Enhancing the TMS320C6713 DSK for DSP Education

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Abstract

The introduction of the Texas Instruments TMS320C6713 DSP Starter Kit (DSK) brought a much more capable, stable, and robust DSP development environment to DSP education. However, while the DSK had many improvements over the TMS320C6711 DSK, it did not include any way to transfer data to and from the host computer except through the debugger interface, which is extremely limited in bandwidth and requires that the TI software tools be available. This means that the existing suite of winDSK6 demonstration tools cannot be run on the 6713 DSK, denying educators a valuable teaching and classroom demonstration resource. Also, there is no way to interface an application on the host PC directly to the DSK, limiting the ability of students to create stand-alone, interactive projects using the DSK. To solve this problem, the authors have created an interface to the TMS320C6713 DSK that uses the Host Port Interface (HPI) to provide both a means for a PC host application to boot software onto the DSK, and to permit the transfer of data between the DSK and the host PC application. A software package makes it possible for students to create stand-alone Windows applications that communicate directly with the DSK. In addition to parallel port communication, the interface provides USB, RS-232, and digital input/output ports as user selectable resources available to the DSK software. This paper discusses the specific capabilities of the hardware and software interface, summarizes the software applications and library calls available, and relates our experiences in using all of it. The presentation will include a demonstration of the capabilities and uses of this interface. The authors freely distribute the software components of the interface for educational use.

1 Introduction

The introduction of the Texas Instruments (TI) TMS320C6713 DSP Starter Kit (DSK) brought a much more capable, stable, and robust DSP development environment to DSP education compared to the previously available DSK that was based upon the TMS320C6711. However, while this new 6713 DSK had many improvements over the 6711 DSK, it did not include any way to transfer data to and from the host computer except through the JTAG debugger interface, which is extremely limited in bandwidth and requires that the TI Code Composer Studio (CCS) software tools be available. This means that the existing suite of winDSK6 [1–3] demonstration software

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and other software tools cannot be run on the 6713 DSK, denying educators a valuable teaching and classroom demonstration resource. Also, there is no way to interface an application on the host PC directly to the DSK, limiting the ability of students to create stand-alone, interactive projects using the DSK.

For a number of years, the authors have advocated the systematic employment of proven DSP teaching methodologies, using interactive hardware and software solutions that have helped motivate students and faculty to implement DSP-based systems in real-time [4–7]. While the utility of the TMS320C6713 DSK in this effort is severely hindered by its interface limitations, the overall improvement to this new DSK makes it attractive to create a low-cost modification that permits the continued use of our established tool set.

2 TMS320C6713 DSK Capabilities and Issues

In many ways, the TMS320C6713 DSK is a significant improvement to the previously available TMS320C6211/6711 DSK. In particular, a new USB interface eliminates the problems that were routinely experienced with the parallel port connection, resulting in a much more reliable and robust interface to the host computer. Additionally, the 6713 DSK is designed with a CD-quality, stereo audio codec that provides significantly better audio quality than the monaural telephone quality codec on the 6211/6711 DSKs, and the new DSK is not susceptible to the frequent processor lock-ups that its predecessors were.

The one area where the TMS320C6713 DSK is less useful as an educational tool is the lack of a Host Port Interface (HPI) connection. The HPI is intended to be used by a microprocessor to directly access the internal memory of the DSP, and provides a high bandwidth, non-intrusive link that was the primary communication link used by software tools such as winDSK6 on the TMS320C6211/6711 DSKs. In the TMS320C6713 DSK design, the only data connection available between the host computer and the DSK is through the JTAG emulation port [8]. The JTAG emulation port is a serial connection that is used to control the DSP for program loading and debugging. While this port can be used to send data back to host computer using `printf()` and similar functions, the DSP is actually halted while these transfers occur, and the transfers are quite slow. Obviously, this is not acceptable for real-time software. The JTAG connection has been enhanced to permit transferring data in a non-intrusive way (i.e., while the DSP continues to run) using TI's real-time data transfer (RTDX) protocol, but this mechanism is extremely limited in bandwidth and can only be used with the TI CCS software. Interfacing to other applications on the host computer is also possible through RTDX, but it is extremely complicated due to the need to develop COM software modules to interface to the CCS RTDX server, and still suffers from the same JTAG port bandwidth limitations.

3 TMS320C6713 DSK Host Post Interface (HPI) Daughtercard

Although TI did not design a connection to the host port interface into the DSK, it is fortunate that they did provide an additional connector which exposes the DSP's host port interface pins. Taking advantage of this, we have developed a daughtercard that attaches to the DSK, as shown in Figure 1 and Figure 2. The daughtercard is designed not to interfere with the DSK's standard daughtercard connectors, so the various evaluation modules available for the DSK can still be used with the HPI daughtercard installed. Also, the DSK's JTAG debugger interface can still be used while the HPI daughtercard is attached. A block diagram of the daughtercard's functionality is shown below in Figure 3.

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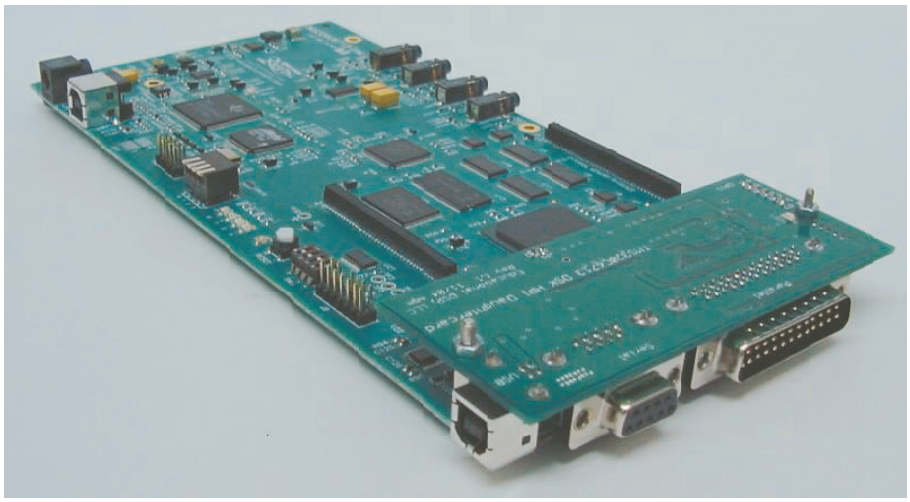

Figure 1: TMS320C6713 DSK with HPI daughtercard mounted.

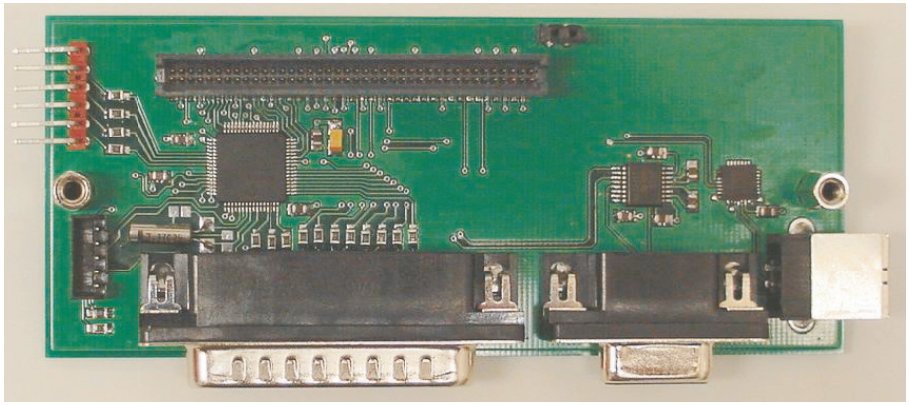

Figure 2: Underside of HPI daughtercard.

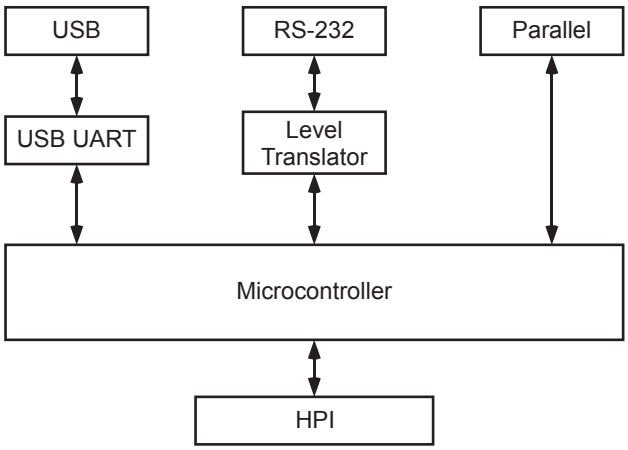

Figure 3: HPI daughtercard functional block diagram.

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There are three communications interfaces available on the HPI daughtercard; a bidirectional parallel port interface, an RS-232 serial interface, and a universal serial bus (USB) interface. Any of the three interfaces (or even all three simultaneously) can be used for control of the DSP via the host PC. An additional benefit, expounded upon below, is that the host PC need not have the TI CCS software tools installed, which provides much greater flexibility in where and how classroom demonstrations are performed.

4 Host-Side Software and Tools

The HPI daughtercard makes the new 6713 DSK accessible from a wide range of educational software tools that have been described in prior publications, a few of which were referenced above. These tools all allow the use of the DSK without the need to have the Texas Instruments' Code Composer Studio (CCS) software installed.

The winDSK6 software package provides a number of demonstration and debugging tools. Full support has been added for the TMS320C6713 DSK with the HPI daughtercard. Selection boxes are provided to choose whether the DSK is to be controlled using the parallel port interface, the RS-232 serial interface, or the USB interface. Faculty using winDSK6 at a variety of institutions have reported significant increase in student enthusiasm and willingness to "dig deeper" into the intricacies of real-time DSP [1, 2, 4–7].

The C6XControl package is designed to give students the basics of a custom PC host application that controls an application running on the DSP. Sample source code is supplied for both the PC host and DSP programs. The host PC software is a complete Microsoft Visual C++ application providing a graphical user interface. The DSP software is a complete CCS project. This skeletal code forms a complete and functional application with minimal features, but one that is easily extended and customized by the student. C6XControl provides a significant boost to get students "over the hump" toward developing their own fully functional real-time DSP application using both the PC and the DSK.

5 DSK-Side Capabilities and Software Interface

One of the nagging problems that students often encounter is the difficulty in easily establishing communications with their software on the DSP in a simple, non-intrusive way. Something as simple as providing basic `printf()` functionality or a simple text command interface is a very difficult endeavor for many students (and teachers), especially those without a significant digital hardware engineering background. The HPI daughtercard for the 6713 DSK provides a simple solution to this class of problems.

In addition to providing access to the DSP from the host computer, the HPI daughtercard also provides additional communications resources and input/output possibilities that are made available to the software running on the DSP. Specifically, the DSP will now have access to the following new capabilities:

- Bidirectional communications with a host computer using the USB interface.
- Bidirectional communications with a host computer using the RS-232 interface.
- Up to 16 bits of digital input/output with individually selectable direction.
- Up to 4 analog input channels.

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The DSP can signal the HPI daughtercard to provide these services through a software library we have developed. This software library provides a simple but useful set of functions:

- `StartHpiServices()` signals the daughtercard that it is to provide the desired services.
- `SetDigitalIoDirection()` sets the direction of the individual digital input/output pins.
- `ReadDigitalIo()` returns the current state of the digital pins configured as inputs.
- `WriteDigitalIo()` sets the state of the digital pins configured as outputs.
- `ReadAnalog()` returns the current values of the analog inputs.
- `ReadSerial()` returns the characters that have been received over the RS-232 communications link.
- `WriteSerial()` transmits a specified number of characters over the RS-232 communications link.
- `ReadUsb()` returns the characters that have been received over the USB communications link.
- `WriteUsb()` transmits a specified number of characters over the USB communications link.

This library provides the essential services required by a student or even a professor who is just learning to control and manipulate real-time DSP hardware from a PC.

With the additional resources of the HPI daughtercard, software on the DSK can now have easily-implemented user interfaces, perform direct control of external devices, and respond to external inputs in addition to the audio codec. Some example uses of the daughtercard might include:

- A communications receiver that sends the received data (in real time) to a terminal window on the host PC for display.
- A communications transmitter that accepts message data from a terminal window on the host PC.
- A bank of LEDs displays system status or acts as a level meter.
- A potentiometer is used to set the gain of a filter bank.

6 Conclusions

The HPI daughtercard significantly enhances the value of the TMS320C6713 DSK as an educational platform. In addition to providing access to a number of software tools, the HPI daughtercard provides services that can be used by the software running on the DSP itself. These include additional communications channels, digital input/output, and analog input capabilities.

The winDSK6 and other software packages we have developed are freely available for educational, non-profit use, and we invite user suggestions for improvement. See `http://eceserv0.ece.wisc.edu/~morrow/software/`. Interested parties are also invited to contact the authors via e-mail.

The HPI daughtercard will be available for purchase from Educational DSP, LLC (`http://www.educationaldsp.com`) as a completed unit or as a bare printed circuit board. As of the submission deadline for this paper, the final prices had not been determined.

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