## E·XFL



Welcome to E-XFL.COM

#### What is "Embedded - Microcontrollers"?

"Embedded - Microcontrollers" refer to small, integrated circuits designed to perform specific tasks within larger systems. These microcontrollers are essentially compact computers on a single chip, containing a processor core, memory, and programmable input/output peripherals. They are called "embedded" because they are embedded within electronic devices to control various functions, rather than serving as standalone computers. Microcontrollers are crucial in modern electronics, providing the intelligence and control needed for a wide range of applications.

Applications of "<u>Embedded -</u> <u>Microcontrollers</u>"

#### Details

Product Status	Active
Core Processor	PIC
Core Size	8-Bit
Speed	20MHz
Connectivity	-
Peripherals	Brown-out Detect/Reset, POR, PWM, WDT
Number of I/O	11
Program Memory Size	3.5KB (2K x 14)
Program Memory Type	FLASH
EEPROM Size	-
RAM Size	128 x 8
Voltage - Supply (Vcc/Vdd)	2V ~ 5.5V
Data Converters	A/D 8x10b
Oscillator Type	Internal
Operating Temperature	-40°C ~ 125°C (TA)
Mounting Type	Surface Mount
Package / Case	16-VQFN Exposed Pad
Supplier Device Package	16-QFN (4x4)
Purchase URL	https://www.e-xfl.com/product-detail/microchip-technology/pic16f616-e-ml

Email: info@E-XFL.COM

Address: Room A, 16/F, Full Win Commercial Centre, 573 Nathan Road, Mongkok, Hong Kong

# MICROCHIP PIC16F610/616/16HV610/616

### 14-Pin Flash-Based, 8-Bit CMOS Microcontrollers

#### High-Performance RISC CPU:

- Only 35 Instructions to Learn:
  - All single-cycle instructions except branches
- Operating Speed:
  - DC 20 MHz oscillator/clock input
  - DC 200 ns instruction cycle
- Interrupt Capability
- 8-Level Deep Hardware Stack
- Direct, Indirect and Relative Addressing modes

#### **Special Microcontroller Features:**

- Precision Internal Oscillator:
- Factory calibrated to ±1%, typical
- User selectable frequency: 4 MHz or 8 MHz
- Power-Saving Sleep mode
- Voltage Range:
  - PIC16F610/616: 2.0V to 5.5V
  - PIC16HV610/616: 2.0V to user defined maximum (see note)
- Industrial and Extended Temperature Range
- Power-on Reset (POR)
- Power-up Timer (PWRT) and Oscillator Start-up Timer (OST)
- Brown-out Reset (BOR)
- Watchdog Timer (WDT) with Independent Oscillator for Reliable Operation
- Multiplexed Master Clear with Pull-up/Input Pin
- Programmable Code Protection
- High Endurance Flash:
  - 100,000 write Flash endurance
  - Flash retention: > 40 years

#### Low-Power Features:

Standby Current:

Note:

- 50 nA @ 2.0V, typical
- Operating Current:
  - 20 μA @ 32 kHz, 2.0V, typical

cannot exceed 5V.

Voltage across internal shunt regulator

- 220  $\mu\text{A}$  @ 4 MHz, 2.0V, typical
- Watchdog Timer Current:
  - 1 μA @ 2.0V, typical

#### **Peripheral Features:**

- Shunt Voltage Regulator (PIC16HV610/616 only):
  - 5 volt regulation
  - 4 mA to 50 mA shunt range
- 11 I/O Pins and 1 Input Only
  - High current source/sink for direct LED drive
  - Interrupt-on-Change pins
  - Individually programmable weak pull-ups
- Analog Comparator module with:
  - Two analog comparators
  - Programmable on-chip voltage reference (CVREF) module (% of VDD)
  - Fixed Voltage Reference
  - Comparator inputs and outputs externally accessible
  - SR Latch
  - Built-In Hysteresis (user selectable)
- Timer0: 8-Bit Timer/Counter with 8-Bit Programmable Prescaler
- Enhanced Timer1:
  - 16-bit timer/counter with prescaler
  - External Timer1 Gate (count enable)
  - Option to use OSC1 and OSC2 in LP mode as Timer1 oscillator if INTOSC mode selected
  - Timer1 oscillator
- In-Circuit Serial Programming<sup>™</sup> (ICSP<sup>™</sup>) via Two Pins

#### PIC16F616/16HV616 only:

- A/D Converter:
  - 10-bit resolution
  - 8 external input channels
  - 2 internal reference channels
- Timer2: 8-Bit Timer/Counter with 8-Bit Period Register, Prescaler and Postscaler
- Enhanced Capture, Compare, PWM module:
  - 16-bit Capture, max. resolution 12.5 ns
  - 16-bit Compare, max. resolution 200 ns
  - 10-bit PWM with 1, 2 or 4 output channels, programmable "dead time", max. frequency 20 kHz

#### PIC16F610/16HV610 16-Pin Diagram (QFN)



TABLE 3:	PIC16F610/16HV610	<b>16-PIN SUMMARY</b>

I/O	Pin	Comparators	Timers	Interrupts	Pull-ups	Basic
RA0	12	C1IN+	-	IOC	Y	ICSPDAT
RA1	11	C12IN0-		IOC	Y	ICSPCLK
RA2	10	C1OUT	TOCKI	INT/IOC	Y	—
RA3 <sup>(1)</sup>	3	—	_	IOC	Y(2)	MCLR/VPP
RA4	2	—	T1G	IOC	Y	OSC2/CLKOUT
RA5	1	—	T1CKI	IOC	Y	OSC1/CLKIN
RC0	9	C2IN+	—	—	—	—
RC1	8	C12IN1-		—		—
RC2	7	C12IN2-	—	—	_	—
RC3	6	C12IN3-		—	—	_
RC4	5	C2OUT	_	—	—	—
RC5	4	—		—	_	_
—	16	—	_	—	_	Vdd
—	13					Vss

Note 1: Input only.

**2:** Only when pin is configured for external  $\overline{MCLR}$ .

#### 1.0 DEVICE OVERVIEW

The PIC16F610/616/16HV610/616 is covered by this data sheet. It is available in 14-pin PDIP, SOIC, TSSOP and 16-pin QFN packages.

Block Diagrams and pinout descriptions of the devices are as follows:

- PIC16F610/16HV610 (Figure 1-1, Table 1-1)
- PIC16F616/16HV616 (Figure 1-2, Table 1-2)

#### FIGURE 1-1: PIC16F610/16HV610 BLOCK DIAGRAM







#### 2.0 MEMORY ORGANIZATION

#### 2.1 Program Memory Organization

The PIC16F610/616/16HV610/616 has a 13-bit program counter capable of addressing an 8K x 14 program memory space. Only the first 1K x 14 (0000h-3FF) for the PIC16F610/16HV610 and the first 2K x 14 (0000h-07FFh) for the PIC16F616/16HV616 is physically implemented. Accessing a location above these boundaries will cause a wraparound within the first 1K x 14 space (PIC16F610/16HV610) and 2K x 14 space (PIC16F616/16HV616). The Reset vector is at 0000h and the interrupt vector is at 0004h (see Figure 2-1).

#### FIGURE 2-1: PROGRAM MEMORY MAP AND STACK FOR THE PIC16F610/16HV610



#### FIGURE 2-2:

#### PROGRAM MEMORY MAP AND STACK FOR THE PIC16F616/16HV616



#### 4.2.4.3 RA2/AN2<sup>(1)</sup>/T0CKI/INT/C1OUT

Figure 4-2 shows the diagram for this pin. The RA2 pin is configurable to function as one of the following:

- a general purpose I/O
- an analog input for the ADC<sup>(1)</sup>
- the clock input for TMR0
- an external edge triggered interrupt
- a digital output from Comparator C1



#### FIGURE 4-2: BLOCK DIAGRAM OF RA2



R/W-0	R/W-0	R/W-0	R/W-0	R/S-0	R/S-0	U-0	R/W-0	
SR1 <sup>(2)</sup>	SR0 <sup>(2)</sup>	C1SEN	C2REN	PULSS	PULSR		SRCLKEN	
bit 7							bit 0	
Legend:				S = Bit is set o	nly -			
R = Readable	bit	W = Writable b	it	U = Unimpleme	ented bit, read as	s 'O'		
-n = Value at P	OR	'1' = Bit is set		'0' = Bit is clea	red	x = Bit is unkno	wn	
bit 7	<b>SR1:</b> SR Latch 1 = C2OUT 0 = C2OUT	Configuration bip pin is the latch $\overline{C}$ pin is the C2 cor	t <mark>(2)</mark> output nparator output					
bit 6	<b>SR0:</b> SR Latch 1 = C1OUT 0 = C1OUT	Configuration bi pin is the latch C pin is the C1 Co	ts <b>(2)</b> output mparator output					
bit 5	C1SEN: C1 Se 1 = C1 compa 0 = C1 compa	t Enable bit irator output sets irator output has	SR latch no effect on SR	latch				
bit 4	<b>C2REN:</b> C2 Re 1 = C2 compa 0 = C2 compa	eset Enable bit irator output rese irator output has	ets SR latch no effect on SR	latch				
bit 3	bit 3 <b>PULSS:</b> Pulse the SET Input of the SR Latch bit 1 = Triggers pulse generator to set SR latch. Bit is immediately reset by hardware. 0 = Does not trigger pulse generator							
bit 2	PULSR: Pulse 1 = Triggers p 0 = Does not t	the Reset Input ulse generator to trigger pulse gen	of the SR Latch o reset SR latch. erator	bit Bit is immediate	ly reset by hardw	vare.		
bit 1	Unimplemente	ed: Read as '0'						
bit 0	SRCLKEN: SR	Latch Set Clock	c Enable bit					
	1 = Set input of	of SR latch is pu	sed with SRCLK	(				
	0 = Set input of	of SR latch is not	t pulsed with the	SRCLK				
Note 1: Th	e C1OUT and C20	OUT bits in the C	MxCON0 registe	er will always refle	ect the actual com	nparator output (n	ot the level on	

#### REGISTER 8-4: SRCON0: SR LATCH CONTROL 0 REGISTER

the pin), regardless of the SR latch operation.2: To enable an SR Latch output to the pin, the appropriate CxOE, and TRIS bits must be properly configured.

#### REGISTER 8-5: SRCON1: SR LATCH CONTROL 1 REGISTER

R/W-0	R/W-0	U-0	U-0	U-0	U-0	U-0	U-0	
SRCS1	SRCS0	—	—	—	—	—	—	
bit 7 bit 0								

Legend:		S = Bit is set only -			
R = Readable bit	W = Writable bit	U = Unimplemented bit, read as '0'			
-n = Value at POR	'1' = Bit is set	'0' = Bit is cleared	x = Bit is unknown		

bit 7-6	SRCS<1:0>: SR Latch Clock Prescale bits
	00 = Fosc/16
	01 = Fosc/32
	10 = Fosc/64

11 = Fosc/128

bit 5-0 Unimplemented: Read as '0'

#### 9.2.7 ADC REGISTER DEFINITIONS

The following registers are used to control the operation of the ADC.

#### REGISTER 9-1: ADCON0: A/D CONTROL REGISTER 0

R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0
ADFM	VCFG	CHS3	CHS2	CHS1	CHS0	GO/DONE	ADON
bit 7							bit 0
Legend:							
R = Readab	ole bit	W = Writable bit	t	U = Unimpleme	ented bit, read a	is '0'	
-n = Value a	it POR	'1' = Bit is set		'0' = Bit is clear	red	x = Bit is unknow	wn
b.:  7		nuoraian Daault I		h.:4			
DIT 7	1 = Right justif 0 = Left justifie	ied ied	-ormat Select	DIT			
bit 6	VCFG: Voltage 1 = VREF pin 0 = VDD	e Reference bit					
bit 5-2	CHS<3:0>: Ar 0000 = Chan 0001 = Chan 0010 = Chan 0010 = Chan 0100 = Chan 0101 = Chan 0110 = Chan 0111 = Chan 1000 = Rese 1001 = Rese 1010 = Rese 1011 = Rese 1011 = Rese 1100 = CVRE 1101 = 0.6V 1110 = 1.2V 1111 = Rese	alog Channel Sel nel 00 (AN0) nel 01 (AN1) nel 02 (AN2) nel 03 (AN3) nel 04 (AN4) nel 05 (AN5) nel 06 (AN6) nel 07 (AN7) rved – do not use rved – do not use rved – do not use F Fixed Voltage Ref Fixed Voltage Ref	ect bits erence <sup>(1)</sup> erence <sup>(1)</sup>				
bit 1	GO/DONE: A// 1 = A/D conve This bit is a 0 = A/D conve	D Conversion Sta rsion cycle in prog automatically clea rsion completed/r	tus bit gress. Setting t red by hardwa lot in progress	his bit starts an A re when the A/D c	/D conversion c conversion has (	ycle. completed.	
bit 0	ADON: ADC E 1 = ADC is ena 0 = ADC is dis	Enable bit abled abled and consur	nes no operati	ng current			
Note 1:	When the CHS<3:0	> bits change to s	elect the 1.2V	or 0.6V Fixed Volt	tage Reference	the reference out	put voltage will

Note 1: When the CHS<3:0> bits change to select the 1.2V or 0.6V Fixed Voltage Reference, the reference output voltage will have a transient. If the Comparator module uses this VP6 reference voltage, the comparator output may momentarily change state due to the transient.

NOTES:

#### 10.3.1 PWM PERIOD

The PWM period is specified by writing to the PR2 register of Timer2. The PWM period can be calculated using the formula of Equation 10-1.

#### EQUATION 10-1: PWM PERIOD

$$PWM Period = [(PR2) + 1] \bullet 4 \bullet Tosc \bullet$$
$$(TMR2 Prescale Value)$$

When TMR2 is equal to PR2, the following three events occur on the next increment cycle:

- TMR2 is cleared
- The CCP1 pin is set. (Exception: If the PWM duty cycle = 0%, the pin will not be set.)
- The PWM duty cycle is latched from CCPR1L into CCPR1H.

Note:	The Timer2 postscaler (see Section 7.1
	"Timer2 Operation") is not used in the
	determination of the PWM frequency.

#### 10.3.2 PWM DUTY CYCLE

The PWM duty cycle is specified by writing a 10-bit value to multiple registers: CCPR1L register and CCP1<1:0> bits of the CCP1CON register. The CCPR1L contains the eight MSbs and the CCP1<1:0> bits of the CCP1CON register contain the two LSbs. CCPR1L and CCP1<1:0> bits of the CCP1CON register can be written to at any time. The duty cycle value is not latched into CCPR1H until after the period completes (i.e., a match between PR2 and TMR2 registers occurs). While using the PWM, the CCPR1H register is read-only.

Equation 10-2 is used to calculate the PWM pulse width.

Equation 10-3 is used to calculate the PWM duty cycle ratio.

#### EQUATION 10-2: PULSE WIDTH

 $Pulse Width = (CCPR1L:CCP1CON < 5:4>) \bullet$ 

TOSC • (TMR2 Prescale Value)

#### EQUATION 10-3: DUTY CYCLE RATIO

$$Duty Cycle Ratio = \frac{(CCPR1L:CCP1CON < 5:4>)}{4(PR2 + 1)}$$

The CCPR1H register and a 2-bit internal latch are used to double buffer the PWM duty cycle. This double buffering is essential for glitchless PWM operation.

The 8-bit timer TMR2 register is concatenated with either the 2-bit internal system clock (Fosc), or 2 bits of the prescaler, to create the 10-bit time base. The system clock is used if the Timer2 prescaler is set to 1:1.

When the 10-bit time base matches the CCPR1H and 2-bit latch, then the CCP1 pin is cleared (see Figure 10-3).

#### 10.3.3 PWM RESOLUTION

The resolution determines the number of available duty cycles for a given period. For example, a 10-bit resolution will result in 1024 discrete duty cycles, whereas an 8-bit resolution will result in 256 discrete duty cycles.

The maximum PWM resolution is 10 bits when PR2 is 255. The resolution is a function of the PR2 register value as shown by Equation 10-4.

#### EQUATION 10-4: PWM RESOLUTION

Resolution = 
$$\frac{\log[4(PR2 + 1)]}{\log(2)}$$
 bits

Note: If the pulse width value is greater than the period the assigned PWM pin(s) will remain unchanged.

#### TABLE 10-4: EXAMPLE PWM FREQUENCIES AND RESOLUTIONS (Fosc = 20 MHz)

PWM Frequency	1.22 kHz	4.88 kHz	19.53 kHz	78.12 kHz	156.3 kHz	208.3 kHz
Timer Prescale (1, 4, 16)	16	4	1	1	1	1
PR2 Value	0xFF	0xFF	0xFF	0x3F	0x1F	0x17
Maximum Resolution (bits)	10	10	10	8	7	6.6

#### TABLE 10-5: EXAMPLE PWM FREQUENCIES AND RESOLUTIONS (Fosc = 8 MHz)

PWM Frequency	1.22 kHz	4.90 kHz	19.61 kHz	76.92 kHz	153.85 kHz	200.0 kHz
Timer Prescale (1, 4, 16)	16	4	1	1	1	1
PR2 Value	0x65	0x65	0x65	0x19	0x0C	0x09
Maximum Resolution (bits)	8	8	8	6	5	5

© 2009 Microchip Technology Inc.

NOTES:

FIGURE 15-3: PIC16F610/616 FREQUENCY TOLERANCE GRAPH,



FIGURE 15-4: PIC16HV610/616 FREQUENCY TOLERANCE GRAPH,





#### TABLE 15-3: CLKOUT AND I/O TIMING PARAMETERS

<b>Standar</b> Operatin	<b>d Operating</b> g Temperatu	Conditions (unless otherwise stated) re -40°C $\leq$ TA $\leq$ +125°C					
Param No.	Sym	Characteristic	Min	Тур†	Max	Units	Conditions
OS11	TosH2cкL	Fosc↑ to CLKOUT↓ <sup>(1)</sup>	—	_	70	ns	VDD = 5.0V
OS12	TosH2ckH	Fosc↑ to CLKOUT↑ <sup>(1)</sup>	—	_	72	ns	VDD = 5.0V
OS13	TCKL2IOV	CLKOUT↓ to Port out valid <sup>(1)</sup>	—	—	20	ns	
OS14	ТюV2скН	Port input valid before CLKOUT <sup>(1)</sup>	Tosc + 200 ns	—	_	ns	
OS15	TosH2IoV	Fosc↑ (Q1 cycle) to Port out valid	—	50	70*	ns	VDD = 5.0V
OS16	TosH2IOI	Fosc↑ (Q2 cycle) to Port input invalid (I/O in hold time)	50	—	_	ns	VDD = 5.0V
OS17	TioV2osH	Port input valid to Fosc↑ (Q2 cycle) (I/O in setup time)	20		_	ns	
OS18	TIOR	Port output rise time <sup>(2)</sup>		15 40	72 32	ns	VDD = 2.0V VDD = 5.0V
OS19	TIOF	Port output fall time <sup>(2)</sup>		28 15	55 30	ns	VDD = 2.0V VDD = 5.0V
OS20*	Tinp	INT pin input high or low time	25	_		ns	
OS21*	Trap	PORTA interrupt-on-change new input level time	Тсү	_	_	ns	

\* These parameters are characterized but not tested.

† Data in "Typ" column is at 5.0V, 25°C unless otherwise stated.

Note 1: Measurements are taken in RC mode where CLKOUT output is 4 x Tosc.

2: Includes OSC2 in CLKOUT mode.









#### FIGURE 16-20: PIC16HV610/616 IDD EC (1 MHz) vs. VDD

















#### FIGURE 16-54: COMPARATOR RESPONSE TIME (FALLING EDGE)





#### 16-Lead Plastic Quad Flat, No Lead Package (ML) – 4x4x0.9 mm Body [QFN]

**Note:** For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging



Units		MILLIMETERS		
Dimension Limits		MIN	NOM	MAX
Number of Pins	Ν		16	
Pitch	е	0.65 BSC		
Overall Height	Α	0.80	0.90	1.00
Standoff	A1	0.00	0.02	0.05
Contact Thickness	A3	0.20 REF		
Overall Width	Е	4.00 BSC		
Exposed Pad Width	E2	2.50	2.65	2.80
Overall Length	D	4.00 BSC		
Exposed Pad Length	D2	2.50	2.65	2.80
Contact Width	b	0.25	0.30	0.35
Contact Length	L	0.30	0.40	0.50
Contact-to-Exposed Pad	K	0.20	-	-

#### Notes:

- 1. Pin 1 visual index feature may vary, but must be located within the hatched area.
- 2. Package is saw singulated.
- 3. Dimensioning and tolerancing per ASME Y14.5M.
  - BSC: Basic Dimension. Theoretically exact value shown without tolerances.

REF: Reference Dimension, usually without tolerance, for information purposes only.

Microchip Technology Drawing C04-127B

#### READER RESPONSE

It is our intention to provide you with the best documentation possible to ensure successful use of your Microchip product. If you wish to provide your comments on organization, clarity, subject matter, and ways in which our documentation can better serve you, please FAX your comments to the Technical Publications Manager at (480) 792-4150.

Please list the following information, and use this outline to provide us with your comments about this document.

To:	Technical Publications Manager	Total Pages Sent			
RE:	Reader Response				
From	n: Name				
	Company				
	Address				
	City / State / ZIP / Country				
	Telephone: ()	FAX: ()			
Application (optional):					
Would you like a reply?YN					
Devi	ce: PIC16F610/616/16HV610/616	Literature Number: DS41288F			
Ques	stions:				
1 What are the best features of this document?					
	2. How does this document meet your hardware and software development needs?				
_					
3. C	Do you find the organization of this document easy to follow? If not, why?				
_					
_					
4. V	What additions to the document do you think would enhance the structure and subject?				
_					
_					
5. V	What deletions from the document co	ould be made without affecting the overall usefulness?			
_					
_					
6. l:	s there any incorrect or misleading in	nformation (what and where)?			
-					
7. H	. How would you improve this document?				
_					



### WORLDWIDE SALES AND SERVICE

#### AMERICAS

Corporate Office 2355 West Chandler Blvd. Chandler, AZ 85224-6199 Tel: 480-792-7200 Fax: 480-792-7277 Technical Support: http://support.microchip.com Web Address: www.microchip.com

Atlanta Duluth, GA Tel: 678-957-9614 Fax: 678-957-1455

Boston Westborough, MA Tel: 774-760-0087 Fax: 774-760-0088

Chicago Itasca, IL Tel: 630-285-0071 Fax: 630-285-0075

**Cleveland** Independence, OH Tel: 216-447-0464 Fax: 216-447-0643

**Dallas** Addison, TX Tel: 972-818-7423 Fax: 972-818-2924

Detroit Farmington Hills, MI Tel: 248-538-2250 Fax: 248-538-2260

Kokomo Kokomo, IN Tel: 765-864-8360 Fax: 765-864-8387

Los Angeles Mission Viejo, CA Tel: 949-462-9523 Fax: 949-462-9608

Santa Clara Santa Clara, CA Tel: 408-961-6444 Fax: 408-961-6445

Toronto Mississauga, Ontario, Canada Tel: 905-673-0699 Fax: 905-673-6509

#### ASIA/PACIFIC

Asia Pacific Office Suites 3707-14, 37th Floor Tower 6, The Gateway Harbour City, Kowloon Hong Kong Tel: 852-2401-1200 Fax: 852-2401-3431

Australia - Sydney Tel: 61-2-9868-6733 Fax: 61-2-9868-6755

**China - Beijing** Tel: 86-10-8528-2100 Fax: 86-10-8528-2104

**China - Chengdu** Tel: 86-28-8665-5511 Fax: 86-28-8665-7889

**China - Hong Kong SAR** Tel: 852-2401-1200 Fax: 852-2401-3431

**China - Nanjing** Tel: 86-25-8473-2460

Fax: 86-25-8473-2470 China - Qingdao

Tel: 86-532-8502-7355 Fax: 86-532-8502-7205

**China - Shanghai** Tel: 86-21-5407-5533 Fax: 86-21-5407-5066

**China - Shenyang** Tel: 86-24-2334-2829 Fax: 86-24-2334-2393

**China - Shenzhen** Tel: 86-755-8203-2660 Fax: 86-755-8203-1760

**China - Wuhan** Tel: 86-27-5980-5300 Fax: 86-27-5980-5118

**China - Xiamen** Tel: 86-592-2388138 Fax: 86-592-2388130

**China - Xian** Tel: 86-29-8833-7252 Fax: 86-29-8833-7256

**China - Zhuhai** Tel: 86-756-3210040 Fax: 86-756-3210049

#### ASIA/PACIFIC

India - Bangalore Tel: 91-80-3090-4444 Fax: 91-80-3090-4080

India - New Delhi Tel: 91-11-4160-8631 Fax: 91-11-4160-8632

India - Pune Tel: 91-20-2566-1512 Fax: 91-20-2566-1513

**Japan - Yokohama** Tel: 81-45-471- 6166 Fax: 81-45-471-6122

**Korea - Daegu** Tel: 82-53-744-4301 Fax: 82-53-744-4302

Korea - Seoul Tel: 82-2-554-7200 Fax: 82-2-558-5932 or 82-2-558-5934

Malaysia - Kuala Lumpur Tel: 60-3-6201-9857 Fax: 60-3-6201-9859

Malaysia - Penang Tel: 60-4-227-8870 Fax: 60-4-227-4068

Philippines - Manila Tel: 63-2-634-9065 Fax: 63-2-634-9069

Singapore Tel: 65-6334-8870 Fax: 65-6334-8850

Taiwan - Hsin Chu Tel: 886-3-6578-300 Fax: 886-3-6578-370

**Taiwan - Kaohsiung** Tel: 886-7-536-4818 Fax: 886-7-536-4803

**Taiwan - Taipei** Tel: 886-2-2500-6610 Fax: 886-2-2508-0102

**Thailand - Bangkok** Tel: 66-2-694-1351 Fax: 66-2-694-1350

#### EUROPE

Austria - Wels Tel: 43-7242-2244-39 Fax: 43-7242-2244-393 Denmark - Copenhagen Tel: 45-4450-2828 Fax: 45-4485-2829

France - Paris Tel: 33-1-69-53-63-20 Fax: 33-1-69-30-90-79

**Germany - Munich** Tel: 49-89-627-144-0 Fax: 49-89-627-144-44

**Italy - Milan** Tel: 39-0331-742611 Fax: 39-0331-466781

Netherlands - Drunen Tel: 31-416-690399 Fax: 31-416-690340

**Spain - Madrid** Tel: 34-91-708-08-90 Fax: 34-91-708-08-91

**UK - Wokingham** Tel: 44-118-921-5869 Fax: 44-118-921-5820