## Introduction

The picoIO expansion board adds digital inputs, digital outputs and analog inputs to the picoFlash single board computer. The picoIO stacks on top of the picoFlash without the need for cabling. A 9-pin connector is provided on the picoIO that brings out the picoFlash Serial Debug Port so that it can be used with a standard 9-pin ribbon cable. A library of C and Quickbasic functions is supplied to facilitate your applications development.

## Specifications:

**Digital Inputs**

32 total, 4 with 10 k ohm pull up resistors
TTL compatible

**Digital Outputs**

20 total
TTL compatible, 25mA source and sink

**Analog Inputs**

12 bits, 11 channels
Input range 0 to 5.000 volts
Resolution 1.22mV
Each channel op-amp buffered and low-pass filtered
Precise input impedance of 100.7 k ohms
Accuracy by design of 1%, typical accuracy of .1%
$11^{th}$ channel can be configured for on-board temperature measurement
Sample rate of better than 100 kHz achievable

**Software Drivers**

Unified A/D and digital I/O driver for C/C++ and Quickbasic
Matrix Keypad driver
Alphanumeric LCD driver

**System Requirements**

picoFlash SBC
Stacking Standoffs

## Configuration

The only hardware configuration required is analog input 11. JP1, in the upper right hand corner of the board, can be used to connect analog input 11 to the output of an on-board thermistor. Set the jumper to the right (1-2) for a thermistor temperature measurement and to the left (2-3) for use as a voltage input.

## Installation

The picoIO mounts over the picoFlash board with 4 stacking standoffs. Three header connectors mounted on the bottom of the picoIO make electrical connection to the picoFlash.

To install the picoIO, first remove the 4 screws from the picoFlash that hold the short standoffs in place. Set the screws aside and replace them with the stacking standoffs. When you are done, the short standoffs should be on the bottom of the board and the tall stacking standoffs should be on top. Connect any cables to the picoFlash and gently mate the picoIO to the top of it. All four holes on top of the picoIO should line up with the four stacking standoffs. Use the four screws to secure the picoIO to the picoFlash.

! *The maximum current that can be supplied from a single digital output is 25 milliamperes and the total current from all of the outputs must not exceed 330mA. The digital outputs do not supply enough current to drive a solenoid, a motor or an incandescent lamp. If you need more current, use a Driver16 board between the picoIO and your load. See the document "Switching Inductive Loads" on the JK microsystems web site before connecting any inductive load to a JK microsystems controller.*

! *The voltage applied to the digital and analog inputs must never go more negative than 0 volts nor more positive than +5 volts. Voltages applied outside this range may damage the picoIO or picoFlash and void the warranty.*

## Software Overview

The following software drivers and applications are supplied with the picoIO board:

**PIO_DRVR.ASM, PIO_DRVR.OBJ, PIO_DRVR.H**

PIO_DRVR.ASM is the assembly language source code for the picoIO board driver. The supplied object file (PIO_DRVR.OBJ) can be linked with a large memory model C/C++, Quickbasic or Powerbasic program. PIO_DRVR.H contains the C function prototypes. Care must be taken to ensure that the memory model of the driver matches the memory model of the application. The driver memory model is specified near the top of the PIO_DRVR.ASM code with the 'largemodel' constant. The driver must be reassembled after changing the memory model. If Borland C and its IDE are used, it is recommended to attach the assembly language source file to the project rather than object code. When the project is built, the driver will automatically be assembled and linked with the other modules. See the JK microsystems application note "Getting Started with the Borland IDE" for more information about adding project nodes and memory models.

**C_PIO.EXE, C_PIO.C and C_PIO.IDE**

C_PIO is a C program that demonstrates the functions of the picoIO and how to use them via the PIO_DRVR.ASM driver. The source is supplied as C_PIO.C and C_PIO.IDE.

**PIO.BAS and PIO.EXE**

PIO.BAS is a Quickbasic program that demonstrates the functions of the picoIO and how to use them via the PIO_DRVR.OBJ driver. The source code is supplied as PIO.BAS.

**PICOIO.EXE, PICOIO.C, PICOIO.IDE and PICOIO.PDF**

PICOIO.EXE is a C program that demonstrates the remote TCP/IP communications abilities of the picoFlash and picoIO along with an example of a keypad and LCD local user interface. A local user can read the A/D and digital inputs from a LCD and change the digital outputs from a hex keypad. Remote users can telnet into the picoFlash and monitor all of the I/O.
See the document PICOIO.PDF for more information.

**LCD_PIO.COM**

LCD_PIO.COM is a DOS TSR driver that uses the digital I/Os on J8 to communicate with an alphanumeric LCD. See Appendix A for cabling and programming information.

**KEY_PIO.COM**

KEY_PIO.COM is a DOS TSR driver that uses the digital I/Os on J8 to communicate with a 4x4 or smaller matrix keypad. See Appendix B for cabling and programming information.

## Driver Functions Overview

The picoIO driver contains routines callable from C or Quickbasic. This library allows easy access to the various functions of the picoIO board. Although the C and BASIC routines have common names, the C routines are functions (returning values when required) and the BASIC routines are subroutines (results are returned in variables passed to the subroutine). Functionally they are identical.

All values passed and returned from the library functions are 16 bits wide. Many functions do not use all 16 bits, but the complete word is required. When the complete word is not used, data fills the low order bits and the high order bits are unused and ignored. In the following descriptions, C function syntax is shown first and BASIC syntax, where different, is shown in brackets ( [ ] ).

## Driver Functions

*int* GetVersion( ) [ GetVersion( *data* ) ]

Returns the version number of the driver.
Least significant digit is minor revision.
Most significant digits are major revision.

*void* InitIO( )

Initializes the picoIO board.
Must be performed once before any function except GetVersion is called.

*void* SetIOPt( *value* )

Sets the specified output channel.
*value* refers to a channel and ranges from 0 to 19.
Channels 0-3 not available if keypad driver used, Channels 4-10 not available if LCD driver used.

*void* ClrIOPt*( value )*

Clears the specified output channel.
*value* refers to a channel and ranges from 0 to 19.
Channels 0-3 not available if keypad driver used, Channels 4-10 not available if LCD driver used.

*int* GetIOPt( *value* ) [ GetIOPt( *data* ) ]

Returns the input state from the specified input channel, 0 = OFF, non-zero = ON (logic high)
*value* refers to a channel and ranges from 0 to 31, Channels 28-31 not available if keypad driver used.

*int* GetAD( *value* ) [GetAD ( *data* ) ]

Returns the input value from the specified AD channel, return value ranges from 0 to 4095
*value* refers to a channel and ranges from 0 to 10.

## Connectors

Interface connectors use Molex C-Grid style housings and pins or equivalent.

| Connector | Description | Molex Part No. | JKmicro Part No. |
|---|---|---|---|
| J1, J2, J4 | 2x5 0.1" Housing | 22-55-2101 | 28-0030 |
| J6, J7, J8 | 2x13 0.1" Housing | 22-55-2261 | 28-0031 |
| All | Pins | 16-02-0096 | 28-0033 |
| All | Crimping Tool | 11-010208 | Not stocked |

## Connector Pinouts

| J1 | | | AD 0-5 |
|---|---|---|---|
| AD0[1] | 1 | 2 | AD3[1] |
| AD1[1] | 3 | 4 | AD4[1] |
| AD2[1] | 5 | 6 | AD5[1] |
| 4.096V[3] | 7 | 8 | GND |
| 5V | 9 | 10 | GND |

| J2 | | | AD 6-10 |
|---|---|---|---|
| AD6[1] | 1 | 2 | AD9[1] |
| AD7[1] | 3 | 4 | AD10[1,2] |
| AD8[1] | 5 | 6 | N/C |
| 4.096V[3] | 7 | 8 | GND |
| 5V | 9 | 10 | GND |

| J4 | | | DEBUG I/O |
|---|---|---|---|
| DCD[4] | 1 | 2 | N/C |
| TXD[5] | 3 | 4 | CTS[4] |
| RXD[5] | 5 | 6 | RTS[4] |
| N/C | 7 | 8 | TTLTX[6] |
| GND | 9 | 10 | TTLRX[6] |

| J7 | | | DIGITAL 3 |
|---|---|---|---|
| GND | 1 | 2 | 5V |
| GND | 3 | 4 | 5V |
| GND | 5 | 6 | 3.3V[7] |
| IN0 | 7 | 8 | IN2 |
| IN1 | 9 | 10 | IN3 |
| IN4 | 11 | 12 | IN12 |
| IN5 | 13 | 14 | IN13 |
| IN6 | 15 | 16 | IN14 |
| IN7 | 17 | 18 | IN15 |
| IN8 | 19 | 20 | IN16 |
| IN9 | 21 | 22 | IN17 |
| IN10 | 23 | 24 | IN18 |
| IN11 | 25 | 26 | IN19 |

| J8 | | | DIGITAL 1 |
|---|---|---|---|
| GND | 1 | 2 | 5V |
| GND | 3 | 4 | 5V |
| GND | 5 | 6 | 3.3V[7] |
| GND | 7 | 8 | 3.3V[7] |
| J5-8[8] | 9 | 10 | CONT[9] |
| OUT0[11] | 11 | 12 | OUT4[12] |
| OUT1[11] | 13 | 14 | OUT5[12] |
| OUT2[11] | 15 | 16 | OUT6[12] |
| OUT3[11] | 17 | 18 | OUT7[12] |
| IN28[4,11] | 19 | 20 | OUT8[12] |
| IN29[4,11] | 21 | 22 | OUT9[12] |
| IN30[4,11] | 23 | 24 | OUT10[12] |
| IN31[4,11] | 25 | 26 | OUT11 |

| J6 | | | DIGITAL 2 |
|---|---|---|---|
| GND | 1 | 2 | 5V |
| GND | 3 | 4 | 5V |
| CLK[10] | 5 | 6 | 3.3V[7] |
| STB/[10] | 7 | 8 | DATA[10] |
| CLR/[10] | 9 | 10 | SO[10] |
| IN20 | 11 | 12 | OUT12 |
| IN21 | 13 | 14 | OUT13 |
| IN22 | 15 | 16 | OUT14 |
| IN23 | 17 | 18 | OUT15 |
| IN24 | 19 | 20 | OUT16 |
| IN25 | 21 | 22 | OUT17 |
| IN26 | 23 | 24 | OUT18 |
| IN27 | 25 | 26 | OUT19 |

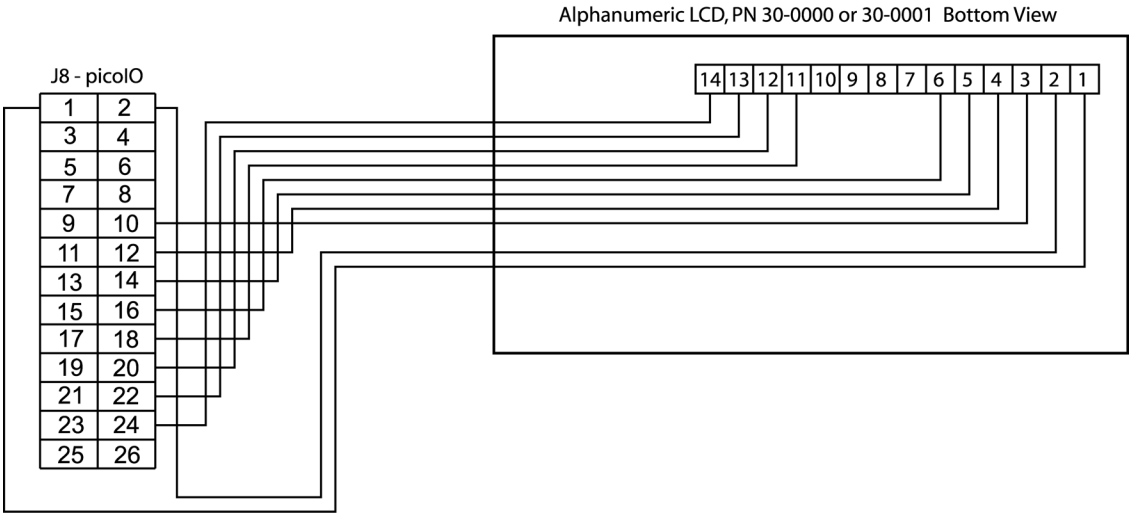
Notes:

1. Analog input, 0 – 5.00 volts DC.
2. Jumper selectable, analog input or thermistor.
3. 4.096 volts +/- 0.1% buffered reference, do not draw more than 2mA.
4. Pulled up to +5 volts with 10k resistor.
5. picoFlash debug port RS-232 signals.
6. picoFlash serial port 0 TTL signals, polarity opposite from RS-232.
7. 3.3 volts from picoFlash, do not draw more than 200mA.
8. Reserved for possible input expansion.
9. LCD contrast voltage.
10. Reserved for possible output expansion.
11. Not available for general use if hex keypad installed.
12. Not available for general use if LCD installed.

## Appendix A - LCD Interface

### Electrical Interface

Connect the LCD to the picoIO as shown below.




The following chart details the cable pinout and signal names used for connecting an LCD to the picoIO. The signal names are given for information only and are not needed for normal operation of the LCD.

| LCD Pin | picoIO J8 Pin | LCD Signal | picoIO Signal |
|---|---|---|---|
| 1 | 1 | Gnd | Gnd |
| 2 | 2 | +5 Volts | +5 Volts |
| 3 | 10 | Contrast | Cont |
| 4 | 12 | RS | OUT4 |
| 5 | 14 | R/W | OUT5 |
| 6 | 16 | E | OUT6 |
| 7 | N/C | D0[1] | N/C |
| 8 | N/C | D1[1] | N/C |
| 9 | N/C | D2[1] | N/C |
| 10 | N/C | D3[1] | N/C |
| 11 | 18 | D4 | OUT7 |
| 12 | 20 | D5 | OUT8 |
| 13 | 22 | D6 | OUT9 |
| 14 | 24 | D7 | OUT10 |

Notes:

1. The LCD is always operated in 4-bit mode to conserve I/O pins. In 4-bit mode, D0-D3 are not used and are not connected.

**Driver Software**

LCD_PIO.COM is a terminate and stay resident (TSR) driver program which redirects data sent to LPT1 to an LCD device connected to J8 of the picoIO. The driver is designed to work with standard alpha-numeric displays using a 14-pin interface and the Hitachi HD44780A controller chip. The LCD used must be capable of operating in 4-bit mode.

Upload the program LCD_PIO.COM to the picoFlash and execute it. LCD_PIO may be placed in the STARTUP.BAT file so that it loads each time the board is reset.

Data is written to the LCD(s) by sending data to LPT1. This can be done at the BIOS level through int 17h or through the DOS LPT1 handler. Instruction codes are sent by first sending a 160 decimal (A0 hex) code to the display. The handler will not send the 160 code to the display but will issue the following byte to the display as an instruction code. Note that when performing the Function Set instruction, the display must always be set to 4-bit data length.

The following Quickbasic code will initialize the display and then show and update the time on it.

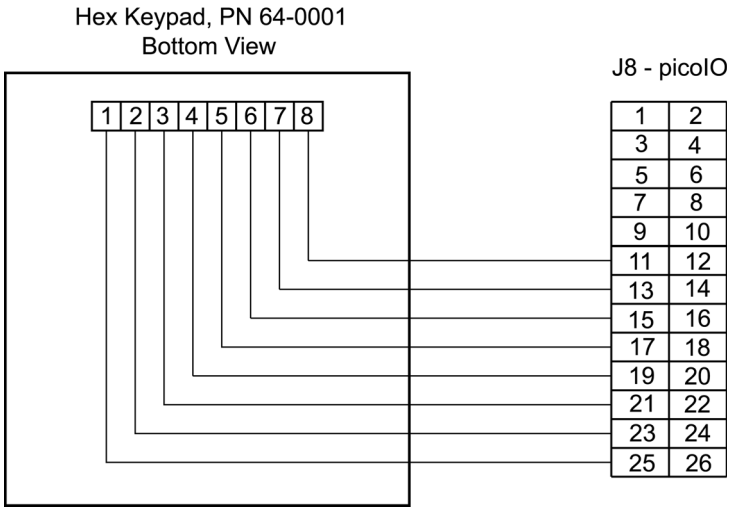
```
start:
      open "o",1,"lpt1"
      print #1,chr$(160);chr$(40);     '4 bits, 2 lines, 5x7 matrix
      print #1,chr$(160);chr$(12);     'display on, cursor and blink off
      print #1,chr$(160);chr$(6);      'increment cursor, no display shift
      print #1,chr$(160);chr$(1);      'clear and home display

timeloop:
      print #1,chr$(160);chr$(3);time$;     'home cursor and print time
      if inkey$="" then goto timeloop
      end
```

See www.jkmicro.com/tutorials/lcdprogramming.html for more information.

## Appendix B - Hex Keypad Interface

### Electrical Interface

Connect the Hex Keypad to the picoIO as shown below.

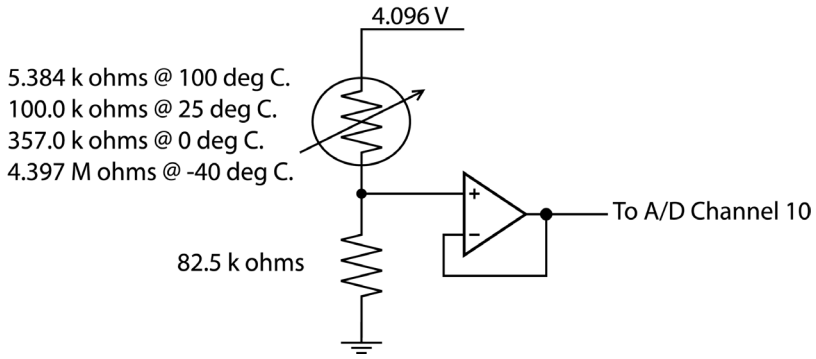



### Driver Software

Upload the program KEY_PIO.COM to the picoFlash and execute it. Key presses from the hex keypad should appear as console input. KEY_PIO.COM may be placed in the STARTUP.BAT file so that it loads each time the board is reset.

## Appendix C – Thermistor

Channel 10 of the analog inputs can be jumpered to measure the voltage across a 100 k ohm thermistor. A simplified circuit diagram of the thermistor input is shown below.




### Determining the Thermistor Resistance

The first step is to determine the current through the thermistor and the 82.5 k ohm resistor. We can do that by reading the A/D, dividing that value by 1000 to convert it to volts, then dividing it by 82,500 to get current.

Next we have to find the voltage across the thermistor. We can find this by subtracting the A/D voltage from 4.096. By taking this value and dividing it by the current, we have the thermistor resistance.

### Determining the Thermistor Temperature

Since the thermistor's temperature response is highly non-linear, we can't just do an interpolation to find the temperature. The chart at the right shows the resistance of the thermistor to temperatures ranging from –40 degrees C. to 125 degrees C.

The two demo programs included with the picoIO use a lookup table to find the nearest 5 degree temperature of the thermistor and then use a linear interpolation formula to estimate the temperature within .1 degree C. This method returns temperature accurate to better than 1 degree C. at room temperature.

It is the user's responsiblility to determine this algorithm's overall accuracy and suitability for his or her design.

| Temp. (°C) | NCP□□WF104J type Resistance (kΩ) | | |
|---|---|---|---|
| | Low | Center | High |
| −40 | 3729.0380 | 4397.1193 | 5171.9295 |
| −35 | 2647.2336 | 3088.5989 | 3594.5428 |
| −30 | 1902.5755 | 2197.2250 | 2531.1628 |
| −25 | 1383.3182 | 1581.8805 | 1804.4223 |
| −20 | 1016.2022 | 1151.0367 | 1300.5024 |
| −15 | 754.3293 | 846.5788 | 947.7345 |
| −10 | 565.4664 | 628.9882 | 697.8966 |
| −5 | 427.6799 | 471.6321 | 518.8009 |
| 0 | 326.4567 | 357.0117 | 389.4505 |
| 5 | 251.2051 | 272.4995 | 294.8601 |
| 10 | 194.8470 | 209.7098 | 225.1420 |
| 15 | 152.2795 | 162.6506 | 173.2936 |
| 20 | 119.8614 | 127.0802 | 134.3970 |
| 25 | 95.0000 | 100.0000 | 105.0000 |
| 30 | 74.7365 | 79.2216 | 83.7660 |
| 35 | 59.1874 | 63.1671 | 67.2459 |
| 40 | 47.1711 | 50.6766 | 54.3066 |
| 45 | 37.8301 | 40.9035 | 44.1161 |
| 50 | 30.5087 | 33.1946 | 36.0267 |
| 55 | 24.7475 | 27.0909 | 29.5820 |
| 60 | 20.1817 | 22.2243 | 24.4126 |
| 65 | 16.5424 | 18.3225 | 20.2434 |
| 70 | 13.6319 | 15.1841 | 16.8709 |
| 75 | 11.2813 | 12.6354 | 14.1166 |
| 80 | 9.3830 | 10.5657 | 11.8678 |
| 85 | 7.8382 | 8.8726 | 10.0184 |
| 90 | 6.5752 | 7.4811 | 8.4905 |
| 95 | 5.5415 | 6.3365 | 7.2274 |
| 100 | 4.6855 | 5.3839 | 6.1709 |
| 105 | 3.9793 | 4.5942 | 5.2910 |
| 110 | 3.3918 | 3.9342 | 4.5520 |
| 115 | 2.9011 | 3.3804 | 3.9291 |
| 120 | 2.4918 | 2.9164 | 3.4048 |
| 125 | 2.1455 | 2.5220 | 2.9573 |

Thermistor resistance chart abstracted from muRata *NTC Thermistor* manual.

| Revision | Date | Author | Changes |
|---|---|---|---|
| A | 05 Aug 04 | JDS/ED | First Issue<br>\\Server1\D_Parts\94-0032\Manual\picoIO_man.doc |