

TORNADO-E3x

Stand-alone DSP Controllers with Floating-Point TMS320C3x DSP

User's Guide

covers:
TORNADO-E31 rev.2A
TORNADO-E33 rev.1A/1B

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About this Document

This user's guide contains description for *TORNADO-E3x (TORNADO-E31/E33)* stand-alone digital signal processing (DSP) controllers with 32-bit floating-point TMS320C3x/VC33 DSP from Texas Instruments Inc (TI).

This document does not include detail description neither for TI TMS320C3x DSP, nor for on-board peripheral controllers, nor for the corresponding software and hardware applications. To get the corresponding information please refer to the following original documentation:

1. ***TMS320C3x User's Guide.*** Texas Instruments Inc, SPRU031D, USA, 1994.
2. ***TMS320VC33 Datasheet.*** Texas Instruments Inc, USA, 2000.
3. ***Data Communication ICs. Enhanced Serial Communication Controller ESCC2 SAB82532. User's Manual..*** Siemens, 1994.
4. ***USS-820/USS-825 USB Device Controller.*** Lucent Technologies, 1999.
5. ***TMS320 Floating-Point DSP Optimizing C Compiler User's Guide.*** Texas Instruments Inc, SPRU034B, USA, 1995.
6. ***TMS320 Floating-Point DSP Assembly Language Tools User's Guide.*** Texas Instruments Inc, SPRU035B, USA, 1995.
7. ***TMS320C3x C Source Debugger User's Guide.*** Texas Instruments Inc, SPRU053D, USA, 1994.
8. ***TMS320C3x/C4x Code Composer User's Guide.*** Texas Instruments Inc, USA, 2000.

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Contents

Chapter 1. Introduction	1
1.1 General Information	1
1.2 Technical Specification	3
Chapter 2. System Architecture and Construction	7
2.1 <i>TORNADO-E3x</i> System Architecture	7
2.2 TMS320C3x DSP Environment	11
2.3 Parallel I/O Expansion Interface Site (PIOX-16)	26
2.4 Serial I/O Expansion Interface Sites (SIOX)	30
2.5 Dual-channel USART	38
2.6 Parallel I/O	43
2.7 USB Device Interface	44
2.8 Emulation Tools for <i>TORNADO-E3x</i>	46
2.9 Software Development Tools	46
Chapter 3. Installation and Configuration	49
3.1 Applying the power	49
3.2 Installation of FLASH/EPROM chip	49
3.3 Configuring <i>TORNADO-E3x</i> board	50
Appendix A. On-board Jumpers, Connectors, Switches and Sockets.	53

Figures

<i>Fig.1-1a.</i> <i>TORNADO-E31</i> DSP controller board.	2
<i>Fig.1-1b.</i> <i>TORNADO-E33</i> DSP controller board.	2
<i>Fig.2-1.</i> System architecture of <i>TORNADO-E3x</i> DSP controllers.	7
<i>Fig.2-2a.</i> Construction of <i>TORNADO-E31</i> DSP controller.	8
<i>Fig.2-2b.</i> Construction of <i>TORNADO-E33</i> DSP controller.	9
<i>Fig.2-3.</i> <i>TORNADO-E3x</i> DSP controller with PIOX-16 DCM installed.	26
<i>Fig.2-4.</i> PIOX-16 connector pinout (top view).	27
<i>Fig.2-5a.</i> Timing diagram for PIOX-16 data transfer strobe for <i>TORNADO-E31</i> .	29
<i>Fig.2-5b.</i> Timing diagram for PIOX-16 data transfer strobe for <i>TORNADO-E33</i> .	29
<i>Fig.2-6.</i> Physical dimensions for PIOX-16 DCMs.	30
<i>Fig.2-7.</i> SIOX sites connection diagram for <i>TORNADO-E3x</i> .	31
<i>Fig.2-8a.</i> <i>TORNADO-E3x</i> DSP controller with SIOX rev.B DCM installed.	32
<i>Fig.2-8c.</i> Installation of SIOX rev.C DCM onto <i>TORNADO-E33</i> DSP controller.	32
<i>Fig.2-9.</i> SIOX rev.B site connector pinout (top view).	33
<i>Fig.2-10.</i> SIOX rev.C connector pinout for <i>TORNADO-E33</i> DSP Controller (top view).	35
<i>Fig.2-11.</i> Timing diagram for parallel data transfer via SIOX rev.C site.	37
<i>Fig.2-12a.</i> Physical dimensions for SIOX rev.B DCM.	37
<i>Fig.2-12b.</i> Physical dimensions for SIOX rev.C DCM.	38
<i>Fig. 2-13.</i> RS232C interface connectors pinout for <i>TORNADO-E3x</i> .	41
<i>Fig. 2-14.</i> RS422/EIA-530 interface connectors pinout for <i>TORNADO-E3x</i> .	42
<i>Fig. 2-15.</i> USART transmitter/receiver clock output connectors.	43
<i>Fig.2-16.</i> Parallel digital I/O connector pinout (<i>DIO-0..7</i> signals) for <i>TORNADO-E3x</i> .	44
<i>Fig.2-17.</i> XF0/XF1 I/O signal connector of <i>TORNADO-E3x</i> .	44
<i>Fig. 2-18.</i> Pinout of USB device connector for <i>TORNADO-E33</i> .	45
<i>Fig.3-1.</i> Installation of EPROM chip onto <i>TORNADO-E3x</i> board.	50
<i>Fig.A-1a.</i> On-board layout for <i>TORNADO-E31</i> DSP controller.	53
<i>Fig.A-1b.</i> On-board layout for <i>TORNADO-E33</i> DSP controller.	54

Tables

<i>Table 2-1.</i> TMS320C3x DSP Bootmode Configurations.	12
<i>Table 2-2.</i> Address areas for TMS320C3x DSP in <i>TORNADO-E3x</i> DSP controllers.	16
<i>Table 2-3.</i> FLASH/EPROM chip type selector.	18
<i>Table 2-4.</i> External Hardware Interrupts for TMS320C31 DSP of <i>TORNADO-E31</i> DSP Controller.	21
<i>Table 2-5.</i> External Hardware Interrupts for TMS320VC33 DSP of <i>TORNADO-E33</i> DSP Controller.	22
<i>Table 2-6.</i> PIOX-16 signal description.	27
<i>Table 2-7.</i> SIOX rev.B site signal description.	33
<i>Table 2-8.</i> SIOX rev.C site signal description.	35
<i>Table 2-9.</i> Configuration of external interfaces for channel “A” of USART.	40
<i>Table 2-10.</i> Configuration of external interfaces for channel “B” of USART.	41
<i>Table A-1.</i> On-board configuration jumpers for <i>TORNADO-E3x</i> .	54
<i>Table A-2.</i> On-board connectors for <i>TORNADO-E3x</i> .	55
<i>Table A-3.</i> On-board switches for <i>TORNADO-E3x</i> .	56
<i>Table A-4.</i> On-board sockets for <i>TORNADO-E3x</i> .	56
<i>Table A-5.</i> On-board LED for <i>TORNADO-E3x</i> .	56

Chapter 1. Introduction

This chapter contains general description for *TORNADO-E3x* stand-alone DSP controllers product line, which comprises of *TORNADO-E31/E33* DSP controllers.

CAUTION

The '*TORNADO-E3x*' stand-alone DSP controllers have been designed to accommodate either TMS320C3x or TMS320VC33 32-bit floating-point DSP from TI. The particular DSP installed specifies the final name of *TORNADO-E3x* DSP controller, i.e. *TORNADO-E31* or *TORNADO-E33*.

Since the only differences between TMS320C3x and TMS320VC33 DSP imply to the performance value and on-chip SRAM capacity, then there is no difference for programming between the *TORNADO-E31* and *TORNADO-E33* DSP controllers.

CAUTION

'*TORNADO-E3x*' notation denotes that the supplied information is applicable to all *TORNADO-E3x* DSP controllers (*TORNADO-E31* and *TORNADO-E33* products).

Should information be a product specific, then the name of the corresponding product (*TORNADO-E31* or *TORNADO-E33*) will be highlighted.

1.1 General Information

TORNADO-E3x are high performance 32-bit floating-point DSP controllers with TI TMS320C3x DSP for stand-alone DSP applications.

TORNADO-E3x product line comprises of *TORNADO-E31* and *TORNADO-E33* stand-alone DSP controllers, which feature industry-standard 3U form-factor and flexible modular system construction with daughter-card modules (DCM) in order to meet requirements of multiple floating-point DSP applications while keeping a cost to a minimum.

The only differences between *TORNADO-E31* and *TORNADO-E33* stand-alone DSP controllers are the DSP type installed, DSP performance, on-board SIOX rev.C expansion facility (*TORNADO-E33* only), and on-board USB device interface (*TORNADO-E33* only).

System architecture and construction of *TORNADO-E3x* DSP controllers are compatible with that of *TORNADO-E* product line of DSP controllers.

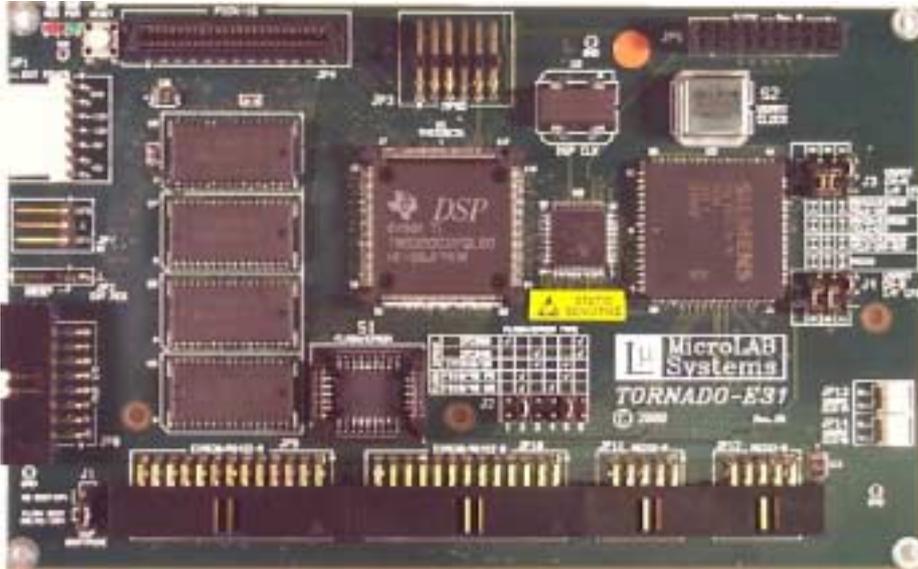


Fig.1-1a. TORNADO-E31 DSP controller board.

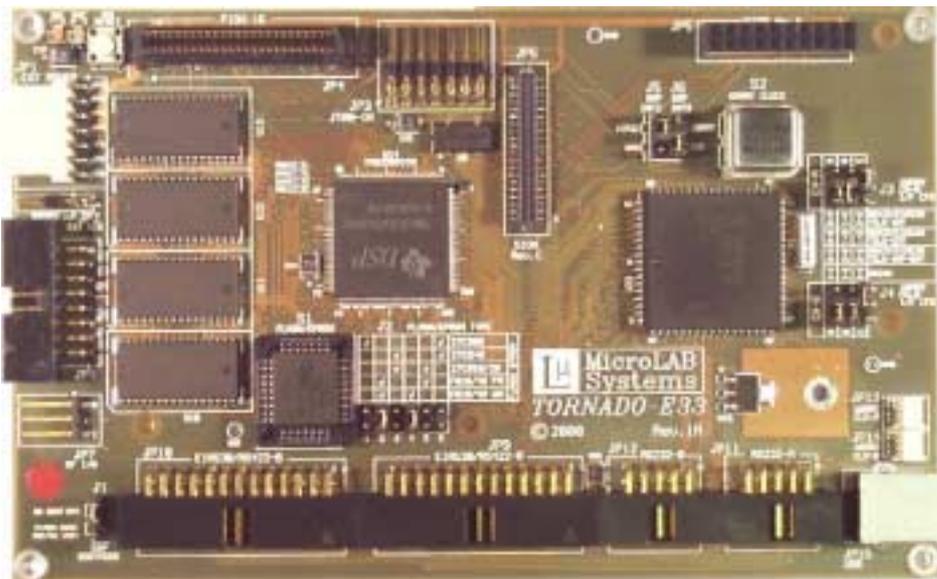


Fig.1-1b. TORNADO-E33 DSP controller board.

TORNADO-E3x DSP controller features:

- 60 MFLOPS TMS320C3x (*TORNADO-E31*) or 150 MFLOPS TMS320VC33 (*TORNADO-E33*) 32-bit floating-point DSP
- up to 512Kx32 on-board static RAM and up to 1Mx8 on-board FLASH/EPROM
- dual-channel 10Mbit/s USART (universal synchronous/asynchronous receiver/transmitter) with external RS232C and RS422/EIA-530 interfaces for communication with host computer and peripherals
- 12 Mbit/s USB device controller for communication with host computers (*TORNADO-E33* only)
- software boot from either the on-board FLASH/EPROM or no boot
- site for serial I/O expansion (SIOX) rev.B DCM for real-time telecom, speech/fax/modem, audio, instrumentation, industrial, digital radio, etc signal processing applications
- site for enhanced serial I/O expansion (SIOX rev.C) DCM (*TORNADO-E33* only) for real-time telecom, speech/fax/modem, audio, digital radio, etc signal processing applications using application specific SIOX rev.C DSP coprocessors
- site for parallel I/O expansion (PIOX-16) DCM for multichannel high-speed telecom, instrumentation, industrial, and application specific coprocessors
- general purpose 10-bit parallel digital I/O for local system control
- industry-standard 3U form-factor

The following are only few of many applications for *TORNADO-E3x* DSP controllers:

- *real-time DSP and signal acquisition*
- *fax/modem*
- *vocoders and speech signal processing*
- *networking*
- *audio and acoustics signal processing*
- *multimedia*
- *radars*
- *digital radio*
- *instrumentation and industrial*
- *evaluation and education*
- many more ...

1.2 Technical Specification

The following are the technical specifications for *TORNADO-E3x* DSP controllers.

<u>Parameter description</u>	<u>parameter value</u>
power supply voltage	+5V for <i>TORNADO-E3x</i> board, optional -5V and $\pm 12V$ for SIOX/PIOX-16 DCMs
power consumption (128Kx32 SRAM installed)	<i>TORNADO-E31</i> : +5V@1.3A (t=+20°C) <i>TORNADO-E33</i> : +5V@1.2A (t=+20°C)

DSP performance	TORNADO-E31: 60 MFLOPS TORNADO-E33: 150 MFLOPS
dimensions	3U (100x160 mm)
operating temperature	+5..+60°C
I/O expansion interfaces	one SIOX rev.B site one SIOX rev.C site (TORNADO-E33) one PIOX-16 site
<i>on-board SRAM and FLASH/EPROM:</i>	
SRAM capacity	TORNADO-E31: 128K/512Kx32 0ws TORNADO-E33: 128K/512Kx32 1ws
FLASH/EPROM capacity	128K..1Mx8 (3ws, Ta≤120ns) with write-protection feature (user installed as PLCC-32 FLASH/EPROM chip)
<i>watchdog timer (WDT) and reset controller:</i>	
WDT latency period	1.6 sec typical
duration of the WDT reset signal (generated by the DSP software)	>100 ns
duration of external reset input signal	>500 ns
duration of the output DSP reset signal	>0.2 sec
<i>on-board parallel digital I/O</i>	10 bits
<i>on-board USART (universal synchronous/asynchronous receiver/transmitter):</i>	
number of channels	2
supported protocols for each channel	<i>synchronous:</i> HDLC/X.25, SDLC, MONOSYNC, BISYNC <i>asynchronous:</i> ASYNC
external electrical interfaces for each channel	RS232C or RS422/EIA-530 pinout
maximum data transfer speed for synchronous protocols (HDLC, SDLC, MONOSYNC, BISYNC) and external RS422/EIA-530 interface	10 Mbit/s
maximum data transfer speed for asynchronous protocol (ASYNC) and external RS232C interface	115 kBaud
maximum data transfer speed for asynchronous protocol (ASYNC) and external RS422/EIA-530 interface	2.5 Mbaud

on-board USB interface

12 Mbit/s USB device interface, meets USB specs rev. 1.1, USB B connector pinout

The main components of *TORNADO-E3x* DSP controller are:

- 60 MFLOPS TMS320C3x (*TORNADO-E31*) or 150 MFLOPS TMS320VC33 (*TORNADO-E33*) 32-bit floating-point DSP from TI
- up to 512Kx32 on-board static RAM
- up to 1Mx8 on-board FLASH/EPROM
- dual-channel multiprotocol 10Mbit/s USART (universal synchronous/asynchronous receiver/transmitter), which supports HDLC/X.25, SDLC, MONOSYNC, BISYNC, ASYNC protocols
- electrical interface multiplexer for each of USART channel, which connects I/O pins of USART to either to 115 kBaud RS232C or 10 Mbit/s RS422/EIA-530 interfaces
- 12 Mbit/s USB device interface (*TORNADO-E33* only) with type 'B' USB interface connector
- 8-bit parallel digital I/O controller (as the part of USART) with individual masking for DSP interrupt generation and optional 2-bit XF0/XF1 DSP digital I/O
- serial I/O expansion (SIOX) rev.B interface site for SIOX rev.B DCM
- enhanced serial I/O expansion (SIOX rev.C) interface site (*TORNADO-E33* only) for SIOX rev.C DCM
- parallel I/O expansion (PIOX-16) interface site for PIOX-16 DCM
- interrupt request controller (IRQ Controller)
- watch-dog timer (WDT)
- DSP reset controller (RC) with on-board RESET switch and external RESET connector
- MPSD-IN (*TORNADO-E31* only) or JTAG-IN (*TORNADO-E33* only) connector for connection to external MPSD/JTAG emulator
- external power connector

Constructions for *TORNADO-E3x* DSP controllers are presented at fig.2-2.

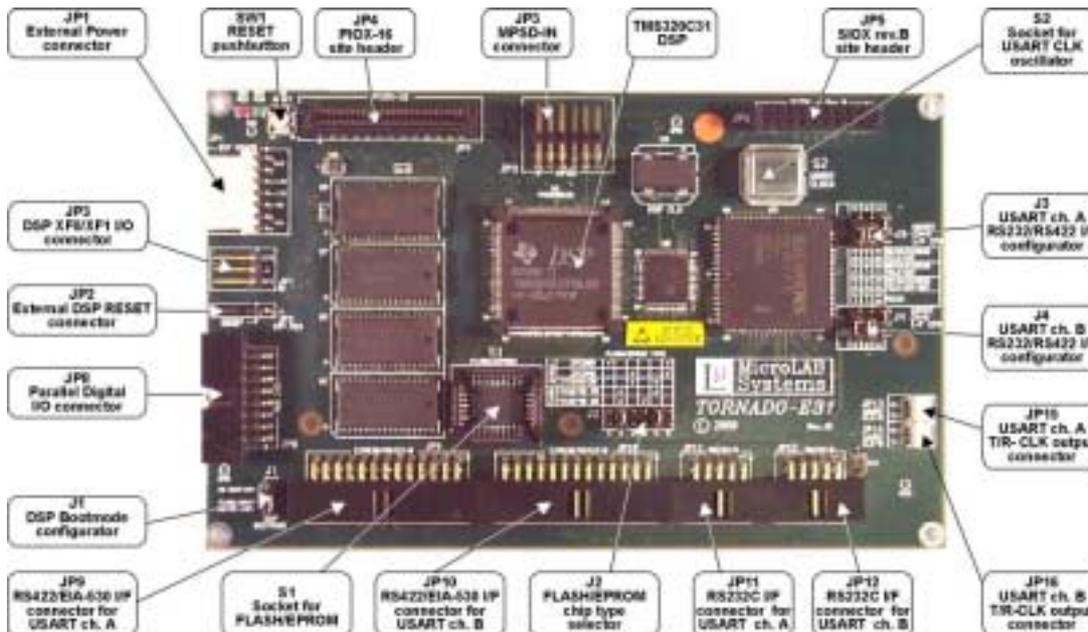


Fig.2-2a. Construction of *TORNADO-E31* DSP controller.

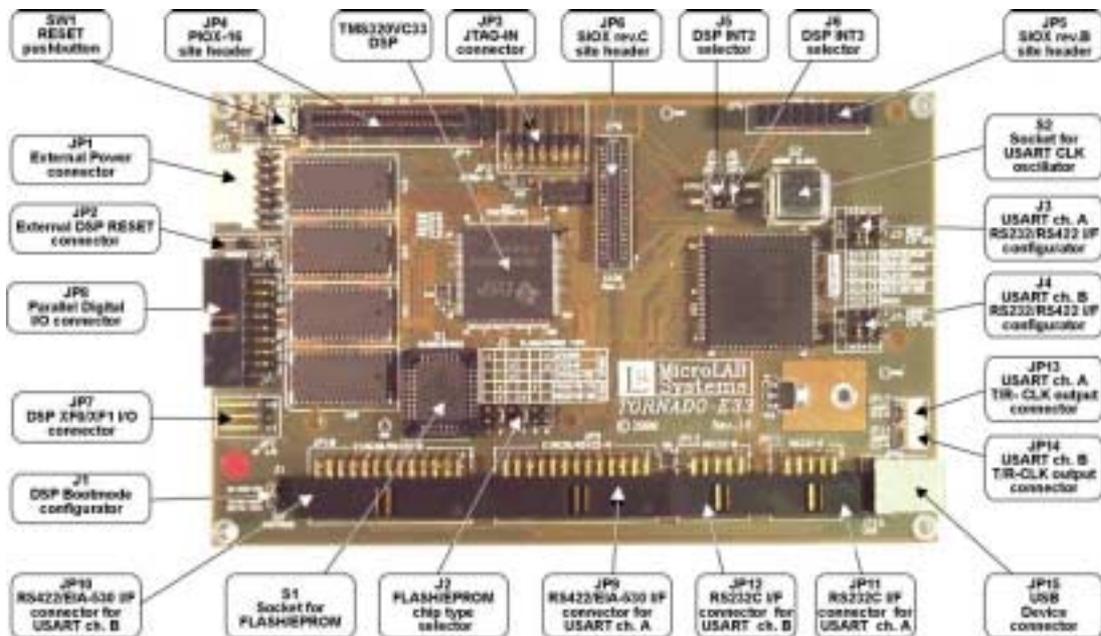


Fig.2-2b. Construction of TORNADO-E33 DSP controller.

TMS320C3x DSP

TORNADO-E31 DSP controller is based around TI 60 MFLOPS 32-bit floating-point TMS320C3x DSP, whereas TORNADO-E33 DSP controller is based around newest 150 MFLOPS 32-bit floating-point TMS320VC33 DSP.

Static RAM (SRAM)

TORNADO-E3x provides up to 512Kx32 on-board static RAM (SRAM) for TMS320C3x DSP external program and data memory areas. On-board SRAM bank is not user upgradable and its capacity must be defined during the purchasing procedure.

FLASH/EPROM

TORNADO-E3x provides up to 1Mx8 of user installed on-board FLASH/EPROM memory for software boot. FLASH/EPROM memory bank is designed to accommodate FLASH/EPROM memory chips in PLCC-32 IC package. Once FLASH memory is used, then on-board hardware provides write-protection feature in order to exclude damage of boot code.

Dual-channel USART

TORNADO-E3x features the on-board dual-channel USART (universal synchronous/asynchronous receiver/transmitter) for communication with host computers, terminals, network adapters, or external peripherals.

USART is based around the SIEMENS SAB82532 chip and supports popular synchronous protocols (HDLC/X.25, SDLC, MONOSYNC, BISYNC) at up to 10 Mbit/s data transfer rate and industry-standard asynchronous protocol at up to 2.5 Mbaud independent for each channel.

Each channel of USART connects to external equipment via jumper selectable either RS232C or RS422/EIA-530 electrical interface.

USB device interface (*TORNADO-E33* only)

TORNADO-E33 provides the on-board 12 Mbit/s USB device interface for communication with external host computers. On-board USB interface connector is the USB type 'B' device connector. USB device controller and external interface meets USB rev.1.1 specifications.

Parallel digital I/O

TORNADO-E3x provides general purpose 8-bit parallel digital I/O, which might be used as external control I/O signals. These digital I/O signals are the part of internal USART facility, and allow generation of DSP interrupt on individually programmable high-to-low or low-to-high transitions when programmed as input pins. Also, XF0/XF1 DSP I/O pins are also available for user I/O via the edge-board connector.

Serial I/O Expansion Interface (SIOX) sites

TORNADO-E3x on-board SIOX interface sites are used for installation of AD/DA/DIO DCM and comprises of SIOX rev.B and new enhanced SIOX rev.C sites (*TORNADO-E33* only).

SIOX rev.B site includes signals for TMS320C3x DSP on-chip serial port, timers and interrupt control, whereas SIOX rev.C provides optional 8-bit parallel data bus with 6-bit address and data strobes.

SIOX compatible DCM include a variety of AD/DA/DIO modules for telecom, speech/fax/modem, audio, and many more applications.

Parallel I/O Expansion Interface (PIOX-16) site

TORNADO-E3x provides 16-bit parallel PIOX-16 interface site for installation of compatible PIOX-16 DCM. PIOX-16 interface is allocated into TMS320C3x external bus.

PIOX-16 interface comprises of the signals for DSP 16-bit address and 16-bit data buses, data strobes and TMS320C3x DSP on-chip timers and interrupts control.

PIOX-16 compatible DCMs include a variety of high-speed multichannel AD/DA/DIO modules for high-speed telecom, instrumentation, and application specific I/O coprocessors.

Watch-dog timer (WDT)

TORNADO-E3x features on-board watch-dog timer (WDT) in order to increase the reliability of stand-alone operation. While the DSP is operating properly, it should perform reset of WDT every 1.6 sec, otherwise the WDT will generate the DSP reset signal and will restart *TORNADO-E3x*.

DSP Reset Controller (RC)

The DSP reset signal for *TORNADO-E3x* is generated by the DSP reset controller (RC) on the power-on/off conditions, external reset condition, on-board DSP RESET switch condition and on the WDT expiration condition. Generated DSP reset signal has duration 0.2 sec, whereas the minimum duration of external reset signal is 500ns.

Interrupt Request Controller (IRQ Controller)

TORNADO-E3x features on-board IRQ controller, which provides selection of interrupt source signal for TMS320C3x DSP INT2 and INT3 hardware interrupts (*TORNADO-E33* only), converts level-sensitive external hardware interrupt requests to edge-sensitive DSP interrupt requests, and is also used to define FLASH memory as the DSP boot code source during DSP microcontroller start-up mode.

Debugging TMS320C3x DSP Software

Resident TMS320C3x DSP software for *TORNADO-E3x* can be debugged using TI XDS510 and MicroLAB' *MIRAGE-510DX* JTAG/MPSD emulators using the industry standard TI C3x HLL Debugger or TMS320C3x/C4x Code Composer IDE.

2.2 TMS320C3x DSP Environment

TORNADO-E31 DSP controller utilizes the industry-standard TI 60 MFLOPS 32-bit floating-point TMS320C3x DSP, whereas *TORNADO-E33* DSP controller is based around the newest 150 MFLOPS 32-bit floating-point TMS320VC33 DSP.

TMS320VC33 DSP is the latest innovation to the industry-standard TI TMS320C3x floating-point DSP product line. TMS320VC33 DSP is upward compatible with TMS320C3x DSP and features x17 times extended on-chip RAM (34 Kwords) and x2.5 times performance (150 MFLOPS).

CAUTION

For more details about TI TMS320C3x DSP refer to original TI TMS320C3x User's Guide, which is available in electronic form from TI web-site (www.ti.com) and in the paper form upon request from your nearest TI office.

TMS320C3x DSP Bootmode Configurations

The TMS320C3x DSP bootmode configuration is defined by the on-board jumper J1 (refer to fig.2-2 or fig.A-1). Supported bootmode configurations are presented in table 2-1.

Table 2-1. TMS320C3x DSP Bootmode Configurations.

Jumper J1	Bootmode	Description
1-2	<i>MP-BMODE</i>	<p>Corresponds to the DSP Microprocessor start-up mode without boot process.</p> <p>After DSP reset will be released, the DSP will fetch the reset vector from address 000000H of on-board SRAM, which must contain valid DSP code.</p>
2-3	<i>MC/MP-BMODE</i>	<p>Corresponds to the DSP Microcontroller start-up mode with boot from the on-board FLASH/EPROM with further transition to the DSP Microprocessor mode.</p> <p>The lowest 4Kx32 words of SRAM within the 000000H..000FFFH address range will be not available, since they are remapped to the DSP on-chip ROM. However alias of entire SRAM area is available starting from 100000H address. The DSP interrupts will be automatically unlocked after the first read from the on-board FLASH/EPROM, and will be immediately available for application after boot process completes.</p> <p>In case J1 jumper will be installed or DSP will execute write to the BMODE_RG after bootload process will complete, then the DSP Microcontroller mode with the DSP on-chip ROM and remap of interrupt vectors to the on-chip SRAM will be all disabled, and the DSP Microprocessor mode will be set. Full SRAM will be available starting from the 000000H base address. Once the DSP Microprocessor mode will be set, then there is no way to return back to the DSP Microcontroller mode except as via applying the DSP reset condition.</p>

Note:

1. 'ON' corresponds to the installed jumper; 'OFF' corresponds to the removed jumper.
2. Highlighted configuration corresponds to the factory setting.

The *MP-BMODE* DSP bootmode configuration of *TORNADO-E3x* corresponds to the DSP microprocessor start-up mode with the DSP vector mapped to the on-board SRAM. This mode is useful for the DSP software development and debugging.

CAUTION

When designing DSP software for *TORNADO-E3x* for *MC/MP-BMODE* DSP bootmode configuration without transition to the DSP microprocessor mode it is recommended to allocate all external DSP SRAM areas for program/data starting from the 001000H address.

CAUTION

When designing DSP software for *TORNADO-E3x* for *MP-BMODE* DSP bootmode configuration and *MC/MP-BMODE* DSP bootmode configuration with further transition to the DSP microprocessor mode it is recommended to allocate all external DSP SRAM areas for program/data starting from the 100000H address (refer to table 2-2 for details).

The *MC/MP-BMODE* DSP bootmode configuration for *TORNADO-E3x* corresponds to the DSP microcontroller start-up mode with boot from the on-board FLASH/EPROM and further software controlled transition to the DSP microprocessor mode.

Once *TORNADO-E3x* is configured in the *MC/MP-BMODE* DSP bootmode, then the DSP will enter the microcontroller mode after the DSP reset will be released, with the DSP on-chip ROM mapped into the 000000H..000FFFH DSP memory area and the DSP interrupt vectors table remapped to the DSP on-chip SRAM. This remap will take place until DSP will stay in the microcontroller mode. Note, that the FLASH/EPROM contents shall meet format of the TMS320C3x DSP on-chip ROM bootloader.

CAUTION

DSP external interrupt request inputs, which are used to define the FLASH/EPROM memory boot code source during *MC/MP-BMODE* DSP bootmode, will be unlocked and become available for application usage immediately after the first read from the on-board FLASH/EPROM during the boot process.

CAUTION

Some DSP applications (FFT, etc), which require full utilization of TMS320C3x DSP on-chip SRAM, cannot run in the DSP microcontroller mode due to the remapping of interrupt vector table to the DSP on-chip SRAM (in DSP microcontroller mode interrupt vectors table 'eats out' 64 memory locations from the DSP on-chip SRAM). Also, since TMS320C3x DSP code for DSP microprocessor mode requires modification in order to run in the DSP microcontroller mode, it is desirable to boot with the DSP microprocessor mode in order to exclude any confusions.

Although the *MC/MP-BMODE* DSP bootmode configuration of *TORNADO-E3x* initially sets on-board DSP into the microcontroller bootmode, the *MC/MP-BMODE* DSP bootmode allows further software transition to the DSP microprocessor mode.

The restored DSP microprocessor mode enables SRAM area at the 000000H base address and remaps the DSP interrupt vectors table back to external SRAM starting from 000000H memory address. This is useful for embedded operation of *TORNADO-E3x* and when full DSP on-chip memory must be used for program/data in order to get maximum DSP performance, and in order to obtain full compatibility with the *MP-BMODE* software debug mode.

In order to set the TMS320C3x microprocessor mode while DSP is in the microcontroller mode, the DSP must perform write operation to the *BMODE_RG* register (refer to table 2-2). The data written to the *BMODE_RG* register will be ignored, and DSP microprocessor mode will be set with four DSP cycles.

CAUTION

While DSP is in the microcontroller mode, the DSP code, which contains the first write instruction to the *BMODE_RG* register, must be allocated beyond of the first 4K words of SRAM (000000H..000FFFH).

For *MC/MP-BMODE* DSP bootmode, the DSP microprocessor mode will be restored within four DSP cycles after DSP will execute write to the *BMODE_RG* register.

In case the on-board J1 jumper will be set to the 1-2 position after DSP has been released from the reset state and while DSP is in the microcontroller mode, then DSP will be set to the microprocessor mode.

After the DSP microprocessor mode has been restored, then the only way to return back to the DSP microcontroller mode is to apply DSP hardware reset.

CAUTION

DSP software can recognize start-up bootmode and current DSP mode (microprocessor or microcontroller) via bits *STARTUP_BMODE* and *BMODE* read-back bits of the *BMODE_RG* register (refer to the corresponding subsection later in this section).

TMS320C3x DSP Address Space

TORNADO-E3x on-board TMS320C3x DSP address area comprises of the SRAM, EPROM and I/O areas in accordance with table 2-2.

Table 2-2. Address areas for TMS320C3x DSP in TORNADO-E3x DSP controllers.

Address area	DSP address range	word length	access mode	wait states	applicable DSP bootmodes
SRAM	000000H..07FFFFH alias at: 100000H..17FFFFH	32	r/w	0ws (TORNADO-E31) 1ws (TORNADO-E33)	MP-BMODE
FLASH/EPROM (Ta<132ns)	400000H..5FFFFFFH	8 (D0..D7)	r	3ws ²⁾ (TORNADO-E31) 11ws (TORNADO-E33)	
SRAM	before write to the BMODE_RG register: 001000H..07FFFFH after write to the BMODE_RG register: 000000H..07FFFFH mirror at: 100000H..17FFFFH	32	r/w	0ws (TORNADO-E31) 1ws (TORNADO-E33)	MC/MP- BMODE
EPROM (Ta<132ns)	400000H..5FFFFFFH	8 (D0..D7)	r	3ws ²⁾ (TORNADO-E31) 11ws (TORNADO-E33)	
DSP on-chip peripherals and memory (refer to TI TMS320C3x documentation for details)	800000H..809FFFFH	32	r/w	0ws	all
BMODE_RG (DSP bootmode control register)	900000H	2 (D0/D1)	r/w	0ws (TORNADO-E31) 1ws (TORNADO-E33)	all
dual-channel USART	channel A: A00000H..A0003FH channel B: A00040H..A0007FH	8 (D0..D7)	r/w	2ws (TORNADO-E31) 5ws (TORNADO-E33)	all
USB device controller (TORNADO-E33 only)	B00000H..B0001FH	8 (D0..D7)	r/w	7ws (TORNADO-E33)	all

PXSX_RUN_RG (PIOX/SIOX reset control register)	C00000H	2 (D0/D1)	r/w	0ws (TORNADO-E31) 1ws (TORNADO-E33)	all
WDT_EN_RG (WDT enable register)	D00000H	1 (D0)	r/w	0ws (TORNADO-E31) 1ws (TORNADO-E33)	all
SIOX rev.C expansion DCM site (TORNADO-E33 only)	E00000H..E0003FH	8 (D0..D7)	r/w	(2ws+SIOX_RDY) (TORNADO-E33)	all
PIOX-16 expansion DCM site	FF0000H..FFFFFFH	16 (D0..D15)	r/w	(1ws+PIOX_RDY) (TORNADO-E31) (2ws+PIOX_RDY) (TORNADO-E33)	all

- Notes:
1. Register access modes: *r* - read only, *w* - write only, *r/w* - read/write.
 2. DSP access to the on-board EPROM is performed with 3ws for TORNADO-E31 and 11ws for TORNADO-E33, which corresponds to 132ns and 160ns access times for FLASH/EPROM. In order to meet the access times of slower FLASH/EPROM chips ($T_a \leq 260\text{ns}$) for TORNADO-E31, the DSP boot procedure for MC/MP-BMODE must be performed with seven DSP software wait states and logical AND between the DSP software wait states and external ready signal by means of programming the DSP Primary Bus Control Register (@808064H) to the 000006F8H value for the DSP boot procedure. The DSP Primary Bus Control Register (@808064H) for the DSP boot procedure can be set via the configuration file for the HEX30.EXE software utility, which is the part of TI TMS320 Floating-Point DSP Assembler Tools and TI TMS320 Floating-Point DSP Optimizing C Compiler. It is not possible to use slower FLASH/EPROM chips with TORNADO-E33.
 3. ' T_a ' denotes the access time.

CAUTION

In order to provide correct operation of the on-board hardware, the DSP Primary Bus Control Register (@808064H) must be set to the 00000500H value.

SRAM Area

TORNADO-E3x on-board SRAM operates at full DSP performance without hardware wait states. On-board SRAM can be used to store both program and data. The on-board SRAM is not user upgradable and its capacity must be defined during product purchasing.

TORNADO-E3x on-board SRAM is allocated at the 000000H DSP address and has alias at 100000H DSP address. SRAM alias area is useful for providing compatibility between software, which is designed for both MP-BMODE and MC/MP-BMODE DSP bootmode configurations.

FLASH/EPROM Area

On-board FLASH/EPROM bank of *TORNADO-E3x* shall be used to accommodate the FLASH/EPROM chip in order to store the DSP boot code, which will be reloaded to the on-board SRAM during DSP boot procedure.

FLASH/EPROM bank assumes installation of 128K..1Mx8 either EPROM or 5v only FLASH chip in PLCC-32 IC package with access time lower than 120ns into the dedicated on-board PLCC-32 S1 socket (refer to fig.2-2 and A-1).

The EPROM chip must be programmed in the external programmer only, and can be used for read-only software boot purposes in *TORNADO-E3x*, whereas the 5v only FLASH memory can be programmed directly in the *TORNADO-E3x*. There is also possibility to inhibit FLASH writes in order to maintain integrity of FLASH contents.

The on-board J2 jumper set (jumpers J2-1..J2-6) must be used to select the particular FLASH/EPROM chip type in accordance with table 2-3.

Table 2-3. FLASH/EPROM chip type selector.

FLASH/EPROM (PLCC-32 IC pack)	J2 jumper setting					
	J2-1	J2-2	J2-3	J2-4	J2-5	J2-6
<i>Am29F010</i> 128Kx8 FLASH <i>Am29F040</i> 512Kx8 FLASH WRITE ENABLE	OFF	ON	OFF	ON	OFF	OFF
<i>Am29F010</i> 128Kx8 FLASH <i>Am29F040</i> 512Kx8 FLASH WRITE DISABLE	OFF	ON	OFF	OFF	ON	OFF
<i>27C010</i> 128Kx8 EPROM <i>27C020</i> 256Kx8 EPROM	OFF	OFF	ON	OFF	ON	OFF
<i>27C040</i> 512Kx8 EPROM	OFF	OFF	ON	OFF	OFF	ON
<i>27C080</i> 1Mx8 EPROM	ON	OFF	OFF	OFF	OFF	ON

Notes:.

1. The highlighted configuration corresponds to the factory setting.
2. The recommended access time for the FLASH/EPROM chip is 120ns or less.

CAUTION

TMS320C3x DSP allocates 8-bit FLASH/EPROM data words at the 32-bit data word boundaries.

FLASH/EPROM memory bank provides FLASH memory write protection in order to exclude unauthorized FLASH memory data update.

CAUTION

If J2-5 jumper is removed and J2-4 jumper is installed while the FLASH memory chip is installed, then the FLASH memory can be programmed by the DSP software

If J2-5 jumper is installed and J2-4 jumper is removed while the FLASH memory chip is installed, then writing to FLASH memory is disabled.

CAUTION

Installation of FLASH/EPROM chip other than that specified in table 2-3 may result in damage of FLASH/EPROM chip and/or of *TORNADO-E6x* hardware.

I/O Area

TMS320C3x DSP environment of *TORNADO-E3x* features asynchronous I/O area, which is allocated into external bus address space of TMS320C3x DSP and includes the following on-board peripherals and registers:

- *dual-channel USART*
- *USB device controller (TORNADO-E33 only)*
- *BMODE_RG* (DSP bootmode control/status) register
- *WDT_EN_RG* (WDT enable) register
- *PXSX_RUN_RG* (PIOX/SIOX reset control) register
- *SIOX rev.C* interface area for compatible DCM (*TORNADO-E33* only)
- *PIOX-16* interface area for compatible DCM.

Dual-channel USART

TORNADO-E3x features the on-board dual-channel USART (universal synchronous/asynchronous receiver/transmitter) for communication with host computers, terminals, network adapters, or external peripherals using industry standard serial communication protocols.

USART is based around the SIEMENS SAB82532 chip and supports popular synchronous protocols (HDLC/X.25, SDLC, MONOSYNC, BISYNC) at up to 10 Mbit/s data transfer rate and the industry-standard asynchronous protocol (ASYNC) at up to 2.5 Mbaud independently for each channel.

Each channel of USART connects to external communication equipment via either RS232C or RS422/EIA-530 electrical interface. Selection of particular interface is performed by the on-board jumper sets J3 and J4.

For detail information about USART and how to configure external RS232C/RS422 interfaces for USART please refer to the *USART* section later in this chapter.

USB interface

TORNADO-E33 DSP controller provides the on-board USB device controller with external USB type 'B' interface connector for communication with external host computers via the industry standard 12 Mbit/s USB protocol.

USB device controller is based around the Lucent Technologies USS-820/USS-825 chip and meets USB rev.1.1 specifications. USB device controller can generate interrupt to on-board DSP. For more details about USB controller and interface refer to the corresponding section later in this chapter.

PIOX-16 DCM Site

TORNADO-E3x controller provides on-board 16-bit parallel I/O expansion interface (PIOX-16) site for compatible high-speed AD/DA/DIO DCMs. PIOX-16 area is mapped directly to the address space of TMS320C3x DSP.

PIOX-16 occupies 64Kx16 address area within the address space of TMS320C3x DSP. PIOX-16 site comprises of the TMS320C3x DSP 16-bit data and 16-bit address buses, data strobes, DSP-on-chip timers TM-0/TM-1 input/output, *INT0..INT2* external interrupt requests and $\pm 5v/\pm 12v$ power supply lines. For details about PIOX-16 site refer to the corresponding section later in this chapter.

SIOX rev.B DCM site

TORNADO-E3x provides on-board site for serial I/O expansion interface (SIOX) rev.B for compatible AD/DA/DIO DCM. SIOX rev.B comes standard with all *TORNADO* DSP systems/controllers/coprocessors since 1994.

SIOX rev.B site comprises of the TMS320C3x DSP-on-chip serial port control lines, DSP-on-chip timers TM-0/TM-1 input/output, *IRQ-0..2* external interrupt requests and $\pm 5v/\pm 12v$ power supply lines. For details about SIOX rev.B site refer to the corresponding section later in this chapter.

SIOX rev.C enhanced DCM site

Along with SIOX rev.B DCM site *TORNADO-E33* also provides on-board site for serial I/O expansion interface SIOX rev.C for compatible AD/DA/DIO DCM.

SIOX rev.C is an enhanced version of SIOX rev.B interface site and comprises of the TMS320C3x DSP-on-chip serial port control lines, DSP-on-chip timers TM-0/TM-1 input/output, *IRQ-0* external interrupt requests, 8-bit DSP parallel data bus, 6-bit DSP address lines, parallel data strobes, and $+5v/\pm 12v$ power supply lines. Parallel data bus area of SIOX rev.C site is mapped into the TMS320C3x DSP address space (refer to table 2-2). For

details about SIOX rev.C site refer to the corresponding section later in this chapter.

External Hardware Interrupts for TMS320C3x DSP

TORNADO-E3x on-board TMS320C3x DSP supports four external hardware interrupt requests *INT0...INT3* with the *INT0* request having the highest priority. These requests correspond to the following events:

- *INT0...INT1* interrupt requests can be generated by SIOX/PIOX/PIOX-16 DCMs
- *INT2* interrupt request can be generated by SIOX/PIOX/PIOX-16 DCMs for *TORNADO-E31*, and can be selected between either interrupt request from SIOX/PIOX/PIOX-16 DCM or USB interrupt for *TORNADO-E33* via on-board J5 jumper
- *INT3* is wired to the interrupt request from the on-board USART for *TORNADO-E31*, and can be selected between either USART or USB interrupts for *TORNADO-E33* via on-board J6 jumper.

Tables 2-4 and 2-5 describe details about external hardware interrupts for TMS320C3x DSP of *TORNADO-E3x* DSP controllers.

Table 2-4. External Hardware Interrupts for TMS320C31 DSP of *TORNADO-E31* DSP Controller.

interrupt request input of TMS320C3x DSP	interrupt source on <i>TORNADO-E3x</i> controller	Description
INT0	<i>IRQ-0</i>	Active low interrupt request input from SIOX rev.B and PIOX-16 DCM sites (activated by either level or falling-edge).
INT1	<i>IRQ-1</i>	Active low interrupt request input from SIOX rev.B and PIOX-16 DCM sites (activated by either level or falling-edge).
INT2	<i>IRQ-2</i>	Active low interrupt request input from SIOX rev.B and PIOX-16 DCM sites (activated by either level or falling-edge).
INT3	<i>USART interrupt (active low)</i>	Interrupt output from on-board USART. Note, that DSP software must configure USART interrupt output pin as active-low push-pull output.

Table 2-5. External Hardware Interrupts for TMS320VC33 DSP of TORNADO-E33 DSP Controller.

Interrupt request input of TMS320C3x DSP	interrupt source on TORNADO-E3x controller	J5 jumper	J6 jumper	Description
INT0	IRQ-0	x	x	Active low interrupt request input from SIOX rev.B, SIOX rev.C and PIOX-16 DCM sites (activated by either level or falling-edge).
INT1	IRQ-1	x	x	Active low interrupt request input from SIOX rev.B and PIOX-16 DCM sites (activated by either level or falling-edge).
INT2	IRQ-2	1-2	x	Active low interrupt request input from SIOX rev.B and PIOX-16 DCM sites (activated by either level or falling-edge).
	USB interrupt (active low)	2-3	x	Interrupt output from on-board USB controller. Note, that DSP software must configure USB interrupt output pin as active-low push-pull output.
INT3	USART interrupt (active low)	x	1-2	Interrupt output from on-board USART. Note, that DSP software must configure USART interrupt output pin as active-low push-pull output.
	USB interrupt (active low)	x	2-3	Interrupt output from on-board USB controller. Note, that DSP software must configure USB interrupt output pin as active-low push-pull output.

Notes:.

1. The highlighted configuration corresponds to the factory setting.
2. 'X' for jumper setting denotes 'DON'T CARE' jumper configuration.

TORNADO-E3x hardware provides wiring of external interrupt request signals to the corresponding INT0..INT3 interrupt request pins of TMS320C3x DSP chip via the on-board interrupt controller. Both static (active-low level sensitive) and pulse (falling-edge sensitive) interrupt requests are supported with active falling edge and active pulse duration 66ns (TORNADO-E31) and 28ns (TORNADO-E33) and longer.

CAUTION

TORNADO-E3x hardware is designed for external active-low DSP interrupts input INT0...INT3.

BMODE_RG Register for DSP Bootmode Control/Status

BMODE_RG register is available for read/write and must be used to read-back startup/current DSP bootmode and to set the DSP microprocessor mode in case DSP has been initialized in the MC/MP-BMODE bootmode (refer to the corresponding 'TMS320C3x DSP Bootmode Configurations' subsection above in this chapter for more details).

When *BMODE_RG* register is read by DSP software, it has the following data format with bits D0/D1 being valid only:

***BMODE_RG* register (r)**

x	x	x	x	x	x	x	<i>BMODE</i> (r)	<i>STARTUP_BMODE</i> (r)
bit-31...bit-8	bit-7	bit-6	bit-5	bit-4	bit-3	bit-2	bit-1	bit-0

Bit *STARTUP_BMODE* provides information about DSP start-up bootmode:

- if *STARTUP_BMODE* bit equals to '0', then this means that DSP has been initialized in the microprocessor mode (*MP-BMODE* bootmode configuration of jumper J1 in accordance with table 2-1), and, therefore, the *BMODE* bit will always read as '0', and all writes to *BMODE_RG* will have no effect
- if *STARTUP_BMODE* bit equals to '1', then this means that DSP has been initialized in the microcomputer mode (*MC/MP-BMODE* bootmode configuration of jumper J1 in accordance with table 2-1), and, therefore, the DSP microprocessor mode can be restored by means of writing to the *BMODE_RG*.

Bit *STARTUP_BMODE* reflects current state of DSP bootmode as the following:

- if *BMODE* bit equals to '0', then this means that DSP is already in microprocessor mode, and all writes to *BMODE_RG* will have no effect
- if *BMODE* bit equals to '1', then this means that DSP has been initialized in microcomputer mode (*MC/MP-BMODE* bootmode configuration of jumper J1 in accordance with table 2-2), and was not yet set to the DSP microprocessor mode by means of writing to the *BMODE_RG*.

CAUTION

In case DSP has been initialized in *MC/MP-BMODE* DSP bootmode, then DSP microprocessor mode can be restored by means of writing to the *BMODE_RG* register. Written data is ignored.

TMS320C3x DSP Reset Controller (RC)

TORNADO-E3x on-board reset controller (RC) is designed to generate the DSP reset pulse on the following input conditions (minimum duration of the DSP reset pulse is 0.2 sec):

- in case of power-on and power-off condition (the power is controlled by built-in high accuracy power supervisory circuit)
- external reset signal is applied via on-board connector JP2
- on-board RESET pushbutton (SW1) has been pressed
- WDT is enabled via *WDT_EN_RG* register and the WDT latency period (0.8 sec typical) has been expired.

XF0/XF1 DSP I/O pins

TORNADO-E3x provides optional two-bit external I/O facility via DSP XF0/1 I/O pins, which are wired to the on-board JP7 connector. The DSP XF0/XF1 I/O pins are controlled by the TMS320C3x DSP on-chip IOF register (refer to original TMS320C3x documentation for more details).

The XF1 I/O pin of TMS320C3x DSP can be used for external I/O purposes only, whereas the XF0 I/O pin of TMS320C3x DSP can be also used to reset the on-board watch-dog timer (WDT) in case the WDT feature is enabled via the *WDT_EN_RG* register.

Watchdog Timer (WDT)

TORNADO-E3x provides on-board watchdog timer (WDT) feature, which generates output pulse in case WDT has not been reset by DSP software within the latency period (typically 0.8 sec) since the last reset event. This WDT feature increases the reliability of controller operation in embedded environment and allows to restart the on-board DSP in case of the DSP idling or software crash.

DSP reset on the WDT expiration event is enabled by the *WDT_EN* bit of *WDT_EN_RG* register (note that only bit D0 is valid):

***WDT_EN_RG* register (r/w)**

x	x	x	x	x	x	x	x	x	<i>WDT_EN</i> (r/w, 0+)
bit-31...bit-8	bit-7	bit-6	bit-5	bit-4	bit-3	bit-2	bit-1	bit-0	

In case the *WDT_EN* bit of *WDT_EN_RG* register is set to '0' (this value is also set as default on the DSP reset condition), then the DSP reset on the WDT expiration event is disabled, and WDT output is ignored by the DSP reset controller.

In case the *WDT_EN* bit of *WDT_EN_RG* register flag is set to '1', then the DSP reset on the WDT expiration event is enabled and the WDT output is enabled to generate the DSP reset signal.

2.3 Parallel I/O Expansion Interface Site (PIOX-16)

TORNADO-E3x architecture provides expansion of the on-board I/O resources using 16-bit parallel I/O expansion interface (PIOX-16) site.

PIOX-16 site of *TORNADO-E3x* mainboard is compatible with PIOX-16 site for all *TORNADO* DSP systems and controllers and is designed to carry compatible PIOX-16 DCM over the *TORNADO-E3x* mainboard.

Description

TORNADO-E3x PIOX-16 interfaces appear as 64Kx16 I/O address area of the TMS320C3x DSP address space. PIOX-16 includes DSP data/address buses, data strobes, TMS320C3x DSP on-chip timers I/O pins and external interrupt inputs, DSP reset signal, and power supply lines. PIOX-16 supports 16-bit data transfer cycles only.

Installation of PIOX-16 DCMs onto *TORNADO-E3x*

Figure 2-3 shows installation of PIOX-16 DCM onto *TORNADO-E3x* DSP controller.



Fig.2-3. *TORNADO-E3x* DSP controller with PIOX-16 DCM installed.

PIOX-16 connector pinout

TORNADO-E3x on-board PIOX-16 connector is a high-density DDK 50-pin DHB-series dual-row female connector with 0.05" pin pitch. Compatible PIOX-16 plugs for customer designed DCMs are available on request from MicroLAB Systems upon request.

PIOX-16 connector pinout specification is presented at fig 2-4 whereas description for PIOX-16 signals is presented in table 2-6.

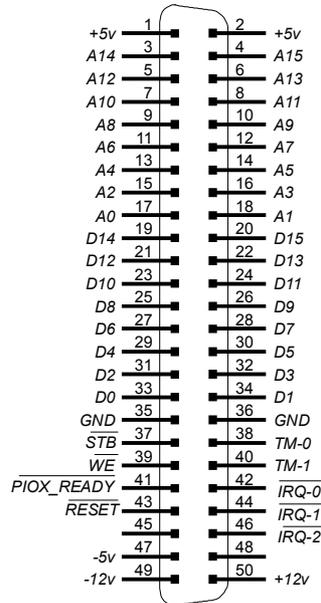


Fig.2-4. PIOX-16 connector pinout (top view).

Table 2-6. PIOX-16 signal description.

Signal name	signal type	description
A0..A15	O	DSP Address bus.
D0..D15	I/O	DSP Data bus.
\overline{STB}	O	Active low data transfer strobe.
\overline{WE}	O	Active low write enable signal.
$\overline{PIOX_READY}$	I	Active low PIOX-16 DCM data ready signal, which must be generated by PIOX-16 DCM in order to match the PIOX-16 cycle timing with timing requirements of memory and I/O devices used in PIOX-16 module.
TM-0	I/O/Z	Input/output signal from TMS320C3x DSP on-chip Timer-0.
TM-1	I/O/Z	Input/output signal from TMS320C3x DSP on-chip Timer-1.
\overline{RESET}	O	Active low reset signal for the on-board PIOX/PIOX-16 expansion interface site, which is the output state of the <i>PIOX_RUN</i> bit from <i>PXSX_RUN_RG</i> register from the DSP environment (refer to table 2-2 and section 2.2).

$\overline{IRQ-0}$, $\overline{IRQ-1}$, $\overline{IRQ-2}$	I	Active low external interrupt request lines for the on-board TMS320C3x DSP chip. These line are pulled up with the on-board resistors. DSP interrupt request is generated on the falling edge of input signals. The minimum duration of interrupt request signals must be 66ns for <i>TORNADO-E31</i> and 28ns for <i>TORNADO-E33</i> .
GND		Ground.
+5v		+5v power.
+12v		+12v power.
-5v		-5v power.
-12v		-12v power.

Note: 1. Signal type is denoted as the following: I - input, O - output, Z - high impedance.

CAUTION

All logical signal levels and load currents for PIOX-16 expansion interface site correspond to that for 5v CMOS/TTL logic for *TORNADO-E31* DSP controller and 3v/5v CMOS/TTL logic for *TORNADO-E33* DSP controller.

PIOX-16 data transfer cycles

PIOX-16 interface site supports 16-bit data transfer cycles only, and, therefore PIOX-16 connector does not contain the cycle definition signals.

Data transfer timing for PIOX-16

The PIOX-16 data transfer timing is presented at fig.2-5. This data transfer timing is known as MOTO mode and assumes usage of data strobe signal and write enable signal.

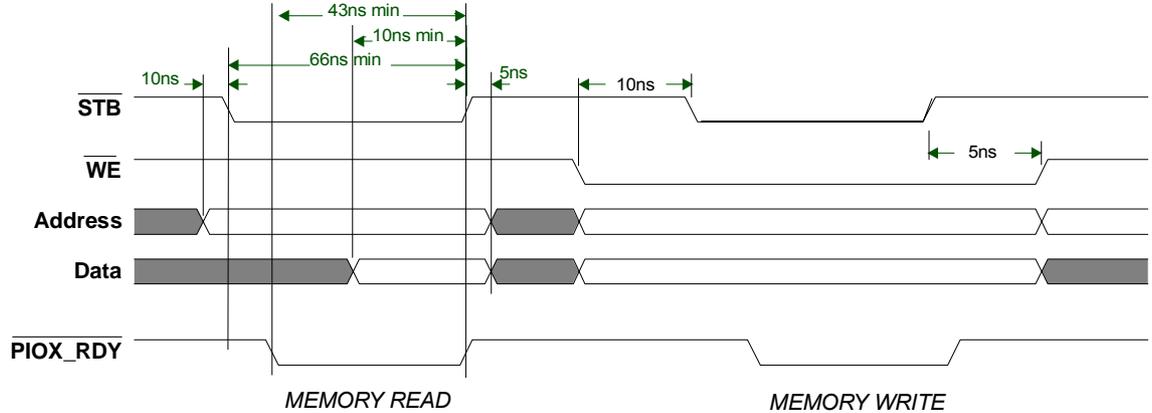


Fig.2-5a. Timing diagram for PIOX-16 data transfer strobe for *TORNADO-E31*.

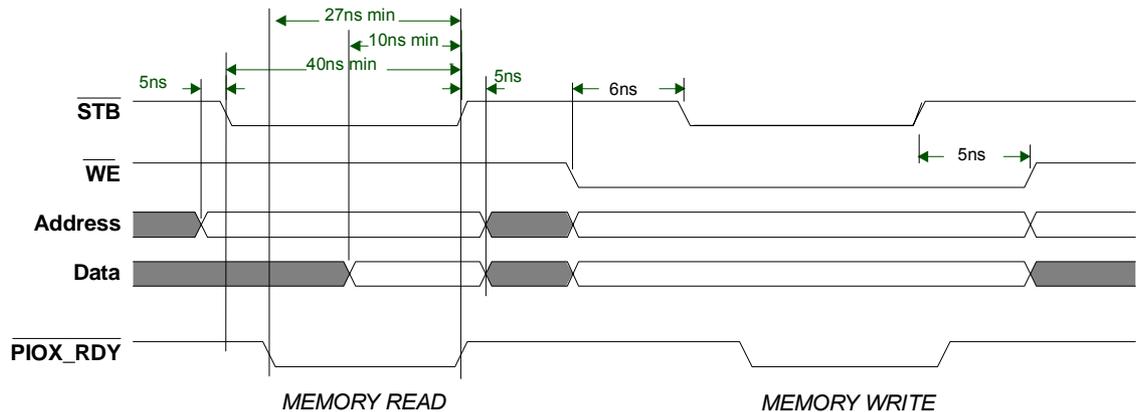


Fig.2-5b. Timing diagram for PIOX-16 data transfer strobe for *TORNADO-E33*.

PIOX-16 wait states

TORNADO-E31 generates one hardware wait state for access cycle of PIOX-16 interface. *TORNADO-E33* generates two hardware wait state for access cycle of PIOX-16 interface. The final duration of the PIOX-16 access cycle is defined by asynchronous *PIOX_READY* signal, which must be generated by installed PIOX-16 DCM.

Generating Reset Signal for PIOX/PIOX-16 Site

TORNADO-E3x provide individual reset signal for PIOX-16 site, which is controlled by *PX_RUN* bit of *PXSX_RUN_RG* register (refer to table 2-2 and section 2.2 for more details). This allows correct initialization of installed PIOX-16 DCM hardware and correct synchronization with host *TORNADO-E3x* DSP software.

Physical dimensions for PIOX-16 DCMs

Physical dimensions for PIOX-16 DCMs are presented at fig.2-6. This information is intended for those *TORNADO* customers, who need to design customized PIOX-16 DCMs.

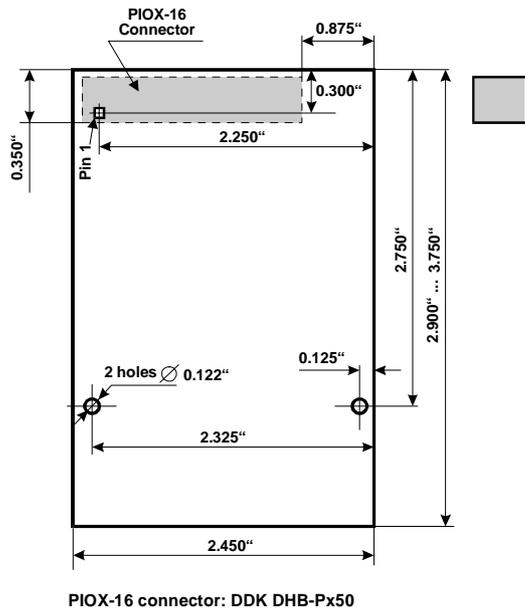


Fig.2-6. Physical dimensions for PIOX-16 DCMs.

2.4 Serial I/O Expansion Interface Sites (SIOX)

TORNADO-E3x architecture provides expansion of the on-board TMS320C3x I/O resources via on-board serial I/O expansion interface sites (SIOX) (refer to fig.1-1 and fig.2-2), which are designed to carry compatible DCM.

TORNADO-E31 provides one on-board SIOX rev.B site, whereas *TORNADO-E33* provides on-board SIOX rev.B site and enhanced SIOX rev.C sites. On-board SIOX sites of *TORNADO-E3x* are compatible with SIOX sites for all *TORNADO* DSP systems for PC, DSP coprocessors and stand-alone DSP controllers.

Available SIOX DCM for *TORNADO* comprise from a variety of off-the-shelf AD/DA/DIO and application specific I/O Coprocessors DCM for telecommunication, speech and audio signal processing, industrial and instrumentation applications, and many more.

Description

TORNADO-E3x provides two different types of on-board SIOX sites (fig.2-7):

- SIOX-A rev.B site (JP5) comprises of the signals for SIO-0 serial port, TMS320C3x DSP on-chip TM-0 and TM-1 timers, external *IRQ-0..2* interrupts request inputs, SIOX reset signal and power supply lines

- enhanced SIOX rev.C site (JP6), which is available on *TORNADO-E33* only, comprises of the signals for SIO-0 serial port, DSP on-chip TM-0 and TM-1 timers, external *IRQ-0* interrupts request, SIOX reset signal, 8-bit DSP data bus, 6-bit DSP address bus, parallel data bus strobes, and power supply lines.

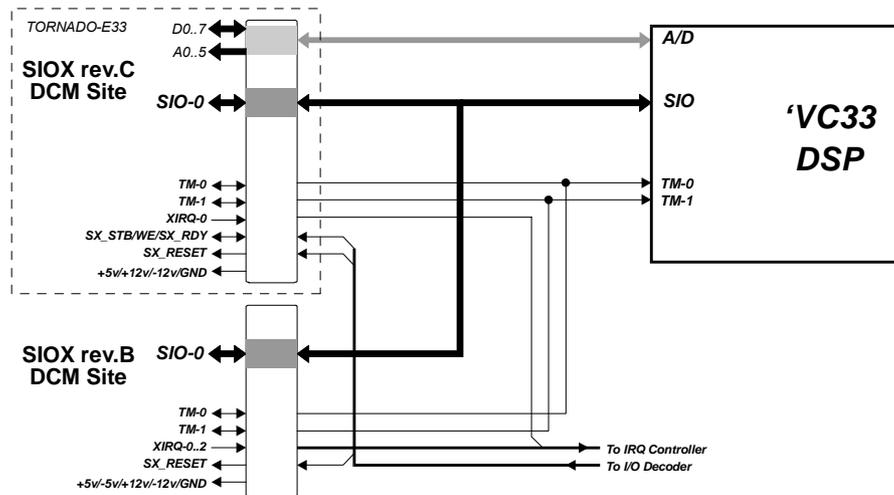


Fig.2-7. SIOX sites connection diagram for *TORNADO-E3x*.

CAUTION

SIO-0 serial port of SIOX rev.B and rev.C sites of *TORNADO-E3x* are connected to the TMS320C3x DSP on-chip serial port.

Maximum throughput of SIO-0 serial port of SIOX sites is 15 Mbit/s for *TORNADO-E31* DSP controller and 37.5 Mbit/s for *TORNADO-E33* DSP controller. Maximum I/O clock frequency for SIOX TM-0/1 timer pins is 30 MHz for *TORNADO-E31* DSP controller and 75MHz for *TORNADO-E33* DSP controller.

External analog and digital I/O signals for installed SIOX DCM have to be connected by means of the SIOX on-module I/O connector.

Installation of SIOX DCMs onto *TORNADO-E3x*

Figure 2-8 shows installation examples of different SIOX DCM onto *TORNADO-E3x* mainboards.



Fig.2-8a. TORNADO-E3x DSP controller with SIOX rev.B DCM installed.

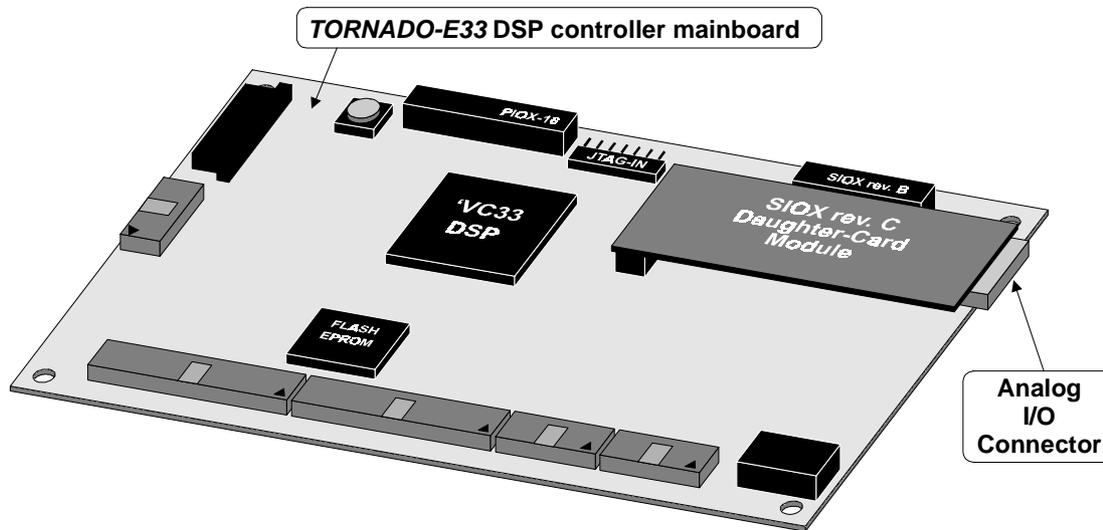


Fig.2-8c. Installation of SIOX rev.C DCM onto TORNADO-E33 DSP controller.

CAUTION

TORNADO-E33 on-board area for SIOX rev.B DCM is shared with the on-board area for SIOX rev.C DCM. Either SIOX rev.B DCM or SIOX rev.C can be installed onto *TORNADO-E33* mainboard.

SIOX rev.B site connector

SIOX rev.B site connector is an industry standard dual-row 20-pin female header with 0.1"x0.1" pin pattern. Pinout and signals description for SIOX rev.B site connector are presented at fig.2-9 and table 2-7 correspondingly.

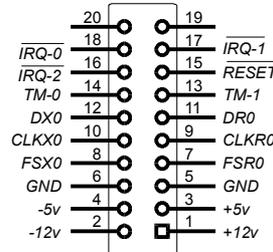


Fig.2-9. SIOX rev.B site connector pinout (top view).

Table 2-7. SIOX rev.B site signal description.

SIOX signal name	signal type	description
SIO-0 port control		
<i>DX0</i> <i>FSX0</i> <i>CLKX0</i>	O/Z I/O I/O	Data, frame synchronization and serial clock signals for transmitter of SIO-0 port of SIOX site. For SIOX rev.B site of <i>TORNADO-E3x</i> DSP controllers these signals correspond to the TMS320C3x DSP on-chip serial port transmitter.
<i>DR0</i> <i>FSR0</i> <i>CLKR0</i>	I I/O I/O	Data, frame synchronization and serial clock signals for receiver of SIO-0 port of SIOX site. For SIOX rev.B site of <i>TORNADO-E3x</i> DSP controllers these signals correspond to the TMS320C3x DSP on-chip serial port receiver.
Timers, Reset and Interrupt Requests		
<i>TM-0</i>	I/O	Input/output signal from TMS320C3x DSP on-chip Timer-0.
<i>TM-1</i>	I/O	Input/output signal from TMS320C3x DSP on-chip Timer-1.

\overline{RESET}	O	Active low reset signal for SIOX site, which is the output state of the <i>SIOX_RUN</i> bit from <i>PXSX_RUN_RG</i> register from the DSP environment (refer to table 2-2 and section 2.2).
$\overline{IRQ-0}$, $\overline{IRQ-1}$, $\overline{IRQ-2}$	I	Active low external interrupt request lines for the on-board TMS320C3x DSP chip. These line are pulled up with the on-board resistors. DSP interrupt request is generated on the falling edge of input signals. The minimum duration of interrupt request signals must be 66ns for <i>TORNADO-E31</i> and 28ns for <i>TORNADO-E33</i> .
Power Supplies		
<i>GND</i>		Ground.
+5v		+5v power.
+12v		+12v power.
-5v		-5v power.
-12v		-12v power.

Note: 1. Signal type is denoted as the following: I - input, O - output, Z - high impedance.

CAUTION

All logical signal levels and load currents for SIOX rev.B expansion interface site correspond to that for 5v CMOS/TTL logic for *TORNADO-E31* DSP controller and 3v/5v CMOS/TTL logic for *TORNADO-E33* DSP controller.

SIOX rev.C site connector (*TORNADO-E33* only)

TORNADO-E33 on-board SIOX rev.C site connector (JP6) is a high-density Samtec dual-row 40-pin female header with 0.05"x0.05" pin pattern. Compatible SIOX rev.C plugs (Samtec p/n TFM-120-22-S-D-LC) for design of custom DCM are available from MicroLAB Systems upon request.

Pinout and signals description for SIOX rev.C site connector are presented at fig.2-10 and table 2-8 correspondingly.

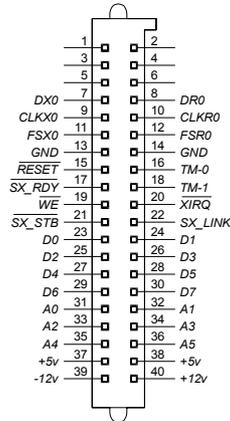
Fig.2-10. SIOX rev.C connector pinout for *TORNADO-E33* DSP Controller (top view).

Table 2-8. SIOX rev.C site signal description.

SIOX rev.B connector pin	signal type	description
SIO-0 port control		
DX0 FSX0 CLKX0	O/Z I/O/Z	Data, frame synchronization and serial clock signals for transmitter of SIO-0 port of SIOX site. For SIOX rev.C site of <i>TORNADO-E33</i> DSP controller these signals correspond to the TMS320C3x DSP on-chip serial port transmitter.
DR0 FSR0 CLKR0	I I/O/Z	Data, frame synchronization and serial clock signals for receiver of SIO-0 port of SIOX site. For SIOX rev.C site of <i>TORNADO-E33</i> DSP controller these signals correspond to the TMS320C3x DSP on-chip serial port receiver.
DSP Timers, Reset and Interrupt Requests		
TM-0	I/O/Z	Input/output signal from TMS320C3x DSP on-chip Timer-0.
TM-1	I/O/Z	Input/output signal from TMS320C3x DSP on-chip Timer-1.
RESET	O	Active low reset signal for SIOX site, which is the output state of the SIOX_RUN bit from PXSX_RUN_RG register from the DSP environment (refer to table 2-2 and section 2.2).
IRQ-0, IRQ-1, IRQ-2	I	Active low external interrupt request lines for the on-board TMS320C3x DSP chip. These line are pulled up with the on-board resistors. DSP interrupt request is generated on the falling edge of input signals. The minimum duration of interrupt request signals must be 66ns for <i>TORNADO-E31</i> and 28ns for <i>TORNADO-E33</i> .

Parallel Data Bus		
<i>D0..D7</i>	I/O	DSP D0..D7 buffered data bus.
<i>A0..A5</i>	O	DSP A2..A7 address bus.
<i>SX_STB</i>	O	Active low data transfer strobe, which is generated when TMS320C3x DSP performs access to the SIOX rev.C address area in accordance with table 2-2.
<i>WE</i>	O	Active low write enable signal.
<i>SX_RDY</i>	I	Active low pulled-up data ready acknowledge signal, which must be generated by installed SIOX rev.C module in order to terminate current SIOX rev.C cycle in accordance with the timing requirements for SIOX rev.C interface.
Power Supplies		
<i>GND</i>		Ground.
<i>+5v</i>		+5v power.
<i>+12v</i>		+12v power.
<i>-12v</i>		-12v power.

Note: 1. Signal type is denoted as the following: I - input, O - output, Z - high impedance.

CAUTION

All logical signal levels and load currents for SIOX rev.C expansion interface site of *TORNADO-E33* DSP controller correspond to that for *TORNADO-E31* DSP controller and 3v/5v CMOS/TTL logic.

Generating Reset Signal for SIOX Sites

TORNADO-E3x provides individual reset signal for SIOX sites, which is controlled by *SIOX_RUN* bit of *PXSX_RUN_RG* register (refer to table 2-2 and section “TMS320C3x DSP Environment” for more details). This allows correct initialization of installed SIOX DCM hardware and correct synchronization with host *TORNADO-E3x* DSP software.

Parallel Data Transfer Timing for SIOX rev.C Site (*TORNADO-E33* only)

Timing diagram for parallel data transfer via SIOX rev.C interface site for *TORNADO-E33* DSP controller is presented at fig.2-11. This data transfer timing is known as the industry standard MOTO mode and assumes usage of data strobe signal and write enable signal.

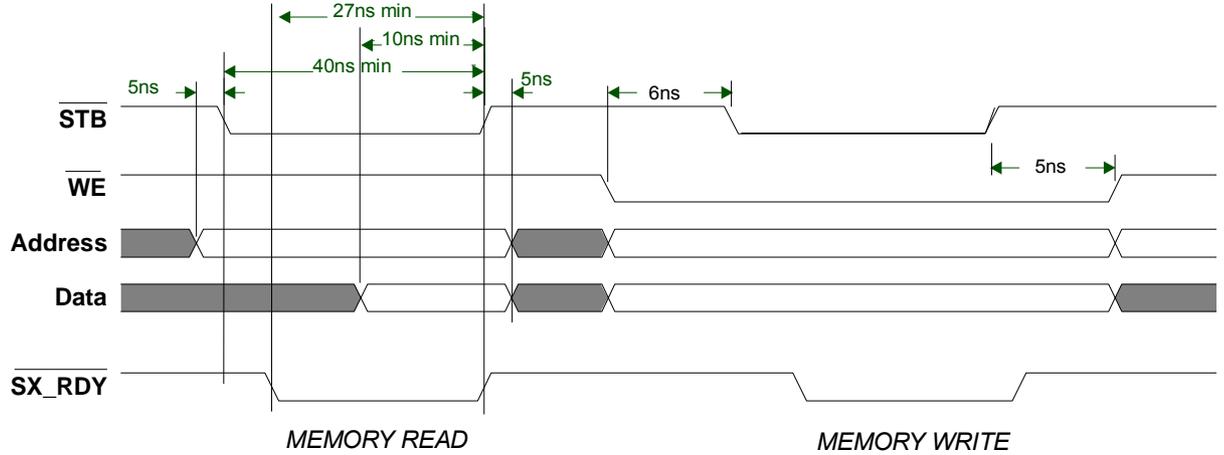
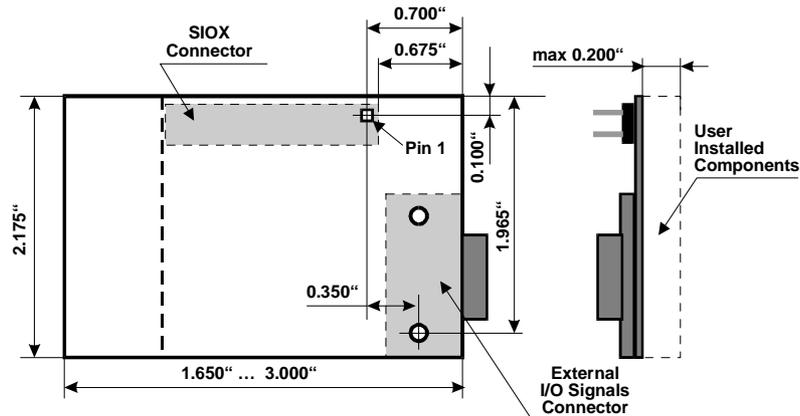


Fig.2-11. Timing diagram for parallel data transfer via SIOX rev.C site.

Physical dimensions for SIOX DCM

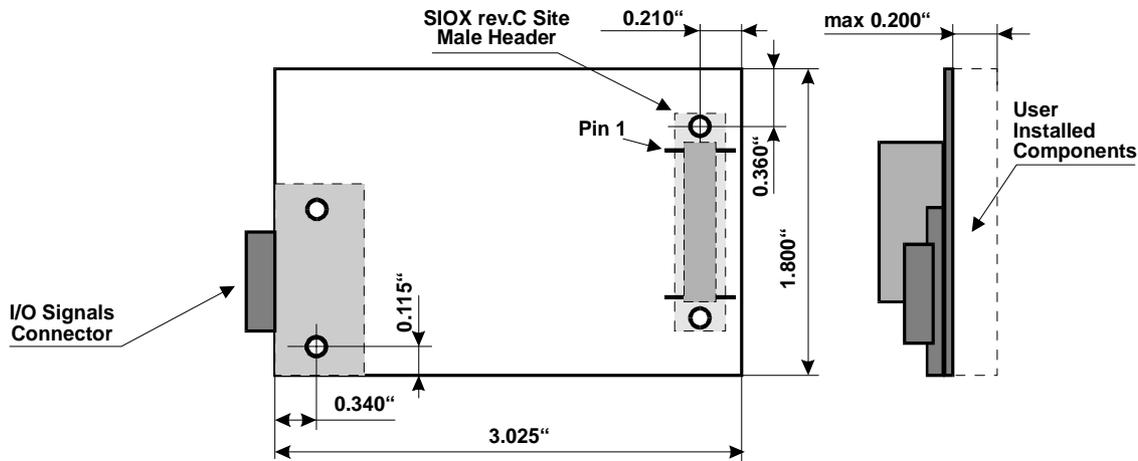
Physical dimensions for SIOX rev.B and SIOX rev.C DCM are presented at fig.2-12. This information is intended for those *TORNADO* customers, who need to design customized SIOX DCM.



SIOX connector: 20-pin or 26-pin straight dual-row mail header
(0.025" Sq., 0.1"x0.1" pattern)

Recommended connector for Analog I/O: DDK DHA-RC14-R122N
DDK DHA-RC20-R122N
DDK DHA-RC26-R122N

Fig.2-12a. Physical dimensions for SIOX rev.B DCM.



SIOX rev.C Site Male Header: SAMTEC TFM-120-22-S-D-LC

Recommended connector for Analog I/O: DDK DHA-RC26-R122N

Fig.2-12b. Physical dimensions for SIOX rev.C DCM.

2.5 Dual-channel USART

TORNADO-E3x features the on-board dual-channel USART (universal synchronous/asynchronous receiver/transmitter) for communication with host computers, terminals, network adapters, or external peripherals using industry standard serial communication protocols.

USART is based around the SIEMENS SAB82532 chip and supports popular synchronous protocols (HDLC/X.25, SDLC, MONOSYNC, BISYNC) at up to 10 Mbit/s data transfer rate and the industry-standard asynchronous protocol at up to 2.5 Mbaud. Protocol selection is performed independent for each channel.

Each channel of USART connects to external communication equipment via either RS232C or RS422/EIA-530 electrical interface. Selection of particular interface is performed by the on-board jumpers. The RS232C interface provides communication at up to 115kBaund and the RS422/EIA-530 interface provides up to 10 Mbit/s of data transfer rate.

USART also provides 8-bit of general purpose parallel digital I/O (*DIO-0..7*), which is wired to the on-board JP8 connector. For details about parallel digital I/O refer to the corresponding section later in this chapter.

CAUTION

This databook does not contain detail information for architecture and programming of SIEMENS SAB82532 USART.

For details about SIEMENS SAB82532 USART refer to original manufacturer documentation, which is supplied in either electronic or paper form together with *TORNADO-E3x* DSP controller.

USART register set allocation

The USART register set comprises of 128 8-bit registers totally for on-chip channels “A” and “B”. SAB82532 chip is extremely flexible software programmable device with build-in FIFO for each of communication channel, PLL and system configuration registers. For details about how to program SIEMENS SAB82532 USART refer to original manufacturer documentation, which is supplied in electronic or paper form together with *TORNADO-E3x* board.

USART is allocated in the 32-bit I/O memory area of the on-board TMS320C3x DSP (table 2-2). USART has 8-bit data bus, which is wired to the lowest significant byte of 32-bit DSP data bus. Therefore, the 8-bit USART registers are allocated at the 32-bit word boundaries of DSP data bus.

USART-to-DSP interrupt

USART can generate the interrupt request to TMS320C3x DSP via the DSP *INT3* external interrupt request line (refer to section 2.2 and tables 2-4 and 2-5 for more details). The USART interrupt is internal logical OR from many interrupt sources inside USART including the interrupt requests from parallel digital I/O port.

CAUTION

The interrupt request of the SAB82532 USART chip must be configured by the DSP software as “pushed-pulled” “active-low” output (refer to SIEMENS SAB82532 USART documentation for how to configure the interrupt request output).

USART-hardware reset

USART hardware reset is performed simultaneously with the hardware reset of *TORNADO-E3x* board, and is actually the hardware reset signal for on-board TMS320C3x DSP.

Configuring external RS232C/RS422 interfaces for USART

Each channel of USART connects to external communication equipment via either RS232C or RS422/EIA-530 electrical interface. Selection of particular interface is performed by the on-board jumpers set J3 for channel “A” and jumper J4 for channel “B” (see fig.A-1) in accordance with tables 2-9 and 2-10.

Table 2-9. Configuration of external interfaces for channel "A" of USART.

Interface	interface connector	jumper J3-A	jumper J3-B	jumper J3-C
<i>RS422/EIA-530</i> (transmitter data transfer clock is generated by the USART on-chip clock generator and does not appear at the CLKX+/CLKX- pins of RS422/EIA-530 connector)	JP9 (DB-25 male)	2-3	1-2	2-3
<i>RS422/EIA-530</i> (external data transfer clocking is used from pins CLKX+/CLKX- RS422/EIA-530 connector)	JP9 (DB-25 male)	2-3	1-2	1-2
<i>RS422/EIA-530</i> (transmitter data transfer clock is generated by the USART on-chip clock generator and appears at the CLKX+/CLKX- pins of RS422/EIA-530 connector)	JP9 (DB-25 male)	2-3	2-3	2-3
<i>RS232C</i>	JP11 (DB-9 male)	1-2	1-2	2-3

Notes: 1. The highlighted configuration corresponds to the factory settings.

Table 2-10. Configuration of external interfaces for channel “B” of USART.

Interface	interface connector	jumper J4-A	jumper J4-B	jumper J4-C
<i>RS422/EIA-530</i> (transmitter data transfer clock is generated by the USART on-chip clock generator and does not appear at the CLKX+/CLKX- pins of RS422/EIA-530 connector)	JP10 (DB-25 male)	2-3	1-2	2-3
<i>RS422/EIA-530</i> (external data transfer clocking is used from pins CLKX+/CLKX- RS422/EIA-530 connector)	JP10 (DB-25 male)	2-3	1-2	1-2
<i>RS422/EIA-530</i> (transmitter data transfer clock is generated by the USART on-chip clock generator and appears at the CLKX+/CLKX- pins of RS422/EIA-530 connector)	JP10 (DB-25 male)	2-3	2-3	2-3
<i>RS232C</i>	JP12 (DB-9 male)	1-2	1-2	2-3

Notes: 1. The highlighted configuration corresponds to the factory settings.

RS232C interface connectors

RS232C interface assumes single-ended bipolar I/O signals, provides communication at up to 115 kBaud and is generally designed for usage in tandem with ASYNC asynchronous protocol of USART. The RS232C interface is an industry standard interface for communication with personal computers, computer peripherals, industrial control devices, etc.

The *TORNADO-E3x* on-board RS232C interface connectors pinout is presented at figure 2-13.

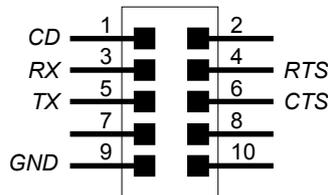


Fig. 2-13. RS232C interface connectors pinout for *TORNADO-E3x*.

CAUTION

TORNADO-E3x on-board RS232C connectors are the industry 10-pin 0.1"×0.1" male headers, which are widely used for connection RS232C ports to PC motherboards.

You have to use standard 10-pin female to male DB-9 or DB-26 converter flat cables for PC to convert the *TORNADO-E3x* on-board RS232C connectors to the industry standard DB-9 or DB-26 male connectors for RS232C interface.

RS422/EIA-530 interface connectors

RS422/EIA-530 interface assumes differential unipolar I/O signals with 110 Ohm line terminators, provides communication at up to 10 Mbit/s and is generally designed for usage in tandem with all synchronous protocols. RS422/EIA-530 interface may be also used with ASYNC asynchronous protocol of USART delivering up to the 2.5 Mbaud of data transfer rate, however this solution is not standard. The RS422/EIA-530 interface is an industry standard electrical interface for communication with network equipment, high-speed computer peripherals, etc.

The *TORNADO-E3x* on-board RS422/EIA-530 interface connectors pinout is presented at figure 2-14.

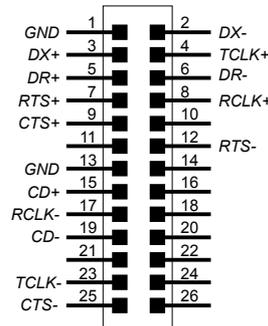


Fig. 2-14. RS422/EIA-530 interface connectors pinout for *TORNADO-E3x*.

USART transmitter/receiver output clocks

TORNADO-E3x provides optional on-board USART transmitter/receiver clocks output connectors separately for each channel (JP13 and JP14 at fig.2-2 and A-1) in order external AD/DA or I/O equipment can synchronize its clock with USART transmitter and receiver clocks. This feature is useful, for example, for satellite modems, which provide external synchronous communication from one side and AD/DA from the other side.

TORNADO-E3x on-board connectors for USART clock outputs are the industry standard 0.05" 3-pin male headers from Molex. The mating plugs are included as standard with *TORNADO-E3x* shipment pack. Pinout for on-board USART transmitter/receiver clocks output connectors is presented at fig 2-15. The output USART transmitter/receiver clock signals are 5v CMOS/TTL compatible.

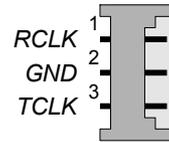


Fig. 2-15. USART transmitter/receiver clock output connectors.

USART source clock

TORNADO-E3x DSP controller allows user to select any desired USART source clock by means of crystal oscillator, which must be installed into the on-board S2 socket (refer to fig.2-2 and A-1). SAB82532 USART allows source clock up to 10 MHz, however not all source clock frequencies allow generation of standard baud rate frequencies for USART ASYNC protocol, and, therefore, are application specific.

CAUTION

TORNADO-E3x is shipped from factory with default 1.8432 MHz USART source clock oscillator, which allows generation of all standard baud rates for USART ASYNC protocol.

TORNADO-E3x on-board S4 socket for USART source clock oscillator is designed to accommodate any industry-standard 5v TTL/CMOS crystal oscillators (example: Epson SG-531 crystal oscillators) in DIP-4 package (0.3"x0.3" pin pattern).

2.6 Parallel I/O

TORNADO-E3x also provides 8-bit of general purpose parallel digital I/O signals (*DIO-0..7*), which are wired to the on-board JP8 connector (see fig.2-2 and fig.A-1) and 2-bit general purpose I/O (*XF0/XF1*), which are wired to the on-board JP7 connector.

Digital I/O lines are useful for interfacing to external sensors, switches, etc and for generation of local control signals in a variety of applications.

DIO-0..DIO-7 parallel I/O

DIO-0..7 parallel digital I/O lines are programmable I/O pins of the on-board SAB82532 USART (for more information about USART refer to the corresponding section earlier in this chapter).

Each of the *DIO-0..7* parallel digital I/O lines allows individual programming of direction and masking of USART interrupt, which might be generated on the user programmable input signal edge. For more details about how to program the parallel digital I/O signals of USART refer to the original manufacturing documentation for SIEMENS SAB82532 USART.

The JP8 parallel digital I/O connector pinout is presented at fig.2-16.

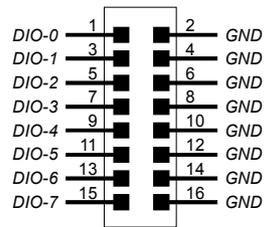


Fig.2-16. Parallel digital I/O connector pinout (DIO-0..7 signals) for TORNADO-E3x.

XF0/XF1 parallel I/O

XF0/XF1 parallel digital I/O lines are programmable I/O pins of the on-board TMS320C3x DSP, which are available via the JP7 on-board connector (fig.2-17).

For more details about how to use XF0/XF1 DSP I/O line refer to the ‘TMS320C3x DSP Environment’ section earlier in this chapter.

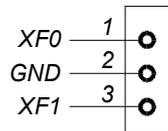


Fig.2-17. XF0/XF1 I/O signal connector of TORNADO-E3x.

2.7 USB Device Interface

TORNADO-E33 features the on-board 12 Mbit/s USB device interface for communication with host computers.

USB device interface is based around the Lucent Technologies USS-820/USS-825 chip and supports the industry USB protocol at up to 12 Mbit/s data transfer rate. On-board USB connector (JP15) is the USB type ‘B’ device connector. USB device controller and external interface meets USB rev.1.1 specifications.

CAUTION

This databook does not contain detail information for architecture and programming of Lucent USS-820/USS-825 USB device controller.

For details about Lucent USS-820/USS-825 USB device controller refer to original manufacturer documentation, which is supplied in either electronic or paper form together with *TORNADO-E33* DSP controller.

CAUTION

The on-board USS-820/USS-825 USB device controller is sourced from 12 MHz clock, which allows full-speed 12 Mbit/s communication over the USB bus.

USB interface connector

TORNADO-E33 on-board USB device connector is the industry standard USB type 'B' receptacle with pinout presented at figure 2-18. The mating plug is the USB device plug available on all host-to-device USB cables.

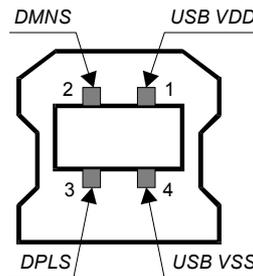


Fig. 2-18. Pinout of USB device connector for *TORNADO-E33*.

USB register set allocation

USS-820/USS-825 USB device controller register set comprises of 32 8-bit registers. USS-820/USS-825 USB device controller is extremely flexible programmable device with build-in programmable FIFO for transmitter and receiver, dual-packet support, support for 16 USB endpoints, integrated USB transceivers, and many more features.

USB device controller is allocated in the TMS320C3x DSP address space (refer to table 2-2). USB device controller features 8-bit data bus, which is wired to the lowest significant byte of 32-bit DSP data bus.

CAUTION

The DPPU output pin of on-board USS-820/USS-825 USB device controller is connected to the on-board hardware, which allows simulation of the USB device disconnect.

In order to activate presence of the USS-820/USS-825 USB device controller on host USB bus, the DPPU output must be set to logical '1' value via the DPEN bit of MCSR register of USS-820/USS-825 USB device controller.

USB-to-DSP interrupt

USB device controller can generate the interrupt request to TMS320C3x DSP via either *INT2* or *INT3* DSP external interrupt request inputs in accordance with the setting of J5 and J6 jumpers (refer to section 2.2 and table 2-5 for more details).

2.8 Emulation Tools for *TORNADO-E3x*

TORNADO-E3x uses scan-path emulation technique for the on-board TMS320C3x DSP in order to debug resident TMS320C3x DSP environment and software. Compatible scan-path emulation tools include the TI XDS510 or MicroLAB' *MIRAGE-510DX* universal JTAG/MPSD emulators with MPSD (C3x) external pod, which must connect to JP3 MPSD-IN connector on *TORNADO-E3x* mainboard.

2.9 Software Development Tools

TMS320C3x DSP are now an industry standard DSP and is supported by a variety of software development tools from multiple 3rd party vendors.

Compilers and Debuggers

Software development for *TORNADO-E3x* is supported by TI TMS320C3x DSP Optimizing C Compiler and Assembly Language Tools, which now come as the part of TI TMS320C3x/C4x Code Composer IDE.

Compatible emulators include TI XDS510 and MicroLAB' *MIRAGE-510DX* JTAG/MPSD emulators running under TI C3x HLL Debugger and TMS320C3x/C4x Code Composer IDE.

CAUTION

TORNADO-E31 DSP controller requires that *MIRAGE-510DX* emulator with 'C3x MPSD pod is used to debug on-board TMS320C31 DSP environment via on-board MPSD-IN connector (JP3).

TORNADO-E33 DSP controller requires that *MIRAGE-510DX* emulator with JTAG pod is used to debug on-board TMS320C31 DSP environment via on-board JTAG-IN connector (JP3).

Hypersignal RIDE Visual DSP Algorithm Development and Simulation Tool

TORNADO-E3x DSP controllers are supported by DSP algorithm development tools from Hyperception Inc (www.hyperception.com), which include Hypersignal Block Diagram, RIDE and Code Generator. Hypersignal RIDE is the visual real-time integrated DSP algorithm development and simulation environment for Windows 95/NT, and allows design entry using high-level function blocks (FIR, FFT, math, etc). The designed DSP algorithm is compiled and might be loaded into *TORNADO-E3x* in order to evaluate the algorithm parameters for real-time execution and to benefit from the ultra-high performance of *TORNADO-E3x* DSP controllers.

Real-time Multitasking Operating Systems (RTOS)

TORNADO-E3x is supported by multiple RTOS that provide multitasking capabilities:

- *VIRTUOSO* from Eonic Systems Inc (www.eonic.com) is an industry standard high-performance RTOS and provides full feature multitasking support. It comes standard with capabilities for host file, keyboard and screen text/graphics I/O from DSP environment via *TORNADO-E3x* host ISA-bus interface, and is available with a wide selection of function libraries for DSP, math, matrix, 2D, etc. computations.
- *NUCLEUS PLUS* from Accelerated Technology Inc (www.atinucleus.com) is an industry standard single-processor high-performance RTOS and provides full feature multitasking support. It features low cost and comes standard with source codes. Available options include *NUCLEUS FILE*, *NUCLEUS NET*, and *NUCLEUS DBUG+* that also come in source codes.

Application Software Tools for TORNADO-E3x

Application specific tools for *TORNADO-E3x* DSP controller include a variety of function libraries for DSP, math, vector, image, etc computation, as well as function libraries for vocoder/fax/modem applications and audio multimedia.

Chapter 3. Installation and Configuration

This chapter includes instructions for installation of *TORNADO-E3x* DSP controller.

3.1 Applying the power

The power to *TORNADO-E3x* controller should apply via on-board JP1 connector (see fig.A-1). *TORNADO-E3x* controller board requires +5v power only, whereas optional -5v and ± 12 v power inputs are routed to the on-board SIOX and PIOX-16 DCM sites.

3.2 Installation of FLASH/EPROM chip

Installation of EPROM chip (refer to fig.2-2 and fig.A-1) into the S1 socket on *TORNADO-E3x* board must be performed while the board power is off (fig.3-1).

CAUTION

TORNADO-E3x on-board S1 socket is designed to carry either FLASH 5v-only 128K..512Kx8 chips or EPROM 128K..1Mx8 chips in the PLCC-32 IC package.

Installation of FLASH/EPROM chip other than that specified in table 2-3 may result in damage of FLASH/EPROM chip and/or of *TORNADO-E6x* hardware.

CAUTION

You have to set the on-board J2 jumper in accordance with table 2-3 in order to meet the installed FLASH/EPROM chip type.

Installation of FLASH/EPROM chip

In order to install FLASH/EPROM chip into *TORNADO-E3x* on-board S1 socket you have to follow the recommendations below (refer to fig. 3-1):

- switch off the power
- pick-up FLASH/EPROM chip by your fingers in such way that its front (labeling) surface is turned at you
- adjust FLASH /EPROM chip to be parallel to surface of the *TORNADO-E3x* on-board S1 PLCC-32 socket

- orient FLASH/EPROM chip in such way, that the key corner of its PLCC-32 package would match the corresponding corner of *TORNADO-E3x* on-board S1 socket
- safely insert FLASH/EPROM chip into the *TORNADO-E3x* on-board S1 socket
- safely plug and fix FLASH/EPROM chip in the *TORNADO-E3x* on-board S1 socket
- configure J2 jumper set in accordance with table 2-3 to meet the installed FLASH/EPROM chip type
- switch on the power of *TORNADO-E3x* controller.

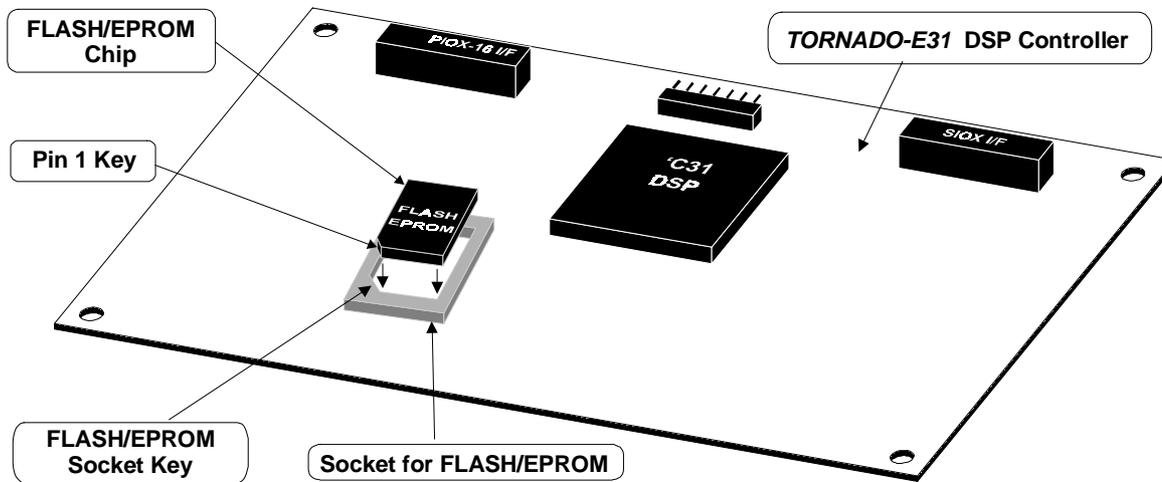


Fig.3-1. Installation of EPROM chip onto *TORNADO-E3x* board.

3.3 Configuring *TORNADO-E3x* board

Generally, the following first-time configuration efforts shall be done during first installation and prior applying power to *TORNADO-E3x* DSP controller (refer to fig.A-1 for on-board jumpers and connectors list):

- set up the TMS320C3x DSP bootmode configuration (jumper J1) in accordance with table 2-1
- if required, install FLASH/EPROM chip and configure jumper J2 in accordance with the FLASH/EPROM chip type and table 2-3
- select appropriate RS232 or RS422/EIA-530 interface for each channel of USART and configure jumpers J3 and J4 in accordance with tables 2-9 and 2-10
- connect RS232C or RS422/EIA-530 cables to connectors JP9..JP12 and parallel I/O cable to connector JP8
- connect USB type 'B' cable plug of external USB cable into the on-board JP15 connector (*TORNADO-E33* only)
- configure J5 and J6 jumpers of *TORNADO-E33* in accordance with table 2-5 in order to select INT2 and INT3 TMS320C3x DSP external hardware interrupt source
- if required, install SIOX rev.B or SIOX rev.C DCM (*TORNADO-E33* only)
- if required, install PIOX-16 DCM
- connect MPSD pod (*TORNADO-E31*) or JTAG pod (*TORNADO-E33*) of external TMS320 emulator to the MPSD-IN/JTAG-IN connector (JP3)
- connect external power supply via power connector JP1

- switch on the power supply

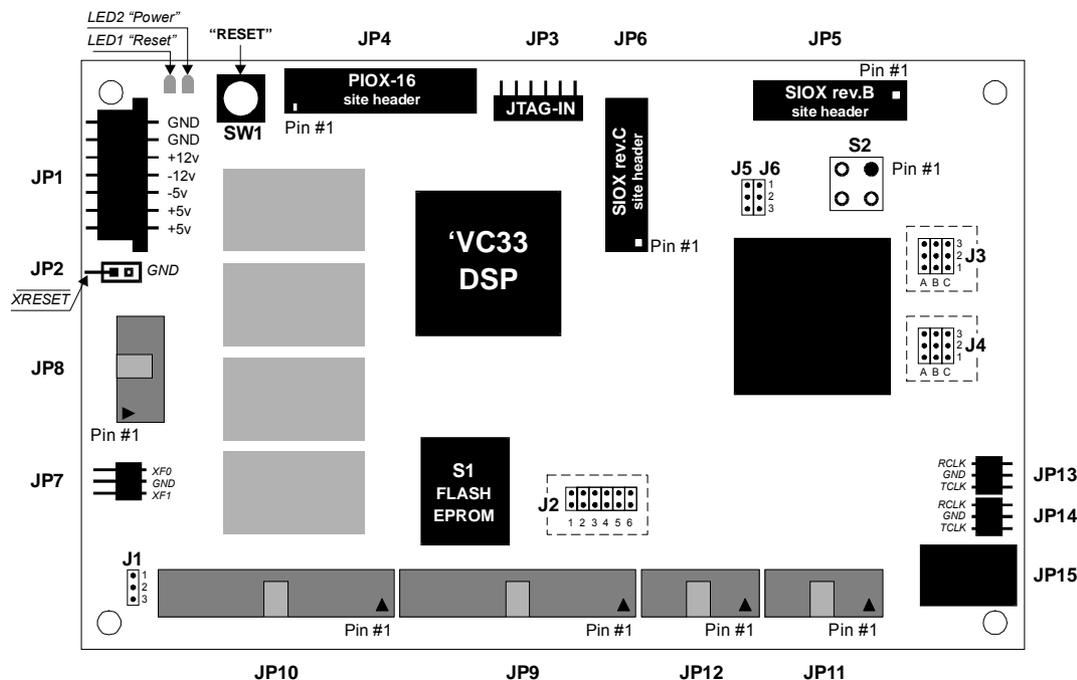


Fig.A-1b. On-board layout for TORNADO-E33 DSP controller.

On-board Configuration Jumpers

All on-board configuration jumpers for TORNADO-E3x DSP controller are summarized in table A-1.

Table A-1. On-board configuration jumpers for TORNADO-E3x.

Jumper	jumper function description	reference information
J1	TMS320C3x DSP Bootmode configuration.	Section 2.2; table 2-1.
J2 (J2-1..J2-6)	FLASH/iEPROM chip type selector.	Sections 2.2 and 3.2 table 2-3
J3 (J3-A..J3-C)	External interface selector for USART channel "A".	Section 2.5; table 2-9; figures 2-13 and 2-14
J4 (J4-A..J4-C)	External interface selector for USART channel "B".	Section 2.5; table 2-10; figures 2-13 and 2-14

<i>J5</i>	Source selector for INT2 external hardware interrupt input of TMS320C3x DSP (<i>TORNADO-E33</i> only).	Section 2.2; table 2-5
<i>J6</i>	Source selector for INT3 external hardware interrupt input of TMS320C3x DSP (<i>TORNADO-E33</i> only).	Section 2.2; table 2-5

On-board Connectors

All on-board connectors for *TORNADO-E3x* DSP controller are summarized in table A-2.

Table A-2. On-board connectors for *TORNADO-E3x*.

Connector	connector function description	reference information
<i>JP1</i>	External power connector.	Section 3-1.
<i>JP2</i>	External DSP reset connector.	Section 2.2.
<i>JP3</i>	MPSD-IN (<i>TORNADO-E31</i>) or JTAG-IN (<i>TORNADO-E33</i>) connector for external emulator	Section 2.8
<i>JP4</i>	PIOX-16 expansion interface site header.	Section 2.3 figure 2-4
<i>JP5</i>	SIOX rev.B expansion interface site header.	Section 2.4 figure 2-9
<i>JP6</i>	SIOX rev.C expansion interface site header (<i>TORNADO-E33</i> only).	Section 2.4 figure 2-10
<i>JP7</i>	DSP XF0/XF1 I/O connector	Sections 2.2 and 2.6 figure 2-17
<i>JP8</i>	8-bit parallel digital I/O connector.	Section 2.6 figure 2-16
<i>JP9</i> <i>JP10</i>	RS422/EIA-530 interface connectors for channels "A" and "B" of USART.	Section 2.5 figure 2-14.
<i>JP11</i> <i>JP12</i>	RS232C interface connectors for channels "A" and "B" of USART.	Section 2.5 figure 2-13
<i>JP13</i> <i>JP14</i>	Transmitter/receiver clock outputs for USART channels "A" and "B".	Section 2.5 figure 2-15
<i>JP15</i>	USB rev.1.1 type 'B' device connector (<i>TORNADO-E33</i> only).	Section 2.7 figure 2-18

On-board Switches

All on-board switches for *TORNADO-E3x* DSP controller are summarized in table A-3.

Table A-3. On-board switches for *TORNADO-E3x*.

Switch	switch function description	reference information
SW1	Reset pushbutton for on-board DSP environment.	Section 2.2

On-board Sockets

All on-board sockets for *TORNADO-E3x* DSP controller are summarized in table A-4.

Table A-4. On-board sockets for *TORNADO-E3x*.

Socket	socket function description	reference information
S1	FLASH/EPROM chip socket	Sections 2.2 and 3-2
S2	DIP-4 (0.3"x0.3") socket for 5V crystal oscillator (example: EPSON SG-531) for USART source clock.	Sections 2.5

On-board LED

All on-board LED for *TORNADO-E3x* DSP controller are summarized in table A-4.

Table A-5. On-board LED for *TORNADO-E3x*.

LED	LED function description
LED1	DSP reset (RED)
LED2	DSP power (GREEN)

