

# **XS40, XSP, and XS95 Board Manual**

*XESS Corporation*

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## **Getting Help!**

If you follow the instructions in this manual and you encounter problems, here are some places to get help:

- If you can't get the XS Board hardware to work, send an e-mail message describing your problem to [fpga-bugs@xess.com](mailto:fpga-bugs@xess.com) or check our web site at <http://www.xess.com/FPGA>. Our web site also has
  - answers to frequently-asked-questions (<http://www.xess.com/FPGA/ho01000.html>),
  - example designs for the XS Boards (<http://www.xess.com/FPGA/ho03000.html>),
  - a place to sign-up for our email forum where you can post questions to other XS Board users ([http://www.xess.com/FPGA/list\\_reg.html](http://www.xess.com/FPGA/list_reg.html)).
- If you can't get your XILINX F1 software tools installed properly, send an e-mail message describing your problem to [hotline@xilinx.com](mailto:hotline@xilinx.com) or check their web site at <http://www.xilinx.com>.

## **1 Installing the XS40, XSP and XS95 Boards**

### **1.1 WARNING!**

The XS40, XSP and XS95 Boards require a power supply to operate! They do not draw power through the downloading cable from the PC parallel port.

### **1.2 Packing List**

Here is what you should have received in your package:

- an XS40, XS95 or XSP Board (note that your XSP Board will be labeled as an XS40 but the socket will contain a Xilinx Spartan FPGA with an "XCS" prefix);
- a 6' cable with a male DB-25 connector on each end;
- a floppy diskette with software utilities for using the XS40, XSP or XS95 Board and documentation (you should be OK on this one).

### **1.3 Installing the XS Board Software Tools**

XILINX currently provides the XACTstep F1 tools for programming their FPGAs and CPLDs. Any recent version of XILINX software should generate bitstream configuration files that are compatible with the XS40, XSP and XS95 Boards. Follow the directions XILINX provides for installing their software.

XESS Corp. provides the additional software utilities for interfacing the PC to the XS Board. Just activate the SETUP.EXE program on the 3.5" diskette to install these tools.

Once the additional software tools are installed, you will see the following subdirectories:

**XSTOOLS\BIN** contains the executable programs for downloading to the XS Board and for applying signals to the XS Board through the printer port. An assembler for the microcontroller is also included.

**XSTOOLS\DOCS** contains the documentation and schematics for the XS40, XSP and XS95 Boards.

## 1.4 Installing the XS40, XSP and XS95 Boards

### 1.4.1 Free-Standing Operation

You can use the XS Board all by itself to experiment with XC4000/XC9500 + 8031 designs. Just place the XS Board on a non-conducting surface. Then apply power to jack J9 of the XS Board from a 9V DC wall transformer with a 2.1 mm female, center-positive plug. The on-board voltage regulation circuitry will create the voltages required by the rest of the XS Board circuitry.

### 1.4.2 Protoboard Installation

The two rows of pins from the XS Board can be plugged into a protoboard with holes spaced at 0.1" intervals. (One of the A.C.E. protoboards from 3M is a good choice.) Once plugged in, all the pins of the XC4000/XC9500 and the 8031 microcontroller are accessible to other circuits on the protoboard. (The numbers printed next to the rows of pins on the XS Board correspond to the pin numbers of the XC4000 or XC9500.) Power can still be supplied to the XS Board though jack J9, or power can be applied directly through several pins of the XS Board. Just connect +5V and +3.3V to the following VCC pins of the XS40, XSP or XS95 Board, and connect ground to the GND pin. (You need +3.3V if your XS40 Board contains an XC4000XL type of FPGA.)

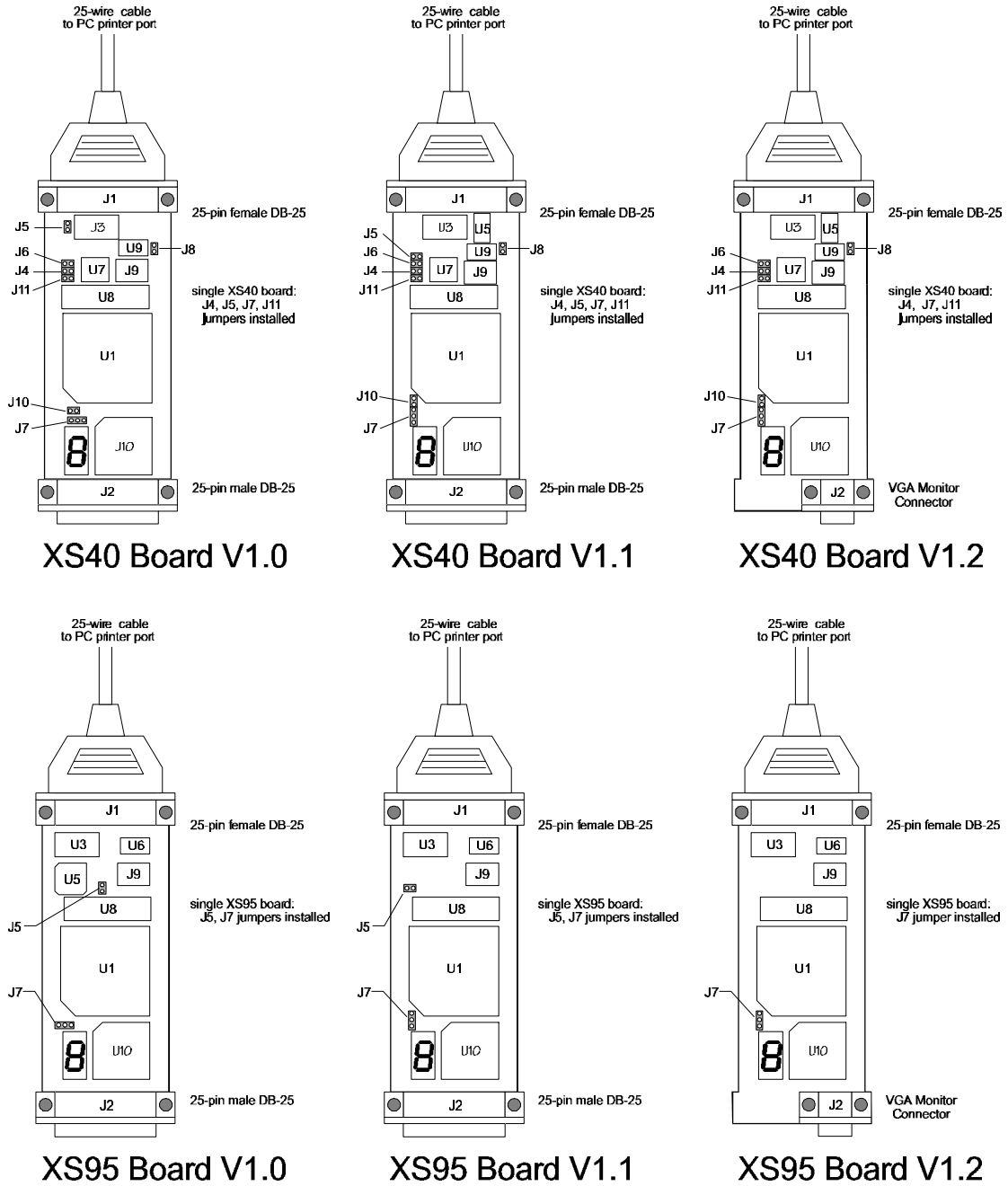
<b>XS Board Type</b>	<b>GND Pin</b>	<b>+5V Pin</b>	<b>+3.3V Pin</b>
XS95-072 V1.0	49	78	none
XS95-072 V1.1	49	78	none
XS95-072 V1.2	49	78	none
XS95-108 V1.0	49	78	none
XS95-108 V1.1	49	78	none
XS95-108 V1.2	49	78	none
XS40-005E V1.0	52	2	none
XS40-005E V1.1	52	2, 54	none
XS40-005E V1.2	52	2, 54	none

<b>XS Board Type</b>	<b>GND Pin</b>	<b>+5V Pin</b>	<b>+3.3V Pin</b>
XS40-005XL V1.0	52	none	54
XS40-005XL V1.1	52	2	54
XS40-005XL V1.2	52	2	54
XS40-010E V1.0	52	2	none
XS40-010E V1.1	52	2, 54	none
XS40-010E V1.2	52	2, 54	none
XS40-010XL V1.0	52	none	54
XS40-010XL V1.1	52	2	54
XS40-010XL V1.2	52	2	54
XSP-010	52	2,54	none

**Table 1:** Power and ground connections for all types and versions of the XS Boards.

### **1.5 XS Board-PC Connection**

The 6' cable included with your XS Board connects it to the parallel port of your PC. One end of the cable attaches to the printer port and the other connects to the female DB-25 connector (J1) at the top of the XS Board as shown in Figure 1 (the XSP Board is identical with the XS40 Board V1.2).



**Figure 1:** XS40/XSP/XS95-PC parallel port connection.

## 1.6 Configuring the XS40, XSP and XS95 Boards Jumpers

Jumper	Setting	Purpose
J4	<b>On (default)</b>	A shunt should be installed if you are downloading the XS40 or XSP Board through the parallel port.
	Off	The shunt should be removed if the XS40 or XSP Board is being configured from the on-board serial EEPROM (U7).
J5 (absent on V1.2 of XS40 or XSP)	<b>On (default)</b>	The shunt should be installed if you are using a single XS40 Board or if this is the last board in a cascaded chain of XS40 Boards.
	Off	The shunt should be removed on all but the last board in a chain of cascaded XS40 Boards.
J6	On	The shunt should be installed when the on-board serial EEPROM (U7) is being programmed.
	<b>Off (default)</b>	The shunt should be removed during normal board use.
J7	<b>1-2 (ext) (default)</b>	The shunt should be installed on pins 1 and 2 ( <i>ext</i> ) if the 8031 microcontroller program is stored in the external 32 KByte RAM (U8) of the XS40 Board.
	2-3 ( <i>int</i> )	The shunt should be installed on pins 2 and 3 ( <i>int</i> ) if the program is stored internally in the 8031 chip.
J8	On	The shunt should be installed in XS40 or XSP Boards which use the 3.3V XC4000XL type of FPGAs.
	Off	The shunt should be removed on XS40 or XSP Boards which use the 5V XC4000E type of FPGAs.
J10	On	The shunt should be installed if the XS40 or XSP Board is being configured from the on-board serial EEPROM.
	<b>Off (default)</b>	The shunt should be removed if the XS40 or XSP Board is being downloaded from the PC parallel port.
J11	<b>On (default)</b>	The shunt should be installed if the XS40 or XSP Board is being downloaded from the PC parallel port.

Jumper	Setting	Purpose
	Off	The shunt should be removed if the XS40 or XSP Board is being configured from the on-board serial EEPROM.

**Table 2:** Jumper settings for the XS40 and XSP Boards.

Jumper	Setting	Purpose
J5 (absent on V1.2 of XS95)	<b>On (default)</b>	The shunt should be installed if you are using a single XS95 Board or if this is the last board in a cascaded chain of XS95 Boards.
	Off	The shunt should be removed on all but the last board in a chain of cascaded XS95 Boards.
J7	<b>1-2 (ext) (default)</b>	The shunt should be installed on pins 1 and 2 ( <i>ext</i> ) if the 8031 microcontroller program is stored in the external 32 KByte RAM (U8) of the XS95 Board.
	2-3 ( <i>int</i> )	The shunt should be installed on pins 2 and 3 ( <i>int</i> ) if the program is stored internally in the 8031 chip.

**Table 3:** Jumper settings for the XS95 Board.

## 1.7 Testing the XS40, XSP and XS95 Boards

Once your XS Board is installed and the jumpers are in their default configuration, you can test the board using one of the following commands (you must be in the XSTOOLS\BIN directory to run the XSTEST command):

XS Board Type	Test Command
XS95-072	XSTEST XS95-072
XS95-108	XSTEST XS95-108
XS40-005E	XSTEST XS40-005E
XS40-005XL	XSTEST XS40-005XL
XS40-010E	XSTEST XS40-010E
XS40-010XL	XSTEST XS40-010XL
XSP-010	XSTEST XSP-010

**Table 4:** Commands for testing the various types of XS Boards.

The test procedure programs the FPGA or CPLD, loads the RAM with a test program for the microcontroller, and then the microcontroller executes this program. The total test period (including programming the board) is about 20 seconds for an XS40 or XSP Board, and about a minute for an XS95 Board. If the test completes successfully, then you will see a O displayed on the LED digit.

However, if the test program detects an error, then the LED digit displays an E or remains blank. In this case, check the following items:

- Make sure the board is receiving power from a 9V DC power supply through jack J9 or through the VCC and GND pins.
- Check that the board is sitting upon a non-conducting surface and that there are no connections to any of the pins (except for the VCC and GND pins if this is the way you are powering the board).
- Verify that the jumpers are in their default configuration.
- Make sure the downloading cable is securely attached to the XS Board and the PC parallel port.
- Verify that the parallel port is in SPP mode. (The mode is usually set in the BIOS as either SPP, EPP, or ECP. SPP is the safest and least ambitious mode.)

If all these checks are positive, then test the board using another PC. In our experience, 99.9% of all problems are due to the parallel port.

## 1.8 Programming the XS40, XSP and XS95 Boards

You can download an XC4000-based design into the XS40 or XSP Board as follows:

```
C:\> XSLOAD CIRCUIT.BIT
```

where CIRCUIT.BIT is an XC4000 bitstream file that contains the configuration for the XC4000 or XCS FPGA. Make sure the file contains a bitstream for the type of FPGA chip installed on your XS40 or XSP Board. This file is created using the XILINX F1 software tools.

You can download an XC9500-based design into the XS95 Board as follows:

```
C:\> XSLOAD CIRCUIT.SVF
```

where CIRCUIT.SVF is an XC9500 bitstream file that contains the configuration for the XC9500 CPLD. Make sure the file contains a bitstream for the type of XC9500 chip installed on your XS95 Board. This file is created using the XILINX F1 software tools.



Use one of the following commands if you need to configure the FPGA or CPLD and also download an Intel-formatted HEX file into the RAM of the XS Board:

```
C:\> XSLOAD FILE.HEX CIRCUIT.BIT
```

```
C:\> XSLOAD FILE.HEX CIRCUIT.SVF
```

XSLOAD assumes the XS Board is connected to parallel port #1 of your PC. You can use another port number like so:

```
XSLOAD -P 2 FILE.HEX CIRCUIT.BIT
```

## 1.9 Stand-Alone Configuration of the XS40, XSP and XS95 Boards

During the development and testing phases, you will usually connect the XS Board to the parallel port of a PC and download your circuit each time you make changes to it. But once your design is finished, you may want to store the design on the XS Board so that it is configured for operation as soon as power is applied.

This is easy with the XS95 Board. The XC9500 CPLD always stores its current configuration in an on-chip Flash memory. This configuration is restored whenever power is applied to the XS95 Board. So your design is always available even when the board is not connected to a PC.

But the XC4000 or XCS FPGA on the XS40 or XSP Board stores its configuration in an on-chip RAM which is erased whenever power is interrupted. However, an external serial EEPROM (such as the Atmel AT17C65/128/256) can be placed in socket U7 to store the FPGA configuration and reload it on power-up. You will have to perform several manual steps to 1) load the FPGA configuration into the EEPROM and 2) enable the configuration of the FPGA from the EEPROM.

Perform the following steps to load your design into the EEPROM:

1. Turn off power to the XS Board.
2. Place a shunt on jumper J6. This enables the programming circuitry in the Atmel EEPROM chip.
3. Apply power to the XS Board.
4. Use the following command to load the FPGA bitstream file into the EEPROM:

```
C:\> XSLOAD -SERIAL_EEPROM CIRCUIT.BIT
```

5. Turn off power to the XS Board.
6. Remove the shunt on jumper J6. This disables the programming circuitry in the Atmel EEPROM chip so your design cannot be overwritten.

Once your design is loaded into the EEPROM, you must do the following to make the XS Board configure itself from the EEPROM instead of the PC parallel port interface:

1. Remove the downloading cable from connector J1 of the XS Board.
2. Place a shunt on jumper J10. This sets the FPGA into the active-serial mode so it will provide a clock signal to the EEPROM which sequences the loading of the configuration from the EEPROM into the FPGA.
3. Remove the shunt on jumper J4. This prevents the PC interface circuitry from interfering with the clock signal from the FPGA.
4. Remove the shunt on jumper J11. This prevents the PC interface circuitry from interfering with the data coming from the EEPROM.
5. Apply power to the XS Board. The FPGA will be configured from the serial EEPROM. You may reattach the downloading cable if you need to inject test signals into your design using the XSPORT program.

## **2 Designing with the XS40, XSP and XS95 Boards**

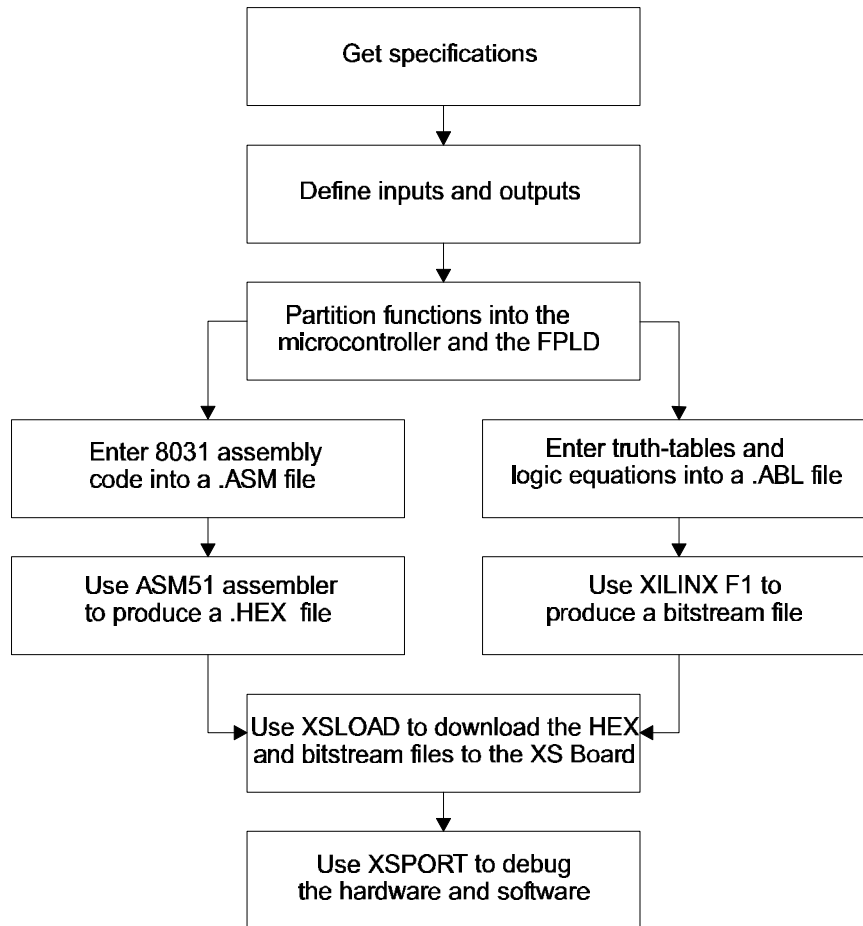
This section introduces the concepts required to create applications that use both the microcontroller and the FPLD (field programmable logic device). Building FPLD-based designs is covered in detail in the *Practical Xilinx Designer* by Prentice-Hall.

### **2.1 Microcontroller + FPLD Design Flow**

The basic design flow for building microcontroller+FPLD applications is shown in Figure 2. Initially you have to get the specifications for the system you are trying to design. Then you have to determine what inputs are available to your system and what outputs it will generate.

At this point, you have to partition the functions of your system between the microcontroller and the FPLD. Some of the input signals will go to the microcontroller, some will go to the FPLD, and some will go to both. Likewise, some of the outputs will be computed by the microcontroller and some by the FPLD. There will also be some new intra-system inputs and outputs created by the need for the microcontroller and the FPLD to cooperate.

In general, the FPLD will be used mainly for low-level functions where signal transitions occur more frequently and the control logic is simpler. A specialized serial transmitter/receiver would be a good example. Conversely, the microcontroller will be used for higher-level functions where the responses occur less quickly and the control logic is more complex. Reacting to commands passed in by the receiver is a good example.



**Figure 2:** Microcontroller + FPLD design flow.

Once the design has been partitioned and you have assigned the various inputs, outputs, and functions to the microcontroller and the FPGA, then you can begin doing detailed design of the software and hardware. For the software, you can use your favorite editor to create a .ASM assembly-language file and assemble it with ASM51 to create a .HEX file for the 8031 microcontroller on the XS Board. For the FPLD hardware portion, you will enter truth-tables and logic equations into a .ABL file and compile it into a .BIT or .SVF bitstream file using the XILINX F1 programming software.

With the .HEX 8031-program file and the FPLD bitstream file in hand, you can download them to the XS Board using the XSLOAD program. XSLOAD stores the contents of the .HEX file into the 32 KByte RAM on the XS Board and then it reconfigures the FPLD by loading it with the bitstream file.

When the XS Board is loaded with the hardware and software, you need to test it to see if it really works. The answer usually starts as "No" so you need a method of injecting test signals and observing the results. XSPORT is a simple program that lets you send test signals to the XS Board through the PC parallel port. You can trace the reaction of your system to signals from the parallel port by programming the microcontroller and the

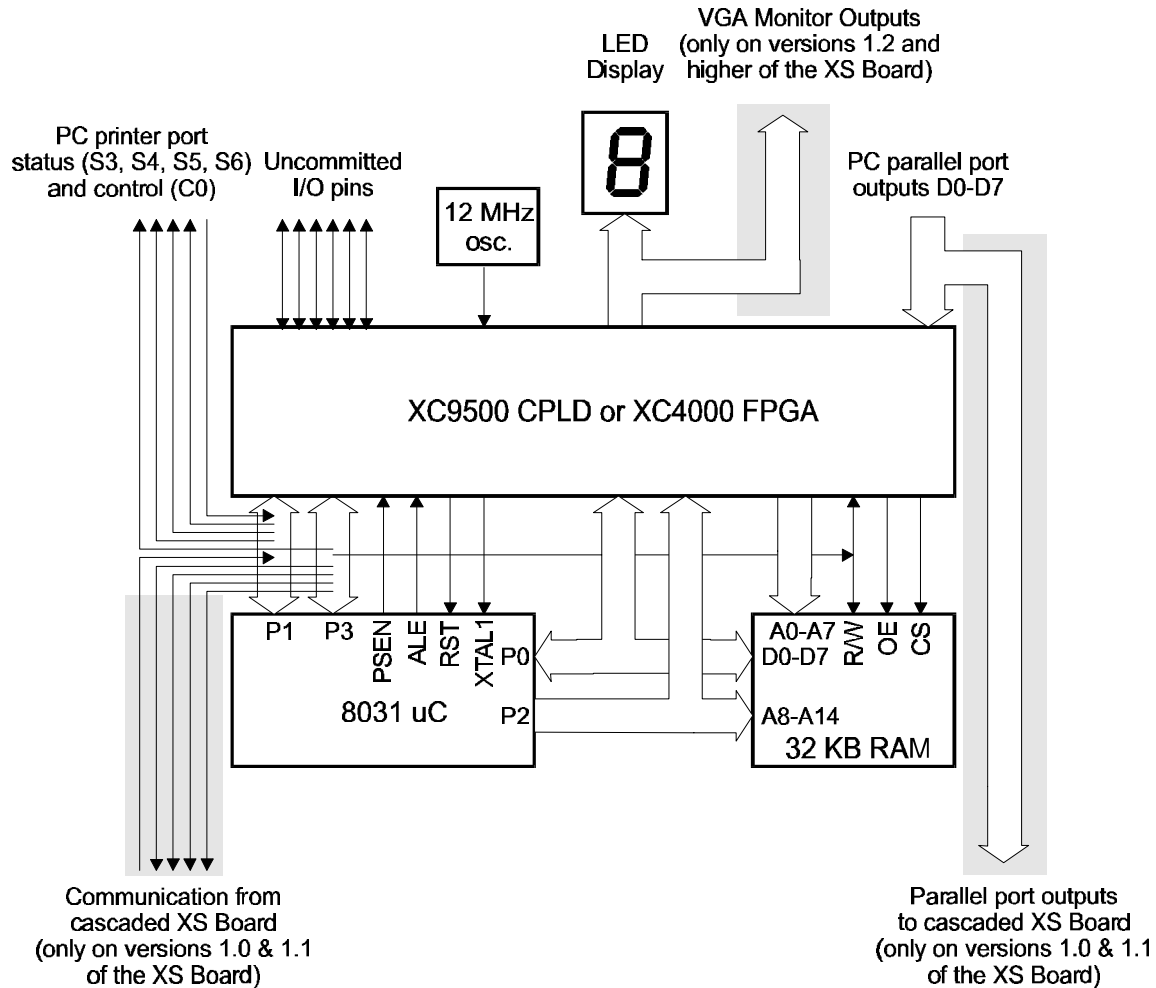
FPLD to output status information on the LED digit (much like placing "printf" statements in your C language programs). This is admittedly crude but will serve if you don't have access to programmable stimulus generators and logic analyzers.

## **2.2 Microcontroller+FPLD Interconnections**

The 8031 microcontroller and the FPLD on the XS Board are already connected together. These existing connections save you the effort of having to wire them yourself, but they also impose limitations on how your program and the FPLD hardware will interact. A high-level view of how the microcontroller, RAM, and FPLD are connected is shown in Figure 3. More detailed schematics are presented at the end of this addendum.

The 12 MHz oscillator output goes directly to a synchronous clock input of the FPLD. The FPLD can control the clock it sends to the XTAL1 input of the microcontroller.

The 8031 multiplexes the lower eight bits of a memory address with eight bits of data and outputs this on its P0 port. Both the RAM data lines and the FPLD are connected to P0. The RAM uses this connection to send and receive data to and from the 8031. The FPLD is programmed to latch the address from P0 under control of the ALE signal and send the latched address bits to the lower eight address lines of the RAM.



**Figure 3:** Connections between the 8031 microcontroller, RAM, and FPLD of the XS Board.

Meanwhile, the upper eight bits of the address are output on port P2 of the 8031. The RAM uses the lower seven of these address bits. The FPLD also receives the upper eight address bits and decodes these along with the PSEN and read/write control line (from pin P3.6 of port P3 ) from the 8031 to generate the CS and OE signals that enable the RAM and its output drivers, respectively. Either of the CS or OE signals can be pulled high to disable the RAM and prevent it from having any effect on the rest of the XS Board circuitry.

One of the outputs of the CPLD controls the reset line of the microcontroller. The 8031 can be prevented from having any effect on the rest of the circuitry by forcing the RST pin high through the FPLD. (When RST is active, most of the 8031 pins are weakly pulled high.)

Many of the I/O pins of ports P1 and P3 of the 8031 connect to the FPLD and can be used for general-purpose I/O between the microcontroller and the FPLD. In addition to

being general-purpose I/O, the P3 pins also have special functions such as serial transmitters, receivers, interrupt inputs, timer inputs, and external RAM read/write control signals. If you aren't using a particular special function, then you can use the associated pin for general-purpose I/O between the microcontroller and the FPLD. In many cases, however, you will program the FPLD to make use of the special-purpose 8031 pins. (For example, the FPLD could generate 8031 interrupts.) If you want to use the special-purpose pin with an external circuit, then the FPLD I/O pin connected to it must be tristated.

An LED digit connects directly to the FPLD. (These same FPLD pins also drive the VGA monitor connector on versions 1.2 and higher of the XS Board.) The FPLD can be programmed so the microcontroller can control the LEDs either through P1 or P3 or by memory-mapping a latch for the LED into the memory space of the 8031.

The PC can transmit signals to the XS Board through the eight data output bits of the printer port. The FPLD has direct access to these signals. The microcontroller can also access them by programming the FPLD to pass the data output bits onto the FPLD I/O pins connected to the 8031. The printer port data bits are also passed through the cascade header to the next XS Board in the chain (if there is one).

Communication from the XS Board back to the PC also occurs through the parallel port. Four of the parallel port status pins are connected to three pins of P1 and one pin of P3. Either the microcontroller or the FPLD can drive the status pins. The PC can read the status pins to fetch data from the XS Board.