Introduction to the DSP Circuit Board

EXERCISE OBJECTIVES

Upon completion of this unit, you will be familiar with the location and the function of each of the various components of the DIGITAL SIGNAL PROCESSOR training system.

DISCUSSION

The circuit board has two functional sections:

The section containing the circuit board accessories,
and the section containing the Digital Signal Processor and its peripherals.
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The circuit board accessories are the:

- POWER SUPPLY with AUXILIARY POWER INPUT
- DC SOURCE
- MICROPHONE PRE-AMPLIFIER
- AUDIO AMPLIFIER

The POWER SUPPLY circuit block delivers a filtered and regulated DC supply to the entire circuit board.

The circuit board can be operated in two different ways. Either the input voltage for the Power Supply can be received from a Lab-Volt FACET Base Unit or it can be received through external ±15 V connections found on the AUXILIARY POWER INPUT block.
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The DC SOURCE block delivers a DC voltage varying, depending on the position of the potentiometer, between -3.5 Vdc and +3.5 Vdc.

The DC SOURCE can be used as the source of an input reference signal for programs run on the DSP.

The MICROPHONE PRE-AMPLIFIER is used to adjust a microphone's signal to a level suitable for input into the DSP.

The GAIN potentiometer varies the output-level between a low and a high value.
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To be able to hear the signal from the ANALOG OUTPUT, located on the CODEC block, the AUDIO AMPLIFIER is used. Either the speaker or the headphones can be used to listen to the signal.

The second functional section of the circuit board, the DSP and its peripherals, contains the:

- DSP
- CODEC
- I/O INTERFACE
- INTERRUPTS
- AUXILIARY I/O
- SERIAL PORT
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The Digital Signal Processor is found at the heart of a digital signal processing system.

The DSP block contains a TMS320C50 DSP integrated circuit (IC) in a 132-pin surface mount package.

It may reach execution speeds of up to 50 MIPS.

There are many kinds of DSPs, they may vary in cycle speeds.

The calculation speed is set by a DSP's clock.

However, the speed is limited by the IC's internal system design constraints.

Some DSPs use an internal oscillator to set the clock and others use an external oscillator.
The DSP used on the circuit board is configured to use an external oscillator.

The Oscillator located on the circuit board provides it with a 40 MHz reference signal.

The DSP divides this signal to make a 20 MHz internal one (the master clock frequency) that it uses to time its instruction cycles.

What is the calculation speed of the DSP?

a. 20 MHz
b. 40 MHz
c. 20 MIPS
d. 40 MIPS
Some DSP programs are written to internal ROM during the manufacturing process, most, however, use external ROM to store their program.

Both types of DSPs access their ROM at boot-up and store the program to RAM for execution.

A DSP uses digital signals.

To be able to interact with the outside world it must have a translator to convert the analog signals to digital ones and then back again.

A **CODEC** is the translator that is used for this purpose.
A CODEC is usually made up of the following components:

- a programmable input GAIN
- an **ANTI-ALIASING FILTER**
- an Analog-to-Digital converter
- a Digital-to-Analog converter
- a **POST-FILTER**

The I/O INTERFACE is a means to display and to input program information. The 8-position DIP switch enters an 8-bit number into the DSP. Depending on the program being used the information will be processed in different ways.

The 7-segments displays are used to show program information to the DSP user.
Like most microprocessors, DSPs have interrupt control capabilities.

Two push-buttons can be used as user input devices for a program.

When one of the push-buttons is pressed an interrupt is signaled within the DSP and the program code associated with it is executed.

The AUXILIARY I/O section was added for signal monitoring purposes and for prototyping of additional DSP exercises done with the circuit board.
The headers of the AUXILIARY I/O block can be used to interface the DSP with an external circuit.

The external circuit can be powered by the 10-pin header located in the AUXILIARY I/O block.

The AUXILIARY I/O section has three headers.

±5 Vdc and ±15 Vdc connection points are available on the 10-pin right header; these can be used to power an external circuit. The circuit board supplies have a common ground.

The left header outputs the 8 LSB pins (labelled D0 to D7) of the external DSP data bus, and include 4 pre-decoded addresses (labeled PA0# to PA3#) which can be used for prototype development are also included.
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The middle header has the following input/output (I/O) pins:

- Data, Program, and I/O space select (DS#, PS#, IS#)
- Timer output (TOUT)
- Read select and Write enable for external devices (RD#, WE#)
- Read/Write select for external accesses (R/W#)
- Interrupt acknowledge signal (IACK#)
- External interrupt input (INT4#)
- Directional and Chip select to control external data transfer (DIR, CS#)

The DSP on the circuit board is programmed to be the slave of a host computer.

For the DSP Trainer to be used the circuit board SERIAL PORT must be connected to one of your computer's serial ports.

**Note:** If the host computer does not have a second serial port connection available, then at the appropriate times during the exercise procedures, you can disconnect the Base Unit serial link and use it to connect the circuit board SERIAL PORT to the computer.
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The C5x Visual Development Environment (VDE) manages hand-shaking between the circuit board and your computer. It controls all input and output from the DSP’s memory via the serial link.

Once the communication link between your computer and the DSP board is established, the C5x VDE can be used to download a program into the DSP.

PROCEDURE

Circuit Board Introduction

In this procedure section, you will familiarize yourself with some of the components and circuit blocks found on your DIGITAL SIGNAL PROCESSOR circuit board.
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1. Locate, on the DIGITAL SIGNAL PROCESSOR circuit board, all of the common terminals. Using an ohmmeter, verify if the common terminals are connected together.

See HELP Unit 01 shelp1

Are all of the common terminals connected together?

- Yes
- No

2. Turn ON the power supply for the DIGITAL SIGNAL PROCESSOR circuit board.
3. Using a DC voltmeter, and by varying the potentiometer of the DC SOURCE from its smallest to its largest values, measure the DC voltage range at the OUTPUT of the DC SOURCE.

See HELP Unit 01 shelp2

What is the minimum DC voltage \( (V_{DC \ min}) \) and the maximum DC voltage \( (V_{DC \ max}) \) output from the DC SOURCE?

\[
V_{DC \ min} = \underline{\text{__________}} \ V
\]
\[
V_{DC \ max} = \underline{\text{__________}} \ V
\]

4. Make the connections to the DIGITAL SIGNAL PROCESSOR shown in the figure.

\textbf{Note:} If you are in an area where an audio output from the speaker is not desired then use the earphones provided with the circuit board. These connect to the earphone jack located within the AUDIO AMPLIFIER circuit block.

5. While talking into the microphone familiarize yourself with the use of the potentiometers of the MICROPHONE PRE-AMPLIFIER and of the AUDIO AMPLIFIER.

6. Remove all of the connections present on the circuit board.
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Familiarization with the Circuit Board Using a DSP Program

In this procedure section, the C5x VDE will be used to load and run a program inside of the DSP.

![Diagram of C5x VDE program and circuit board]

*Note: Before using the C5x VDE please make certain the circuit board power source is turned ON, and that the serial connection is present between the host computer and the DIGITAL SIGNAL PROCESSOR circuit block labeled SERIAL PORT.*

☐ 7. Open the C5x Visual Development Environment (VDE) program.

☐ 8. Use the Load Program command in the File menu to load the ex1_1.dsk program into the DSP.

What two display windows are now open inside of the C5x VDE?

a. The C5x Registers and the Peripheral Registers displays.
b. The Dis-Assembly Window and the Peripheral Registers displays.
c. The C5x Registers and the Dis-Assembly Window displays.
d. The Peripheral Registers display and the File Selection Window.
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9. Make the circuit board connections shown in the figure. These will allow for proper operation of the ex1_1.dsk program.

   Note: Use the earphones if necessary.

10. Execute the RUN command found on the C5x VDE Toolbar.

11. Observe the read-out displayed within the I/O INTERFACE circuit block. Adjust the DIP switch (every bit in the 0 position) so that the display reads 0000.

   See HELP Unit 01 shelp3

12. Press the INT1# push-button, found in the INTERRUPTS circuit block, to transmit to the DSP the value entered through the DIP switch.

13. Using the microphone, input a signal (your voice) into the DSP.

   Note: Adjust the GAIN potentiometers of the MICROPHONE PRE-AMPLIFIER and of the AUDIO AMPLIFIER to improve the output sound.

14. Note that when you are talking into the microphone, dots on the display of the I/O INTERFACE circuit block light up.
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What do these dots indicate?

a. The DSP processing speed in MIPS.
b. The magnitude of the input signal received from the microphone.
c. Which I/O INTERFACE display, out of the four, is currently being refreshed by the DSP.
d. None of the above choices describe what the dots are displaying.

☐ 15. Adjust the DIP switch such that the I/O INTERFACE display reads 0015.

☐ 16. Transmit the DIP switch value into the DSP by pressing the INT1# push-button.

☐ 17. Observe the effect of the signal processing modification on the sound of your voice.

☐ 18. Repeat steps; 15 to 17 for each of the following I/O INTERFACE display values:

0031, 0063, 0127, 0255

Remember to press the INT1# push-button after setting the DIP switch to a new value.
Which of the following choices best describes the ex1_1.dsk program loaded in the DSP?

a. It is a voice recorder  
b. It is a Base Unit operating system  
c. It is a function generator  
d. It is an echo generator  

With what is the number displayed in the I/O INTERFACE proportional?

a. The time delay (in milliseconds) between consecutive echoes. 
b. The number of echoes created.  
c. The time taken (in milliseconds) to generate the echoes for a sound.  
d. The number of samples to be made on the input signal per second.


CONCLUSION

• The DIGITAL SIGNAL PROCESSOR has two sections: the circuit board accessories section and the DSP with peripherals section.  

• The circuit board is divided into individual circuit blocks.  

• Before a DSP program can be loaded or used, the DIGITAL SIGNAL PROCESSOR power supply must be turned ON and a serial connection between the SERIAL PORT circuit block and the host computer must be made.  

• The CODEC, I/O INTERFACE, INTERRUPT and AUXILIARY I/O circuit blocks can only be used by the user if the program loaded into the DSP requires their use.  

• The user has access to the auxiliary circuit board headers for prototype development.

REVIEW QUESTIONS

1. Before your DIGITAL SIGNAL PROCESSOR circuit board is ready to be used there are certain steps that must be followed. Which of the following statements is necessary to complete before using the circuit board?

a. Make certain that the I/O INTERFACE switches are all in the O position.  
b. Make certain the serial connection is present between the host computer and the DIGITAL SIGNAL PROCESSOR circuit block labeled SERIAL PORT.  
c. Make certain the circuit board power source is turned ON.  
d. Statements b. and c.
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2. What is the DC voltage range that the potentiometer for the DC source is adjusted over?
   a. -3.3 V to +3.6 V  
   b. -3.0 V to +3.0 V  
   c. -3.5 V to +3.5 V  
   d. None of the above.

3. Which of the following pins are located on the middle header of the AUXILIARY I/O circuit block?
   a. The 4 pre-decoded addresses (labeled PA0# to PA3#)  
   b. TOUT, IACK#, INT4#, and RD#  
   c. DS#, D0, D1, and D2  
   d. CS#, INT4#, DS#, and PA1#

4. What does the TMS320C50 DSP found on the DIGITAL SIGNAL PROCESSOR circuit board use to set the frequency of its master clock (recall that it is the clock that sets the calculation speed of the DSP)?
   a. The DSP uses its 20 MHz internal oscillator.  
   b. The DSP uses a 40 MHz external oscillator.  
   c. Through a serial connection, the DSP uses the 33.3 MHz internal oscillator CODEC.  
   d. Through the SERIAL PORT circuit block connection, the DSP uses the internal oscillator of the host computer.

5. Which of the following components is usually found in a CODEC?
   a. An anti-aliasing filter  
   b. An analog-to-digital converter (ADC)  
   c. A digital-to-analog converter (DAC)  
   d. All of the above