

3.3V, 3.2 Gbps CML Limiting Post Amplifier with High Gain TTL Loss-of-Signal

Features

- Single 3.3V Power Supply
- DC to 3.2 Gbps Operation
- Low-Noise CML Data Outputs
- High Gain LOS
- Chatter-Free Open-Collector TTL Loss-of-Signal (LOS) Output with Internal 4.75 kΩ Pull-Up Resistor
- TTL /EN Input
- Programmable LOS Level Set (LOS_{LVL})
- Ideal for Multi-Rate Applications
- Available in a 16-Lead VQFN Package

Applications

- APON, BPON, EPON, and GPON
- Gigabit Ethernet
- Fibre Channel
- OC-3 and OC-12/24 SONET/SDH
- High-Gain Line Driver and Line Receiver

Markets

- FTTP
- Optical Transceivers
- Datacom/Telecom
- Low-Gain TIA Interface
- Long-Reach FOM

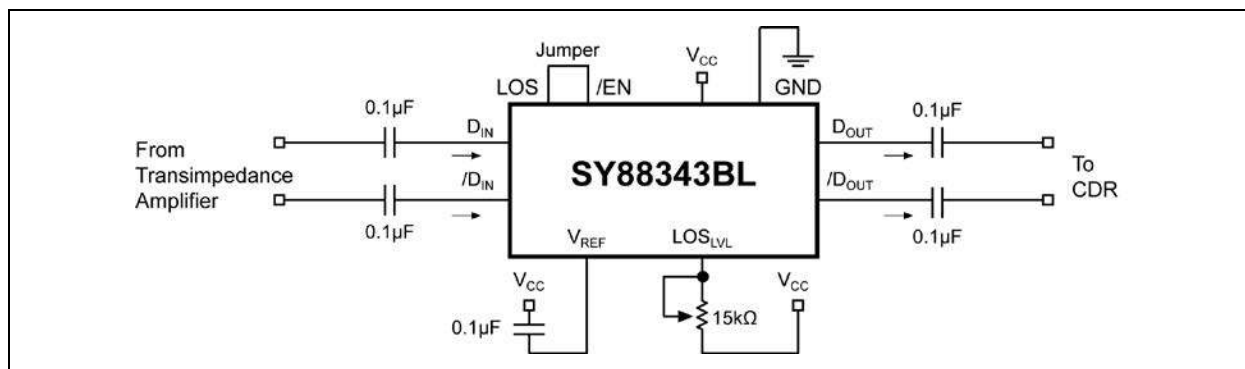
General Description

The SY88343BL low-power limiting post amplifier is designed for use in fiber-optic receivers. The device connects to typical transimpedance amplifiers (TIAs) that are AC-coupled. The linear signal output from TIAs can contain significant amounts of noise and may vary in amplitude over time. The SY88343BL quantizes these signals and outputs CML-level waveforms.

The SY88343BL operates from a single +3.3V power supply, over temperatures ranging from -40°C to $+85^{\circ}\text{C}$. With its wide bandwidth and high gain, signals with data rates up to 3.2 Gbps and as small as 5 mV_{PP} can be amplified to drive devices with CML inputs or AC-coupled CML/PECL inputs.

The SY88343BL generates a high-gain loss-of-signal (LOS) open-collector TTL output. The LOS function has a high gain input stage for increased sensitivity. A programmable loss-of-signal level set pin (LOS_{LVL}) sets the sensitivity of the input amplitude detection. LOS asserts high if the input amplitude falls below the threshold set by LOS_{LVL} and de-asserts low otherwise. The enable bar input (/EN) de-asserts the true output signal without removing the input signal. The LOS output can be fed back to the /EN input to maintain output stability under a loss-of-signal condition. Typically, 3.5 dB LOS hysteresis is provided to prevent chattering.

Typical Application Circuit



SY88343BL

1.0 ELECTRICAL CHARACTERISTICS

Absolute Maximum Ratings †

Supply Voltage (V_{CC})	0V to +7.0V
input Voltage (DIN, /DIN)	0V to V_{CC}
Output Current (I_{OUT})	
Continuous	±50 mA
Surge	±100 mA
/EN Voltage	0V to V_{CC}
V_{REF} Current	-800 μ A to +500 μ A
LO _{LVL} Voltage	V_{REF} to V_{CC}

Operating Ratings ‡

Supply Voltage (V_{CC})	+3.0V to +3.6V
-----------------------------	----------------

† **Notice:** Stresses above those listed under “Absolute Maximum Ratings” may cause permanent damage to the device. This is a stress rating only and functional operation of the device at those or any other conditions above those indicated in the operational sections of this specification is not intended. Exposure to maximum rating conditions for extended periods may affect device reliability.

‡ **Notice:** The device is not guaranteed to function outside its operating ratings.

Note 1: Devices are ESD sensitive. Handling precautions recommended.

DC ELECTRICAL CHARACTERISTICS

Electrical Characteristics: $V_{CC} = 3.0V$ to $3.6V$; $R_L = 50\Omega$ to V_{CC} ; $T_A = -40^\circ C$ to $+85^\circ C$; typical values at $V_{CC} = 3.3V$, $T_A = +25^\circ C$.

Parameter	Symbol	Min.	Typ.	Max.	Units	Conditions
Power Supply Current	I_{CC}	—	45	62	mA	No output load
LO _{LVL} Voltage	V_{LOSLVL}	V_{REF}	—	V_{CC}	V	—
CML Output HIGH Voltage	V_{OH}	$V_{CC} - 0.020$	$V_{CC} - 0.005$	V_{CC}	V	—
CML Output LOW Voltage	V_{OL}	$V_{CC} - 0.475$	$V_{CC} - 0.4$	$V_{CC} - 0.350$	V	—
Differential Output Offset	V_{OFFSET}	—	—	±80	mV	—
Reference Voltage	V_{REF}	$V_{CC} - 1.48$	$V_{CC} - 1.32$	$V_{CC} - 1.16$	V	—
Input Common Mode Range	V_{IHCMR}	GND + 2.0	—	V_{CC}	V	—
Single-Ended Output Impedance	Z_O	40	50	60	Ω	—
Single-Ended Input Impedance	Z_I	40	50	60	Ω	—

TTL DC ELECTRICAL CHARACTERISTICS

Electrical Characteristics: $V_{CC} = 3.0V$ to $3.6V$; $T_A = -40^\circ C$ to $+85^\circ C$.

Parameter	Symbol	Min.	Typ.	Max.	Units	Conditions
/EN Input HIGH Voltage	V_{IH}	2.0	—	—	V	—
/EN Input LOW Voltage	V_{IL}	—	—	0.8	V	—
/EN Input HIGH Current	I_{IH}	—	—	20	μ A	$V_{IN} = 2.7V$
		—	—	100	μ A	$V_{IN} = V_{CC}$
/EN Input LOW Current	I_{IL}	-0.3	—	—	mA	$V_{IN} = 0.5V$
LOS Output HIGH Level	V_{OH}	2.4	—	—	V	$V_{CC} \geq 3.3V$, $I_{OH-MAX} < 160 \mu A$
		2.0	—	—	V	$V_{CC} < 3.3V$, $I_{OH-MAX} < 160 \mu A$
LOS Output LOW Level	V_{OL}	—	—	0.5	V	$I_{OL} = +2 mA$

AC ELECTRICAL CHARACTERISTICS

Electrical Characteristics: $V_{CC} = 3.0V$ to $3.6V$; $T_A = -40^{\circ}C$ to $+85^{\circ}C$.

Parameter	Symbol	Min.	Typ.	Max.	Units	Conditions
Output Rise/Fall Time (20% to 80%)	t_r/t_f	—	60	120	ps	Note 1
Deterministic Jitter	t_{JITTER}	—	15	—	ps _{PP}	Note 2
Random Jitter		—	5	—	ps _{RMS}	Note 3
Differential Input Voltage Swing	V_{ID}	5	—	1800	mV _{PP}	Figure 4-2
Differential Output Voltage Swing	V_{OD}	700	800	950	mV _{PP}	$V_{ID} \geq 12$ mV _{PP} , Figure 4-2
LOS Release Time	t_{OFF}	—	2	10	μs	—
LOS Assert Time	t_{ON}	—	2	10	μs	—
Low LOS De-assert Level	LOS_{DL}	—	4.8	—	mV _{PP}	$R_{LOSLVL} = 15$ k Ω , Note 5
Low LOS Assert Level	LOS_{AL}	—	3.1	—	mV _{PP}	$R_{LOSLVL} = 15$ k Ω , Note 5
Low LOS Hysteresis	HYS_L	—	3.8	—	dB	$R_{LOSLVL} = 15$ k Ω , Note 4
Medium LOS De-assert Level	LOS_{DM}	—	7.5	11	mV _{PP}	$R_{LOSLVL} = 5$ k Ω , Note 5
Medium LOS Assert Level	LOS_{AM}	3	5.2	—	mV _{PP}	$R_{LOSLVL} = 5$ k Ω , Note 5
LOS Hysteresis	HYS_M	2	3.2	4.5	dB	$R_{LOSLVL} = 5$ k Ω , Note 4
High LOS De-assert Level	LOS_{DH}	—	18	23	mV _{PP}	$R_{LOSLVL} = 100\Omega$, Note 5
High LOS Assert Level	LOS_{AH}	8	12	—	mV _{PP}	$R_{LOSLVL} = 100\Omega$, Note 5
High LOS Hysteresis	HYS_H	2	3.5	4.5	dB	$R_{LOSLVL} = 100\Omega$, Note 4
3 dB Bandwidth	B_{-3dB}	—	2	—	GHz	—
Differential Voltage Gain	$A_{V(DIFF)}$	32	38	—	dB	—
Single-Ended Small-Signal Gain	S_{21}	26	32	—	dB	—

- Note 1:** Amplifier in limiting mode. Input is a 200 MHz square wave.
- 2:** Deterministic jitter measured using 3.2 Gbps K28.5 pattern, $V_{ID} = 10$ mV_{PP}.
- 3:** Random jitter measured using 3.2 Gbps K28.7 pattern, $V_{ID} = 10$ mV_{PP}.
- 4:** This specification defines electrical hysteresis as $20\log$ (LOS De-assert/LOS Assert). The ratio between optical hysteresis and electrical hysteresis is found to vary between 1.5 and 2, depending upon the level of received optical power and ROSA characteristics. Based upon that ratio, the optical hysteresis corresponding to the electrical hysteresis range 2 dB to 4.5 dB, shown in the AC characteristics table, will be 1 dB to 3 dB Optical Hysteresis.
- 5:** See Figure 2-1 for a graph showing how to choose a particular R_{LOSLVL} for a particular LOS assert and its associated de-assert amplitude.

SY88343BL

TEMPERATURE SPECIFICATIONS (Note 1)

Parameters	Sym.	Min.	Typ.	Max.	Units	Conditions
Temperature Ranges						
Ambient Temperature	T_A	-40	—	+85	°C	—
Lead Temperature	—	—	—	+260	°C	Soldering, 10 sec.
Storage Temperature	T_S	-65	—	+150	°C	—
Package Thermal Resistance						
Thermal Resistance, VQFN 16-Ld, Note 2	θ_{JA}	—	61	—	°C/W	—
	ψ_{JB}	—	38	—	°C/W	—

- Note 1:** The maximum allowable power dissipation is a function of ambient temperature, the maximum allowable junction temperature and the thermal resistance from junction to air (i.e., T_A , T_J , θ_{JA}). Exceeding the maximum allowable power dissipation will cause the device operating junction temperature to exceed the maximum +85°C rating. Sustained junction temperatures above +85°C can impact the device reliability.
- 2:** Thermal performance assumes the use of a 4-layer PCB. Exposed pad must be soldered (or equivalent) to the device's most negative potential on the PCB.

2.0 TYPICAL PERFORMANCE CURVES

Note: The graphs and tables provided following this note are a statistical summary based on a limited number of samples and are provided for informational purposes only. The performance characteristics listed herein are not tested or guaranteed. In some graphs or tables, the data presented may be outside the specified operating range (e.g., outside specified power supply range) and therefore outside the warranted range.

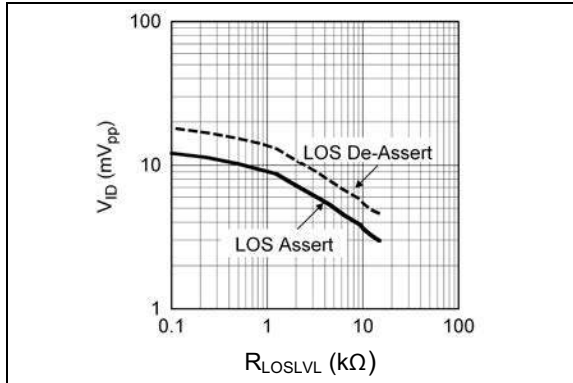


FIGURE 2-1: V_{ID} to Assert/De-Assert LOS vs. R_{LOSLVL} .

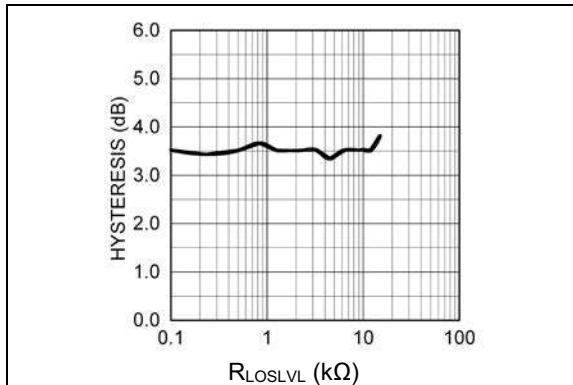
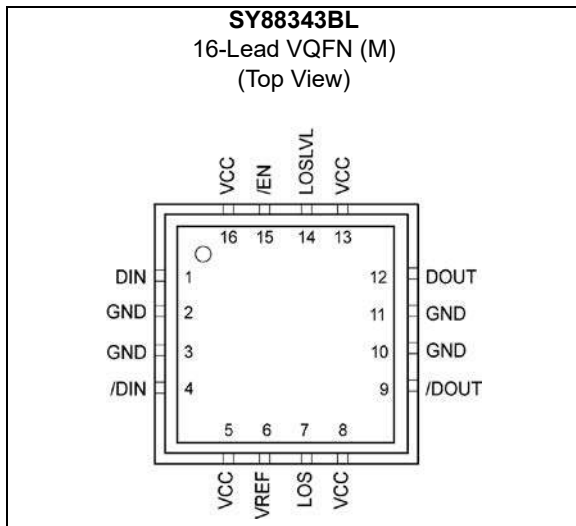


FIGURE 2-2: LOS Hysteresis vs. R_{LOSLVL} .

SY88343BL

3.0 PIN DESCRIPTIONS

Package Type



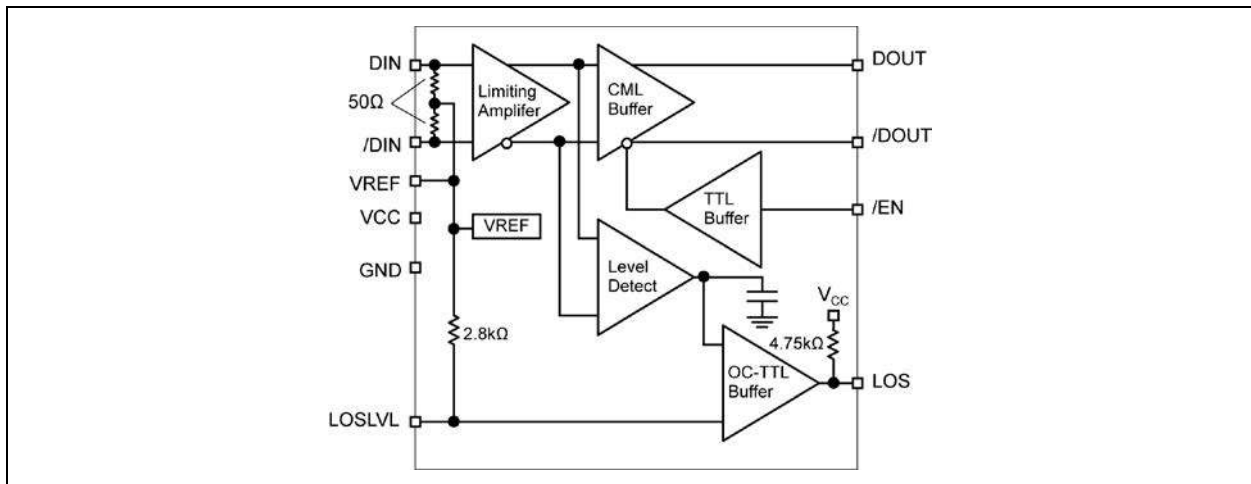
The descriptions of the pins are listed in [Table 3-1](#).

TABLE 3-1: PIN FUNCTION TABLE

Pin Number	Pin Name	Type	Description
15	/EN	TTL Input: Default is high	/Enable: This input enables the outputs when it is LOW. Note that this input is internally connected to a 25 kΩ pull-up resistor and will default to logic HIGH state if left open.
1	DIN	Data Input	True data input.
4	/DIN	Data Input	Complementary data input.
6	VREF	—	Reference Voltage: Bypass with 0.01 μF low ESR capacitor from VREF to VCC to stabilize LOS _{LVL} and V _{REF} .
14	LOSLVL	Input	Loss-of-Signal Level Set: A resistor from this pin to V _{CC} sets the threshold for the data input amplitude at which the LOS output will be asserted.
2, 3, 10, 11	GND, Exposed Pad	Ground	Device ground. Exposed pad must be connected to PCB ground plane.
7	LOS	Open Collector TTL Output with internal 4.75 kΩ pull-down resistor	Loss-of-Signal: Asserts high when the data input amplitude falls below the threshold set by LOS _{LVL} .
9	/DOUT	CML Output	Complementary data output.
12	DOUT	CML Output	True data output.
5, 8, 13, 16	VCC	Power Supply	Positive power supply.

4.0 FUNCTIONAL DESCRIPTION

Functional Block Diagram



The SY88343BL low-power limiting post amplifier operates from a single +3.3V power supply, over temperatures from -40°C to $+85^{\circ}\text{C}$. Signals with data rates up to 3.2 Gbps and as small as 5 mV_{PP} can be amplified. Figure 4-1 shows the allowed input voltage swing. The SY88343BL generates a LOS output allowing feedback to /EN for output stability. LOSLVL sets the sensitivity of the input amplitude detection.

4.1 Input Amplifier Buffer

Figure 4-2 shows a simplified schematic of the input stage. The high-sensitivity of the input amplifier allows signals as small as 5 mV_{PP} to be detected and amplified. The input amplifier also allows input signals as large as $1800\text{ mV}_{\text{PP}}$. Input signals are linearly amplified with a typical 38 dB differential voltage gain. Because it is a limiting amplifier, this device outputs typically $800\text{ mV}_{\text{PP}}$ voltage-limited waveforms for input signals greater than 12 mV_{PP} . Applications that require the SY88343BL to operate with high gain should have the upstream TIA placed as close as possible to the device's input pins. This ensures the best performance of the device.

4.2 Output Buffer

The SY88343BL's CML output buffer is designed to drive 50Ω lines. The output buffer requires appropriate termination for proper operation. An external 50Ω resistor to V_{CC} for each output pin provides this. Figure 4-4 shows a simplified schematic of the output stage.

4.3 Loss-of-Signal

The SY88343BL generates a chatter-free LOS open-collector TTL output with an internal $4.75\text{ k}\Omega$ pull-up resistor, as shown in Figure 4-3. LOS is used to determine that the input amplitude is large enough to be considered a valid input. LOS asserts high if the input amplitude falls below the threshold sets by LOSLVL and de-asserts low otherwise. LOS can be fed back to the enable bar (/EN) input to maintain output stability under a loss-of-signal condition. /EN de-asserts the true output signal without removing the input signals. Typical, 3.5 dB LOS hysteresis is provided to prevent chattering.

4.4 Loss-of-Signal Level Set

Programmable LOS level-set pin (LOSLVL) sets the threshold of the input amplitude detection. Connecting an external resistor between V_{CC} and LOSLVL sets the voltage at LOSLVL . This voltage ranges from V_{CC} to V_{REF} . The external resistor creates a voltage divider between V_{CC} and V_{REF} , as shown in Figure 4-5.

4.5 Hysteresis

The SY88343BL provides typically 3.5 dB LOS electrical hysteresis. By definition, a power ratio measured in dB is $10\log(\text{power ratio})$. Power is calculated as V_{IN}^2/R for an electrical signal. Hence, the same ratio can be stated as 20log (voltage ratio). While in linear mode, the electrical voltage input changes linearly with the optical power and therefore, the ratios change linearly. Thus, the optical hysteresis in dB is half the electrical hysteresis in dB given in the data sheet. Because the SY88343BL is an electrical device, this data sheet refers to hysteresis in electrical terms. With 3.5 dB LOS hysteresis, a voltage factor of 1.5 is required to assert or de-assert LOS.

SY88343BL

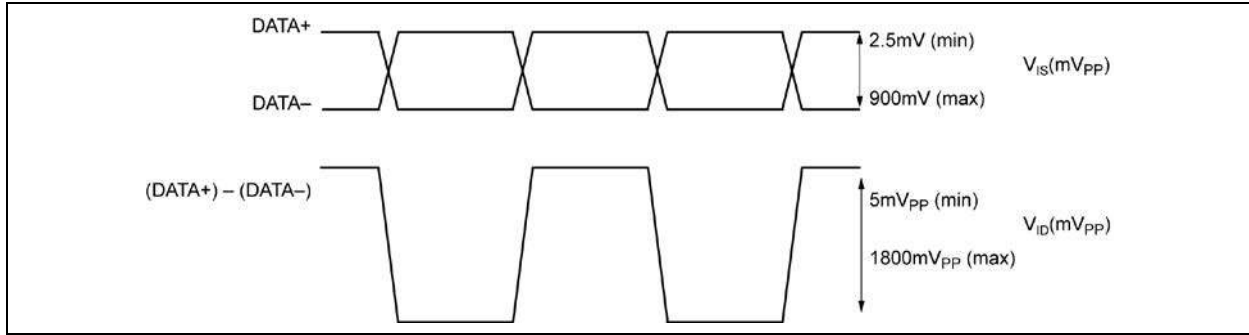


FIGURE 4-1: V_{IS} and V_{ID} .

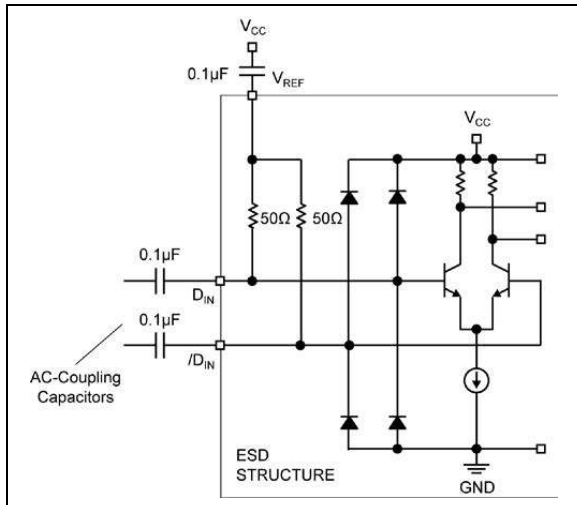


FIGURE 4-2: Input Structure.

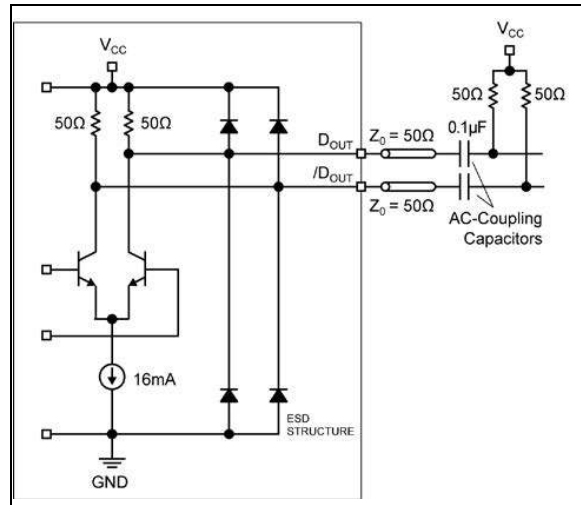


FIGURE 4-4: Output Structure.

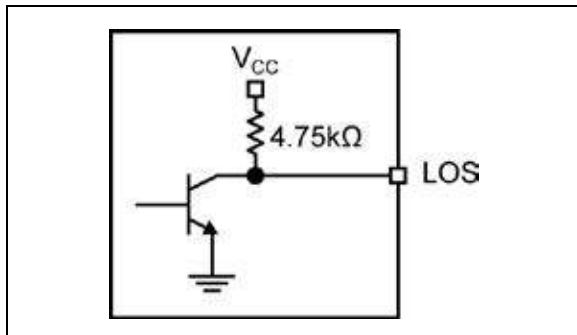


FIGURE 4-3: LOS Output Structure.

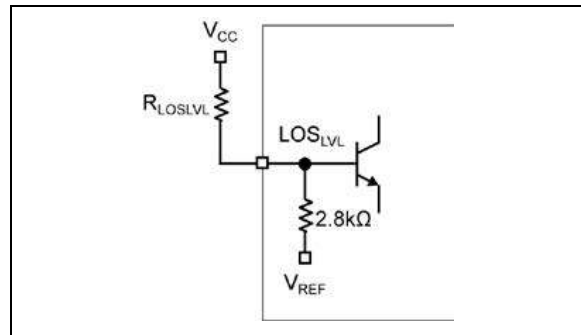
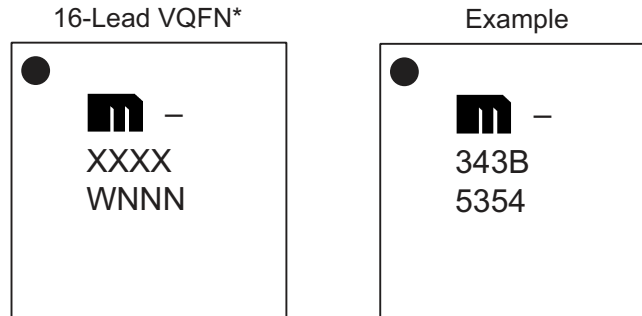


FIGURE 4-5: LOS_{LVL} Setting Circuit.

5.0 PACKAGING INFORMATION

5.1 Package Marking Information



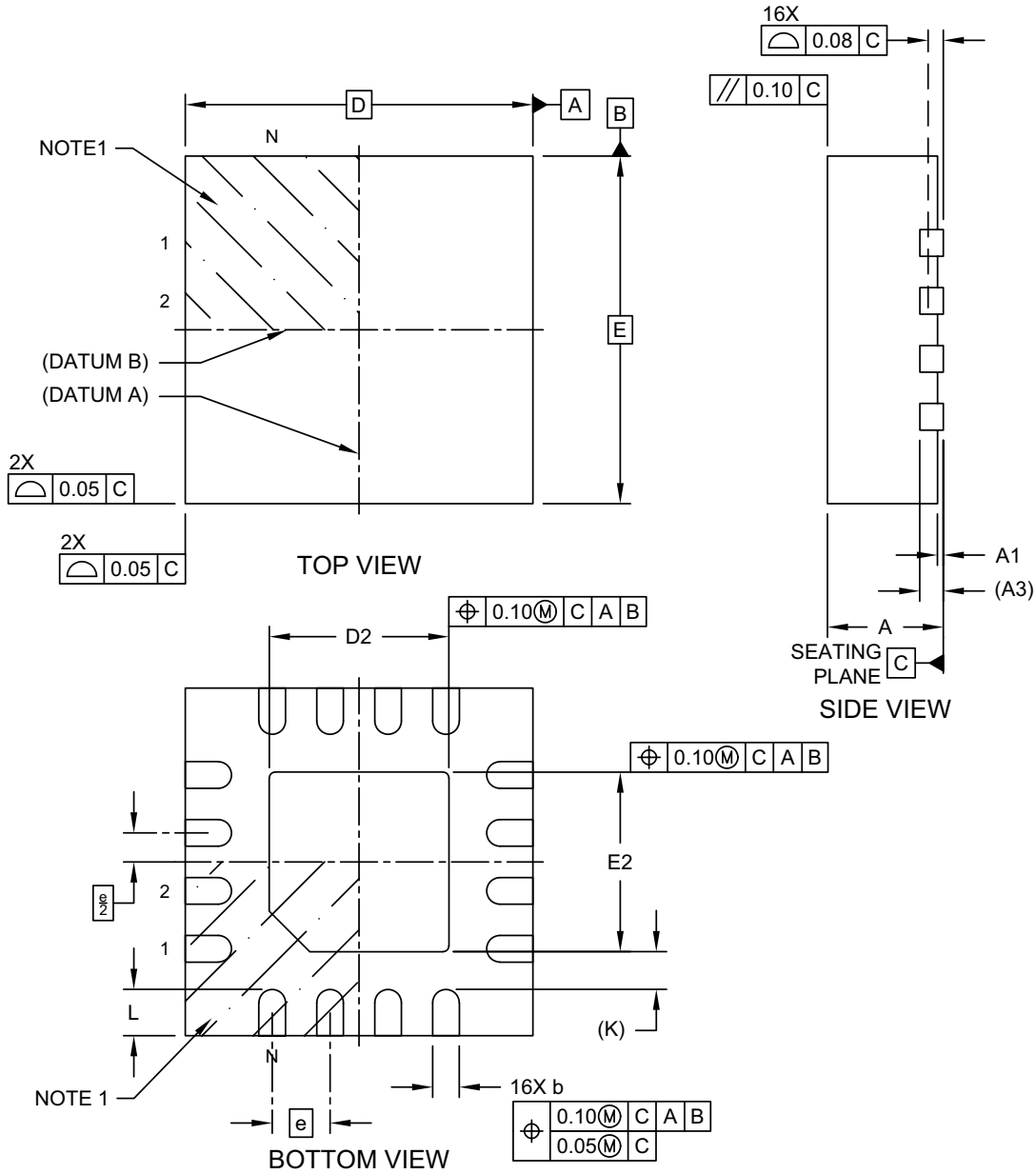
Legend:	XX...X	Product code or customer-specific information
	Y	Year code (last digit of calendar year)
	YY	Year code (last 2 digits of calendar year)
	WW	Week code (week of January 1 is week '01')
	NNN	Alphanumeric traceability code
	(e3)	Pb-free JEDEC® designator for Matte Tin (Sn)
	*	This package is Pb-free. The Pb-free JEDEC designator ((e3)) can be found on the outer packaging for this package.
	•, ▲, ▼	Pin one index is identified by a dot, delta up, or delta down (triangle mark).
Note:	In the event the full Microchip part number cannot be marked on one line, it will be carried over to the next line, thus limiting the number of available characters for customer-specific information. Package may or may not include the corporate logo.	
	Underbar () and/or Overbar () symbol may not be to scale.	

SY88343BL

16-Lead VQFN Package Outline and Recommended Land Pattern

16-Lead Very Thin Plastic Quad Flat, No Lead Package (NCA) - 3x3x1.0 mm Body [VQFN] With 1.55 mm Exposed Pad

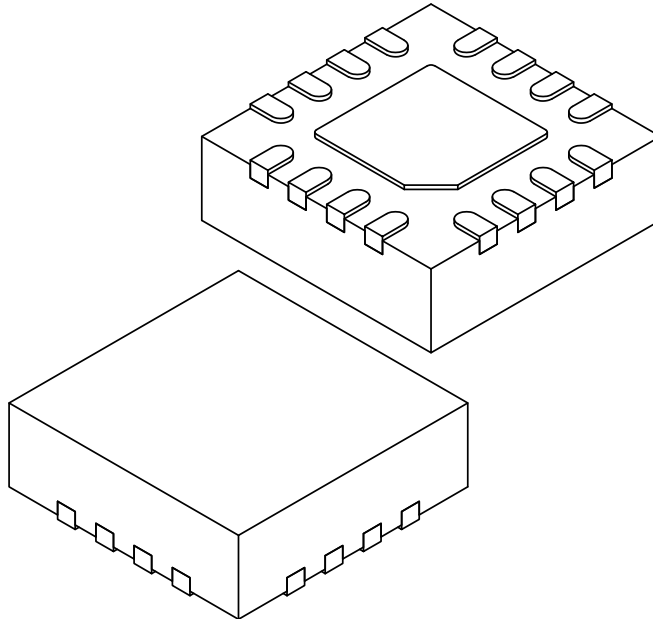
Note: For the most current package drawings, please see the Microchip Packaging Specification located at <http://www.microchip.com/packaging>



Microchip Technology Drawing C04-1103-NCA Rev B Sheet 1 of 2

16-Lead Very Thin Plastic Quad Flat, No Lead Package (NCA) - 3x3x1.0 mm Body [VQFN] With 1.55 mm Exposed Pad

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 Terminals	N		16		
Pitch	e		0.50 BSC		
Overall Height	A		0.80	0.90	1.00
Standoff	A1		0.00	0.02	0.05
Terminal Thickness	A3		0.203 REF		
Overall Length	D		3.00 BSC		
Exposed Pad Length	D2		1.50	1.55	1.60
Overall Width	E		3.00 BSC		
Exposed Pad Width	E2		1.50	1.55	1.60
Terminal Width	b		0.18	0.23	0.28
Terminal Length	L		0.35	0.40	0.45
Terminal-to-Exposed-Pad	K		0.33 REF		

Notes:

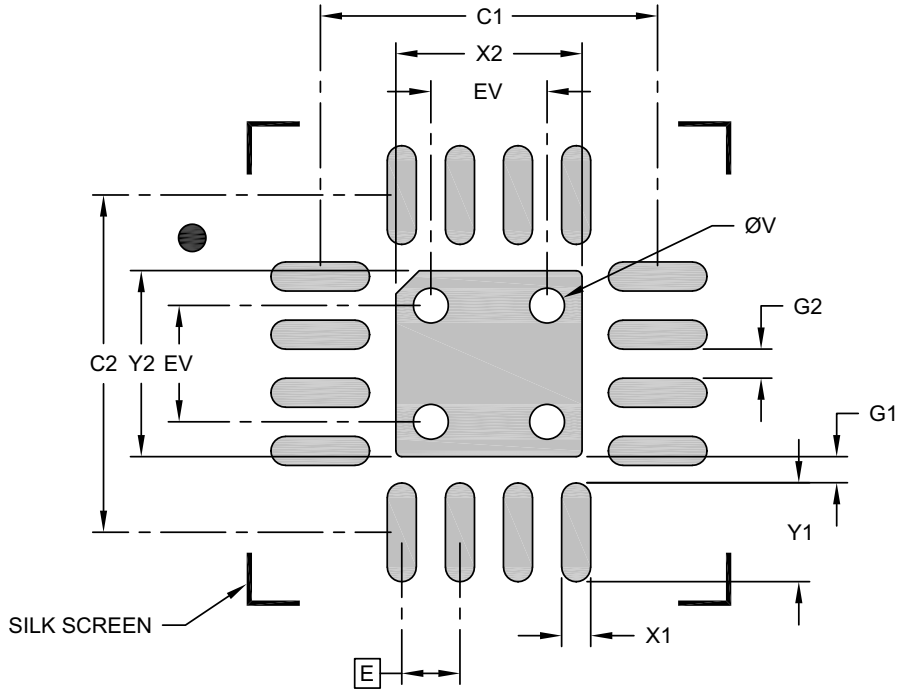
- Pin 1 visual index feature may vary, but must be located within the hatched area.
- Package is saw singulated
- Dimensioning and tolerancing per ASME Y14.5M
 BSC: Basic Dimension. Theoretically exact value shown without tolerances.
 REF: Reference Dimension, usually without tolerance, for information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

Microchip Technology Drawing C04-1103-NCA Rev B Sheet 2 of 2

SY88343BL

16-Lead Very Thin Plastic Quad Flat, No Lead Package (NCA) - 3x3x1.0 mm Body [VQFN] With 1.55 mm Exposed Pad

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



RECOMMENDED LAND PATTERN

Dimension Limits	Units	MILLIMETERS		
		MIN	NOM	MAX
Contact Pitch	E	0.50 BSC		
Center Pad Width	X2			1.60
Center Pad Length	Y2			1.60
Contact Pad Spacing	C1		2.90	
Contact Pad Spacing	C2		2.90	
Contact Pad Width (Xnn)	X1			0.25
Contact Pad Length (Xnn)	Y1			0.85
Contact Pad to Center Pad (Xnn)	G1	0.23		
Contact Pad to Contact Pad (Xnn)	G2	0.25		
Thermal Via Diameter	V		0.30	
Thermal Via Pitch	EV		1.00	

Notes:

1. Dimensioning and tolerancing per ASME Y14.5M
BSC: Basic Dimension. Theoretically exact value shown without tolerances.
2. For best soldering results, thermal vias, if used, should be filled or tented to avoid solder loss during reflow process

Microchip Technology Drawing C04-3103-NCA Rev B

APPENDIX A: REVISION HISTORY

Revision A (November 2021)

- Converted Micrel document SY88343BL to Microchip data sheet DS20006622A.
- Minor text changes throughout.

SY88343BL

NOTES:

PRODUCT IDENTIFICATION SYSTEM

To order or obtain information, e.g., on pricing or delivery, contact your local Microchip representative or sales office.

<u>PART No.</u>	<u>X</u>	<u>X</u>	<u>X</u>	<u>-XX</u>	Examples:
Device	Supply Voltage	Package	Temperature Range	Media Type	
Device:	SY88343B:	3.2 Gbps CML Limiting Post Amplifier with High Gain TTL Loss-of-Signal			a) SY88343BLMG: SY88343B, 3.3V Supply Voltage, 16-Lead 3x3 VQFN, -40°C to +85°C Temp. Range, 100/Tube
Supply Voltage:	L	=	3.3V		b) SY88343BLMG-TR: SY88343B, 3.3V Supply Voltage, 16-Lead 3x3 VQFN, -40°C to +85°C Temp. Range, 1,000/Reel
Package:	M	=	16-Lead 3 mm x 3 mm VQFN		Note 1: Tape and Reel identifier only appears in the catalog part number description. This identifier is used for ordering purposes and is not printed on the device package. Check with your Microchip Sales Office for package availability with the Tape and Reel option.
Temperature Range:	G	=	-40°C to +85°C		
Media Type:	(blank)	=	100/Tube		
	TR	=	1,000/Reel		

SY88343BL

NOTES:

Note the following details of the code protection feature on Microchip products:

- 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, within operating specifications, and under normal conditions.
- Microchip values and aggressively protects its intellectual property rights. Attempts to breach the code protection features of Microchip product is strictly prohibited and may violate the Digital Millennium Copyright Act.
- 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. Microchip is committed to continuously improving the code protection features of our products.

This publication and the information herein may be used only with Microchip products, including to design, test, and integrate Microchip products with your application. Use of this information in any other manner violates these terms. Information regarding device applications 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. Contact your local Microchip sales office for additional support or, obtain additional support at <https://www.microchip.com/en-us/support/design-help/client-support-services>.

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.

For information regarding Microchip's Quality Management Systems, please visit www.microchip.com/quality.

Trademarks

The Microchip name and logo, the Microchip logo, Adaptec, AnyRate, AVR, AVR logo, AVR Freaks, BesTime, BitCloud, CryptoMemory, CryptoRF, dsPIC, flexPWR, HELDO, IGLOO, JukeBlox, KeeLoq, Klear, LANCheck, LinkMD, maXStylus, maXTouch, MediaLB, megaAVR, Microsemi, Microsemi logo, MOST, MOST logo, MPLAB, OptoLyzer, 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, QuietWire, SmartFusion, SyncWorld, Temux, TimeCesium, TimeHub, TimePictra, TimeProvider, TrueTime, 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, GridTime, IdealBridge, In-Circuit Serial Programming, ICSP, INICnet, Intelligent Paralleling, Inter-Chip Connectivity, JitterBlocker, Knob-on-Display, maxCrypto, maxView, memBrain, Mindi, MiWi, MPASM, MPF, MPLAB Certified logo, MPLIB, MPLINK, MultiTRAK, NetDetach, NVM Express, NVMe, Omniscient 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, SmartHLS, SMART-I.S., storClad, SQI, 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, Symmcom, and Trusted Time 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.

© 2021, Microchip Technology Incorporated and its subsidiaries.

All Rights Reserved.

ISBN: 978-1-5224-9302-0



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

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