

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

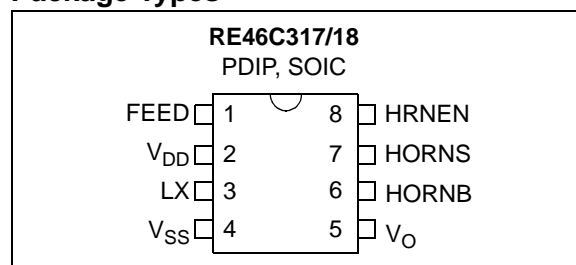
Description:

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.

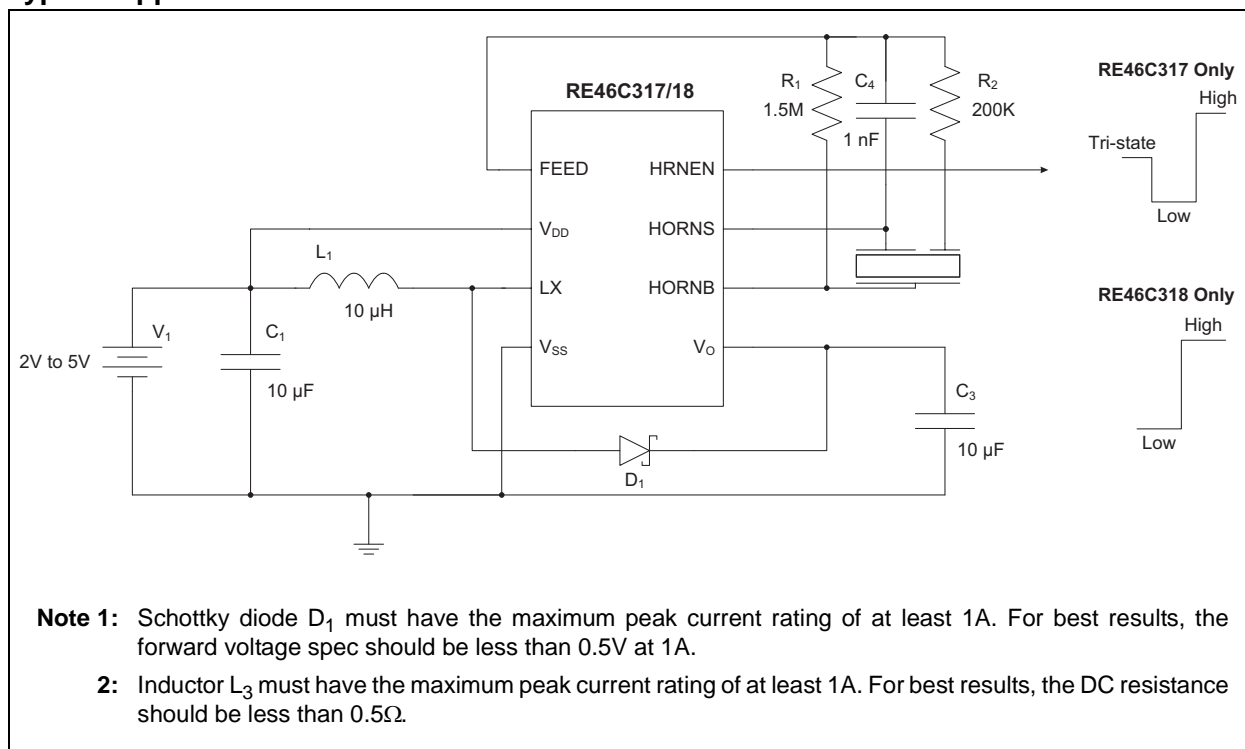
The RE46C317/18 are compatible with the RE46C117 device and offer lower standby current.

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

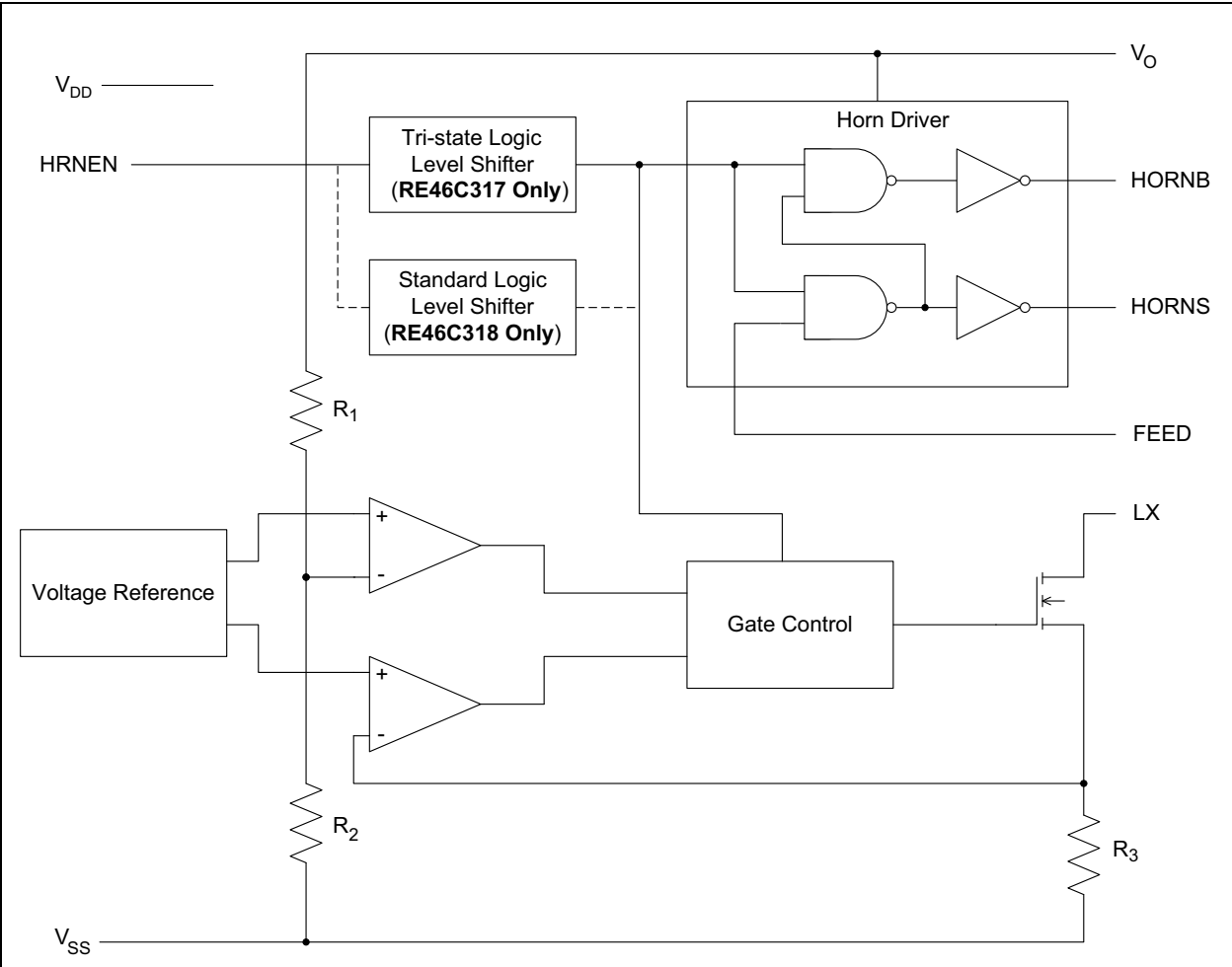


Typical Application



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°C to +60°C |
| Storage Temperature | T _{STG} = -55°C to +125°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°C to +60°C, V_{DD} = 3V, V_{SS} = 0V, C₃ = 10 μF. Typical values are at T_A = +25°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 | μA | HRNEN = Float; No loads |
| Standby I _{VO} | I _{VO1} | 5 | — | 0 | 0.3 | μA | HRNEN = Float; No loads |
| Quiescent Supply Current | I _{DD2} | 2 | — | 27 | 49 | μA | HRNEN = Low; No Loads; V _O = 11V; V _{LX} = 0.5V |
| Quiescent I _{VO} | I _{VO2} | 5 | — | 71 | 115 | μA | HRNEN = Low; No Loads; V _O = 11V; V _{LX} = 0.5V |
| Supply current | I _{SUP} | 2 | — | 300 | — | μA | HRNEN = Low; No Loads, Boost Running |
| Input Current for Tri-state | I _{IT} | 8 | -5 | — | 5 | μA | HRNEN = Float (Note 4) |
| 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 ~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 0.3Ω. The internal battery resistance should be no more than 0.5Ω. A low ESR capacitance of 10 μF 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°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 | μA | FEED = 22V; $V_O = 10\text{V}$ |
| | I_{ILF} | 1 | -50 | -15 | — | μA | FEED = -10V; $V_O = 10\text{V}$ |
| | I_{IHH} | 8 | — | 20 | 50 | μA | HRNEN = V_{DD} |
| | I_{ILH} | 8 | -50 | -20 | — | μA | HRNEN = V_{SS} |
| Output Leakage | I_{OZH} | 3 | — | — | 1 | μA | 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 0.3Ω . The internal battery resistance should be no more than 0.5Ω . 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 | μA | 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 | μA | FEED = 22V; $V_O = 10\text{V}$ |
| | I_{ILF} | 1 | -50 | -15 | — | μA | 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 | μA | 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 or HORNS; $I_{OUT} = -16\text{mA}$; $V_{DD} = 3\text{V}$ |
| Output High Voltage | V_{OH} | 6, 7 | 9.5 | 9.7 | — | V | HORN or HORNS; $V_O = 10\text{V}$; $V_{DD} = \text{HRNEN} = 3\text{V}$; $I_{OUT} = 16\text{mA}$ |

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 |
|------------------------------------|---------------|------|-------|------|----------------------|------------|
| Temperature Ranges | | | | | | |
| Operating Temperature Range | T_A | -10 | — | 60 | $^{\circ}\text{C}$ | |
| Storage Temperature Range | T_{STG} | -55 | — | 125 | $^{\circ}\text{C}$ | |
| Thermal Package Resistances | | | | | | |
| Thermal Resistance, 8L-PDIP | θ_{JA} | — | 89.3 | — | $^{\circ}\text{C/W}$ | |
| Thermal Resistance, 8L-SOIC | θ_{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 _{DD} | Positive supply voltage |
| 3 | LX | External inductor |
| 4 | V _{SS} | Negative supply voltage |
| 5 | V _O | 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_{SS}.

2.2 Positive Supply Pin (V_{DD})

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_{SS})

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

2.5 Boost Converter Output Pin (V_O)

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.

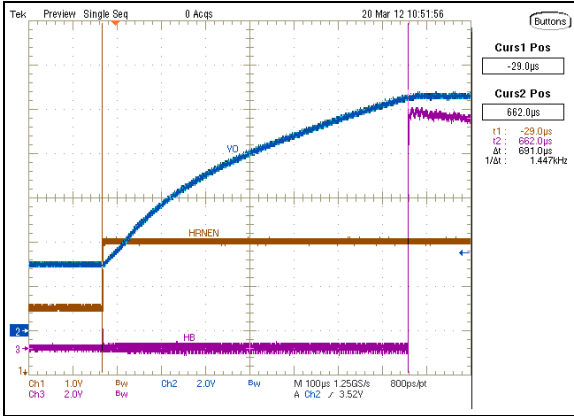


FIGURE 3-1: RE46C317 Horn Turn-On Delay.

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.

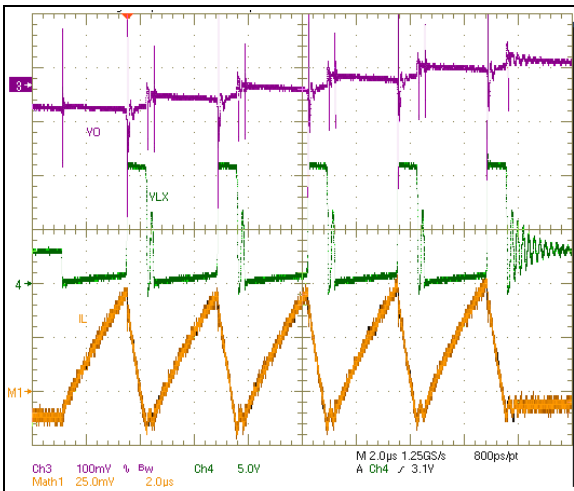
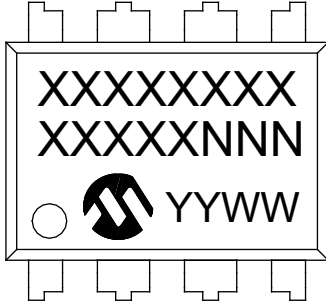


FIGURE 3-2: RE46C317/18 Switching Waveforms.

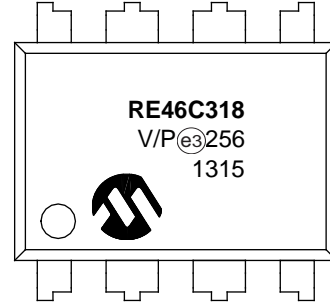
4.0 PACKAGING INFORMATION

4.1 Package Marking Information

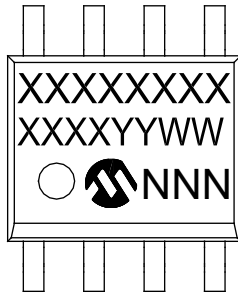
8-Lead PDIP (300 mil)



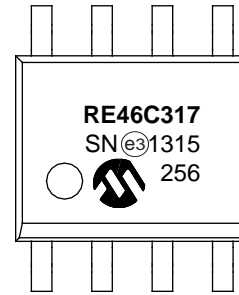
Example



8-Lead SOIC (3.90 mm)



Example



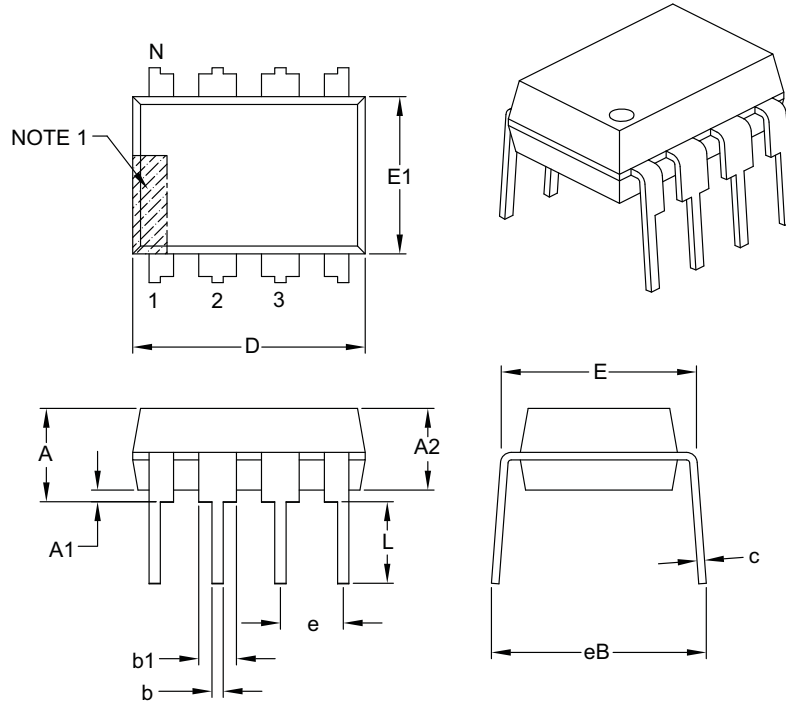
| | | |
|----------------|--------|--|
| Legend: | XX...X | Customer-specific information |
| | Y | Year code (last digit of calendar year) |
| | YY | Year code (last 2 digits of calendar year) |
| | WW | Week code (week of January 1 is week '01') |
| | NNN | Alphanumeric traceability code |
| | (e3) | 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:

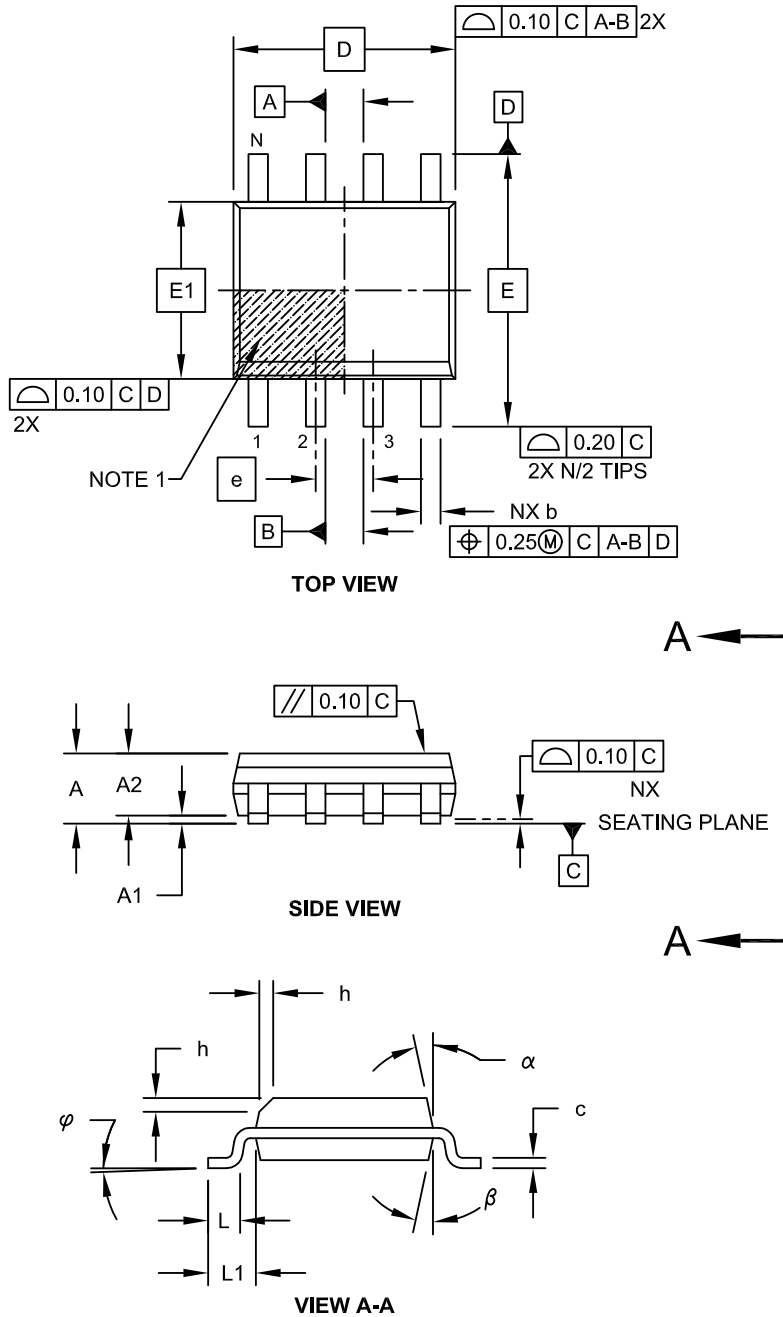
- Pin 1 visual index feature may vary, but must be located with the hatched area.
- § Significant Characteristic.
- Dimensions D and E1 do not include mold flash or protrusions. Mold flash or protrusions shall not exceed .010" per side.
- Dimensioning and tolerancing per ASME Y14.5M.

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>

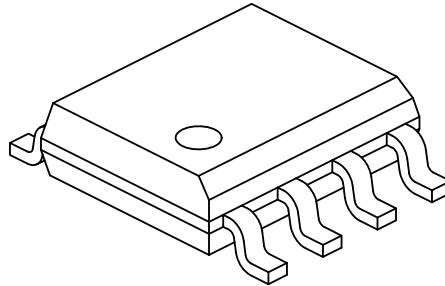


Microchip Technology Drawing No. C04-057C Sheet 1 of 2

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 | φ | 0° | - | 8° |
| Lead Thickness | c | 0.17 | - | 0.25 |
| Lead Width | b | 0.31 | - | 0.51 |
| Mold Draft Angle Top | α | 5° | - | 15° |
| Mold Draft Angle Bottom | β | 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

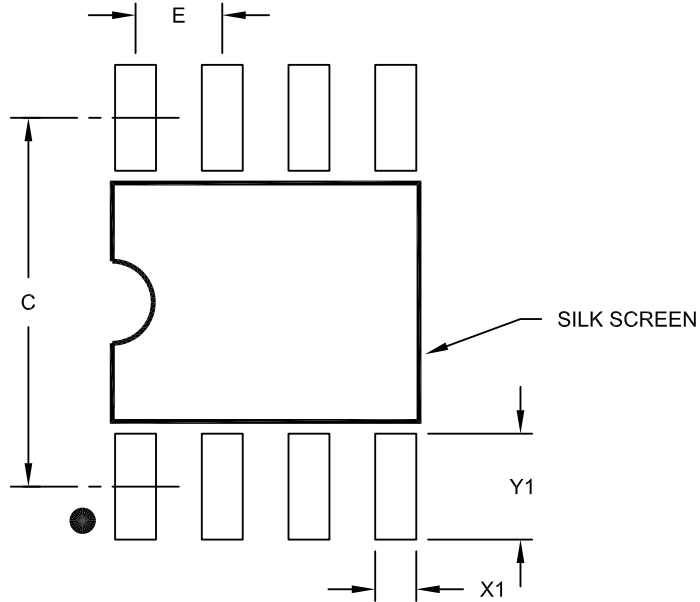
BSC: Basic Dimension. Theoretically exact value shown without tolerances.

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 |
| Device: RE46C317 CMOS Piezo Horn Driver IC RE46C318 CMOS Piezo Horn Driver IC | | | |
| Package: E = Plastic Dual In-Line (300 mil Body), 8-Lead (PDIP) S = Small Plastic Outline - Narrow, 3.90 mm Body, 8-Lead (SOIC) | | | |
| Examples: | | | |
| 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, PIC³² 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[®] MCUs and dsPIC[®] DSCs, KEELOQ[®] 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

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