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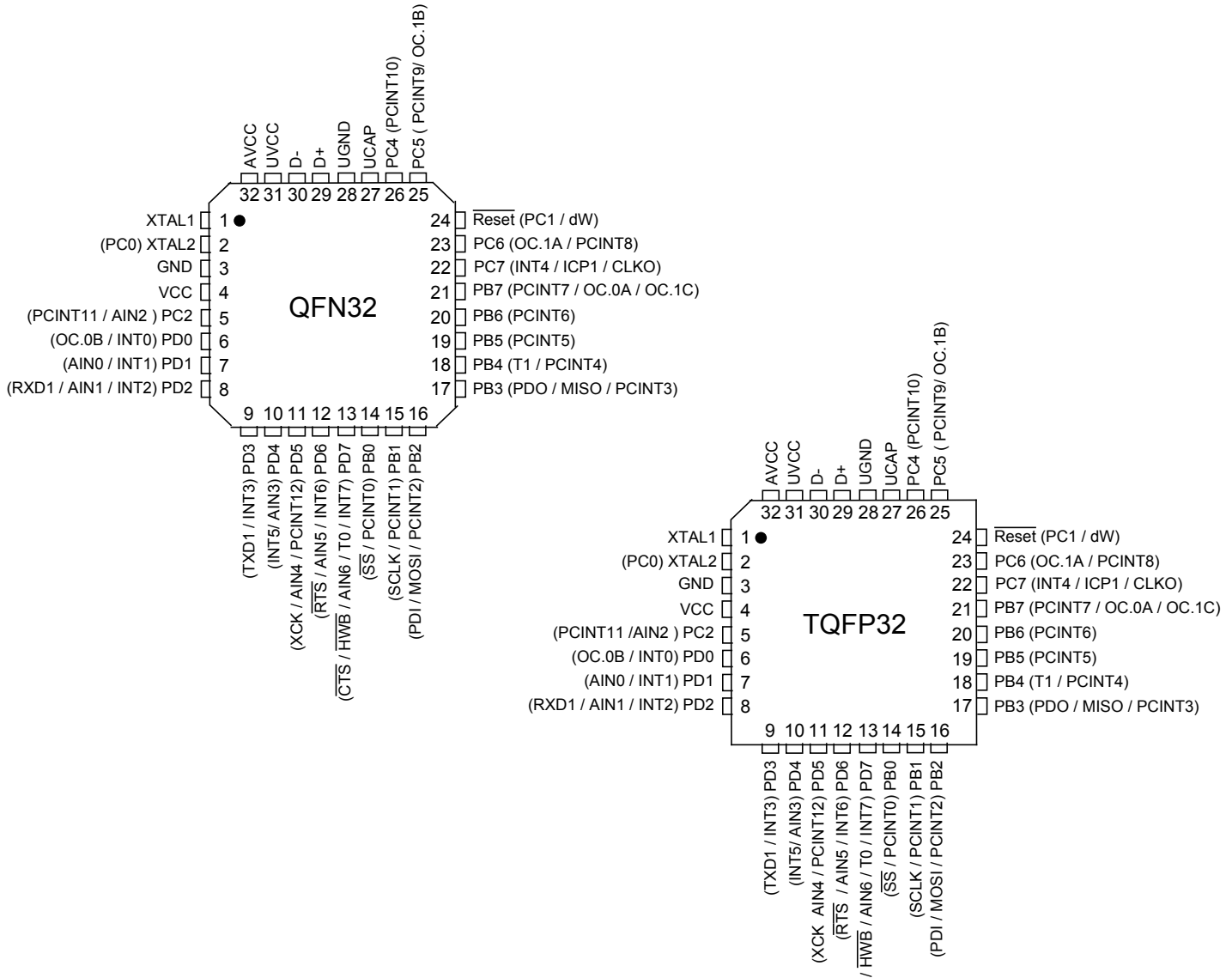
Applications of "[Embedded - Microcontrollers](#)"

Details

Product Status	Active
Core Processor	AVR
Core Size	8-Bit
Speed	16MHz
Connectivity	SPI, UART/USART, USB
Peripherals	Brown-out Detect/Reset, POR, PWM, WDT
Number of I/O	22
Program Memory Size	32KB (16K x 16)
Program Memory Type	FLASH
EEPROM Size	1K x 8
RAM Size	1K x 8
Voltage - Supply (Vcc/Vdd)	2.7V ~ 5.5V
Data Converters	-
Oscillator Type	Internal
Operating Temperature	-40°C ~ 85°C (TA)
Mounting Type	Surface Mount
Package / Case	32-VFQFN Exposed Pad
Supplier Device Package	32-VQFN (5x5)
Purchase URL	https://www.e-xfl.com/product-detail/microchip-technology/atmega32u2-mur

1. Pin Configurations

Figure 1-1. Pinout



Note: The large center pad underneath the QFN package should be soldered to ground on the board to ensure good mechanical stability.

1.1 Disclaimer

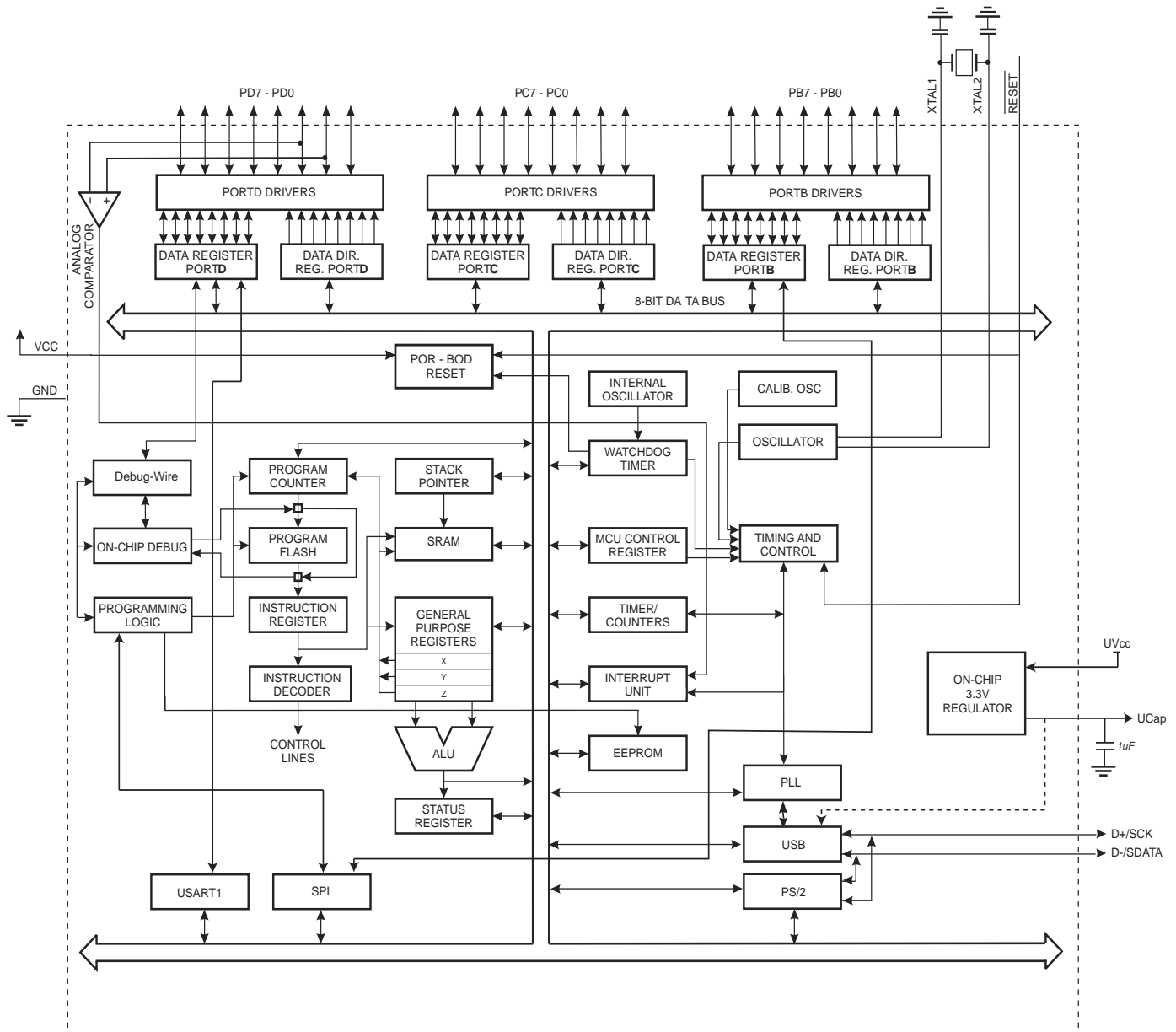
Typical values contained in this datasheet are based on simulations and characterization of other AVR microcontrollers manufactured on the same process technology. Min and Max values will be available after the device is characterized.

2. Overview

The ATmega8U2/16U2/32U2 is a low-power CMOS 8-bit microcontroller based on the AVR enhanced RISC architecture. By executing powerful instructions in a single clock cycle, the ATmega8U2/16U2/32U2 achieves throughputs approaching 1 MIPS per MHz allowing the system designer to optimize power consumption versus processing speed.

2.1 Block Diagram

Figure 2-1. Block Diagram



The AVR core combines a rich instruction set with 32 general purpose working registers. All the 32 registers are directly connected to the Arithmetic Logic Unit (ALU), allowing two independent registers to be accessed in one single instruction executed in one clock cycle. The resulting

architecture is more code efficient while achieving throughputs up to ten times faster than conventional CISC microcontrollers.

The ATmega8U2/16U2/32U2 provides the following features: 8K/16K/32K Bytes of In-System Programmable Flash with Read-While-Write capabilities, 512/512/1024 Bytes EEPROM, 512/512/1024 SRAM, 22 general purpose I/O lines, 32 general purpose working registers, two flexible Timer/Counters with compare modes and PWM, one USART, a programmable Watch-dog Timer with Internal Oscillator, an SPI serial port, debugWIRE interface, also used for accessing the On-chip Debug system and programming and five software selectable power saving modes. The Idle mode stops the CPU while allowing the SRAM, Timer/Counters, SPI port, and interrupt system to continue functioning. The Power-down mode saves the register contents but freezes the Oscillator, disabling all other chip functions until the next interrupt or Hardware Reset. In Standby mode, the Crystal/Resonator Oscillator is running while the rest of the device is sleeping. This allows very fast start-up combined with low power consumption. In Extended Standby mode, the main Oscillator continues to run.

The device is manufactured using Atmel's high-density nonvolatile memory technology. The on-chip ISP Flash allows the program memory to be reprogrammed in-system through an SPI serial interface, by a conventional nonvolatile memory programmer, or by an on-chip Boot program running on the AVR core. The boot program can use any interface to download the application program in the application Flash memory. Software in the Boot Flash section will continue to run while the Application Flash section is updated, providing true Read-While-Write operation. By combining an 8-bit RISC CPU with In-System Self-Programmable Flash on a monolithic chip, the Atmel ATmega8U2/16U2/32U2 is a powerful microcontroller that provides a highly flexible and cost effective solution to many embedded control applications.

The ATmega8U2/16U2/32U2 are supported with a full suite of program and system development tools including: C compilers, macro assemblers, program debugger/simulators, in-circuit emulators, and evaluation kits.

2.2 Pin Descriptions

2.2.1 VCC

Digital supply voltage.

2.2.2 GND

Ground.

2.2.3 AVCC

AVCC is the supply voltage pin (input) for all analog features (Analog Comparator, PLL). It should be externally connected to VCC through a low-pass filter.

2.2.4 Port B (PB7..PB0)

Port B is an 8-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The Port B output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, Port B pins that are externally pulled low will source current if the pull-up resistors are activated. The Port B pins are tri-stated when a reset condition becomes active, even if the clock is not running.

Port B also serves the functions of various special features of the ATmega8U2/16U2/32U2 as listed on-page 74.

2.2.5 Port C (PC7..PC0)

Port C is an 8-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The Port C output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, Port C pins that are externally pulled low will source current if the pull-up resistors are activated. The Port C pins are tri-stated when a reset condition becomes active, even if the clock is not running.

Port C also serves the functions of various special features of the ATmega8U2/16U2/32U2 as listed on page 77.

2.2.6 Port D (PD7..PD0)

Port D serves as analog inputs to the analog comparator.

Port D also serves as an 8-bit bi-directional I/O port, if the analog comparator is not used (concerns PD2/PD1 pins). Port pins can provide internal pull-up resistors (selected for each bit). The Port D output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, Port D pins that are externally pulled low will source current if the pull-up resistors are activated. The Port D pins are tri-stated when a reset condition becomes active, even if the clock is not running.

2.2.7 D-

USB Full Speed Negative Data Upstream Port

2.2.8 D+

USB Full Speed Positive Data Upstream Port

2.2.9 UGND

USB Ground.

2.2.10 UVCC

USB Pads Internal Regulator Input supply voltage.

2.2.11 UCAP

USB Pads Internal Regulator Output supply voltage. Should be connected to an external capacitor (1 μ F).

2.2.12 RESET/PC1/dW

Reset input. A low level on this pin for longer than the minimum pulse length will generate a reset, even if the clock is not running. The minimum pulse length is given in "System Control and Reset" on page 47. Shorter pulses are not guaranteed to generate a reset. This pin alternatively serves as debugWire channel or as generic I/O. The configuration depends on the fuses RSTDISBL and DWEN.

2.2.13 XTAL1

Input to the inverting Oscillator amplifier and input to the internal clock operating circuit.

2.2.14 XTAL2/PC0

Output from the inverting Oscillator amplifier if enabled by Fuse. Also serves as a generic I/O.

3. Resources

A comprehensive set of development tools, application notes and datasheets are available for download on <http://www.atmel.com/avr>.

4. Code Examples

This documentation contains simple code examples that briefly show how to use various parts of the device. Be aware that not all C compiler vendors include bit definitions in the header files and interrupt handling in C is compiler dependent. Please confirm with the C compiler documentation for more details.

These code examples assume that the part specific header file is included before compilation. For I/O registers located in extended I/O map, "IN", "OUT", "SBIS", "SBIC", "CBI", and "SBI" instructions must be replaced with instructions that allow access to extended I/O. Typically "LDS" and "STS" combined with "SBRS", "SBRC", "SBR", and "CBR".

5. Data Retention

Reliability Qualification results show that the projected data retention failure rate is much less than 1 PPM over 20 years at 85°C or 100 years at 25°C.

6. Register Summary

Address	Name	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	Page	
(0xFF)	Reserved	-	-	-	-	-	-	-	-		
(0xFE)	Reserved	-	-	-	-	-	-	-	-		
(0xFD)	Reserved	-	-	-	-	-	-	-	-		
(0xFC)	Reserved	-	-	-	-	-	-	-	-		
(0xFB)	UPOE	UPWE1	UPWE0	UPDRV1	UPDRV0	SCKI	DATAI	DPI	DMI	page 195	
(0xFA)	Reserved	-	-	-	-	-	-	-	-		
(0xF9)	Reserved	-	-	-	-	-	-	-	-		
(0xF8)	Reserved	-	-	-	-	-	-	-	-		
(0xF7)	Reserved	-	-	-	-	-	-	-	-		
(0xF6)	Reserved	-	-	-	-	-	-	-	-		
(0xF5)	Reserved	-	-	-	-	-	-	-	-		
(0xF4)	UEINT	-	-	-	EPINT4:0					-	page 222
(0xF3)	Reserved	-	-	-	-	-	-	-	-		
(0xF2)	UEBCLX	BYCT7:0								-	page 221
(0xF1)	UEDATX	DAT7:0								-	page 221
(0xF0)	UEIENX	FLERRE	NAKINE	-	NAKOUTE	RXSTPE	RXOUTE	STALLEDE	TXINE	page 220	
(0xEF)	UESTA1X	-	-	-	-	-	CTRLDIR	CURRBK1:0		page 218	
(0xEE)	UESTA0X	CFGOK	OVERFI	UNDERFI	-	DTSEQ1:0		NBUSYBK1:0		page 217	
(0xED)	UECFG1X	-	EPSIZE2:0			EPBK1:0		ALLOC	-	page 216	
(0xEC)	UECFG0X	EPTYPE1:0		-	-	-	-	-	EPDIR	page 215	
(0xEB)	UECONX	-	-	STALLRQ	STALLRQC	RSTDT	-	-	EPEN	page 214	
(0xEA)	UERST	-	-	-	EPRST4:0					-	page 214
(0xE9)	UENUM	-	-	-	-	-	EPNUM2:0			-	page 214
(0xE8)	UEINTX	FIFOCON	NAKINI	RWAL	NAKOUTI	RXSTPI	RXOUTI	STALLEDI	TXINI	page 219	
(0xE7)	Reserved	-	-	-	-	-	-	-	-		
(0xE6)	UDMFN	-	-	-	FNCERR	-	-	-	-	page 213	
(0xE5)	UDFNUMH	-	-	-	-	-	FNUM10:8			page 213	
(0xE4)	UDFNUML	FNUM7:0								-	page 213
(0xE3)	UDADDR	ADDEN	UADD6:0							-	page 212
(0xE2)	UDIEN	-	UPRSME	EORSME	WAKEUPE	EORSTE	SOFE	-	SUSPE	page 211	
(0xE1)	UDINT	-	UPRSMI	EORSMI	WAKEUPI	EORSTI	SOFI	-	SUSPI	page 210	
(0xE0)	UDCON	-	-	-	RPUTX	-	RSTCPU	RMWKUP	DETACH	page 209	
(0xDF)	Reserved	-	-	-	-	-	-	-	-		
(0xDE)	Reserved	-	-	-	-	-	-	-	-		
(0xDD)	Reserved	-	-	-	-	-	-	-	-		
(0xDC)	Reserved	-	-	-	-	-	-	-	-		
(0xDB)	Reserved	-	-	-	-	-	-	-	-		
(0xDA)	Reserved	-	-	-	-	-	-	-	-		
(0xD9)	Reserved	-	-	-	-	-	-	-	-		
(0xD8)	USBCON	USBE	-	FRZCLK	-	-	-	-	-	page 195	
(0xD7)	Reserved	-	-	-	-	-	-	-	-		
(0xD6)	Reserved	-	-	-	-	-	-	-	-		
(0xD5)	Reserved	-	-	-	-	-	-	-	-		
(0xD4)	Reserved	-	-	-	-	-	-	-	-		
(0xD3)	Reserved	-	-	-	-	-	-	-	-		
(0xD2)	CLKSTA	-	-	-	-	-	-	RCON	EXTON	page 38	
(0xD1)	CLKSEL1	RCCKSEL3	RCCKSEL2	RCCKSEL1	RCCKSEL0	EXCKSEL3	EXCKSEL2	EXCKSEL1	EXCKSEL0	page 38	
(0xD0)	CLKSEL0	RCSUT1	RCSUT0	EXSUT1	EXSUT0	RCE	EXTE	-	CLKS	page 37	
(0xCF)	Reserved	-	-	-	-	-	-	-	-		
(0xCE)	UDR1	USART1 I/O Data Register								-	page 167
(0xCD)	UBRR1H	-	-	-	-	USART1 Baud Rate Register High Byte					page 171
(0xCC)	UBRR1L	USART1 Baud Rate Register Low Byte								-	page 171
(0xCB)	UCSR1D	-	-	-	-	-	-	CTSEN	RTSEN	page 171	
(0xCA)	UCSR1C	UMSEL11	UMSEL10	UPM11	UPM10	USBS1	UCSZ11	UCSZ10	UCPOL1	page 169	
(0xC9)	UCSR1B	RXCIE1	TXCIE1	UDRIE1	RXEN1	TXEN1	UCSZ12	RXB81	TXB81	page 168	
(0xC8)	UCSR1A	RXC1	TXC1	UDRE1	FE1	DOR1	PE1	U2X1	MPCM1	page 167	
(0xC7)	Reserved	-	-	-	-	-	-	-	-		
(0xC6)	Reserved	-	-	-	-	-	-	-	-		
(0xC5)	Reserved	-	-	-	-	-	-	-	-		
(0xC4)	Reserved	-	-	-	-	-	-	-	-		
(0xC3)	Reserved	-	-	-	-	-	-	-	-		
(0xC2)	Reserved	-	-	-	-	-	-	-	-		
(0xC1)	Reserved	-	-	-	-	-	-	-	-		
(0xC0)	Reserved	-	-	-	-	-	-	-	-		
(0xBF)	Reserved	-	-	-	-	-	-	-	-		

Address	Name	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	Page
(0xBE)	Reserved	-	-	-	-	-	-	-	-	
(0xBD)	Reserved	-	-	-	-	-	-	-	-	
(0xBC)	Reserved	-	-	-	-	-	-	-	-	
(0xBB)	Reserved	-	-	-	-	-	-	-	-	
(0xBA)	Reserved	-	-	-	-	-	-	-	-	
(0xB9)	Reserved	-	-	-	-	-	-	-	-	
(0xB8)	Reserved	-	-	-	-	-	-	-	-	
(0xB7)	Reserved	-	-	-	-	-	-	-	-	
(0xB6)	Reserved	-	-	-	-	-	-	-	-	
(0xB5)	Reserved	-	-	-	-	-	-	-	-	
(0xB4)	Reserved	-	-	-	-	-	-	-	-	
(0xB3)	Reserved	-	-	-	-	-	-	-	-	
(0xB2)	Reserved	-	-	-	-	-	-	-	-	
(0xB1)	Reserved	-	-	-	-	-	-	-	-	
(0xB0)	Reserved	-	-	-	-	-	-	-	-	
(0xAF)	Reserved	-	-	-	-	-	-	-	-	
(0xAE)	Reserved	-	-	-	-	-	-	-	-	
(0xAD)	Reserved	-	-	-	-	-	-	-	-	
(0xAC)	Reserved	-	-	-	-	-	-	-	-	
(0xAB)	Reserved	-	-	-	-	-	-	-	-	
(0xAA)	Reserved	-	-	-	-	-	-	-	-	
(0xA9)	Reserved	-	-	-	-	-	-	-	-	
(0xA8)	Reserved	-	-	-	-	-	-	-	-	
(0xA7)	Reserved	-	-	-	-	-	-	-	-	
(0xA6)	Reserved	-	-	-	-	-	-	-	-	
(0xA5)	Reserved	-	-	-	-	-	-	-	-	
(0xA4)	Reserved	-	-	-	-	-	-	-	-	
(0xA3)	Reserved	-	-	-	-	-	-	-	-	
(0xA2)	Reserved	-	-	-	-	-	-	-	-	
(0xA1)	Reserved	-	-	-	-	-	-	-	-	
(0xA0)	Reserved	-	-	-	-	-	-	-	-	
(0x9F)	Reserved	-	-	-	-	-	-	-	-	
(0x9E)	Reserved	-	-	-	-	-	-	-	-	
(0x9D)	Reserved	-	-	-	-	-	-	-	-	
(0x9C)	Reserved	-	-	-	-	-	-	-	-	
(0x9B)	Reserved	-	-	-	-	-	-	-	-	
(0x9A)	Reserved	-	-	-	-	-	-	-	-	
(0x99)	Reserved	-	-	-	-	-	-	-	-	
(0x98)	Reserved	-	-	-	-	-	-	-	-	
(0x97)	Reserved	-	-	-	-	-	-	-	-	
(0x96)	Reserved	-	-	-	-	-	-	-	-	
(0x95)	Reserved	-	-	-	-	-	-	-	-	
(0x94)	Reserved	-	-	-	-	-	-	-	-	
(0x93)	Reserved	-	-	-	-	-	-	-	-	
(0x92)	Reserved	-	-	-	-	-	-	-	-	
(0x91)	Reserved	-	-	-	-	-	-	-	-	
(0x90)	Reserved	-	-	-	-	-	-	-	-	
(0x8F)	Reserved	-	-	-	-	-	-	-	-	
(0x8E)	Reserved	-	-	-	-	-	-	-	-	
(0x8D)	OCR1CH	Timer/Counter1 - Output Compare Register C High Byte								page 135
(0x8C)	OCR1CL	Timer/Counter1 - Output Compare Register C Low Byte								page 135
(0x8B)	OCR1BH	Timer/Counter1 - Output Compare Register B High Byte								page 135
(0x8A)	OCR1BL	Timer/Counter1 - Output Compare Register B Low Byte								page 135
(0x89)	OCR1AH	Timer/Counter1 - Output Compare Register A High Byte								page 135
(0x88)	OCR1AL	Timer/Counter1 - Output Compare Register A Low Byte								page 135
(0x87)	ICR1H	Timer/Counter1 - Input Capture Register High Byte								page 135
(0x86)	ICR1L	Timer/Counter1 - Input Capture Register Low Byte								page 135
(0x85)	TCNT1H	Timer/Counter1 - Counter Register High Byte								page 134
(0x84)	TCNT1L	Timer/Counter1 - Counter Register Low Byte								page 134
(0x83)	Reserved	-	-	-	-	-	-	-	-	
(0x82)	TCCR1C	FOC1A	FOC1B	FOC1C	-	-	-	-	-	page 134
(0x81)	TCCR1B	ICNC1	ICES1	-	WGM13	WGM12	CS12	CS11	CS10	page 133
(0x80)	TCCR1A	COM1A1	COM1A0	COM1B1	COM1B0	COM1C1	COM1C0	WGM11	WGM10	page 129
(0x7F)	DIDR1	-	AIN6D	AIN5D	AIN4D	AIN3D	AIN2D	AIN1D	AIN0D	page 225
(0x7E)	Reserved	-	-	-	-	-	-	-	-	
(0x7D)	ACMUX	-	-	-	-	-	CMUX2	CMUX1	CMUX0	page 225

Address	Name	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0	Page
0x1A (0x3A)	Reserved	-	-	-	-	-	-	-	-	
0x19 (0x39)	Reserved	-	-	-	-	-	-	-	-	
0x18 (0x38)	Reserved	-	-	-	-	-	-	-	-	
0x17 (0x37)	Reserved	-	-	-	-	-	-	-	-	
0x16 (0x36)	TIFR1	-	-	ICF1	-	OCF1C	OCF1B	OCF1A	TOV1	page 136
0x15 (0x35)	TIFR0	-	-	-	-	-	OCF0B	OCF0A	TOV0	page 107
0x14 (0x34)	Reserved	-	-	-	-	-	-	-	-	
0x13 (0x33)	Reserved	-	-	-	-	-	-	-	-	
0x12 (0x32)	Reserved	-	-	-	-	-	-	-	-	
0x11 (0x31)	Reserved	-	-	-	-	-	-	-	-	
0x10 (0x30)	Reserved	-	-	-	-	-	-	-	-	
0x0F (0x2F)	Reserved	-	-	-	-	-	-	-	-	
0x0E (0x2E)	Reserved	-	-	-	-	-	-	-	-	
0x0D (0x2D)	Reserved	-	-	-	-	-	-	-	-	
0x0C (0x2C)	Reserved	-	-	-	-	-	-	-	-	
0x0B (0x2B)	PORTD	PORTD7	PORTD6	PORTD5	PORTD4	PORTD3	PORTD2	PORTD1	PORTD0	page 83
0x0A (0x2A)	DDRD	DDD7	DDD6	DDD5	DDD4	DDD3	DDD2	DDD1	DDD0	page 83
0x09 (0x29)	PIND	PIND7	PIND6	PIND5	PIND4	PIND3	PIND2	PIND1	PIND0	page 83
0x08 (0x28)	PORTC	PORTC7	PORTC6	PORTC5	PORTC4	-	PORTC2	PORTC1	PORTC0	page 82
0x07 (0x27)	DDRC	DDC7	DDC6	DDC5	DDC4	-	DDC2	DDC1	DDC0	page 82
0x06 (0x26)	PINC	PINC7	PINC6	PINC5	PINC4	-	PINC2	PINC1	PINC0	page 82
0x05 (0x25)	PORTB	PORTB7	PORTB6	PORTB5	PORTB4	PORTB3	PORTB2	PORTB1	PORTB0	page 82
0x04 (0x24)	DDRB	DDB7	DDB6	DDB5	DDB4	DDB3	DDB2	DDB1	DDB0	page 82
0x03 (0x23)	PINB	PINB7	PINB6	PINB5	PINB4	PINB3	PINB2	PINB1	PINB0	page 82
0x02 (0x22)	Reserved	-	-	-	-	-	-	-	-	
0x01 (0x21)	Reserved	-	-	-	-	-	-	-	-	
0x00 (0x20)	Reserved	-	-	-	-	-	-	-	-	

- Note:
1. For compatibility with future devices, reserved bits should be written to zero if accessed. Moreover reserved bits are not guaranteed to be read as "0". Reserved I/O memory addresses should never be written.
 2. I/O registers within the address range \$00 - \$1F are directly bit-accessible using the SBI and CBI instructions. In these registers, the value of single bits can be checked by using the SBIS and SBIC instructions.
 3. Some of the status flags are cleared by writing a logical one to them. Note that the CBI and SBI instructions will operate on all bits in the I/O register, writing a one back into any flag read as set, thus clearing the flag. The CBI and SBI instructions work with registers 0x00 to 0x1F only.
 4. When using the I/O specific commands IN and OUT, the I/O addresses \$00 - \$3F must be used. When addressing I/O registers as data space using LD and ST instructions, \$20 must be added to these addresses. The ATmega8U2/16U2/32U2 is a complex microcontroller with more peripheral units than can be supported within the 64 location reserved in Opcode for the IN and OUT instructions. For the Extended I/O space from \$60 - \$1FF in SRAM, only the ST/STS/STD and LD/LDS/LDD instructions can be used.

7. Instruction Set Summary

Mnemonics	Operands	Description	Operation	Flags	#Clocks
ARITHMETIC AND LOGIC INSTRUCTIONS					
ADD	Rd, Rr	Add two Registers	$Rd \leftarrow Rd + Rr$	Z,C,N,V,H	1
ADC	Rd, Rr	Add with Carry two Registers	$Rd \leftarrow Rd + Rr + C$	Z,C,N,V,H	1
ADIW	RdI, K	Add Immediate to Word	$Rdh:Rdl \leftarrow Rdh:Rdl + K$	Z,C,N,V,S	2
SUB	Rd, Rr	Subtract two Registers	$Rd \leftarrow Rd - Rr$	Z,C,N,V,H	1
SUBI	Rd, K	Subtract Constant from Register	$Rd \leftarrow Rd - K$	Z,C,N,V,H	1
SBC	Rd, Rr	Subtract with Carry two Registers	$Rd \leftarrow Rd - Rr - C$	Z,C,N,V,H	1
SBCI	Rd, K	Subtract with Carry Constant from Reg.	$Rd \leftarrow Rd - K - C$	Z,C,N,V,H	1
SBIW	RdI, K	Subtract Immediate from Word	$Rdh:Rdl \leftarrow Rdh:Rdl - K$	Z,C,N,V,S	2
AND	Rd, Rr	Logical AND Registers	$Rd \leftarrow Rd \bullet Rr$	Z,N,V	1
ANDI	Rd, K	Logical AND Register and Constant	$Rd \leftarrow Rd \bullet K$	Z,N,V	1
OR	Rd, Rr	Logical OR Registers	$Rd \leftarrow Rd \vee Rr$	Z,N,V	1
ORI	Rd, K	Logical OR Register and Constant	$Rd \leftarrow Rd \vee K$	Z,N,V	1
EOR	Rd, Rr	Exclusive OR Registers	$Rd \leftarrow Rd \oplus Rr$	Z,N,V	1
COM	Rd	One's Complement	$Rd \leftarrow 0xFF - Rd$	Z,C,N,V	1
NEG	Rd	Two's Complement	$Rd \leftarrow 0x00 - Rd$	Z,C,N,V,H	1
SBR	Rd, K	Set Bit(s) in Register	$Rd \leftarrow Rd \vee K$	Z,N,V	1
CBR	Rd, K	Clear Bit(s) in Register	$Rd \leftarrow Rd \bullet (0xFF - K)$	Z,N,V	1
INC	Rd	Increment	$Rd \leftarrow Rd + 1$	Z,N,V	1
DEC	Rd	Decrement	$Rd \leftarrow Rd - 1$	Z,N,V	1
TST	Rd	Test for Zero or Minus	$Rd \leftarrow Rd \bullet Rd$	Z,N,V	1
CLR	Rd	Clear Register	$Rd \leftarrow Rd \oplus Rd$	Z,N,V	1
SER	Rd	Set Register	$Rd \leftarrow 0xFF$	None	1
BRANCH INSTRUCTIONS					
RJMP	k	Relative Jump	$PC \leftarrow PC + k + 1$	None	2
IJMP		Indirect Jump to (Z)	$PC \leftarrow Z$	None	2
JMP	k	Direct Jump	$PC \leftarrow k$	None	3
RCALL	k	Relative Subroutine Call	$PC \leftarrow PC + k + 1$	None	4
ICALL		Indirect Call to (Z)	$PC \leftarrow Z$	None	4
CALL	k	Direct Subroutine Call	$PC \leftarrow k$	None	5
RET		Subroutine Return	$PC \leftarrow STACK$	None	5
RETI		Interrupt Return	$PC \leftarrow STACK$	I	5
CPSE	Rd, Rr	Compare, Skip if Equal	if (Rd = Rr) $PC \leftarrow PC + 2$ or 3	None	1/2/3
CP	Rd, Rr	Compare	$Rd - Rr$	Z, N, V, C, H	1
CPC	Rd, Rr	Compare with Carry	$Rd - Rr - C$	Z, N, V, C, H	1
CPI	Rd, K	Compare Register with Immediate	$Rd - K$	Z, N, V, C, H	1
SBRC	Rr, b	Skip if Bit in Register Cleared	if (Rr(b)=0) $PC \leftarrow PC + 2$ or 3	None	1/2/3
SBRs	Rr, b	Skip if Bit in Register is Set	if (Rr(b)=1) $PC \leftarrow PC + 2$ or 3	None	1/2/3
SBIC	P, b	Skip if Bit in I/O Register Cleared	if (P(b)=0) $PC \leftarrow PC + 2$ or 3	None	1/2/3
SBIS	P, b	Skip if Bit in I/O Register is Set	if (P(b)=1) $PC \leftarrow PC + 2$ or 3	None	1/2/3
BRBS	s, k	Branch if Status Flag Set	if (SREG(s) = 1) then $PC \leftarrow PC + k + 1$	None	1/2
BRBC	s, k	Branch if Status Flag Cleared	if (SREG(s) = 0) then $PC \leftarrow PC + k + 1$	None	1/2
BREQ	k	Branch if Equal	if (Z = 1) then $PC \leftarrow PC + k + 1$	None	1/2
BRNE	k	Branch if Not Equal	if (Z = 0) then $PC \leftarrow PC + k + 1$	None	1/2
BRCS	k	Branch if Carry Set	if (C = 1) then $PC \leftarrow PC + k + 1$	None	1/2
BRCC	k	Branch if Carry Cleared	if (C = 0) then $PC \leftarrow PC + k + 1$	None	1/2
BRSH	k	Branch if Same or Higher	if (C = 0) then $PC \leftarrow PC + k + 1$	None	1/2
BRLO	k	Branch if Lower	if (C = 1) then $PC \leftarrow PC + k + 1$	None	1/2
BRMI	k	Branch if Minus	if (N = 1) then $PC \leftarrow PC + k + 1$	None	1/2
BRPL	k	Branch if Plus	if (N = 0) then $PC \leftarrow PC + k + 1$	None	1/2
BRGE	k	Branch if Greater or Equal, Signed	if (N \oplus V = 0) then $PC \leftarrow PC + k + 1$	None	1/2
BRLT	k	Branch if Less Than Zero, Signed	if (N \oplus V = 1) then $PC \leftarrow PC + k + 1$	None	1/2
BRHS	k	Branch if Half Carry Flag Set	if (H = 1) then $PC \leftarrow PC + k + 1$	None	1/2
BRHC	k	Branch if Half Carry Flag Cleared	if (H = 0) then $PC \leftarrow PC + k + 1$	None	1/2
BRTS	k	Branch if T Flag Set	if (T = 1) then $PC \leftarrow PC + k + 1$	None	1/2
BRTC	k	Branch if T Flag Cleared	if (T = 0) then $PC \leftarrow PC + k + 1$	None	1/2
BRVS	k	Branch if Overflow Flag is Set	if (V = 1) then $PC \leftarrow PC + k + 1$	None	1/2
BRVC	k	Branch if Overflow Flag is Cleared	if (V = 0) then $PC \leftarrow PC + k + 1$	None	1/2
BRIE	k	Branch if Interrupt Enabled	if (I = 1) then $PC \leftarrow PC + k + 1$	None	1/2
BRID	k	Branch if Interrupt Disabled	if (I = 0) then $PC \leftarrow PC + k + 1$	None	1/2
BIT AND BIT-TEST INSTRUCTIONS					
SBI	P, b	Set Bit in I/O Register	$I/O(P, b) \leftarrow 1$	None	2
CBI	P, b	Clear Bit in I/O Register	$I/O(P, b) \leftarrow 0$	None	2
LSL	Rd	Logical Shift Left	$Rd(n+1) \leftarrow Rd(n), Rd(0) \leftarrow 0$	Z,C,N,V	1
LSR	Rd	Logical Shift Right	$Rd(n) \leftarrow Rd(n+1), Rd(7) \leftarrow 0$	Z,C,N,V	1

Mnemonics	Operands	Description	Operation	Flags	#Clocks
ROL	Rd	Rotate Left Through Carry	$Rd(0) \leftarrow C, Rd(n+1) \leftarrow Rd(n), C \leftarrow Rd(7)$	Z, C, N, V	1
ROR	Rd	Rotate Right Through Carry	$Rd(7) \leftarrow C, Rd(n) \leftarrow Rd(n+1), C \leftarrow Rd(0)$	Z, C, N, V	1
ASR	Rd	Arithmetic Shift Right	$Rd(n) \leftarrow Rd(n+1), n=0..6$	Z, C, N, V	1
SWAP	Rd	Swap Nibbles	$Rd(3..0) \leftrightarrow Rd(7..4), Rd(7..4) \leftrightarrow Rd(3..0)$	None	1
BSET	s	Flag Set	$SREG(s) \leftarrow 1$	SREG(s)	1
BCLR	s	Flag Clear	$SREG(s) \leftarrow 0$	SREG(s)	1
BST	Rr, b	Bit Store from Register to T	$T \leftarrow Rr(b)$	T	1
BLD	Rd, b	Bit load from T to Register	$Rd(b) \leftarrow T$	None	1
SEC		Set Carry	$C \leftarrow 1$	C	1
CLC		Clear Carry	$C \leftarrow 0$	C	1
SEN		Set Negative Flag	$N \leftarrow 1$	N	1
CLN		Clear Negative Flag	$N \leftarrow 0$	N	1
SEZ		Set Zero Flag	$Z \leftarrow 1$	Z	1
CLZ		Clear Zero Flag	$Z \leftarrow 0$	Z	1
SEI		Global Interrupt Enable	$I \leftarrow 1$	I	1
CLI		Global Interrupt Disable	$I \leftarrow 0$	I	1
SES		Set Signed Test Flag	$S \leftarrow 1$	S	1
CLS		Clear Signed Test Flag	$S \leftarrow 0$	S	1
SEV		Set Twos Complement Overflow	$V \leftarrow 1$	V	1
CLV		Clear Twos Complement Overflow	$V \leftarrow 0$	V	1
SET		Set T in SREG	$T \leftarrow 1$	T	1
CLT		Clear T in SREG	$T \leftarrow 0$	T	1
SEH		Set Half Carry Flag in SREG	$H \leftarrow 1$	H	1
CLH		Clear Half Carry Flag in SREG	$H \leftarrow 0$	H	1
DATA TRANSFER INSTRUCTIONS					
MOV	Rd, Rr	Move Between Registers	$Rd \leftarrow Rr$	None	1
MOVW	Rd, Rr	Copy Register Word	$Rd+1:Rd \leftarrow Rr+1:Rr$	None	1
LDI	Rd, K	Load Immediate	$Rd \leftarrow K$	None	1
LD	Rd, X	Load Indirect	$Rd \leftarrow (X)$	None	2
LD	Rd, X+	Load Indirect and Post-Inc.	$Rd \leftarrow (X), X \leftarrow X + 1$	None	2
LD	Rd, -X	Load Indirect and Pre-Dec.	$X \leftarrow X - 1, Rd \leftarrow (X)$	None	2
LD	Rd, Y	Load Indirect	$Rd \leftarrow (Y)$	None	2
LD	Rd, Y+	Load Indirect and Post-Inc.	$Rd \leftarrow (Y), Y \leftarrow Y + 1$	None	2
LD	Rd, -Y	Load Indirect and Pre-Dec.	$Y \leftarrow Y - 1, Rd \leftarrow (Y)$	None	2
LDD	Rd, Y+q	Load Indirect with Displacement	$Rd \leftarrow (Y + q)$	None	2
LD	Rd, Z	Load Indirect	$Rd \leftarrow (Z)$	None	2
LD	Rd, Z+	Load Indirect and Post-Inc.	$Rd \leftarrow (Z), Z \leftarrow Z + 1$	None	2
LD	Rd, -Z	Load Indirect and Pre-Dec.	$Z \leftarrow Z - 1, Rd \leftarrow (Z)$	None	2
LDD	Rd, Z+q	Load Indirect with Displacement	$Rd \leftarrow (Z + q)$	None	2
LDS	Rd, k	Load Direct from SRAM	$Rd \leftarrow (k)$	None	2
ST	X, Rr	Store Indirect	$(X) \leftarrow Rr$	None	2
ST	X+, Rr	Store Indirect and Post-Inc.	$(X) \leftarrow Rr, X \leftarrow X + 1$	None	2
ST	-X, Rr	Store Indirect and Pre-Dec.	$X \leftarrow X - 1, (X) \leftarrow Rr$	None	2
ST	Y, Rr	Store Indirect	$(Y) \leftarrow Rr$	None	2
ST	Y+, Rr	Store Indirect and Post-Inc.	$(Y) \leftarrow Rr, Y \leftarrow Y + 1$	None	2
ST	-Y, Rr	Store Indirect and Pre-Dec.	$Y \leftarrow Y - 1, (Y) \leftarrow Rr$	None	2
STD	Y+q, Rr	Store Indirect with Displacement	$(Y + q) \leftarrow Rr$	None	2
ST	Z, Rr	Store Indirect	$(Z) \leftarrow Rr$	None	2
ST	Z+, Rr	Store Indirect and Post-Inc.	$(Z) \leftarrow Rr, Z \leftarrow Z + 1$	None	2
ST	-Z, Rr	Store Indirect and Pre-Dec.	$Z \leftarrow Z - 1, (Z) \leftarrow Rr$	None	2
STD	Z+q, Rr	Store Indirect with Displacement	$(Z + q) \leftarrow Rr$	None	2
STS	k, Rr	Store Direct to SRAM	$(k) \leftarrow Rr$	None	2
LPM		Load Program Memory	$R0 \leftarrow (Z)$	None	3
LPM	Rd, Z	Load Program Memory	$Rd \leftarrow (Z)$	None	3
LPM	Rd, Z+	Load Program Memory and Post-Inc	$Rd \leftarrow (Z), Z \leftarrow Z + 1$	None	3
SPM		Store Program Memory	$(Z) \leftarrow R1:R0$	None	-
IN	Rd, P	In Port	$Rd \leftarrow P$	None	1
OUT	P, Rr	Out Port	$P \leftarrow Rr$	None	1
PUSH	Rr	Push Register on Stack	$STACK \leftarrow Rr$	None	2
POP	Rd	Pop Register from Stack	$Rd \leftarrow STACK$	None	2
MCU CONTROL INSTRUCTIONS					
NOP		No Operation		None	1
SLEEP		Sleep	(see specific descr. for Sleep function)	None	1
WDR		Watchdog Reset	(see specific descr. for WDR/timer)	None	1
BREAK		Break	For On-chip Debug Only	None	N/A

8. Ordering Information

8.1 ATmega8U2

Speed	Power Supply	Ordering Code	Package	Operational Range
16 MHz	2.7 - 5.5V	ATmega8U2-AU	32A	-40°C to +85°C
		ATmega8U2-MU	32M1-A	

Package Type	
32A	32-lead, 7 x 7 x 1.2 mm, lead pitch 0.8 mm Thin Quad Flat Package
32M1	32-pad, 5 x 5 x 1 mm body, pad pitch 0.50 mm Quad Flat No lead (QFN)

8.2 ATmega16U2

Speed	Power Supply	Ordering Code	Package	Operational Range
16 MHz	2.7 - 5.5V	ATmega16U2-AU	32A	-40°C to +85°C
		ATmega16U2-MU	32M1-A	

Package Type	
32A	32-lead, 7 x7 x 1.2 mm, lead pitch 0.8 mm Thin Quad Flat Package
32M1	32-pad, 5 x 5 x 1 mm body, pad pitch 0.50 mm Quad Flat No lead (QFN)

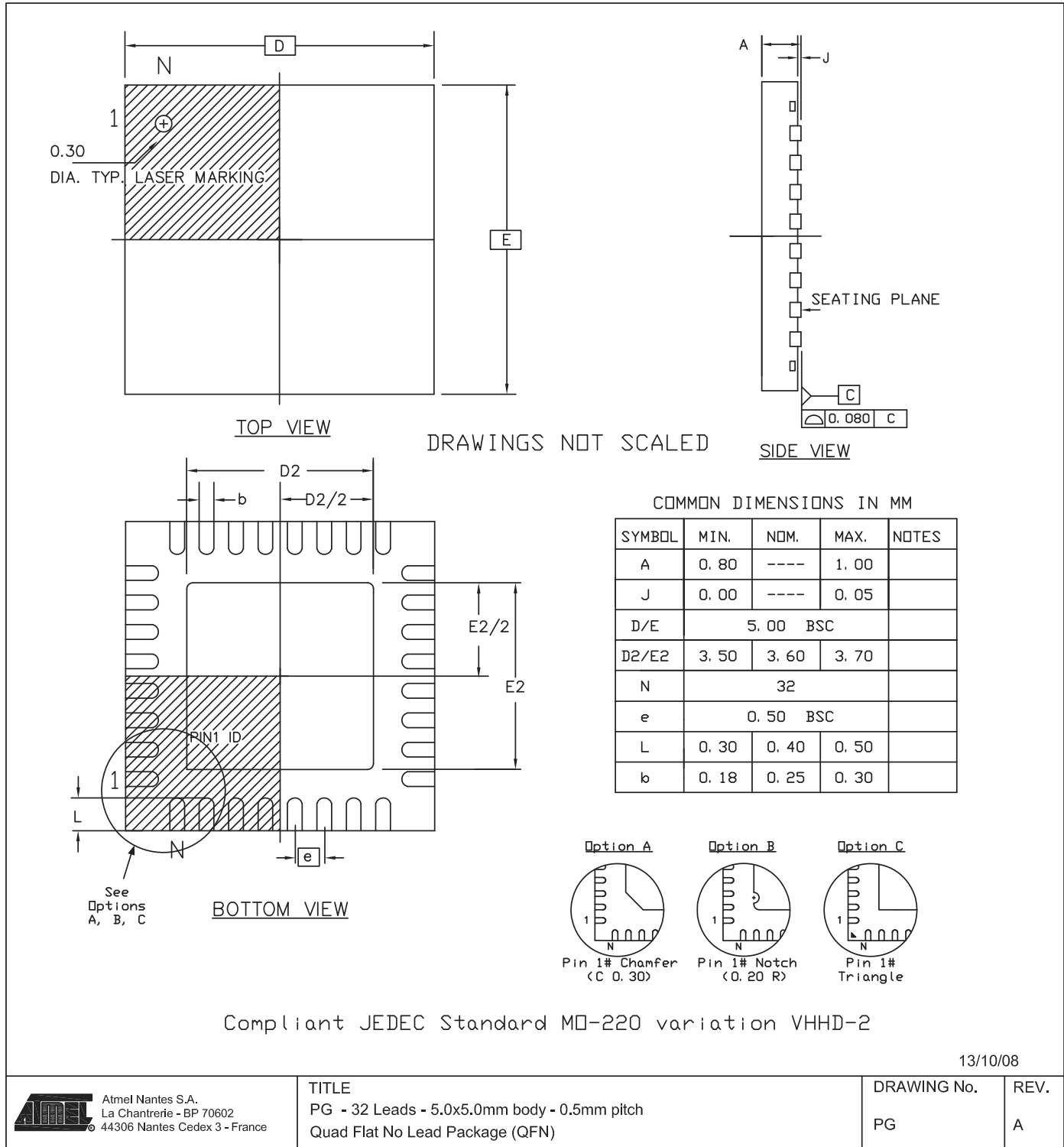
8.3 ATmega32U2

Speed	Power Supply	Ordering Code	Package	Operational Range
16 MHz	2.7 - 5.5V	ATmega32U2-AU	32A	-40°C to +85°C
		ATmega32U2-MU	32M1-A	

Package Type	
32A	32-lead, 7 x7 x 1.2 mm, lead pitch 0.8 mm Thin Quad Flat Package
32M1	32-pad, 5 x 5 x 1 mm body, pad pitch 0.50 mm Quad Flat No lead (QFN)

9. Packaging Information

9.1 QFN32



10. Errata

10.1 Errata ATmega8U2

The revision letter in this section refers to the revision of the ATmega8U2 device.

10.1.1 rev. A and rev B

- **Full Swing oscillator**

- 1. Full Swing oscillator**

The maximum frequency for the Full Swing Crystal Oscillator is 8MHz. For Crystal frequencies > 8MHz the Full Swing Crystal Oscillator is not guaranteed to operate correctly.

Problem fix/Workaround

If a Crystal with frequency > 8MHz is used, the Low Power Crystal Oscillator option should be used instead. See table 8-1 for an overview of the Device Clocking Options. Note that the Low Power Crystal Oscillator will not provide full rail-to-rail swing on the XTAL2 pin. If system clock output is needed to drive other clock inputs while running from the Low Power Crystal Oscillator, the system clock can be output on PORTC7 by programming the CKOUT fuse.

10.2 Errata ATmega16U2

The revision letter in this section refers to the revision of the ATmega16U2 device.

10.2.1 rev. A and rev B

- **Full Swing oscillator**

- 1. Full Swing oscillator**

The maximum frequency for the Full Swing Crystal Oscillator is 8MHz. For Crystal frequencies > 8MHz the Full Swing Crystal Oscillator is not guaranteed to operate correctly.

Problem fix/Workaround

If a Crystal with frequency > 8MHz is used, the Low Power Crystal Oscillator option should be used instead. See table 8-1 for an overview of the Device Clocking Options. Note that the Low Power Crystal Oscillator will not provide full rail-to-rail swing on the XTAL2 pin. If system clock output is needed to drive other clock inputs while running from the Low Power Crystal Oscillator, the system clock can be output on PORTC7 by programming the CKOUT fuse.

10.3 Errata ATmega32U2

The revision letter in this section refers to the revision of the ATmega32U2 device.

10.3.1 rev. C

No Known Errata

10.3.2 rev. A and rev B

- **Full Swing oscillator**

1. Full Swing oscillator

The maximum frequency for the Full Swing Crystal Oscillator is 8MHz. For Crystal frequencies > 8MHz the Full Swing Crystal Oscillator is not guaranteed to operate correctly.

Problem fix/Workaround

If a Crystal with frequency > 8MHz is used, the Low Power Crystal Oscillator option should be used instead. See table 8-1 for an overview of the Device Clocking Options. Note that the Low Power Crystal Oscillator will not provide full rail-to-rail swing on the XTAL2 pin. If system clock output is needed to drive other clock inputs while running from the Low Power Crystal Oscillator, the system clock can be output on PORTC7 by programming the CKOUT fuse.

11. Datasheet Revision History

Please note that the referring page numbers in this section are referred to this document. The referring revision in this section are referring to the document revision.

11.1 Rev.7799E – 09/12

1. Renamed package name in Figure 1-1 on page 2 from VQFP32 to TQFP32.
2. Corrected typos.

11.2 Rev. 7799D – 11/10

1. Updated the footnote on page 2. Removed the VQFP from the footnote
2. Updated Section 20-4 "Typical Bus powered application with 3.3V I/O" on page 187.
3. Updated Figure 20-6 on page 188. By connecting UVCC to 3V power-supply.
4. Updated Table 21-2 on page 215. 10: Bulk Type, and 01: Isochronous Type
5. Added UVCC limits in Electrical Characteristics
6. Updated "Electrical Characteristics" on page 264. Added USB D+ Internal Pull-up (streaming mode)
7. Updated "Register Summary" on page 7. Added DIDR1 (address: 0x7F)
8. Removed Figure 27-26: USB Regulator Consumption with load 75Ω vs. Vcc

11.3 Rev. 7799C – 12/09

1. Updated "Features" on page 1.
2. Added description of "AVCC" on page 4.
3. Updated Figure 7-2 on page 18.
4. Updated Figure 20-3 on page 186 and Figure 20-4 on page 187.
5. Updated "Fuse Bits" on page 247.
6. Updated "DC Characteristics" on page 264.
7. Updated Table 26-3 on page 267, by removing Vrst.
8. Updated Table 26-4 on page 268.
9. Updated "Typical Characteristics" on page 273.
10. Added new "Errata" on page 18.

11.4 Rev. 7799B – 06/09

1. Updated "Typical Characteristics" on page 273.

11.5 Rev. 7799A – 03/09

1. Initial revision.

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