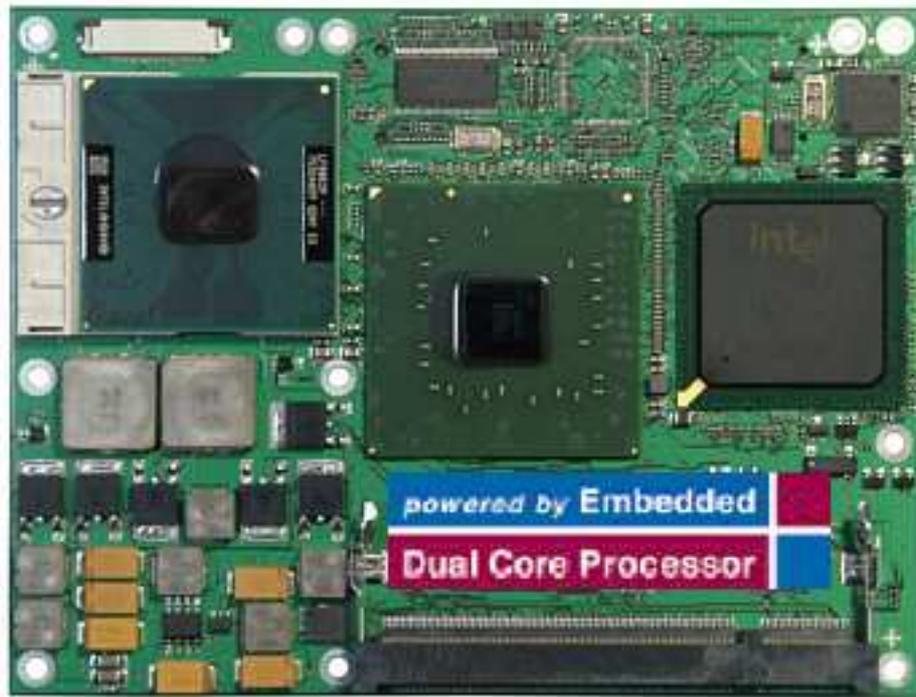## ➢ COM Express™ Extension

➢ Specification

Rev. 013

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Table of Contents

1 User Information

1.1 About This Document

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1.3 Technical Support

Technicians and engineers from COM Industrial Group Members are available for technical support. We are committed to making our product easy to use and will help you use our products in your systems.

http://www.comexpress-extension.org/members/members.php

Before contacting COM Industrial Group Members technical support, please consult our web site at http://www.comexpress-extension.org for the latest product documentation, utilities, and drivers. If the information does not help solve the problem, contact us by email.

http://www.comexpress-extension.org/contact/contact.php

1.4 Disclaimer

Although the information presented in this document was carefully reviewed and is believed to be accurate, it is not guaranteed. The reader assumes all liability for the use of the information herein.

2 Introduction

2.1 COM Express™ Extension Specification

The COM Express™ Extension Specification builds on the COM Express™ (COM.0) standard as defined by the PCI Industrial Computer Manufacturers' Group (PICMG®) which is an industry standard adopted for Computer-On-Modules. The COM Express™ Extension Specification is focused with its intellectual properties on the deep embedded market and is intended to be an add-on to the PICMG's COM Express™ COM.0 Specification. It is the intention of the authors of this specification to propose the information contained here within to PICMG® as a means of updating the current COM Express™ standard to ensure continued saleability and compatibility of all COM Express™ solutions.

2.2 COM Express™ Extension Design Guide

The COM Express™ Design Guide, a separate document from both the PICMG® COM Express™ Specification and this COM Express™ Extension Specification, is available to COM Express™ module customers upon request. For download the COM Express™ Extension Design guide please visit our web page:

http://www.comexpress-extension.com/specs/specs.php

The COM Express™ Design Guide explores the requirements of the COM Express™ Extension Specification and provides recommendations on designing COM Express™ baseboards to support various features of COM Express™ compliant modules.

The COM Express™ Design Guide, based upon the COM Express™ Extension Specification and PICMG® COM Express™ Specification, discusses capabilities in the specification with schematic examples where applicable and offers ideas to consider for maximum flexibility in designing baseboards.

2.3 COM Express™ Computer-On-Module

A COM Express™ Computer-On-Module (COM) is a module with all components necessary for a bootable host computer, packaged as a super component. COMs require a carrier board in order to bring out I/O and to power up the CPU module.

COMs are used to build single board computer solutions and offer OEMs fast time-to-market with reduced development cost.

Like integrated circuits, they provide OEMs with significant freedom when working to meet form-fit-function requirements. For all of these reasons, COM methodology has gained significant popularity with OEMs in the embedded industry. The COM Express™ standard is designed to be future proof and to provide a smooth transition path from legacy parallel interfaces to LVDS (Low Voltage

Differential Signalling) interfaces. These include the PCI bus and parallel ATA on the one hand and PCI Express and Serial ATA on the other hand.

Key features include:

> Rich complement of contemporary high bandwidth serial interfaces, including PCI Express, Serial ATA, USB 2.0, and Gigabit Ethernet

> 32-bit PCI, LPC and Parallel ATA options preserved for easy interface to a range of peripherals

> Extended power-management capabilities

> Robust thermal and mechanical concept

Cost-effective design

> Legacy-free design (no Super I/O, PS2 keyboard or mouse)

> COM Express™ module size with two currently defined footprint options ("Basic" and "Extended") to satisfy a range of performance requirements. The option for future more compact footprints like microETXexpress and nanoETXexpress are present.

> High-performance mezzanine connector with several defined pin-out types to satisfy a range of application requirements

The COM Express™ Extension specification has been created to support to a range of vertical embedded markets. It has been formulated to be applicable to a broad range of system types, from floor-installed and bench-top to mobile handheld.

Markets and applications include but are not limited to:

> Healthcare - clinical diagnostic imaging systems, patient bedside monitors, etc.

> Retail & advertising - electronic shopping carts, billboards, kiosks, POS/POI systems, etc.

> Gaming & entertainment - simulators, slot machines, etc.

> Test & measurement - scientific and industrial test and measurement instruments

> Industrial automation - industrial robots, vision systems, etc.

> Security - digital CCTV, luggage scanners, intrusion detectors, etc.

> Defence & government - unmanned vehicles, rugged laptops, wearable computers, etc.

Systems developed according to the COM Express™ Extension Specification require the implementation of an application-specific carrier board that accepts the module. The carrier board is typically a 4- to 8-layer PCB. User-specific features such as external connector choices and locations and peripheral circuits can be tailored to suit the application. The OEM can focus on application-

specific features rather than caring for a CPU board design. The OEM also benefits from a wide choice of modules providing a scalable range of price and performance upgrade options.

2.4   Objective

Consistent with the objective of the PICMG® COM Express™ Specification, the COM Express™ Extension specification defines COM Express™ compliant modules at a level of detail sufficient to allow interoperability between independent vendor modules and carrier boards.

3 COM Express™ Module sizes

3.1 Overview - Module Size

The primary difference between the current basic module and the extended module as well as future compact footprints like microETXexpress and nanoETXexpress is the over-all physical size and the performance envelope supported by each. The extended module offers larger real estate and can accommodate larger processor, chips and memory solutions which are not possible on the basic module.

The extended module and the basic module use the same connectors and pin-outs and utilize several common mounting hole positions. This level of compatibility allows that a carrier board designed to accommodate an extended module can also support a basic module, microETXexpress or nanoETXexpress modules. This holds true for any future defined compact modules as they too will utilize the same connectors and pin-outs

Up to 440 pins of connectivity are available between COM Express™ modules and the carrier board. Legacy buses such as PCI, parallel ATA, LPC, AC'97 can be supported as well as new high speed serial interconnects such as PCI Express, Serial ATA or SAS and Gigabit Ethernet. To enhance interoperability between COM Express™ modules and carrier boards, five common signalling configurations (Pin-out Types) have been defined to ease system integration. Some Pin-out Types definitions require only a single 220-pin connector, like nanoETXexpress and others require both 220-pin connectors to supply all the defined signalling.

Figure - Overview – three module sizes

All coordinates in mm. top view (X1 is on bottom side, seen through pcb)

3.1.1   Small Form Factor nano, COM Express™ Type 1

The PCB size for the nano module is defined as 55mm x 84mm.

The holes shown in this drawing are intended for mounting the module / heat-spreader combination to the carrier board. An independent, implementation specific set of holes and spacers shall be used to attach the heat-spreader to the module.

Figure - Small Form Factor nano

Holes Compatible to COM Express™

All dimensions are shown in millimetres. Tolerances should be ± 0.25mm [±0.010"], unless noted otherwise. The tolerances on the module connector locating peg holes (dimensions [16.50, 6.00]) should be ± 0.10mm [±0.004"].

The 220 pin connector shall be mounted on the backside of the PCB and is seen "through" the board in this view. The X mounting holes shown should use 6mm diameter pads and should have 2.7mm plated holes, for use with 2.5mm hardware. The pads should be tied to the PCB ground plane.

4 Signal Description

4.1 Graphic Signal Description

Based on the different available graphic interfaces offered by the different chipsets from silicon vendors including Intel, ATI, VIA, etc., there is a need for optional assignment in addition to the ones already defined by PICMG in the COM.0 specification. These will allow for ease when integrating upcoming new graphic interfaces while still assuring compatibility of COM Express™ compliant modules and carrier boards.

Graphic signals are defined on Row C and Row D.
The following table describes the signal uses up on the required graphic interface.

4.1.1 Table – Graphic Signal Description - Row C for Pin-out Type 2

Row C				
Definition	PCIE x 16	SDVO	TMDS(DVI)/HDMI/DVO	Display Port
Pin No.	Pin Name			
C52	PEG_RX0+	SDVO_TVCLK+	HDMI_TVCLKIN	
C53	PEG_RX0-	SDVO_TVCLK-	HDMI_TVCLKIN#	
C54	TYPE0#	TYPE0#	TYPE0#	TYPE0#
C55	PEG_RX1+	SDVOB_INT+		
C56	PEG_RX1-	SDVOB_INT-		
C57	TYPE1#	TYPE1#	TYPE1#	TYPE1#
C58	PEG_RX2+	SDVO_FLDSTALL+	TMDS_DDC_DAT	DPB_AUX
C59	PEG_RX2-	SDVO_FLDSTALL-	TMDS_DDC_CLK	DPB_AUXB
C60	GND (FIXED)	GND (FIXED)	GND (FIXED)	GND (FIXED)
C61	PEG_RX3+		TMDS_HPD	DPB_HPD
C62	PEG_RX3-			
C63	RSVD	RSVD	RSVD	RSVD
C64	RSVD	RSVD	RSVD	RSVD
C65	PEG_RX4+			
C66	PEG_RX4-			
C67	RSVD	RSVD	RSVD	RSVD
C68	PEG_RX5+	SDVOC_INT+		
C69	PEG_RX5-	SDVOC_INT-		
C70	GND (FIXED)	GND (FIXED)	GND (FIXED)	GND (FIXED)
C71	PEG_RX6+		TMDS_2_DDC_DAT	DPC_AUX
C72	PEG_RX6-		TMDS_2_DDC_CLK	DPC_AUXB
C73	SDVO_DATA	SDVO_DATA		
C74	PEG_RX7+		TMDS_2_HPD	DPC_HPD
C75	PEG_RX7-			
C76	GND		GND	GND
C77	RSVD		RSVD	RSVD

C78	PEG_RX8+		DVO D11	
C79	PEG_RX8-		DVO D10	
C80	GND (FIXED)		GND (FIXED)	GND (FIXED)
C81	PEG_RX9+		DVO D9	
C82	PEG_RX9-		DVO D8	
C83	RSVD		RSVD	RSVD
C84	GND		GND	GND
C85	PEG_RX10+		DVO D7	DPD_AUX
C86	PEG_RX10-		DVO D6	DPD_AUXB
C87	GND		GND	GND
C88	PEG_RX11+		DVO CLK+	DPD_HPD
C89	PEG_RX11-		DVO D5	
C90	GND (FIXED)		GND (FIXED)	GND (FIXED)
C91	PEG_RX12+		DVO D4	
C92	PEG_RX12-		DVO D3	
C93	GND		GND	GND
C94	PEG_RX13+		DVO D2	
C95	PEG_RX13-		DVO D1	
C96	GND		GND	GND
C97	RSVD		RSVD	RSVD
C98	PEG_RX14+		DVO D0	
C99	PEG_RX14-		DVO DE	
C100	GND (FIXED)		GND (FIXED)	GND (FIXED)
C101	PEG_RX15+		DVO HS	
C102	PEG_RX15-		DVO VS	
C103	GND		GND	GND
C104	VCC_12V		VCC_12V	VCC_12V
C105	VCC_12V		VCC_12V	VCC_12V
C106	VCC_12V		VCC_12V	VCC_12V
C107	VCC_12V		VCC_12V	VCC_12V
C108	VCC_12V		VCC_12V	VCC_12V
C109	VCC_12V		VCC_12V	VCC_12V
C110	GND (FIXED)		GND (FIXED)	GND (FIXED)

4.1.2   Table – Graphic Signal Description - Row D for Pin-out Type 2

Row D				
Definition	PCIE x 16	SDVO	TMDS(DVI)/HDMI/DVO	Display Port
Pin No.	Pin Name			
D52	PEG_TX0+	SDVOB_RED+	TMDS DATA 2+	DPB_LANE0
D53	PEG_TX0-	SDVOB_RED-	TMDS DATA 2-	DPB_LANE0#
D54	PEG_LANE_RV#	PEG_LANE_RV#	PEG_LANE_RV#	PEG_LANE_RV#
D55	PEG_TX1+	SDVOB_GRE+	TMDS DATA 1+	DPB_LANE1
D56	PEG_TX1-	SDVOB_GRE-	TMDS DATA 1-	DPB_LANE1#
D57	TYPE2#	TYPE2#	TYPE2#	TYPE2#
D58	PEG_TX2+	SDVOB_BLU+	TMDS DATA 0+	DPB_LANE2
D59	PEG_TX2-	SDVOB_BLU-	TMDS DATA 0-	DPB_LANE2#
D60	GND (FIXED)	GND (FIXED)	GND (FIXED)	GND (FIXED)

D61	PEG_TX3+	SDVOB_CLK+	TMDS Clock +	DPB_LANE3
D62	PEG_TX3-	SDVOB_CLK-	TMDS Clock -	DPB_LANE3#
D63	RSVD	RSVD	RSVD	RSVD
D64	RSVD	RSVD	RSVD	RSVD
D65	PEG_TX4+	SDVOC_RED+	TMDS DATA 5+	DPC_LANE0
D66	PEG_TX4-	SDVOC_RED-	TMDS DATA 5-	DPC_LANE0#
D67	GND	GND	GND	GND
D68	PEG_TX5+	SDVOC_GRE+	TMDS DATA 4+	DPC_LANE1
D69	PEG_TX5-	SDVOC_GRE-	TMDS DATA 4-	DPC_LANE1#
D70	GND (FIXED)	GND (FIXED)	GND (FIXED)	GND (FIXED)
D71	PEG_TX6+	SDVOC_BLU+	TMDS DATA 3+	DPC_LANE2
D72	PEG_TX6-	SDVOC_BLU-	TMDS DATA 3-	DPC_LANE2#
D73		SDVO_CLK		
D74	PEG_TX7+	SDVOC_CLK+	TMDS_2_CLK +	DPC_LANE3
D75	PEG_TX7-	SDVOC_CLK-	TMDS_2_CLK -	DPC_LANE3#
D76	GND		GND	GND
D77	IDE_CBLID#		IDE_CBLID#	IDE_CBLID#
D78	PEG_TX8+		DVO_SDA	DPD_LANE0
D79	PEG_TX8-		DVO_SCL	DPD_LANE0#
D80	GND (FIXED)		GND (FIXED)	GND (FIXED)
D81	PEG_TX9+		DVO_HPD	DPD_LANE1
D82	PEG_TX9-			DPD_LANE1#
D83	RSVD		RSVD	RSVD
D84	GND		GND	GND
D85	PEG_TX10+			DPD_LANE2
D86	PEG_TX10-			DPD_LANE2#
D87	GND		GND	GND
D88	PEG_TX11+		DVO CLK-	DPD_LANE3
D89	PEG_TX11-			DPD_LANE3#
D90	GND (FIXED)		GND (FIXED)	GND (FIXED)
D91	PEG_TX12+			
D92	PEG_TX12-			
D93	GND		GND	GND
D94	PEG_TX13+			
D95	PEG_TX13-			
D96	GND		GND	GND
D97	PEG_ENABLE#		PEG_ENABLE#	PEG_ENABLE#
D98	PEG_TX14+			
D99	PEG_TX14-			
D100	GND (FIXED)		GND (FIXED)	GND (FIXED)
D101	PEG_TX15+			
D102	PEG_TX15-			
D103	GND		GND	GND
D104	VCC_12V		VCC_12V	VCC_12V
D105	VCC_12V		VCC_12V	VCC_12V
D106	VCC_12V		VCC_12V	VCC_12V
D107	VCC_12V		VCC_12V	VCC_12V
D108	VCC_12V		VCC_12V	VCC_12V
D109	VCC_12V		VCC_12V	VCC_12V
D110	GND (FIXED)		GND (FIXED)	GND (FIXED)

5   Hardware extensions

Wide Range Input Power for basic, extended and micro form factor

Wide range input power: +8.5VDC to +18VDC

It allows direct operation from 108 nominal 3 cell lithium ion battery pack to 4-cell lithium-ion battery packs (16,8 V fully charged)

Additionally, Smart Battery Support offers a great base for a mobile application. See Software section for more details

5.1.1   Wide Range Input Power for nano SmallFormFactor (SFF)

The nano modules should use a single main power rail with a wide range power supply of 5V to +14V+/-5% (4,75V to 14,7V)

Two additional rails are specified, a +5V standby power rail and a +3V battery input to power the module real-time clock (RTC) circuit in the absence of other power sources. The +5V standby rail could be left unconnected on the carrier board if the standby functions are not required by the application. Likewise, the +3V battery input may be left open if the application does not require the RTC to keep time in the absence of the main and standby sources. There may be module specific concerns regarding storage of system setup parameters that may be affected by the absence of the +5V standby and / or the +3V battery.

The rationale for this power-delivery scheme is:

* Module pins are scarce. It is more pin-efficient to bring power in on a higher voltage rail.

* Single supply operation is attractive to many users.

* Lithium ion battery packs for mobile systems are most prevalent with a +14.4V output. This is well suited for the +12V main power rail.

* Contemporary chipsets have no power requirements for +5V other than to provide a reference voltage for +5V tolerant inputs. No COM Express™ module pins are allocated to accept +5V except for the +5V standby pins. In the case of an ATX supply, the switched (non standby) +5V line would not be used for the COM Express™ module, but it might be used elsewhere on the carrier board.

5.2 GPIO General Purpose I/O Recommended Use

In general, GPIOs are defined for specific customers. Any generic GPIOs should be be set as well in order to assure compatibility of various COM Express™ compliant modules and carrier boards.

	Pin Description	Recomended Use	Function	Comment
GPI0	General Purpose Input	LID Button	Power Management Event	Please see Board Specification
GPI1	General Purpose Input			
GPI2	General Purpose Input			
GPI3	General Purpose Input			
GPO0	General Purpose Output	Fan Control	TTL output for external fan	Please see Board Specification
GPO1	General Purpose Output			
GPO2	General Purpose Output			
GPO3	General Purpose Output			

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5.2.1 Alternative GPIO use for SDIO Interface

Pin	GPIO	SDIO	Pin	GPIO	SDIO
A54	GPI0	DATA0	B54	GPO1	CMD
A63	GPI1	DATA1	B57	GPO2	WP
A67	GPI2	DATA2	B63	GPO3	CD#
A85	GPI3	DATA3			
A93	GPO0	CLK			

SDIO Pin description

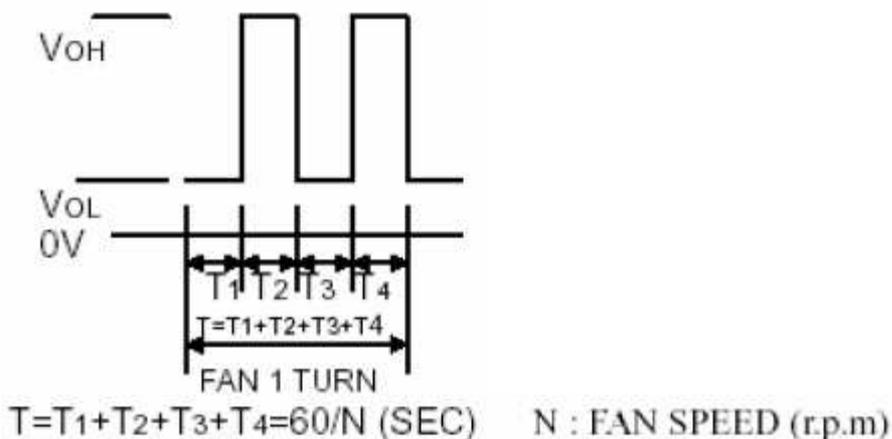| Signal	Type	Description
SD_DATA[3:0]	I/O CMOS3.3	**SDIO Controller 0/1/2 Data:** These signals operate in push-pull mode. The SD card includes internal pull-up resistors for all data lines. By default, after power-up, only SDn_DATA0 is used for data transfer. Wider data bus widths can be configured for data transfer.
SD_CMD	I/O CMOS3.3	**SDIO Controller 0/1/2 Command:** This signal is used for card initialization and transfer of commands. It has two operating modes: open-drain for initialization mode, and push-pull for fast command transfer.
SD1_CLK	O CMOS3.3	**SDIO Controller 0/1/2 Clock:** With each cycle of this signal a one-bit ransfer on the command and each data line occurs. This signal is generated by Intel SCH at a maximum frequency of: 24 Mhz for SD and SDIO. 48 Mhz for MMC.
SD0_WP	I CMOS3.3	**SDIO Controller 0/1/2 Write Protect**: These signals denote the state of the write-protect tab on SD cards.
SD1_CD#	I CMOS3.3	**SDIO Controller 0/1/2 Card Detect:** Indicates when a card is present in an external slot.

5.3   Thermal Control

A three-pin fan header is stuffed onboard the module to support thermal control through the use of a fan. Through BIOS-settings, it is possible to control the fan depending on the Active Trip Point temperature. The fan switches on/off depending on the adjusted Active Trip Point temperature. In order for this feature to function properly, an ACPI compliant OS is necessary. (Except for nanoETXexpress modules)

- Part number (Molex):   53261-0390

- Mates with: 51021-0300

- Crimp terminals: 50079-8100

Electrical characteristics:

- Vcc = 5 V

- Imax (continuous) = 0,68 A

- Imax (pulsed) = 2 A

- Sense (Tacho-pulse) = 4 Pulses per turn

6 Software extensions

6.1 TPM support

Trusted Computing is a technology developed and promoted by the <u>Trusted Computing Group</u> (TCG). The term is taken from the field of <u>trusted systems</u> and has a specialized meaning. "Trusted computing" means that the computer will consistently behave in specific ways and those behaviors will be enforced by hardware and software.

Trusted computing encompasses five key technology concepts, of which all are required for a fully trusted system.

> ➢ Endorsement Key
>
> ➢ Secure Input and Output
>
> ➢ Memory curtaining / Protected execution
>
> ➢ Sealed storage
>
> ➢ Remote attestation

COM Express™ Extension COMs are designed to support basic TPM features.

(more information: TBD)

COM Express™ Extension COMs are compliant to TCG 1.2. That includes efficient processing of hash and RSA algorithms with key length up to 2048bit and random generator.

This technology is necessary for all security -sensitive applications such as those for the gaming and e-commerce industries.

6.2 Smart Battery BIOS support

The BIOS supports smart battery to monitor the actual battery state on your system.

MARS is a Smart Battery reference System that is able to control up to two Smart batteries. The reference system will be implemented on a customized carrier board. The core of the SBS *MARS* is a dual Smart Battery System Manager. Additionally, the system contains a buck-boost converter at the input side, a dual buck converter and a buck-boost converter at the output side. There is also a CPLD used in *MARS* to get the functionality of an ATX power supply and for additional tasks.

MARS = **M**obile **A**pplication platform for **R**echargeable **S**ystems

Please following the link listed below to the document where you can find more information regarding a Smart Battery reference system:

http://emea.kontron.com/products/computeronmodules/etx/mars.html

6.3 Legacy Super I/O support in BIOS

Although COM Express™ is meant for legacy free systems there still often is the need for legacy interfaces like serial port, parallel port, floppy, etc.

To make an adaption of these ports possible the BIOS of COM Express™ modules has integrated support for LPC SUPER I/O chips. For detailed description, please see the COM Express™ Design Guide.

More information:

http://www.comexpress-extension.com/datasheet/COM_Express_Design_Guide_Rev_14.pdf

6.4 CMOS backup in BIOS

CMOS backup is supported by the BIOS.

Customer settings are saved in spite of battery remove in the EEPROM.

6.4.1 Console redirection in BIOS

(More information: TBD)

6.4.2 User editor for default settings

(More information: TBD)

7 Apendix A: PC Architecture Information

The following sources of information can help you better understand PC architecture.

7.1 Buses

7.1.1 ISA, Standard PS/2 – Connectors

➢ AT Bus Design: Eight and Sixteen-Bit ISA, E-ISA and EISA Design, Edward Solari, Annabooks, 1990, ISBN 0-929392-08-6

➢ AT IBM Technical Reference Vol. 1 & 2, 1985

➢ ISA & EISA Theory and Operation, Edward Solari, Annabooks, 1992, ISBN 0929392159

➢ ISA Bus Specifications and Application Notes, Jan. 30, 1990, Intel

➢ ISA System Architecture, Third Edition, Tom Shanley and Don Anderson, Addison-Wesley Publishing Company, 1995, ISBN 0-201-40996-8

➢ Personal Computer Bus Standard P996, Draft D2.00, Jan. 18, 1990, IEEE Inc

➢ Technical Reference Guide, Extended Industry Standard Architecture Expansion Bus, Compaq 1989

7.1.2 PCI

➢ PCI SIG
The PCI-SIG provides a forum for its ~900 member companies, who develop PCI products based on the specifications that are created by the PCI-SIG. You can search for information about the SIG on the Web.

➢ *PCI & PCI-X Hardware and Software Architecture & Design*, Fifth Edition, Edward Solari and George Willse, Annabooks, 2001, ISBN 0-929392-63-9.

➢ *PCI System Architecture,* Tom Shanley and Don Anderson, Addison-Wesley, 2000, ISBN 0-201-30974-2.

7.2 General PC Architecture

➢ *Embedded PCs*, Markt & Technik GmbH, ISBN 3-8272-5314-4 (German)

➢ *Hardware Bible*, Winn L. Rosch, SAMS, 1997, 0-672-30954-8

➢ *Interfacing to the IBM Personal Computer*, Second Edition, Lewis C. Eggebrecht, SAMS, 1990, ISBN 0-672-22722-3

➢ *The Indispensable PC Hardware Book*, Hans-Peter Messmer, Addison-Wesley, 1994, ISBN 0-201-62424-9

➢ *The PC Handbook: For Engineers, Programmers, and Other Serious PC Users, Sixth Edition*, John P. Choisser and John O. Foster, Annabooks, 1997, ISBN 0-929392-36-1

7.3   Ports

7.3.1   RS-232 Serial

➢ EIA-232-E standard
The EIA-232-E standard specifies the interface between (for example) a modem and a computer so that they can exchange data. The computer can then send data to the modem, which then sends the data over a telephone line. The data that the modem receives from the telephone line can then be sent to the computer. You can search for information about the standard on the Web.

➢ *RS-232 Made Easy: Connecting Computers, Printers, Terminals, and Modems*, Martin D. Seyer, Prentice Hall, 1991, ISBN 0-13-749854-3

➢ National Semiconductor
The Interface Data Book includes application notes. Type "232" as search criteria to obtain a list of application notes. You can search for information about the data book on National Semiconductor's Web site.

7.3.2   Serial ATA

➢ Serial AT Attachment (ATA) Working Group.

➢ This X3T10 standard defines an integrated bus interface between disk drives and host processors. It provides a common point of attachment for systems manufacturers and the system. You can search for information about the working group on the Web. We recommend you also search the Web for information on *4.2 I/O cable*, if you use hard disks in a DMA3 or PIO4 mode.

7.3.3   USB

➢ USB Specification.

➢ USB Implementers Forum, Inc. is a non-profit corporation founded by the group of companies that developed the Universal Serial Bus specification. The USB-IF was formed to provide a support organization and forum for the advancement and adoption of Universal Serial Bus technology. You can search for information about the standard on the Web.

7.4 Programming

- *C Programmer's Guide to Serial Communications*, Second Edition, Joe Campbell, SAMS, 1987, ISBN 0-672-22584-0

- *Programmer's Guide to the EGA, VGA, and Super VGA Cards*, Third Edition, Richard Ferraro, Addison-Wesley, 1990, ISBN 0-201-57025-4

- *The Programmer's PC Sourcebook,* Second Edition, Thom Hogan, Microsoft Press, 1991, ISBN 1-55615-321-X

- *Undocumented PC, A Programmer's Guide to I/O, CPUs, and Fixed Memory Areas*, Frank van Gilluwe, Second Edition, Addison-Wesley, 1997, ISBN 0-201-47950-8

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8   APPENDIX B: DOCUMENT-REVISION HISTORY

Revision	Date	Edited by	Changes
0.1	02.06.06	Z. Loncaric	Created preliminary specification.
0.2	05.10.06	Z. Loncaric	Index updates: - no microETXexpress inputs anymore, now a separate specification - new hardware, software and mechanical issues
0.3	02.04.07	Z. Loncaric	Defined new chapter, 4.0 Signal Description, 4.1 Graphic signal description
0.4	02.04.07	Z. Loncaric / Aaron Su	Neutral document format. Update by comments of Aaron Su.
0.5	15.05.07	Z. Loncaric / P. Müller	Brand COM Express Extension, Updates for chapters: 4.1 Grafic signal description, 5.2 General GPIOs, 5.3 Thermal Control, 6.1 TPM Support, 6.3 Legacy SuperI/O Support
0.6	16.05.07	C. Van De Graaf	Minor message and grammar edits
0.7	24.07.07	M. Ciolacu/ N. Feuerecker	New neutral layout
1.1	31.05.08	VGG	Add 3.1.2 new small form factor nano, add 5.2.1alternative GPIO use for SDIO interface, add 5.1.1 wide Range for SFF
1.1	02.06.08	G.Szczuka	Minor changes and grammar edits
1.2	11.06.08	VGG	Minor changes, enter reverence to micro and nano
1.3	12.12.2008	G.Szczuka	Correction of revision numbers 0.11 to 1.1 / 0.12 to 1.2

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