A HOST PORT INTERFACE BOARD TO ENHANCE THE TMS320C6713 DSK

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ABSTRACT

The fairly recent introduction of the TMS320C6713 DSP Starter Kit (DSK) from Texas Instruments (TI) brought a much more capable, stable, and robust DSP development environment to both university and industry engineers. However, while this new DSK had many improvements over the TMS320C6711 DSK it replaced, it did not include any way to transfer data to and from the host computer except through the debugger interface. Unfortunately, this interface 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 these problems, 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. This paper discusses the specific capabilities of the hardware and software interface, summarizes the software applications and library calls available, and relates a few of our teaching experiences using this new capability. The authors freely distribute the software components of the interface for educational use.

1. INTRODUCTION

The introduction of the TI TMS320C6713 DSK brought a much more capable, stable, and robust DSP development environment to engineers in in both industry and university settings. However, while this new 6713 DSK had many improvements over the 6711 DSK that it replaced, it did not include any method to transfer data to and from the host computer except through the JTAG (IEEE Std 1149.1) debugger interface. This debug interface 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 demonstration software and other software tools cannot be run on the 6713 DSK, denying educators a valuable teaching and classroom demonstration resource [1–3]. Figure 1 shows the winDSK6 opening screen, which gives the reader an idea of the variety of demos available. Another drawback to the 6713 DSK is that there is no way for a software application on the host PC to directly communicate with the DSK, limiting the ability of students to create stand-alone, interactive projects using the DSK.

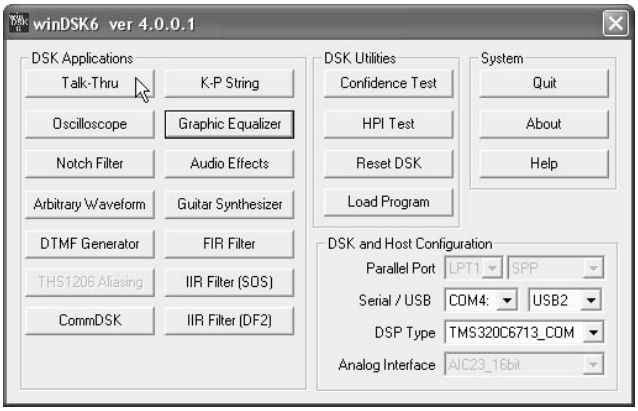

Fig. 1. The winDSK6 user interface.

For a number of years, the authors have advocated a systematic use of proven DSP teaching methodologies, coupled with interactive hardware and software solutions, that have helped motivate students and faculty to implement DSP-based systems in real-time [4–7]. While the suitability of the 6713 DSK for this approach is severely hindered by its "out-of-the-box" interface limitations, the other overall improvements to this new DSK still make it attractive enough that we were motivated 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 TMS320C6711 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 6711 DSKs. The new DSK is also not susceptible to the frequent codec lock-ups that its predecessor experienced.

From an educational point of view, the 6713 DSK is less useful due to its 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 communications link for software tools such as winDSK6 on other DSKs, such as the previously available 6211 and 6711 DSKs. In the 6713 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, originally designed for boundary scan testing of chips such as ASICs or FPGAs, that is used to control the DSP for program loading and debugging. While this port can be used to send data back to the host computer using `printf()` and similar C-language functions, the DSK's CPU 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 it still suffers from the same JTAG port bandwidth limitations.

3. TMS320C6713 DSK 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 HPI pins. Taking advantage of this, we have developed a daughtercard that attaches to the DSK, as shown in Figure 2 and Figure 3. This daughtercard does not interfere with the DSK's standard daughtercard connectors. This allows the various evaluation modules available for the DSK to 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 4.

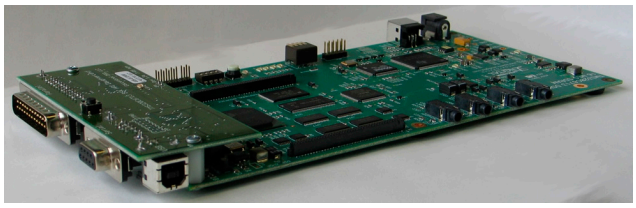

Fig. 2. TMS320C6713 DSK with HPI daughtercard mounted.

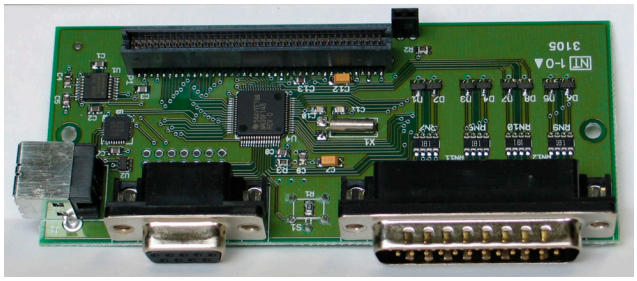

Fig. 3. Underside of HPI daughtercard.

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, or interaction with, the DSK via the host PC. An additional benefit, discussed below, is that the host PC need not have the TI CCS software tools installed. This relaxation 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 to a wide range of educational software tools that have al-

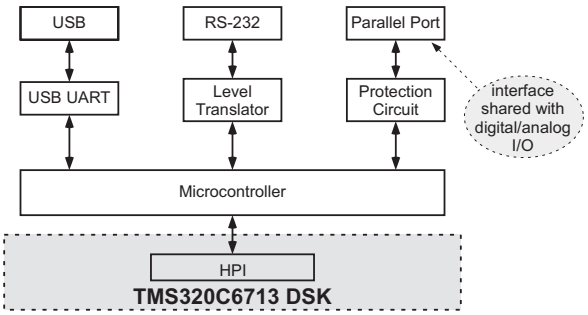

Fig. 4. HPI daughtercard functional block diagram.

ready been developed. These tools allow the use of the DSK without the need to have TI's CCS software installed.

The winDSK6 software package provides a number of demonstration and debugging tools. Full support has been added for the 6713 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 members using winDSK6 at a variety of institutions have reported a 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 skeleton of a custom PC host application that controls an embedded application running on the DSK. Sample source code is supplied for both the PC host and DSK programs. The host PC software is a complete Microsoft Visual C++ application providing a graphical user interface. The DSK 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 recurring problems that students encounter is the difficulty in establishing simple and non-intrusive communications with their software on the DSP. Something as simple as providing basic `printf()` functionality or a simple text command interface is a very difficult endeavor for many students (and professors), especially those without significant experience in digital hardware engineering. The HPI daughtercard for the 6713 DSK provides a simple solution to these problems.

In addition to providing access to the DSP from the host computer, the HPI daughtercard also provides enhanced communications resources and input/output possibilities that are made available to the software running on the DSK. Specifically, the DSK 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 8 analog input channels.

The DSK's CPU can signal the HPI daughtercard to provide these services through a software library that 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.
- `SetBaudRate()` sets the baud rate used on the RS-232 communications link.
- `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. Figure 5 shows a screen capture from a student-created caller ID recovery project [9].
- A communications transmitter that accepts message data from a terminal window on the host PC.
- A bank of LEDs that displays system status or acts as a level meter.
- A potentiometer that is used to set the gain of a filter bank.

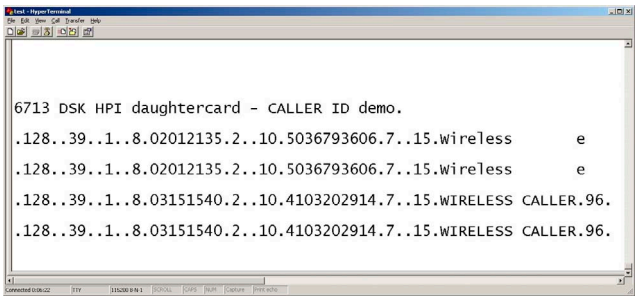

Fig. 5. Screen capture associated with a student-created caller ID recovery project.

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 DSK and a host PC. These include additional communications channels, digital input/output pins, 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 [3]). Interested parties are also invited to contact the authors via e-mail. The HPI daughtercard is available for purchase from Educational DSP, LLC as a fully assembled unit [10].

7. REFERENCES

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