Chipsmall Limited consists of a professional team with an average of over 10 year of expertise in the distribution of electronic components. Based in Hongkong, we have already established firm and mutual-benefit business relationships with customers from,Europe,America and south Asia,supplying obsolete and hard-to-find components to meet their specific needs.

With the principle of “Quality Parts,Customers Priority,Honest Operation,and Considerate Service”,our business mainly focus on the distribution of electronic components. Line cards we deal with include Microchip,ALPS,ROHM,Xilinx,Pulse,ON,Everlight and Freescale. Main products comprise IC,Modules,Potentiometer,IC Socket,Relay,Connector.Our parts cover such applications as commercial,industrial, and automotives areas.

We are looking forward to setting up business relationship with you and hope to provide you with the best service and solution. Let us make a better world for our industry!

Contact us

Tel: +86-755-8981 8866 Fax: +86-755-8427 6832
Email & Skype: info@chipsmall.com Web: www.chipsmall.com
Address: A1208, Overseas Decoration Building, #122 Zhenhua RD., Futian, Shenzhen, China

PL138-48

2.5V to 3.3V, Low-Skew, 1:4 Differential PECL Fanout Buffer

Features

- Four Differential 2.5V/3.3V LVPECL Output Pairs
- Output Frequency: ≤800 MHz
- Two Selectable Differential Input Pairs
- Translates Any Standard Single-Ended or Differential Input Format to LVPECL Output. It Can Accept the Following Standard Input Formats and More:
  - LVPECL, LVCMOS, LVDS, HCSL, SSTL, LVHSTL, CML
- Output Skew: 25 ps (typ.)
- Part-to-Part Skew: 140 ps (typ.)
- Propagation Delay: 1.5 ns (typ.)
- Additive Jitter: <100 fs (max.)
- Operating Supply Voltage: 2.375V ~ 3.63V
- Operating Temperature Range from –40°C to +85°C
- Package Availability: 16-Pin QFN and 20-Pin TSSOP

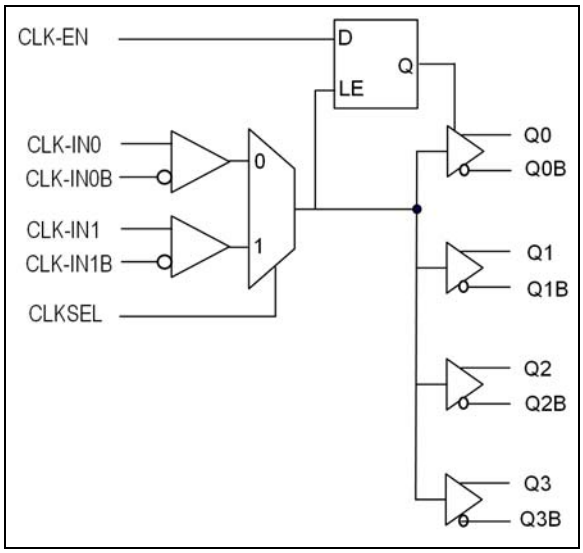
General Description

The PL138-48 is a high performance low-cost 1:4 outputs differential LVPECL fanout buffer.

Microchip's family of differential LVPECL buffers are designed to operate from a single power supply of 2.5V ±5% or 3.3V ±10%. The differential input pairs are designed to accept most standard input signal levels, using an appropriate resistor bias network, and produce a high quality set of outputs with the lowest possible skew on the outputs, which is guaranteed for part-to-part or lot-to-lot skew.

Designed to fit in a small form-factor package, the PL138-48 offers up to 800 MHz of output operation with very low-power consumption and lowest additive jitter of any comparable device.

Block Diagram



1.0 ELECTRICAL CHARACTERISTICS

Absolute Maximum Ratings †

Supply Voltage (V_{DD}) .....+4.6V
Input Voltage, DC (V_I).....–0.5V to V_{DD}+0.5V
Output Voltage, DC (V_O) .....–0.5V to V_{DD}+0.5V
ESD Protection (HBM) .....2 kV

† 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.

DC ELECTRICAL CHARACTERISTICS

Specifications: V_{CC} = 3.3V; V_{EE} = 0V. Input and output parameters vary 1:1 with V_{CC} when V_{CC} varies ±10%.

Parameters	Symbol	Min.	Typ.	Max.	Units	Conditions
Output High Voltage, (Note 1)	V_{OH}	2.215	2.320	2.420	V	At –40°C
		2.275	2.350	2.420		At +25°C
		2.275	2.350	2.420		At +85°C
Output Voltage Low, (Note 1)	V_{OL}	1.470	1.610	1.745	V	At –40°C
		1.490	1.585	1.680		At +25°C
		1.490	1.585	1.680		At +85°C
Input High Voltage	V_{IH}	2.075	—	2.420	V	At –40°C
		2.135	—	2.420		At +25°C
		2.135	—	2.420		At +85°C
Input Low Voltage	V_{IL}	1.470	—	1.890	V	At –40°C
		1.490	—	1.825		At +25°C
		1.490	—	1.825		At +85°C
Output Voltage Reference, (Note 2)	V_{BB}	1.86	—	1.98	V	At –40°C
		1.92	—	2.04		At +25°C
		1.92	—	2.04		At +85°C
Input High Voltage Common Mode Range, (Note 3, Note 4)	V_{CMR}	1.2	—	3.3	V	At –40°C
		1.2	—	3.3		At +25°C
		1.2	—	3.3		At +85°C
Input High Current, (Note 5)	I_{IH}	—	—	75	µA	At –40°C
		—	—	75		At +25°C
		—	—	75		At +85°C
Input Low Current, (Note 5)	I_{IL}	–75	—	—	µA	At –40°C
		–75	—	—		At +25°C
		–75	—	—		At +85°C

Note 1: Outputs terminated with 50Ω to V_{CCO}–2V.
2: Single-ended input operation is limited to VCC ≥ 3V in LVPECL mode.
3: Common mode voltage is defined as V_{IH}.
4: For single-ended applications, the maximum input voltage for CLK-INx, CLK-INxB is V_{CC}+0.3V.
5: CLK-IN0, CLK-IN1; CLK-IN0B, CLK-IN1B.

DC ELECTRICAL CHARACTERISTICS

Specifications: V_{CC} = 2.5V; V_{EE} = 0V. Input and output parameters vary 1:1 with V_{CC} when V_{CC} varies ±5%.

Parameters	Symbol	Min.	Typ.	Max.	Units	Conditions
Output High Voltage, (Note 1)	V_{OH}	1.415	1.520	1.620	V	At –40°C
		1.475	1.550	1.620		At +25°C
		1.475	1.550	1.620		At +85°C
Output Voltage Low, (Note 1)	V_{OL}	0.670	0.810	0.945	V	At –40°C
		0.690	0.785	0.880		At +25°C
		0.690	0.785	0.880		At +85°C
Input High Voltage	V_{IH}	1.275	—	1.620	V	At –40°C
		1.335	—	1.620		At +25°C
		1.335	—	1.620		At +85°C
Input Low Voltage	V_{IL}	0.670	—	1.090	V	At –40°C
		0.690	—	1.025		At +25°C
		0.690	—	1.025		At +85°C
Input High Voltage Common Mode Range, (Note 2, Note 3)	V_{CMR}	1.2	—	2.5	V	At –40°C
		1.2	—	2.5		At +25°C
		1.2	—	2.5		At +85°C
Input High Current, (Note 4)	I_{IH}	—	—	60	µA	At –40°C
		—	—	60		At +25°C
		—	—	60		At +85°C
Input Low Current, (Note 4)	I_{IL}	–60	—	—	µA	At –40°C
		–60	—	—		At +25°C
		–60	—	—		At +85°C

Note 1: Outputs terminated with 50Ω to V_{CCO}–2V.

2: Common mode voltage is defined as V_{IH}.

3: For single-ended applications, the maximum input voltage for CLK-INx, CLK-INxB is V_{CC}+0.3V.

4: CLK-IN0, CLK-IN1; CLK-IN0B, CLK-IN1B.

AC ELECTRICAL CHARACTERISTICS

V_{CC} = –3.8V to –2.375 or V_{CC} = 2.375V to 3.8V; V_{EE} = 0V; T_A = –40°C to +85°C. All parameters are measured at f ≤ 800 MHz unless otherwise noted.

Parameters	Symbol	Min.	Typ.	Max.	Units	Conditions
Output Frequency	f_{MAX}	—	—	800	MHz	At all temperatures
Propagation Delay, (Note 1)	t_{PD}	600	680	750	ps	At –40°C
		650	725	790		At +25°C
		690	790	890		At +85°C
Output Skew, (Note 2, Note 4)	$t_{SK(O)}$	—	25	37	ps	At all temperatures
Part-to-Part Skew, (Note 3, Note 4)	$t_{SK(PP)}$	—	85	225	ps	At all temperatures
Buffer Additive Phase Jitter, RMS	t_{APJ}	—	—	0.10	ps	At all temperatures; refer to Noise Characteristics section
Peak-to-Peak Input Voltage (Differential Configuration)	V_{PP}	150	800	1200	mV	At all temperatures
Peak-to-Peak Output Voltage	V_{SWING}	470	800	950	mV	At –40°C
		600	800	930		At +25°C
		600	800	930		At +85°C
Output Rise/Fall Time	t_R/t_F	200	—	550	ps	At all temperatures; 20% to 80% at full output swing.

Note 1: Measured from the differential input crossing point to the differential output crossing point.

2: Defined as skew between outputs at the same supply voltage and with equal load conditions. Measured at the output differential cross points.

3: Defined as skew between outputs on different devices operating at the same supply voltages and with equal load conditions. Using the same type of inputs on each device, the outputs are measured at the differential cross points.

4: This parameter is defined in accordance with JEDEC Standard 65.

TEMPERATURE SPECIFICATIONS (Note 1)

Parameters	Sym.	Min.	Typ.	Max.	Units	Conditions
Temperature Ranges						
Ambient Operating Temperature	T_A	–40	—	+85	°C	Note 2
Junction Temperature	T_J	—	—	+110	°C	—
Storage Temperature Range	T_S	–65	—	+150	°C	—
Soldering Temperature	—	—	—	+260	°C	10 sec.

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 +125°C rating. Sustained junction temperatures above +125°C can impact the device reliability.

2: Operating temperature is guaranteed by design for all parts (commercial and industrial), but tested for commercial grade only.

2.0 PIN DESCRIPTIONS

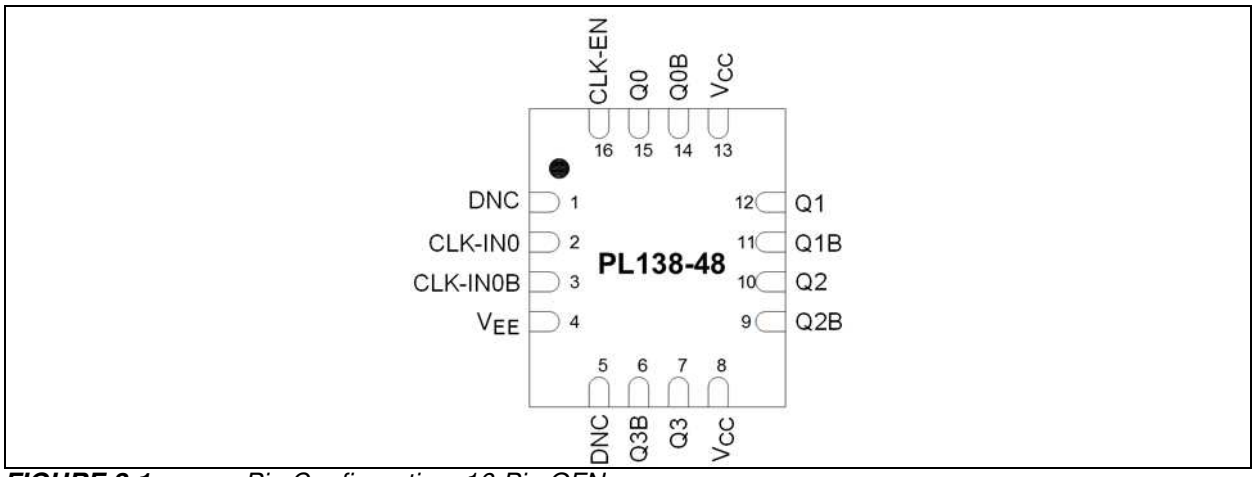


FIGURE 2-1: *Pin Configuration, 16-Pin QFN.*

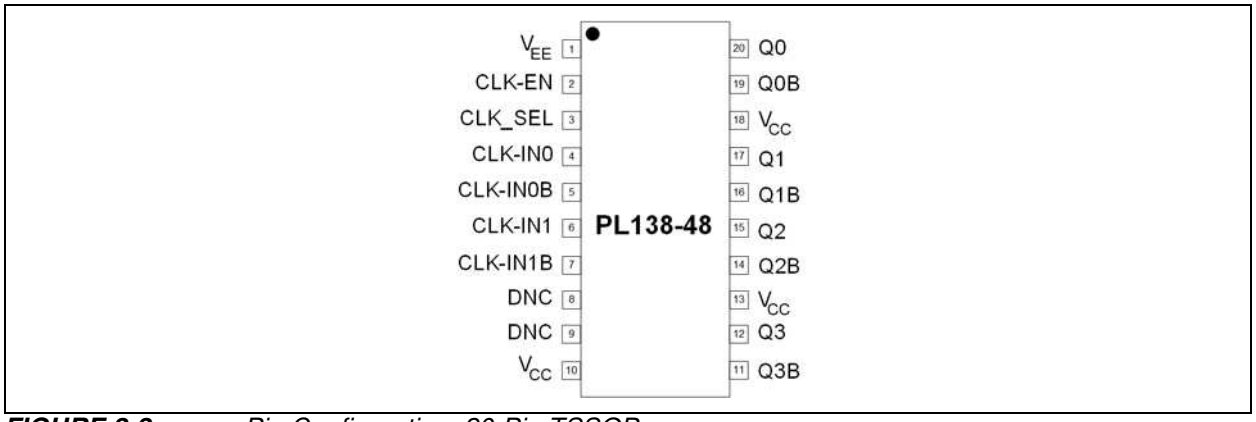


FIGURE 2-2: *Pin Configuration, 20-Pin TSSOP.*

The descriptions of the pins are listed in Table 2-1.

TABLE 2-1: PIN FUNCTION TABLE

Pin Number QFN-16	Pin Number TSSOP-20	Pin Name	Type	Description
4	1	V_{EE}	P	Power supply pin connection.
16	2	CLK-EN	I	Synchronizing clock enable. When HIGH, clock outputs follow clock input. When LOW, Q outputs are forced low, QB outputs are forced high. LVTTL/LVCMOS interface levels. 50 kΩ internal pull-up resistor.
—	3	CLK-SEL	I	Clock select input. When HIGH, selects CLK1 input. When LOW, selects CLK0 input. LVTTL/LVCMOS interface levels. 50 kΩ internal pull-down resistor.
2	4	CLK-IN0	I	True part of differential clock input signal. 75 kΩ internal pull-down resistor.
3	5	CLK-IN0B	I	Complementary part of differential clock input signal. 100 kΩ internal pull-up and pull-down resistors.

TABLE 2-1: PIN FUNCTION TABLE (CONTINUED)

Pin Number QFN-16	Pin Number TSSOP-20	Pin Name	Type	Description
—	6	CLK-IN1	I	True part of differential clock input signal. 75 kΩ internal pull-down resistor.
—	7	CLK-IN1B	I	Complementary part of differential clock input signal. 100 kΩ internal pull-up and pull-down resistors.
1, 5	8, 9	DNC	—	Do Not Connect.
8, 13	10, 13, 18	V_{CC}	P	Power supply pin connection.
6, 9, 11 ,14	11, 14, 16, 19	QB0 ~ QB3	O	LVPECL Complementary output.
7, 10, 12, 15	12, 15, 17, 20	Q0 ~ Q3	O	LVPECL True output.

3.0 NOISE CHARACTERISTICS

When a buffer is used to pass a signal, the buffer adds a little bit of its own noise. The phase noise on the output of the buffer will be a little bit more than the phase noise of the input signal. To quantify the noise addition in the buffer we compare the Phase Jitter numbers from the input and the output. The difference is called "Additive Phase Jitter". The formula for the Additive Phase Jitter is as follows:

EQUATION 3-1:

$$AdditivePhaseJitter = \sqrt{OutputPhaseJitter^2 - InputPhaseJitter^2}$$

TABLE 3-1: PL138-48 NOISE CHARACTERISTICS

Parameters	Symbol	Min.	Typ.	Max.	Units	Conditions
Additive Phase Jitter	t_{APJ}	—	20	40	fs	V_{DD} = 3.3V, Frequency = 622.08 MHz Offset = 12 kHz ~ 20 MHz
		—	50	100		V_{DD} = 3.3V, Frequency = 156.25 MHz Offset = 12 kHz ~ 20 MHz
		—	50	100		V_{DD} = 3.3V, Frequency = 50 MHz Offset = 1 kHz ~ 1 MHz
		—	50	100		V_{DD} = 3.3V, Frequency = 25 MHz Offset = 1 kHz ~ 1 MHz

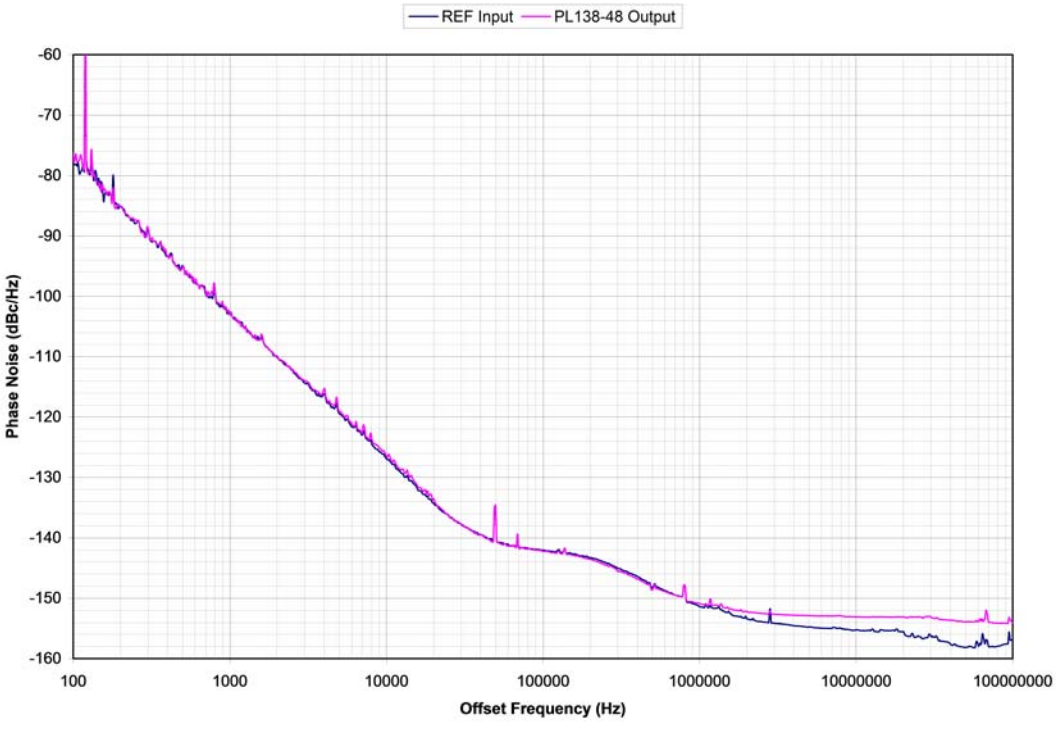


FIGURE 3-1: *PL138-48 Additive Phase Jitter Plot, 622 MHz.*

4.0 PARAMETER MEASUREMENT INFORMATION

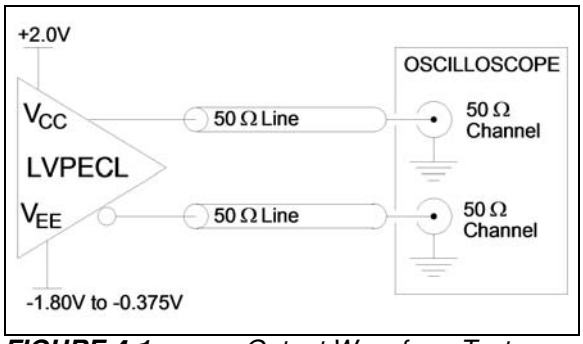


FIGURE 4-1: *Output Waveform Test Circuit.*

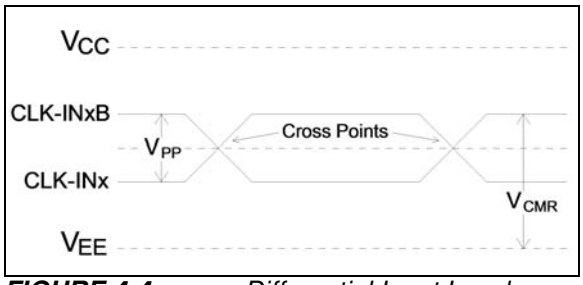


FIGURE 4-4: *Differential Input Level.*

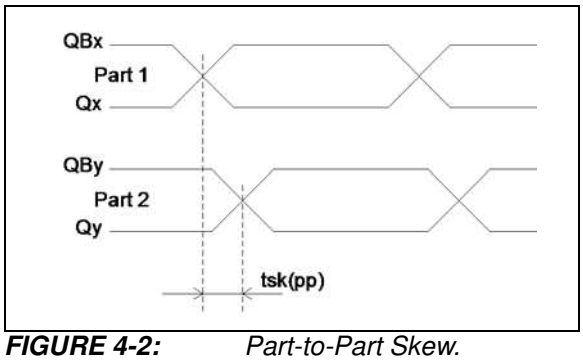


FIGURE 4-2: *Part-to-Part Skew.*

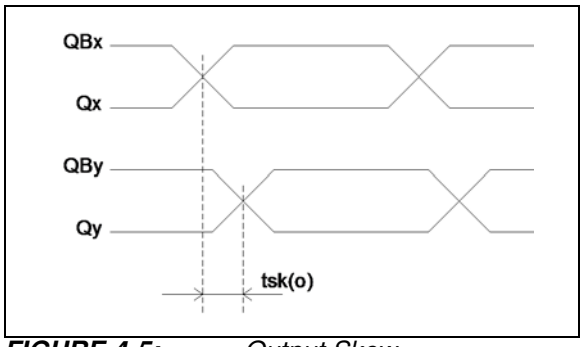


FIGURE 4-5: *Output Skew.*

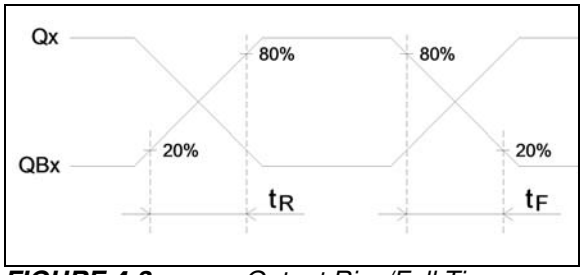


FIGURE 4-3: *Output Rise/Fall Time.*

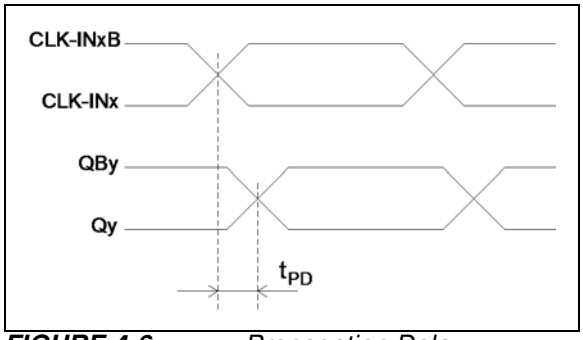


FIGURE 4-6: *Propagation Delay.*

5.0 APPLICATION INFORMATION

5.1 Input Logic Configurations

The following circuits show different configurations for different input logic type signals. For good signal integrity at the PL138 input, the signals need to be properly terminated according to the logic type requirements. The signals need to be presented at the PL138 input according to V_{CMR}, V_{PP}, and other input requirements.

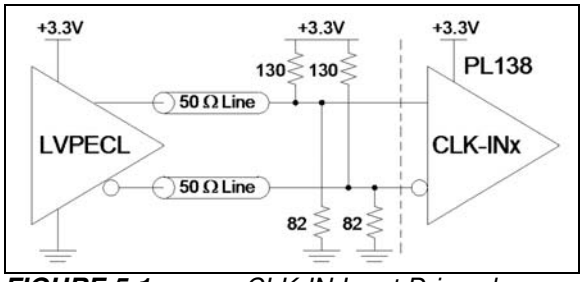


FIGURE 5-1: *CLK-IN Input Driven by a 3.3V LVPECL Driver.*

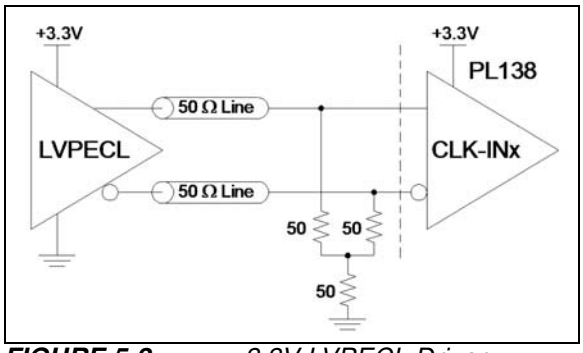


FIGURE 5-2: *3.3V LVPECL Driver, Alternative Termination.*

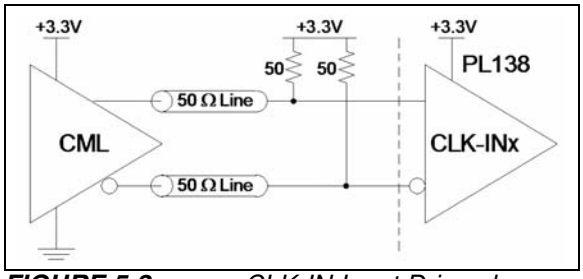


FIGURE 5-3: *CLK-IN Input Driven by a CML Driver.*

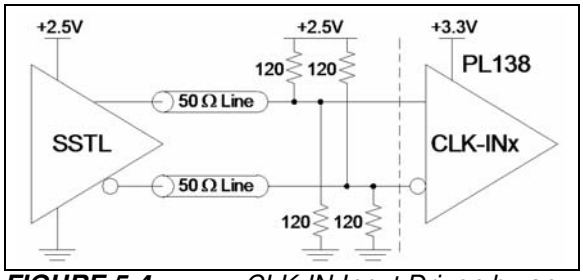


FIGURE 5-4: *CLK-IN Input Driven by an SSTL Driver.*

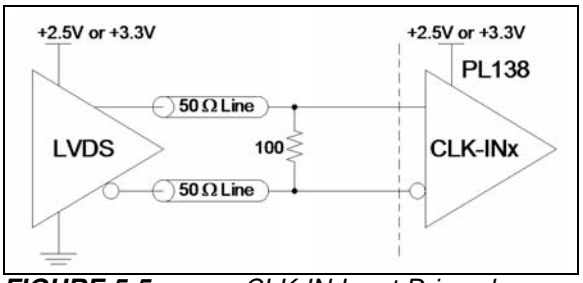


FIGURE 5-5: *CLK-IN Input Driven by an LVDS Driver.*

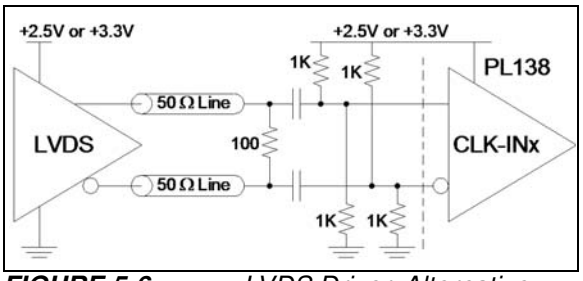


FIGURE 5-6: *LVDS Driver, Alternative AC-Coupling.*

This circuit is for compatibility only. AC-coupling is not really required for LVDS. The V_{CMR} range of the PL138 reaches low enough that LVDS signals can be connected directly to the PL138 input like in the circuit in Figure 5-5.

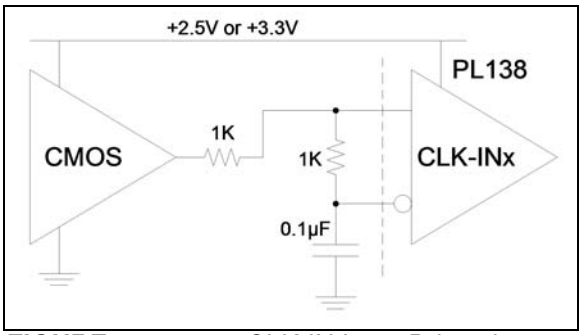


FIGURE 5-7: *CLK-IN Input Driven by a CMOS Driver.*

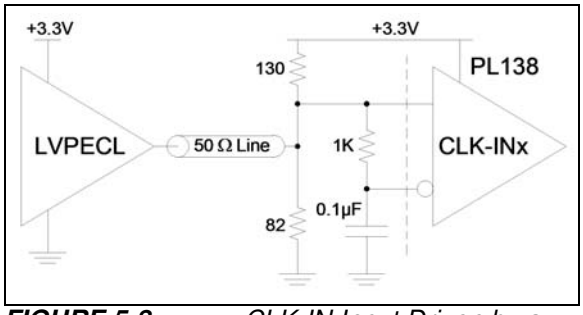


FIGURE 5-8: *CLK-IN Input Driven by a Single-Ended LVPECL.*

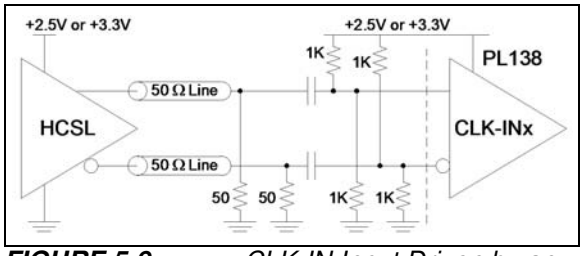


FIGURE 5-9: *CLK-IN Input Driven by an HCSL Driver.*

HCSL presents its signals very close to the ground rail, below the V_{CMR} range, so the HCSL signals cannot be connected to the PL138 input directly. AC-coupling is required for HCSL signals on the PL138 input.

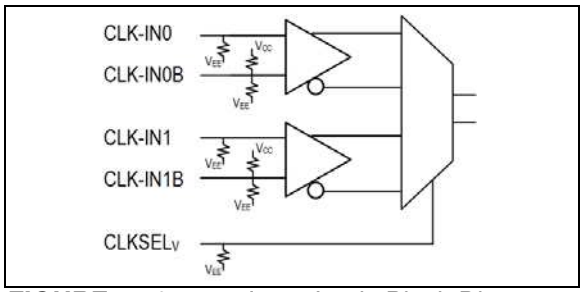


FIGURE 5-10: *Input Logic Block Diagram.*

TABLE 5-1: INPUT PIN CHARACTERISTICS

Input	Parameter	Min.	Typ.	Max.	Units
CLK-IN0, CLK-IN1	Pull-Down Resistor	—	75	—	kΩ
CLK-IN0B, CLK_IN1B	Pull-Up & Pull-Down Resistors	—	100	—	
CLK-EN	Pull-Up Resistor	—	50	—	
CLKSEL	Pull-Down Resistor	—	50	—	

TABLE 5-2: INPUT CLOCK CONTROL SELECTION

CLK_SEL	Selected Source
0	CLK-IN0
1	CLK-IN1

TABLE 5-3: INPUT CLOCK FUNCTION

Inputs			Outputs	
CLK-EN	CLKSEL	Source	Q0:Q3	Q0B:Q3B
0	0	CLK-IN0	Disabled Low	Disabled High
0	1	CLK-IN1	Disabled Low	Disabled High
1	0	CLK-IN0	Enabled	Enabled
1	1	CLK-IN1	Enabled	Enabled

5.2 Termination for LVPECL Outputs

The required termination for LVPECL is 50Ω to a V_{CC}-2V DC voltage level. Below are two schematics to implement this termination.

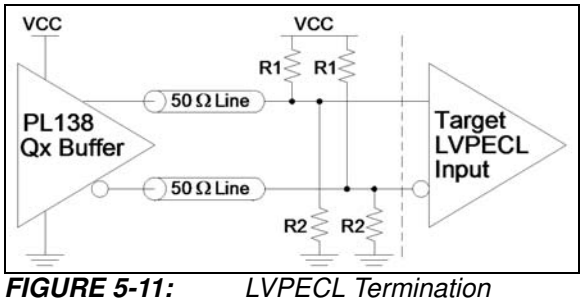


FIGURE 5-11: *LVPECL Termination Schematic #1.*

- V_{CC} = 3.3V
  - Ideal values: R1 = 127Ω, R2 = 82.5Ω
  - Commercial values (E24): R1 = 130Ω, R2 = 82Ω
- V_{CC} = 2.5V
  - Ideal values: R1 = 250Ω, R2 = 62.5Ω
  - Commercial values (E24): R1 = 240Ω, R2 = 62Ω

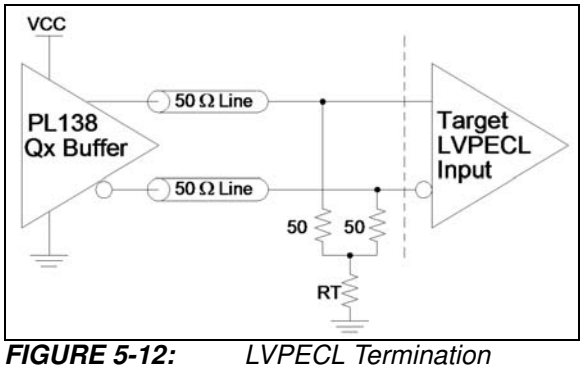


FIGURE 5-12: *LVPECL Termination Schematic #2.*

Schematic #2 is an alternative simplified termination.

- V_{CC} = 3.3V
  - Ideal value: RT = 48.7Ω
  - Commercial value: RT = 50Ω (E24: 51Ω)
- V_{CC} = 2.5V
  - Ideal value: RT = 18.7Ω
  - Commercial value: RT = 18Ω

5.3 Power Considerations

Driving LVPECL outputs requires an amount of power that can warm up the chip significantly.

The general requirement for the chip is that the junction temperature should not exceed +110°C.

The power consumption can be divided into two parts:

1. Core power dissipation
2. Output buffer power dissipation

5.3.1 CORE POWER DISSIPATION

The chip core power is equal to $V_{CC} \times I_{EE}$. With a worst case V_{CC} and I_{EE}, the power dissipation in the core is 3.63V × 45 mA = 163 mW.

5.3.2 OUTPUT BUFFER POWER DISSIPATION

The output buffers are not exposed to the full $V_{CC} - V_{EE}$ voltage. On the differential output, one line is at logic 1 with a small voltage across the buffer and a large output current. The other line is at logic 0 with a larger voltage across the buffer and a smaller output current. The power dissipation per output buffer is 32 mW. Only buffers that are loaded will have power dissipation. With all 4 buffers loaded the worst case output buffer power dissipation will be 128 mW.

Total chip power dissipation, worst case, is 163 mW + 128 mW = 291 mW.

5.3.3 JUNCTION TEMPERATURE

How much the chip is warmed up from the power dissipation depends upon the thermal resistance from the chip to the environment, also known as “junction to ambient”. The thermal resistance depends upon the type of package, how the package is assembled to the PCB and if there is additional air flow for improved cooling.

TABLE 5-4: 20-PIN TSSOP THERMAL RESISTANCE

Air Flow Velocity in Linear Feet/Minute	θ_{JA} Value for JEDEC Standard Multi-Layer PCB
0	73°C/W
200	67°C/W
500	64°C/W

The temperature of the chip (junction) will be higher than the environment (ambient) with an amount equal to $\theta_{JA} \times$ Power. For an ambient temperature of +85°C, all outputs loaded and no air flow, the junction temperature T_J = 85°C + 73 × 0.291 = 106°C.

TABLE 5-5: 16-PIN QFN THERMAL RESISTANCE

Air Flow Velocity in Linear Feet/Minute	θ_{JA} Value for JEDEC Standard Multi-Layer PCB
0	60°C/W
200	53°C/W
500	46°C/W

The temperature of the chip (junction) will be higher than the environment (ambient) with an amount equal to $\theta_{JA} \times$ Power. For an ambient temperature of +85°C, all outputs loaded and no air flow, the junction temperature T_J = 85°C + 60 × 0.291 = 102°C.

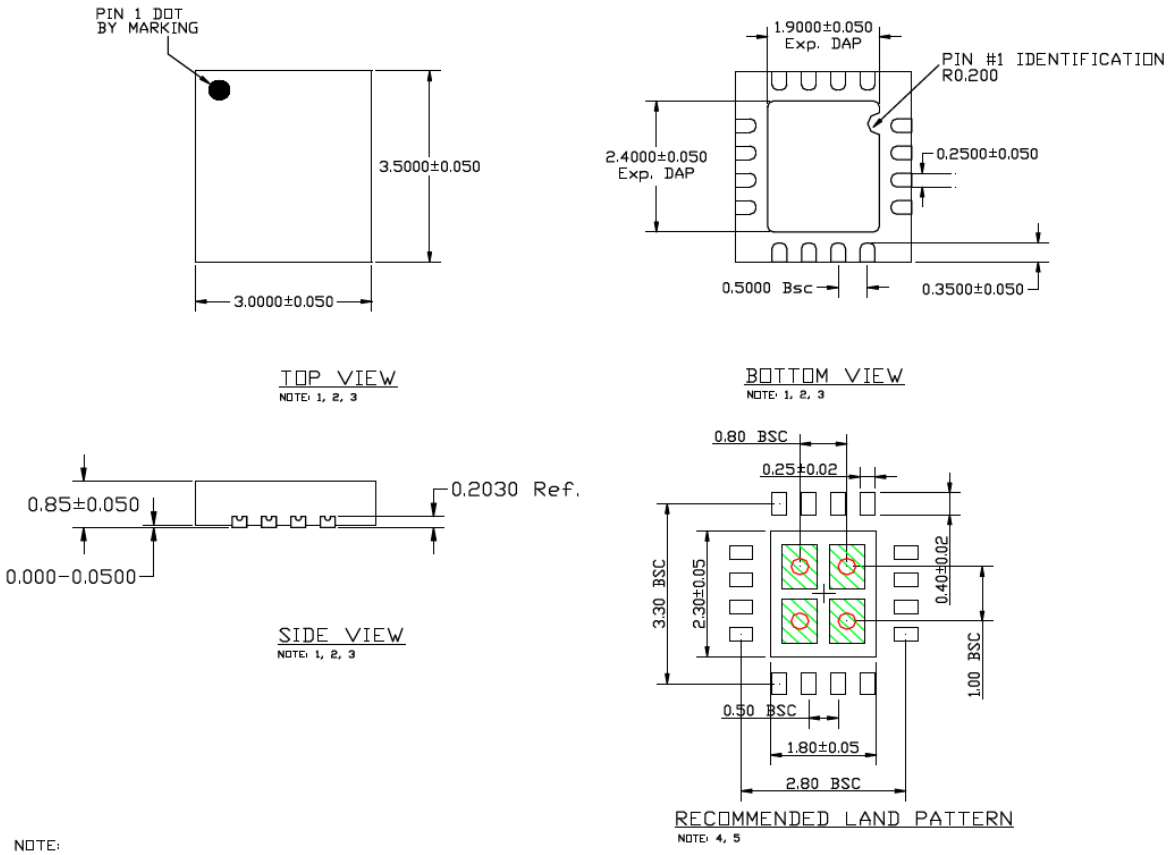
6.0 PACKAGE MARKING INFORMATION

16-Lead QFN 3.0 mm x 3.5 mm Package Outline and Recommended Land Pattern

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

TITLE
16 LEAD QFN 3.0x3.5mm PACKAGE OUTLINE & RECOMMENDED LAND PATTERN

DRAWING #	QFN3035-16LD-PL-1	UNIT	MM



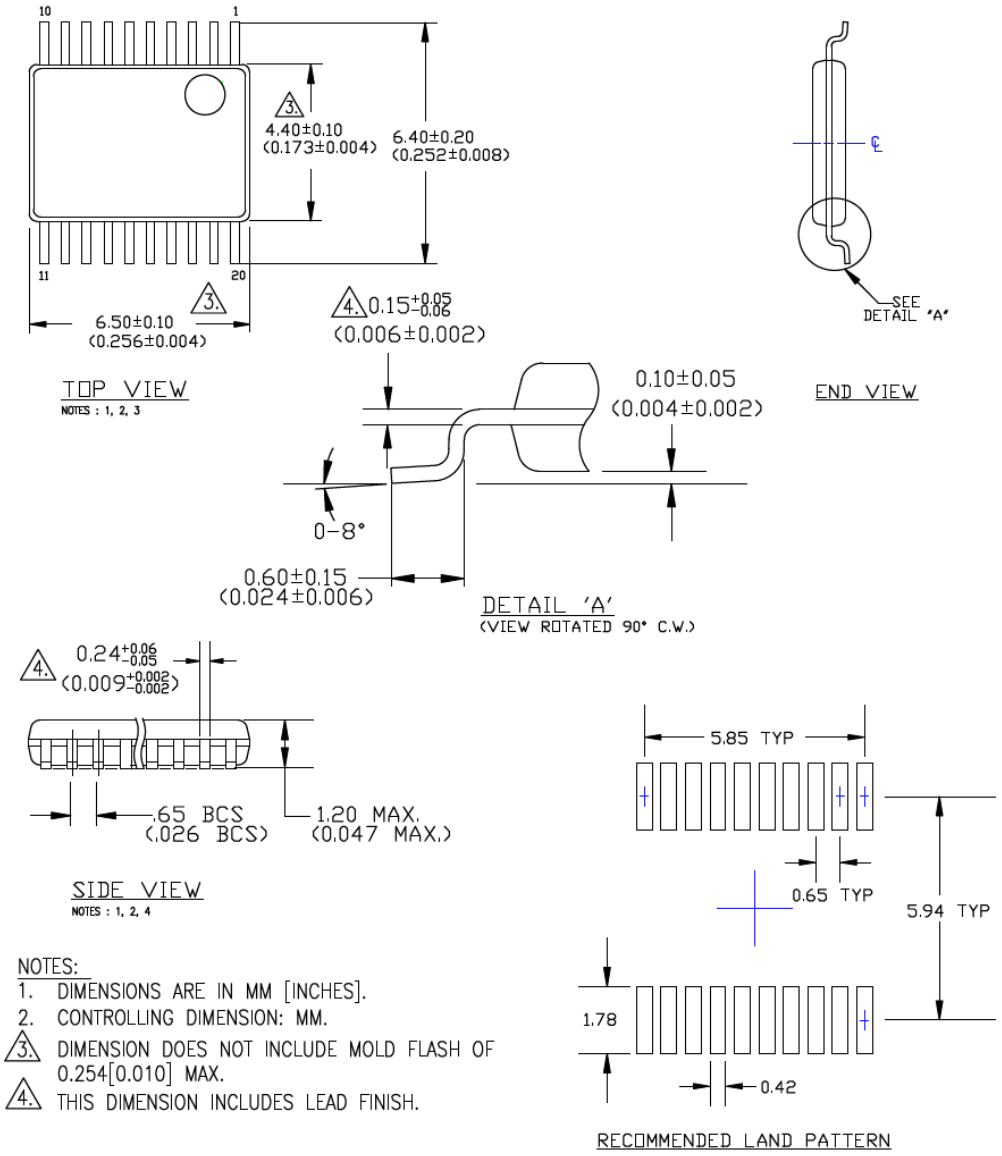
NOTE:
1. MAX PACKAGE WARPAGE IS 0.05 MM
2. MAX ALLOWABLE BURR IS 0.076MM IN ALL DIRECTIONS
3. PIN #1 IS ON TOP WILL BE LASER MARKED
4. RED CIRCLE IN LAND PATTERN REPRESENT THERMAL VIA. RECOMMENDED DIAMETER IS 0.30 - 0.35 MM AND SHOULD BE CONNECTED TO GND FOR MAX THERMAL PERFORMANCE
5. GREEN RECTANGLES (SHADED AREA) REPRESENT SOLDER STENCIL OPENING ON EXPOSED PAD AREA. SIZE SHOULD BE 0.80x0.60 MM, 0.20 MM SPACING.

20-Lead TSSOP Package Outline and Recommended Land Pattern

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

TITLE
20 LEAD TSSOP PACKAGE OUTLINE & RECOMMENDED LAND PATTERN

DRAWING #	TSSOP-20LD-PL-1	UNIT	MM [INCH]



NOTES:
1. DIMENSIONS ARE IN MM [INCHES].
2. CONTROLLING DIMENSION: MM.
3. DIMENSION DOES NOT INCLUDE MOLD FLASH OF 0.254[0.010] MAX.
4. THIS DIMENSION INCLUDES LEAD FINISH.

APPENDIX A: REVISION HISTORY

Revision A (May 2016)

- Converted Micrel data sheet PL138-48 to Microchip DS20005543A.
- Minor text changes throughout.

Revision B (June 2016)

- Updated output frequency tolerances to 800 MHz.

NOTES:

PRODUCT IDENTIFICATION SYSTEM

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

PART NO.	X	X	-X
Device	Package	Temperature Range	Packing Option

Device:	PL138-48:	2.5V - 3.3V, Low-Skew, 1:4 Differential PECL Fanout Buffer	
Package:	O	=	20-Pin TSSOP
	Q	=	16-Pin QFN
Temperature Range:	C	=	0°C to +70°C (Commercial)
	I	=	–40°C to +85°C (Industrial)
Packing Option:	Blank	=	Tube
	R	=	Tape & Reel

Examples:

a) PL138-48OC-R: 2.5V - 3.3V, Low-Skew, 1:4 Differential PECL Fanout Buffer, 20-Pin TSSOP, Commercial Temperature Range, Tape & Reel

b) PL138-48QI: 2.5V - 3.3V, Low-Skew, 1:4 Differential PECL Fanout Buffer, 16-Pin QFN, Industrial Temperature Range, Tube

c) PL138-48OI-R: 2.5V - 3.3V, Low-Skew, 1:4 Differential PECL Fanout Buffer, 20-Pin TSSOP, Industrial Temperature Range, Tape & Reel

d) PL138-48QC: 2.5V - 3.3V, Low-Skew, 1:4 Differential PECL Fanout Buffer, 16-Pin QFN, Commercial Temperature Range, Tube

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.

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.

QUALITY MANAGEMENT SYSTEM
CERTIFIED BY DNV
═ ISO/TS 16949 ═

Trademarks

ISBN: 978-1-5224-0540-5

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

Cleveland
Independence, OH
Tel: 216-447-0464
Fax: 216-447-0643

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

Los Angeles
Mission Viejo, CA
Tel: 949-462-9523
Fax: 949-462-9608

New York, NY
Tel: 631-435-6000

San Jose, CA
Tel: 408-735-9110

Canada - Toronto
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: 852-2943-5100
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 - Dongguan
Tel: 86-769-8702-9880

China - Guangzhou
Tel: 86-20-8755-8029

China - Hangzhou
Tel: 86-571-8792-8115
Fax: 86-571-8792-8116

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

ASIA/PACIFIC

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

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

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: 91-20-3019-1500

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

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 - Dusseldorf
Tel: 49-2129-3766400

Germany - Karlsruhe
Tel: 49-721-625370

Germany - Munich
Tel: 49-89-627-144-0
Fax: 49-89-627-144-44

Italy - Milan
Tel: 39-0331-742611
Fax: 39-0331-466781

Italy - Venice
Tel: 39-049-7625286

Netherlands - Drunen
Tel: 31-416-690399
Fax: 31-416-690340

Poland - Warsaw
Tel: 48-22-3325737

Spain - Madrid
Tel: 34-91-708-08-90
Fax: 34-91-708-08-91

Sweden - Stockholm
Tel: 46-8-5090-4654

UK - Wokingham
Tel: 44-118-921-5800
Fax: 44-118-921-5820

06/17/16