

## Piezoelectric Horn Driver with Boost Converter

### Features:

- 3V Operation
- Low Quiescent Current
- 10V Boost Converter
- Low Horn Driver On-Resistance
- Compatible with RE46C117

### Applications:

- Smoke Detectors
- CO Detectors
- Personal Security Products
- Electronic Toys

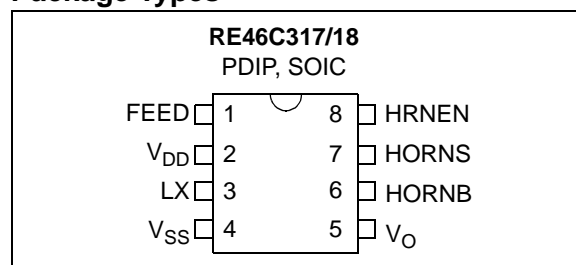
### Description:

The RE46C317/18 are CMOS piezoelectric horn driver ICs with built-in boost converter. They are intended for use in 3V battery or battery-backed applications. The circuits feature a boost converter and a driver circuit suitable for driving a piezoelectric horn.

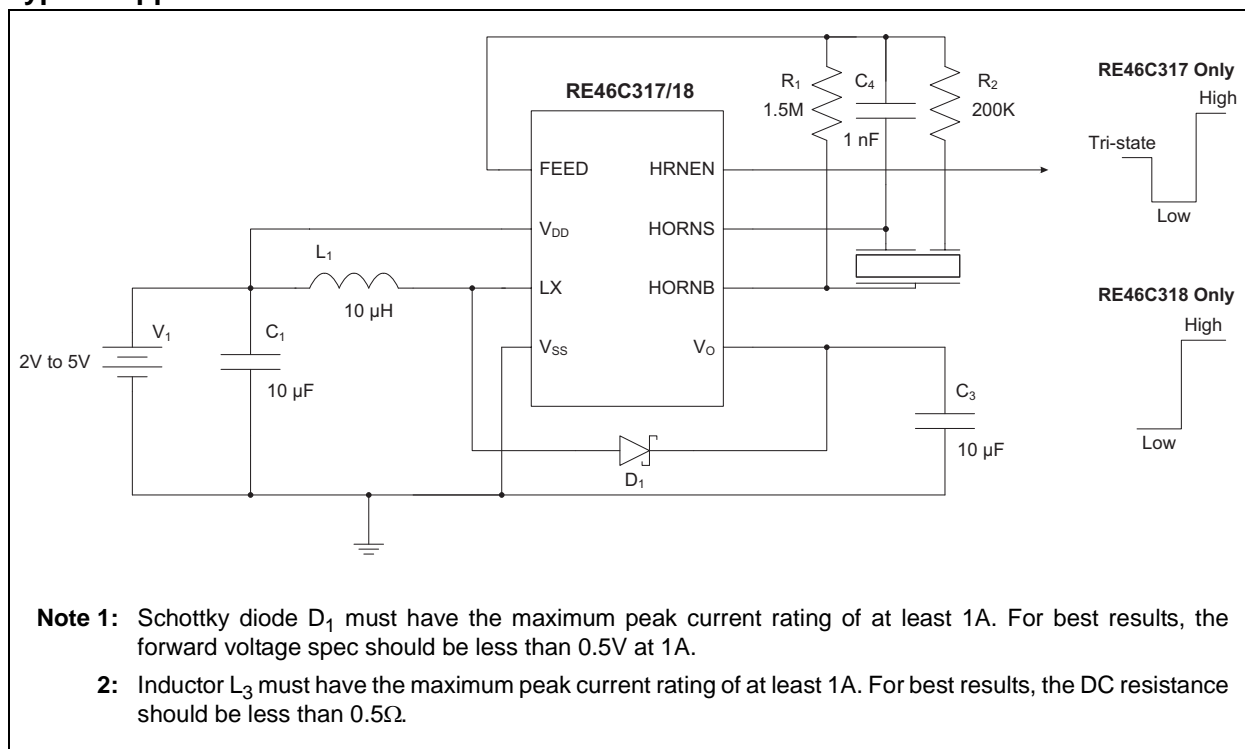
The RE46C317/18 are compatible with the RE46C117 device and offer lower standby current.

The RE46C317 has three valid states of Horn Enable (tri-state, low and high), while the RE46C318 has only two valid states, low and high.

### Package Types

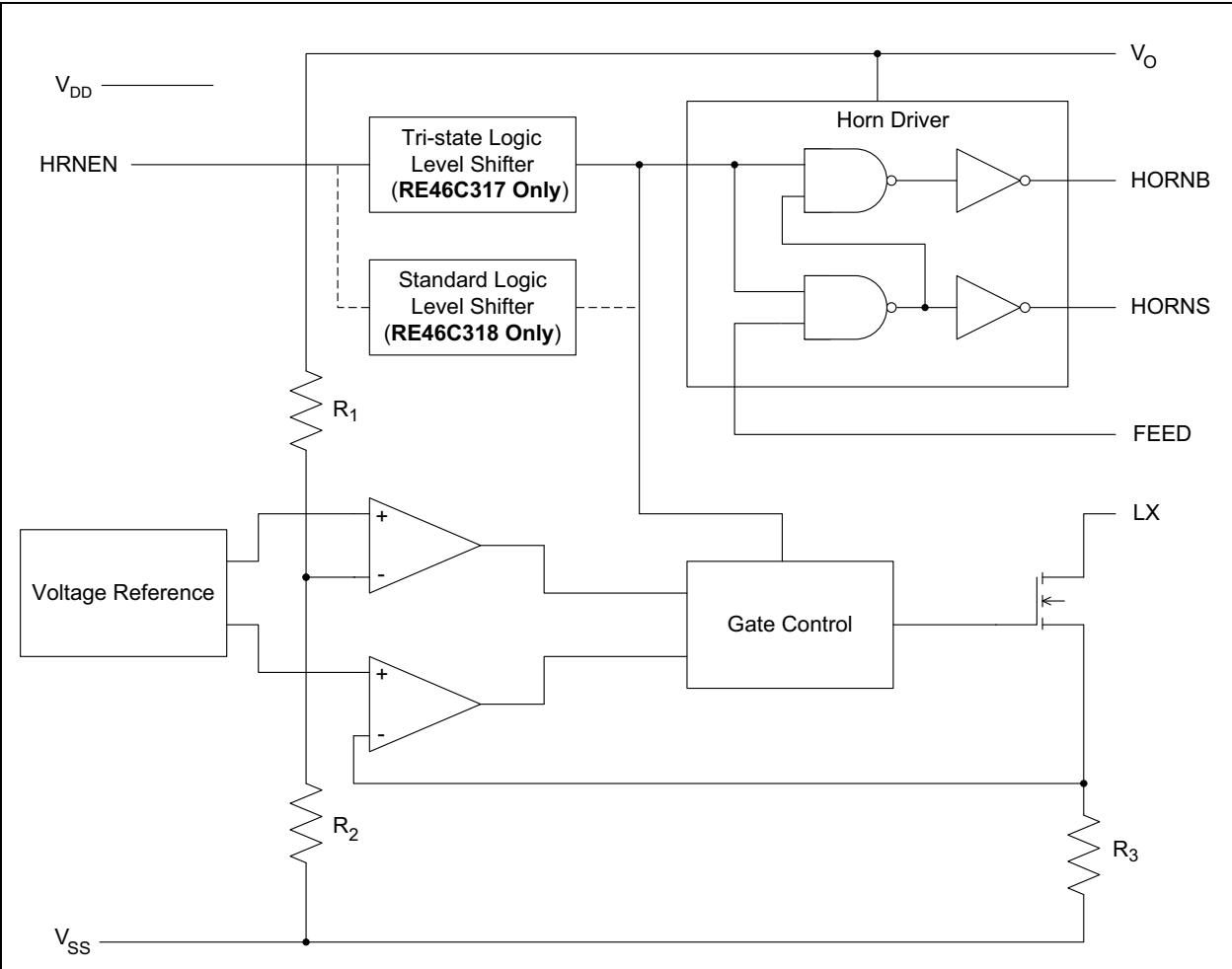


### Typical Application



# RE46C317/18

## Functional Block Diagram



## 1.0 ELECTRICAL CHARACTERISTICS

### 1.1 Absolute Maximum Ratings†

$V_{DD}$ .....	5.5V
$V_{OUT}$ .....	12.5V
Input Voltage Range Except FEED, LX.....	$V_{IN} = V_{SS} - .3V$ to $V_{DD} + .3V$
FEED Input Voltage Range .....	$V_{INFD} = -10V$ to $+22V$
LX Input Voltage .....	$V_{INLX} = V_{OUT} + 0.8V$
Input Current except FEED, LX .....	$I_{IN} = 10$ mA
LX Current (Peak) .....	$I_{INLX} = 1.0A$
Operating Temperature .....	$T_A = -10^{\circ}C$ to $+60^{\circ}C$
Storage Temperature .....	$T_{STG} = -55^{\circ}C$ to $+125^{\circ}C$
Continuous Operating Current (HORNS, HORN B, $V_O$ ) .....	$I_O = 40$ mA
Maximum Human Body Model ESD.....	1500V

† **Notice:** Stresses above those listed under “Maximum ratings” may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or any other conditions above those indicated in the operation listings of this specification is not implied. Exposure to maximum rating conditions for extended periods may affect device reliability. This product utilizes CMOS technology with static protection; however proper ESD prevention procedures should be used when handling this product. Damage can occur when exposed to extremely high static electrical charge.

### DC ELECTRICAL CHARACTERISTICS – RE46C317

**Unless otherwise indicated,** all parameters apply at  $T_A = -10^{\circ}C$  to  $+60^{\circ}C$ ,  $V_{DD} = 3V$ ,  $V_{SS} = 0V$ ,  $C_3 = 10 \mu F$ . Typical values are at  $T_A = +25^{\circ}C$

Parameter	Symbol	Test Pin	Min.	Typ.	Max.	Units	Conditions
Supply Voltage	$V_{DD}$	2	2	—	5	V	Operating
Standby Supply Current	$I_{DD1}$	2	—	0.5	1	$\mu A$	HRNEN = Float; No loads
Standby $I_{VO}$	$I_{VO1}$	5	—	0	0.3	$\mu A$	HRNEN = Float; No loads
Quiescent Supply Current	$I_{DD2}$	2	—	27	49	$\mu A$	HRNEN = Low; No Loads; $V_O = 11V$ ; $V_{LX} = 0.5V$
Quiescent $I_{VO}$	$I_{VO2}$	5	—	71	115	$\mu A$	HRNEN = Low; No Loads; $V_O = 11V$ ; $V_{LX} = 0.5V$
Supply current	$I_{SUP}$	2	—	300	—	$\mu A$	HRNEN = Low; No Loads, Boost Running
Input Current for Tri-state	$I_{IT}$	8	-5	—	5	$\mu A$	HRNEN = Float ( <b>Note 4</b> )
Input Voltage High	$V_{IHH}$	8	2.6	—	—	V	HRNEN input
	$V_{IHF}$	1	7	—	—	V	FEED input; $V_O = 10V$

- Note 1:** The boost converter in Boost mode (normal  $V_O = 10V$ ) can draw current pulses of  $\sim 0.8A$  and therefore is very sensitive to series resistance. The critical components of this resistance are the inductor DC resistance, the internal resistance of the battery and the resistance in the connections from the inductor to the battery, from the inductor to the LX pin. In order to function properly under full load at  $V_{DD} = 2V$ , the total of the inductor and the interconnect resistances should not exceed  $0.3\Omega$ . The internal battery resistance should be no more than  $0.5\Omega$ . A low ESR capacitance of  $10 \mu F$  or more should be connected in parallel with the battery to average current over the boost converter cycle.
- 2:** In the above table, wherever a specific  $V_O$  value is listed under test conditions, the  $V_O$  is forced externally with the inductor disconnected, and the boost converter is not running.
- 3:** The limits shown are 100% tested at  $+25^{\circ}C$  only. Test limits are guard-banded, based on temperature characterization to ensure compliance at temperature extremes.
- 4:** This is the maximum input current that will not cause a logic high or logic low to be asserted.

# RE46C317/18

## DC ELECTRICAL CHARACTERISTICS – RE46C317 (CONTINUED)

Unless otherwise indicated, all parameters apply at  $T_A = -10^{\circ}\text{C}$  to  $+60^{\circ}\text{C}$ ,  $V_{DD} = 3\text{V}$ ,  $V_{SS} = 0\text{V}$ ,  $C_3 = 10\ \mu\text{F}$ . Typical values are at  $T_A = +25^{\circ}\text{C}$

Parameter	Symbol	Test Pin	Min.	Typ.	Max.	Units	Conditions
Input Voltage Low	$V_{ILH}$	8	—	—	0.4	V	HRNEN input
	$V_{ILF}$	1	—	—	3	V	FEED input; $V_O = 10\text{V}$
Input Leakage	$I_{IHF}$	1	—	20	50	$\mu\text{A}$	FEED = 22V; $V_O = 10\text{V}$
	$I_{ILF}$	1	-50	-15	—	$\mu\text{A}$	FEED = -10V; $V_O = 10\text{V}$
	$I_{IHH}$	8	—	20	50	$\mu\text{A}$	HRNEN = $V_{DD}$
	$I_{ILH}$	8	-50	-20	—	$\mu\text{A}$	HRNEN = $V_{SS}$
Output Leakage	$I_{OZH}$	3	—	—	1	$\mu\text{A}$	HRNEN = Float; $V_O = 12.5\text{V}$ ; $V_{LX} = 10\text{V}$
$V_O$ Output Voltage	$V_{VO}$	5	9	10	11	V	$V_{DD} = 3\text{V}$ , HRNEN = Low or High, $I_{OUT} = 10\ \text{mA}$
$V_O$ Efficiency	$V_{OEFF}$	5	—	80	—	%	$I_{LOAD} = 10\ \text{mA}$ , $V_{DD} = 3\text{V}$ , HRNEN = 0V
Output Low Voltage	$V_{OL}$	6, 7	—	0.3	0.5	V	HORN B or HORN S $I_{OUT} = -16\ \text{mA}$ , $V_{DD} = 3\text{V}$
Output High Voltage	$V_{OH}$	6, 7	9.5	9.7	—	V	HORN B or HORN S $V_O = 10\text{V}$ $V_{DD} = \text{HRNEN} = 3\text{V}$ $I_{OUT} = 16\ \text{mA}$

- Note 1:** The boost converter in Boost mode (normal  $V_O = 10\text{V}$ ) can draw current pulses of  $\sim 0.8\text{A}$  and therefore is very sensitive to series resistance. The critical components of this resistance are the inductor DC resistance, the internal resistance of the battery and the resistance in the connections from the inductor to the battery, from the inductor to the LX pin. In order to function properly under full load at  $V_{DD} = 2\text{V}$ , the total of the inductor and the interconnect resistances should not exceed  $0.3\Omega$ . The internal battery resistance should be no more than  $0.5\Omega$ . A low ESR capacitance of  $10\ \mu\text{F}$  or more should be connected in parallel with the battery to average current over the boost converter cycle.
- 2:** In the above table, wherever a specific  $V_O$  value is listed under test conditions, the  $V_O$  is forced externally with the inductor disconnected, and the boost converter is not running.
- 3:** The limits shown are 100% tested at  $+25^{\circ}\text{C}$  only. Test limits are guard-banded, based on temperature characterization to ensure compliance at temperature extremes.
- 4:** This is the maximum input current that will not cause a logic high or logic low to be asserted.

## DC ELECTRICAL CHARACTERISTICS - RE46C318

Unless otherwise indicated, all parameters apply at  $T_A = -10^{\circ}\text{C}$  to  $+60^{\circ}\text{C}$ ,  $V_{DD} = 3\text{V}$ ,  $V_{SS} = 0\text{V}$ ,  $C_3 = 10\ \mu\text{F}$ . Typical values are at  $T_A = +25^{\circ}\text{C}$ .

Parameter	Symbol	Test Pin	Min.	Typ.	Max.	Units	Conditions
Supply Voltage	$V_{DD}$	2	2	—	5	V	Operating
Standby Supply Current	$I_{DD1}$	2	—	—	0.1	$\mu\text{A}$	HRNEN = Low; No loads
Input Voltage High	$V_{IHH}$	8	2.3	—	—	V	HRNEN input
	$V_{IHF}$	1	7	—	—	V	FEED input; $V_O = 10\text{V}$
Input Voltage Low	$V_{ILH}$	8	—	—	1	V	HRNEN input
	$V_{ILF}$	1	—	—	3	V	FEED input; $V_O = 10\text{V}$
Input Leakage	$I_{IHF}$	1	—	20	50	$\mu\text{A}$	FEED = 22V; $V_O = 10\text{V}$
	$I_{ILF}$	1	-50	-15	—	$\mu\text{A}$	FEED = -10V; $V_O = 10\text{V}$
	$I_{IN}$	8	-100	—	100	nA	HRNEN = $V_{DD}$ or $V_{SS}$
Output Leakage	$I_{OZH}$	3	—	—	1	$\mu\text{A}$	HRNEN = $V_{SS}$ , $V_O = 12.5\text{V}$ , $V_{LX} = 10\text{V}$
$V_O$ Output Voltage	$V_{VO}$	5	9	10	11	V	$V_{DD} = 3\text{V}$ , HRNEN = High, $I_{OUT} = 10\text{mA}$
$V_O$ Efficiency	$V_{VOEFF}$	5	—	80	—	%	$I_{LOAD} = 10\text{mA}$ , $V_{DD} = 3\text{V}$ , HRNEN = 0V
Output Low Voltage	$V_{OL}$	6, 7	—	0.3	0.5	V	HORN B or HORN S; $I_{OUT} = -16\text{mA}$ ; $V_{DD} = 3\text{V}$
Output High Voltage	$V_{OH}$	6, 7	9.5	9.7	—	V	HORN B or HORN S; $V_O = 10\text{V}$ ; $V_{DD} = \text{HRNEN} = 3\text{V}$ ; $I_{OUT} = 16\text{mA}$

## AC ELECTRICAL CHARACTERISTICS

Unless otherwise indicated, all parameters apply at  $T_A = -10^{\circ}\text{C}$  to  $+60^{\circ}\text{C}$ ,  $V_{DD} = 3\text{V}$ ,  $V_{SS} = 0\text{V}$ ,  $C_3 = 10\ \mu\text{F}$ . Typical values are at  $T_A = +25^{\circ}\text{C}$ .

Parameter	Symbol	Test Pin	Min.	Typ.	Max.	Units	Conditions
Horn Delay	$T_{HRN}$	8/6 or 8/7	—	—	1	ms	HRNEN = High; Boost Running; 16 mA Load

**Note 1:** Horn Delay is the delay between a high signal on HRNEN and the horn output turning ON. The internal circuitry delays the horn output until the Boost voltage reaches its set point, 10V nominally.

## TEMPERATURE CHARACTERISTICS

**Electrical Characteristics:** Unless otherwise indicated,  $V_{DD} = 3\text{V}$ ,  $V_{SS} = 0\text{V}$

Parameter	Symbol	Min.	Typ.	Max.	Units	Conditions
<b>Temperature Ranges</b>						
Operating Temperature Range	$T_A$	-10	—	60	$^{\circ}\text{C}$	
Storage Temperature Range	$T_{STG}$	-55	—	125	$^{\circ}\text{C}$	
<b>Thermal Package Resistances</b>						
Thermal Resistance, 8L-PDIP	$\theta_{JA}$	—	89.3	—	$^{\circ}\text{C/W}$	
Thermal Resistance, 8L-SOIC	$\theta_{JA}$	—	149.5	—	$^{\circ}\text{C/W}$	

# RE46C317/18

---

NOTES:

## 2.0 PIN DESCRIPTION

The descriptions of the pins are listed in [Table 2-1](#).

**TABLE 2-1: PIN FUNCTION TABLE**

RE46C317/18	Symbol	Description
PDIP, SOIC		
1	FEED	Horn Feedback
2	V <sub>DD</sub>	Positive supply voltage
3	LX	External inductor
4	V <sub>SS</sub>	Negative supply voltage
5	V <sub>O</sub>	Output of Boost converter
6	HORNB	Horn Brass
7	HORNS	Horn Silver
8	HRNEN	Horn Enable

### 2.1 Horn Feedback Pin (FEED)

This pin is usually connected to the feedback electrode of the piezoelectric horn through a current limiting resistor. If not used, this pin must be connected to V<sub>SS</sub>.

### 2.2 Positive Supply Pin (V<sub>DD</sub>)

This pin is connected to the positive supply voltage of the system.

### 2.3 External Inductor Pin (LX)

This is the open drain NMOS output used to drive the boost converter inductor. The inductor should be connected from this pin to the positive supply voltage through a low resistance path.

### 2.4 Negative Supply Pin (V<sub>SS</sub>)

This pin is connected to the negative supply voltage of the system.

### 2.5 Boost Converter Output Pin (V<sub>O</sub>)

This is the output pin of the boost converter, typically 10V.

### 2.6 Horn Brass Pin (HORNB)

This pin is connected to the metal electrode (B) of the piezoelectric transducer.

### 2.7 Horn Silver Pin (HORNS)

This is the complementary output to HORNB. It connects to the ceramic electrode (S) of the piezoelectric transducer.

### 2.8 Horn Enable Pin (HRNEN)

This is the logic input for horn enable. [Tables 2-2](#) and [2-3](#) show the different HRNEN states and their description.

**TABLE 2-2: RE46C317 HORN ENABLE**

State	Description
Tri-state	Standby mode; Boost converter is Disabled, Horn is Disabled
Low	Boost converter is Enabled, Horn is Disabled
High	Boost converter is Enabled, Horn is Enabled

**TABLE 2-3: RE46C318 HORN ENABLE**

State	Description
Low	Standby mode; Boost converter is Disabled, Horn is Disabled
High	Boost converter is Enabled, Horn is Enabled

# RE46C317/18

---

NOTES:



## 3.0 DEVICE DESCRIPTION

RE46C317 and RE46C318 have three main blocks:

- Horn driver
- Boost regulator
- Horn Enable logic

The following sections describe these blocks.

### 3.1 Horn Driver

The horn driver is a push-pull circuit, capable of driving a three-terminal piezoelectric horn. It can also drive a modified two-terminal Piezo horn.

### 3.2 Horn Enable

In RE46C317, the HRNEN is a tri-state signal with three valid states: low, high and tri-state (or mid-supply). The three levels of HRNEN determine the modes of operation.

When HRNEN is in tri-state, the device is in Standby mode and all circuits are disabled. This is the lowest current operating mode.

When HRNEN is low, the device is in Boost-Only mode. In this mode, only the boost regulator is enabled and the output voltage is boosted to 10V nominally. The horn driver circuit is disabled in this mode. This mode can be used to check for a low battery condition.

When HRNEN is high, the part is in Normal Operation. The boost regulator and the horn driver circuits are enabled in this mode.

The RE46C318 uses a binary logic circuit, rather than tri-state logic, to determine the mode of operation.

When HRNEN is low, the boost and horn driver circuits are disabled and the device is in Standby. This is the lowest current operating mode.

When HRNEN is high, the boost and horn driver circuits are enabled.

### 3.3 Boost Regulator

The boost regulator in the RE46C317/18 is a current-mode controller with two control loops, that work together in maintaining a constant output voltage and supply the required load current. The inner current control loop provides cycle-by-cycle current limiting, while the outer control loop provides output voltage control. When the boost converter is turned on using the HRNEN input, the NMOS switch turns on and the inductor current ramps up to its peak value, approximately 0.6A nominally.

The current comparator turns off the NMOS switch for a fixed period of time to allow energy to be transferred to the output capacitor. When the voltage on the output capacitor equals or exceeds the desired output voltage, 10V nominally, the current loop is disabled until the load discharges the output capacitor to a voltage lower than the desired output voltage.

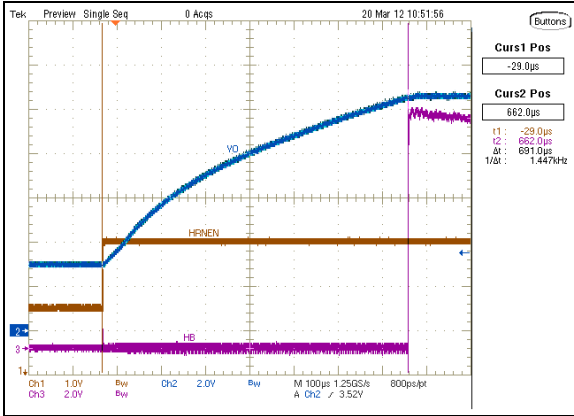
Every time the output voltage falls below the desired value, the switching cycle starts and continues until the desired value is reached. The constant switching resulting in the charging and discharging of the output capacitor causes a ripple on the output voltage. The ripple on the output voltage depends on the external component parameters, such as the value of external capacitor, its ESR, etc.

In both RE46C317 and RE46C318, when logic high is asserted on the HRNEN pin, the boost regulator is enabled. However, the horn output is not enabled until the output voltage reaches its nominal set point, 10V nominally. This ensures that the output voltage rises quickly to the necessary drive voltage for the Piezo horn.

The boost regulator has been optimized to work with the external components as shown in the [Typical Application](#) circuit.

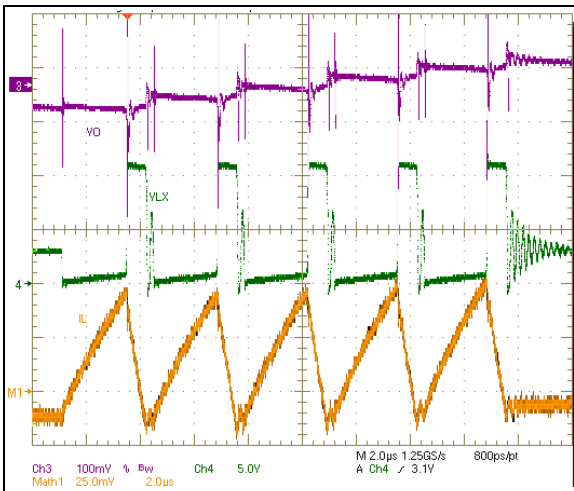
# RE46C317/18

Figure 3-1 shows the horn turn-on delay after the HRNEN has been asserted high. After the boost voltage reaches its nominal set point, the HORN output turns on. In this case, the HORN output is driving a load current of 20 mA DC.



**FIGURE 3-1:** RE46C317 Horn Turn-On Delay.

Figure 3-2 shows the typical switching waveforms of the boost regulator. The top waveform shows the boost output, the center waveform shows the LX switching waveform, and the lower waveform shows the inductor current.

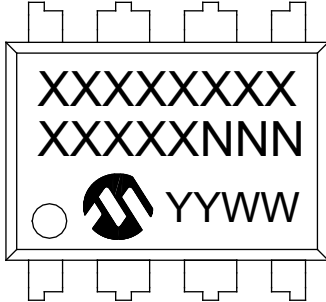


**FIGURE 3-2:** RE46C317/18 Switching Waveforms.

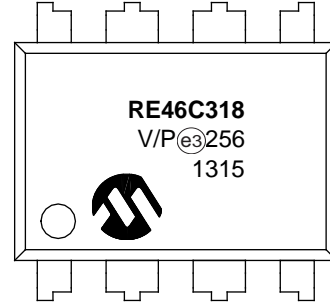
## 4.0 PACKAGING INFORMATION

### 4.1 Package Marking Information

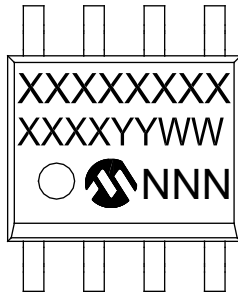
8-Lead PDIP (300 mil)



Example



8-Lead SOIC (3.90 mm)



Example



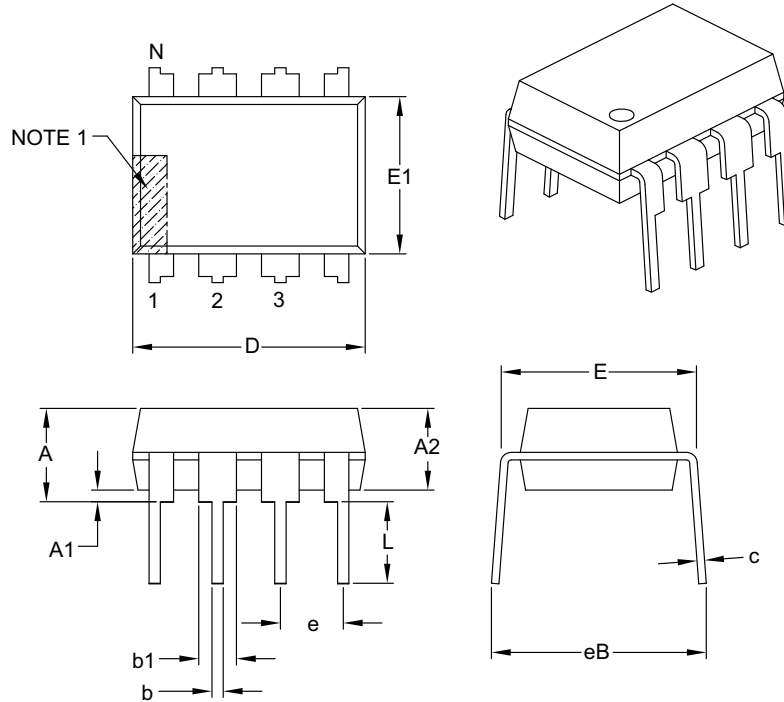
<b>Legend:</b>	XX...X	Customer-specific information
	Y	Year code (last digit of calendar year)
	YY	Year code (last 2 digits of calendar year)
	WW	Week code (week of January 1 is week '01')
	NNN	Alphanumeric traceability code
	(e3)	Pb-free JEDEC designator for Matte Tin (Sn)
	*	This package is Pb-free. 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 customer-specific information.

# RE46C317/18

## 8-Lead Plastic Dual In-Line (P) – 300 mil Body [PDIP]

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



Dimension Limits	Units	INCHES		
		MIN	NOM	MAX
Number of Pins	N	8		
Pitch	e	.100 BSC		
Top to Seating Plane	A	–	–	.210
Molded Package Thickness	A2	.115	.130	.195
Base to Seating Plane	A1	.015	–	–
Shoulder to Shoulder Width	E	.290	.310	.325
Molded Package Width	E1	.240	.250	.280
Overall Length	D	.348	.365	.400
Tip to Seating Plane	L	.115	.130	.150
Lead Thickness	c	.008	.010	.015
Upper Lead Width	b1	.040	.060	.070
Lower Lead Width	b	.014	.018	.022
Overall Row Spacing §	eB	–	–	.430

### Notes:

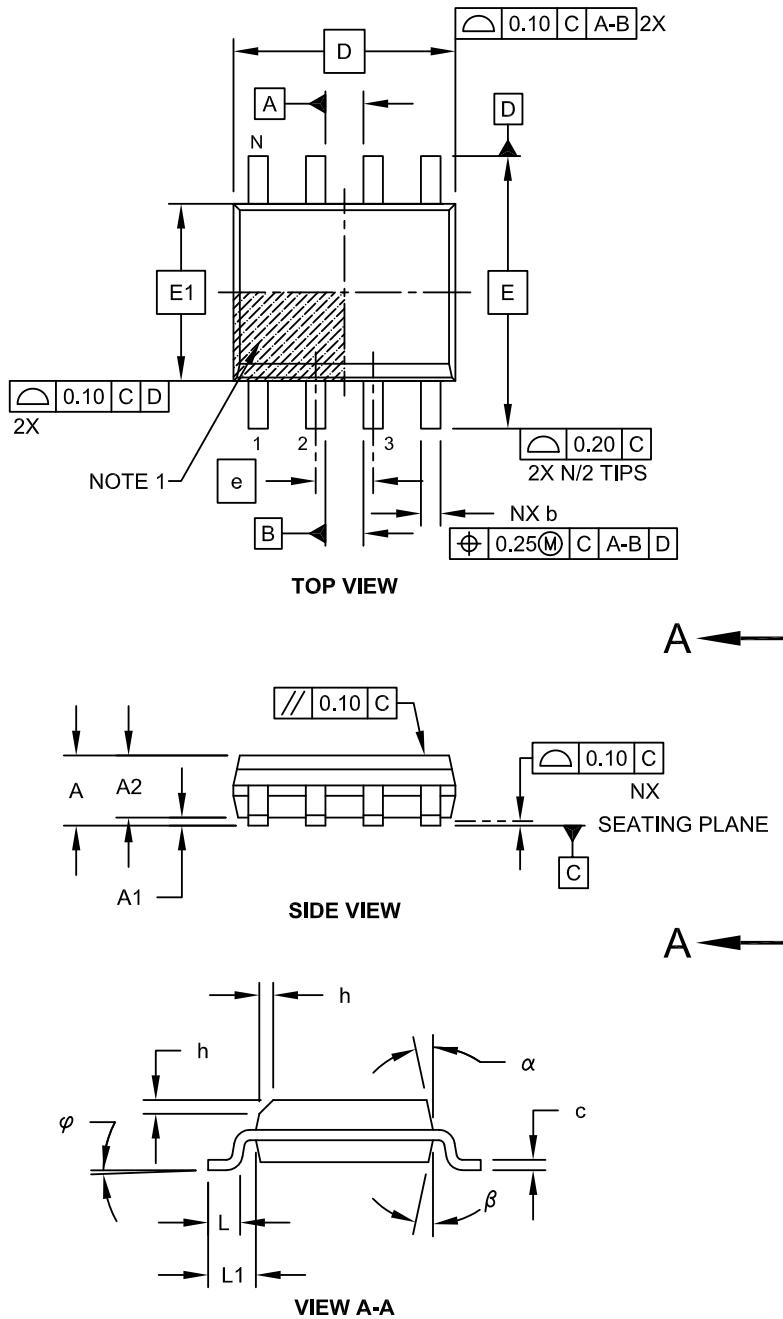
- Pin 1 visual index feature may vary, but must be located with the hatched area.
- § Significant Characteristic.
- Dimensions D and E1 do not include mold flash or protrusions. Mold flash or protrusions shall not exceed .010" per side.
- Dimensioning and tolerancing per ASME Y14.5M.

BSC: Basic Dimension. Theoretically exact value shown without tolerances.

Microchip Technology Drawing C04-018B

## 8-Lead Plastic Small Outline (SN) - Narrow, 3.90 mm Body [SOIC]

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

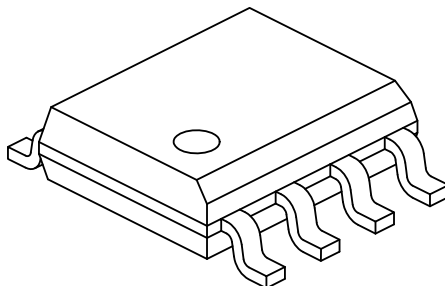


Microchip Technology Drawing No. C04-057C Sheet 1 of 2

# RE46C317/18

## 8-Lead Plastic Small Outline (SN) - Narrow, 3.90 mm Body [SOIC]

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



Dimension Limits	Units	MILLIMETERS		
		MIN	NOM	MAX
Number of Pins	N	8		
Pitch	e	1.27 BSC		
Overall Height	A	-	-	1.75
Molded Package Thickness	A2	1.25	-	-
Standoff §	A1	0.10	-	0.25
Overall Width	E	6.00 BSC		
Molded Package Width	E1	3.90 BSC		
Overall Length	D	4.90 BSC		
Chamfer (Optional)	h	0.25	-	0.50
Foot Length	L	0.40	-	1.27
Footprint	L1	1.04 REF		
Foot Angle	$\varphi$	0°	-	8°
Lead Thickness	c	0.17	-	0.25
Lead Width	b	0.31	-	0.51
Mold Draft Angle Top	$\alpha$	5°	-	15°
Mold Draft Angle Bottom	$\beta$	5°	-	15°

### Notes:

1. Pin 1 visual index feature may vary, but must be located within the hatched area.
2. § Significant Characteristic
3. Dimensions D and E1 do not include mold flash or protrusions. Mold flash or protrusions shall not exceed 0.15mm per side.
4. Dimensioning and tolerancing per ASME Y14.5M

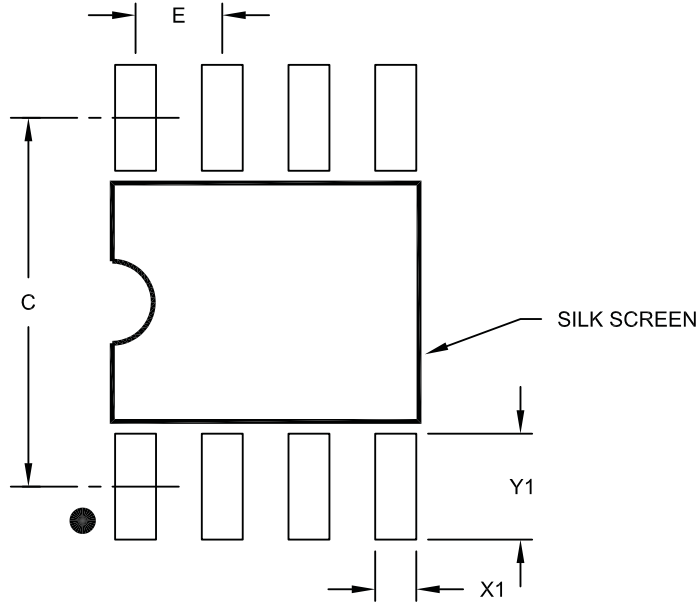
BSC: Basic Dimension. Theoretically exact value shown without tolerances.

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

Microchip Technology Drawing No. C04-057C Sheet 2 of 2

## 8-Lead Plastic Small Outline (SN) – Narrow, 3.90 mm Body [SOIC]

**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	1.27 BSC		
Contact Pad Spacing	C	5.40		
Contact Pad Width (X8)	X1			0.60
Contact Pad Length (X8)	Y1			1.55

**Notes:**

1. Dimensioning and tolerancing per ASME Y14.5M

BSC: Basic Dimension. Theoretically exact value shown without tolerances.

Microchip Technology Drawing No. C04-2057A

# RE46C317/18

---

NOTES:



## APPENDIX A: REVISION HISTORY

### Revision B (May 2013)

The following has been modified:

1. Added Maximum Human Body Model ESD value to [Section 1.1, Absolute Maximum Ratings†](#).

### Revision A (June 2012)

- Original Release of this Document.

# RE46C317/18

---

NOTES:

## PRODUCT IDENTIFICATION SYSTEM

To order or obtain information, e.g., on pricing or delivery, refer to the factory or the listed sales office.

<u>PART NO.</u>	X	X	X
Device	Package	Number of Pins	Lead Free/ Tape and Reel
<b>Device:</b> RE46C317 CMOS Piezo Horn Driver IC RE46C318 CMOS Piezo Horn Driver IC			
<b>Package:</b> E = Plastic Dual In-Line (300 mil Body), 8-Lead (PDIP) S = Small Plastic Outline - Narrow, 3.90 mm Body, 8-Lead (SOIC)			
<b>Examples:</b>			
a) RE46C317E8F:	8LD PDIP package, Lead Free		
b) RE46C317S8F:	8LD SOIC package, Lead Free		
c) RE46C317S8TF:	8LD SOIC package, Tape and Reel		
a) RE46C318E8F:	8LD PDIP package, Lead Free		
b) RE46C318S8F:	8LD SOIC package, Lead Free		
c) RE46C318S8TF:	8LD SOIC package, Tape and Reel		

# RE46C317/18

---

NOTES:

---

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

- Microchip products meet the specification contained in their particular Microchip Data Sheet.
- Microchip believes that its family of products is one of the most secure families of its kind on the market today, when used in the intended manner and under normal conditions.
- There are dishonest and possibly illegal methods used to breach the code protection feature. All of these methods, to our knowledge, require using the Microchip products in a manner outside the operating specifications contained in Microchip's Data Sheets. Most likely, the person doing so is engaged in theft of intellectual property.
- Microchip is willing to work with the customer who is concerned about the integrity of their code.
- Neither Microchip nor any other semiconductor manufacturer can guarantee the security of their code. Code protection does not mean that we are guaranteeing the product as “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 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. 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 ITS CONDITION, QUALITY, PERFORMANCE, MERCHANTABILITY OR FITNESS FOR PURPOSE. Microchip disclaims all liability arising from this information and its use. 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.

#### **Trademarks**

The Microchip name and logo, the Microchip logo, dsPIC, FlashFlex, KEELOQ, KEELOQ logo, MPLAB, PIC, PICmicro, PICSTART, PIC<sup>32</sup> logo, rPIC, SST, SST Logo, SuperFlash and UNI/O are registered trademarks of Microchip Technology Incorporated in the U.S.A. and other countries.

FilterLab, Hampshire, HI-TECH C, Linear Active Thermistor, MTP, SEEVAL and The Embedded Control Solutions Company are registered trademarks of Microchip Technology Incorporated in the U.S.A.

Silicon Storage Technology is a registered trademark of Microchip Technology Inc. in other countries.

Analog-for-the-Digital Age, Application Maestro, BodyCom, chipKIT, chipKIT logo, CodeGuard, dsPICDEM, dsPICDEM.net, dsPICworks, dsSPEAK, ECAN, ECONOMONITOR, FanSense, HI-TIDE, In-Circuit Serial Programming, ICSP, Mindi, MiWi, MPASM, MPF, MPLAB Certified logo, MPLIB, MPLINK, mTouch, Omniclient Code Generation, PICC, PICC-18, PICDEM, PICDEM.net, PICkit, PICTail, REAL ICE, rLAB, Select Mode, SQI, Serial Quad I/O, Total Endurance, TSHARC, UniWinDriver, WiperLock, ZENA and Z-Scale 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.

GestIC and ULPP are registered trademarks 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.

© 2012-2013, Microchip Technology Incorporated, Printed in the U.S.A., All Rights Reserved.

 Printed on recycled paper.

ISBN: 978-1-62077-213-3

**QUALITY MANAGEMENT SYSTEM**  
**CERTIFIED BY DNV**  
**== ISO/TS 16949 ==**

*Microchip received ISO/TS-16949:2009 certification for its worldwide headquarters, design and wafer fabrication facilities in Chandler and Tempe, Arizona; Gresham, Oregon and design centers in California and India. The Company's quality system processes and procedures are for its PIC<sup>®</sup> MCUs and dsPIC<sup>®</sup> DSCs, KEELOQ<sup>®</sup> code hopping devices, Serial EEPROMs, microperipherals, nonvolatile memory and analog products. In addition, Microchip's quality system for the design and manufacture of development systems is ISO 9001:2000 certified.*



# 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

**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

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

**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: 86-10-8569-7000  
Fax: 86-10-8528-2104

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

**China - Chongqing**  
Tel: 86-23-8980-9588  
Fax: 86-23-8980-9500

**China - Hangzhou**  
Tel: 86-571-2819-3187  
Fax: 86-571-2819-3189

**China - Hong Kong SAR**  
Tel: 852-2943-5100  
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: 86-755-8864-2200  
Fax: 86-755-8203-1760

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

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

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

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

### ASIA/PACIFIC

**India - Bangalore**  
Tel: 91-80-3090-4444  
Fax: 91-80-3090-4123

**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 - Osaka**  
Tel: 81-6-6152-7160  
Fax: 81-6-6152-9310

**Japan - Tokyo**  
Tel: 81-3-6880-3770  
Fax: 81-3-6880-3771

**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: 886-3-5778-366  
Fax: 886-3-5770-955

**Taiwan - Kaohsiung**  
Tel: 886-7-213-7828  
Fax: 886-7-330-9305

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

11/29/12