AN2477

Microchip MEMS Oscillator and Clock Products for Automotive Applications

Author: Graham Mostyn
Microchip Technology Inc.

INTRODUCTION

For decades, oscillators and clocks have relied on quartz crystals for the creation of a stable frequency reference. Crystals perform very well for many applications. However, microelectromechanical systems (MEMS) technology—replacing quartz crystals with MEMS resonators—entered the marketplace ten years ago and is rapidly gaining traction.

MEMS-based timing devices offer high reliability, extended operating temperatures, small size, and low power consumption.

Microchip acquired MEMS timing technology through the acquisition of Micrel, which had earlier acquired Discera, in 2015. Discera shipped its first production oscillators in 2008 and, since then, has manufactured and sold almost 100 million devices.

This paper describes automotive applications for MEMS-based oscillators and clocks, the benefits of a MEMS solution, and provides a reference to Microchip's white paper Microchip Oscillators and Clocks Using Microelectromechanical Systems (MEMS) Technology.

AUTOMOTIVE APPLICATIONS

There are three main applications for MEMS-based oscillators and clocks. As Figure 1 shows, these are ADAS, an Advanced Driver Assistance System; the User Interface, which includes Infotainment and Connectivity; and Smart Actuators that deal with transmission and engine control.

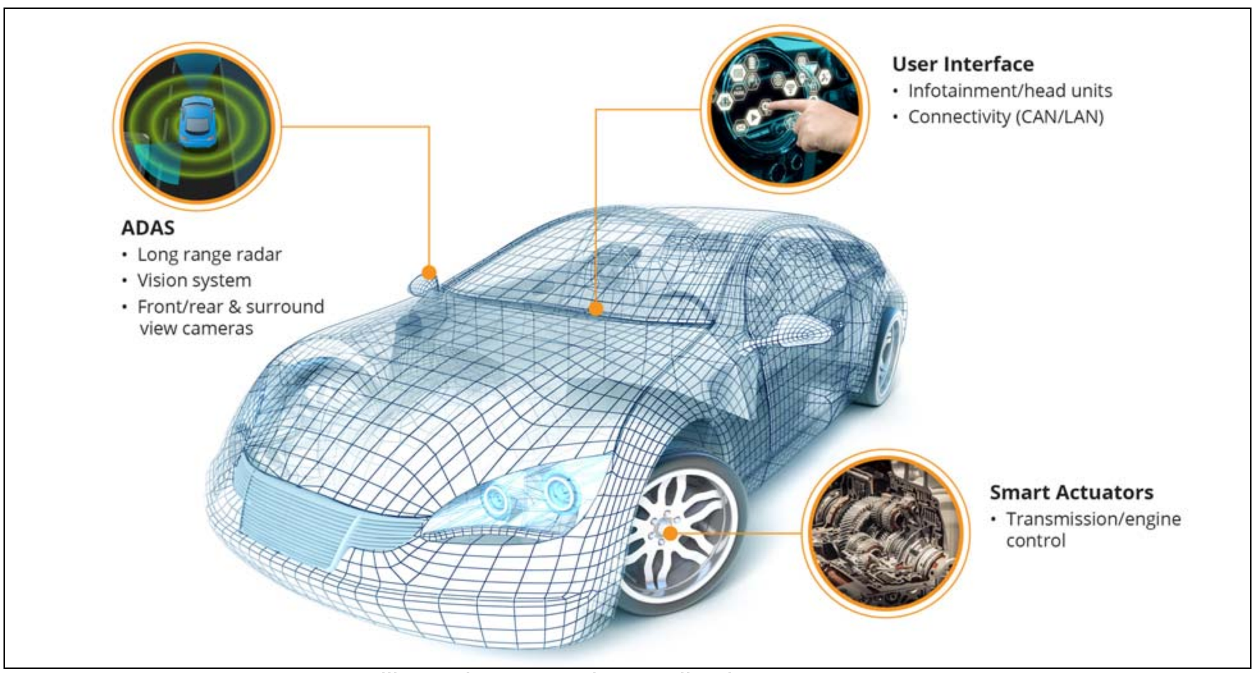

FIGURE 1: *MEMS Oscillators in Automotive Applications.*

Advanced Driver Assistance System

An Advanced Driver Assistance System (ADAS) is designed to improve safety by providing advanced notice of collision risk, alerting the driver, and, in some cases, taking control of the vehicle. Computer vision technology, including object recognition and tracking, is employed with multiple sensors mounted on the vehicle that may include cameras, LiDAR systems, and radar. Additionally, data may be received by radio from other vehicles and Internet-connected data sources.

Figure 2 shows an ADAS LiDAR module. An FPGA provides signal generation and system control. Pulses generated by the FPGA are amplified and sent to a laser. Received reflections are then sensed and digitized by a Microchip high speed ADC, the data is then sent to a second FPGA image processor. The processor detects and signals collision alerts to the vehicle network.

A DSA400 MEMS clock drives the high speed ADC and the FPGA processors. The DSA400 is a four-output clock with low phase noise, ideal for high speed FPGAs, and is AEC-Q100 capable.

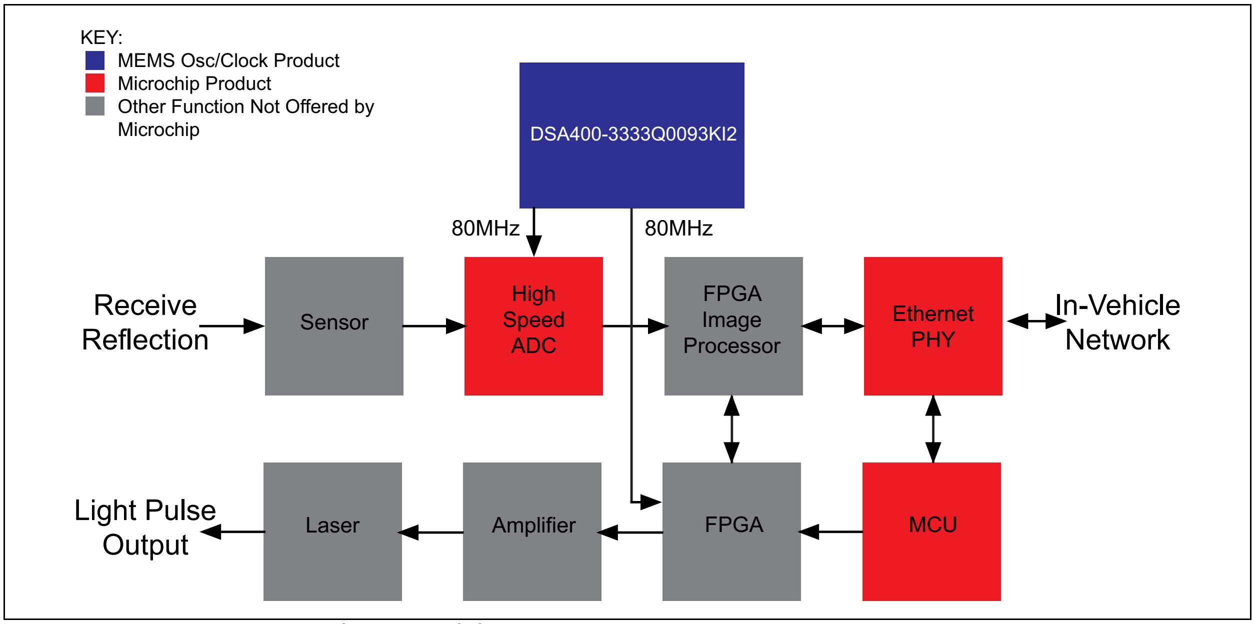

FIGURE 2: *ADAS LiDAR Module.*

Figure 3 illustrates an ADAS Long Range Radar System. The DSP generates pulse waveforms that are converted to modulation signals in the RF baseband unit, driving the 77 GHz transmitter (RF TX). Conversely, the pulse reflections reaching the 77 GHz receiver (RF RX) are demodulated by the baseband unit and processed by the DSP. A Microchip 32-bit MCU with CAN interface provides overall system control and Microchip power management ICs regulate the supply from the vehicle's electrical system.

The DSA2311 is a two-output MEMS clock, with low phase noise similar to the DSA400, and is AEC-Q100 certified.

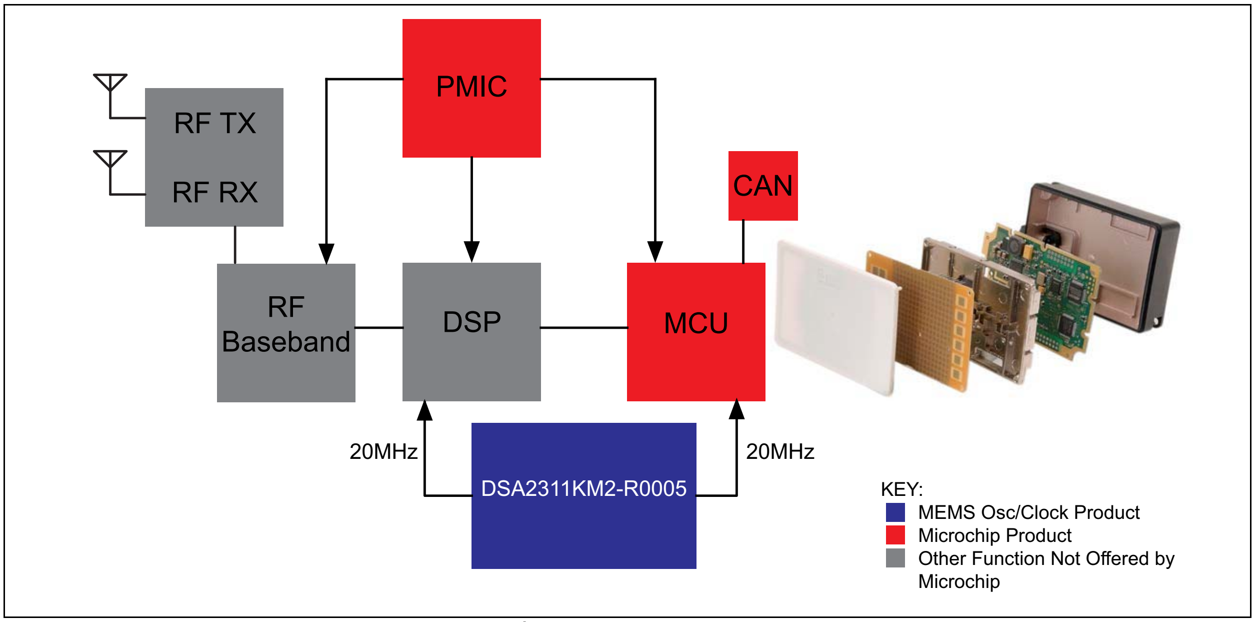

FIGURE 3: *ADAS Long Range Radar System.*

User Interface

The user interface category includes In-Car Entertainment (ICE) and In-Vehicle Infotainment (IVI). These provide audio and video entertainment and driver information, such as navigation.

Figure 4 illustrates how data streams are received from a rear-view camera, on-vehicle WiFi and Bluetooth, an AM/FM radio, and a CD/DVD drive, and then transmitted to an Automotive Application Processor. The processor decodes the incoming streams and converts them to audio and video. The user communicates via a touch panel concerning the selection of infotainment menu choices, and the requested media is presented on the audio system and display.

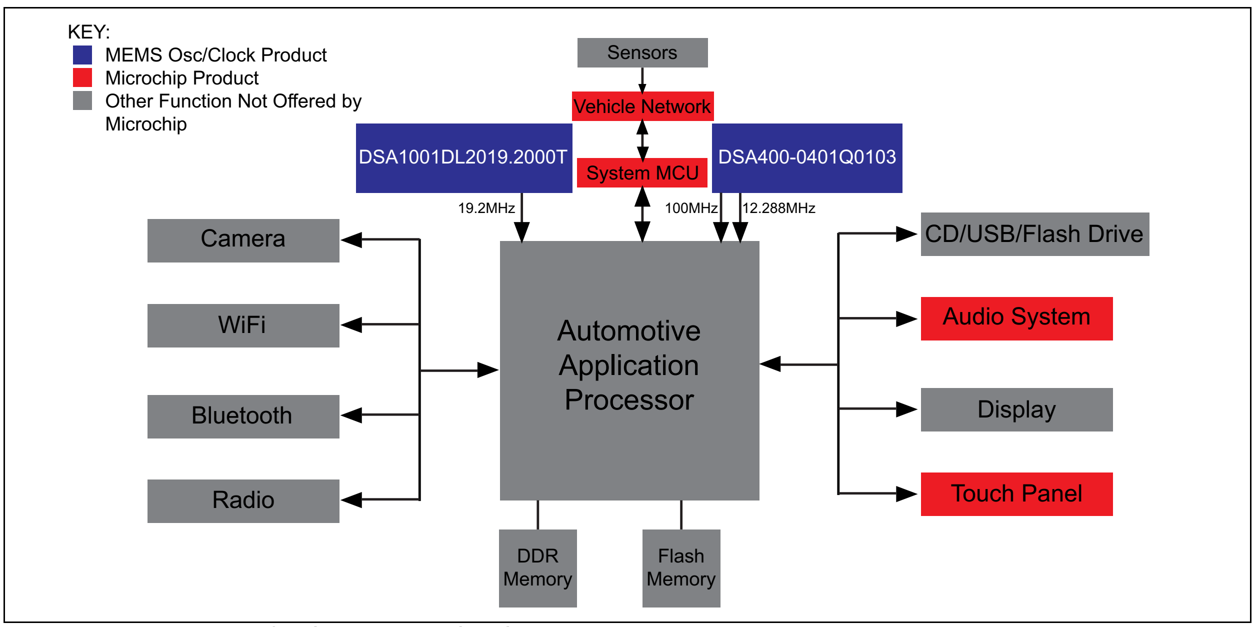

FIGURE 4: *Infotainment Head Unit.*

The DSA1001 is an AEC-Q100 qualified low power oscillator that's ideal for clocking microcontrollers and microprocessors. In this system, the two outputs of the DSA400 are used for audio processing (12.288 MHz) and PCIe communication (100 MHz) to flash memory. Two additional outputs are available for other peripherals.

Transmission Control Units

A Transmission Control Unit (TCU) is a system that controls the vehicle's automatic transmission. Input from multiple sensors is processed to optimally change gears, achieving improved engine emissions, fuel consumption, more stable handling, and gear shift system reliability.

Figure 4 shows the transmission control unit processing multiple sensor inputs (such as wheel speed and throttle position) via a 32-bit MCU. Output data is sent via amplifier drivers to solenoids that control the transmission, specifically shifting and torque converter lockup. Data is also exchanged with the In-Vehicle network for communication to other sensors and driver displays.

A DSA1104 is a MEMS-based single output HCSL clock, and is ideal for PCIe transactions from processor to memory. It is PCIe Gen1, 2, 3, and 4 qualified.

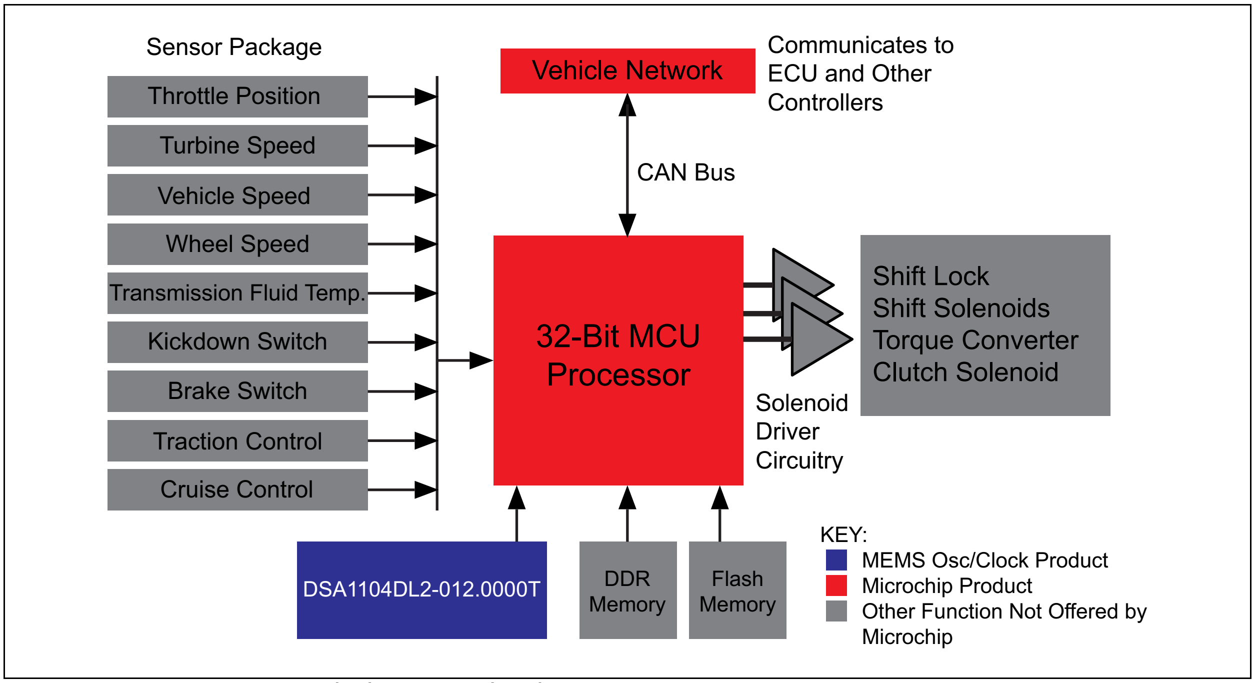

FIGURE 5: *Transmission Control Unit.*

BENEFITS OF A MEMS SOLUTION

Microchip's MEMS-based oscillators and clocks offer benefits over traditional quartz solutions. These include stable frequency, small size, high reliability, flexibility, many programmable features, fast guaranteed start-up and high integration. All of the MEMS-based oscillators and clocks are either AEC-Q100 certified or AEC-Q100 capable.

TABLE 1: BENEFITS OF MICROCHIP'S MEMS-BASED OSCILLATORS AND CLOCKS

Factor	Traditional Crystal Oscillator	Microchip MEMS-Based Oscillator	Features
Frequency Stability Over Temperature	Fair	Best	• MEMS offers ±10 ppm over a wide temperature range. • Microchip quartz achieves superior aging.
Size	Good	Best	• MEMS offers ultra-small footprints (1.6 mm x 1.2 mm). • Leads industry trend in size reduction.
Reliability	Fair	Best	• MEMS wafer-stage ultra-clean hermetic seal. • Microchip quartz separates crystal and ASIC enclosures.
Jitter Close-In Phase Noise	Good	Fair	• Microchip quartz is superior with reduced close-in phase noise. • MEMS and quartz comparable at high-frequency offsets.
Features	Worst	Best	• Selectable frequencies from one output. • OTP programmable at any frequency, anytime.
Start-Up	Fair	Best	• MEMS achieves fast start-up times (<2 ms). • Eliminates start-up issue of crystal-based designs.
Integration	Worst	Best	• Multiple outputs from a single device. • Uses highly integrated ASIC.

Key: Best > Good > Fair > Worst.

MEMS-BASED OSCILLATOR AND CLOCK PERFORMANCE

A comprehensive account of Microchip's MEMS technology and performance is presented in our MEMS white paper, with details at the end of this section. This Application Note explores frequency stability over temperature extremes (Grade 1, –40°C to +125°C) and with time (aging performance).

Frequency Stability

MEMS-based oscillators and clocks measure the die temperature and digitally compensate for any frequency variations that result from the temperature coefficient of the MEMS resonator. In this way, frequency stability is assured, in contrast to the traditional S-curve of a quartz XO. Figure 6 shows frequency deviations less than 10 ppm.

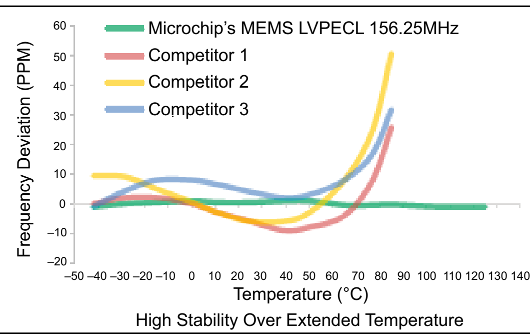

FIGURE 6: *Frequency Stability of a MEMS Oscillator vs. Quartz Options.*

Oscillator and Clock Aging

Figure 7 shows 1,000 hour accelerated aging (+85°C) of a sample of 16 DSA60xx devices. Frequency deviation is a maximum of 2.5 ppm; 1,000 hours aging at +85°C is equivalent to approximately 12 years' operation at room temperature (+25°C).

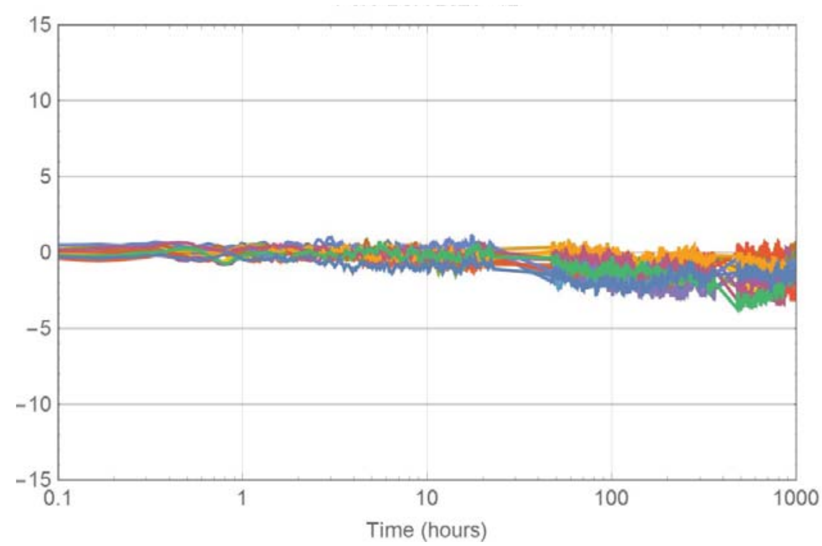

FIGURE 7: *Aging of Sixteen Units of the DSA60xx at +85°C.*

MEMS WHITE PAPER

For full details of the MEMS Oscillator and Clock technology and performance, please visit Microchip's MEMS Timing page at http://www.microchip.com/design-centers/clock-and-timing/mems-timing.

The MEMS white paper can also be found on that page.

CONCLUSION

Microchip's MEMS-based oscillators and clocks are an ideal match for automotive applications, on account of their high reliability, frequency stability and extended operating temperature range. The products are AEC-Q100 certified or AEC-Q100 capable.

Samples of our MEMS oscillators and clocks can be obtained via the ClockWorks tool: http://clockworks.microchip.com/Timing/.

In addition, MEMS-based product samples can be created at the customers' facility using our TimeFlash programmer: http://www.microchip.com/promo/timeflash.

ISBN: 978-1-5224-3098-8

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://www.microchip.com/support
Web Address:
www.microchip.com

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

Austin, TX
Tel: 512-257-3370

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

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

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

Detroit
Novi, MI
Tel: 248-848-4000

Houston, TX
Tel: 281-894-5983

Indianapolis
Noblesville, IN
Tel: 317-773-8323
Fax: 317-773-5453
Tel: 317-536-2380

Los Angeles
Mission Viejo, CA
Tel: 949-462-9523
Fax: 949-462-9608
Tel: 951-273-7800

Raleigh, NC
Tel: 919-844-7510

New York, NY
Tel: 631-435-6000

San Jose, CA
Tel: 408-735-9110
Tel: 408-436-4270

Canada - Toronto
Tel: 905-695-1980
Fax: 905-695-2078

ASIA/PACIFIC

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

China - Beijing
Tel: 86-10-8569-7000

China - Chengdu
Tel: 86-28-8665-5511

China - Chongqing
Tel: 86-23-8980-9588

China - Dongguan
Tel: 86-769-8702-9880

China - Guangzhou
Tel: 86-20-8755-8029

China - Hangzhou
Tel: 86-571-8792-8115

China - Hong Kong SAR
Tel: 852-2943-5100

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

China - Qingdao
Tel: 86-532-8502-7355

China - Shanghai
Tel: 86-21-3326-8000

China - Shenyang
Tel: 86-24-2334-2829

China - Shenzhen
Tel: 86-755-8864-2200

China - Suzhou
Tel: 86-186-6233-1526

China - Wuhan
Tel: 86-27-5980-5300

China - Xian
Tel: 86-29-8833-7252

China - Xiamen
Tel: 86-592-2388138

China - Zhuhai
Tel: 86-756-3210040

ASIA/PACIFIC

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

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

India - Pune
Tel: 91-20-4121-0141

Japan - Osaka
Tel: 81-6-6152-7160

Japan - Tokyo
Tel: 81-3-6880- 3770

Korea - Daegu
Tel: 82-53-744-4301

Korea - Seoul
Tel: 82-2-554-7200

Malaysia - Kuala Lumpur
Tel: 60-3-7651-7906

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

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

Singapore
Tel: 65-6334-8870

Taiwan - Hsin Chu
Tel: 886-3-577-8366

Taiwan - Kaohsiung
Tel: 886-7-213-7830

Taiwan - Taipei
Tel: 886-2-2508-8600

Thailand - Bangkok
Tel: 66-2-694-1351

Vietnam - Ho Chi Minh
Tel: 84-28-5448-2100

EUROPE

Austria - Wels
Tel: 43-7242-2244-39
Fax: 43-7242-2244-393

Denmark - Copenhagen
Tel: 45-4450-2828
Fax: 45-4485-2829

Finland - Espoo
Tel: 358-9-4520-820

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

Germany - Garching
Tel: 49-8931-9700

Germany - Haan
Tel: 49-2129-3766400

Germany - Heilbronn
Tel: 49-7131-67-3636

Germany - Karlsruhe
Tel: 49-721-625370

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

Germany - Rosenheim
Tel: 49-8031-354-560

Israel - Ra'anana
Tel: 972-9-744-7705

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

Italy - Padova
Tel: 39-049-7625286

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

Norway - Trondheim
Tel: 47-7289-7561

Poland - Warsaw
Tel: 48-22-3325737

Romania - Bucharest
Tel: 40-21-407-87-50

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

Sweden - Gothenberg
Tel: 46-31-704-60-40

Sweden - Stockholm
Tel: 46-8-5090-4654

UK - Wokingham
Tel: 44-118-921-5800
Fax: 44-118-921-5820