

---

## LAN9253 and LAN9254 Cable Diagnostics

---

<p><i>Author: Parthiv Pandya Microchip Technology Inc.</i></p>
--

### INTRODUCTION

The PHYs provide cable diagnostics that allow detection of open or shorted Ethernet cabling, as well as estimation of cable length to the open or short fault. The cable diagnostics consist of two primary modes of operation:

- Time Domain Reflectometry (TDR) Cable Diagnostics, which enable the detection of open or shorted cabling on the transmit (TX) or receive (RX) pair, as well as cable length estimation to the open or short fault
- Matched Cable Diagnostics, which enable cable length estimation on 100 Mbps-linked cables

This application note describes the cable diagnostics for the LAN9253 and LAN9254 devices.

### Sections

This document includes the following topics:

[Time Domain Reflectometry Cable Diagnostics on page 2](#)

[Matched Cable Diagnostics on page 4](#)

### References

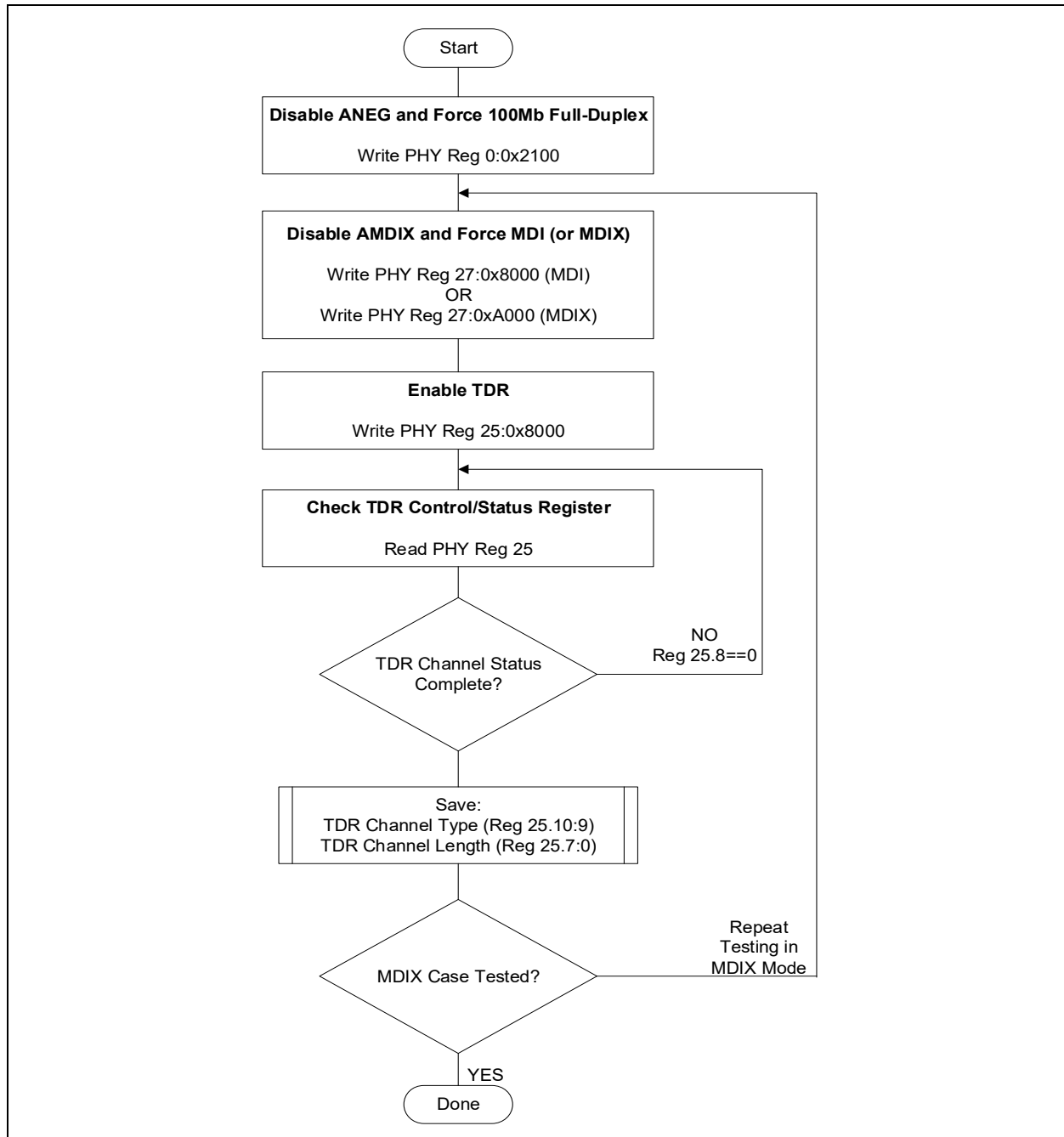
Consult the following documents for details on the specific parts referred to in this document.

- *LAN9253 Data Sheet* ([www.microchip.com/DS00003421](http://www.microchip.com/DS00003421))
- *LAN9254 Data Sheet* ([www.microchip.com/DS00003422](http://www.microchip.com/DS00003422))

## TIME DOMAIN REFLECTOMETRY CABLE DIAGNOSTICS

The PHYs provide TDR cable diagnostics that enable the detection of open or shorted cabling on the TX or RX pair, as well as cable length estimation to the open or short fault. To utilize the TDR cable diagnostics, Auto-MDIX and Auto Negotiation must be disabled, and the PHY must be forced to 100 Mbps Full-duplex mode. These actions must be performed before setting the TDR Enable bit in the PHY x TDR Control/Status Register (PHY\_TDR\_CONTROL\_STAT\_x). With Auto-MDIX disabled, the TDR will test the TX or RX pair selected by register bit 27.13 (Auto-MDIX state (AMDIX-STATE)). Proper cable testing should include a test of each pair. When TDR testing is complete, prior register settings may be restored. [Figure 1](#) provides a flow diagram of proper TDR usage.

**FIGURE 1: TDR USAGE FLOW DIAGRAM**



**Note:** The registers in [Figure 1](#) are defined in the device data sheet.

The TDR operates by transmitting pulses on the selected twisted pair within the Ethernet cable (TX in MDI mode, and RX in MDIX mode). If the pair being tested is open or shorted, the resulting impedance discontinuity results in a reflected signal that can be detected by the PHY. The PHY measures the time between the transmitted signal and received reflection, and indicates the results in the TDR Channel Length field of the PHY x TDR Control/Status Register (PHY\_TDR\_CONTROL\_STAT\_x). The TDR Channel Length field indicates the “electrical” length of the cable and can be multiplied by the appropriate propagation constant in [Table 1](#) to determine the approximate physical distance to the fault.

**Note:** The TDR function is typically used when the link is inoperable. However, an active link will drop when operating the TDR.

**TABLE 1: TDR PROPAGATION CONSTANTS**

TDR Propagation Constant	Cable Type			
	Unknown	CAT 6	CAT 5E	CAT 5
P <sub>OPEN</sub>	0.769	0.745	0.76	0.85
P <sub>SHORT</sub>	0.793	0.759	0.788	0.873

Since the TDR relies on the reflected signal of an improperly terminated cable, several factors can affect the accuracy of the physical length estimate, which include:

- **Cable Type (CAT 5, CAT5e, CAT6):** The electrical length of each cable type is slightly different due to the twists-per-meter of the internal signal pairs and differences in signal propagation speeds. If the cable type is known, the length estimate can be calculated more accurately by using the propagation constant appropriate for the cable type (see [Table 1](#)). In many real-world applications, the cable type is unknown or may be a mix of different cable types and lengths. In this case, use the propagation constant for the “Unknown” cable type (see [Table 1](#)).
- **TX and RX Pair:** For each cable type, the EIA standards specify different twist rates (twists-per-meter) for each signal pair within the Ethernet cable. This results in different measurements for the TX and RX pairs.
- **Actual Cable Length:** The difference between the estimated cable length and actual cable length grows as the physical cable length increases, with the most accurate results at less than approximately 100 meter.
- **Open/Short Case:** Open and shorted cases will return different TDR Channel Length values (electrical lengths) for the same physical distance to the fault. Compensation for this is achieved using different propagation constants to calculate the physical length of the cable.

For an open case, the estimated distance to the fault can be calculated as follows:

$$\text{Distance to Open fault in meters} \approx \text{TDR Channel Length} * P_{\text{OPEN}}$$

Where, P<sub>OPEN</sub> is the propagation constant selected from [Table 1](#)

For a shorted case, the estimated distance to the fault can be calculated as follows:

$$\text{Distance to Short fault in meters} \approx \text{TDR Channel Length} * P_{\text{SHORT}}$$

Where, P<sub>SHORT</sub> is the propagation constant selected from [Table 1](#)

The typical cable length measurement margin of error for Open and Shorted cases is dependent on system factors such as the selected cable type and the distance of the open/short from the device. It is also dependent on other factors such as connector selection and trace routing on the PCB. [Table 2](#) and [Table 3](#) detail the typical measurement error for Open and Shorted cases, respectively. These numbers are provided as a reference. The customer should always test the behavior with their specific system.

**TABLE 2: TYPICAL MEASUREMENT ERROR FOR OPEN CABLE (± METERS)**

Physical Distance to Fault	Selected Propagation Constant
	P <sub>OPEN</sub> = CAT 6
CAT 6 Cable, 10m	3
CAT 6 Cable, 50m	6
CAT 6 Cable, 100m	8
CAT 6 Cable, 140m	12

# AN3756

**TABLE 3: TYPICAL MEASUREMENT ERROR FOR SHORTED CABLE (± METERS)**

Physical Distance to Fault	Selected Propagation Constant
	P <sub>SHORT</sub> = CAT 6
CAT 6 Cable, 10m	1
CAT 6 Cable, 50m	5
CAT 6 Cable, 100m	7
CAT 6 Cable, 140m	11

## MATCHED CABLE DIAGNOSTICS

Matched cable diagnostics enable cable length estimation on 100 Mbps-linked cables of up to 120 meters. If there is an active 100 Mb link, the approximate distance to the link partner can be estimated using the PHY x Cable Length Register (PHY\_CABLE\_LEN\_x). If the cable is properly terminated, but there is no active 100 Mb link (for example, the link partner is disabled, non-functional, the link is at 10 Mb, and so on), the cable length cannot be estimated and the PHY x Cable Length Register (PHY\_CABLE\_LEN\_x) should be ignored. The estimated distance to the link partner can be determined via the Cable Length (CBLN) field of the PHY x Cable Length Register (PHY\_CABLE\_LEN\_x) using the lookup table provided in [Table 4](#). The typical cable length measurement margin of error for a matched cable case is ±20m. The matched cable length margin of error is consistent for all cable types from 0 to 120m.

**TABLE 4: MATCH CASE ESTIMATED CABLE LENGTH (CBLN) LOOKUP**

CBLN Field Value	Estimated Cable Length
0 to 3	0
4	6
5	17
6	27
7	38
8	49
9	59
10	70
11	81
12	91
13	102
14	113
15	123

**Note:** For a properly terminated cable (Match case), there is no reflected signal. In this case, the TDR Channel Length field is invalid and should be ignored.

## SUMMARY

This application note describes the two primary modes of cable diagnostics for LAN9253 and LAN9254 devices, and describes a way to locate a fault in the Ethernet cable in the EtherCAT system.

---

## APPENDIX A: APPLICATION NOTE REVISION HISTORY

TABLE A-1: REVISION HISTORY

Revision Level & Date	Section/Figure/Entry	Correction
DS00003756A (12-18-20)	Initial release	

## THE MICROCHIP WEB SITE

Microchip provides online support via our WWW site at [www.microchip.com](http://www.microchip.com). This web site is used as a means to make files and information easily available to customers. Accessible by using your favorite Internet browser, the web site contains the following information:

- **Product Support** – Data sheets and errata, application notes and sample programs, design resources, user's guides and hardware support documents, latest software releases and archived software
- **General Technical Support** – Frequently Asked Questions (FAQ), technical support requests, online discussion groups, Microchip consultant program member listing
- **Business of Microchip** – Product selector and ordering guides, latest Microchip press releases, listing of seminars and events, listings of Microchip sales offices, distributors and factory representatives

## CUSTOMER CHANGE NOTIFICATION SERVICE

Microchip's customer notification service helps keep customers current on Microchip products. Subscribers will receive e-mail notification whenever there are changes, updates, revisions or errata related to a specified product family or development tool of interest.

To register, access the Microchip web site at [www.microchip.com](http://www.microchip.com). Under "Support", click on "Customer Change Notification" and follow the registration instructions.

## CUSTOMER SUPPORT

Users of Microchip products can receive assistance through several channels:

- Distributor or Representative
- Local Sales Office
- Field Application Engineer (FAE)
- Technical Support

Customers should contact their distributor, representative or Field Application Engineer (FAE) for support. Local sales offices are also available to help customers. A listing of sales offices and locations is included in the back of this document.

**Technical support is available through the web site at: <http://microchip.com/support>**

---

**Note the following details of the code protection feature on Microchip devices:**

- Microchip products meet the specifications contained in their particular Microchip Data Sheet.
- Microchip believes that its family of products is secure when used in the intended manner and under normal conditions.
- There are dishonest and possibly illegal methods being used in attempts to breach the code protection features of the Microchip devices. We believe that these methods require using the Microchip products in a manner outside the operating specifications contained in Microchip's Data Sheets. Attempts to breach these code protection features, most likely, cannot be accomplished without violating Microchip's intellectual property rights.
- Microchip is willing to work with any customer who is concerned about the integrity of its code.
- Neither Microchip nor any other semiconductor manufacturer can guarantee the security of its code. Code protection does not mean that we are guaranteeing the product is "unbreakable." Code protection is constantly evolving. We at Microchip are committed to continuously improving the code protection features of our products. Attempts to break Microchip's code protection feature may be a violation of the Digital Millennium Copyright Act. If such acts allow unauthorized access to your software or other copyrighted work, you may have a right to sue for relief under that Act.

---

Information contained in this publication is provided for the sole purpose of designing with and using Microchip products. Information regarding device applications and the like is provided only for your convenience and may be superseded by updates. It is your responsibility to ensure that your application meets with your specifications.

THIS INFORMATION IS PROVIDED BY MICROCHIP "AS IS". MICROCHIP MAKES NO REPRESENTATIONS OR WARRANTIES OF ANY KIND WHETHER EXPRESS OR IMPLIED, WRITTEN OR ORAL, STATUTORY OR OTHERWISE, RELATED TO THE INFORMATION INCLUDING BUT NOT LIMITED TO ANY IMPLIED WARRANTIES OF NON-INFRINGEMENT, MERCHANTABILITY, AND FITNESS FOR A PARTICULAR PURPOSE OR WARRANTIES RELATED TO ITS CONDITION, QUALITY, OR PERFORMANCE.

IN NO EVENT WILL MICROCHIP BE LIABLE FOR ANY INDIRECT, SPECIAL, PUNITIVE, INCIDENTAL OR CONSEQUENTIAL LOSS, DAMAGE, COST OR EXPENSE OF ANY KIND WHATSOEVER RELATED TO THE INFORMATION OR ITS USE, HOWEVER CAUSED, EVEN IF MICROCHIP HAS BEEN ADVISED OF THE POSSIBILITY OR THE DAMAGES ARE FORESEEABLE. TO THE FULLEST EXTENT ALLOWED BY LAW, MICROCHIP'S TOTAL LIABILITY ON ALL CLAIMS IN ANY WAY RELATED TO THE INFORMATION OR ITS USE WILL NOT EXCEED THE AMOUNT OF FEES, IF ANY, THAT YOU HAVE PAID DIRECTLY TO MICROCHIP FOR THE INFORMATION. Use of Microchip devices in life support and/or safety applications is entirely at the buyer's risk, and the buyer agrees to defend, indemnify and hold harmless Microchip from any and all damages, claims, suits, or expenses resulting from such use. No licenses are conveyed, implicitly or otherwise, under any Microchip intellectual property rights unless otherwise stated.

#### **Trademarks**

The Microchip name and logo, the Microchip logo, Adaptec, AnyRate, AVR, AVR logo, AVR Freaks, BesTime, BitCloud, chipKIT, chipKIT logo, CryptoMemory, CryptoRF, dsPIC, FlashFlex, flexPWR, HELDO, IGLOO, JukeBlox, KeeLoq, Klear, LANCheck, LinkMD, maXStylus, maXTouch, MediaLB, megaAVR, Microsemi, Microsemi logo, MOST, MOST logo, MPLAB, OptoLyzer, PackeTime, PIC, picoPower, PICSTART, PIC32 logo, PolarFire, Prochip Designer, QTouch, SAM-BA, SenGenuity, SpyNIC, SST, SST Logo, SuperFlash, Symmetricom, SyncServer, Tachyon, TimeSource, tinyAVR, UNI/O, Vectron, and XMEGA are registered trademarks of Microchip Technology Incorporated in the U.S.A. and other countries.

AgileSwitch, APT, ClockWorks, The Embedded Control Solutions Company, EtherSynch, FlashTec, Hyper Speed Control, HyperLight Load, IntelliMOS, Libero, motorBench, mTouch, Powermite 3, Precision Edge, ProASIC, ProASIC Plus, ProASIC Plus logo, Quiet-Wire, SmartFusion, SyncWorld, Temux, TimeCesium, TimeHub, TimePictra, TimeProvider, WinPath, and ZL are registered trademarks of Microchip Technology Incorporated in the U.S.A.

Adjacent Key Suppression, AKS, Analog-for-the-Digital Age, Any Capacitor, AnyIn, AnyOut, Augmented Switching, BlueSky, BodyCom, CodeGuard, CryptoAuthentication, CryptoAutomotive, CryptoCompanion, CryptoController, dsPICDEM, dsPICDEM.net, Dynamic Average Matching, DAM, ECAN, Espresso T1S, EtherGREEN, IdealBridge, In-Circuit Serial Programming, ICSP, INICnet, Intelligent Paralleling, Inter-Chip Connectivity, JitterBlocker, maxCrypto, maxView, memBrain, Mindi, MiWi, MPASM, MPF, MPLAB Certified logo, MPLIB, MPLINK, MultiTRAK, NetDetach, Omniscent Code Generation, PICDEM, PICDEM.net, PICkit, PICtail, PowerSmart, PureSilicon, QMatrix, REAL ICE, Ripple Blocker, RTAX, RTG4, SAM-ICE, Serial Quad I/O, simpleMAP, SimpliPHY, SmartBuffer, SMART-I.S., storClad, SQL, SuperSwitcher, SuperSwitcher II, Switchtec, SynchroPHY, Total Endurance, TSHARC, USBCheck, VariSense, VectorBlox, VeriPHY, ViewSpan, WiperLock, XpressConnect, and ZENA are trademarks of Microchip Technology Incorporated in the U.S.A. and other countries.

SQTP is a service mark of Microchip Technology Incorporated in the U.S.A.

The Adaptec logo, Frequency on Demand, Silicon Storage Technology, and Symmcom are registered trademarks of Microchip Technology Inc. in other countries.

GestIC is a registered trademark of Microchip Technology Germany II GmbH & Co. KG, a subsidiary of Microchip Technology Inc., in other countries.

All other trademarks mentioned herein are property of their respective companies.

© 2020, Microchip Technology Incorporated, All Rights Reserved.

ISBN: 978-1-5224-7387-9

For information regarding Microchip's Quality Management Systems, please visit [www.microchip.com/quality](http://www.microchip.com/quality).



# MICROCHIP

## 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](http://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: 45-4485-5910  
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: 49-7131-72400

**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: 47-7288-4388

**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