

XP8700 and XP8800

RS-232 and Motion Control Expansion Boards

User's Manual

Revision C

XP8700 and XP8800 User's Manual

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ABOUT THIS MANUAL

This manual provides instructions for installing, testing, configuring, and interconnecting the Z-World XP8700 RS-232 and XP8800 motion control expansion boards. Instructions are also provided for using Dynamic C functions.

Assumptions

Assumptions are made regarding the user's knowledge and experience in the following areas.

- Ability to design and engineer the target system that the controller used with the XP8700 or XP8800 expansion boards will control.
- Understanding of the basics of operating a software program and editing files under Windows on a PC.
- Knowledge of the basics of C programming.



For a full treatment of C, refer to the following texts.

The C Programming Language by Kernighan and Ritchie
C: A Reference Manual by Harbison and Steel

- Knowledge of basic Z80 assembly language and architecture for controllers with a Z180 microprocessor.



For documentation from Zilog, refer to the following texts.

Z180 MPU User's Manual
Z180 Serial Communication Controllers
Z80 Microprocessor Family User's Manual

- Knowledge of basic Intel assembly language and architecture for controllers with an Intel™386 EX processor.



For documentation from Intel, refer to the following texts.

Intel™386 EX Embedded Microprocessor User's Manual
Intel™386 SX Microprocessor Programmer's Reference Manual

Acronyms

Table 1 lists and defines the acronyms that may be used in this manual.







Table 1. Acronyms

Acronym	Meaning
EPROM	Erasable Programmable Read-Only Memory
EEPROM	Electrically Erasable Programmable Read-Only Memory
LCD	Liquid Crystal Display
LED	Light-Emitting Diode
NMI	Nonmaskable Interrupt
PIO	Parallel Input/Output Circuit (Individually Programmable Input/Output)
PRT	Programmable Reload Timer
RAM	Random Access Memory
RTC	Real-Time Clock
SIB	Serial Interface Board
SRAM	Static Random Access Memory
UART	Universal Asynchronous Receiver Transmitter

Icons

Table 2 displays and defines icons that may be used in this manual.

Table 2. Icons

Icon	Meaning	Icon	Meaning
	Refer to or see		Note
	Please contact	Tip	Tip
	Caution		High Voltage
	Factory Default		

Conventions

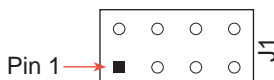
Table 3 lists and defines the typographical conventions that may be used in this manual.

Table 3. Typographical Conventions

Example	Description
while	Courier font (bold) indicates a program, a fragment of a program, or a Dynamic C keyword or phrase.
// IN-01...	Program comments are written in Courier font, plain face.
<i>Italics</i>	Indicates that something should be typed instead of the italicized words (e.g., in place of <i>filename</i> , type a file's name).
Edit	Sans serif font (bold) signifies a menu or menu selection.
...	An ellipsis indicates that (1) irrelevant program text is omitted for brevity or that (2) preceding program text may be repeated indefinitely.
[]	Brackets in a C function's definition or program segment indicate that the enclosed directive is optional.
< >	Angle brackets occasionally enclose classes of terms.
a b c	A vertical bar indicates that a choice should be made from among the items listed.

Pin Number 1

A black square indicates pin 1 of all headers.



Measurements

All diagram and graphic measurements are in inches followed by millimeters enclosed in parenthesis.

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XP8700



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CHAPTER 1: OVERVIEW

Chapter 1 provides an overview and description of the XP8700 RS-232 expansion board.

Z-World's XP8700 expansion board provides a simple way to add a UART to a control system built around a Z-World controller. The XP8700 connects directly to a PLCBus port. The XP8700 does not have the software drivers to enable it to be used with other Z-World controllers.

The XP8700 may be connected on the PLCBus with other expansion boards. Up to four XP8700s can be addressed on a single bus. Unlike most other expansion boards, which take 12-bit addresses (4 bits at a time), XP8700s have 15-bit addresses, placed on the bus five bits at a time.

The XP8700 features a Signetics SCC2691 UART, which is described briefly. The UART is operated by reading and writing to two registers on the XP8700, the control register (CTRL) and data register (DATA).

In addition, the XP8700 may be used as an additional programming board for controllers with a PLCBus port. This frees up the existing RS-232 ports on the controller. The XP8700 also can raise a processor interrupt INT1. The manual discusses methods for dealing with several interrupting devices.

Like other Z-World expansion boards, the XP8700 can be installed in modular plastic circuit-board holders attached to a DIN rail. The XP8700 can also be mounted, with plastic standoffs, on any surface that will accept screws.



The XP8700 expansion board cannot be used as a Dynamic C interface to program the BL1700 controller. Such an interface is not supported by the BIOS.

The Serial Interface Board 2 is available to program the BL1700 if there is a need to have all the BL1700 communication ports used by the application.

The XP8700 expansion board may still be used on the BL1700's PLCBus to provide another RS-232 port.



CHAPTER 2: **GETTING STARTED**

Chapter 2 provides instructions for connecting XP8700 expansion boards to a Z-World controller. The following sections are included.

- XP8700 Components
- Connecting Expansion Boards to a Z-World Controller
- Setting Expansion Board Addresses

XP8700 Components

The XP8700 boards offer a modular RJ-12 jack (H2) and a standard 10-pin header (H1) to interface with other devices. Figure 2-1 illustrates the basic layout and orientation of components, headers, and connectors.

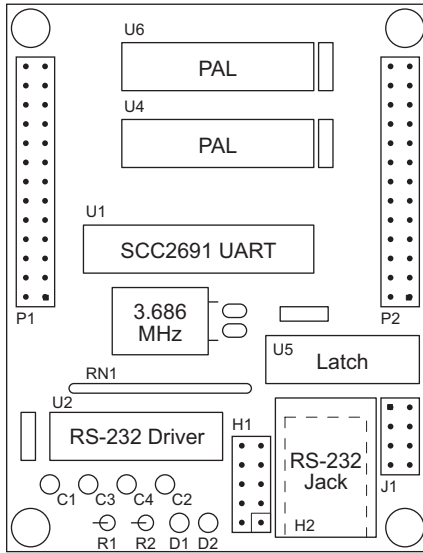


Figure 2-1. XP8700 Board Layout

Connecting Expansion Boards to a Z-World Controller

Use the 26-conductor ribbon cable supplied with the XP8700 to connect the XP8700 to the PLCBus on a Z-World controller. See Figure 2-2. The XP8700's two 26-pin PLCBus connectors, P1 and P2, are used with the ribbon cable. Z-World recommends using the cable supplied to avoid any connection problems.

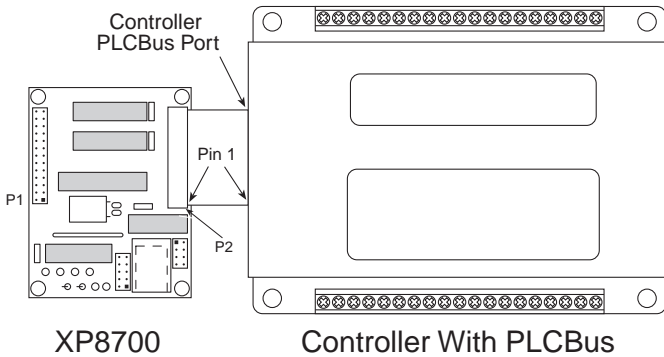


Figure 2-2. Connecting XP8700 Expansion Board to Controller PLCBus



Be sure power to the controller is disconnected before adding any expansion board to the PLCBus.

Follow these steps to connect an expansion board to a Z-World controller.

1. Attach the 26-pin ribbon cable to the expansion board's **P2** or **H2** PLCBus header.
2. Connect the other end of the ribbon cable to the PLCBus port of the controller.



Be sure pin 1 of the connector cable matches up with pin 1 of both the controller and the expansion board(s).

3. If additional expansion boards are to be added, connect header **P2/H2** on the new board to header **P1/H1** of the board that is already connected. Lay the expansion boards side by side with headers P1/H1 and P2/H2 on adjacent boards close together, and make sure that all expansion boards are facing right side up.



See Appendix C, “Connecting and Mounting Multiple Boards,” for more information on connecting multiple expansion boards.

4. Each expansion board comes with a factory-default board address. If more than one expansion board of each type is to be used, be sure to set a unique address for each board.



The following section on “Setting Expansion Board Addresses,” and Chapter 4, “Software Reference,” provide details on how to set and use expansion board addresses.

5. Power may be applied to the controller once the controller and the expansion boards are properly connected using the PLCBus ribbon cable.

Setting Expansion Board Addresses

Z-World has established an addressing scheme for the PLCBus on its controllers to allow multiple expansion boards to be connected to a controller.



Remember that each expansion board must have a unique PLCBus address if multiple boards are to be connected. If two boards have the same address, communication problems will occur that may go undetected by the controller.

XP8700 Addresses

XP8700 expansion boards are shipped from the factory with no pins on header J1 connected. Each of the two registers on the XP8700 board is addressable on the PLCBus, with the jumper connections on pins 1–4 of header J1 determining the address of the register, as explained in Chapter 4.



See Chapter 4, “Software Reference,” for further details on how to determine the physical address for XP8700 expansion boards.

Power

Z-World’s expansion boards receive power from the controller over the +24 V and VCC lines of the PLCBus. XP8700 expansion boards use VCC, which is +5 V. The XP8700 typically draws about 80 mA at 5 V.



CHAPTER 3: I/O CONFIGURATIONS

Chapter 3 describes the built-in flexibility of the XP8700 expansion boards, and describes how to configure the available inputs/outputs. The following sections are included.

- XP8700 Pin Assignments
- Using D/A Converter Boards

XP8700 Pin Assignments

There are two RS-232 connectors on the XP8700 expansion board. One is a 10-pin header, H1, and the other is a 6-wire RJ-12 “phone jack,” H2. Either one can be used. Figure 3-1 shows the pin assignments for header H1 and RJ-12 jack H2.

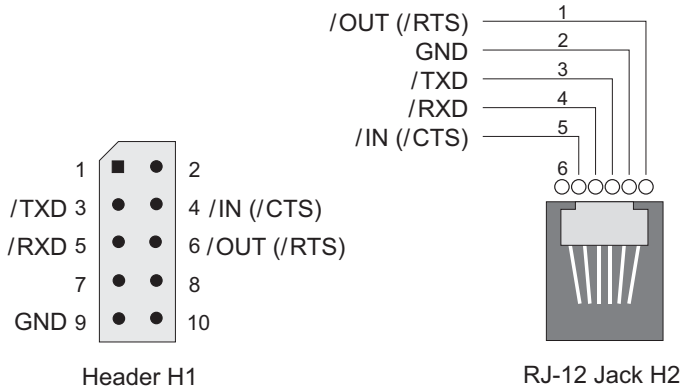


Figure 3-1. XP8700 Header H1 and RJ-12 Jack H2

Using Expansion Boards

The following steps summarize how to use the XP8700 expansion boards.

1. Send a reset command to the PLCBus.
2. Place the address of the XP8700 registers on the PLCBus. Write a reset command to a CTRL register.
3. Write to the XP8700 registers as needed to control the XP8700. Read the internal registers to monitor what is happening.
4. Read the receive holding register (RHR) or write to the transmit holding register to communicate.

These steps are done using software drivers in Dynamic C function libraries.



Refer to Chapter 4, “Software Reference,” for the applicable libraries and where they are used.

XP8700 Operation

The XP8700 can be connected on the PLCBus with other expansion boards. Up to four XP8700s can be addressed on a single PLCBus. XP8700 expansion boards have 15-bit addresses, placed on the PLCBus five bits at a time.

The XP8700 uses a Signetics SCC2691 UART, which is described briefly below. Two registers on the XP8700, the control register and the data register, are used to read and write to the UART. The XP8700 can also raise a processor interrupt, INT1. Methods for dealing with many interrupting devices are discussed.

Signetics SCC2691 UART

The SCC2691 UART is a full-duplex asynchronous receiver/transmitter. It supports 18 baud rates from 50 bps to 38,400 bps. Data may be framed with 5 to 8 data bits, four parity modes, and 1, 1.5, or 2 stop bits. The UART provides error detection (framing errors, parity errors, and overrun errors), break detection and generation, and echo. There are two diagnostic modes. The chip also has a multifunction 16-bit counter/time.

The SCC2691 chip generates interrupts under seven maskable conditions. It has a low-power mode and a “wake-up” mode. Receiver data are quadruple-buffered (FIFO).

The SCC2691 is controlled by reading or writing its internal registers. A counter or timer may be set up, RS-232 communication may be initiated, or control interrupts may be initiated. Options include setting baud rates, parity, and ot

Figure 3-2 shows a block diagram of the SCC2691 architecture.

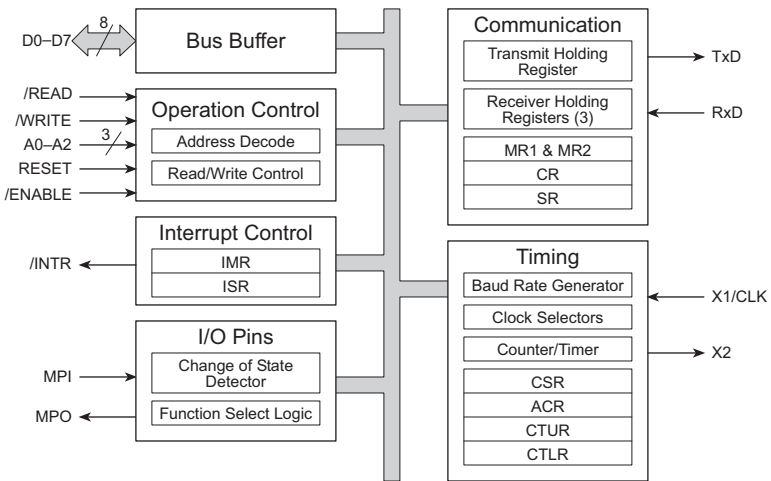


Figure 3-5. SCC2691 Architectural Block Diagram

There are 14 internal registers, 7 of which can be read, and 9 of which can be written, as shown in Table 3-1.

Table 3-1. SCC2691 UART Internal Registers

Address			Read	Write
A2	A1	A0		
0	0	0	MR1, MR2	MR1, MR2
0	0	1	SR	CSR
0	1	0	<i>Reserved</i>	CR
0	1	1	RHR	THR
1	0	0	<i>Reserved</i>	ACR
1	0	1	ISR	IMR
1	1	0	CTU	CTUR
1	1	1	CTL	CTLR

The address bits A2–A0 specify a register only partially. The full determination of which register is accessed depends on the state of the UART. If the UART is being read, one set of registers is addressed. If it is being written, the other set is addressed.

Furthermore, MR1 (mode register 1) is selected when the UART is reset. When MR1 is read or written, the UART switches to MR2, and thereafter uses MR2. (MR1 can be reselected by a command.)

The registers are described below.

MR1, MR2—are mode registers 1 and 2. The mode registers control much of the serial communication to and from the UART.

RxRTS control	RxInt select	error mode	parity mode	parity type	bits per char
---------------	--------------	------------	-------------	-------------	---------------

channel mode	TxRTS control	CTS enable Tx	stop bit length (9/16–2 bits)
--------------	---------------	---------------	-------------------------------

SR—is the channel status register. The upper half of this register represents communication conditions. The lower half represents the condition of the receive and transmit buffers. MR1 bit 6 controls whether FIFO full (FFULL) or Receiver ready (RxRDY) is reported.

received break	framing error	parity error	overrun error	TxE _{MT}	TxR _{DY}	FIFO full	RxR _{DY}
----------------	---------------	--------------	---------------	-------------------	-------------------	-----------	-------------------

CR—is the RS-232 command register.

miscellaneous commands				disable Tx	enable Tx	disable Rx	enable Rx
------------------------	--	--	--	------------	-----------	------------	-----------

The upper half of the CR register represents the commands, listed in Table 3-2, that can be given to the RS-232 channel.

Table 3-2. CR Register Commands for RS-232 Channel

CR[7:4]	Command
0000	No command.
0001	Reset mode register pointer to MR1.
0010	Reset receiver. FIFO is flushed.
0011	Reset transmitter.
0100	Reset error status.
0101	Reset break change interrupt.
0110	Start break. Forces Tx _D output low (spacing).
0111	Stop break.
1000	Start counter/timer. Counter/timer registers must have been loaded.
1001	Stop counter.
1010	Assert /RTS on the MPO pin.
1011	Negate /RTS (on the MPO pin).
1100	Reset MPI change interrupt.
1101	<i>Reserved.</i>
111x	<i>Reserved.</i>

The lower half of the command register disables or enables the receiver and transmitter.

CSR—is the clock select register.

receiver clock select	transmitter clock select
-----------------------	--------------------------

The upper half of the CSR register selects the baud rate of the receiver, while the lower half selects the baud rate of the transmitter. The two sets of baud rates, selectable by ACR bit 7 on the auxiliary control register, are listed in Table 3-3.

Table 3-3. CSR Baud Rates Selected by ACR Bit 7

CSR Code	ACR[7] = 0	ACR[7] = 1
0000	50	50
0001	110	110
0010	134.5	134.5
0011	200	150
0100	300	300
0101	600	600
0110	1,200	1,200
0111	1,050	1,050
1000	2,400	2,400
1001	4,800	4,800
1010	7,200	1,800
1011	9,600	9,600
1100	38,400	19,200
1101	timer	timer
1110	MPI-16X	MPI-16X
1111	MPI-1X	MPI-1X

CTU, CTL, CTUR, CTLR—are the counter/timer registers. Register pairs CTUR/CTLR and CTU/CTL are the upper and lower halves of 16-bit counter/timer values. The counter/timer value is set through CTUR/CTLR and is read through CTU/CTL.

THR—is the transmitter holding register. It holds one character.

RHR—is the receiver holding register. RHR is actually the frontmost entry in a 3-character FIFO queue. (A receiver shift register constitutes the fourth buffer in a quadruple-buffering scheme.)

IMR, ISR—are the interrupt mask register and interrupt status registers.

The interrupt mask register selectively enables or disables interrupts.

MPI change	MPI level	—	counter ready	delta break	RxRDY /FFULL	TxEINT	TxRDY
------------	-----------	---	---------------	-------------	--------------	--------	-------

The interrupt status register can be read to determine what caused the interrupt.

MPI pin change	MPI pin state	—	counter ready	delta break	RxRDY /FFULL	TxEINT	TxRDY
----------------	---------------	---	---------------	-------------	--------------	--------	-------

The upper halves of both the IMR and the ISR reflect the I/O pins and the counter. The lower halves represent the state of RS-232 communication. MR1 bit 6 controls whether FIFO full (FFULL) or Receiver Ready (RxRDY) is reported.

ACR—is the auxiliary control register.

BRG set select	counter/timer mode, source		low power	MPO pin function select
----------------	----------------------------	--	-----------	-------------------------

ACR bit 7 controls which set of baud rates is selected. The CSR (clock select register) specifies one rate from the selected set for the receiver and a separate rate from the selected set for the transmitter.



Refer to the Signetics SCC2691 product description for a description of other bits in this register and in other registers.

Reading and Writing to the UART

The PLCBus cycles have special meaning when addressing an XP8700. Reading or writing to one of the bus registers causes the bus cycle to occur according to Table 3-4.

Table 3-4. XP8700 Bus Cycles

Register	Address	Usage
BUSADR0	0xC8	First address byte.
BUSADR1	0xCA	Second address byte.
BUSADR2	0xCC	Third address byte.
BUSWR	0xCE	Write data to control or data register, whichever was addressed.
BUSRD0	0xC0	Read XP8700 information. Bit 0 (when 0) indicates the presence of a properly addressed XP8700. Bit 1 (when set) indicates that the UART needs servicing. This read is valid only when the board's control register has been addressed.
BUSRD1	0xC2	Read the UART internal register selected by the board's control register. This read is valid only when the board's data register has been addressed.
BUSRESET	0xC6	Resets all expansion cards on the PLCBus. However, an XP8700 does not respond to this. The UART is reset with the RESET bit of the control register.

Controlling the UART

To control the UART on the XP8700, data are sent to, or read data from, one of its internal registers. This uses the XP8700's control and data registers. The control register looks like this.

—	—	/CE	A0	RESET	A1	LT1180 on	A2
---	---	-----	----	-------	----	--------------	----

Table 3-5 explains the meaning of the control bits.

Table 3-5. Explanation of XP8700 Control Register Bits

Bit	Meaning
/CE	Enables the UART chip when low. The UART must be enabled to read from it or write to it.
A0–A2	Select one of the UART's internal registers. The register selection depends also on whether you are reading or writing, and on whether MR1 or MR2 has been selected.
RESET	Resets the UART.
LT1180 on	When set, enables the LT1180 RS-232 driver. When clear, reduces power consumption.

Place one of the constants in Table 3-6 into the XP8700's control register to select a UART internal register. These constants are defined in **UART232.LIB**.

When the UART is reset, it uses MR1 (mode register 1). The UART automatically switches to MR2 whenever MR1 is read or written to, and thereafter uses MR2. You can switch back to MR1 with a command to the command register (CR).

All of the constants in Table 3-6 have bit 1 set to enable the LT1180 chip.

To reset the UART, call `uart_reset()`.

Examples

The following examples suppose that there is one XP8700 on the bus and that its addresses are 0x040018 (control register) and 0x040019 (data register). The examples show the basics. Higher level functions are available.

Table 3-6. XP8700 Control Register Constants to Select UART Internal Register

Name	Internal Register	Usage	A2-A0	Control Value
UART_MR1	Mode reg 1	R/W	000	0x02 = 00 0010
UART_MR2	Mode reg 2	R/W	000	0x02 = 00 0010
UART_SR	Channel status reg	R	001	0x12 = 01 0010
UART_CSR	Clock select reg	W	001	0x12 = 01 0010
UART_CR	Command reg	W	010	0x06 = 00 0110
UART_RHR	Receive holding reg	R	011	0x16 = 01 0110
UART_THR	Transmit holding reg	W	011	0x16 = 01 0110
UART_ACR	Aux control reg	W	100	0x03 = 00 0011
UART_ISR	Interrupt status reg	R	101	0x13 = 01 0011
UART_IMR	Interrupt mask reg	W	101	0x13 = 01 0011
UART_CTU	Counter/timer, upper	R	110	0x07 = 00 0111
UART_CTUR	C/T reload, upper	W	110	0x07 = 00 0111
UART_CTL	Counter/timer, lower	R	111	0x17 = 01 0111
UART_CTLR	C/T reload, lower	W	111	0x17 = 01 0111

Example 1. Write the clock select register (CSR) to set the UART to 9600 bps.

```

ld  a,0x04      ;1st address byte (5x3 mode)
out0 (BUSADR0),a
ld  a,0x00      ;2nd address byte (5x3 mode)
out0 (BUSADR1),a
ld  a,0x18      ;3rd address byte (5x3 mode)
out0 (BUSADR2),a
ld  a,UART_CSR ;UART's clock select register
                ;selected
ld  a,0x19      ;address byte for
out0 (BUSADR2),a ;DATA register, = CTRL+1
ld  a,0xCC      ;9600 baud for receive & transmit
out0 (BUSWR),a

```

Example 2. Read the RHR (receiver holding register).

```
ld    a,0x04      ;1st address byte (5x3 mode)
out0 (BUSADR0),a
ld    a,0x00      ;2nd address byte (5x3 mode)
out0 (BUSADR1),a
ld    a,0x18      ;3rd address byte (5x3 mode)
out0 (BUSADR2),a
ld    a,UART_RHR  ;UART's receive holding register
out0 (BUSWR),a    ;selected
ld    a,0x19      ;address byte for
out0 (BUSADR2),a  ;DATA register, = CTRL+1
in0  (BUSRD1),a   ;get the character from RHR
```

Communicating

The XP8700 can communicate with any RS-232 device such as

- a COM port on a PC,
- a dumb terminal, or
- a modem.

Figure 3-6 shows typical RS-232 communication arrangements for the XP8700.

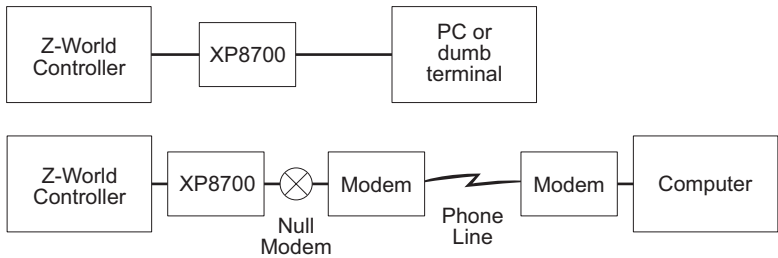



Figure 3-6. Placement of UART in Communication Sequence

Z-World recommends using a Hayes SmartModem or compatible modem. Otherwise, the RTS, CTS and DTR lines must be tied together. A null modem between the XP8700 and the modem takes care of this.

When programming the UART to communicate with a modem, set **ismodem** = 1 when calling **Dinit_uart**. The baud rate must be 2400 bps or 1200 bps. The library software will then handle modem communication commands transparently and pass data directly to the application.

 Refer to Chapter 4, “Software Reference,” for details.

Interrupts

The XP8700 has the capability of interrupting the controller through the INT1 line whenever

- a character has been received (RxRDY), or
- the transmit buffer is empty (TxEMT).

When such an interrupt occurs, the application may check for errors (parity, framing, and overrun errors).

The /AT line of the PLCBus is connected to INT1 of the Z180. Since there may be more than one interrupting device on the PLCBus, Z-World provides a framework for handling more than one device through the same (INT1) line.

The following function from **DRIVERS.LIB** illustrates the framework.

```
#INT_VEC INT1_VEC plcbus_isr
#asm root
plcbus_isr::
    push af ;protect general registers
    in0 a,(CBR) ;and save CBR
    push af
    push hl
    push bc
    push de
    in0 a,(ITC) ;disable INT1. prevents bus
    and 11111101b ;interrupts on /AT
    out0 (ITC),a ; (ITC=Interrupt Trap Control (x34)

#ifdef USE_UARTEXP
    call Duart_circ_int ;service UART interrupt
#endif

...insert calls to other INT1 service routines here as needed

    in0 a,(ITC) ;enable INT1
    or 00000010b
    out0 (ITC),a
    ei ;enable interrupts
    pop de ;restore general registers
    pop bc
    pop hl
    pop af
    out0 (CBR),a ;and CBR
    pop af
    ret
#endasm
```

The framework consists of a single interrupt service routine (`plcbus_isr`) that responds to the interrupt. It then checks all devices that could possibly have caused the interrupt, and services the devices that need service.

It is also possible to determine whether an XP8700 expansion board is responding to interrupts by executing a BUSRD0 cycle. Use the following sample program with a control register address of 0x040018.

```

ld    a,0x04    ;1st address byte (5x3 mode)
out0  (BUSADR0),a
ld    a,0x00    ;2nd address byte...
out0  (BUSADR1),a
ld    a,0x18    ;3rd address byte...
out0  (BUSADR2),a ;...of CTRL reg
in0   (BUSRD0),a ;get condition bits
and   00000010b ;test for interrupt requests
jp    z,done

      process any interrupts here

done:
      ret

```

Z-World supports Dynamic C programming of a controller through the XP8700 expansion board. Since all expansion boards share the same INT1 interrupt, the following protocol maintains control of the INT1 interrupt.

1. Load the address of the interrupt service routine into vector location 0x18.
2. Place a jump opcode (0xC3) in location 0x17.
3. Place the location of the jump instruction in the INT1 vector location.

The following function and declaration will accomplish this.

```

#INT_VEC 0x18 plcbus_isr    // isr now at 2018
nodebug relocate_int1(){
    *((int*)(0x2000))=0x2017
                                // jump addr in INT1 vector
    *((char*)(0x2017))=0xC3    // jump instr in 2017
}

```

Do not use the above function when generating code to download to ROM or to RAM. Simply make the following declaration.

```

#INT_VEC INT1_VEC plcbus_isr

```

Delays

Delays in the software are implemented with calls to `suspend()` if the real-time kernel is in use (that is, when RUNKERNEL is defined).

Blank



CHAPTER 4: SOFTWARE REFERENCE

Chapter 4 describes the Dynamic C functions used to initialize the XP8700 expansion boards and to control the resulting outputs. The following major sections are included.

- Expansion Board Addresses
- Dynamic C Libraries
- XP8700 Software

Expansion Board Addresses

There are two registers on an XP8700—the control register and the data register. Each is addressable on the PLCBus. The 15-bit address is determined by jumpers across header J1.

J1 can be set four different ways, giving four boards per bus. Each register's address has the following format.

00100 00000 xy00R

where

R = 0 for the control register, 1 for the data register,

x = 0 when pins 3–4 on J1 are connected, and

y = 0 when pins 1–2 on J1 are connected.

The 15-bit address can be placed on the bus using the functions `set24adr`, `read24datax`, and `write24data` in `DRIVERS.LIB`.

Logical Addresses

PLCBus expansion boards have “logical addresses.” RS-232-specific software defines four integer board addresses, 0–3. The following formula maps the physical address to the logical address.

logical address = xy

where x and y (jumper bits) are defined above. For example, consider an XP8700 with pins 1–2 on J1 connected. This is the physical address of its control register.

00100 00000 xy000 = 00100 00000 10000

The XP8700's logical address is $10_{\text{B}} = 2$.

Table 4-1 shows how to address the registers on the four XP8700s that can exist on a single PLCBus.

Table 4-1. XP8700 Register Addresses

Header J1		Logical Address	Control Register	Data Register
pins 1–2	pins 3–4			
connected	connected	0	0x040000	0x040001
unconnected	connected	1	0x040008	0x040009
connected	unconnected	2	0x040010	0x040011
unconnected	unconnected.	3	0x040018	0x040019

The 15-bit addresses are placed on the bus as 3 bytes using the lower 5 bits of each byte. In each case, data address = control address + 1.

Dynamic C Libraries

Several Dynamic C function libraries contain the software functions described in this chapter. The chart in Table 4-2 identifies which libraries must be used with particular Z-World controllers.

Table 4-2. Dynamic C Libraries Required by Z-World Controllers for XP8700 Expansion Boards

Library Needed	Controller
DRIVERS.LIB	BL1200, BL1600, PK2100, PK2200
EZIOCMN.LIB	BL1200, BL1600, PK2100, PK2200
EZIOBDV.LIB	BL1200, BL1600, PK2100, PK2200
EZIOPLC.LIB	BL1200, BL1600, PK2100, PK2200
EZIOPLC2.LIB	BL1700
EZIOBL17.LIB	BL1700
PLC_EXP.LIB	BL1200, BL1600, PK2100, PK2200



The XP8700 expansion board cannot be used as a Dynamic C interface to program the BL1700 controller because the interface is not supported by the BIOS.

Before using one of these libraries in an application, first include the library name in a **#use** command. For example, to use functions in the library **PLC_EXP.LIB**, be sure there is a line at the beginning of the program in the following format.

```
#use plc_exp.lib
```

XP8700 Software

There are several levels of software for operating the XP8700. The basic functions may be found in **DRIVERS.LIB**. Other functions are more specific. The highest level functions relate to serial communication. They support circular buffering, modem communication, and uploading and downloading data. Table 4-3 lists these other libraries.

Table 4-3. XP8700-Related Libraries

Library	Use
UART232.LIB	Used with first XP8700 board connected to BL1200, PK2100, and PK2200 controllers
UART2.LIB	Used with second XP8700 board connected to BL1200, PK2100, and PK2200 controllers
MODEM232.LIB	Support library for other communication libraries
AASCUART.LIB	Operates up to four XP8700 boards for most controllers with 8-bit PLCBus addressing
AASCURT2.LIB	Operates up to four XP8700 boards for controllers with 16-bit PLCBus addressing (e.g., BL1700)

XP8700 addresses are 15-bit addresses encoded in the lower 5 bits of three bytes. When using these functions, interchange the first and third byte of the address. For example, if the bus address is 0x040018, pass 0x180004.

General Functions in DRIVERS.LIB

- **void set24adr(long address)**
Places the 3-byte address on the PLCBus.
- **void set8adr(long address)**
Places the third byte of the address on the PLCBus. This function assumes that the first two bytes of the address have already been sent.
- **void write24data(long address, byte value)**
Writes **value** at the specified bus address. The address will be either that of the XP8700's control register or data register.
- **void write8data(long address, byte value)**
This is an abbreviated form of **write24data**, and is used when only the third byte of the address needs to be sent.

- **int read24data0(long address)**

Returns a value read (using the BUSRD0 cycle) from the specified bus address. The address must be that of the control register.

Bit 0 of the returned value (when 0) indicates that the addressed board actually exists. Bit 1 (when set) indicates that the UART on the board is interrupting.

- **int read8data0(long address)**

This is an abbreviated form of **read24data0**, and is used when only the third byte of the address needs to be sent.

- **int read24data1(long address)**

Returns a value read (using the BUSRD1 cycle) from the specified bus address. The address must be that of the data register.

The data to be read is one of the UART's internal registers, such as the channel status register (SR) or the receiver holding register (RHR).

Specify which register with a prior write to the board's control register.

- **int read8data1(long address)**

This is an abbreviated form of **read24data1**, and is used when only the third byte of the address needs to be sent.

UART Support Functions

- **void uart_reset(long uart_addr)**

Resets the addressed XP8700 at **uart_addr**. Unlike other PLCBus boards, which can be reset by reading BUSRESET, the XP8700 must be reset by pulsing the RESET bit of the board's control register. The minimum reset pulse time is 100 ns.

- **long uart_addr(int logical_board)**

Returns the PLCBus address of the control register of the XP8700 whose logical address is **logical_board**.

- **int find_uart(long uart_addr)**

Returns 1 if an XP8700 exists at the specified address **uart_addr**. Otherwise, the function returns 0.

- **int uart_reg_rd(long uart_addr, char regnum)**

Reads the UART register **regnum** from the SCC on the XP8700 at PLCBus address **uart_addr**. Does not check to see if the board exists. The value **regnum** represents the intended register, and is sent to the board's control register. The codes in **UART232.LIB** can be used. For example, use **UART_SR** to read the channel status register.

The function returns data from the register.

- **void uart_reg_wr(long uart_addr, char regnum, char data)**

Writes **data** to the SCC register **regnum** on the specified XP8700 at PLCBus address **uart_addr**. Does not check to see if the board exists. The value **regnum** represents the intended register, and is sent to the board's control register. The codes in **UART232.LIB** can be used. For example, use **UART_CR** to write to the command register.

- **void uartbinaryset(void)**

Puts the serial receiver in binary mode. This means that *all* characters received are placed in the receive buffer.

- **void uartbinaryreset()**

Places the serial receiver in ASCII mode, where the BACKSPACE character (0x08) is parsed out of the receive buffer. Character echo also resumes if it was selected.

- **int uartmodemstat()**

Returns the status of the modem.

RETURN VALUE: 1 if the modem is in command mode, 0 if the modem is in data mode (i.e., open to communication).

- **int uartmodemset()**

Returns information about modem selection.

RETURN VALUE: 1 if the modem option is selected, otherwise 0.

RS-232 Communication Support

These functions from **UART232.LIB** support RS-232 communication by the XP8700 expansion board. Be sure to include the following definition when using these functions in an application.

```
#define USE_UARTEXP
```

This declaration ensures that the communication service routine **Duart_circ_int** is called within **plcbus_isr**, which responds to PLCBus interrupts.

The **UART232.LIB** library assumes that there is only one XP8700 in the system. Its address is defined as shown here

```
#define UARTADDR 0x040018 // no jumpers at J1
```

This constant must be changed if the XP8700 uses a different address. If there is more than one XP8700, some of the **UART232.LIB** library may have to be rewritten to handle multiple boards.

Call **Dinit_uart** before using any of the other functions described here.

- `int Dinit_uart(char *rbuf, char *tbuf, int rsize, int tsize, char mode, char baud, char ismodem, char isecho)`

Initializes the XP8700 and software for RS-232 communication. This library uses circular receive and transmit buffers, which are allocated by the programmer. This function tells the software what the setup is.

PARAMETERS: **rbuf** is a pointer to the receive buffer.

tbuf pointer to the transmit buffer

rsize is the size, in bytes, of the receive buffer.

tsize is the size, in bytes, of the transmit buffer.

mode selects communication criteria as follows.

bit 0	0	1 stop bit
	1	2 stop bits
bit 1	0	no parity
	1	with parity
bit 2	0	7 data bits
	1	8 data bits
bit 3	0	even parity
	1	odd parity
bit 4	0	no CTS/RTS control
	1	CTS/RTS enabled

baud selects the baud rate in multiples of 1200 bps. Valid multipliers are 1, 2, 4, 8, 16, 24, 32, 48 and 64. Pass a value of 8 to get 9600 bps.

ismodem if 1, modem communication is supported. Otherwise is 0.

isecho if 1, every character is echoed. Otherwise is 0.

If CTS/RTS handshaking is selected, the software negates RTS when the receive buffer is 80% full. It will reassert RTS when the receive buffer falls below 20% capacity.

RETURN VALUE: 1 when the XP8700 is found and initialized, -1 otherwise.

- `int Dread_uart(char *buf, char terminate)`

Copies the contents of the receive buffer to **buf** until the specified terminating character is reached or until the buffer is empty. The terminating character is replaced with a null byte in **buf**.

RETURN VALUE: 1 if it is successful, 0 if the buffer is empty or becomes empty before the terminating character can be found.

- **int Dread_uart1ch(char *data)**

Reads one character from the receive buffer and stores it in location pointed to by **data**.

RETURN VALUE: 1 if successful, 0 if the receive buffer is empty.

- **int Dwrite_uart(char *buf, int count)**

Copies **count** characters from **buf** to the transmit buffer. If the transmitter is not already transmitting, the function initiates transmission.

RETURN VALUE: 1 if successful, 0 if the transmit buffer does not have enough space for **count** bytes.

- **int Dwrite_uart1ch(char data)**

Writes one character (**data**) into the transmit buffer. The function initiates transmission if the transmit interrupt was off.

RETURN VALUE: 1 if successful, 0 if the transmit buffer is full.

- **void Duartsend_prompt()**

Sends CR, LF, and > to the transmit buffer. The assumption here is that the receiver is a “dumb terminal.” The function fails without warning if the transmit buffer is full.

- **void Dkill_uart()**

Resets the XP8700.



The library assumes there is only one board on the bus with an address of 0x040018.

- **void Dreset_uartdbuf()**

- **void Dreset_uarttbuf()**

These functions reset the circular receive and transmit buffers, respectively. Be sure to call **Dinit_uart** at least once before one of these calls. Otherwise the reset functions will use uninitialized pointers.

XMODEM Support

These two functions use the XMODEM protocol.

- **int Dxmodem_uartdown(char *buf, int count)**

Sends (downloads) **count** 128-byte blocks from **buf**.

RETURN VALUE:

0—timed out (no transfer).

1—successful transfer.

2—transfer canceled by receiver.

- **int Dxmodem_uartup(unsigned long address, int *pages, int dest, int(*handler)())**

Receives (uploads) a file using the XMODEM protocol.

PARAMETERS: **address** is the physical address in RAM where the received characters are to be stored. If the receive buffer is created using **xdata**, the base name of the array may be used for the base address. Otherwise, the logical address of the buffer must be converted to a physical address using the library function **phy_adr**.

pages is a pointer to an integer storing the number of 4K blocks that have been transferred.

dest is the destination of the transfer when a RS-485 master-slave network has been set up. If **dest** = 0, the destination is the network master. If **dest** is from 1 to 9, the upload is intended for a network slave.

handler is a pointer to a function that handles the uploaded data. It is the nature of the data that determines what sort of handler is needed. If a handler is not needed, build a handler that does nothing and use it.



Examine **Dxmodem_uartup** in the **UART232.LIB** library for further details.

RETURN VALUE:

- 0—timed out (no transfer).
- 1—successful transfer.
- 2—transfer canceled by sender.

Miscellaneous Functions

These functions are found in **UART232.LIB** and **MODEM232.LIB**.

- **int Dget_modem_command(char *buffer)**
Scans **buffer** for a (Hayes-compatible) modem command.

RETURN VALUE:

- | | |
|-----------------------|--------------------------------|
| -1—no command present | 5—“CONNECT 1200” |
| 0—“OK” | 6—“NO DIALTONE” |
| 1—“CONNECT” | 7—“BUSY” |
| 2—“RING” | 8—“NO ANSWER” |
| 3—“NO CARRIER” | 9—“CONNECT 2400” |
| 4—“ERROR” | 10—“\n” <i>just a new line</i> |



A Hayes SmartModem or compatible modem is recommended. A *null* modem cable is needed between the XP8700 expansion board and the modem. Some modems require that the RTS, CTS, and DTR lines be tied together. The XP8700 does not support DTR.

- **void Drestart_uartmodem()**
Restarts a modem during startup or because of abnormal operation.
- **int Duartmodem_chk(char *buf)**
Checks the buffer **buf** for a valid modem command. **buf** points to a stream terminated by **<CR>** that was copied from the receive buffer.
RETURN VALUE: 0 if a valid modem command is present, -1 otherwise.
- **void Ddelay_1sec()**
void Ddelay_100ms()
void Ddelay_5sec()
Produces a delay of approximately 1 second, 100 ms, or 5 seconds, respectively. The function **Ddelay_1sec** uses **suspend(50)** if **RUNKERNEL** is defined. The function **Ddelay_5sec** calls **Ddelay_1sec** five times.
- **interrupt Duart_circ_int()**
This is the interrupt service routine for the XP8700. The interrupt service routine **plcbus_isr** in **DRIVERS.LIB** responds to the interrupt and calls **Duart_circ_int**.

Sample Project

The sample project presented here demonstrates the use of the XP8700 expansion board in communicating with a dumb terminal. The program solicits “commands” from the dumb terminal. If the command is recognizable, the program performs the command. Otherwise, it simply writes back the input line.

Connecting a dumb terminal to a Z-World controller and being able to issue commands or make inquiries to the controller has obvious advantages. Remember that this is only one of many tasks to which an XP8700 can be applied.

Setting up this demo requires some care and requires that you make your PC operate like a dumb terminal. There is a terminal-emulation program in Windows—**TERMINAL**—that does this. Other programs, such as **PROCOM**, will work too. The instructions that follow are detailed and assume that you are using **TERMINAL** in Windows to emulate a dumb terminal.

Instructions

1. Power up your controller and make sure it is working properly. If you encounter problems, consult the controller's user's manual. Now disconnect power from the controller.
2. Connect the XP8700 to the controller.



See Chapter 2, "Getting Started," for more information on installing expansion boards.

3. Check header J1 on the XP8700. Leave it unjumped.
4. Power up the controller and bring up Dynamic C on your PC. If you encounter problems re-establishing communications between your PC and the controller, consult the controller's user's manual.
5. Open and run the sample program **UARTDEMO.C** that appears below. After a few seconds, the word "Running" will appear in the upper right-hand corner of the screen.
6. Exit from Dynamic C. The sample program will continue to run on the controller. Disconnect the cable from the RS-232 connector on the controller and plug it into the RS-232 jack on the XP8700 expansion board. Use the 10-pin connector or RJ-12 jack, whichever matches the cable you have.
7. Run Windows and start up **TERMINAL**, the terminal emulation program. Make sure that you are communicating at 9600 bps with one stop bit and no parity. If you do not have Windows, use another terminal-emulation program such as **PROCOM**.
8. Type something—anything. The sample program will respond. If you type one of these commands, the controller will execute the command.

help deliver a short help message
time print the time (according to the controller)
date print the date (according to the controller)

If you type anything else, the controller will simply repeat what you typed. Press **ALT-F4** to get out of the Windows **TERMINAL** program. The controller will continue to run the sample program indefinitely until the controller is reset.

Sample Program

This sample program demonstrates the use of the XP8700 expansion board in communicating with a dumb terminal. The program solicits “commands” from the dumb terminal. If the command is recognizable, the program performs the command. Otherwise, it simply writes back the input line.

UARTDEMO.C

```
// globals
#define USE_UARTEXP          // enable uart interrupts
byte baud = 9600/1200; // 9600 baud
byte mode = 0x04; // 1 stop, no parity,
// 7 data, no cts/rts
byte modem = 0; // no modem is connected
byte echo = 1; // chars are echoed.
char tbuf[100]; // transmit buffer
char rbuf[100]; // receive buffer

// prototypes
void interpret_cmd( char* );
void crlf();
main(){
    char buf[100];
    #if BOARD_TYPE==CPLC_BOARD
        uplc_init();
    #endif
    Reset_PBus(); Reset_PBus_Wait();
    relocate_int1();
    Dinit_uart(rbuf,tbuf,100,100,mode,baud,modem,echo);
    while(1)
        Duartsend_prompt(); // CR,LF,">"
        // read command & take action
        while( Dread_uart(buf,ENTER)==0 ){
            interpret( buf );
        }
}

void crlf(){
    Dwrite_uart1ch( ENTER );
    Dwrite_uart1ch( LINEFEED );
    Dwrite_uart1ch( SPACE );
}
```

```

void interpret( char* buf ){
    struct tm x;
    tmc_rd( &x );
    crlf();
    if( strcmp(buf,"help")==0 ){
        Dwrite_uart(
            "Commands are: 'help' 'time' & 'date'",36 );
    }else if( strcmp(buf,"time")==0 ){
        Dwrite_uart( "Time: ",6 );
        Dwrite_uartlch( x.tm_hour/10 + '0' );
        Dwrite_uartlch( x.tm_hour%10 + '0' );
        Dwrite_uartlch( ':' );
        Dwrite_uartlch( x.tm_min /10 + '0' );
        Dwrite_uartlch( x.tm_min %10 + '0' );
        Dwrite_uartlch( ':' );
        Dwrite_uartlch( x.tm_sec /10 + '0' );
        Dwrite_uartlch( x.tm_sec %10 + '0' );
    }else if( strcmp(buf,"date")==0 ){
        Dwrite_uart( "Date: ",6 );
        Dwrite_uartlch( x.tm_mday/10 + '0' );
        Dwrite_uartlch( x.tm_mday%10 + '0' );
        Dwrite_uartlch( '-' );
        Dwrite_uartlch( x.tm_mon /10 + '0' );
        Dwrite_uartlch( x.tm_mon %10 + '0' );
        Dwrite_uartlch( '-' );
        Dwrite_uartlch( x.tm_year/10 + '0' );
        Dwrite_uartlch( x.tm_year%10 + '0' );
    }else{
        Dwrite_uart( buf, strlen(buf) ); //put buf!
    }
}

```

More elaborate sample programs may be found in **UARTREM.C** and **CUARTREM.C** in the Dynamic C **SAMPLES\NETWORK** subdirectory.

Blank

XP8800



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CHAPTER 5: OVERVIEW

Chapter 5 provides an overview and description of the XP8800 motion control expansion boards.

XP8800 Overview

Z-World's XP8800 expansion board may be attached to a Z-World controller with a PLCBus port. The XP8800 does not have the software drivers to enable it to be used with other Z-World controllers.

The XP8800 controls a single axis of motion. Multiple XP8800s may be connected to provide up to four axes of control. The benefit of the XP8800 is that it can handle motor control operations, leaving the master controller free to perform other tasks.

The onboard motor driver IC (UCN5804) is capable of driving 1 A per phase and motor voltages up to 35 V. The driver automatically generates the sequencing for 1-phase, 2-phase, and half-step operations. The XP8800 includes a 16-bit quadrature decoder / counter (HCTL-2016) that can count at speeds up to 3 MHz.

An XP8810 version of the XP8800 expansion board is available. The XP8810 offers optical isolation for the quadrature and sense inputs.



Note that there is a common ground for the board and the inputs. Therefore the optical isolation is not absolute.

Like other Z-World expansion boards, the XP8800 can be installed in modular plastic circuit board holders attached to a DIN rail. The XP8800 can also be mounted, with plastic standoffs, on any surface that will accept screws.

Features

- Continuous (manual), preset (counted), or origin-seeking modes of operation.
- Switching between high-speed and low-speed operation, with or without acceleration and deceleration.
- “Bidirectional” pulse output modes.
- Sensing of origin, end-limit, and slowdown signals.
- Interrupt generation.
- 13-bit (8,191) step rate resolution, 18-bit (256K) counter.
- User-definable output speed range up to 16 kHz.
- Single-phase, dual-phase, and half-step modes.
- 16-bit quadrature decoder/counter.
- Watchdog reset.
- Optional optical isolation for quadrature and sense inputs.



CHAPTER 6: **GETTING STARTED**

Chapter 6 provides instructions for connecting XP8800 expansion boards to a Z-World controller. The following sections are included.

- XP8800 Series Components
- Connecting Expansion Boards to a Z-World Controller
- Setting Expansion Board Addresses

XP8800 Components

The XP8800 stepper motor control expansion board controls a single axis of motion. Figure 6-1 shows the basic layout and orientation of components, headers, and connectors.

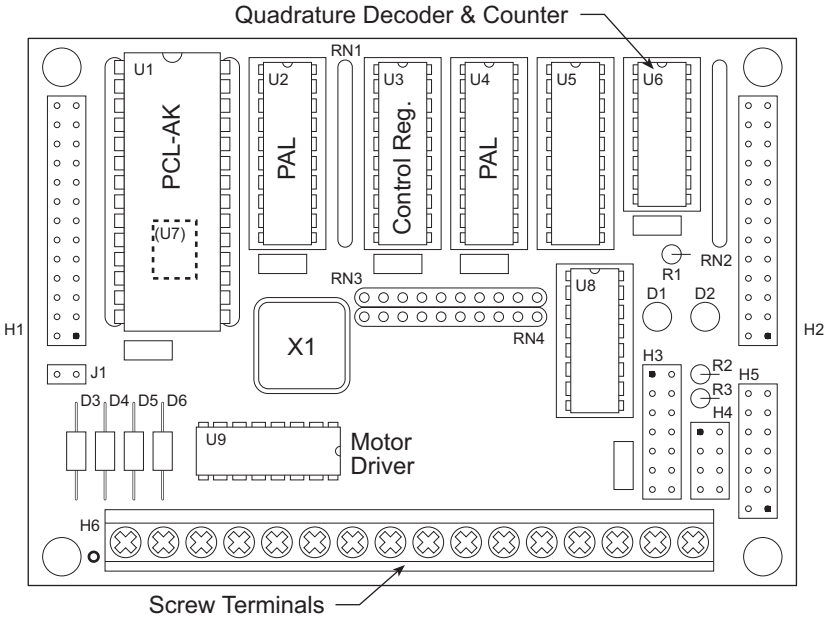


Figure 6-1. XP8800 Board Layout

Connecting Expansion Boards to a Z-World Controller

Use the 26-conductor ribbon cable supplied with an expansion board to connect the expansion board to the PLCBus on a Z-World controller. See Figure 6-2. The expansion board's two 26-pin PLCBus connectors, P1 and P2, are used with the ribbon cable. Z-World recommends using the cable supplied to avoid any connection problems.

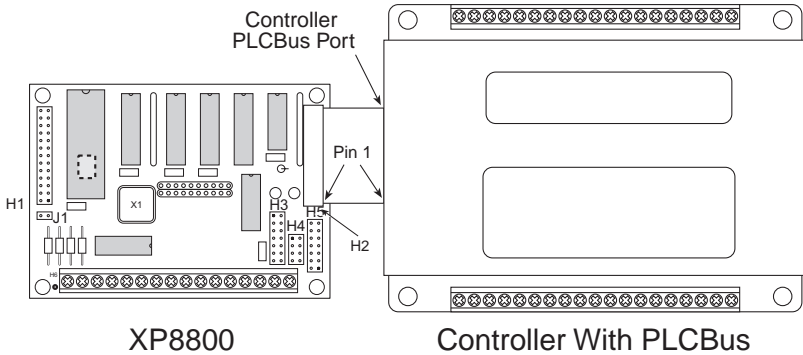


Figure 6-2. Connecting XP8800 Expansion Board to Controller PLCBus



Be sure power to the controller is disconnected before adding any expansion board to the PLCBus.

Follow these steps to connect an expansion board to a Z-World controller.

1. Attach the 26-pin ribbon cable to the expansion board's **P2** or **H2** PLCBus header.
2. Connect the other end of the ribbon cable to the PLCBus port of the controller.



Be sure pin 1 of the connector cable matches up with pin 1 of both the controller and the expansion board(s).

3. If additional expansion boards are to be added, connect header **P2/H2** on the new board to header **P1/H1** of the board that is already connected. Lay the expansion boards side by side with headers P1/H1 and P2/H2 on adjacent boards close together, and make sure that all expansion boards are facing right side up.



See Appendix C, “Connecting and Mounting Multiple Boards,” for more information on connecting multiple expansion boards.

- Each expansion board comes with a factory-default board address. If more than one expansion board of each type is to be used, be sure to set a unique address for each board.



The following section on “Setting Expansion Board Addresses,” and Chapter 8, “Software Reference,” provide details on how to set and use expansion board addresses.

- Power may be applied to the controller once the controller and the expansion boards are properly connected using the PLCBus ribbon cable.

Setting Expansion Board Addresses

Z-World has established an addressing scheme for the PLCBus on its controllers to allow multiple expansion boards to be connected to a controller.



Remember that each expansion board must have a unique PLCBus address if multiple boards are to be connected. If two boards have the same address, communication problems will occur that may go undetected by the controller.

XP8800 Addresses

XP8800 expansion boards are shipped from the factory with no pins on header H4 connected. An XP8800 expansion board may be assigned any one of 16 addresses using jumpers on the pins of header H4. The LED at D2 lights up whenever the XP8800 is addressed on the PLCBus.



See Chapter 8, “Software Reference,” for further details on how to determine the physical address for XP8800 expansion boards.

Power

Z-World’s expansion boards receive power from the controller over the +24 V and VCC lines of the PLCBus. The XP8800 expansion boards use VCC, which is +5 V. The XP8700 draws from 40 mA (quiescent) to a maximum of 105 mA.



CHAPTER 7: I/O CONFIGURATIONS

Chapter 7 describes the built-in flexibility of the XP8800 expansion boards, and describes how to configure the available inputs/outputs. The following sections are included.

- XP8800 Series Pin Assignments
- Using D/A Converter Boards

XP8800 Pin Assignments

External connections are made to the XP8800 expansion board using H5, a 14-pin header, and H6, a 16-screw terminal block. Figure 7-1 shows the pin assignments.

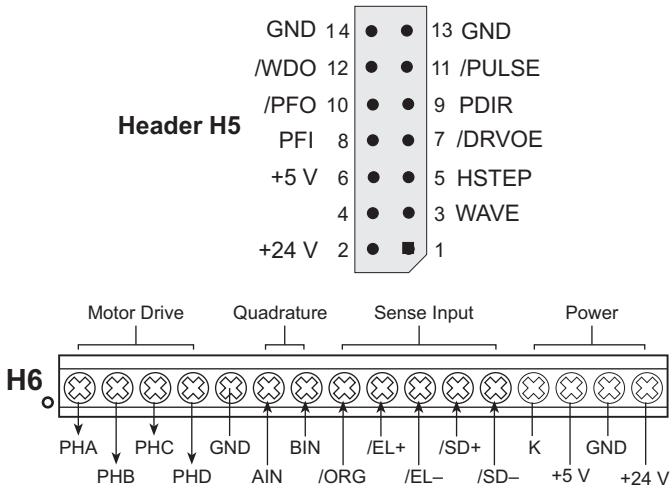


Figure 7-1. XP8800 Output Header H5 and Terminal Block H6

Header H5 Signals

H5 provides connection points for motor control signals, power and ground, power failure, and watchdog signals. The motor control signals are usually used with an amplifier to drive the motor.

/DRVOE—A low signal enables output from the TTL motor driver IC.

GND—is the PLCBus ground, common to the entire system.



Connect the motor power supply ground only to **GND** on the screw terminal block (H6).

HSTEP—Together with the **WAVE** signal, **HSTEP** determines the operation of the TTL motor driver IC: single-phase, two-phase, or half-step.

PDIR—This signal indicates in which direction the TTL motor driver IC is to move. A high level means movement in the + direction. A low level means movement in the – direction.

PFI—is an analog signal input to the power-fail comparator. The **/PFO** line becomes active when **PFI** drops below 1.25 V (± 0.05 V).

/PFO—is the open-collector power-failure indicator. **/PFO** goes low when **PFI** goes below 1.25 V (± 0.05 V). **/PFO** can be connected to the NMI or interrupt line on the master controller.

/PULSE —A low pulse on this line signals a one-step move to the TTL motor driver IC.

WAVE—Together with the **HSTEP** signal, **WAVE** determines the operation of the TTL motor driver IC: single-phase, two-phase, or half-step.

/WDO—This is the active low, open-collector watchdog output line. When the watchdog is enabled, this line will go low—upon a watchdog timeout—to generate a hard reset at the PCL-AK pulse generator.

+5 V—is the regulated PLCBus +5 V digital power supply. This supply should not be used for motor power, but can be used to power external logic.

+24 V—is the unregulated PLCBus +24 V supply. Though nominally 24 V, this can be anywhere from 9 V to 30 V DC. This supply may be used to drive the motor if the controller's power supply can handle the current requirements.

Screw Terminal Block H6 Signals

PHA, PHB, PHC, PHD—are the open-collector motor control outputs. They connect to the motor phase lines, and can sink up to 1 A, depending on the ambient temperature.

AIN, BIN—are the TTL-compatible quadrature-encoded input signals.

/ORG—is the active-low origin pulse input. **/ORG** goes directly to the PCL-AK pulse generator, thereby allowing the PCL-AK to generate pulses until it receives an origin signal. **/ORG** is readable in the PCL-AK (address 0) status bits.

/EL+, /EL- —are the active-low end-limit inputs, one for the + direction, the other for the – direction. These signals go directly to PCL-AK pulse generator, where they are typically used to indicate end-of-travel, usually to stop pulse generation. These signals are readable in the PCL-AK (address 0) status bits.

/SD+, /SD- —are the active-low “slowdown” inputs, one for the + direction, the other for the – direction. These signals go directly to PCL-AK pulse generator, where they are typically used to force the PCL-AK to decelerate to its slower speed. These signals are readable in the PCL-AK (address 3) status bits.

K—is protection for the driver chip. **K** is connected to the motor control voltage source through protective diodes.



Be sure to connect **K** to the motor's voltage source. Damage can occur or performance can degrade if this connection is not made.

+5 V—is the regulated PLCBus +5 V digital power supply. This supply should not be used for motor power, but can be used to power external logic.

+24 V—is the unregulated PLCBus +24 V supply. Though nominally 24 V, this can be anywhere from 9 V to 30 V DC. This supply may be used to drive the motor if the controller's power supply can handle the current requirements.

GND—is the PLCBus ground, common to the entire system. The motor's power supply ground should be connected here only. There are two **GND** connections on H6.

Sample XP8800 Connections

Figure 7-2 shows an example of a stepper motor connected to an XP8800 expansion board.

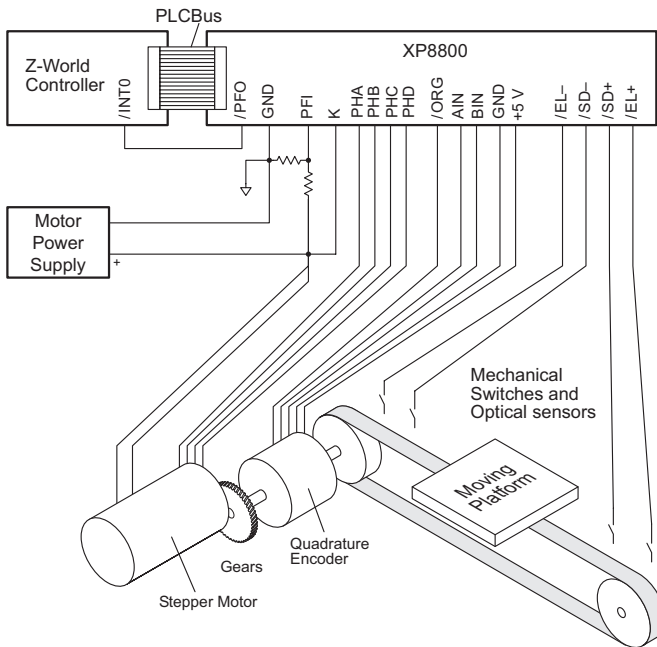


Figure 7-2. Sample Stepper Motor Connection to XP8800

Optional Optical Isolation

The quadrature and sense inputs (AIN, BIN, /ORG, /EL+, /EL-, /SD+, and /SD-) may be optically isolated, as shown in Figure 7-3. The XP8810 version of the XP8800 expansion board features this optical isolation.

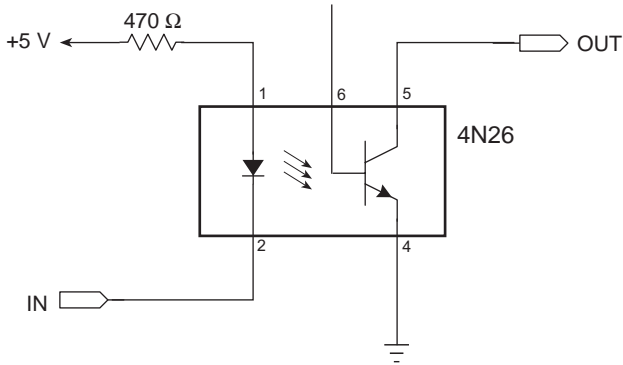


Figure 3-4. XP8810 Optical Isolation Circuit



Note that there is a common ground for the board and the inputs so that the optical isolation is not absolute.

Using Expansion Boards

The following steps summarize how to use the XP8800 boards.

1. Send a reset command to the PLCBus.
2. Place the address of the XP8800 registers on the PLCBus. The address will actually be the address of one of the components, the PCL-AK pulse generator, or the quadrature decoder/counter.
3. Operate the XP8800. The following operations are the ones done most frequently.
 - Set XP8800 control register.
 - Issue command to PCL-AK pulse generator.
 - Set PCL-AK parameters or read PCL-AK registers or status.
 - Reset the quadrature counter or read its value.
 - Wait for interrupt requests.
4. Once the XP8800 operation is done, issue a soft reset to the PCL-AK pulse generator.

The Dynamic C **STEP.LIB** library handles the details of operating the XP8800.

Resetting XP8800 Expansion Boards

There are many ways to reset the XP8800 and its components.

1. Power-Up Reset

On power-up, both the PCL-AK pulse generator chip and the quadrature decoder/counter undergo a hardware reset.

The control register powers up to an unknown state, making it necessary for the application to initialize the control register before using anything else on the board. (Use the function **sm_find_boards** to do this.)

2. PLCBus Reset

A PLCBus reset command strobes both the PCL-AK and quadrature decoder/counter reset lines, forcing hardware resets for both. The control register and motor driver IC are not affected by a PLCBus reset.

3. Watchdog Reset

The watchdog timer is a safety feature that halts the PCL-AK (and therefore motion) in the event of a system crash. When the watchdog is turned on, the application must “hit” the watchdog at least every 1.5 seconds. The watchdog is “hit” every time the application reads the quadrature counter (the actual chip need not be present), writes the control register, or calls the function **sm_hitwd**. The quadrature counter is *not* reset in the event of a watchdog timeout.

Once reset this way, the PCL-AK pulse generator chip will stay reset until the application hits the watchdog again. Connecting the jumper on header J1 enables the watchdog. The watchdog is disabled if this jumper is not connected.

4. PCL-AK Reset

In addition to the watchdog reset and the power-up reset, there are two other ways to reset the PCL-AK pulse generator:

To achieve a hardware reset, drive the PCL-AK reset line low. This line is connected to the control register (bit 1). A hardware reset halts all activity of the controller and resets all internal counters and registers. The function **smc_hardreset** will pulse this line and generate the reset.

To achieve a software reset, write a reset command to the controller. A software reset immediately stops pulse generation and deactivates the PCL-AK's interrupt request line if it is active. The contents of PCL-AK registers are not affected. A software reset is typically used at the end of a programmed operation that generates an interrupt when it finishes. The function **smc_softreset** is used to generate a software reset.

5. Quadrature Counter Reset

The quadrature counter is reset to zero on power-up. Use the function **smq_hardreset** at any time to reset the quadrature counter.

XP8800 Operation

The XP8800 has these three major components.

1. PCL-AK pulse generator.
2. UCN5804 motor driver.
3. HCTL-2016 quadrature decoder/counter.

These components are coupled with a control register (U3) and control logic (U2, U4), as shown in Figure 7-4. One or more of these components may be left unused. For example, the XP8800 can be used solely as a quadrature counter by ignoring the PCL-AK and the motor driver ICs. The XP8800 can even be used as a timer by ignoring or disabling its outputs.

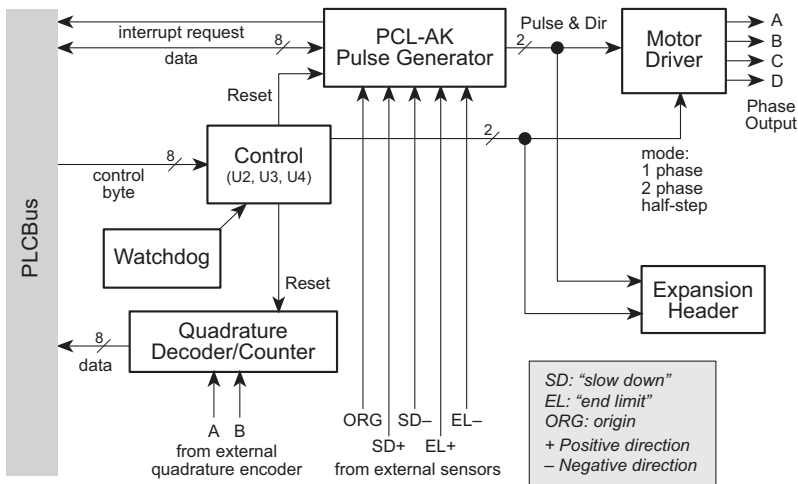


Figure 7-4. XP8800 Block Diagram

PCL-AK Pulse Generator

The PCL-AK pulse generator at the heart of the XP8800 controls the motor driver IC. The bidirectional /PULSE output signal steps a motor. If PDIR is 1, the move is in the + direction, 0 means the move is in the – direction. The PCL-AK can generate thousands of different pulse rates.

The PCL-AK can sense external signals such as “slow down,” “end limit,” and “origin,” and can accelerate and decelerate the motor driver IC between high-speed and low-speed settings. The PCL-AK is able to generate interrupt requests in response to certain conditions such as the end of the operation. The PCL-AK chip can signal the stepper motor to stop immediately or decelerate to a stop.

The PCL-AK has the following three basic modes of operation.

1. Continuous Mode—The PCL-AK continues to generate pulses until instructed to stop or an external signal arrives.
2. Preset Mode—The PCL-AK generates pulses until its preset counter decrements to 0 or an external signal arrives.
3. Origin Mode—The PCL-AK generates pulses until an “origin” pulse arrives.
4. Stop Mode—The PCL-AK either generates pulses for the stepper motor chip to bring the stepper motor to an immediate stop or it generates pulses leading to a deceleration to a stop.

Figure 7-5 shows a block diagram of the PCL-AK.

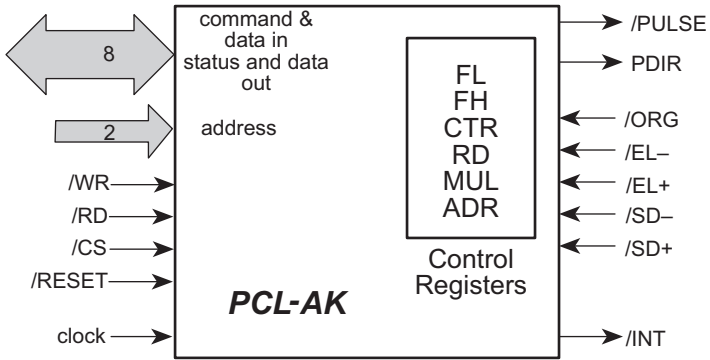


Figure 7-5. Block Diagram of PCL-AK Pulse Generator Chip

Communicating with the PCL-AK

The PCL-AK is controlled by writing to its command buffer and by writing values to its control registers. The chip can be monitored to find out what it is doing by reading the status register or a control register. Only the counter and ramp-down point registers are readable.

The internal registers of the PCL-AK can be reset by pulsing the /RESET line. A software reset does not reset the internal registers.

Table 7-1 provides the meanings for commands used with the PCL-AK.

Table 7-1. PCL-AK Commands

PCL-AK Signals					Meaning
/CS	A1	A0	/RD	/WR	
0	0	0	1	0	Write command buffer.
0	0	1	1	0	Write register bits 0–7.
0	1	0	1	0	Write bits 8–15.
0	1	1	1	0	Write register bits 16–17 (counter).
0	0	0	0	1	Read status.
0	0	1	0	1	Read register bits 0–7.
0	1	0	0	1	Read register bits 8–15.
0	1	1	0	1	Read register bits 16–17 (counter) with assorted status bits.
1	×	×	×	×	D0–D7 at high impedance.
0	×	×	0	0	Inhibit.

Registers

Table 7-2 lists the PCL-AK registers.

Table 7-2. PCL-AK Registers

Register	Bits	Description
CTR	18	Down counter, gives the number of pulses to generate for Preset Mode. This register is readable. When read, it gives the number of remaining pulses.
FL	13	Low frequency from which to accelerate or decelerate.
FH	13	High frequency from which to decelerate or accelerate.
ADR	10	Acceleration/deceleration rate.
RD	16	Ramp-down point. When the PCL-AK is generating pulses in the Preset Mode, the ramp-down point is the point (number of pulses before end-of-count) at which the PCL-AK will start ramping down (decelerating) from high speed to low speed. This register is readable.
MUL	10	Multiplier register, interacts with FL and FH to give various pulse rates.

Acceleration/Deceleration Rate (ADR) Register

The ADR register—with settings from 2 to 1023—governs the ramping-up (acceleration) and ramping-down (deceleration) characteristics. When started in a high-speed mode, the PCL-AK pulse generator starts with the speed set in the FL register and accelerates to reach the speed set in the FH register.

The Z-World reference clock frequency is 6 MHz. Thus, a clock period is 1/6 μ s. The time it takes to accelerate or decelerate is

$$T_{\text{RAMP}} = (FH - FL) \times (\text{rate in ADR}) / 6 \mu\text{s}.$$

The relationship between acceleration and the rate in ADR is

$$\text{acceleration} = \frac{\text{CLOCK}}{\text{rate in ADR}} \text{ pulses/s}^2.$$

The stepper motor might not operate if the ADR rate is too small because the acceleration will then be too fast.

The relationship between the value of a speed register (FL or FH varies from 1 to 8191) and the actual output frequency of PCK-AL is

$$V_{\text{HIGH}} = \frac{FH}{8192} \times \frac{\text{CLOCK}}{\text{MUL}} \text{ pulses/s}.$$

$$V_{\text{LOW}} = \frac{FL}{8192} \times \frac{\text{CLOCK}}{\text{MUL}} \text{ pulses/s}.$$

The term MUL is the value of the multiplier register, and can be from 2 to 1023. With Z-World's 6 MHz reference clock, MUL = 732 (732.421875 rounded off).

Referring to Figure 7-6, the number of pulses output during T_{DEC} is represented by the area of the shaded trapezoid.

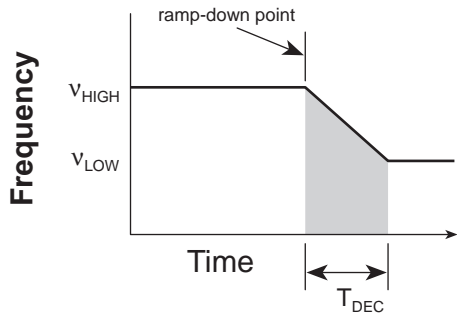


Figure 7-6. Calculating the Number of Pulses

$$\begin{aligned} \text{Number of pulses} &= \frac{(V_{\text{HIGH}} + V_{\text{LOW}}) \times T_{\text{DEC}}}{2} \text{ pulses} \\ &= \frac{(FH^2 - FL^2) \times \text{ADR}}{16,384 \times \text{MUL}} \text{ pulses.} \end{aligned}$$

Status Bits

Status bits are available at PCL-AK address 0 and 3. The status bits for address 0 are explained below.

D7	D6	D5	D4	D3	D2	D1	D0
----	----	----	----	----	----	----	----

- D0 1—**/EL-** (end limit) signal
- D1 1—**/EL+** signal
- D2 1—**/ORG** (origin) signal
- D3 1—counter output = 0
- D4 1—ramp-down point register (**RD**) selected
0—other register selected
- D5 1—frequency stabilized after ramp down or ramp up
- D6 1—operation in progress
- D7 0—**/INT** (interrupt request) active

Bits 0 and 1 of the address 3 status depend on whether the RD (ramp-down point) register was selected prior to reading the status. The status bits for address 3 are explained below.

- D0 If **RD** register is selected
0—stop interrupt signal is being output
else—bit 16 of counter is output
- D1 If **RD** register is selected
0—ramp-down point interrupt signal is being output
else—bit 17 of counter is output
- D2 1—**/SD-** (slow down) signal
- D3 1—**/SD+** signal
- D4 1—Ramp up in progress
- D5 1—Ramp down in progress
- D6 1—counter < ramp-down point
- D7 0—**/PULSE** signal is not active
1—**/PULSE** signal is active



See Z-World Technical Note 101, *Operating the PCL-AK High-Speed Pulse Generator*, for more information on the PCL-AK chip.

UCN5804 Motor Driver IC

The motor driver chip (UCN5804) receives two pulse signals from the PCL-AK pulse generator. One signal, /PULSE, steps the motor. The other signal, PDIR, specifies the motor rotation (high = forward, low = reverse).

The driver receives two mode signals from the control register. Their meanings are summarized in Table 7-3. The 0s in the table indicate that the driver line is ON, that is, it is sinking current.

Table 7-3. Motor Driver Chip Modes

Bit 7	Bit 6	Mode
0	0	Two phase
0	1	Half-step
1	0	Single phase
1	1	Undefined—Do not use

The motor driver chip generates phase signals A, B, C, and D to produce these modes according to the chart in Figure 7-7. The top line of each sequence indicates the state of the driver at power-up.

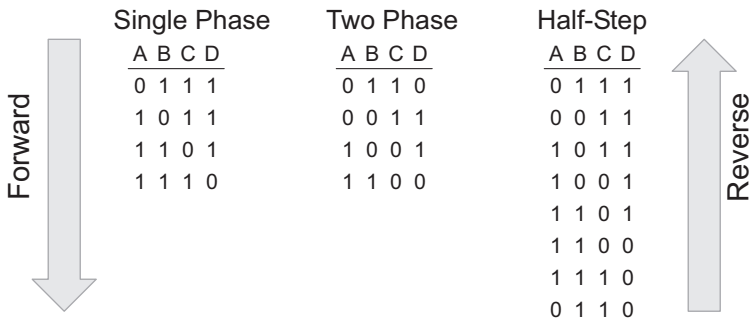


Figure 7-7. Illustration of Phase Signals A, B, C, and D Produced by Motor Driver Chip

Figure 7-8 shows how the phase lines are connected to the motor's windings.

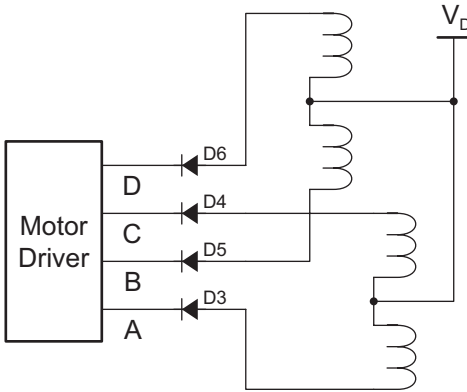


Figure 7-8. Connection of Phase Lines to Motor

Driver Power

To select a voltage for the motor driver chip, be sure to consider the various losses in the drive circuit, including the collector/emitter voltage and the voltage of the blocking diode. Figure 7-9 illustrates these voltages.

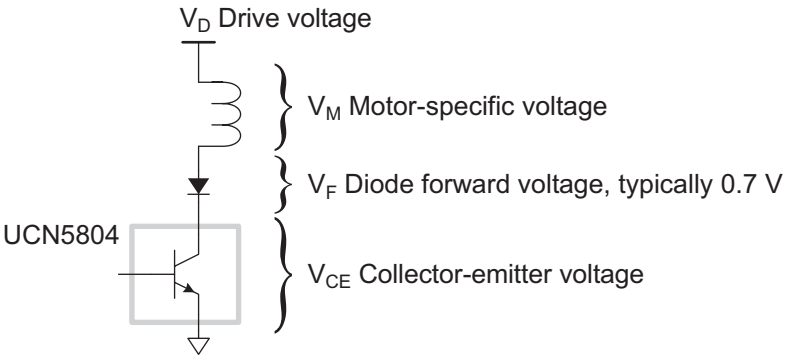


Figure 7-9. Voltage Drops Associated with UCN5804 Motor Driver Chip

Table 7-4 lists typical ratings for the UCN5804 motor driver chip.

Table 7-4. Typical Ratings UCN5804 Motor Driver IC

I_D	V_{CE}
0.7 A	1.0 V
1.0 A	1.1 V
1.25 A	1.2 V

For example, consider a 5 V, 1 A motor.

$$\begin{aligned} V_D &= V_M + V_{CE} + V_F \\ &= 5 \text{ V} + 1.1 \text{ V} + 0.7 \text{ V} \\ &= 6.8 \text{ V} \end{aligned}$$

You would need a 6.8 V, 2 A power supply (for 2-phase drive) in addition to the power required by the logic.



Remember to connect the K line on the screw connector block (H6) to the high side of the drive voltage.

Quadrature Decoder/Counter

The HCTL-2016 is a 16-bit quadrature decoder and counter. Its two lines, A and B, accept two quadrature encoded signals, that is, two square waves 90° out of phase. The order in which these signals make transitions determines the direction that is counted. Figure 7-10 illustrates this counting operation.

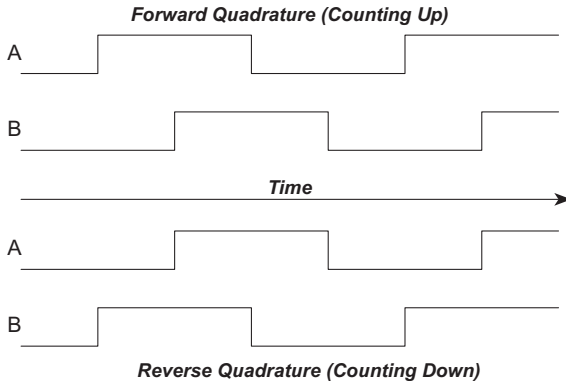


Figure 7-10. HCTL-2016 Quadrature Counting Operation

There are four states of lines A and B, as shown in Figure 7-11. The counter counts up or down, depending on the state transition.

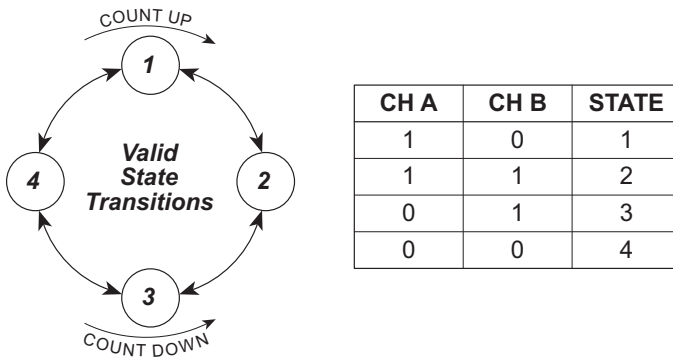


Figure 7-11. HCTL-2016 Quadrature Counting Operation

The speed at which the counter can operate is limited by the reference clock (12 MHz). The counter can operate at up to one quarter of this frequency. Thus, the maximum reliable counting frequency is 3 MHz.

The counter can be read as two successive bytes.

Control Register

The control register is an 8-bit write-only latch that controls the operation of the XP8800. Table 7-5 explains the meaning of each bit in the register (bit 0 is the least significant bit).

Table 7-5. Control Register Bits

Bit	Name	Meaning
0	RESCNT	Reset quadrature decoder/counter. Low means reset.
1	RESCTL	Reset the PCL-AK. Low means reset.
2	LED	LED. Low means ON.
3	SEL0	Local address line.
4	SEL1	Local address line.
5	DRVOE	Enable motor driver IC output. Low means ON.
6	HSTEP	Half-step mode for motor driver IC when this bit is 1 and bit 7 is 0.
7	WAVE	<ul style="list-style-type: none"> • Single-phase mode for motor driver IC when this bit is 1 and bit 6 is 0. • Two-phase mode when this bit is 0 and bit 6 is 0.

The select lines SEL0 and SEL1 have a specific meaning. They are connected to the two address lines of the PCL-AK pulse generator. SEL0 is also connected to the quadrature decoder/counter. Coupled with PAL logic, these select lines allow you to read and write to the PCL-AK and to read the 16-bit counter value. (The function library **STEP.LIB** takes care of the details.)

PLCBus Interrupts

Be careful when processing interrupts from the PLCBus. Interrupts can come from any source, including other expansion boards. A PLCBus interrupt service routine must determine where the interrupt originated and what to do.

Blank



CHAPTER 8: SOFTWARE REFERENCE

Chapter 8 describes the Dynamic C functions used to initialize the XP8800 Series expansion boards and to control the resulting outputs. The following major sections are included.

- Expansion Board Addresses
- Dynamic C Libraries
- XP8800 Software

Expansion Board Addresses

Up to 16 XP8800 addresses are possible on the PLCBus. Power constraints usually limit the number of XP8800 expansion boards to four, allowing four axes of control.

Each XP8800 has three addressable components: the PCL-AK pulse generator, the quadrature decoder/counter, and the control register. The address of a particular XP8800 is determined by jumpers on header H4 as shown here.

abcd1100 x0000Rxx

where

a = 0 if H4 pins 1–2 are connected, and 1 if not

b = 0 if H4 pins 3–4 are connected, and 1 if not

c = 0 if H4 pins 5–6 are connected, and 1 if not

d = 0 if H4 pins 7–8 are connected, and 1 if not

x = does not matter

R = 0 to read or write PCL-AK pulse generator

 = 1 to read the quadrature counter

 = 1 to write the control register

The address is placed on the PLCBus as 2 bytes using two bus cycles, BUSADR0 and BUSADR1. The lower four bits of the first byte (1100) identify the address as being 8×2 format.

The address is placed on the bus using the functions **set82adr** and **set81adr**.

The LED (D2) will light up on the XP8800 that matches the address the software placed on the PLCBus.

Examples

1. Write the control register on the XP8800 whose address jumpers are 3 (abcd = 0011).

```
out0 (BUSADR0), 3Ch ; 00111100 1st addr byte
out0 (BUSADR1), 04h ; 00000100 2nd addr byte
Set shadow variable = control register value, then...
out0 (BUSWR), <shadow> ; control bits
```

2. Write a command to the PCL-AK on the XP8800 whose address jumpers are 8 (abcd = 1000).

```
;first, make select lines 00
  out0 (BUSADR0), 3Ch ; 00111100 1st addr byte
  out0 (BUSADR1), 04h ; 00000100 2nd addr byte
  Set shadow variable = AND( shadow variable,
    0xE7 ), then ...
  out0 (BUSWR), <shadow> ; control bits
;now address the PCL-AK and send command
  out0 (BUSADR1), 00h ; 00000000 2nd addr byte
  out0 (BUSWR), <command> ; command
```

3. Read the 16-bit quadrature counter on the XP8800 whose address jumpers are 13 (abcd = 1101).

```
;first, make select lines 00 to get high byte
  out0 (BUSADR0), 3Ch ; 00111100 1st addr byte
  out0 (BUSADR1), 04h ; 00000100 2nd addr byte
  Set shadow variable = AND( shadow variable,
    0xE7 ), then ...
  out0 (BUSWR), <shadow> ; control bits
  in0 <high>, (BUSRD0) ; get high byte
;next, make select lines 01 to get low byte
  Set shadow variable = OR( shadow variable,
    0x08 ), then ...
  out0 (BUSWR), <shadow> ; control bits
  in0 <low>, (BUSRD0) ; get low byte

Return counter value = high << 8 + low
```

In general there is no need to program the XP8800 at these low levels. Software in the Dynamic C **STEP.LIB** library takes care of these details.

Logical Addresses

Software in the Dynamic C **STEP.LIB** library keeps information for all XP8800s on the PLCBus in a table, sorted by XP8800 address. Thus, XP8800s have “logical addresses” that are simply indexes in the table.

For example, suppose there are three XP8800s on the PLCBus with addresses of 3 (0011), 8 (1000), and 13 (1101). Table 8-1 shows the table used by the software.

The logical addresses for these 3 boards would be 0, 1, and 2. The physical addresses are stored in the table. The function **sm_find_boards** sets up this table.

**Table 8-1. Example of STEP.LIB
Table for XP8800 Logical Addresses**

Index	Address
0	0011
1	1000
2	1101
marker	—

Dynamic C Libraries

Several Dynamic C function libraries contain the software functions described in this chapter. The chart in Table 8-2 identifies which libraries must be used with particular Z-World controllers.

**Table 8-2. Dynamic C Libraries Required by Z-World Controllers
for XP8800 Expansion Boards**

Library Needed	Controller
DRIVERS.LIB	BL1200, BL1600, PK2100, PK2200
EZIOCMN.LIB	BL1200, BL1600, PK2100, PK2200
EZIOBDV.LIB	BL1200, BL1600, PK2100, PK2200
EZIOPLC.LIB	BL1200, BL1600, PK2100, PK2200
EZIOPLC2.LIB	BL1700
EZIOBL17.LIB	BL1700
PLC_EXP.LIB	BL1200, BL1600, PK2100, PK2200

Before using one of these libraries in an application, first include the library name in a **#use** command. For example, to use functions in the library **PLC_EXP.LIB**, be sure there is a line at the beginning of the program in the following format.

```
#use PLC_EXP.LIB
```

XP8800 Software

The sample programs `SM_DEMO1.C`, `SM_DEMO2.C`, and `SM_DEMO3.C` in the Dynamic C `SAMPLES\PLCBUS` subdirectory illustrate the use of these functions.

The software is designed to simplify the task of using the XP8800 on the PLCBus. Z-World recommends using the software or at least following the guidelines for the software structure.

1. Only access the control register using driver functions. These functions keep track of the shadow variables that prevent inadvertently changing other control lines.
2. Initialize and use the arrays designated for handling multiple board addresses and status. These are described in detail.
3. If using interrupts, make the declaration

```
#define USE_STEPPER
```

early in the main program. This tells the PLCBus interrupt service to call the function `sm_int`.

4. Also, if using interrupts, add the call

```
relocate_int1();
```

This connects the proper PLCBus interrupt service routine to the interrupt vector.

Data Structures

The XP8800 driver software uses a table to represent all the XP8800s in a system. There can be up to four XP8800s, and other PLCBus expansion boards may also be used, subject to power constraints.

Table 4-2 shows how the Dynamic C `STEP.LIB` library assigns and sorts the XP8800 logical addresses. These XP8800 “logical addresses” are simply indexes in the table.

For example, the logical addresses for the three boards in Table 8-1 are 0, 1, and 2. The physical addresses are stored in the table. Call `sm_find_boards` before doing anything else. This function searches the PLCBus and initializes the table to represent the state of the XP8800s.

These four arrays define the table.

```
int sm_addr [17];
char sm_stat [16];
char sm_flag [16];
char sm_shadow[16];
```

The array `sm_addr` holds the PLCBus address of each XP8800 existing on the PLCBus. This array has one extra element, because the software places a marker (address = -1 or 0xFFFF) following the last real board address in the array.

The array `sm_stat` contains copies of the address 0 status bits of the PCL-AK pulse generator for each XP8800 on the PLCBus. The array is updated by the motor control interrupt service routine (ISR) every time a PLCBus interrupt is generated.

The array `sm_flag` is updated at the same time as `sm_stat` and represents whether a board is awaiting service (its interrupt line asserted).

The array `sm_shadow` holds shadow variables for the XP8800 control registers. Control registers are write-only. If software fails to remember how control lines are set, chances are good that control lines will become set incorrectly. The shadow variables provide the memory.

Interrupts

Since the PLCBus has a single shared interrupt line, special care must be taken when servicing interrupts across it. During PLCBus interrupt service, all possible interrupt sources must be checked to see if they are currently awaiting service. These include other PLCBus expansion boards.

The interrupt function `sm_int` polls all XP8800s on the PLCBus and updates the arrays `sm_stat` and `sm_flag` for each. It also sends a software reset to each XP8800 that is asserting an interrupt request. The software reset clears the interrupt request. If this reset is not issued, the system would lock up since the interrupt line would never go inactive.

By including the statement

```
#define USE_STEPPER
```

early in the main program, the PLCBus interrupt service routine will call `sm_int`. Your application should periodically check the status of the interrupt request flags in the `sm_flag` array to determine when to service the XP8800.

Although the function `sm_int` does what it is supposed to do, it probably does not do what you would want it to do. Z-World has provided `sm_int` to demonstrate how to use the XP8800 in an interrupt-driven system. Since `sm_int` requires polling flags to provide service, it is not as efficient as a true interrupt-controlled driver would be. What this function does is guarantee that interrupts generated by a motor controller are serviced so that the PLCBus interrupt is not held active by the controller, locking up the system.

If you wish to do all motor processing in the background, replace the code in the function `sm_int` (between the labels `mirq` and `fin`) with your own code.

XP8800 Driver Functions

Tables 8-3, 8-4, 8-5, 8-6, and 8-7 list the various XP8800 software drivers in the Dynamic C `STEP.LIB` library.

Table 8-3. XP8800 General and Initialization Functions

Type	Function	Description
int	<code>sm_bdaddr</code>	Generates address from jumper value
void	<code>sm_board_reset</code>	Issues full board reset
int	<code>sm_find_boards</code>	Finds and initialize all XP8800s
void	<code>sm_hitwd</code>	Hits watchdog timer
void	<code>sm_int</code>	General ISR for XP8800s
int	<code>sm_poll</code>	Polls specified XP8800

Table 8-4. XP8800 Control Register Functions

Type	Function	Description
void	<code>sm_ctlreg</code>	Writes control register and updates shadow variable
void	<code>sm_drvoe</code>	Turns motor driver IC output on or off
void	<code>sm_led</code>	Turns LED (D1) on or off
void	<code>sm_sel00</code>	Sets select lines to 00
void	<code>sm_sel01</code>	Sets select lines to 01
void	<code>sm_sel10</code>	Sets select lines to 10
void	<code>sm_sel11</code>	Sets select lines to 11

Table 8-5. XP8800 Motor Controller Functions

Type	Function	Description
void	<code>smc_cmd</code>	Writes to PCL-AK command register
void	<code>smc_hardreset</code>	Pulses PCL-AK reset line, registers are reset
void	<code>smc_manual_move</code>	Starts continuous movement, movement continues until told to stop
void	<code>smc_seek_origin</code>	Starts continuous movement, movement continues until origin pulse (/ORG)
void	<code>smc_setmove</code>	Sets PCL-AK registers for a move operation
void	<code>smc_setspeed</code>	Sets PCL-AK's two speed registers
void	<code>smc_softreset</code>	Sends reset command to PCL-AK, registers are not reset
char	<code>smc_stat0</code>	Reads PCL-AK status register (at address 0)
char	<code>smc_stat3</code>	Reads PCL-AK status register (at address 3)

Table 8-6. XP8800 Quadrature Counter Functions

Type	Function	Description
void	<code>smq_hardreset</code>	Pulses quadrature counter reset line
unsigned int	<code>smq_read16</code>	Reads entire 16-bit counter value
char	<code>smq_read8</code>	Reads counter's lower 8 bits

Table 8-7. Miscellaneous XP8800 Functions

Type	Function	Description
void	<code>set81adr</code>	Places XP8800 address on bus (shortcut)
void	<code>set82adr</code>	Places XP8800 address on bus
unsigned int	<code>smcq_moveto</code>	Uses the motor's quadrature decoder to move to location

Miscellaneous XP8800 Function Descriptions

In all the following function descriptions, the parameter **index** is a number from 0 to 15 that represents the sequence of boards found by **sm_find_boards**. The board with the lowest jumper setting is at position 0, and so on.

- **void set82adr(int addr)**

Places the specified address on the PLCBus in 8×2 addressing mode. The term **addr** is a physical board address. Its upper byte must be xxxx1100 (binary), and the lower byte should be 0 to read or write the PCL-AK pulse generator, or 1 to read the quadrature counter or to write the control register. The upper 4 bits of the address correspond to the jumpers on the intended XP8800.

The execution time for this function is 87 cycles, assuming 0 wait states, that is

14.16 μs at 6.144 MHz (71 kHz)

9.44 μs at 9.216 MHz (109 kHz)

- **void set81adr(int addr)**

Places the specified address on the PLCBus in 8×2 addressing mode. The term **addr** is the lower byte a physical board address. This function assumes that the upper byte has already been placed on the bus. The lower byte should be 0 to read or write the PCL-AK pulse generator, or 1 to read the quadrature counter or to write the control register. The main purpose of this function is to save PLCBus cycles.

The execution time for this function is 60 cycles, assuming 0 wait states, that is

9.77 μs at 6.144 MHz (102 kHz)

6.50 μs at 9.216 MHz (154 kHz)

- **int sm_bdaddr(int jumpers)**

Returns the physical PLCBus address for an XP8800 that has the specified jumper settings on header H4. The term **jumpers** must be an integer from 0 to 15.

The function returns the physical PLCBus address in a form directly passable to **set82adr**.

- **void sm_board_reset(int index)**

Performs a hardware reset XP8800 identified by **index**. This resets the PCL-AK pulse generator and the quadrature decoder/counter, and disables the motor driver IC and sets it to two-phase mode. The function also sets the control register's two select lines to 00.

- **void sm_ctlreg(int index, int value)**

Writes **value** to the control register on the XP8800 specified by **index**. The function updates the shadow variable for the control register.

- **void sm_drvoe(int index, int onoff)**

Turns the motor driver IC of the XP8800 specified by **index** on or off. The term **onoff** is Boolean: when zero, the motor driver IC gets turned off. Otherwise, it gets turned on.

- **int sm_find_boards()**

Searches for all possible XP8800s and fills in the XP8800 table, which is sorted according to physical board address. The table holds physical addresses in the array **sm_addr**. The table also holds status bytes and interrupt service flags, which this function initializes.

The function return is the number of boards found. The function places a marker (-1 or 0xFFFF) following the last entry in the table.

The function sends a control register value of 0xA7 (1010 0111) to all XP8800s found. This puts the motor driver IC in two-phase mode and turns it off, makes the select lines 00, turns the LED (D2) on, and resets both the PCL-AK pulse generator and the quadrature counter.

The function return is the number of XP8800 boards on the PLCBus that respond to the search.

The XP8800 table consists of these four arrays.

sm_addr a board's physical PLCBus address.

sm_stat holds the last status (address 0) read from the board's PCL-AK.

sm_flag, when non-zero, indicates the XP8800 has requested an interrupt and is awaiting service.

sm_shadow holds the last value written to the board's control register.

This function is among the first to call when operating XP8800 expansion boards. After the table is initialized, function calls will generally refer to XP8800s by their *table index*.

- **void sm_hitwd(int index)**

Resets the watchdog timer on the XP8800 specified by **index**. It does this by reading the quadrature counter. (The quadrature chip does not have to be present.)

- **void sm_int()**

This is a general-purpose XP8800 function that can be called by the PLCBus interrupt service routine (ISR). This function checks the status (at PCL-AK address 0) of all boards, updating the **sm_stat** array. When an interrupt request is detected, the appropriate **sm_flag** value is set and the function issues a software reset to the PCL-AK to deactivate the interrupt request.

The application must then monitor the interrupt service flags to determine when an operation has been completed.

To use this function, do the following.

1. Call **sm_find_boards** at the beginning of the application to initialize the XP8800 table.
2. Add the following statement early in the application to link **sm_int** to the PLCBus ISR.

```
#define USE_STEPPER // activate sm_int
```

3. Add the following statement early in the application to ensure that the PLCBus interrupt line is activated.

```
outport( ITC, (inport(ITC) &0xFD) );  
// enable INT1
```

If all motor processing is to be done in the background (that is, as part of the interrupt service), open and edit **STEP.LIB**. Find **sm_int** and replace the code between the labels **mirq** and **fin** with your own code.

- **void sm_led(int index, int onoff)**

Turns the LED (D1) on the XP8800 specified by **index** on or off. The value **onoff** is Boolean: when zero, the function turns the LED off. Otherwise, it turns the LED on.

- **int sm_poll(unsigned int address)**

Returns 0 if the XP8800 specified by **address** is present (and responding) on the PLCBus. The parameter **address** must be a physical board address, such as that returned by **sm_bdaddr (jumpers)**.

All PLCBus expansion boards respond to a BUSRD1 cycle by sinking data line 0 (normally high). The board is not present if a 1 is returned.

- **void sm_sel00(int index)**

Sets the select lines to 00 on the XP8800 specified by **index**.

- **void sm_sel01(int index)**

Sets the select lines to 01 on the XP8800 specified by **index**.

- **void sm_sell0(int index)**
Sets the select lines to 10 on the XP8800 specified by **index**.
- **void sm_sell1(int index)**
Sets the select lines to 11 on the XP8800 specified by **index**.
- **void smc_cmd(int index, int data)**
Writes **data** to the command register of the PCL-AK pulse generator on the XP8800 specified by **index**.
- **void smc_hardreset(int index)**
Causes a hardware reset of the PCL-AK on the XP8800 specified by **index**. This stops any pulse output (that is, motor movement) and clears the internal registers of the PCL-AK. It does this by giving a negative pulse on bit 1 of the control register.
- **void smc_manual_move(int index, int dir, int speed)**
Starts a manual (or continuous) move operation on the XP8800 specified by **index**. The motor will move until the application issues a decelerating stop command, a software or hardware reset, or until the application detects an end-limit or origin signal (if these are enabled).
The terms **dir** and **speed** are Boolean. If **dir** is non-zero, movement is in the “+” direction. Otherwise, movement is in the “-” direction. If **speed** is zero, the PCL-AK pulse generator operates at low speed. (Pulses are generated at the rate in the FL register.) Otherwise, the PCL-AK pulse generator operates at high speed. (Pulses are generated at the rate in the FH register.)
It is important to note that this function starts the movement and *does not wait* for the movement to complete. The application may then perform other tasks while the movement takes place.
- **void smc_seek_origin(int index, int dir, int speed)**
Starts an “origin mode” operation on the XP8800 specified by **index**. The PCL-AK will generate pulses, expecting an origin pulse to occur. The motor will move until the application issues a decelerating stop command, a software or hardware reset, or until the application detects an end-limit or origin signal (if these are enabled).
The terms **dir** and **speed** are Boolean. If **dir** is non-zero, movement is in the “+” direction. Otherwise, movement is in the “-” direction. If **speed** is zero, the PCL-AK pulse generator operates at low speed.

(Pulses are generated at the rate in the FL register.) Otherwise, the PCL-AK pulse generator operates at high speed. (Pulses are generated at the rate in the FH register.)

It is important to note that this function starts the movement and *does not wait* for the movement to complete. The application may then perform other tasks while the movement takes place.

The function issues a software reset to the board before proceeding.

- **void smc_setmove(int index, long CTR, int FL, int FH, int ADR, int RD, int MUL)**

Sets up the registers of the PCL-AK pulse generator on the XP8800 specified by **index**. The meaning of the registers (listed in Table 7-2) and their interaction is complex.



See Z-World Technical Note 101, *Operating the PLC-AK High-Speed Pulse Generator*, for more information on the PCL-AK chip.

When the value of the MUL register is 732, the values of the FL and FH registers approximate “pulses per second,” that is, when $MUL = 732$, the actual pulse frequency is

$$freq_H = FH \times 1.000576331967 \text{ pulses per second}$$

$$freq_L = FL \times 1.000576331967 \text{ pulses per second}$$

- **void smc_setspeed(int index, int fast, int slow)**

Sets the high (FH) and low (FL) speed registers of PCL-AK pulse generator on the XP8800 specified by **index**. The parameter **fast** is for the FH register and the parameter **slow** is for the FL register. Both must be in the range 1–8191.

- **void smc_softreset(int index)**

Sends a software reset command to the PCL-AK pulse generator on the XP8800 specified by **index**. This stops pulse output (and therefore, motion) without clearing the internal registers.

- **char smc_stat0(int index)**

Reads the 8-bit status register at address 0 ($A1 = A0 = 0$) on the PCL-AK pulse generator on the XP8800 specified by **index**. The function returns the status bits D0–D7 explained in Chapter 7, “Status Bits.”

- **char smc_stat3(int index)**

Reads the 8-bit status register at address 3 (A1 = A0 = 1) of the PCL-AK pulse generator on the XP8800 specified by **index**. If the RD register (ramp-down point) is selected before reading the status with address = 3, bits 0 and 1 are status bits. If any other register is selected, bits 0 and 1 represent bits 16 and 17, respectively, of the counter register.

The function returns the status bits D0–D7 explained in Chapter 7, “Status Bits.”

- **unsigned int smcq_moveto(int index, unsigned dest, int dir, unsigned accuracy)**

Steps the motor on the XP8800 specified by **index** until the quadrature decoder/counter reaches the specified **dest** ± **accuracy**. The movement is done at the slow rate (specified in the FL register) of the PCL-AK pulse generator. The movement continues until the quadrature counter reaches the “zone of acceptance” and then stops.

The parameter **dir** is Boolean: if non-zero, motion is in the “+” direction. Otherwise, motion is in the “-” direction.

The function returns the reading of the quadrature counter when the function finally stops motion. Inertia and step locations may make this value different from the final resting place of the motor’s encoder.

The function issues a software reset to the PCL-AK following the operation.

Example

```
main() {
    ...
    uplc_init();           // init master
    sm_find_boards();     // init all XP8800s
    smc_setspeed(0,100,200); // move at 200 pps
    smcq_moveto(0,5000,1,25); // to location 5000±25
    delay to allow time for motor to stop fully
    loc=smq_read16(0);    // check final pos
    if(loc>5025) {        // overshoot?
        smc_setspeed(0,100,20); // move back at 20 pps
        smcq_moveto(0,5000,0,25); // to location 5000±25
    }
    ...
}
```



The function `smcq_moveto` is not a PID loop. It is the application's responsibility to manage the final position of the motor. The move speed, encoder resolution, and motor degrees/phase will affect how precise you can get. It is possible to miss a stop point if you specify too much precision. Read the quadrature counter after the operation (allowing time for the motor to come to a stop) to obtain its correct location.

- **`void smcq_hardreset(int index)`**

Sends a hardware reset command to the quadrature counter on the XP8800 specified by `index`. The function resets the counter to zero.

- **`unsigned int smcq_read16(int index)`**

Returns the entire 16-bit value of the quadrature counter on the XP8800 specified by `index`.

- **`char smcq_read8(int index);`**

Returns the lower 8 bits of the quadrature counter on the XP8800 specified by `index`, a number from 0 to 15 as in `smcq_read16`.

Sample Program

The sample program simulates a single-axis system with end-limit and slowdown sensors in both directions.

After initialization, the XP8800 first seeks the origin. Then the motor goes back and forth a few times, moving in one direction until an “end-limit” signal occurs, then switches direction. As the motor moves, it responds to any “slowdown” signal it receives.

The following items are needed to run this program.

- A stepper motor connected to an XP8800 connected, via the PLCBus, to a Z-World PK2200 or PK2100 controller.
- A length of wire or a test probe to connect various signals to ground. This simulates the occurrence of end-limit, slowdown or origin conditions.

The sample program prompts you to make the appropriate connections.

```

/*****
Simulate origin signal.
*****/
void wait_origin( int id ){
#define ORG 0x04          // bit 2
    printf("Connect /ORG to GND ");
    printf("to simulate origin signal... ");
    while(!( smc_stat0(id) & ORG )) runwatch();
    printf( "ORG detected.\n" );
}
/*****
Simulates end-limit signal. Dir = CW or CCW.
*****/
void wait_EL( int id, int dir ){
    int mask;                // bit 0 for EL-, bit 1 for EL+
    char sign;              // "+" or "-"
    if( dir ){
        mask = 2; sign = '+'; // + direction (CW)
    }else{
        mask = 1; sign = '-'; // - direction (CCW)
    }
    printf( "Connect /EL%c to GND ", sign );
    printf( "to simulate end-limit... ");
    while(!( smc_stat0(id) & mask ))runwatch();
    printf( "end-limit detected.\n" );
}
/*****
#define CCW 0          // counterclockwise direction (-)
#define CW 1          // clockwise direction (+)
*****/
main(){
    int FL = 10;        // low speed 10 pps
    int FH = 100;      // high speed 100 pps
    int ADR = 500;     // accel/decel "rate" = 500
    int MUL = 732;    // makes FL and FH units "pps"
    int ID = 0;        // board index
    int i;
    uplc_init();      // assume PK2200 or PK2100
    Reset_PBus();     // reset PLCBus with delay
    Reset_PBus_Wait();

    // Search PLCBus. Build table
    if( sm_find_boards() == 0 ){
        printf( "No XP8800s." ); exit(0);
    }

    // Use first board. Set up operation
    sm_board_reset( ID );
    sm_drvoe( ID, 1 ); // motor driver on
    sm_led ( ID, 1 ); // LED on
    smc_setmove( ID,0L,FL,FH,ADR,0,MUL );
                                     // registers

```



```

// find origin
smc_seek_origin( ID, CCW, 1 ); // high speed
wait_origin( ID );
smc_softreset( ID );
// back & forth
for( i=0; i<3; i++ ){
// move till EL+ slowing down upon SD+
// 0x42 = 01xx 0010.
// Q-mode: pos. dir. not preset. SDyes. ORGr.
smc_cmd( ID, 0x42 );
// 0x15 = 00x 10 101.
// Start. High-speed. FH register
smc_cmd( ID, 0x15 );
wait_EL( ID, CW ); // wait for EL signal
smc_softreset( ID );
// move till EL- slowing down upon SD-
// 0x4A = 01xx 1010.
// Q-mode: neg. dir. not preset. SDyes. ORGr.
smc_cmd( ID, 0x4A );
// 0x15 = 00x 10 101.
// Start. High-speed. FH register
smc_cmd( ID, 0x15 );
wait_EL( ID, CCW ); // wait for EL signal
smc_softreset( ID );
}
sm_board_reset( ID ); // cleanup
}/*end*/

```

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APPENDICES



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*APPENDIX A: **PLCBus***

Appendix A provides the pin assignments for the PLCBus, describes the registers, and lists the software drivers.

PLCBus Overview

The PLCBus is a general-purpose expansion bus for Z-World controllers. The PLCBus is available on the BL1200, BL1600, BL1700, PK2100, and PK2200 controllers. The BL1000, BL1100, BL1300, BL1400, and BL1500 controllers support the XP8300, XP8400, XP8600, and XP8900 expansion boards using the controller's parallel input/output port. The BL1400 and BL1500 also support the XP8200 and XP8500 expansion boards. The ZB4100's PLCBus supports most expansion boards, except for the XP8700 and the XP8800. The SE1100 adds expansion capability to boards with or without a PLCBus interface.

Table A-1 lists Z-World's expansion devices that are supported on the PLCBus.

Table A-1. Z-World PLCBus Expansion Devices

Device	Description
Exp-A/D12	Eight channels of 12-bit A/D converters
SE1100	Four SPDT relays for use with all Z-World controllers
XP8100 Series	32 digital inputs/outputs
XP8200	"Universal Input/Output Board" —16 universal inputs, 6 high-current digital outputs
XP8300	Two high-power SPDT and four high-power SPST relays
XP8400	Eight low-power SPST DIP relays
XP8500	11 channels of 12-bit A/D converters
XP8600	Two channels of 12-bit D/A converters
XP8700	One full-duplex asynchronous RS-232 port
XP8800	One-axis stepper motor control
XP8900	Eight channels of 12-bit D/A converters

Multiple expansion boards may be linked together and connected to a Z-World controller to form an extended system.

Figure A-1 shows the pin layout for the PLCBus connector.

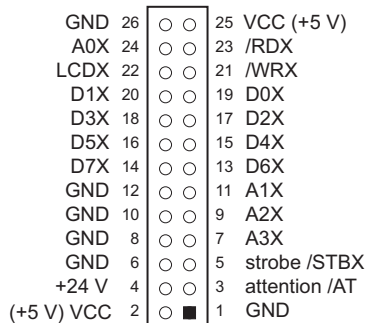


Figure A-1. PLCBus Pin Diagram

Two independent buses, the LCD bus and the PLCBus, exist on the single connector.

The LCD bus consists of the following lines.

- LCDX—positive-going strobe.
- /RDX—negative-going strobe for read.
- /WRX—negative-going strobe for write.
- A0X—address line for LCD register selection.
- D0X-D7X—bidirectional data lines (shared with expansion bus).

The LCD bus is used to connect Z-World's OP6000 series interfaces or to drive certain small liquid crystal displays directly. Figure A-2 illustrates the connection of an OP6000 interface to a PLCBus header.

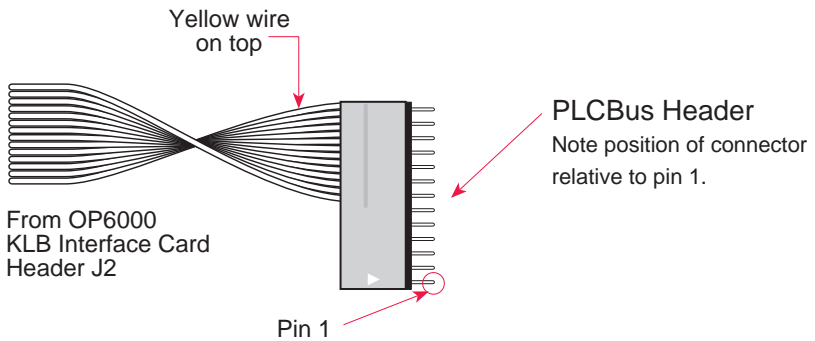


Figure A-2. OP6000 Connection to PLCBus Header

The PLCBus consists of the following lines.

- /STBX—negative-going strobe.
- A1X-A3X—three control lines for selecting bus operation.
- D0X-D3X—four bidirectional data lines used for 4-bit operations.
- D4X-D7X—four additional data lines for 8-bit operations.
- /AT—attention line (open drain) that may be pulled low by any device, causing an interrupt.

The PLCBus may be used as a 4-bit bus (D0X-D3X) or as an 8-bit bus (D0X-D7X). Whether it is used as a 4-bit bus or an 8-bit bus depends on the encoding of the address placed on the bus. Some PLCBus expansion cards require 4-bit addressing and others (such as the XP8700) require 8-bit addressing. These devices may be mixed on a single bus.

There are eight registers corresponding to the modes determined by bus lines A1X, A2X, and A3X. The registers are listed in Table A-2.

Table A-2. PLCBus Registers

Register	Address	A3	A2	A1	Meaning
BUSRD0	C0	0	0	0	Read data, one way
BUSRD1	C2	0	0	1	Read data, another way
BUSRD2	C4	0	1	0	Spare, or read data
BUSRESET	C6	0	1	1	Read this register to reset the PLCBus
BUSADR0	C8	1	0	0	First address nibble or byte
BUSADR1	CA	1	0	1	Second address nibble or byte
BUSADR2	CC	1	1	0	Third address nibble or byte
BUSWR	CE	1	1	1	Write data

Writing or reading one of these registers takes care of all the bus details. Functions are available in Z-World’s software libraries to read from or write to expansion bus devices.

To communicate with a device on the expansion bus, first select a register associated with the device. Then read or write from/to the register. The register is selected by placing its address on the bus. Each device recognizes its own address and latches itself internally.

A typical device has three internal latches corresponding to the three address bytes. The first is latched when a matching BUSADR0 is detected. The second is latched when the first is latched and a matching BUSADR1 is detected. The third is latched if the first two are latched and a matching BUSADR2 is detected. If 4-bit addressing is used, then there are three 4-bit address nibbles, giving 12-bit addresses. In addition, a special register address is reserved for address expansion. This address, if ever used, would provide an additional four bits of addressing when using the 4-bit convention.

If eight data lines are used, then the addressing possibilities of the bus become much greater—more than 256 million addresses according to the conventions established for the bus.

Place an address on the bus by writing (bytes) to BUSADR0, BUSADR1 and BUSADR2 in succession. Since 4-bit and 8-bit addressing modes must coexist, the lower four bits of the first address byte (written to BUSADR0) identify addressing categories, and distinguish 4-bit and 8-bit modes from each other.

There are 16 address categories, as listed in Table A-3. An “x” indicates that the address bit may be a “1” or a “0.”

Table A-3. First-Level PLCBus Address Coding

First Byte	Mode	Addresses	Full Address Encoding
– – – – 0 0 0 0	4 bits × 3	256	0000 xxxx xxxx
– – – – 0 0 0 1		256	0001 xxxx xxxx
– – – – 0 0 1 0		256	0010 xxxx xxxx
– – – – 0 0 1 1		256	0011 xxxx xxxx
– – – x 0 1 0 0	5 bits × 3	2,048	x010 xxxxx xxxxx
– – – x 0 1 0 1		2,048	x0101 xxxxx xxxxx
– – – x 0 1 1 0		2,048	x0110 xxxxx xxxxx
– – – x 0 1 1 1		2,048	x0111 xxxxx xxxxx
– – x x 1 0 0 0	6 bits × 3	16,384	xx1000 xxxxxx xxxxxx
– – x x 1 0 0 1		16,384	xx1001 xxxxxx xxxxxx
– – x x 1 0 1 0	6 bits × 1	4	xx1010
– – – – 1 0 1 1	4 bits × 1	1	1011 (expansion register)
x x x x 1 1 0 0	8 bits × 2	4,096	xxxx1100 xxxxxxxx
x x x x 1 1 0 1	8 bits × 3	1M	xxxx1101 xxxxxxxx xxxxxxxx
x x x x 1 1 1 0	8 bits × 1	16	xxxx1110
x x x x 1 1 1 1	8 bits × 1	16	xxxx1111

This scheme uses less than the full addressing space. The mode notation indicates how many bus address cycles must take place and how many bits are placed on the bus during each cycle. For example, the 5 × 3 mode means three bus cycles with five address bits each time to yield 15-bit addresses, not 24-bit addresses, since the bus uses only the lower five bits of the three address bytes.

Z-World provides software drivers that access the PLCBus. To allow access to bus devices in a multiprocessing environment, the expansion register and the address registers are shadowed with memory locations known as *shadow registers*. The 4-byte shadow registers, which are saved at predefined memory addresses, are as follows.

	SHBUS0	SHBUS0+1	SHBUS1 SHBUS0+2	SHBUS1+1 SHBUS0+3
Bus expansion	BUSADR0		BUSADR1	BUSADR2

Before the new addresses or expansion register values are output to the bus, their values are stored in the shadow registers. All interrupts that use the bus save the four shadow registers on the stack. Then, when exiting the interrupt routine, they restore the shadow registers and output the three address registers and the expansion registers to the bus. This allows an interrupt routine to access the bus without disturbing the activity of a background routine that also accesses the bus.

To work reliably, bus devices must be designed according to the following rules.

1. The device must not rely on critical timing such as a minimum delay between two successive register accesses.
2. The device must be capable of being selected and deselected without adversely affecting the internal operation of the controller.

Allocation of Devices on the Bus

4-Bit Devices

Table A-4 provides the address allocations for the registers of 4-bit devices.

Table A-4. Allocation of Registers

A1	A2	A3	Meaning
000j	000j	xxxj	digital output registers, 64 registers $64 \times 8 = 512$ 1-bit registers
000j	001j	xxxj	analog output modules, 64 registers
000j	01xj	xxxj	digital input registers, 128 registers $128 \times 4 = 512$ input bits
000j	10xj	xxxj	analog input modules, 128 registers
000j	11xj	xxxj	128 spare registers (customer)
001j	xxxj	xxxj	512 spare registers (Z-World)

j controlled by board jumper

x controlled by PAL

Digital output devices, such as relay drivers, should be addressed with three 4-bit addresses followed by a 4-bit data write to the control register. The control registers are configured as follows

bit 3	bit 2	bit 1	bit 0
A2	A1	A0	D

The three address lines determine which output bit is to be written. The output is set as either 1 or 0, according to D. If the device exists on the bus, reading the register drives bit 0 low. Otherwise bit 0 is a 1.

For digital input, each register (BUSRD0) returns four bits. The read register, BUSRD1, drives bit 0 low if the device exists on the bus.

8-Bit Devices

Z-World's XP8700 and XP8800 expansion boards use 8-bit addressing.

Expansion Bus Software

The expansion bus provides a convenient way to interface Z-World's controllers with expansion boards or other specially designed boards. The expansion bus may be accessed by using input functions. Follow the suggested protocol. The software drivers are easier to use, but are less efficient in some cases. Table A-5 lists the libraries.

Table A-5. Dynamic C PLCBus Libraries

Library	Controller
DRIVERS.LIB	All controllers
EZIOTGPL.LIB	BL1000
EZIOLGPL.LIB	BL1100
EZIOMGPL.LIB	BL1400, BL1500
EZIOPLC.LIB	BL1200, BL1600, PK2100, PK2200, ZB4100
EZIOPLC2.LIB	BL1700
EZIOBL17.LIB	BL1700
PBUS_TG.LIB	BL1000
PBUS_LG.LIB	BL1100, BL1300
PLC_EXP.LIB	BL1200, BL1600, PK2100, PK2200

There are 4-bit and 8-bit drivers. The 4-bit drivers employ the following calls.

- **void eioResetPlcBus ()**

Resets all expansion boards on the PLCBus. When using this call, make sure there is sufficient delay between this call and the first access to an expansion board.

LIBRARY: **EZIOPLC.LIB, EZIOPLC2.LIB, EZIOMGPL.LIB.**

- **void eioPlcAdr12(unsigned addr)**

Specifies the address to be written to the PLCBus using cycles BUSADR0, BUSADR1, and BUSADR2.

PARAMETER: **addr** is broken into three nibbles, and one nibble is written in each BUSADR_x cycle.

LIBRARY: **EZIOPLC.LIB, EZIOPLC2.LIB, EZIOMGPL.LIB.**

- **void set16adr(int adr)**

Sets the current address for the PLCBus. All read and write operations access this address until a new address is set.

PARAMETER: **adr** is a 16-bit physical address. The high-order nibble contains the value for the expansion register, and the remaining three 4-bit nibbles form a 12-bit address (the first and last nibbles must be swapped).

LIBRARY: **DRIVERS.LIB.**

- **void set12adr(int adr)**

Sets the current address for the PLCBus. All read and write operations access this address until a new address is set.

PARAMETER: **adr** is a 12-bit physical address (three 4-bit nibbles) with the first and third nibbles swapped.

LIBRARY: **DRIVERS.LIB.**

- **void eioPlcAdr4(unsigned addr)**

Specifies the address to be written to the PLCBus using only cycle BUSADR2.

PARAMETER: **addr** is the nibble corresponding to BUSADR2.

LIBRARY: **EZIOPLC.LIB, EZIOPLC2.LIB, EZIOMGPL.LIB.**

- **void set4adr(int adr)**

Sets the current address for the PLCBus. All read and write operations access this address until a new address is set.

A 12-bit address may be passed to this function, but only the last four bits will be set. Call this function only if the first eight bits of the address are the same as the address in the previous call to set12adr.

PARAMETER: **adr** contains the last four bits (bits 8–11) of the physical address.

LIBRARY: **DRIVERS.LIB**.

- **char _eioReadD0()**

Reads the data on the PLCBus in the BUSADR0 cycle.

RETURN VALUE: the byte read on the PLCBus in the BUSADR0 cycle.

LIBRARY: **EZIOPLC.LIB, EZIOPLC2.LIB, EZIOMGPL.LIB**.

- **char _eioReadD1()**

Reads the data on the PLCBus in the BUSADR1 cycle.

RETURN VALUE: the byte read on the PLCBus in the BUSADR1 cycle.

LIBRARY: **EZIOPLC.LIB, EZIOPLC2.LIB, EZIOMGPL.LIB**.

- **char _eioReadD2()**

Reads the data on the PLCBus in the BUSADR2 cycle.

RETURN VALUE: the byte read on the PLCBus in the BUSADR2 cycle.

LIBRARY: **EZIOPLC.LIB, EZIOPLC2.LIB, EZIOMGPL.LIB**.

- **char read12data(int adr)**

Sets the current PLCBus address using the 12-bit **adr**, then reads four bits of data from the PLCBus with BUSADR0 cycle.

RETURN VALUE: PLCBus data in the lower four bits; the upper bits are undefined.

LIBRARY: **DRIVERS.LIB**.

- **char read4data(int adr)**

Sets the last four bits of the current PLCBus address using `adr` bits 8–11, then reads four bits of data from the bus with `BUSADR0` cycle.

PARAMETER: `adr` bits 8–11 specifies the address to read.

RETURN VALUE: PLCBus data in the lower four bits; the upper bits are undefined.

LIBRARY: `DRIVERS.LIB`.

- **void _eioWriteWR(char ch)**

Writes information to the PLCBus during the `BUSWR` cycle.

PARAMETER: `ch` is the character to be written to the PLCBus.

LIBRARY: `EZIOPLC.LIB`, `EZIOPLC2.LIB`, `EZIOMGPL.LIB`.

- **void write12data(int adr, char dat)**

Sets the current PLCBus address, then writes four bits of data to the PLCBus.

PARAMETER: `adr` is the 12-bit address to which the PLCBus is set.

`dat` (bits 0–3) specifies the data to write to the PLCBus.

LIBRARY: `DRIVERS.LIB`.

- **void write4data(int address, char data)**

Sets the last four bits of the current PLCBus address, then writes four bits of data to the PLCBus.

PARAMETER: `adr` contains the last four bits of the physical address (bits 8–11).

`dat` (bits 0–3) specifies the data to write to the PLCBus.

LIBRARY: `DRIVERS.LIB`.

The 8-bit drivers employ the following calls.

- **void set24adr(long address)**

Sets a 24-bit address (three 8-bit nibbles) on the PLCBus. All read and write operations will access this address until a new address is set.

PARAMETER: `address` is a 24-bit physical address (for 8-bit bus) with the first and third bytes swapped (low byte most significant).

LIBRARY: `DRIVERS.LIB`.

- **void set8adr(long address)**

Sets the current address on the PLCBus. All read and write operations will access this address until a new address is set.

PARAMETER: **address** contains the last eight bits of the physical address in bits 16–23. A 24-bit address may be passed to this function, but only the last eight bits will be set. Call this function only if the first 16 bits of the address are the same as the address in the previous call to **set24adr**.

LIBRARY: **DRIVERS.LIB**.

- **int read24data0(long address)**

Sets the current PLCBus address using the 24-bit address, then reads eight bits of data from the PLCBus with a BUSRD0 cycle.

RETURN VALUE: PLCBus data in lower eight bits (upper bits 0).

LIBRARY: **DRIVERS.LIB**.

- **int read8data0(long address)**

Sets the last eight bits of the current PLCBus address using address bits 16–23, then reads eight bits of data from the PLCBus with a BUSRD0 cycle.

PARAMETER: **address** bits 16–23 are read.

RETURN VALUE: PLCBus data in lower eight bits (upper bits 0).

LIBRARY: **DRIVERS.LIB**.

- **void write24data(long address, char data)**

Sets the current PLCBus address using the 24-bit address, then writes eight bits of data to the PLCBus.

PARAMETERS: **address** is 24-bit address to write to.

data is data to write to the PLCBus.

LIBRARY: **DRIVERS.LIB**.

- **void write8data(long address, char data)**

Sets the last eight bits of the current PLCBus address using address bits 16–23, then writes eight bits of data to the PLCBus.

PARAMETERS: **address** bits 16–23 are the address of the PLCBus to write.

data is data to write to the PLCBus.

LIBRARY: **DRIVERS.LIB**.

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*APPENDIX B: **SPECIFICATIONS***

XP8700 Hardware Specifications

Table B-1 summarizes the specifications for the XP8700 expansion board.

Table B-1. XP8700 Specifications

Parameter	Specification
Board Size	2.835" × 2.2" × 0.58" (72 mm × 56 mm × 15 mm)
Operating Temperature Range	-40°C to +70°C
Humidity	5% to 95%, noncondensing
Power (quiescent, no output)	80 mA @ 5 V DC
I/O	One full-duplex asynchronous RS-232 port, baud rate up to 57,600 bps

Figure B-1 shows the dimensions of the XP8700 expansion board.

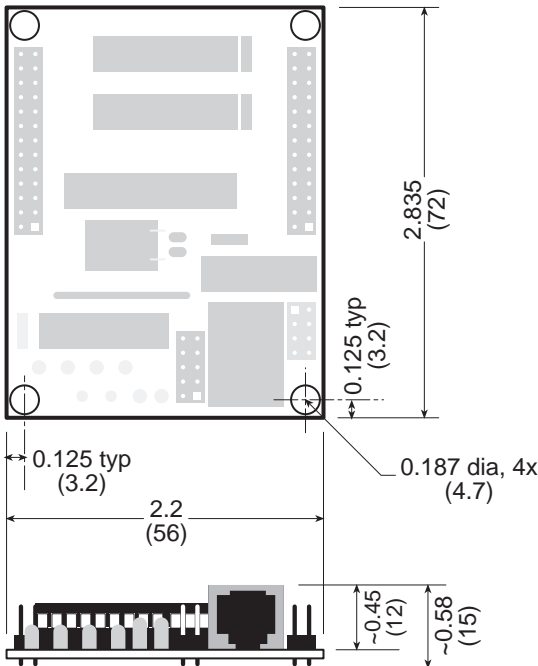


Figure B-1. XP8700 Board Dimensions

XP8800 Hardware Specifications

Table B-2 summarizes the specifications for the XP8800 expansion board.

Table B-2. XP8800 Series Specifications

Parameter	Specification
Board Size	2.835" × 4.0" × 0.58" (72 mm × 102 mm × 15 mm)
Operating Temperature Range	-40°C to +70°C
Humidity	5% to 95%, noncondensing
Power (quiescent, no output)	40 mA @ 5 V DC
Output	One-axis stepper motor control rated at 35 V <ul style="list-style-type: none"> • 1.25 A per phase in full-step mode • 1.0 A per phase in half-step mode

Figure B-2 shows the dimensions of the XP8800 Series expansion boards.

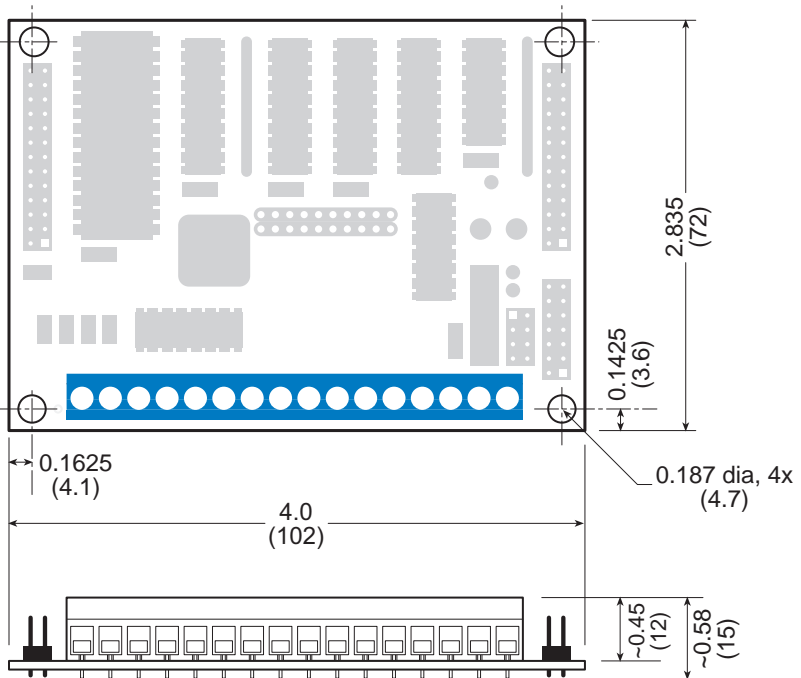


Figure B-2. XP8800 Board Dimensions

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*APPENDIX C: **CONNECTING AND MOUNTING MULTIPLE BOARDS***

Connecting Multiple Boards

Eight or more expansion boards can be connected (“daisy chained”) at one time. The actual number of expansion boards may be limited by capacitive loading on the PLCBus.

Be sure that each expansion board has a unique address to prevent communication problems between the controller and the expansion board.

Follow these steps to install several expansion boards on a single PLCBus.

1. Place all expansion boards right side up.
2. Use the ribbon cable supplied with the boards.
3. Connect one board to the main controller.
4. Connect another expansion board to the first expansion board, connecting each board’s header P1 to the adjacent board’s header P2.

Figure C-1 illustrates a controller with expansion boards attached.

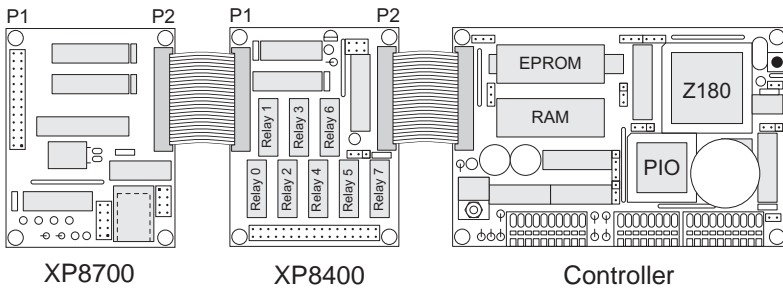


Figure C-1. Connecting Multiple Expansion Boards



Do not twist the ribbon cable or mount the expansion boards upside down! Damage may occur. Be sure Pin 1 of P1 and P2 of each board matches up with Pin 1 of the previous board. Pin 1 should be at the lower right when the expansion board is right side up, that is, the board markings are right side up.

When several expansion boards are connected, there may be a voltage drop along the network of expansion boards. No action is necessary as long as the digital voltage, VCC, is greater than 4.9 V on the last board.



VCC can be measured at pin 2 on header P1, and GND is pin 1 on header P1.

There are two ways to compensate for the voltage dropoff. The easiest way is to connect +5 V DC and ground from the host controller to pins 2 and 1 of header P1 on the last expansion board. Another solution, which can approximately double the number of boards that could otherwise be connected to a single controller, is a Y cable available from Z-World. Figure C-2 illustrates the use of the Y cable.

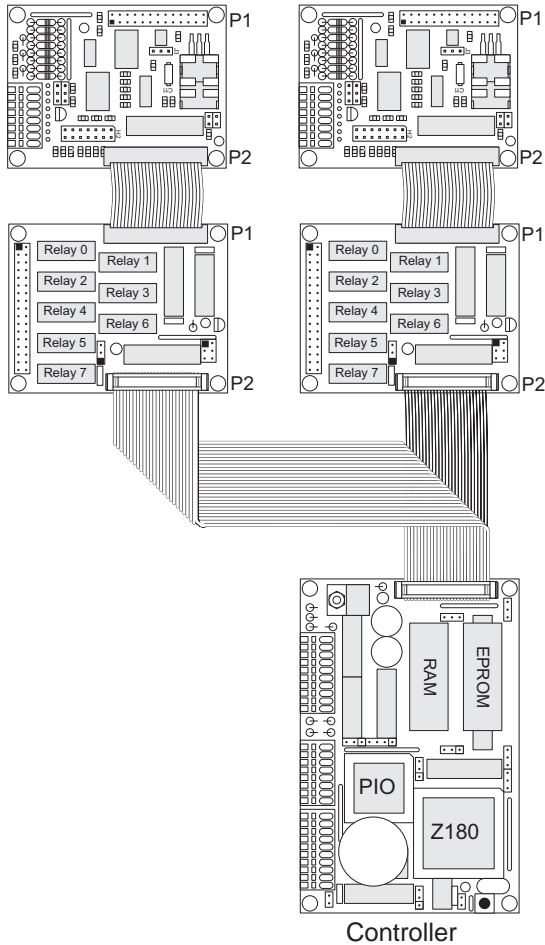


Figure C-2. Use of Y Cable to Connect Multiple Expansion Boards



For more information, call your Z-World Technical Support Representative at (530) 757-3737.

Mounting Expansion Boards

The XP8700 and XP8800 expansion boards can be installed in modular plastic circuit-board holders attached to a DIN rail, a widely used mounting system, as shown in Figure C-3.

The circuit-board holders are 77 mm wide and come in lengths of 11.25 mm, 22.5 mm, and 45 mm. The holders, available from Z-World, snap together to form a tray of almost any length. Z-World's expansion boards are 72 mm wide and fit directly in these circuit-board holders.

Z-World's expansion boards can also be mounted with plastic standoffs to any flat surface that accepts screws. The mounting holes are 0.125 inches (1/8 inch) in from the edge of a board, and have a diameter of 0.190 inches.

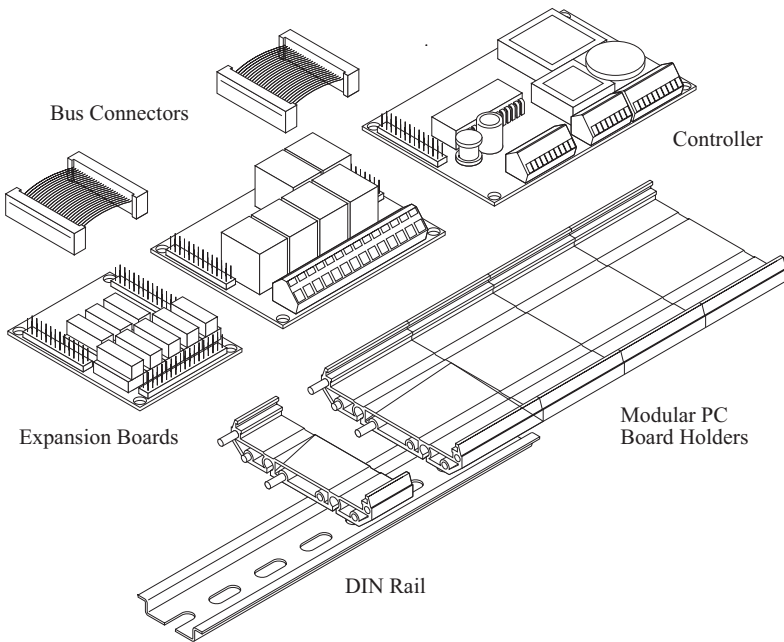


Figure C-2. Mounting Expansion Boards on DIN Rail



For information on ordering DIN rail mounts, call your Z-World Sales Representative at (530) 757-3737.

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