Keywords: 1-Wire, FPGA, temperature, Xilinx, PicoBlaze, 1-Wire Master, One Wire, Spartan-6, LX9, peripheral module, Pmod

REFERENCE SCHEMATIC 5508

Create a 1-Wire Master with Xilinx PicoBlaze

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Oct 31, 2012

Abstract: Designers who must interface 1-Wire® temperature sensors with Xilinx field-programmable gate arrays (FPGAs) can use this reference design to drive a DS28EA00 1-Wire slave device. The downloadable software mentioned in this document can also be used as a starting point to connect other 1-Wire slave devices. The system implements a 1-Wire master connected to a UART and outputs temperature to a PC from the DS28EA00 temperature sensor. In addition, high/low alarm outputs are displayed from the DS28EA00 PIO pins using LEDs.

Introduction

This reference design (RD) describes a 1-Wire® Master with PicoBlaze™ 8-bit embedded microcontroller design implemented and tested on the Xilinx® Spartan®-6 LX9 MicroBoard by Avnet. This example design uses the DS28EA00 1-Wire digital thermometer with sequence detect and PIO on a peripheral module. This module uses the Pmod™ port standard developed by Digilent Inc.

System Design Block Diagram

The system shown in **Figure 1** shows the high-level implementation of the design. The system requires:

- PicoBlaze processor
- 2 BRAMs (each 1024 x 18-bit)
- RS-232 port (USB UART)
- LEDs for alarms
- 681Ω ±1% pullup resistor
- Maxim Integrated DS28EA00 peripheral module (DS28EA00PMB1#)
- Xilinx platform cable USB

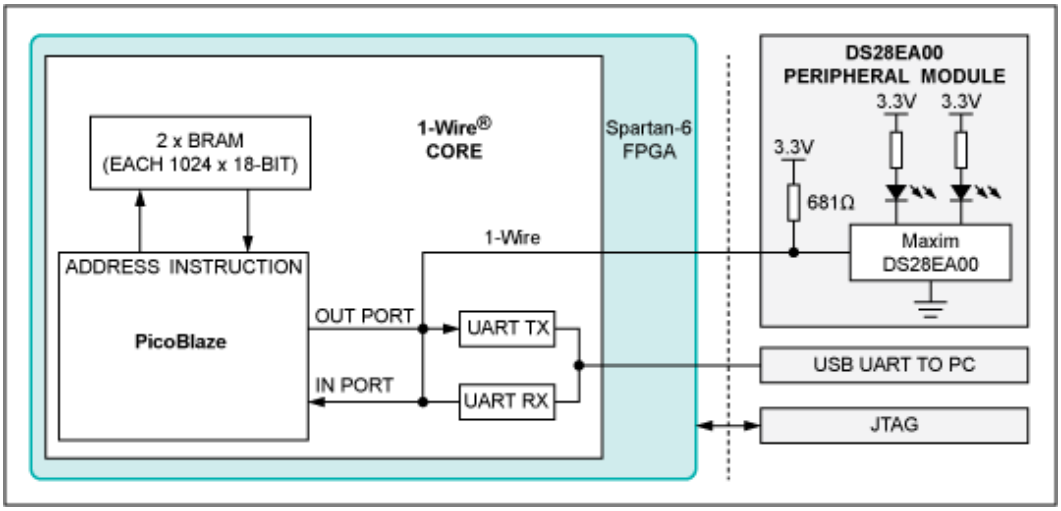


Figure 1. System design block diagram.

Reference Design Requirements

Software

The RD's software requirements are:

- Windows XP® or Windows® 7 OS
- A terminal program such as Tera Term or HyperTerminal®
- Xilinx ISE® Design Suite 14.2, Logic Edition or WebPack
- The PicoBlaze for Spartan-6 FPGAs software compiler
- S6LX9 PicoBlaze 1-Wire project files

Hardware

The RD's hardware setup is:

- PC with 500MB RAM and 500MB virtual memory (recommended)
- Spartan-6 LX9 MicroBoard, designed by Avnet
- DS28EA00 peripheral module (DS28EA00PMB1#)
- USB-A to USB-micro B cable
- Xilinx platform cable USB

File Structure

The directory structure and critical files for this RD are shown in **Table 1**.

Table 1. Reference Design Directory Structure

Directory	Supplied File	Description
S6LX9_PicoBlaze_1Wire_ise_14_2\	All	Contains files for the whole project

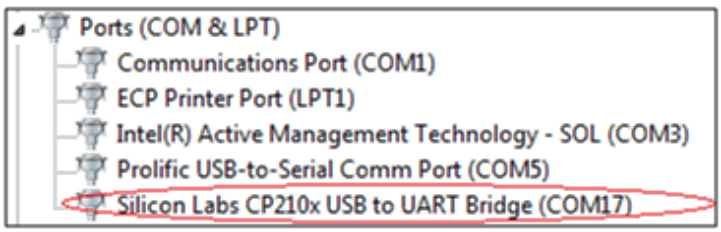
source\ise\	OneWire.xise	ISE project file
source\hdl\	OneWire.vhd	Top-level VHDL source
	kcpsm6.vhd	PicoBlaze microcontroller source
source\hdl\KCPSM3_UART\	UART_Manual.pdf	PicoBlaze UART manual
	UART_real_time_clock.pdf	PicoBlaze UART real-time clock manual
source\hdl\KCPSM3_UART\VHDL\	bbfifo_16x8.vhd	PicoBlaze UART FIFO macro
	kcuart_rx.vhd	PicoBlaze UART receive macro
	kcuart_tx.vhd	PicoBlaze UART transmit macro
	uart_rx.vhd PicoBlaze	UART receive wrapper
	uart_tx.vhd	PicoBlaze UART transmit wrapper
source\psm	kcpsm6.exe	Windows executable to compile the PicoBlaze application
	OWP.psm	
	OWP.log	PicoBlaze 1-Wire log of the compiler output
	OWP.vhd	Compiled PicoBlaze application formatted to initialize the Spartan-6 Block RAM
	ROM.form.vhd	BRAM instantiation template used by the PicoBlaze assembler
		PicoBlaze user's

	KCPSM6_User_Guide_31March11.pdf	guide
source\ucf	OneWire.ucf	User Constraints File that defines timing and pin location constraints for the project
ready_for_download	onewire.bit	Project bitstream
hardware	DS28EA00PMB1_sch.pdf	DS28EA00 peripheral module schematic and board layout
	DS28EA00PMB1_BOM.xls	Bill of materials for the DS28EA00 peripheral module
	DS28EA00PMB1_gerber.zip	Gerber to manufacture the DS28EA00 peripheral module

Installing the UART Driver and Virtual COM Port

If the S6LX9 MicroBoard has not been connected to the PC before, you must install the software driver for the virtual COM port (VCP):

1. Follow the instructions in the "Silicon Labs CP210x USB-to-UART Setup Guide" to complete the installation of the USB driver for the S6LX9 MicroBoard. Click here for the driver location.
2. Connect the USB-A to USB micro-B cable to the host PC and connector J3 on the S6LX9 MicroBoard.
3. Windows 7 will automatically assign a VCP to the board. The **Device Manager** shows which COM port is assigned. It also allows the user to select a COM port. For example in this system, the default virtual COM port is COM17. Look in the **Ports (COM & LPT)** listing for the **Silicon Labs CP210x USB to UART Bridge** item. Note the COM port assigned by the system.



Set Up the S6LX9 MicroBoard

Use the following procedure to set up the application:

1. Connect the USB-JTAG cable with a pod and ribbon connector between the JTAG connector on the board and a USB port on the PC.
2. Plug the USB cable into the PC and port J3 on the S6LX9 board. LED D7 will illuminate.
3. Plug in the DS28EA00 peripheral module with the component side facing the Spartan-6 into J5, the row where pin 1 is marked by the white dot.

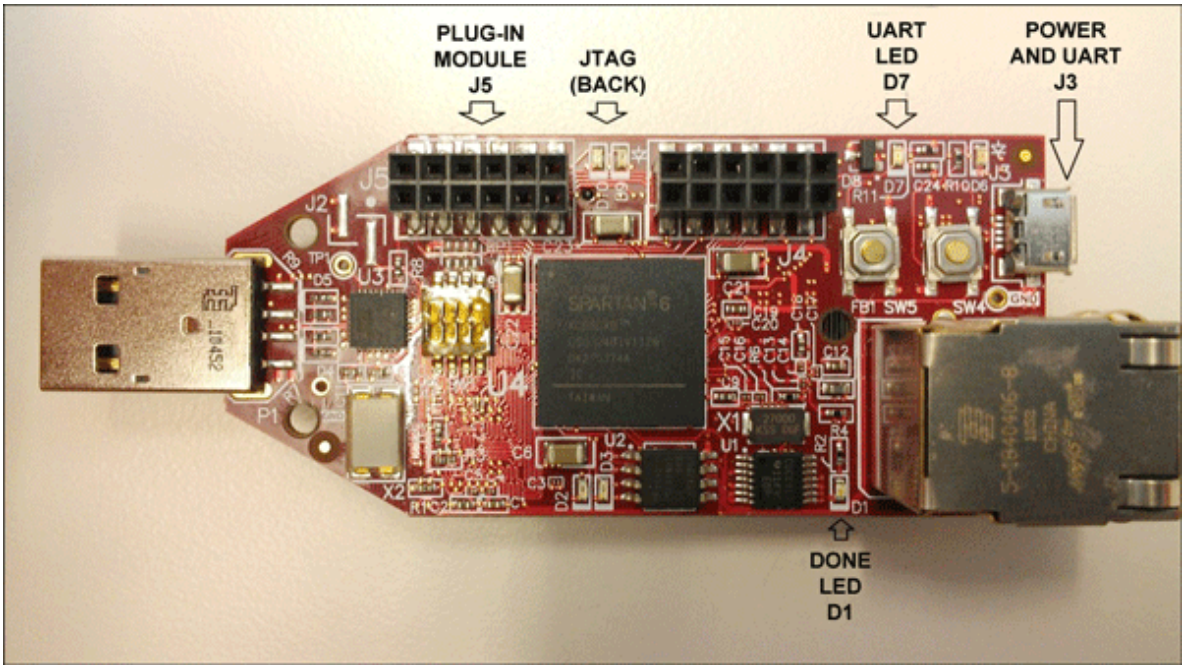
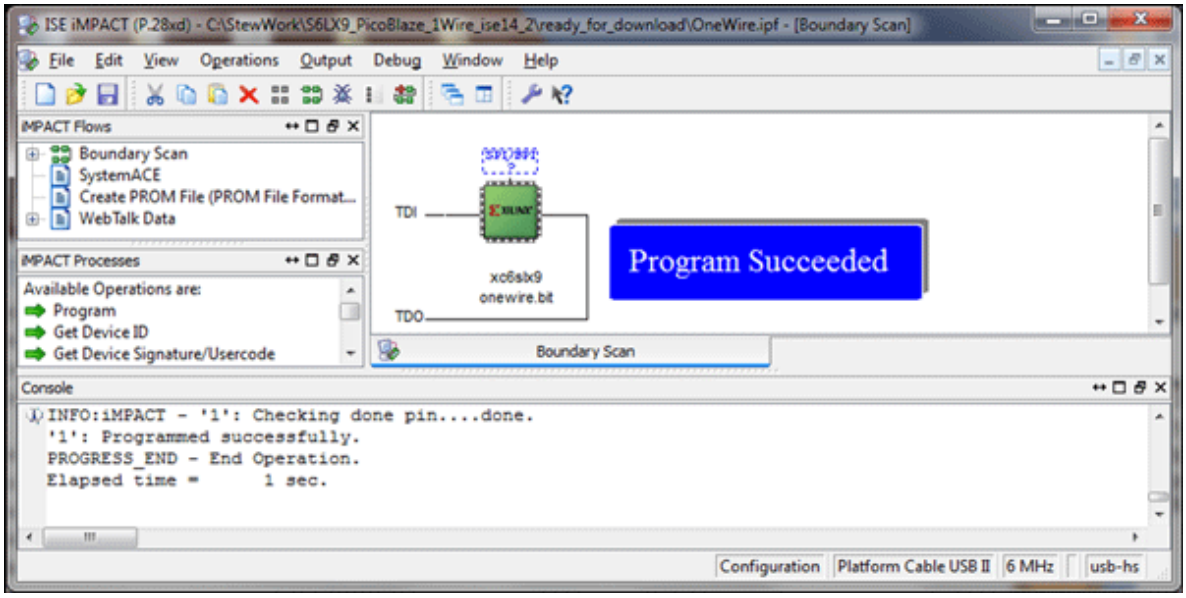


Figure 2. The S6LX9 MicroBoard.

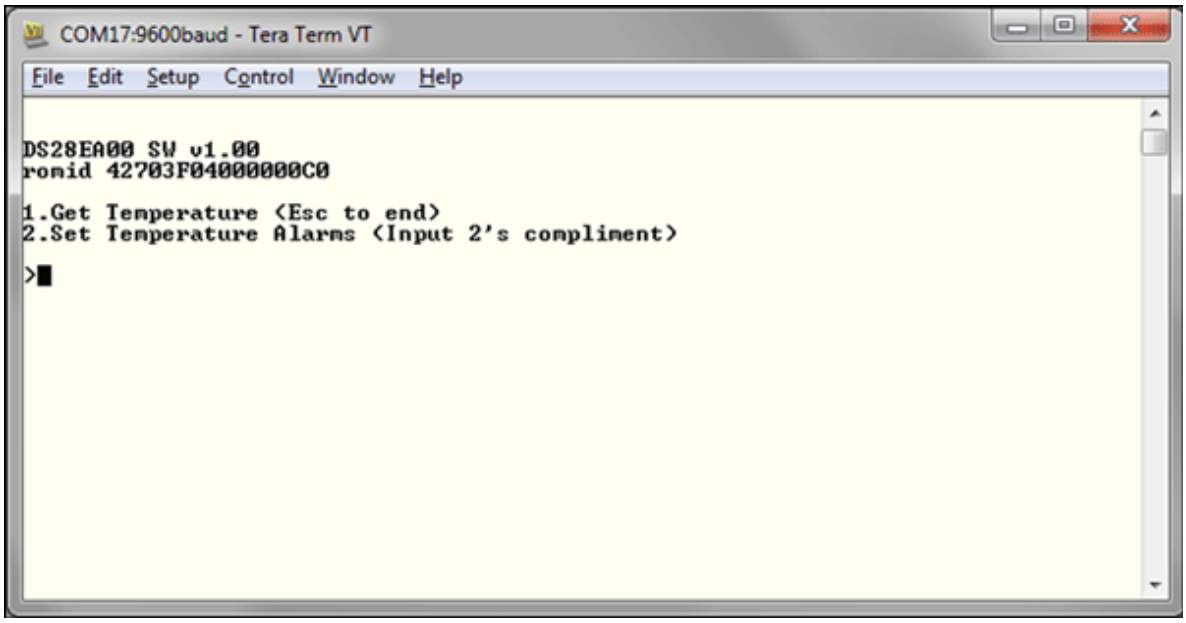
The 1-Wire Demo

Using the prebuilt bitstream file called "onewire.bit", the demo can be loaded into the FPGA and run without building the design. The Xilinx tools must be installed on your host PC, and the hardware should be set up as explained by the instructions in the "Set Up the S6LX9 MicroBoard" and "Installing the UART Driver and Virtual COM Port" sections. Here is the quick procedure to follow:

1. Follow the install directions described in the "Installing the UART Driver and Virtual COM Port" section.
2. Set up the S6LX9 MicroBoard as described in "Set Up the S6LX9 MicroBoard" section.
3. Start a Tera Term or HyperTerminal session. Set the serial port parameters to your VCP, **9600** baud rate, **no** parity, **8** bits, **1** stop bit, and **no flow control**.
4. Using your Xilinx platform cable and the Xilinx software loading tool called iMPACT, load the "onewire.bit" file into the Spartan-6.

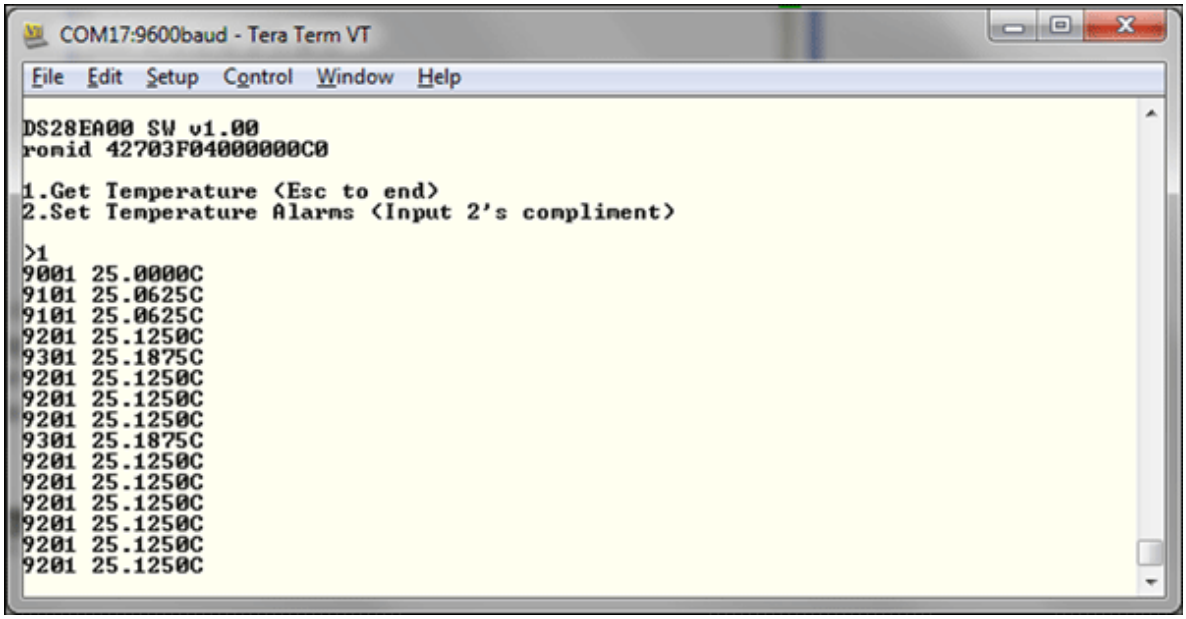


5. If the DS28EA00 peripheral module is plugged in correctly, you will see:

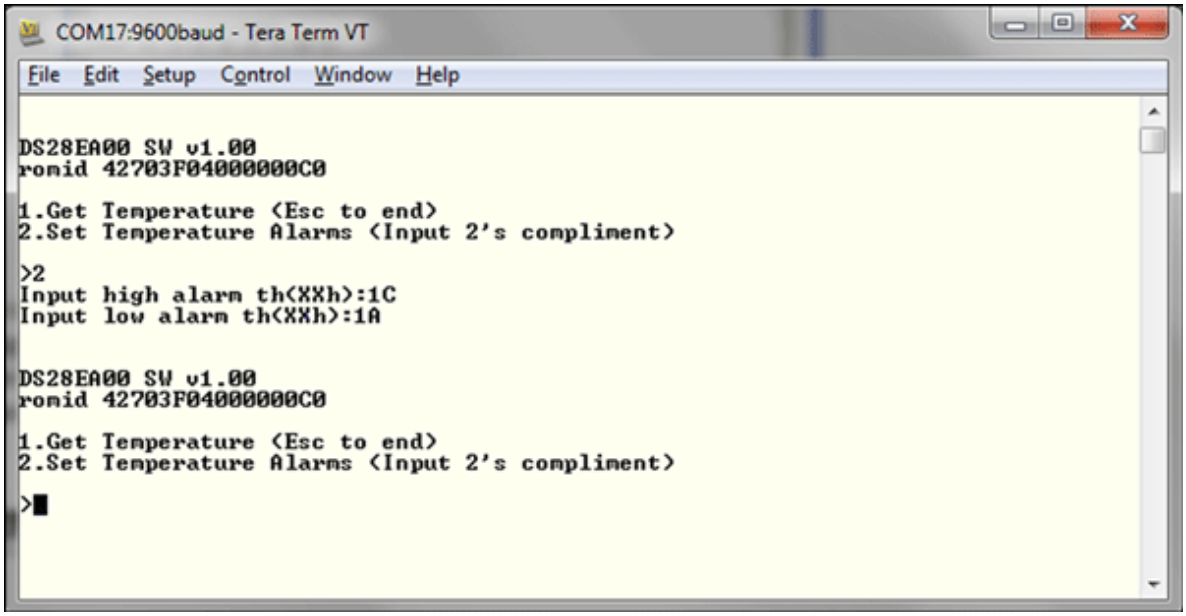


Note: If the "romid" shows all zeroes, recheck your connections. The DS28EA00 peripheral module likely does not have correct orientation or is plugged into the wrong row.

6. You can run the demo by typing "1" at the command prompt. This will display the temperature in 2's complement hex, followed continuously by the temperature in decimal. Also, the two LEDs on the DS28EA00 peripheral module will illuminate to represent the high and low alarms, similar to a thermostat controlling heating and cooling. The high alarm A default threshold is set to turn on at ≥ 29°C and the low alarm B default threshold is set to turn on at < 27°C. To exit at any time, press the **Esc** key.



7. You can change the DS28EA00 peripheral module alarm LEDs by inputting a 2's complement threshold. As an example, if you input 1Ch (28d) into the high alarm threshold, LED A will turn on at ≥ 28°C. If you input 1Ah (26d) into the low alarm threshold, LED B will turn on at < 26°C. These new alarms are activated by typing "1" at the command prompt.



Compiling the Design

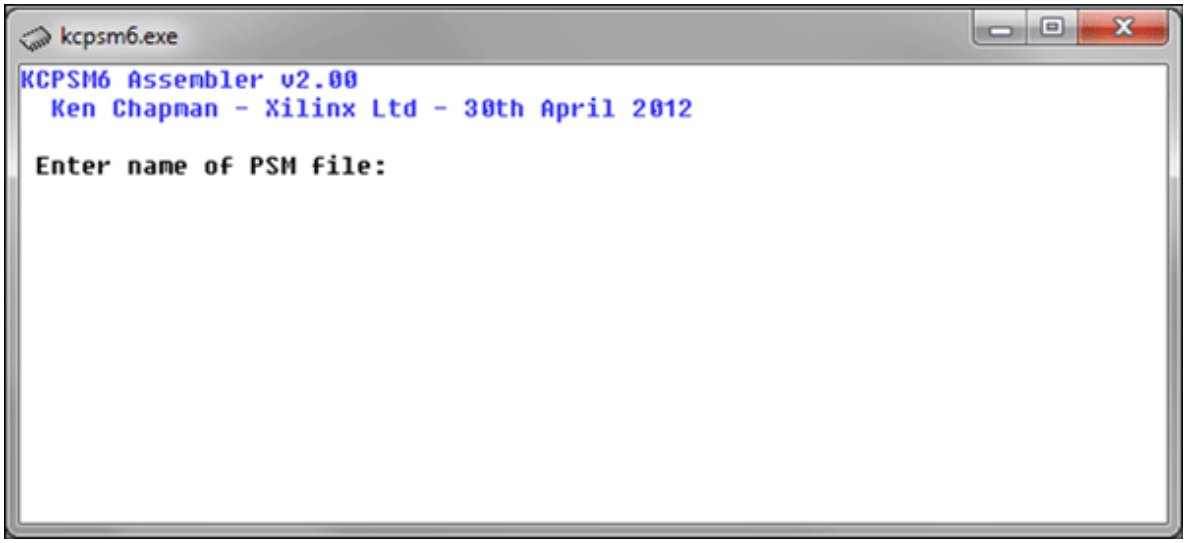
This design is contained within the PicoBlaze application code and can be updated to work with any 1-Wire slave device. There are key 1-Wire subroutines that should be understood by the designer. The low level 1-Wire subroutines are listed in **Table 2**. The design is contained within OWP.psm and if desired can be modified for your application.

Table 2. Key 1-Wire Subroutines

Speed	Subroutine	Description
Standard	ow_reset_slow	Resets the 1-Wire slave devices and prepares them for a command.
Standard	write_byte_slow	Sends 8 bits of communication to the 1-Wire slave devices.
Standard	write_byte_slow_power	Sends 8 bits of communication to the 1-Wire slave devices and then supplies strong pullup. The strong pullup will be cleared when the next 1-Wire subroutine is issued.
Standard	read_byte_slow	Receives 8 bits of communication from the 1-Wire slave devices.
Standard	read_byte_slow_power	Receives 8 bits of communication from 1-Wire slave devices and then supplies strong pullup. The strong pullup will be cleared when the next 1-Wire subroutine is issued.
Overdrive	ow_reset_fast	Resets the 1-Wire bus slave devices and prepares them for a command.
Overdrive	write_byte_fast	Sends 8 bits of communication to the 1-Wire slave devices.
Overdrive	write_byte_fast_power	Sends 8 bits of communication to the 1-Wire slave devices and then supplies strong pullup. The strong pullup will be cleared when the next 1-Wire subroutine is issued.
Overdrive	read_byte_fast	Receives 8 bits of communication from the 1-Wire slave devices.
Overdrive	read_byte_fast_power	Receives 8 bits of communication from the 1-Wire slave devices and then supplies strong pullup. The strong pullup will be cleared when the next 1-Wire subroutine is issued.

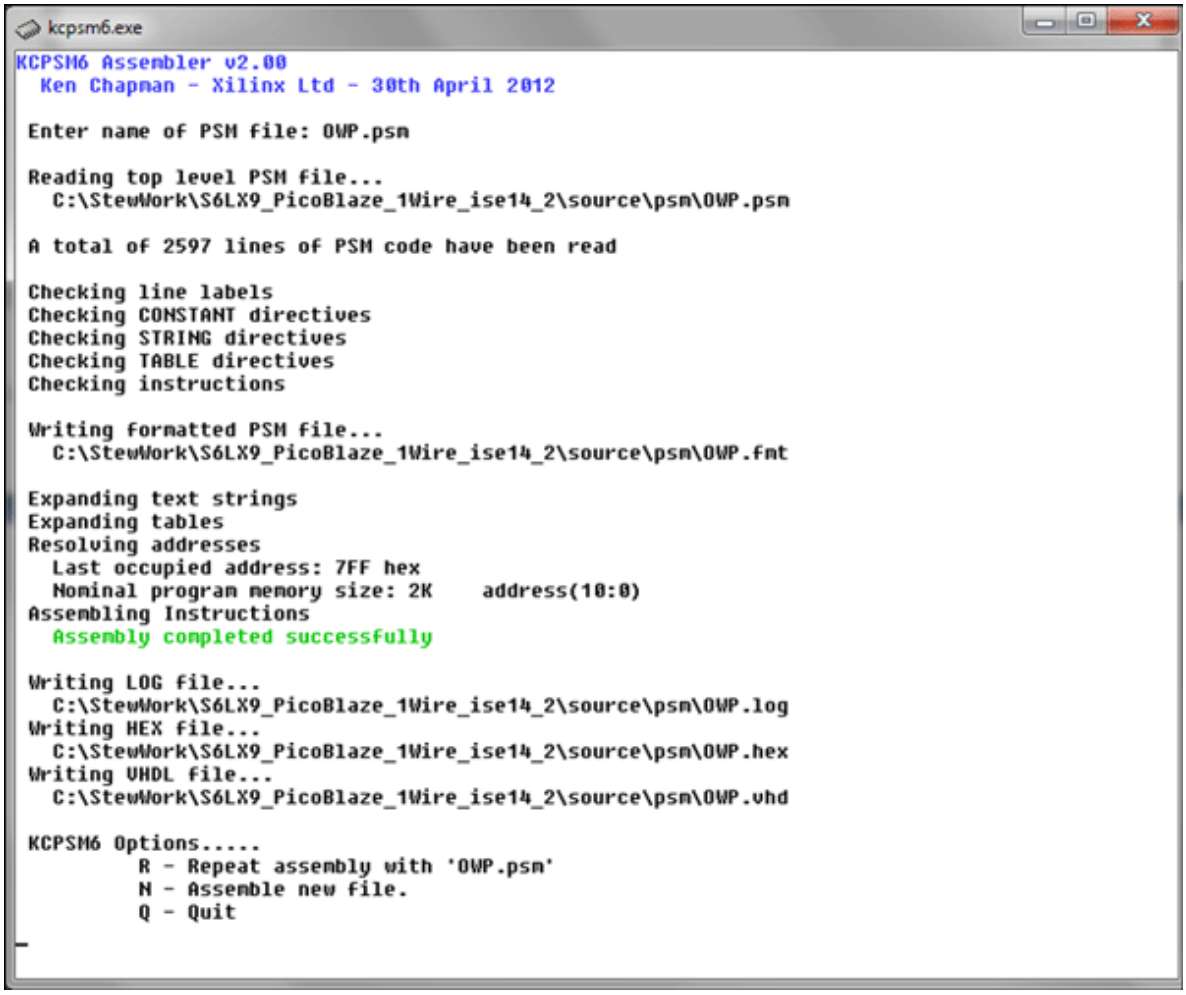
Recompiling Procedure

1. The PicoBlaze assembler will produce the needed files for implementing your design. The new files will overwrite older files, so back up your original files before recompiling. Open **Windows Explorer** by navigating to "source\psm" and double-clicking on the program file called "kcpsm6.exe." You might receive a security warning stating "The publisher could not be verified. Are you sure you want to run this software?" Click **run** and you will get the following KCPSM6 assembler window:

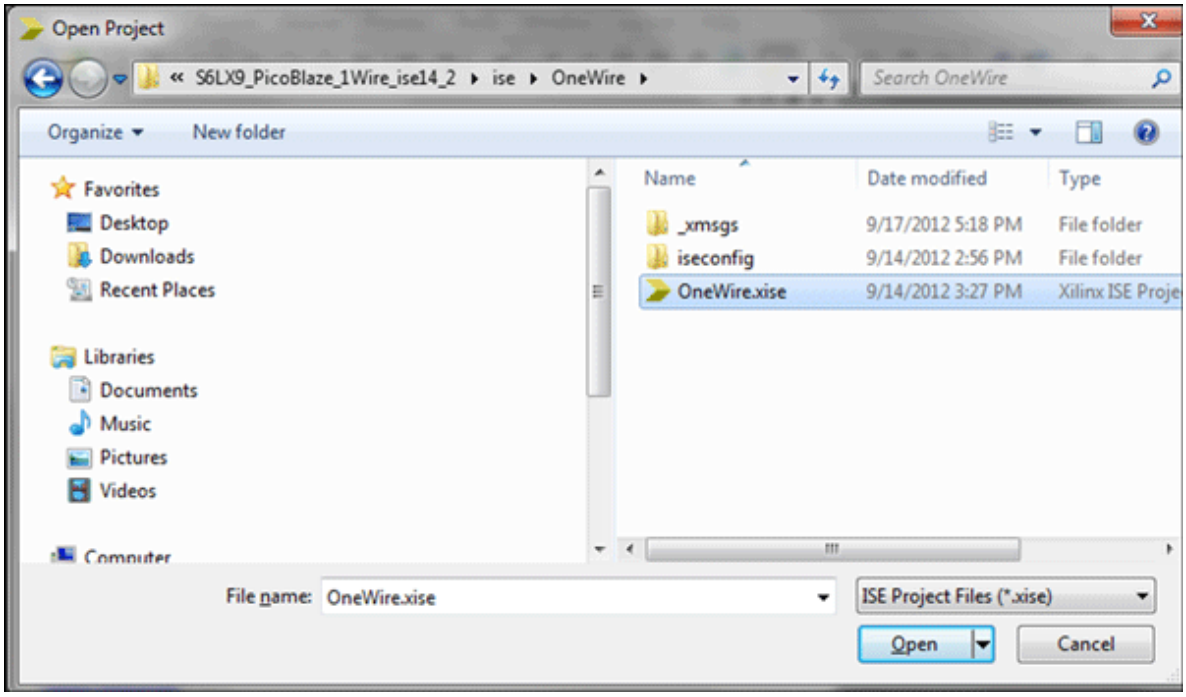


2. Type the **OWP.psm** file name and hit the return key to compile.

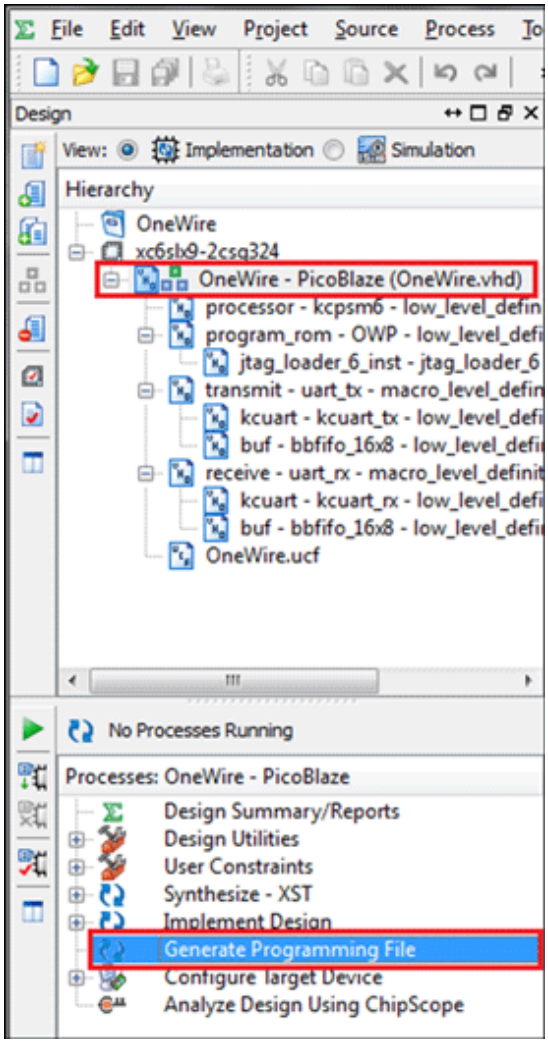
3. The PicoBlaze assembler will begin running. If there are not any errors in the PicoBlaze code, you will see a screen like the one below. If there are errors, you will be alerted with the line number to where the problem is in the code file (i.e., in the OWP.psm file) and prompted to fix the error before rerunning the assembler.



4. Start the Xilinx ISE Project Navigator and open the file in "ise\OneWire\OneWire.xise" as shown below.



5. Select the top level file in the design hierarchy (i.e., **OneWire – PicoBlaze**) in the Hierarchy pane and double-click on **Generate Programming File**.



6. Confirm the hardware set of connections as defined in the "Set Up the S6LX9 MicroBoard" section. Start a Tera Term or HyperTerminal session with the serial port parameters set to your virtual **COM** port, **9600** baud rate, **no** parity, **8** bits, **1** stop bit, and **no flow control**.

7. In the ISE graphical user interface (GUI), select **Configure Target Device** to download the FPGA design to the S6LX9 MicroBoard. The PicoBlaze application will immediately begin running upon the download completion.

Summary

This RD illustrates how to use the Xilinx PicoBlaze to interface with a DS28EA00 peripheral module. The RD also can be used as a starting point to interface to other 1-Wire slave devices.

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Related Parts		
DS1821	Programmable Digital Thermostat and Thermometer	Free Samples
DS1825	Programmable Resolution 1-Wire Digital Thermometer With 4-Bit ID	Free Samples
DS18B20	Programmable Resolution 1-Wire Digital Thermometer	Free Samples
DS18B20-PAR	1-Wire Parasite-Power Digital Thermometer	
DS18S20	1-Wire Parasite-Power Digital Thermometer	Free Samples
DS18S20-PAR	Parasite-Power Digital Thermometer	
DS1920	iButton Temperature Logger	
DS1990A	iButton Serial Number	Free Samples
DS1990R	Serial Number iButton	Free Samples
DS2401	Silicon Serial Number	Free Samples
DS2406	Dual Addressable Switch Plus 1Kb Memory	Free Samples
DS2408	1-Wire 8-Channel Addressable Switch	Free Samples
DS2411	Silicon Serial Number with V_{CC} Input	Free Samples
DS2413	1-Wire Dual Channel Addressable Switch	Free Samples
DS2431	1024-Bit 1-Wire EEPROM	Free Samples
DS28EA00	1-Wire Digital Thermometer with Sequence Detect and PIO	Free Samples
MAX31820	1-Wire Ambient Temperature Sensor	Free Samples
MAX31820PAR	1-Wire Parasite-Power, Ambient Temperature Sensor	
MAX31826	1-Wire Digital Temperature Sensor with 1Kb Lockable EEPROM	Free Samples

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