C-Programmable Controller

PK2100 Series

Introduction

The PK2100 Series of C-programmable controllers is based on the Zilog Z180 microprocessor. The PK2100 includes analog, digital, serial, and high-current switching interfaces. The standard PK2100 includes a rugged enclosure with 2x20 LCD and 2x6 tactile keypad.

With the PK2100 Series you can detect contact closures, count pulses, measure temperature, speed and pressure, control motor speed, control proportional valves, switch fairly large currents, and drive solenoids and external relays directly.

The PK2100 has a PLCBus™ expansion port, allowing you to connect several Z-World expansion boards (such as the XP8100 or XP8300) if you need extra I/O. You can build networks of controllers and communicate with modems. With Dynamic C software and the PK2100's LCD and keypad, you can easily build operator interfaces.

The following PK2100 Series controllers are available:

PK2100	With enclosure, 2x20 LCD, and 2x6 keypad. Operates at 24V nominal.
PK2110	With enclosure, 2x20 LCD, and 2x6 keypad. Operates at 12V nominal.
PK2120	No enclosure, LCD, or keypad. Operates at 24V nominal.
PK2130	No enclosure, LCD, or keypad. Operates at 12V nominal.

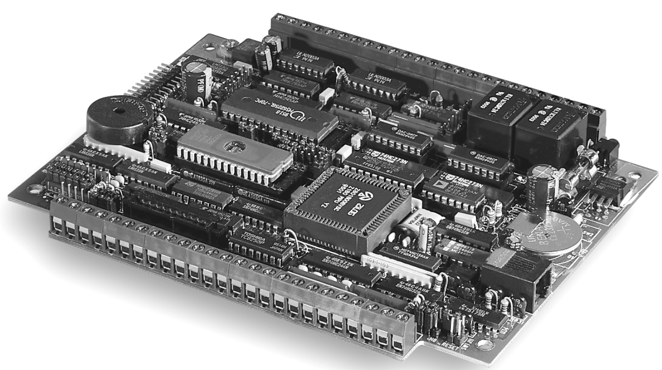
The following PK2100 Series options are available:

- 9.216 MHz clock upgrade. (6.144 MHz standard)
- 128K flash (32K EPROM standard)
- 128K or 512K RAM (32K standard)
- Backlit LCD (with PK2100 or PK2110)

Specifications

Board Size	5.5″ × 6.82″ × 0.78″.
Enclosure Size	5.5″ × 7.0″ × 1.6″.
Operating Temp.	–40°C to +70°C. With LCD, 0°C to 50°C.
Humidity	5% to 95% non-condensing.
Input Power	18–35VDC, 220 mA, linear supply [24V]
Processor	Z180
Clock	6.144 MHz [9.216 MHz optional]
Power Consumption	5.5W

PK2100 or PK2110, with enclosure, LCD, and keypad



PK2120 or PK2130, board-only

Features

- Battery-backed static RAM, up to 512K bytes.
- EPROM, up to 512K bytes, or flash memory to 256K bytes.
- Battery-backed real-time clock (RTC).
- Lithium backup battery, rated at 560 mA-hours. Since the RTC and full 512K RAM draw about 16 μA, the battery will sustain the RTC and RAM for about 4 years [35,000 hours].
- Watchdog timer.
- Power failure warning interrupt.
- EEPROM, standard 512 bytes. Holds calibration constants for the (2) DAC channels, among other data.
- LCD. The standard screen has 2 lines of 20 characters. Other displays can be installed on special order.
- Keypad, 2 rows of 6 keys, for a total of 12 keys. The internal interface provides for possible expansion to 24 keys using a 4 row x 6 column matrix.
- Beeper with high- and low-volume.

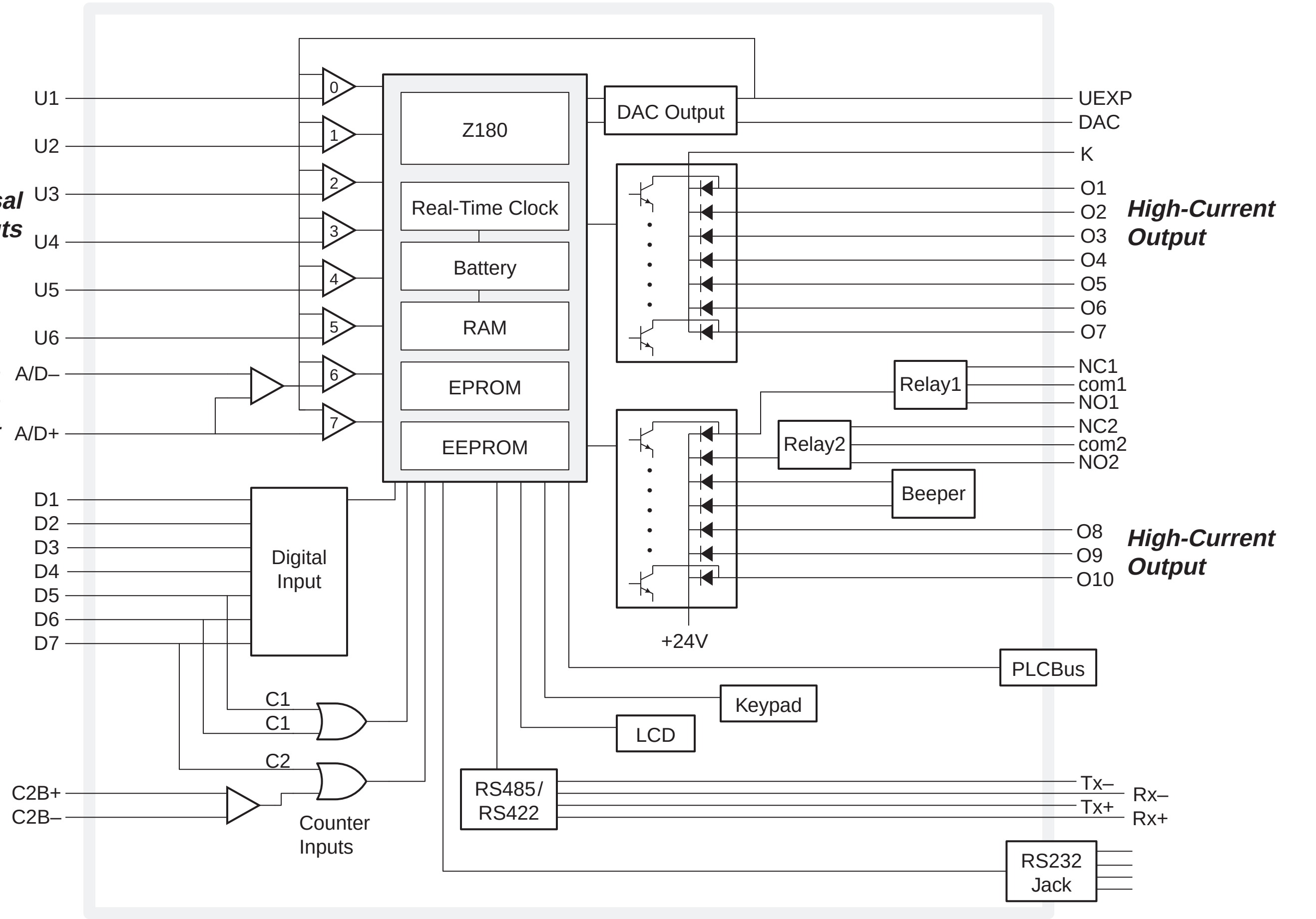
References

Please refer to

- *Z-World PK2100 schematic*
- *Z-World PLCBus data sheet*
- *Z-World Dynamic C data sheet*
- *Zilog Z180 MPU User's Manual*
- *Zilog Z180 Serial Communication Controllers*
- *Zilog Z80 Microprocessor Family User's Manual*

Contents

Figure 1. PK2100 Block Diagram



The Interface

A PK2100 Series controller has the following as its interface:

1 Six universal inputs. Universal inputs can be used as

(A) digital inputs. With a single threshold (in software or hardware) the input channel yields a digital 1 when the input voltage is above threshold and 0 otherwise.

(B) digital inputs with two thresholds. Z-World software returns a digital 1 when the input voltage is above a high threshold, a 0 when voltage is below a low threshold, and reports ‘no change’ otherwise. It is a simple and logical extension to write software that handles several thresholds. Thus, the universal inputs can be used as...

(C) analog inputs (with Z-World software).

The universal inputs accept 0–10V with 10-bit resolution, and are protected against overloads in the range ±48 volts.

2 One high-sensitivity (high-gain) differential analog input. Normally, the high-gain input range is 0–1 volt, but you can change resistors (R5, R11, RP5) on the operational amplifier. It has 10-bit resolution.

If you don’t use the high-gain channel, a seventh universal input is available.

3 Seven protected digital inputs, with a 2.5 volt threshold. Three of the inputs also function as counter inputs.

4 Two counter channels capable of counting pulses at up to 600 kHz or more. The counter inputs can also be used to measure pulse width and other pulse timing characteristics. The counters use DMA hardware.

5 Two on-board relays, rated for 3A at 48V, with NO, NC, and COM terminals for each. You can install MOVs to protect relay contacts.

6 Ten high-current outputs suitable for driving relays or solenoids. These outputs can sink approximately up to 500 mA at voltages up to 48V (when used individually) subject to total heat dissipation restrictions for the driver chips (1.25W).

7 One analog output (DAC) which can be either a 0–10V voltage output or 0–20 mA current output. A second analog voltage output (UEXP), normally used by software to drive the universal inputs, is available when the universal inputs have a fixed hardware threshold. The DACs have 10-bit resolution.

8 An RS422/RS485 serial port and an RS232 serial port with two handshaking lines operate at up to 38,400 baud. A second RS232 port can be configured as a substitute for the RS485 port by changing board jumpers. It has no handshaking lines.

9 A 26-pin expansion bus (PLCBus™) for Z-World PLCBus devices or customer-designed devices. *Refer to the PLCBus data sheet.*

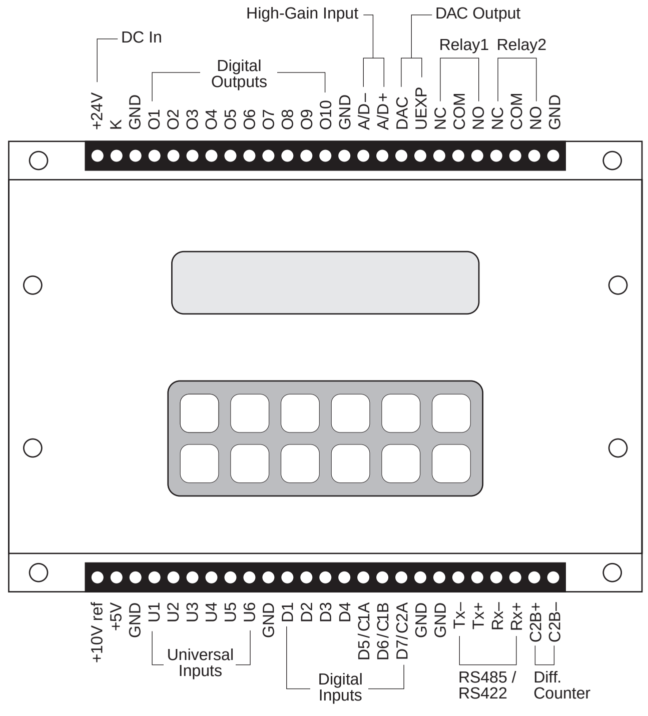
The Terminals

There are 50 screw terminals used for input, output, and power connections. There are two connectors on the sides of the unit: a RJ12 “phone jack” for the RS232 port, and a 26-pin connector for the expansion bus.

The signal names of the screw connectors are shown below.

Signal	**Meaning**
+10V Ref	Output from U11, analog reference voltage.
+5V	Output from 5V regulator
GND	Ground
U1–U6	Universal inputs
D1–D7	Digital inputs
C1A, C1B	Counter 1 inputs
C2A	Counter 2 input
C2B+, C2B–	Counter 2 inputs, differential
TX–,TX+	RS485 Transmit
RX–, RX+	RS485 receive
+24V	External power
K	Protection for high-current outputs O1–O7
O1–O10	High-current outputs
A/D–	Negative side of high-gain input
A/D+	(1) Positive side of high-gain input, or (2) the seventh universal input
DAC	DAC output, 0–20 mA or 0–10 volts.
UEXP	Internal DAC, output is 0–10V.
NC, COM, NO	Relay contacts for relays 1 and 2

Figure 2. PK2100 Signals



For 12-volt versions of the PK2100,

- The connector labeled “+10V ref” is +7 volts.
- The connector labeled “+24V” is +12 volts.
- DAC output (either channel) is not 0–10V, but 0–7V.
- Universal input range (any) is not 0–10V, but 0–7V.
- The high-gain channel is not 0–1V, but 0–0.7V.
- Relay coil voltage is 12V. Relay rating is 5A/120V.

Using the PK2100

Universal Inputs

Figure 3 below shows the six universal inputs and the high-gain input. A seventh universal input is available if you do not use the high-gain channel. (Note that the high-gain input is channel 6 and that the "spare" universal input is channel 7.)

Each input channel has a comparator that yields a 1 when the input level is greater than a threshold, and 0 otherwise.

By placing a jumper at J9, you can (1) choose the fixed hardware threshold (1.6V by default) or (2) use the internal DAC to generate a threshold. When software generates the thresholds using the DAC, you can compare inputs against as many thresholds as you like. Z-World software compares against 1 or 2 thresholds for digital input; it compares against several thresholds for analog input (using successive approximation).

Channel 5 (labelled U6) can be 4-20 mA current loop if you connect pins 7 and 8 of H5.

The internal DAC channel usually generates the reference voltage for the inputs. However, if you connect the fixed hardware reference at jumper J9, this DAC channel is available at UEXP on the screw terminals.

High-Gain Analog Input

This input is useful for devices requiring higher input sensitivity, for example, thermistors or RTDs in a bridge. The input range is 0–1.0V with 10-bit resolution. The gain at the plus and minus inputs is 10 when jumper H7 is installed. If H7 is removed, then the gain of the plus input becomes higher: 11. The calibration gain and offsets are stored in the EEPROM.

The gain, when H7 is connected is

$$y = a_1 \times (x_1 + a_0) - b_1 \times x_2 \qquad [1]$$

where

a_1 is the positive side scale.
a_0 is the positive side offset.
b_1 is the negative side scale.
x_1 is the positive side input.
x_2 is the negative side input.

Note that $b_1 = a_1 - 1$ (with H7 not connected). If the negative input x_2 is tied to ground, then the equation becomes

$$y = a_1 \times (x_1 + a_0) \qquad [2]$$

or, solving for x1,

$$x_1 = y / a_1 - a_0 \qquad [3]$$

This equation returns the input voltage, given the reading. Solving equation 1 for $(x_1 – x_2)$ in terms of y and x_1 yields

$$(x_1 - x_2) = y/b_1 - (a_1/b_1 - 1) \times x_1 - a_0 \times a_1/b_1 \qquad [4]$$

If you want to change the gain of the high-gain input, change R5, R11, and possibly RP5. These are factory set to 47K, 47K, and 470K for a factory gain of 10 (or 11, if H7 is removed). When differential inputs are desired, it is preferable to operate with H7 removed, since the scaling difference between the

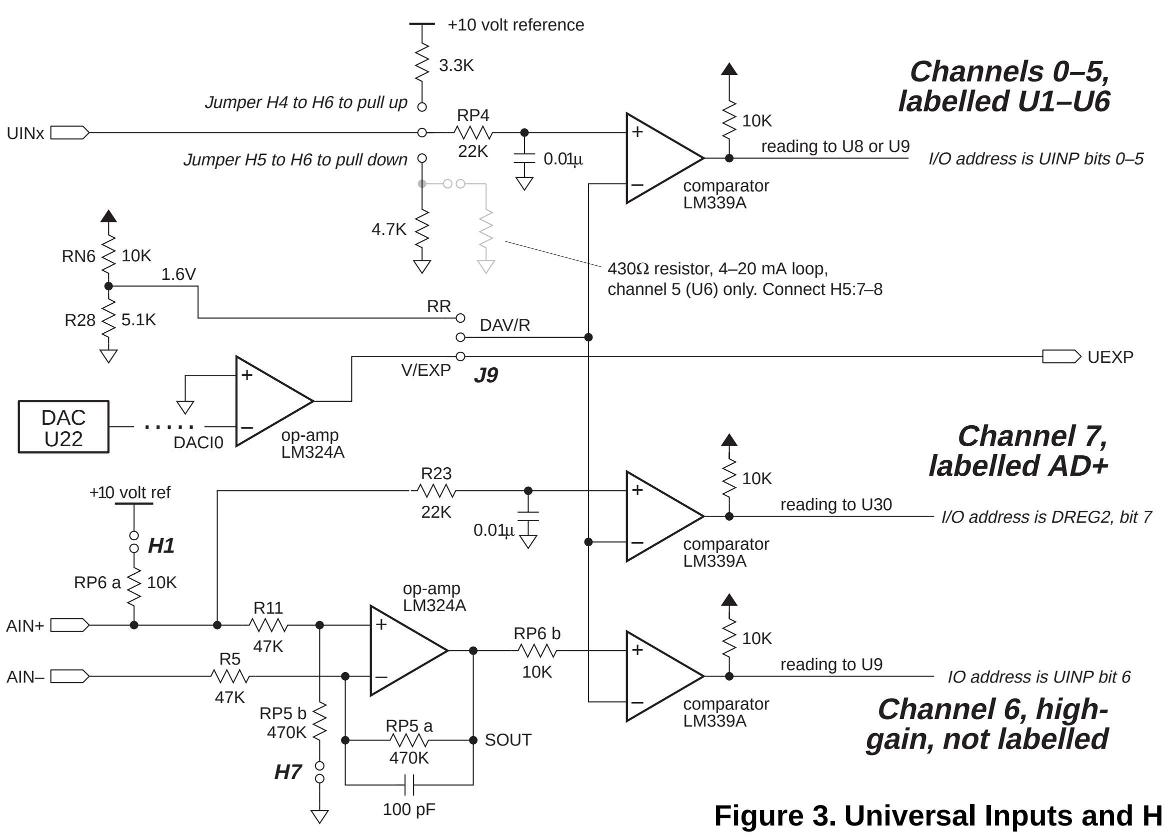


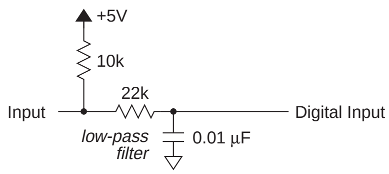
Figure 3. Universal Inputs and High-Gain Channel

positive and negative inputs will be exactly 1 and will not depend on a balance between resistors, making the output 5 volts when both differential inputs are 5 volts.

If the gain is increased, it becomes necessary to use an operational amplifier with a more stable offset voltage than the LM324, which has considerable drift over temperature. The Linear Technology LM1014 is suitable for gains up to 100 or more. The negative input has a low input impedance compared to the positive input (when H7 is removed). If R5 is decreased to increase the gain, this impedance becomes even lower. When a bridge is used, the finite impedance of the negative input has the effect of changing the gain slightly.

Digital Inputs

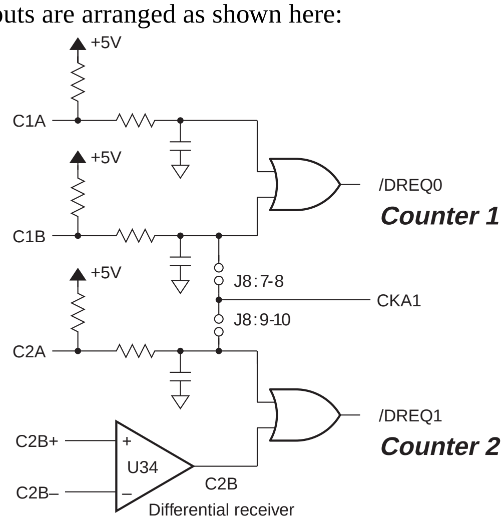
The 7 digital inputs accept an input voltage with a digital threshold at approximately 2.5 volts. The inputs are protected against overload over the range of –48 to +48 volts.



These inputs are convenient for detecting contact closures or sensing devices with open collector transistor outputs. Logic level outputs can also be detected if they are supplied from CMOS logic outputs which are guaranteed to swing to at least 3.5 volts. Three of the digital inputs (D5–D7) also function as inputs to the high speed counters.

Counter Inputs

Three of the digital inputs also serve as counter inputs. There is, in addition, a special differential counter input. The counter inputs are arranged as shown here:



The counters sense negative edges. The differential receiver input can be used as a digital input by attaching one side of it to the desired threshold voltage. It can be used as a true differential input for such devices as inductive pickups. It has a common mode voltage range from –12 to +12 volts with an input hysteresis of 50 millivolts. An internal jumper can connect the signal CKA1 which is controlled by the serial port hardware. It can be set to various speeds from 600 kHz down to 300 Hz.

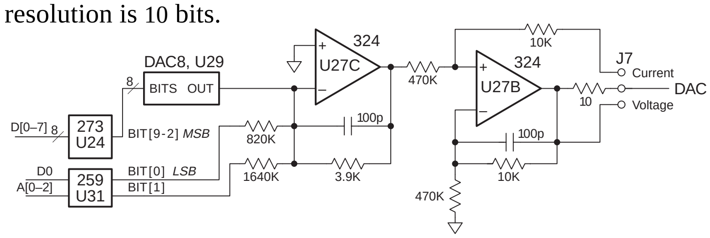
The counters use the DMA channels of the Z180. The maximum counting speed is approximately 600 kHz. The DMA channel can be programmed to store a byte from an I/O port to memory for each count, if desired. This byte can be the least significant byte of the internal programmable counter (PRT) which allows the count edge to be localized in time. This feature can also determine the exact time, within a few microseconds, at which an event occurs by programming the DMA channel to store one byte and then interrupt. The interrupt routine can read the most significant part of the PRT counter and any software extension of this counter. In general, the maximum count is 65,536 which can be extended by software to larger counts if the counting speed is not higher than about 10 kHz.

The capabilities of the counter are summarized as follows:

1. Measure the time at which a negative edge occurs with a precision of a few microseconds. The measurement can be repeated hundreds of times per second. A minimum time must occur between successive events to allow for interrupt processing.
2. Measure the width of a pulse by counting (up to 65,536) at a rates from 600 kHz to 300 Hz.
3. Count negative-going edges for each two channels. The maximum count for high-speed counting (5 kHz to 600 kHz) is 65,536. For low speed counting, the maximum count not limited by hardware.

Analog Output

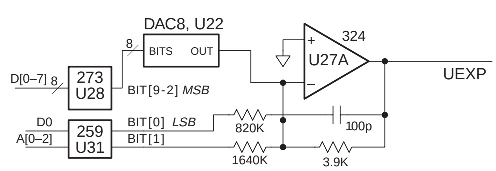
One analog output (named DAC) is provided. The output can be either a 0–10V (connect jumper J7:2-3) voltage output or a 0–20 mA current output (connect J7:1-2) suitable for driving 4–20 mA current loops. It will drive 20 mA up to 470 ohms. The resolution is 10 bits.



An 8-bit DAC chip, a network of resistors, and LM324 op-amps produce the output. Software writes the 10-bit output value to three registers:

DAC	UEXP	Which bits
0x90	0x88	Bits 9–2
0xA2	0xA0	Bit 1
0xA3	0xA1	Bit 0

Another 10-bit analog output channel (UEXP) is available if it is not used to provide reference voltage for the universal inputs. It produces 0–10V with 10-bit resolution.

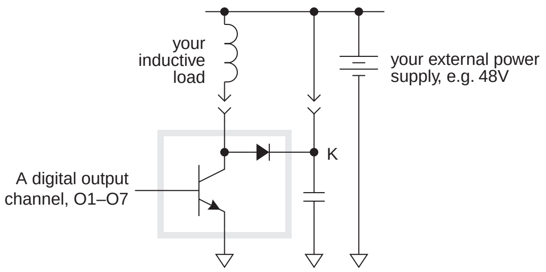


Note that UEXP is not identical to the first DAC channel.

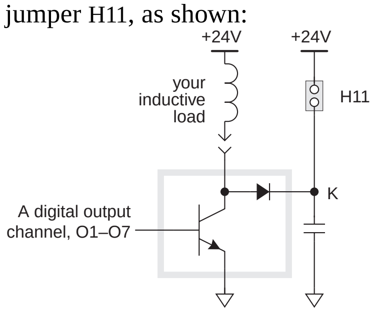
High-Current Switching Outputs

There are 10 high-current outputs O1–O10 available at external terminals. Seven of the outputs belong to one high-current driver (U26) and three belong to another (U35).

Outputs O1–O7 use a common connector ("K") for the protective diodes. All loads connected to the same driver chip must use the same power supply so the diodes can return inductive spikes to the same power supply.



If you use the PK2100's on-board power supply (+24V or +12V nominal) for your load, you should route K to it by connecting jumper H11, as shown:



The diodes for outputs O8–O10 use the on-board power supply directly.

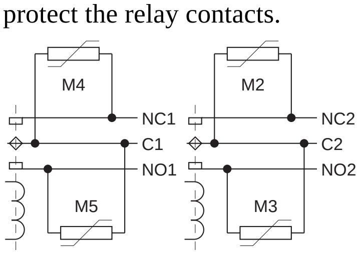
The driver used is the ULN2003 (Texas Instruments). Each driver chip can dissipate a maximum of 1.25 watts when the ambient temperature is 60°C. Each output consumes power, depending on the current, as follows:

100 mA	0.10 watt
200 mA	0.25 watt
350 mA	0.50 watt.

This limits the maximum current to approximately 150 mA per output if all outputs are turned on at the same time continuously. The maximum current for any single output is 500 mA.

Relay Outputs

There are two SPDT relays rated at 3A, 48 volts. The three contacts for each relay have terminals (NC, NO, COM on the terminal strips). You have the option to install MOVs on the board to protect the relay contacts.

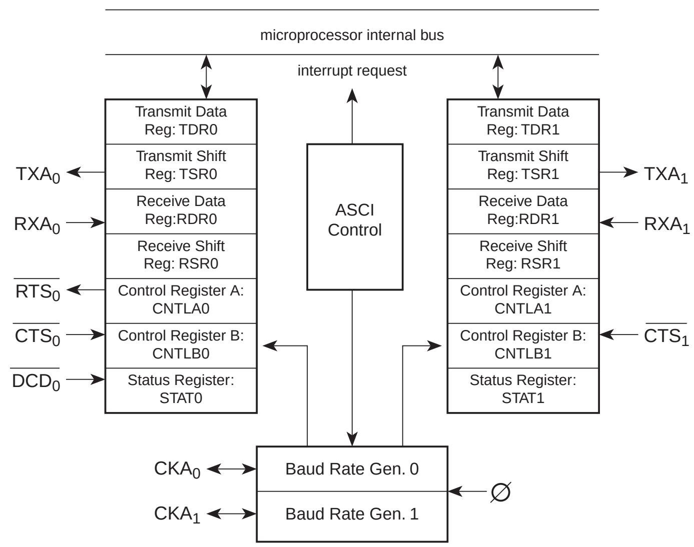


Battery-Backed Real-Time Clock

The real-time clock stores a representation of time and date, and runs independently. The RTC can be programmed to interrupt the processor periodically through the INT2 interrupt line. Please refer to the Toshiba TC8250 data book for detail.

The Serial Ports

The Z180 has two independent, full-duplex asynchronous serial channels, with a separate baud rate generator for each channel. The baud rate can be divided down from the microprocessor clock, or from an external clock for either or both channels.



The serial ports have a multiprocessor communications feature that can be enabled. When enabled, an extra bit is included in the transmitted character (where the parity bit would normally go). Receiving processors can be programmed to ignore all received characters except those with the extra multiprocessing bits enabled. This provides a 1-byte attention message that can wake up a processor without the processor having to monitor (intelligently) all traffic on a shared communications link.

The serial ports can be polled or interrupt-driven. Normal serial options are available: 7 or 8 data bits, 1 or 2 stop bits, odd, even or no parity, and parity, overrun, and framing error detection.

Port 0

Port 0 is RS232; its connector is the RJ12 jack. It has CTS and RTS handshaking lines. Port 0 is constrained by hardware to have the CTS (clear to send) pulled low by the RS232 device with which it is communicating.

If the device with which the port is communicating does not support CTS and RTS, the CTS and RTS lines on the PK2100 side can be tied together to make communication possible.

Port 1

Port 1 is RS485 normally, with transmit and receive lines on the screw terminals. You can use port 1 as an RS232 port, but it has no CTS/RTS handshaking.

Baud Rates

The Z180 serial ports can generate standard baud rates. When the clock is 6.144 MHz, rates range from 150 to 38.4 kHz. When the clock is 9.216 MHz, rates range from 75 Hz to 19.2 kHz.

LCD

The 2×20 LCD used with the PK2100 can come from one of several vendors. All the LCDs are identical in operation, electrical connections, and dimension. They may differ in timing.

An LCD can take up to 1600 µs to carry out an operation. Therefore it provides a busy flag, which you may read at address LCDRD (0xD0). It is an error to send other commands or data to an LCD while it is busy.

To communicate with the LCD, send commands to address LCDWR (0xD8). Command values are built into the command. To write data to the LCD, use address LCDWR+1. To read data from the LCD, except for the busy flag, use address LCDRD+1.

Refer to any of the LCD manufacturers' data sheets for information regarding LCD operations.

The LCD connector is a 2×7 header, P2.

Keypad

To read the 2×6 matrix keypad, you "drive" the row or rows you wish to sample, then read the columns. Any or all keys may be sensed.

There are four keypad "rows" at addresses KEYR1–KEYR4 (0x86, 0x81, 0x85, 0x87 respectively) and six keypad columns readable as bits 2–7 of DREG1 (0x81).

The PK2100 can address four keypad rows, but presently there is support only for 2 keypad rows.

Jumper block J4 uses keypad signals (/KH2, and KV1–KV3) for operation mode settings.

Beeper

The on-board beeper has two volume levels. Alternately send 1 then 0 to make it oscillate. Write to BEEPH (0x83) for high volume. Write to BEEPL (0x98) for low volume.

I/O Map

The internal Z180 I/O registers occupy the first 64 (0x40) addresses of the I/O space. Refer to the *Z180 MPU User's Manual*.

The following I/O addresses control the PK2100 devices which are external to the Z180 processor.

Write Registers

Addr	Bit	Symbol	Function
0x80	0	SDA_W	EEPROM data, write.
0x81	0	KEYR2	Keypad drive row 2. Open collector, "1" drives low.
0x82	0	ENB485	Enable RS485 channel
0x83	0	BEEPH	Beeper, high-voltage drive. "1" drives beeper.
0x84	0	SCL	EEPROM clock.
0x85	0	KEYR3	Keypad drive row 3. Open collector, "1" drives low.
0x86	0	KEYR1	Keypad drive row 1. Open collector, "1" drives low.
0x87	0	KEYR4	Keypad drive row 4. Open collector, "1" drives low. Also, tenth high-current output (DRV10) if key row not used.
0x88	0–7	UEXP	Internal DAC, bits 9-2. *See also UEXPA and UEXPB below*.
0x90	0–7	DAC	External DAC, bits 9-2. *See also DACA and DACB below*.
0x98	0	BEEPL	Beeper, low-voltage drive drive. "1" drives the beeper.
0x99	0	DRV1	Digital output 1. "1" drives output.
0x9A	0	DRV2	Digital output 2. "1" drives output.
0x9B	0	DRV3	Digital output 3. "1" drives output.
0x9C	0	DRV4	Digital output 4. "1" drives output.
0x9D	0	DRV5	Digital output 5. "1" drives output.
0x9E	0	DRV6	Digital output 6. "1" drives output.
0x9F	0	DRV7	Digital output 7. "1" drives output.
0xA0	0	UEXPA	Internal DAC, bit 1.
0xA1	0	UEXPB	Internal DAC, bit 0.
0xA2	0	DACA	External DAC, bit 1.
0xA2	0	DACB	External DAC, bit 0.
0xA4	0	DRV8	Digital output 8. "1" drives output
0xA5	0	DRV9	Digital output 9. "1" drives output
0xA6	0	RLY1	"1" enables relay 1.
0xA7	0	RLY2	"1" enables relay 2.
0xC8	0–7	BUSADR0	Expansion bus, first address byte
0xCA	0–7	BUSADR1	Expansion bus, second address byte
0xCC	0–7	BUSADR2	Expansion bus, third address byte
0xCE	0–7	BUSWR	Expansion bus write to port
0xD8	0–7	LCDWR	LCD write register, control
0xD9	0–7	LCDWR+1	LCD write register, data
OxE0	0–3	RTRW	Real time clock, read/write data registers
0xF0	0–3	RTALE	Real time clock, write address latch

Read Registers

Addr	Bit	Symbol	Function
0x80	0–7	UINP	Bits 0–6 are universal inputs 0–5 and the high-gain analog input (bit 6). Bit 7 is PR, a user-programmable jumper (J8 pins 11-12) and is low when the jumper is installed.
0x81	0–7	DREG1	Bit 0 is EEPROM data bit. Bit 1 is NMI interrupt line (power fail line). Bits 2–7 are keypad columns 0–5.
0x88	0–7	DREG2	Bits 0–6 are digital inputs 0–6. Bit 7 is the universal input channel fed through AD+ (or universal input channel 8).
0x98	—	WDOG	Reading this location "hits" the watchdog timer.
0xC0	0–7	BUSRD0	First read, data port of expansion bus
0xC2	0–7	BUSRD1	Second read, data port of expansion bus
0xC4	0–7	—	Unused bus read address
0xC6	—	BUSRESET	Read this location to reset all devices on the expansion bus.
0xD0	0–7	LCDRD	LCD read register, control
0xD1	0–7	LCDRD+1	LCD read register, data

Interrupt Vectors

Most of the interrupt vectors can be altered under program control. These are the suggested and default vectors:

Addr	Name	Description
0x00	INT1_VEC	Expansion bus attention INT1 vector.
0x02	INT2_VEC	INT2 vector, can be jumpered to output of the real-time clock for periodic interrupt.
0x04	PRT0_VEC	PRT timer channel 0
0x06	PRT1_VEC	PRT timer channel 1
0x08	DMA0_VEC	DMA channel 0
0x0A	DMA1_VEC	DMA channel 1
0x0C	CSIO_VEC	Clocked serial I/O
0x0E	SER0_VEC	Asynchronous Serial Channel 0
0x10	SER1_VEC	Asynchronous Serial Channel 1

Jump Vectors

Instead of loading the address of the interrupt routine from the interrupt vector, the following interrupts cause a jump directly to the address of the vector, which will contain a jump instruction to the interrupt routine. For example,

0x66	non-maskable power-failure interrupt
0x08	INT_0, mode 0
0x38	INT_0, mode 1

Interrupt Priorities from Highest to Lowest

Internal	Trap	(Illegal Instruction)
External	NMI	(non maskable interrupt, power failure)
External	INT0	(non-maskable, level 0)
External	INT1	(non-maskable, level 1, expansion bus attention line)
External	INT2	(non-maskable, level 2)
Internal	PRT timer channel 0	
Internal	PRT timer channel 1	
Internal	DMA channel 0	
Internal	DMA channel 1	
Internal	Clocked serial I/O	
Internal	Serial Port 0	
Internal	Serial Port 1	

EEPROM

The parameters given here apply to the standard 24-volt PK2100. See *The 12-Volt PK2100* (page 9) for changes relating to the 12-volt version.

Addr.	Definition
0x000	Startup Mode. If 1, enter programming mode. If 8, execute loaded program at startup.
0x001	Baud rate in units of 1200 baud.
0x100	Unit “serial number.” BCD time/date with the following format: second, minutes, hours, day, month, year.
0x106	Required power voltage. This value is 24 for standard PK2100s and 12 for the 12-volt version.
0x107	Software test version (times 10). For version 1.2, this is 12.
0x108	Microprocessor clock speed in units of 1200 Hz (16-bits). For 6.144 MHz clock speed, this value is 5120.
0x10C	Bus address for networking. 16 bits.
0x10E	Analog voltage reference units of 1 millivolt. 16 bits. 10300 for 10.300 volts.
0x110	Excitation resistor values for universal inputs 1–6. These are the pull-up resistors to the +10V reference. Six integers in units of 0.5 ohm. 6600 for 3.3K resistors.
0x11C	Pull-down resistor values for universal inputs 1–6. Six integers in units of 0.5 ohm. 9400 (4.7K ohms).
0x128	4–20 mA load resistor. Resistance in units of 1/2 ohm. The nominal value is 780 (2 counts/ohm x 390 ohms). This represents the combined resistance of the load resistor and the pull-down resistor in parallel.
0x12A	*Reserved*
0x130	11 values relating to internal DAC. First value is output voltage when nominal output is zero. Additional values are output voltage increment (above offset) when input value is 1, 2, 4... 256, 512. Stored as integers expressed in 0.5 millivolt units.
0x146	11 values relating to external DAC. First value is output voltage when nominal output is zero. Additional values are output voltage increment (above offset) when input value is 1, 2, 4... 256, 512. Stored as integers expressed in 1/2 millivolt units.
0x15C	For the standard PK2100, this is current in units of 0.001 mA corresponding to voltage output of 2.000V when is set for 0-20 mA output into nominal 392 ohm load resistor. Typically, near 4000. For the 12-volt PK2100, the output range is 0-15 mA.
0x15E	For the standard PK2100, this is current in units of 0.001 mA corresponding to voltage output of 10.000 volts when is set for 0-20 mA output into nominal 392 ohm load resistor. For the 12-volt PK2100, the output range is 0-15 mA.
0x160	With shorting jumper H7 ***connected***, these are 16-bit numbers *a0* and *a1* high-gain plus-side inputs in the gain formula $y = a1 \times (x1 + a0)$ with the minus side grounded. If the minus side is not grounded, the formula is $y = a1 \times (x1 + a0) – b1 \times x2$. where *b1* is the minus-side gain and can be computed from the calibration constants stored at location 0x164. The value *y* is the output of the high-gain amplifier read with universal input channel 7. The value *x1* is the plus-side input read with universal input channel 8 and *x2* is the minus-side input. The coefficient *a0* is signed and is in units of 0.01 mV. The coefficient *a1* is the unsigned dimensionless gain expressed in units such that a gain of 10 is equal to 2000.
0x164	With shorting jumper H7 ***removed***, these are 16-bit numbers *a0* and *a1* high gain plus-side input in the gain formula $y = a1 \times (x1 + a0)$ with the minus side grounded. If the minus side is not grounded, the formula is $y = a1 \times (x1 + a0) – b1 \times x2$. where *b1* is the minus-side gain and can be computed as *a1*–1.
0x168	*Reserved*
0x16A	Resistance of excitation resistor for high-gain plus input in ohms. Nominal value 10K. An unsigned integer.
0x16C	Long coefficient relating speed of microprocessor clock relative to speed of real-time clock. Nominal value is 107,374,182 which is 1/40 of a second microprocessor clock time on the scale where 2^{32} is 1 second. This requires 4 bytes of EEPROM, stored least byte first.

Heat Sinking

A PK2100 Series controller has two power supply regulators. The aluminum enclosure provides the heat sink. In the board-only version, the mounting rails provide the heat sink. The +5V regulator dissipates the most heat and transfers heat to the case or side rails via two mounting “pem” nuts. Maximum heat dissipation by this regulator is 10W when the ambient temperature is 50°C. If an attempt is made to dissipate more heat because of a combination of high input voltage or excessive current draw on the +5V supply, the regulator will shut down protectively. Power dissipation is given by the formula:

$P = (V_{IN} - 5) \times (I + 0.15)$

V_{IN} = input voltage

I = current, in amperes, drawn from +5V supply by external accessories on bus or from VCC terminal.

Environmental Temperature Constraints

No special precautions are necessary over the range of 0–50°C (32–122°F). For operation at temperatures much below 0°C, the PK2100 should be equipped with a low temperature LCD which is specified for operation down to –20°C. The heating effect of the power dissipated by the unit (about 5 watts) may be sufficient to keep the temperature above 0°C, depending on the insulating capability of the enclosure used. The LCD storage temperature is 20°C lower than its operating temperature, which may protect the LCD in case the power should fail, removing the heat source. The LCD unit is specified for a maximum operating temperature of 50°C. Except for the LCD, which fades at higher temperatures, the PK2100 can be expected to operate at 60°C, or more, without problem.

Expansion Bus

The PLCBus,™ is a general purpose expansion bus for Z-World controllers. Z-World currently sells the following expansion devices. The list may change:

Device	Description
XP8100	Several options of 16 or 32 protected digital I/O lines. Some versions have optical isolation.
XP8200	16 “universal inputs,” 6 high-current switching outputs
XP8300	Six SPDT power relays
XP8400	Contains eight DIP relays, each SPST, NO.
XP8500	11 12-bit A/D converters (4 with signal conditioning)
XP8600	2 DACs
XP8700	1 full-duplex RS232 channel
XP8800	Stepper motor controller (based on PCL-AK)

Multiple expansion boards may be daisy-chained together and connected to a Z-World controller to form an extended system. For details, refer to the PLCBus data sheet.

Power Failure Interrupts

The following events occur when power fails:

1 The power-failure NMI (non-maskable interrupt) is triggered when the unregulated DC input voltage falls below approximately 15.6 volts (subject to the voltage divider R9/R33). [7.8V on 12V systems]

2 A system reset is triggered when the regulated +5V supply falls below 4.5 volts. The reset remains enabled as the voltage falls further. At some point, the chip select for the SRAM is forced high (for standby mode). The time/date clock and SRAM are switched to the lithium backup battery when VCC falls below the battery voltage of approximately 3 volts.

The 12-Volt PK2100

The following are changes for the 12-volt PK2100. Note that R40 and U12 are absent on the 12V board, and R9 is 14K, not 22K. The 12V board has 12V relays, nominally 5A, 120V.

Subsystem	Effect
External DAC	The external DAC voltage output (when J7 connects pins 2–3) is reduced to 0–7 volts. The current output (J7 connects pins 1–2) is now 0–15 mA.
Internal DAC	The internal DAC voltage output (UEXP) is reduced to 0–7 volts. This directly affects the universal input channels, since the incoming value is compared against the UEXP output.
Universal Inputs	Because of the change in the internal DAC (UEXP) output, the universal input channels read a nominal range of 0–7V.
High-Gain Input	The effective input range to 0–700 mV.

EEPROM changes for the 12V system

Addr	Meaning
0x106	Required power. This value is 12 for the 12-volt version.
0x15C	For the 12-volt PK2100, this is current in units of 0.001 mA corresponding to voltage output of 2.000V.
0x15E	For the 12-volt PK2100, this is current in units of 0.001 mA corresponding to voltage output of 10.000 volts.

Other EEPROM values remain unchanged.

Reference Voltage

The reference voltage (marked +10V on the terminal connector) is nominally +7 volts. This affects all subsystems using this value as a reference, as described below.

Programming

Developers program a PK2100 Series controller by connecting it to the serial port of an IBM PC running Z-World’s Dynamic C development system. Serial communication for programming takes place at 19,200 baud or at 38,400 baud. While a program is undergoing development, the controller normally remains connected to the PC and Dynamic C.

Once program development is complete, the completed program can reside in one of the following places:

- Battery-backed RAM.
- ROM which is written on a separate ROM programmer and then substituted for the standard Z-World ROM.
- Flash memory which may be programmed or reprogrammed without removing it from the controller.

Programmers generally use Dynamic C function libraries. Dynamic C libraries support direct I/O and virtual I/O (which is easier but slightly less efficient). The virtual driver is a system function that monitors the PK2100 I/O lines, every 25 milliseconds. The programmer reads and writes to virtual registers *as variables*, and does not contend with the hardware details.

Initial PK2100 Setup

When the PK2100 powers up, it consults its board jumpers, the keypad if any, and the contents of the EEPROM to determine its mode of operation. The modes of operation are the following:

- Run a program stored in battery-backed RAM.
- Prepare for Dynamic C programming at 19.2K baud using the RS232 port ("phone" jack).
- Prepare for Dynamic C programming at 38.4K baud using the RS232 port.

If your controller has a keypad, you can use it to select the operation mode. Hold down the menu/setup key and one other key simultaneously (field/run, up/pgm 19.2, or down/pgm 38.4). The unit will beep to acknowledge the change of operating mode. In unusual instances, you might also need to cycle power while holding the key combination.

If the keypad is not available, or you want to override the keypad, use the jumper block J4.

Connecting the PK2100 to your PC & Dynamic C

1 Connect the red-tagged lead from your 24V (or 12V) power-supply to the +24V screw connector. Connect the other power supply lead to the GND screw connector.

2 Plug the serial programming cable into the PK2100 jack and connect it to a PC serial port.

3 Plug the PK2100's power supply into a wall socket. Start Dynamic C.

Software Drivers

Z-World software includes the functions listed here.

Digital Input/Output

- void up_setout(int channel, int value)
- void up_digin(int channel)

Analog Output

- void up_daccal(int value)
- void up_dacout(int rawval)
- void up_expout(int rawval)
- void up_dac420(int current)

Analog Input

- void up_adcal(int channel)
- void up_in420()
- void up_adrd(int channel)
- void up_adtest(int channel, int testval)
- void up_uncal(int calval)
- void up_docal(int calval)
- float up_higain(int mode)

High Speed DMA Counter

- void DMA0Count(uint count)
- void DMA1Count(uint count)
- uint DMASnapShot(byte channel, uint *counter)

EEPROM Read / Write

- int ee_rd(int address)
- int ee_wr(int address, char data)
- int eei_rd(int address)

Flash EPROM Write

- int WriteFlash(ulong addr, char* buf, int num)

Parts List

Listed are major parts. Resistors, capacitors and other small parts may be found on the schematic.

B3	Battery, 3V, 560 mA-H
BZ1	Buzzer
H1	1x9 Header, .100″
H4	1x6 Header, .100″
H5	1x8 Header, .100″
H6	2x6 Header, .100″
H7	1x9 Header, .100″
H8	2x3 Header, .100″
H9	1x9 Header, .100″
H11	2x1 Header, .100″
J1	1x14 Header, .100″
J3	1x3 Header, .100″
J4	1x8 Header, .100″
J7	1x9 Header, .100″
J8	2x7 Header, .100″
J9	1x3 Header, .100″
J11	1x3 Header, .100″
JP1	Phone Jack RJ12
JP2	Terminal strip 25x
JP3	Terminal Strip 25x
K1	Keypad flex connecter
P1	2x13 Header for PLCBus
P2	2x7 Header, .100″
SW1	2x1 Header, .100″
U1	EPROM and socket, 32K
U2	SRAM, 32K, 70ns
U3	Octal 3-state transceiver, 74HC245
U4	Octal 3-state transceiver, 74HC245
U5	EEPROM, 512, 24C04
U6	PAL (for PK2100)
U7	Dual decoder 2:4, 74HC139
U8	Quad 2:1 mux, 74HC257
U9	Quad 2:1 mux, 74HC257
U10	Watchdog, 691
U11	Adjustable Reg, 723, 150mA
U12	Linear Reg, 7805, 15V, TO-220
U13	Switching Reg, 7662
U14	8-bit addressable latch, 74HC259
U15	Real-Time Clock, Toshiba 8250
U16	Z180
U17	Hex inverter, open drain, 74HC05
U18	Quad 2-in OR, 74HC32
U19	Quad 2-in OR, 74HC32
U20	Linear Reg, 7805, 5V, TO-220
U21	Comparator, 339
U22	8-bit DAC

U23 8-bit addressable latch, 74HC259
U24 Octal FF w clear, 74HC273
U25 Diff. Bus transceiver, 75176A
U26 7-chan sinking HC driver, 2003
U27 Opamp, 324
U28 Octal FF w clear, 74HC273
U29 8-bit DAC
U30 Octal 3-state buffer, 74HC244
U31 8-bit addressable latch, 74HC259
U32 Comparator, 339
U33 RS232 driver 1488
U34 Diff. Receiver, 75175
U35 7-chan sinking HC diver, 2003
X1 12.288 MHz crystal for 6.144 MHz system]
X2 32,768 Hz crystal
Z1 Linear reg, 79L05, –5V

Jumpers and Headers

Headers and jumpers are shown in the drawing below. Pin 1 positions are indicate by "+" markers.

H1 When connected, a 10K excitation resistor RP6A is connected between the +10V reference and the high-gain input AD+.

H5 7-8 Connect to engage 4–20 mA load resistor (430 ohm) from universal input 6 to ground.

H6 For universal input *n* (1–6), connect H6-*n* to H4-*n* to engage excitation resistor (3.3K) to +10 volt reference. Connect H6-*n* to H5-*n* to engage pull-down resistor (4.7K).

H7 Connect jumper to cause differential inputs AD+ and AD– to be balanced in gain. If H7 is disconnected, the gain is greater on the AD+ side so that if both inputs are set to 5 volts, the output of the operational amplifier is 5 volts. Use this feature for accepting input from bridges where the taps are nominally at +5V.

H8 1-2 Connect to enable a second RS232 output (at the expense of RS485 output) The output pin will be TX–. The RS232 input will be RX–. RX+ must be tied to ground.

3-4, 5-6 Connect these positions to enable the termination and bias resistors for RS485 communications.

H9 When installed, this connects the on-board battery to relay 1 N.O. contact. Use H9 when a battery self-test circuit is to be implemented by connecting a switched load to the battery.

H11 Normally installed. Connects "K" to +24V power supply. Disconnect only if a separate power supply is to be used for high-current outputs O1–O7. In that case, K must be connected to that power supply.

J1
- 1-2 Connect if using 32K RAM or 128K RAM
- 2-3 Connect for 256K or 512K RAM
- 4-5 Connect if using 32K, 64K, or 128K EPROM
- 5-6 Connect for 512K or 256K EPROM
- 7-8 Connect for ***other than*** 32K EPROM
- 8-9 Connect for 32K EPROM
- 12-13 Connect for 64K, 128K, 256K flash EPROM
- 13-14 Connect for 512K (non-flash) EPROM

J4 This is the operation mode jumper. By software convention, position 7-8 means "enter programming mode at 19.2K baud." Position 6-7 means "run the program in memory." Position 2-3 means "enter programming mode at 38.4K baud." J4 overrides the keypad when a readable jumper is installed.

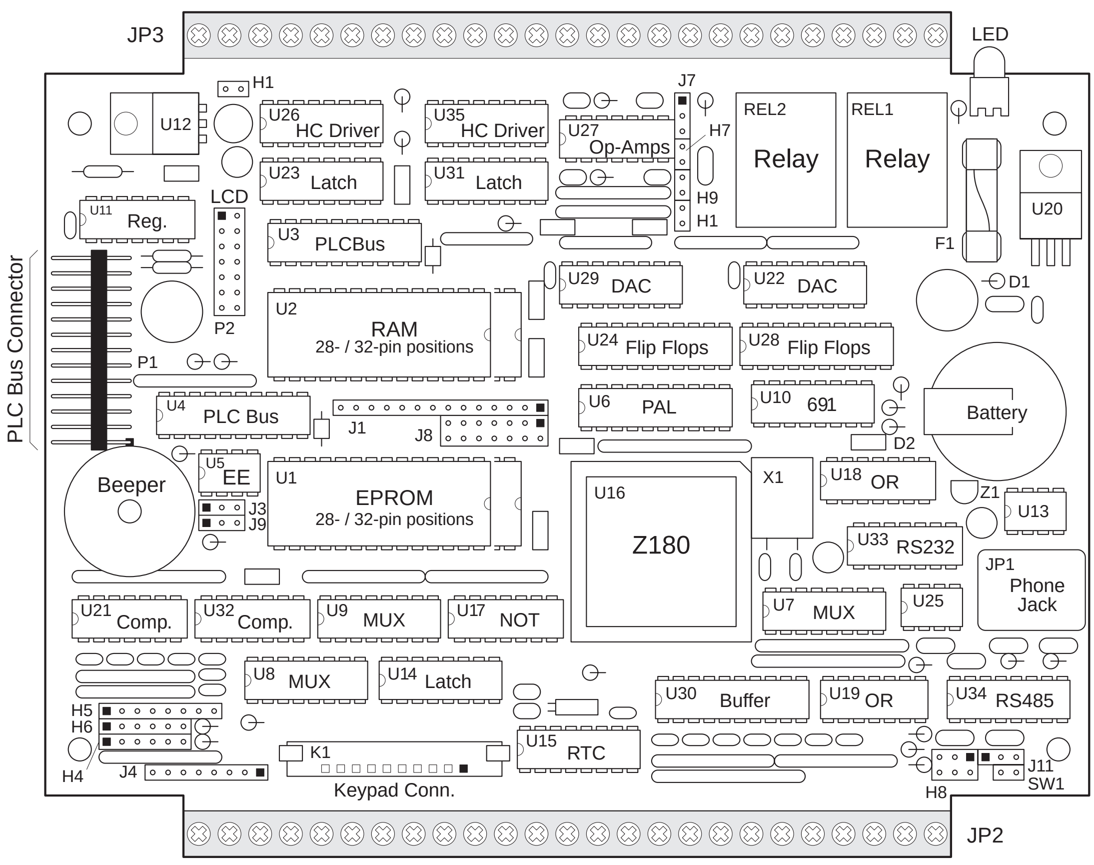


Figure 4. Parts Locations

J7 Connect 2-3 for voltage output on the DAC channel (factory setting). Connect 1-2 for 20 mA current output.

J8 1-2 Enable switching power supply

3-4 Connects timer output T0 to processor /INT2. Can generate periodic interrupts.

5-6 Connects universal input 1 to processor /INT0. *Not recommended*.

7-8 Connect processor I/O CKA1 to digital input 6.

9-10 Connect processor I/O CKA1 to digital input 7.

11-12 Processor-readable jumper. By convention, install whenever 13-14 is installed.

13-14 Install jumper to enable watchdog timer.

J3 1-2 Protect EEPROM against writes at addresses 256–511. This is the factory setting.

2-3 Allow EEPROM writes at addresses 256–511.

J9 1-2 The comparators used for the universal inputs are connected to the voltage divider RR which has a value of 1.6 volts. This causes the universal inputs to have a threshold fixed at this value.

2-3 Factory setting, where the internal DAC is connected to the comparators used for the universal inputs.

J11 1-2 Connect to enable CTS on the RS232 port (0).

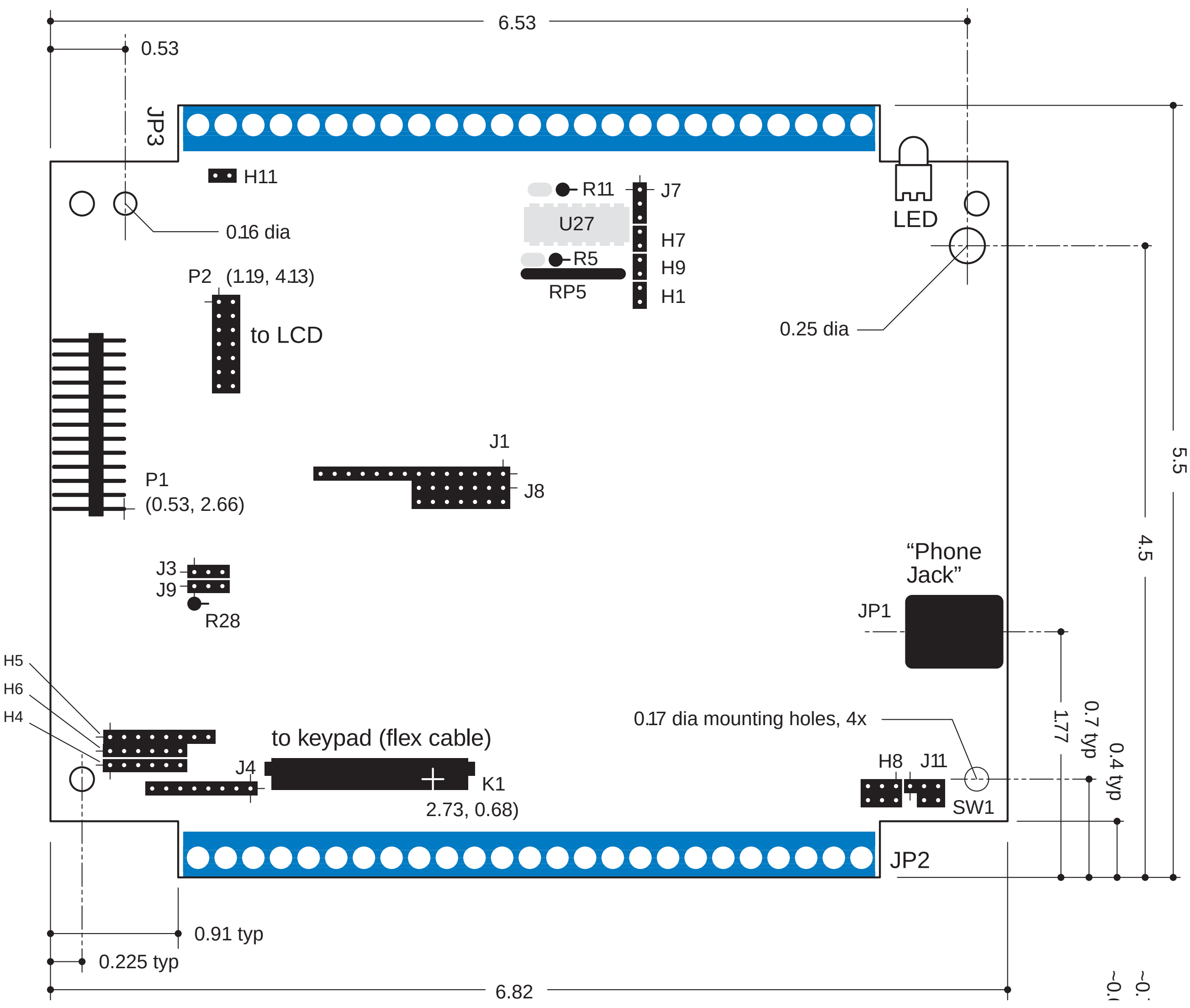
2-3 Connect to use the CTS line as a board reset line. CTS high will reset the PK2100 board.

Board Dimensions

The drawing below shows board dimensions, mounting hole locations and sizes, all the jumpers and headers, pin 1 positions for important headers, and the positions of resistors that affect the universal inputs and the high-gain input. Mounting holes are (0.225, 0.7) from the extreme corners of the board. Resistors R5, R11, and resistor pack RP5 affect the high-gain channel. Resistor R28 (5.1 kΩ) is part of a resistor divider that gives the optional fixed hardware reference voltage for the universal inputs.

Maximum height of components above the board is 0.65″ approximately. Overall height is 0.78″ approximately.

Figure 5. Board Dimensions



Figures 5–8 below show the inportant headers.

Enclosure Dimensions

Figure 9 below shows the size of the aluminum enclosure and the location of the PLCBus port and phone jack.

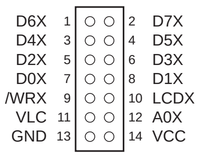


Figure 5. P2, LCD Connector

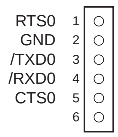


Figure 6. JP1, Phone Jack

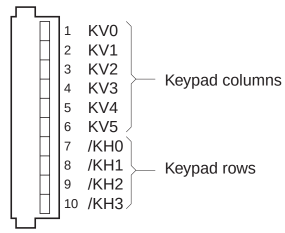


Figure 7. K1, Keypad Connector

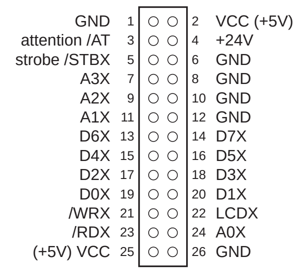


Figure 8. P1, PLCBus connector

Figure 9. Enclosure Dimensions