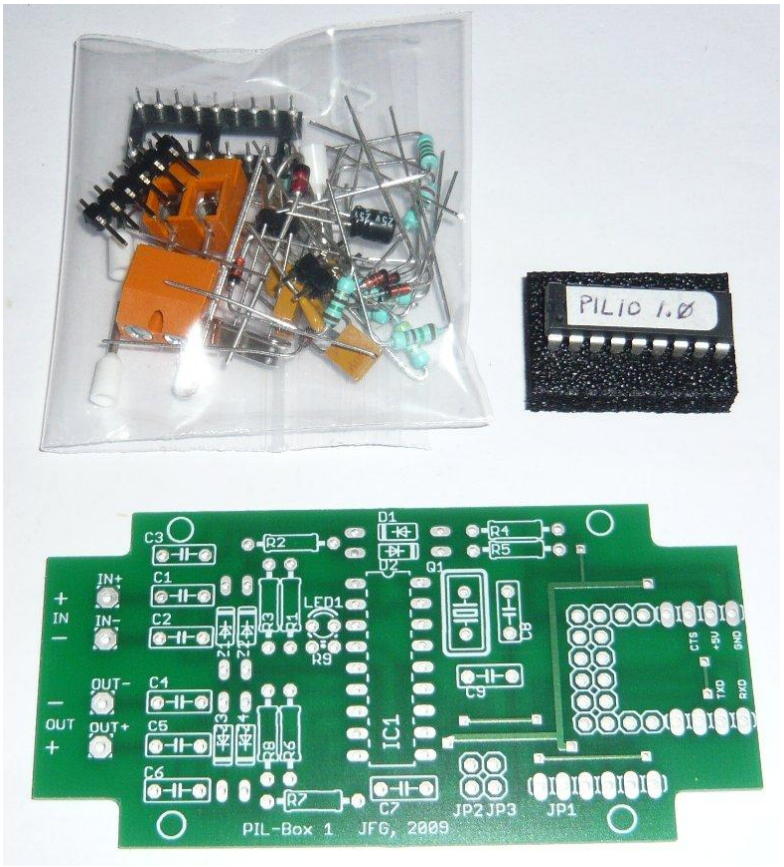
With the HP-41C, OUTA is used to set the 4 I/O lines, by sending a hexa-coded character that is the binay value corresponding to lines 0-3:
For instance "0" OUTA clears all lines 0 to 3,
"2" OUTA sets line 1, and clears lines 0, 2, 3.
INSTAT reads the status of the I/O lines, the result is in flags 0 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.

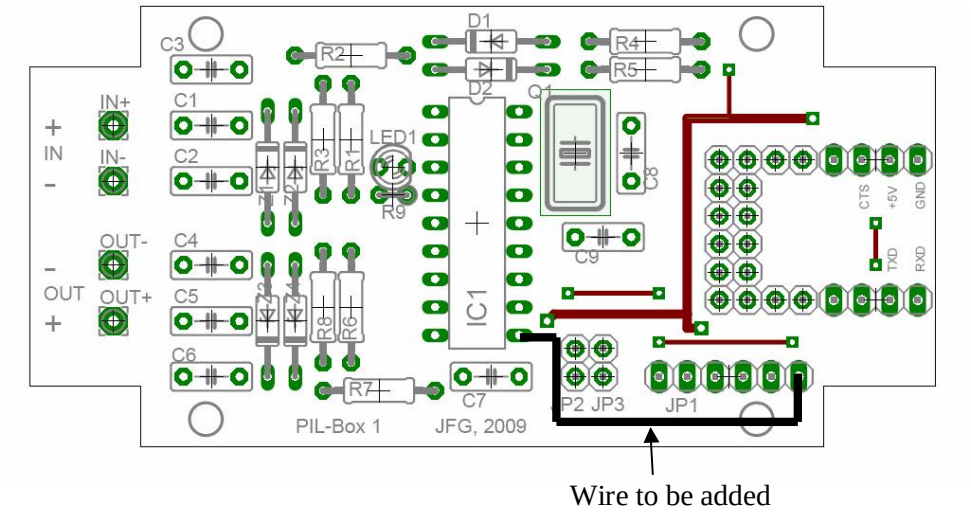
2. PIL-IO Board Description and Setup

PIL-IO board kit



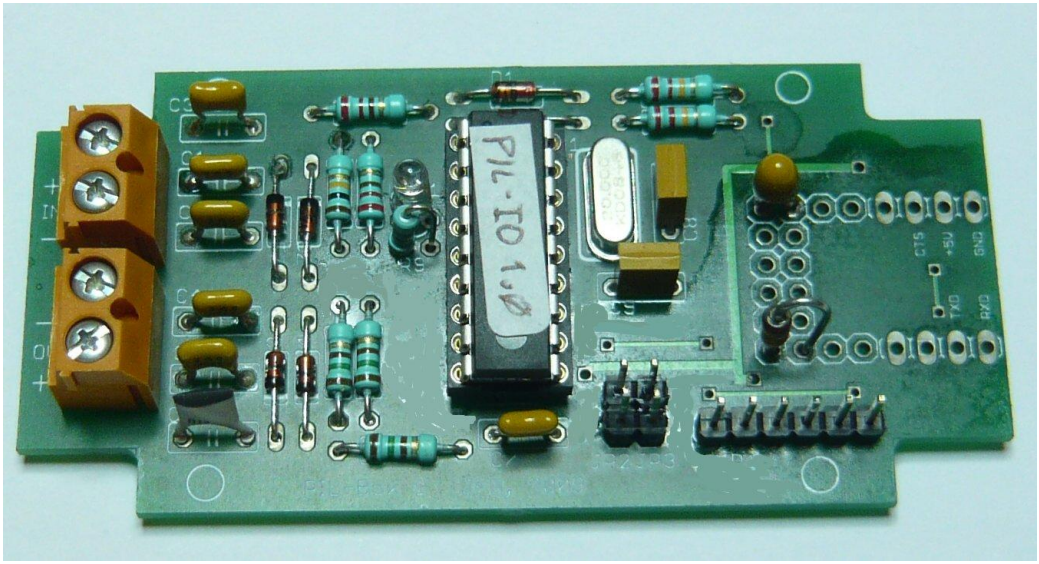
- 1 PCB
- 1 programmed microcontroller PIC 16F628A
- 1 component set:
  - R1..R9
  - C1..C9
  - D1, D2
  - Z1, Z2, Z3, Z4
  - LED
  - Crystal 20 MHz
  - Zener diode BZX85 5.6V
  - capacitor 4.7uF 25V
  - 18 pts socket for the uC
  - connectors for HP-IL cable (2) with wire terminals (4)
  - I/O connectors: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

PCB layout:



Bill of Material:

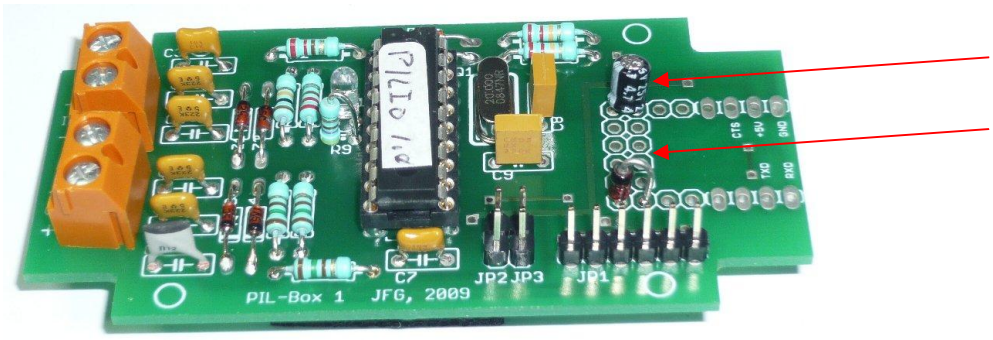
R1, R2: 220 Ohms
R3: 10 kOhms
R4, R5: 22 kOhms
R6, R7, R8: 150 Ohms
R9: 470 Ohms – vertical mounting, used only if LED1 is mounted
C1, C2, C4, C5: 22 nF – 100V rating
C3, C7: 100 nF
C6: 120 pF
C8, C9: 22 pF
D1, D2: 1N4148
Z1, Z2, Z3, Z4: BZX55-5.1V
LED1: 3mm LED, red (optional) – cathode (shortest lead) towards IC1
Q1: 20 MHz crystal
IC1: Microchip 16F628A (on socket)

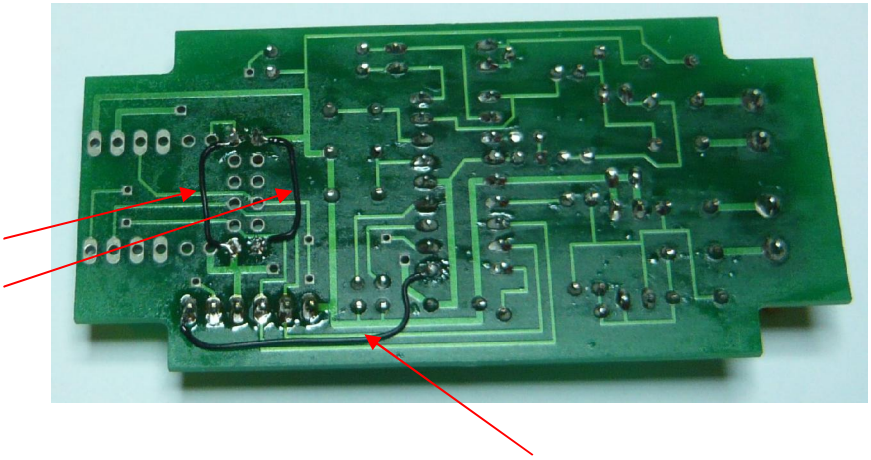


Additional wiring for the PIL-IO board:

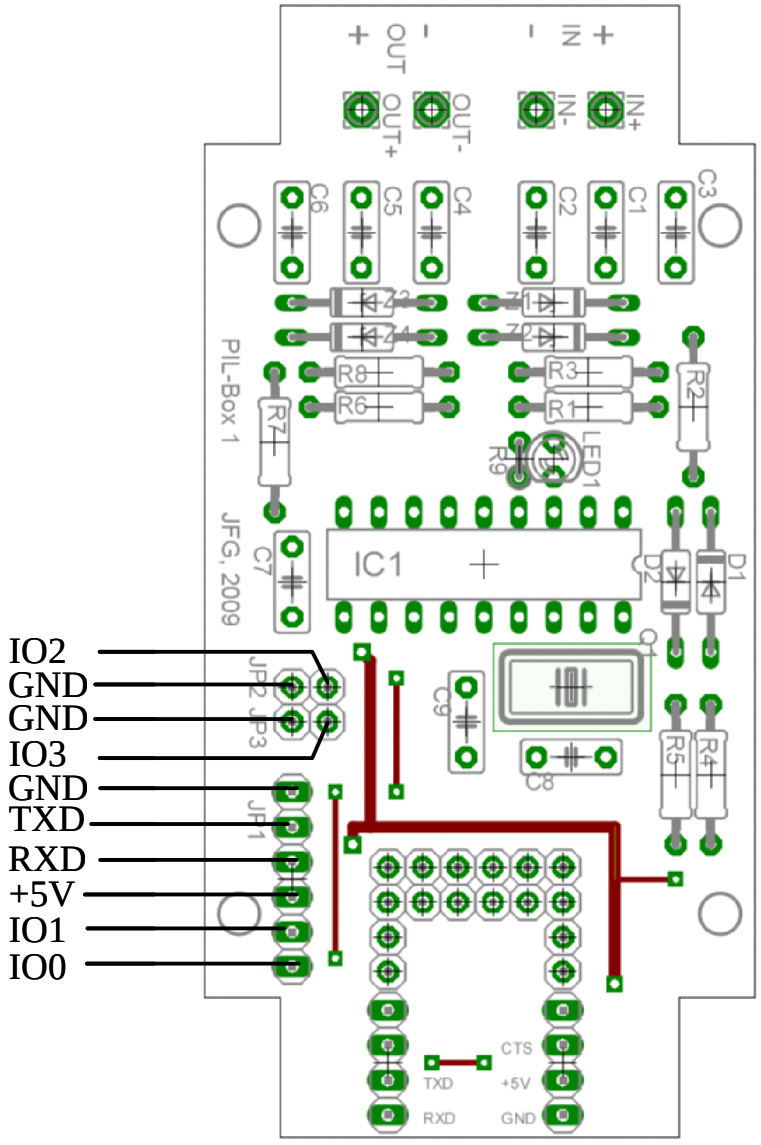
A wire is need between IC1, pin 10 and JP1, pin 6 (see above).

It is recommended to mount a 4.7 to 10uF capacitor (16V min, prefered 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:

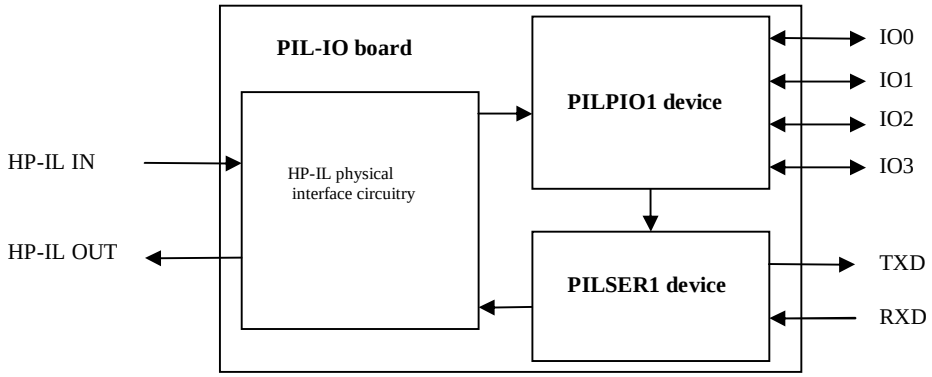
Apply a 5V supply to the PIL-IO board. The LED should blink 3 times. If yes, the uC is working correctly.

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.

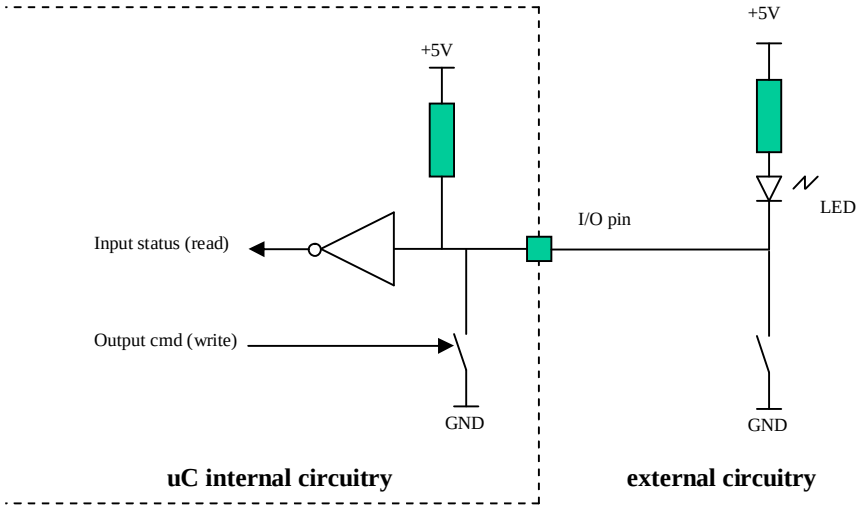
3. PIL-IO Board Usage

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 I03 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	**Input Low Voltage**					
	I/O ports					
	with TTL buffer	VSS	—	0.8	V	VDD = 4.5V to 5.5V
		VSS	—	0.15 VDD	V	otherwise
	with Schmitt Trigger input[4]	VSS	—	0.2 VDD	V	
	MCLR, RA4/T0CKI,OSC1 (in RC mode)	VSS	—	0.2 VDD	V	**(Note1)**
	OSC1 (in HS)	VSS	—	0.3 VDD	V	
	OSC1 (in LP and XT)	VSS	—	0.6	V	
VIH	**Input High Voltage**					
	I/O ports					
	with TTL buffer	2.0V	—	VDD	V	VDD = 4.5V to 5.5V
		.25 VDD + 0.8V	—	VDD	V	otherwise
	with Schmitt Trigger input[4]	0.8 VDD	—	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	**(Note1)**
	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	**Input Leakage Current[2], [3]**					
	I/O ports (Except PORTA)	—	—	±1.0	µA	VSS ≤ VPIN ≤ VDD, pin at high-impedance
	PORTA[4]	—	—	±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	**Output Low Voltage**					
	I/O ports[4]	—	—	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	**Output High Voltage[3]**					
	I/O ports (Except RA4[4])	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:

IO0	I01	IO2	IO3	Decimal	Hexa char.
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.

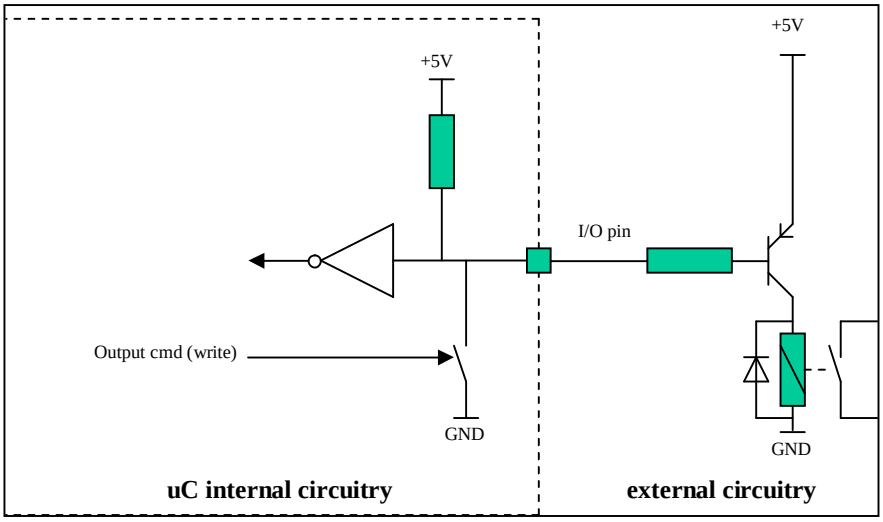
```
LBL “IOEX2”
“PILPIO1”  FINDID  SELECT
“0” OUTA
LBL 01
  INSTAT
  VIEW X
GTO 01
```

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

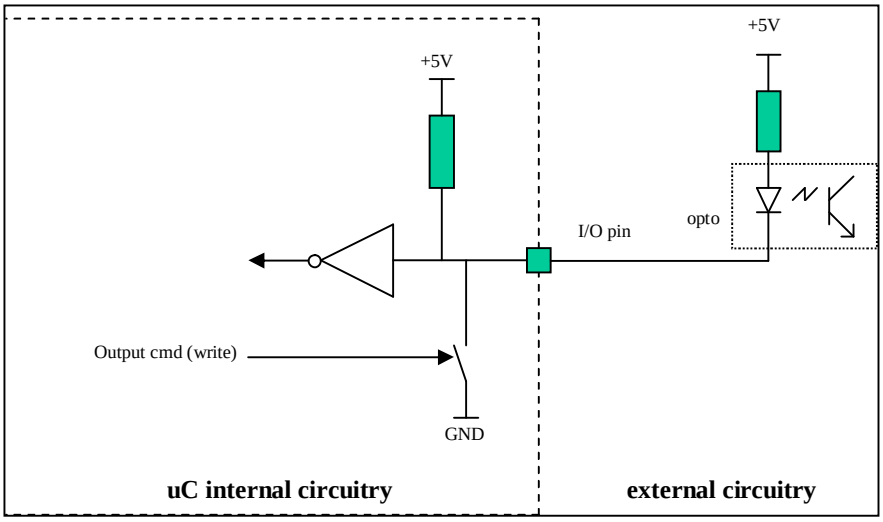
With the Extended I/O module HP82183A:

CLRDEV or CLRLOOP: drives all the I/O line to 0 (open).
ID: returns “PILPIO1A”. The ‘A’ character indicates the firmware revision.
AID: returns 64.
64 FINDAID: finds the PILPIO1 address.

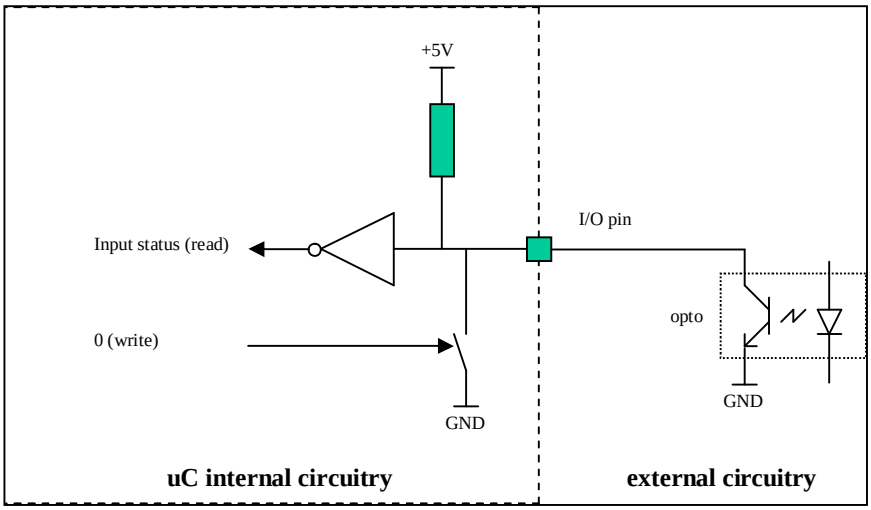
Application examples:



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 hardware or software handshake is provided. 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	(unused)
3	8	Buffer overflow. Cleared after reading the status byte
4	16	Framing error. Cleared after reading the status byte

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:

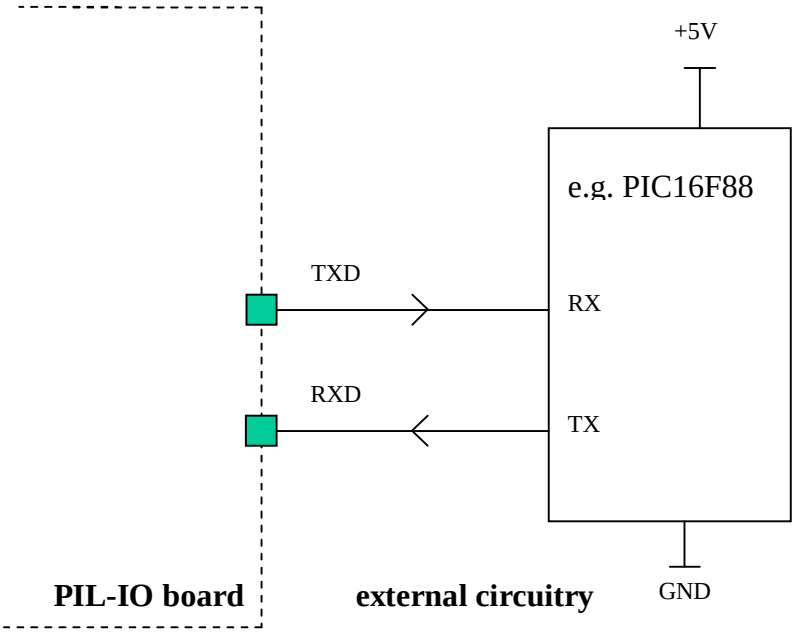
```
LBL "IOEX3"
"PILSER1"  FINDID  SELECT
INSTAT INA
"ABCDEF" OUTA
INSTAT
INA
```

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 "PILSER1A". The 'A' 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.