

32-Channel Low Harmonic Distortion High-Voltage Analog Switch IC

Features

- 32-channel High-voltage Analog Switch
- 2:1 Multiplexer/demultiplexer
- 3.3V or 5V CMOS Input Logic Level
- $-10\ \mu\text{A}$ Low-quiescent Power Dissipation
- Low Parasitic Capacitance
- DC to 50 MHz Analog Signal Frequency
- $-60\ \text{dB}$ Typical Off-isolation at 5 MHz
- CMOS Logic Circuitry for Low Power
- Excellent Noise Immunity
- Flexible Operating Supply Voltages

Applications

- Electromechanical Relay Replacement in Medical Ultrasound Probes

General Description

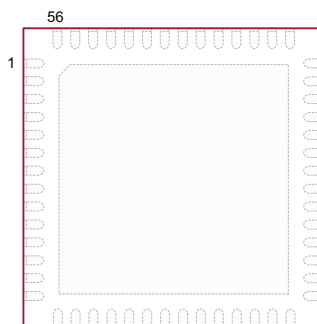
The HV2808 is a 32-channel low-harmonic-distortion high-voltage analog switch integrated circuit designed for medical ultrasound imaging systems as a probe selection relay replacement. It serves as a 16-pole double-throw (PDT) high-voltage analog switch array. The device is a very fast transducer multiplexer that consumes minimal power and emits no audible noise.

This device combines high-voltage bilateral DMOS switches and low-power CMOS logic to provide efficient control of high-voltage analog signals. The HV2808 is suitable for various combinations of high-voltage supplies, such as V_{PP}/V_{NN} : $+40\text{V}/-160\text{V}$, $+100\text{V}/-100\text{V}$ and $+160\text{V}/-40\text{V}$.

Moreover, the HV2808 comes in an 8 mm x 8 mm x 1 mm 56-lead VQFN package. Compared to an electromechanical relay, it does not only save considerable PCB area but also PCB-assembled height.

Package Type

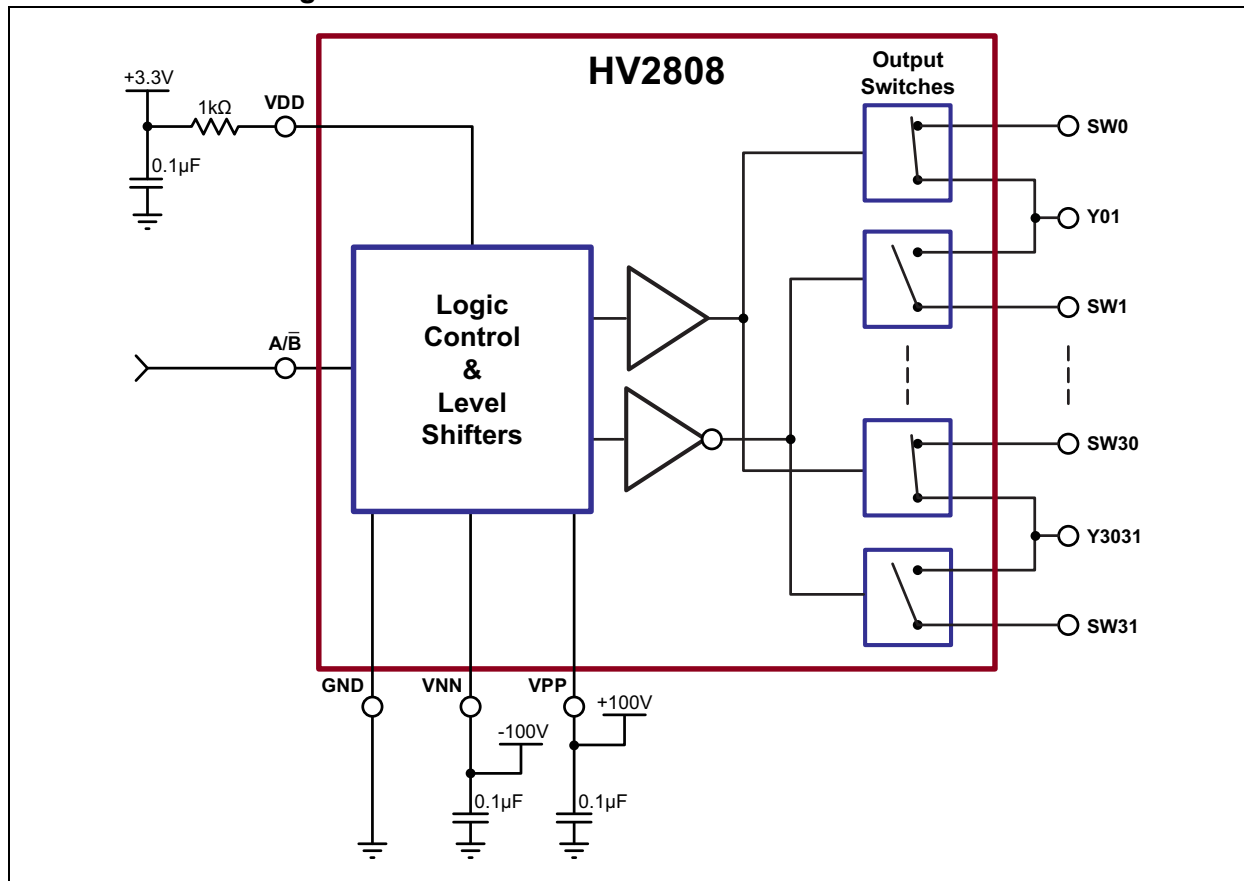
56-lead VQFN
(Top view)



See [Table 2-1](#) for pin information.

HV2808

Functional Block Diagram



1.0 ELECTRICAL CHARACTERISTICS

Absolute Maximum Ratings^(†)

Logic Power Supply Voltage, V_{DD}	–0.5V to +6.5V
Differential Supply Voltage, $V_{PP}-V_{NN}$	220V
High-voltage Positive Supply, V_{PP}	–0.5V to $V_{NN} + 200V$
High-voltage Negative Supply, V_{NN}	+0.5V to –200V
Logic Input Voltage	–0.5V to $V_{DD} + 0.3V$
Analog Signal Range	V_{NN} to V_{PP}
Peak Analog Signal Current/Channel	3A
Storage Temperature, T_S	–65°C to 150°C

† **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.

RECOMMENDED OPERATING CONDITIONS

Parameter	Sym.	Min.	Typ.	Max.	Unit	Conditions
Logic Power Supply Voltage	V_{DD}	3	—	5.5	V	Note 1, Note 3
High-voltage Positive Supply	V_{PP}	40	—	$V_{NN} + 200$	V	Note 1, Note 3
High-voltage Negative Supply	V_{NN}	–40	—	–160	V	Note 1, Note 3
High-level Input Voltage	V_{IH}	$0.9 V_{DD}$	—	V_{DD}	V	
Low-level Input Voltage	V_{IL}	0V	—	$0.1 V_{DD}$	V	
Analog Signal Voltage Peak-to-Peak	V_{SIG}	$V_{NN} + 10V$	—	$V_{PP} - 10V$	V	Note 2
Operating Ambient Temperature	T_A	0	—	70	°C	

Note 1: Power-up or power-down sequence is arbitrary except GND must be powered up first and powered down last.

2: V_{SIG} must be $V_{NN} \leq V_{SIG} \leq V_{PP}$ or floating during power-up or power-down transition.

3: Rise and fall times of power supplies V_{DD} , V_{PP} and V_{NN} should not be less than 1 millisecond.

DC ELECTRICAL CHARACTERISTICS

Electrical Specifications: Unless otherwise specified, all values are over operating conditions. See [Section 3.0](#) “Test Circuits”.

Parameter	Sym.	0°C		+25°C			+70°C		Unit	Conditions	
		Min.	Max.	Min.	Typ.	Max.	Min.	Max.			
Small Signal Switch On-resistance	R _{ONS}	—	30	—	26	38	—	48	Ω	I _{SIG} = 5 mA	V _{PP} = +40V
		—	25	—	22	27	—	32		I _{SIG} = 200 mA	V _{NN} = −160V
		—	25	—	22	27	—	30		I _{SIG} = 5 mA	V _{PP} = +100V
		—	18	—	18	24	—	27		I _{SIG} = 200 mA	V _{NN} = −100V
		—	23	—	20	25	—	30		I _{SIG} = 5 mA	V _{PP} = +160V
		—	22	—	16	25	—	27		I _{SIG} = 200 mA	V _{NN} = −40V
Small Signal Switch On-resistance Matching	ΔR _{ONS}	—	20	—	5	20	—	20	%	I _{SIG} = 5 mA, V _{PP} = +100V, V _{NN} = −100V	
Large Signal Switch On-resistance	R _{ONL}	—	—	—	15	—	—	—	Ω	V _{SIG} = V _{PP} −10V, I _{SIG} = 1A	
Switch-off Leakage per Switch	I _{SOL}	—	5	—	1	10	—	15	μA	V _{SIG} = V _{PP} − 10V, V _{NN} +10V	
DC Offset Switch-off	V _{OS(OFF)}	—	300	—	100	300	—	300	mV	R _{LOAD} = 100 kΩ	
DC Offset Switch-on	V _{OS(ON)}	—	500	—	100	500	—	500			
Quiescent V _{PP} Supply Current	I _{PPQ}	—	—	—	10	50	—	—	μA	All switches off	
Quiescent V _{NN} Supply Current	I _{NNQ}	—	—	—	−10	−50	—	—	μA	All switches off	
Quiescent V _{PP} Supply Current	I _{PPQ}	—	—	—	10	50	—	—	μA	All switches on, I _{SW} = 5 mA	
Quiescent V _{NN} Supply Current	I _{NNQ}	—	—	—	−10	−50	—	—	μA	All switches on, I _{SW} = 5 mA	
Switch Output Peak Current	I _{SW}	—	3	—	3	2	—	2	A	V _{SIG} duty cycle < 0.1%	
Output Switching Frequency	f _{SW}	—	—	—	—	50	—	—	kHz	Duty cycle = 50%	
Average V _{PP} Supply Current	I _{PP}	—	13	—	—	14	—	16	mA	V _{PP} = +40V V _{NN} = −160V	All output switches turn on and off at 50 kHz with no load.
		—	8	—	—	10	—	11		V _{PP} = +100V V _{NN} = −100V	
		—	8	—	—	10	—	11		V _{PP} = +160V V _{NN} = −40V	
Average V _{NN} Supply Current	I _{NN}	—	13	—	—	14	—	16	mA	V _{PP} = +40V V _{NN} = −160V	All output switches turn on and off at 50 kHz with no load.
		—	8	—	—	10	—	11		V _{PP} = +100V V _{NN} = −100V	
		—	8	—	—	10	—	11		V _{PP} = +160V V _{NN} = −40V	
Logic Supply Average Current	I _{DD}	—	0.1	—	—	0.1	—	0.1	mA	V _{DD} = 5V at 50 kHz CW	
Logic Supply Quiescent Current	I _{DDQ}	—	10	—	—	10	—	10	μA	All logic inputs are static.	
Logic Input Capacitance	C _{IN}	—	10	—	—	10	—	10	pF		

AC ELECTRICAL CHARACTERISTICS

Electrical Specifications: Unless otherwise specified, all values are over operating conditions. See [Section 3.0 “Test Circuits”](#).

Parameter	Sym.	0°C		+25°C			+70°C		Unit	Conditions
		Min.	Max.	Min.	Typ.	Max.	Min.	Max.		
Turn-on Time	t_{ON}	—	30	—	15	30	—	30	μs	$V_{SIG} = V_{PP} - 10V$, $V_{PP} = +100V$, $R_{LOAD} = 10\text{ k}\Omega$, $V_{NN} = -100V$
Turn-off Time	t_{OFF}	—	30	—	15	30	—	30		
Maximum V_{SIG} Slew Rate	dv/dt	—	20	—	—	20	—	20	V/ns	$V_{PP} = +40V$, $V_{NN} = -160V$
		—	20	—	—	20	—	20		$V_{PP} = +100V$, $V_{NN} = -100V$
		—	20	—	—	20	—	20		$V_{PP} = +160V$, $V_{NN} = -40V$
Off Isolation	K_O	-30	—	-30	-33	—	-30	—	dB	$f = 5\text{ MHz}$, $1\text{ k}\Omega/15\text{ pF}$ load
		-58	—	-58	—	—	-58	—		$f = 5\text{ MHz}$, 50Ω load
Switch Crosstalk	K_{CR}	-60	—	-60	-70	—	-60	—	dB	$f = 5\text{ MHz}$, 50Ω load
Output Switch Isolation Diode Current	I_{ID}	—	300	—	—	300	—	300	mA	300 ns pulse width, 2% duty cycle
Off Capacitance SW to GND	$C_{SG(OFF)}$	—	14	—	9	14	—	14	pF	$V_{SIG} = 0V$, $f = 1\text{ MHz}$
On Capacitance SW to GND	$C_{SG(ON)}$	—	33	—	23	33	—	33	pF	$V_{SIG} = 0V$, $f = 1\text{ MHz}$, one SW on, one SW off
On Capacitance Y to GND		—	33	—	23	33	—	33		
Output Voltage Spike SW	$+V_{SPK}$	—	250	—	—	250	—	250	mV	$V_{PP} = +40V$, $V_{NN} = -160V$, $R_{LOAD} = 50\Omega$
	$-V_{SPK}$	—	250	—	—	250	—	250		$V_{PP} = +100V$, $V_{NN} = -100V$, $R_{LOAD} = 50\Omega$
	$+V_{SPK}$	—	250	—	—	250	—	250		
	$-V_{SPK}$	—	250	—	—	250	—	250		$V_{PP} = +160V$, $V_{NN} = -40V$, $R_{LOAD} = 50\Omega$
	$+V_{SPK}$	—	250	—	—	250	—	250		
	$-V_{SPK}$	—	250	—	—	250	—	250		
Output Voltage Spike Y	$+V_{SPK}$	—	250	—	—	250	—	250	mV	$V_{PP} = +40V$, $V_{NN} = -160V$, $R_{LOAD} = 50\Omega$
	$-V_{SPK}$	—	250	—	—	250	—	250		$V_{PP} = +100V$, $V_{NN} = -100V$, $R_{LOAD} = 50\Omega$
	$+V_{SPK}$	—	250	—	—	250	—	250		
	$-V_{SPK}$	—	250	—	—	250	—	250		$V_{PP} = +160V$, $V_{NN} = -40V$, $R_{LOAD} = 50\Omega$
	$+V_{SPK}$	—	250	—	—	250	—	250		
	$-V_{SPK}$	—	250	—	—	250	—	250		
Charge Injection	QC	—	—	—	1020	—	—	—	pC	$V_{PP} = +40V$, $V_{NN} = -160V$
		—	—	—	700	—	—	—		$V_{PP} = +100V$, $V_{NN} = -100V$
		—	—	—	370	—	—	—		$V_{PP} = +160V$, $V_{NN} = -40V$

HV2808

TEMPERATURE SPECIFICATIONS

Parameter	Sym.	Min.	Typ.	Max.	Unit	Conditions
TEMPERATURE RANGE						
Junction Temperature	T_J	0	—	125	°C	
Operating Ambient Temperature	T_A	0	—	70	°C	
Storage Temperature	T_S	−65	—	150	°C	
PACKAGE THERMAL RESISTANCE						
56-lead VQFN	θ_{JA}	—	21	—	°C/W	

TRUTH FUNCTION TABLE

$A/\overline{B}$	Switch Status
H	SW0, 2, 4...30 ON, SW1, 3, 5...31 OFF
L	SW0, 2, 4...30 OFF, SW1, 3, 5...31 ON

2.0 PIN DESCRIPTION

The details on the pins of HV2808 are listed in [Table 2-1](#). See [Package Type](#) for the location of pins.

TABLE 2-1: PIN FUNCTION TABLE

Pin Number	Pin Name	Description
1	Y2829	Y terminal of analog switch 28 and 29
2	SW29	SW terminal of analog switch 29
3	SW30	SW terminal of analog switch 30
4	Y3031	Y terminal of analog switch 30 and 31
5	SW31	SW terminal of analog switch 31
6	NC	No connection
7	VDD	Logic supply voltage
8	A/B	SW logic control input
9	GND	Ground
10	SW0	SW terminal of analog switch 0
11	Y01	Y terminal of analog switch 0 and 1
12	SW1	SW terminal of analog switch 1
13	SW2	SW terminal of analog switch 2
14	Y23	Y terminal of analog switch 2 and 3
15	SW3	SW terminal of analog switch 3
16	SW4	SW terminal of analog switch 4
17	Y45	Y terminal of analog switch 4 and 5
18	SW5	SW terminal of analog switch 5
19	SW6	SW terminal of analog switch 6
20	Y67	Y terminal of analog switch 6 and 7
21	SW7	SW terminal of analog switch 7
22	SW8	SW terminal of analog switch 8
23	Y89	Y terminal of analog switch 8 and 9
24	SW9	SW terminal of analog switch 9
25	SW10	SW terminal of analog switch 10
26	Y1011	Y terminal of analog switch 10 and 11
27	SW11	SW terminal of analog switch 11
28	SW12	SW terminal of analog switch 12
29	Y1213	Y terminal of analog switch 12 and 13
30	SW13	SW terminal of analog switch 13
31	VNN	High-voltage negative supply
32	SW14	SW terminal of analog switch 14
33	Y1415	Y terminal of analog switch 14 and 15
34	SW15	SW terminal of analog switch 15
35	VPP	High-voltage positive supply
36	VPP	High-voltage positive supply
37	SW16	SW terminal of analog switch 16
38	Y1617	Y terminal of analog switch 16 and 17
39	SW17	SW terminal of analog switch 17
40	VNN	High-voltage negative supply

TABLE 2-1: PIN FUNCTION TABLE (CONTINUED)

Pin Number	Pin Name	Description
41	SW18	SW terminal of analog switch 18
42	Y1819	Y terminal of analog switch 18 and 19
43	SW19	SW terminal of analog switch 19
44	SW20	SW terminal of analog switch 20
45	Y2021	Y terminal of analog switch 20 and 21
46	SW21	SW terminal of analog switch 21
47	SW22	SW terminal of analog switch 22
48	Y2223	Y terminal of analog switch 22 and 23
49	SW23	SW terminal of analog switch 23
50	SW24	SW terminal of analog switch 24
51	Y2425	Y terminal of analog switch 24 and 25
52	SW25	SW terminal of analog switch 25
53	SW26	SW terminal of analog switch 26
54	Y2627	Y terminal of analog switch 26 and 27
55	SW27	SW terminal of analog switch 27
56	SW28	SW terminal of analog switch 28
VSUB (Thermal Pad)		The central thermal pad on the bottom of package must be connected to VNN externally.

3.0 TEST CIRCUITS

Refer to [Figure 3-1](#) to [Figure 3-9](#) for the test circuits of HV2808.

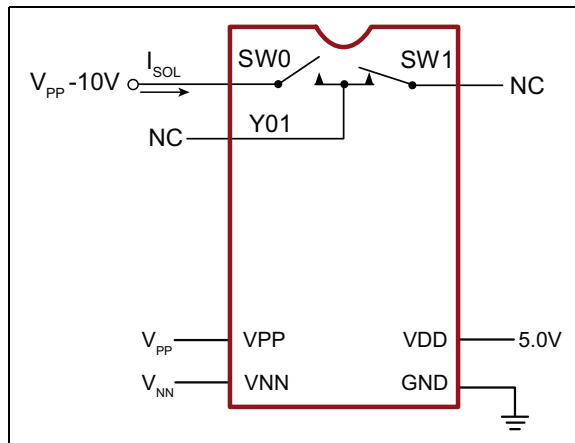


FIGURE 3-1: Switch-off Leakage.

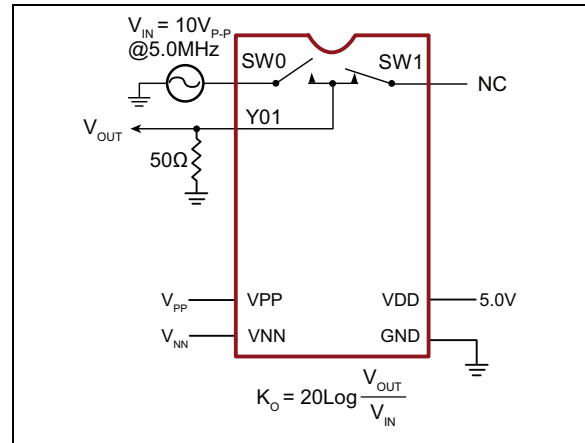


FIGURE 3-4: Off Isolation.

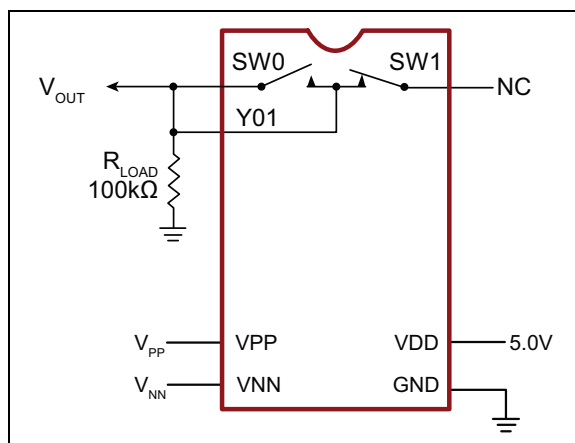


FIGURE 3-2: DC Offset On/Off.

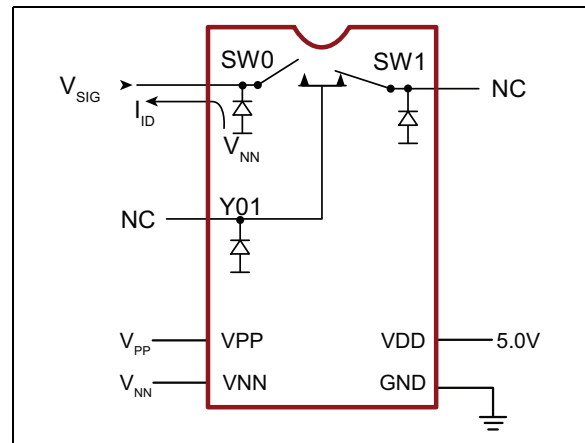


FIGURE 3-5: Isolation Diode Current.

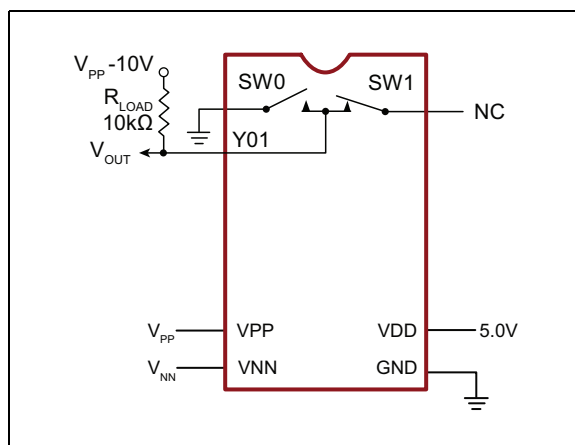


FIGURE 3-3: TON/TOFF Test Circuit.

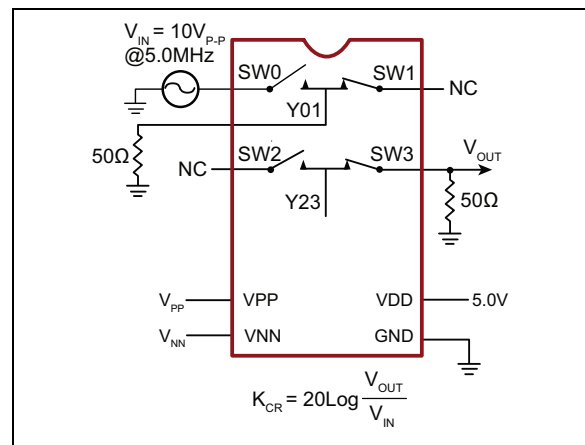


FIGURE 3-6: Crosstalk.

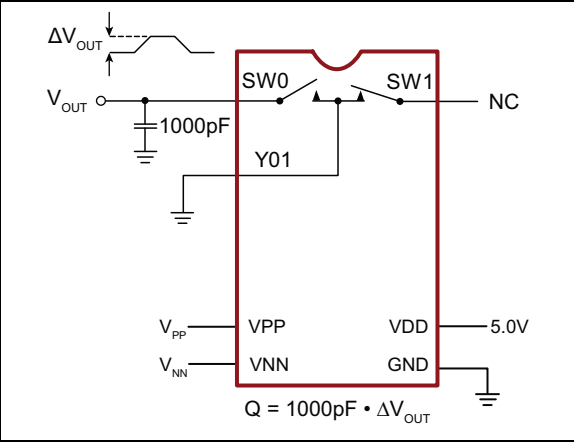


FIGURE 3-7: Charge Injection.

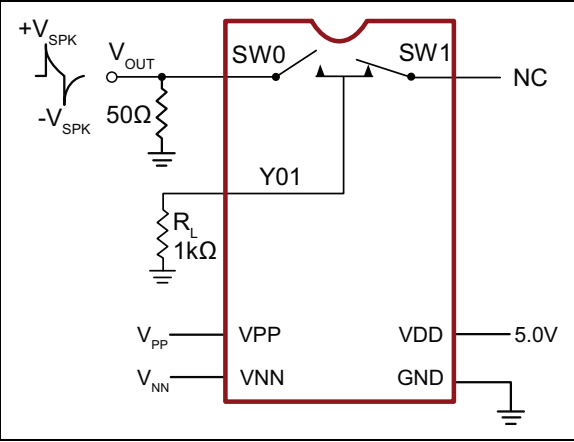


FIGURE 3-8: Output Voltage Spike SW.

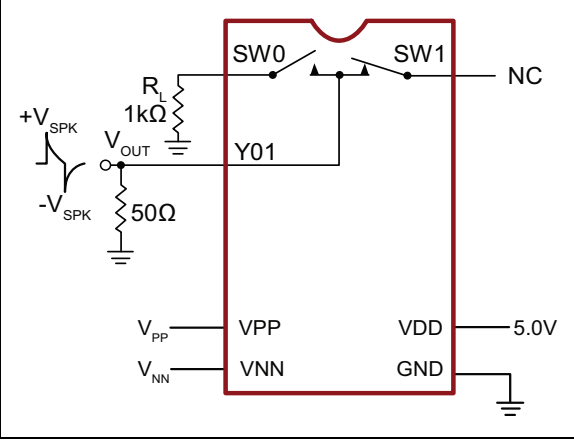
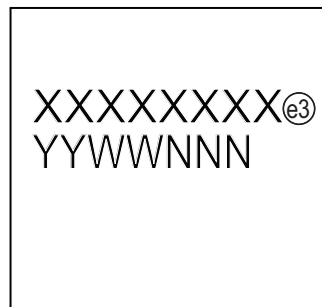


FIGURE 3-9: Output Voltage Spike Y.

4.0 PACKAGING INFORMATION

4.1 Package Marking Information

56-lead VQFN



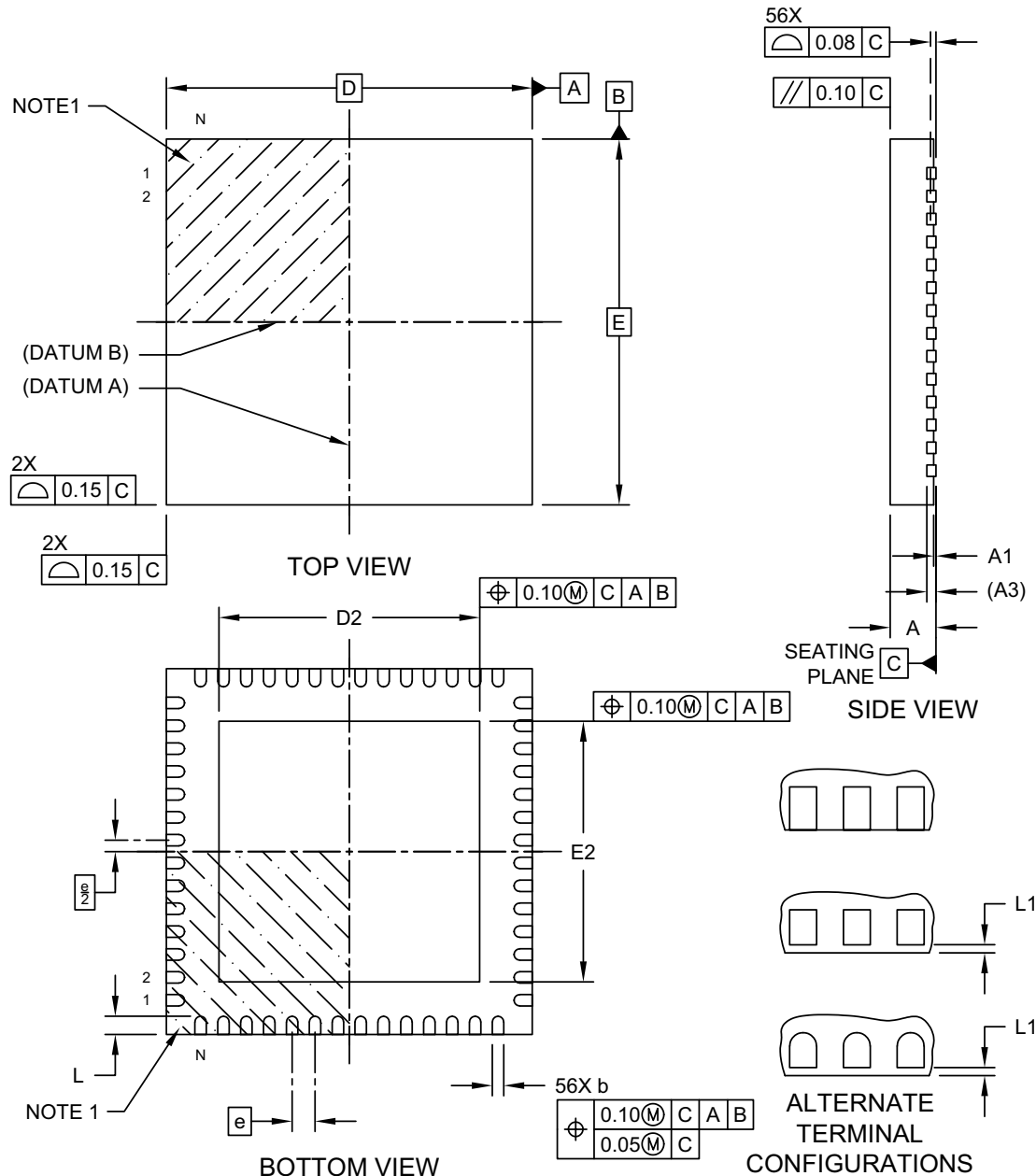
Example



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.
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 product code or customer-specific information. Package may or not include the corporate logo.		

56-Lead Very Thin Quad Flat, No Lead Package (5XF) - 8x8x1.0 mm Body [VQFN] Supertex Legacy Package K6

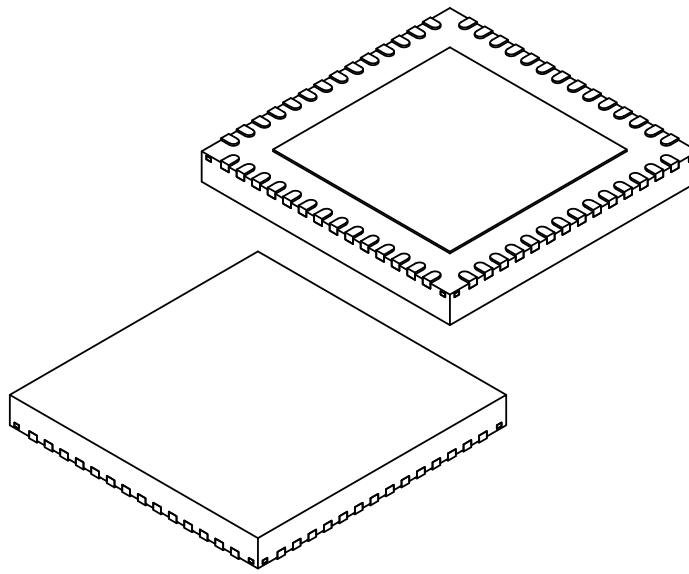
Note: For the most current package drawings, please see the Microchip Packaging Specification located at <http://www.microchip.com/packaging>



Microchip Technology Drawing C04-299-5XF Rev A Sheet 1 of 2

56-Lead Very Thin Quad Flat, No Lead Package (5XF) - 8x8x1.0 mm Body [VQFN] Supertex Legacy Package K6

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	56		
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	0.20 REF		
Overall Length	D	8.00 BSC		
Exposed Pad Length	D2	5.60	5.70	5.80
Overall Width	E	8.00 BSC		
Exposed Pad Width	E2	5.60	5.70	5.80
Terminal Width	b	0.18	0.25	0.30
Terminal Length	L	0.30	0.40	0.50
Pullback (Optional)	L1	-	-	0.15

Notes:

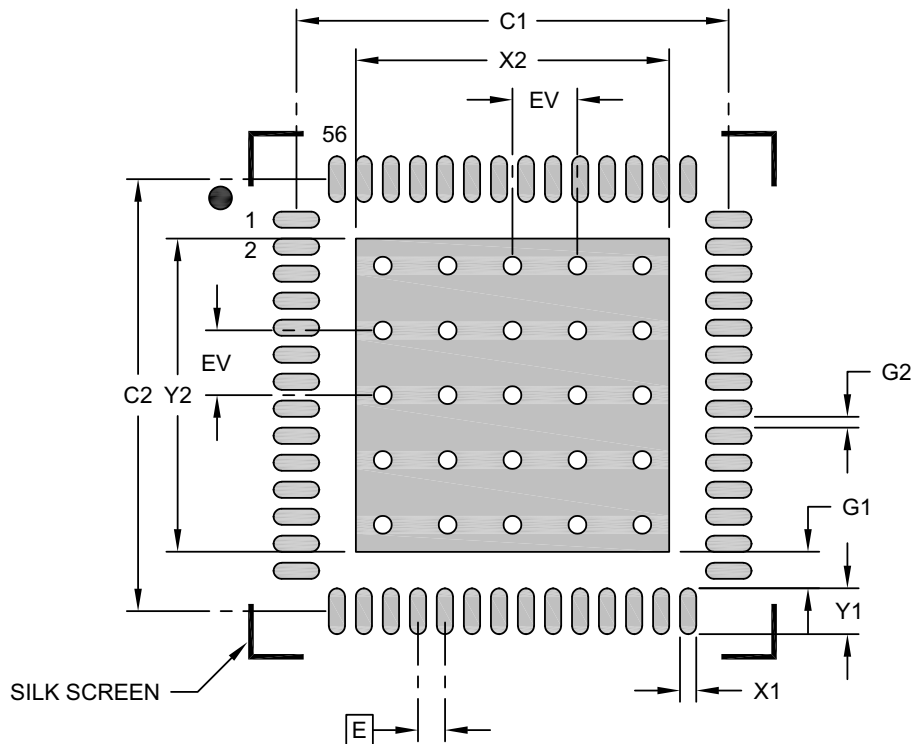
- Pin 1 visual index feature may vary, but must be located within the hatched area.
- Package is saw singulated
- Dimensioning and tolerancing per ASME Y14.5M
BSC: Basic Dimension. Theoretically exact value shown without tolerances.
REF: Reference Dimension, usually without tolerance, for information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

Microchip Technology Drawing C04-299-5XF Rev A Sheet 2 of 2

© 2021 Microchip Technology Inc.

56-Lead Very Thin Quad Flat, No Lead Package (5XF) - 8x8x1.0 mm Body [VQFN] Supertex Legacy Package K6

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



RECOMMENDED LAND PATTERN

Dimension	Units	MILLIMETERS		
		MIN	NOM	MAX
Contact Pitch	E		0.50 BSC	
Center Pad Width	X2			5.80
Center Pad Length	Y2			5.80
Contact Pad Spacing	C1		8.00	
Contact Pad Spacing	C2		8.00	
Contact Pad Width (Xnn)	X1			0.30
Contact Pad Length (Xnn)	Y1			0.85
Contact Pad to Center Pad (Xnn)	G1	0.68		
Contact Pad to Contact Pad (Xnn)	G2	0.20		
Thermal Via Diameter	V		0.33	
Thermal Via Pitch	EV		1.20	

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 C04-2299-5FX Rev A

APPENDIX A: REVISION HISTORY

Revision B (June 2023)

- Removed the $f = 5$ MHz value in the conditions column of the Logic Supply Average Current parameter
- Made minor changes throughout the document

Revision A (June 2023)

- Converted Supertex Doc # DSFP-HV2808 to Microchip DS20005842A
- Removed “HVC MOS[®] Technology for high performance” in the Features and General Description sections
- Updated the K6 package description from “56-lead QFN” to “56-lead VQFN” and removed the M937 media type to align packaging specifications with the actual BQM
- Changed the package marking format
- Made minor changes throughout the document

HV2808

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>XX</u>	-	<u>X</u>	-	<u>X</u>
Device	Package Options			Environmental		Media Type
Device:	HV2808	=		32-Channel Low Harmonic Distortion High-Voltage Analog Switch IC		
Package:	K6	=		56-lead VQFN		
Environmental:	G	=		Lead (Pb)-free/RoHS-compliant Package		
Media Types:	(blank)	=		250/Tray for a K6 Package		

Example:

a) HV2808K6-G:

32-Channel Low Harmonic Distortion High-Voltage Analog Switch IC, 56-lead VQFN Package, 250/Tray

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, 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, Libero, motorBench, mTouch, Powermite 3, Precision Edge, ProASIC, ProASIC Plus, ProASIC Plus logo, Quiet-Wire, SmartFusion, SyncWorld, Temux, TimeCesium, TimeHub, TimePictra, TimeProvider, TrueTime, 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, Clockstudio, 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, IntelliMOS, Inter-Chip Connectivity, JitterBlocker, Knob-on-Display, KoD, maxCrypto, maxView, memBrain, Mindi, MiWi, MPASM, MPF, MPLAB Certified logo, MPLIB, MPLINK, MultiTRAK, NetDetach, 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, Trusted Time, 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.

© 2023, Microchip Technology Incorporated and its subsidiaries.

All Rights Reserved.

ISBN: 978-1-6683-2741-8

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: 45-4485-5910
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