

## Ultra-Small, Ultra-Low Power MEMS Oscillator

### Features

- Wide Frequency Range: 2 KHz to 100 MHz
- Ultra-Low Power Consumption: 3 mA/12  $\mu$ A (Active/Standby)
- Ultra-Small Footprints
  - 1.6 mm  $\times$  1.2 mm
  - 2.0 mm  $\times$  1.6 mm
  - 2.5 mm  $\times$  2.0 mm
  - 3.2 mm  $\times$  2.5 mm
- Frequency Select Input Supports 2 Predefined Frequencies
- High Stability:  $\pm 25$ ,  $\pm 50$  ppm
- Wide Temperature Range
  - Industrial:  $-40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$
  - Ext. Commercial:  $-20^{\circ}$  to  $70^{\circ}\text{C}$
- Excellent Shock & Vibration Immunity
  - Qualified to MIL-STD-883
- High Reliability
  - 20x Better MTF Than Quartz Oscillators
- Supply Range of 1.71V to 3.63V
- Short Sample Lead Time: <2 weeks
- Lead Free & RoHS Compliant

### Applications

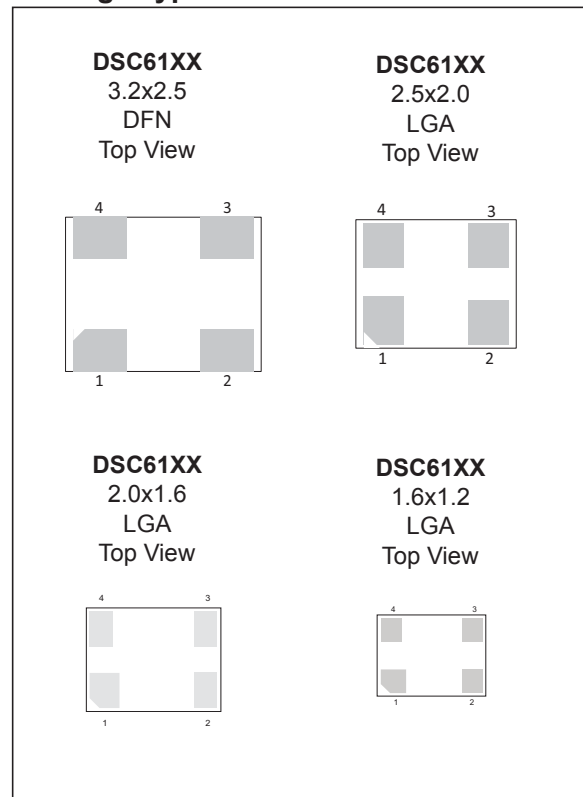
- Low Power/portable Applications - IoT, Embedded/smart Devices
- Consumer - Home Healthcare, Fitness Devices, Home Automation
- Automotive - Rear View/surround View Cameras, Infotainment System
- Industrial - Building/ Factory Automation, Surveillance Camera

### General Description

The DSC61xx family of MEMS oscillators combines the industry leading low power consumption and ultra-small packages with exceptional frequency stability and jitter performance over temperature. The single-output DSC61xx MEMS oscillators are excellent choices for use as clock references in small, battery-powered devices such as wearable and Internet of Things (IoT) devices in which small size, low power consumption, and long-term reliability are paramount. They also meet the stringent mechanical durability and reliability requirements within Automotive Electronics Council standard Q100 (AEC-Q100), so they are well suited for under-hood applications as well.

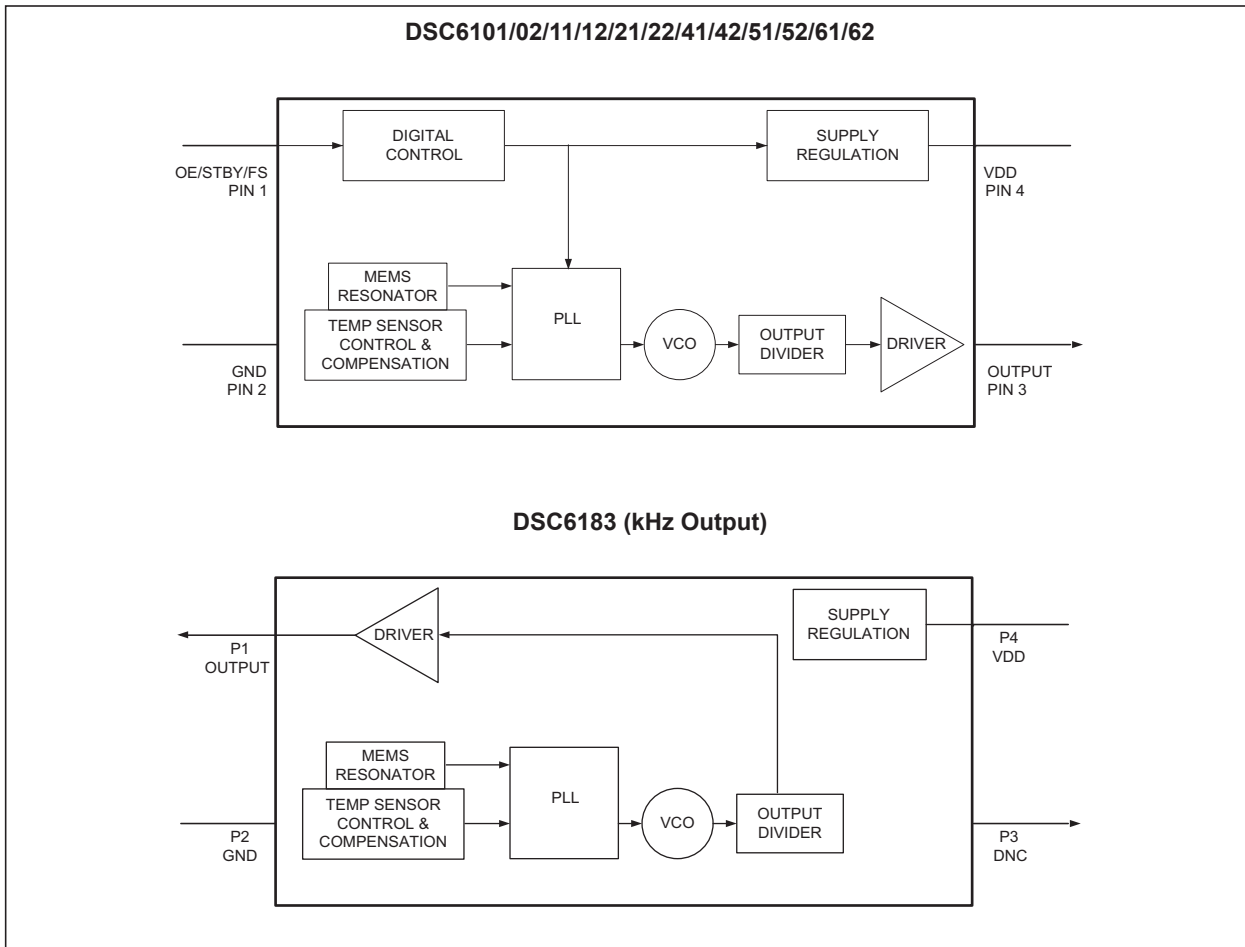
The DSC61xx family is available in ultra-small 1.6 mm  $\times$  1.2 mm and 2.0 mm  $\times$  1.6 mm packages. Other package sizes include: 2.5 mm  $\times$  2.0 mm and 3.2 mm  $\times$  2.5 mm. These packages are “drop-in” replacements for standard 4-pin CMOS quartz crystal oscillators.

### Package Types



# DSC61XX

## Block Diagram



## 1.0 ELECTRICAL CHARACTERISTICS

### Absolute Maximum Ratings

Supply Voltage .....	-0.3V to +4.0V
Input Voltage, $V_{IN}$ .....	-0.3V to $V_{DD}+0.3V$
ESD Protection .....	4000V HBM, 400V MM, 2000V CDM

### DSC61XX ELECTRICAL CHARACTERISTICS

Electrical Characteristics: Unless otherwise indicated, $V_{DD} = 1.8V -5\%$ to $3.3V +10\%$ , $T_A = -40^{\circ}C$ to $85^{\circ}C$ .						
Parameters	Sym.	Min.	Typ.	Max.	Units	Conditions
Supply Voltage, <a href="#">Note 1</a>	$V_{DD}$	1.71	—	3.63	V	—
Active Supply Current	$I_{DD}$	—	3.0	—	mA	$F_{OUT} = 27\text{ MHz}$ , $V_{DD} = 1.8V$ , No Load
Standby Supply Current <a href="#">Note 2</a>	$I_{STBY}$	—	12	—	$\mu A$	$V_{DD} = 1.8/2.5V$
		—	80	—		$V_{DD} = 3.3V$
Frequency Stability <a href="#">Note 3</a>	$\Delta f$	—	—	$\pm 25$ $\pm 50$	ppm	All temp ranges
Aging	$\Delta f$	—	—	$\pm 5$	ppm	1st year @ $25^{\circ}C$
		—	—	$\pm 1$		Per year after first year
Startup Time	$t_{SU}$	—	—	1.3	ms	From 90% $V_{DD}$ to valid clock output, $T = 25^{\circ}C$
Input Logic Levels <a href="#">Note 4</a> Input Logic High Input Logic Low	$V_{IH}$	$0.7xV_{DD}$	—	—	V	—
	$V_{IL}$	—	—	$0.3xV_{DD}$	V	
Output Disable Time <a href="#">Note 5</a>	$t_{DA}$	—	—	200+Period	ns	—
Output Enable Time <a href="#">Note 6</a>	$t_{EN}$	—	—	1	$\mu s$	—
Enable Pull-up Resistor <a href="#">Note 7</a>	—	—	300	—	$k\Omega$	If configured
Output Logic Levels Output Logic High Output Logic Low	$V_{OH}$	$0.8xV_{DD}$	—	—	V	$I = 6mA$
	$V_{OL}$	—	—	$0.2xV_{DD}$	V	$I = -6mA$

- Note 1:** Pin 4  $V_{DD}$  should be filtered with 0.1  $\mu f$  capacitor.
- Note 2:** Not including current through pull-up resistor on EN pin (if configured). Higher standby current seen at  $>3.3V V_{DD}$ .
- Note 3:** Includes frequency variations due to initial tolerance, temp. and power supply voltage.
- Note 4:** Input waveform must be monotonic with rise/fall time  $< 10\text{ ms}$
- Note 5:** Output Disable time takes up to 1 Period of the output waveform + 200 ns.
- Note 6:** For parts configured with OE, not Standby.
- Note 7:** Output is enabled if pad is floated or not connected.

# DSC61XX

## DSC61XX ELECTRICAL CHARACTERISTICS (CONTINUED)

Electrical Characteristics: Unless otherwise indicated, $V_{DD} = 1.8V -5\%$ to $3.3V +10\%$ , $T_A = -40^{\circ}C$ to $85^{\circ}C$ .							
Parameters	Sym.	Min.	Typ.	Max.	Units	Conditions	
Output Transition Time Rise Time/Fall Time	$t_{RX}/t_{FX}$	—	1	1.5	ns	DSC61X2 High Drive, 20% to 80% $C_L = 15$ pF	$V_{DD} = 1.8V$
		—	0.5	1.0	ns		$V_{DD} = 2.5V/3.3V$
	$t_{RY}/t_{FY}$	—	1.2	2.0	ns	DSC61X1 Std Drive, 20% to 80% $C_L = 10$ pF	$V_{DD} = 1.8V$
		—	1.5	2.2	ns		$V_{DD} = 2.5V/3.3V$
Frequency	$f_0$	0.002	—	100	MHz	Output on Pin 1 for < 1 MHz	
Output Duty Cycle	SYM	45	—	55	%	—	
Period Jitter, RMS	$J_{PER}$	—	9.5	11	$ps_{RMS}$	$F_{OUT} = 27$ MHz	$V_{DD} = 1.8V$
		—	7.5	9			$V_{DD} = 2.5V/3.3V$
Cycle-to-Cycle Jitter (peak)	$J_{CY-CY}$	—	50	70	ps	$F_{OUT} = 27$ MHz	$V_{DD} = 1.8V$
		—	35	60			$V_{DD} = 2.5V/3.3V$

- Note 1:** Pin 4  $V_{DD}$  should be filtered with 0.1 uF capacitor.
- 2:** Not including current through pull-up resistor on EN pin (if configured). Higher standby current seen at  $>3.3V V_{DD}$ .
- 3:** Includes frequency variations due to initial tolerance, temp. and power supply voltage.
- 4:** Input waveform must be monotonic with rise/fall time < 10 ms
- 5:** Output Disable time takes up to 1 Period of the output waveform + 200 ns.
- 6:** For parts configured with OE, not Standby.
- 7:** Output is enabled if pad is floated or not connected.

## TEMPERATURE SPECIFICATIONS

Parameters	Sym.	Min.	Typ.	Max.	Units	Conditions
<b>Temperature Ranges</b>						
Junction Operating Temperature	$T_J$	—	+150	—	°C	—
Storage Temperature Range	$T_A$	-55	—	+150	°C	—
Soldering Temperature	$T_S$	—	+260	—	°C	40 Sec. Max.

# DSC61XX

## 2.0 PIN DESCRIPTIONS

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

**TABLE 2-1: DSC6101/03/11/13/21/23/41/43/51/53/61/63 PIN FUNCTION TABLE (OUTPUT FREQUENCY  $\geq 1$ MHZ)**

Pin Number	Pin Name	Pin Type	Description
1	OE	I	Output Enable: H = Specified Frequency Output, <a href="#">Note 1</a> L = Output is high impedance
	STDBY		Standby: H = Specified Frequency Output, <a href="#">Note 1</a> L = Output is high impedance. Device is in low power mode, supply current is at $I_{STBY}$
	FS		Frequency Select: H = Output Frequency 1, <a href="#">Note 2</a> L = Output Frequency 2
2	GND	Power	Power supply ground
3	Output	O	Oscillator clock output
4	VDD	Power	Power supply

**Note 1:** DSC610x/1x/2x has 300 k $\Omega$  internal pull-up resistor on pin1. DSC614x/5x/6x has no internal pull-up resistor on pin1 and needs external pull-up or being driven by other chip.

**2:** Two pre-programmed frequencies can be configured at <http://clockworks.microchip.com/timing/>

**3:** Bypass with 0.1 $\mu$ F capacitor placed as close to  $V_{DD}$  pin as possible.

**TABLE 2-2: DSC6183 PIN FUNCTION TABLE (OUTPUT FREQUENCY  $< 1$ MHZ)**

Pin Number	Pin Name	Pin Type	Description
1	Output	O	Kilohertz Oscillator clock output
2	GND	Power	Power supply ground
3	DNC	DNC	Do Not Connect
4	VDD	Power	Power supply, <a href="#">Note 1</a>

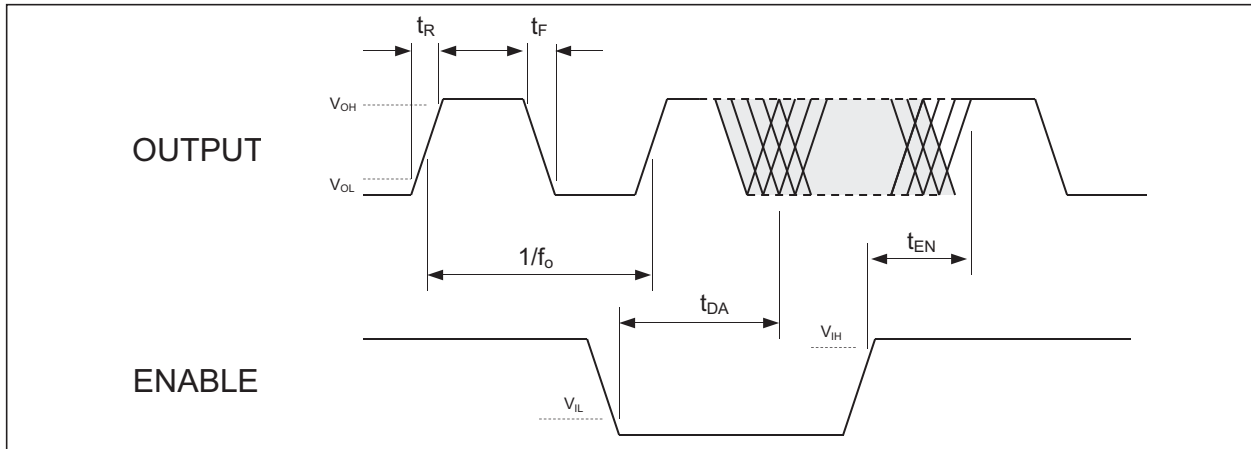
**Note 1:** Bypass with 0.1  $\mu$ F capacitor placed as close to  $V_{DD}$  pin as possible.

DSC61xx family is available in multiple output driver configurations.

The standard-drive (61x1) and high-drive (61x2) deliver respective output currents of greater than 3 mA and 6 mA at 20%/80% of the supply voltage. For heavy loads of 15 pF or higher, the high-drive option is recommended.

## 3.0 OUTPUT WAVEFORM

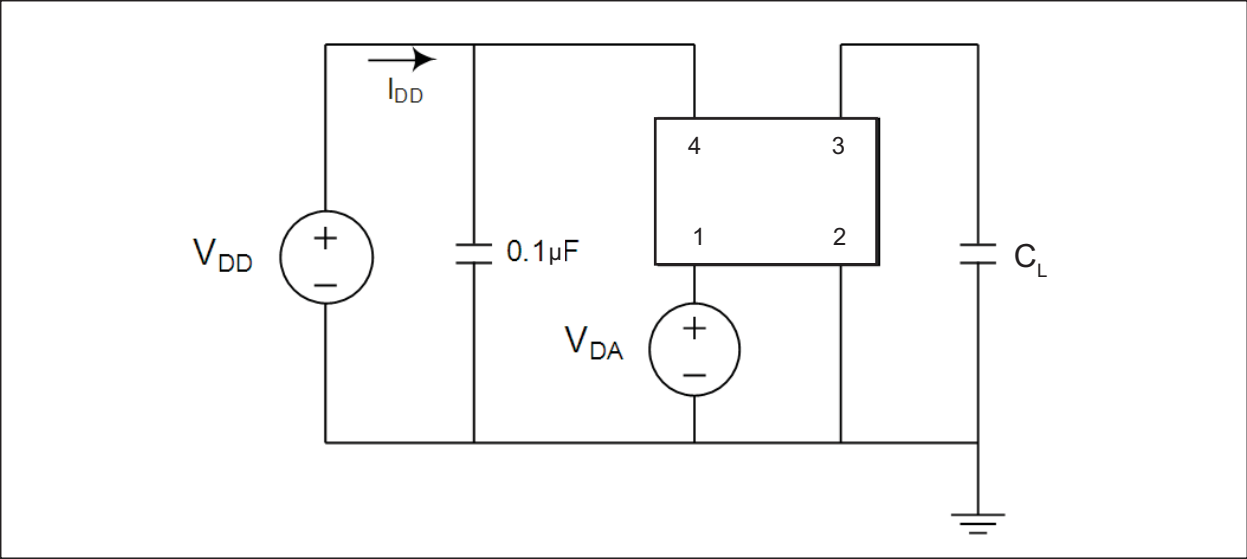
FIGURE 3-1: OUTPUT WAVEFORM



# DSC61XX

## 4.0 TEST CIRCUIT

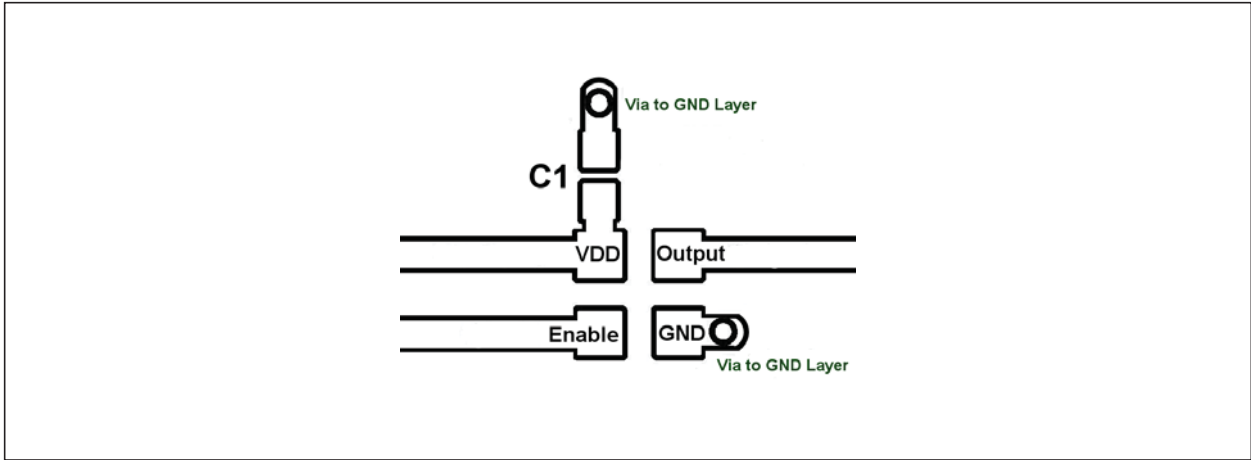
FIGURE 4-1: TEST CIRCUIT





## 5.0 BOARD LAYOUT (RECOMMENDED)

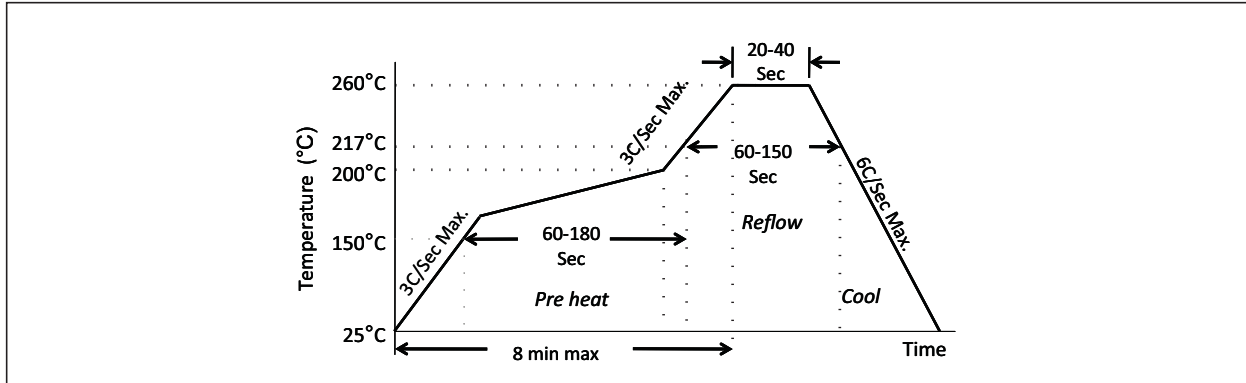
FIGURE 5-1: BOARD LAYOUT (RECOMMENDED)



# DSC61XX

## 6.0 SOLDER REFLOW PROFILE

FIGURE 6-1: SOLDER REFLOW



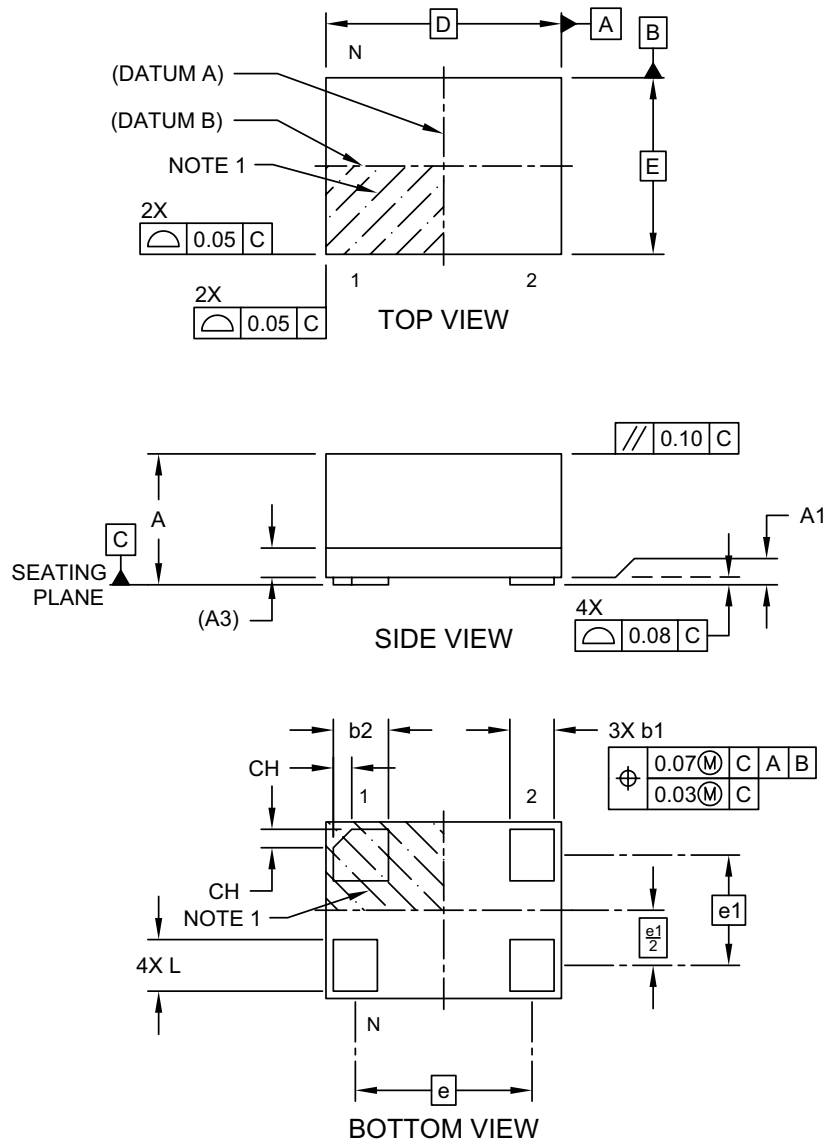
MSL 1 @ 260°C refer to JSTD-020C	
Ramp-Up Rate (200°C to Peak Temp)	3°C/Sec Max.
Preheat Time 150°C to 200°C	60-180 Sec
Time maintained above 217°C	60-150 Sec
Peak Temperature	255-260°C
Time within 5°C of actual Peak	20-40 Sec
Ramp-Down Rate	6°C/Sec Max.
Time 25°C to Peak Temperature	8 min. Max.

## 7.0 PACKAGING INFORMATION

### 4-Lead VFLGA 1.6 mm x 1.2 mm Package Outline

#### 4-Lead Very Thin Fine Pitch Land Grid Array (ARA) - 1.6x1.2 mm Body [VFLGA]

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



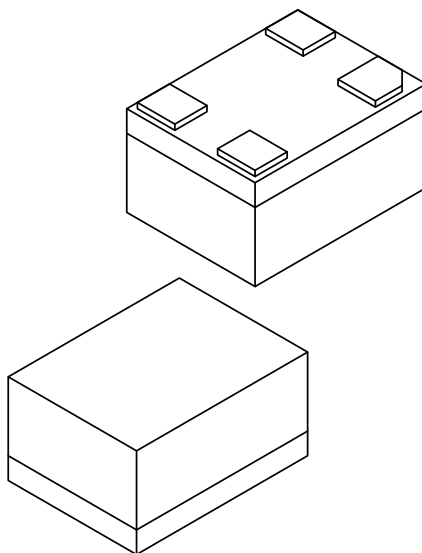
Microchip Technology Drawing C04-1199A Sheet 1 of 2

# DSC61XX

## 4-Lead VFLGA 1.6 mm x 1.2 mm Package Outline

### 4-Lead Very Thin Fine Pitch Land Grid Array (ARA) - 1.6x1.2 mm Body [VFLGA]

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



Units		MILLIMETERS		
Dimension Limits		MIN	NOM	MAX
Number of Terminals	N	4		
Terminal Pitch	e	1.20 BSC		
Terminal Pitch	e1	0.75 BSC		
Overall Height	A	0.79	0.84	0.89
Standoff	A1	0.00	0.02	0.05
Substrate Thickness (with Terminals)	A3	0.20 REF		
Overall Length	D	1.60 BSC		
Overall Width	E	1.20 BSC		
Terminal Width	b1	0.25	0.30	0.35
Terminal Width	b2	0.325	0.375	0.425
Terminal Length	L	0.30	0.35	0.40
Terminal 1 Index Chamfer	CH	-	0.125	-

**Notes:**

1. Pin 1 visual index feature may vary, but must be located within the hatched area.
2. Package is saw singulated
3. Dimensioning and tolerancing per ASME Y14.5M

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

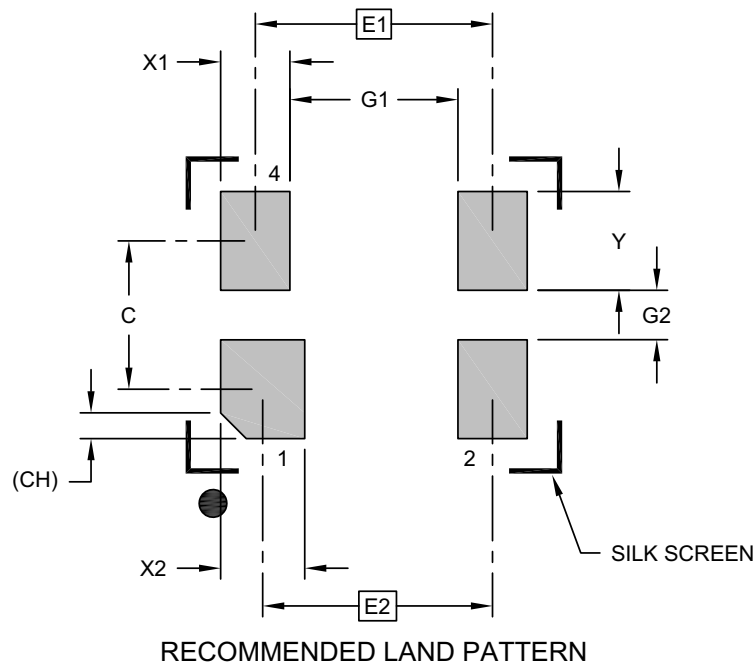
REF: Reference Dimension, usually without tolerance, for information purposes only.

Microchip Technology Drawing C04-1199A Sheet 2 of 2

## 4-Lead VFLGA 1.6 mm x 1.2 mm Recommended Land Pattern

### 4-Lead Very Thin Fine Pitch Land Grid Array (ARA) - 1.6x1.2 mm Body [VFLGA]

**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
Contact Pitch	E1	1.20 BSC		
Contact Pitch	E2	1.16 BSC		
Contact Spacing	C	0.75		
Contact Width (X3)	X1			0.35
Contact Width	X2			0.43
Contact Pad Length (X6)	Y			0.50
Space Between Contacts (X4)	G1	0.85		
Space Between Contacts (X3)	G2	0.25		
Contact 1 Index Chamfer	CH	0.13 X 45° REF		

**Notes:**

1. Dimensioning and tolerancing per ASME Y14.5M  
BSC: Basic Dimension. Theoretically exact value shown without tolerances.

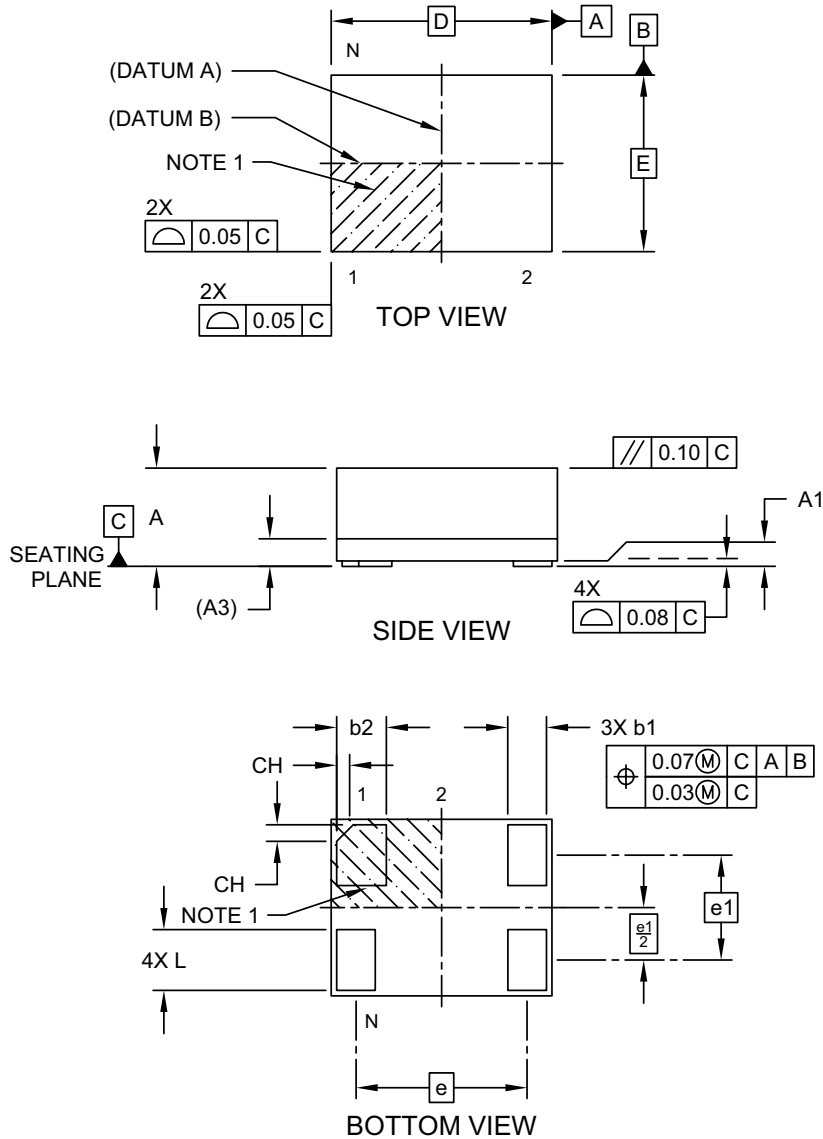
Microchip Technology Drawing C04-3199A

# DSC61XX

## 4-Lead VLGA 2.0 mm x 1.6 mm Package Outline

### 4-Lead Very Thin Fine Pitch Land Grid Array (ASA) - 2.0x1.6 mm Body [VFLGA]

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

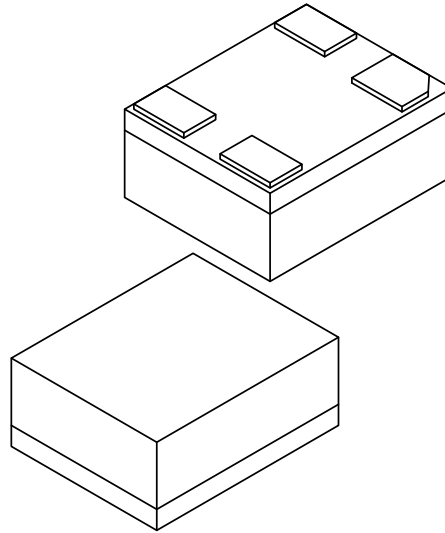


Microchip Technology Drawing C04-1200A Sheet 1 of 2

## 4-Lead VLGA 2.0 mm x 1.6 mm Package Outline (Continued)

### 4-Lead Very Thin Fine Pitch Land Grid Array (ASA) - 2.0x1.6 mm Body [VFLGA]

**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 Terminals	N	6		
Terminal Pitch	e	1.55 BSC		
Terminal Pitch	e1	0.95 BSC		
Overall Height	A	0.79	0.84	0.89
Standoff	A1	0.00	0.02	0.05
Substrate Thickness (with Terminals)	A3	0.20 REF		
Overall Length	D	2.00 BSC		
Overall Width	E	1.60 BSC		
Terminal Width	b1	0.30	0.35	0.40
Terminal Width	b2	0.40	0.45	0.50
Terminal Length	L	0.50	0.55	0.60
Terminal 1 Index Chamfer	CH	-	0.15	-

**Notes:**

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

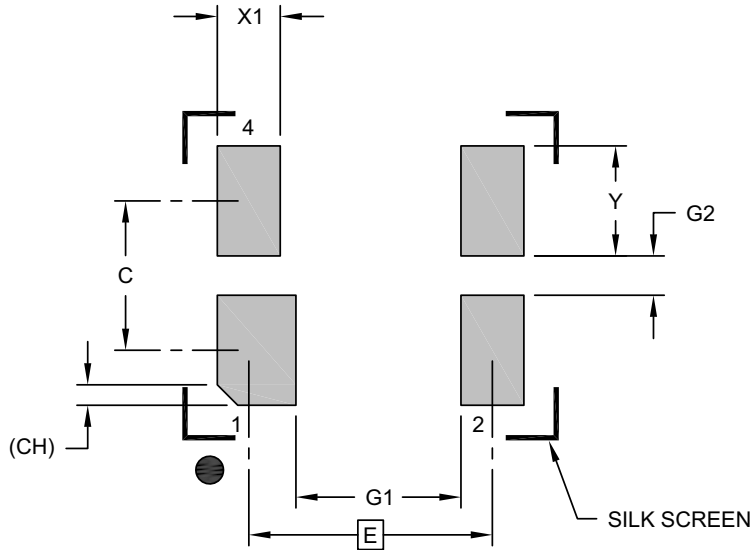
Microchip Technology Drawing C04-1200A Sheet 2 of 2

# DSC61XX

## 4-Lead VFLGA 2.0 mm x 1.6 mm Package Outline

### 4-Lead Very Thin Fine Pitch Land Grid Array (ASA) - 2.0x1.6 mm Body [VFLGA]

**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	1.55 BSC		
Contact Spacing	C		0.95	
Contact Width (X4)	X1			0.50
Contact Width (X2)	X2			0.40
Contact Pad Length (X6)	Y			0.70
Space Between Contacts (X4)	G1	1.05		
Space Between Contacts (X3)	G2	0.25		
Contact 1 Index Chamfer	CH	0.13 X 45° REF		

**Notes:**

1. Dimensioning and tolerancing per ASME Y14.5M

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

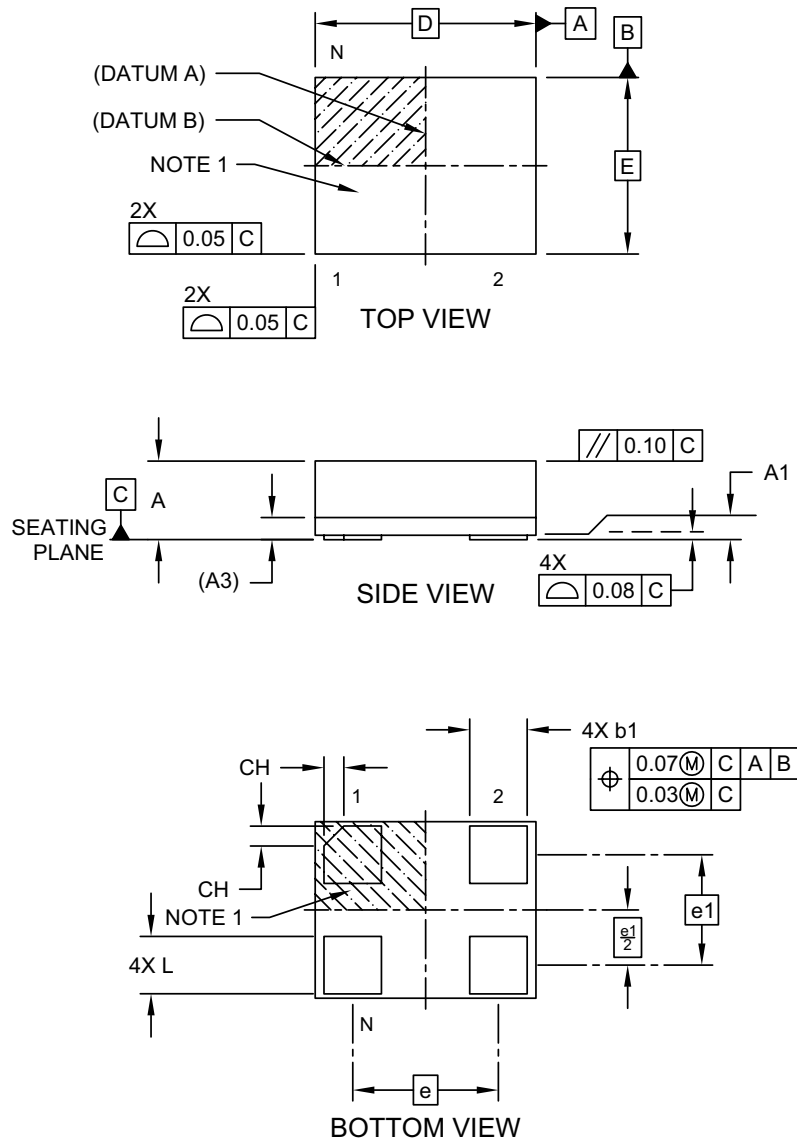
Microchip Technology Drawing C04-3200A



## 4-Lead VLGA 2.5 mm x 2.0 mm Package Outline

### 4-Lead Very Thin Land Grid Array (AUA) - 2.5x2.0 mm Body [VLGA]

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

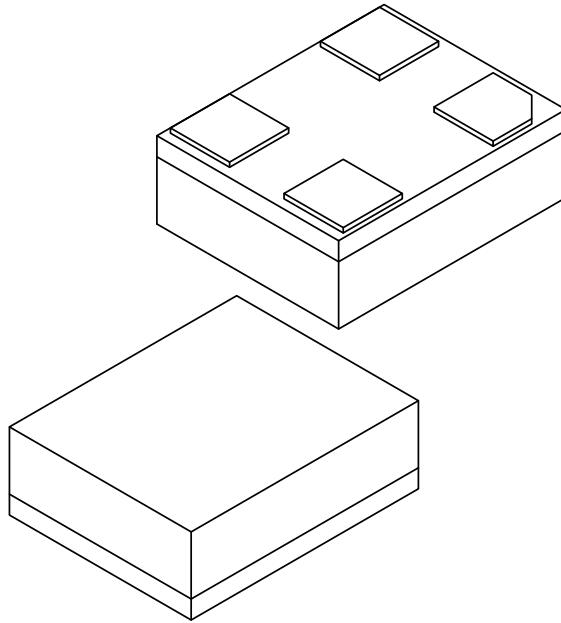


Microchip Technology Drawing C04-1202A Sheet 1 of 2

## 4-Lead VLGA 2.5 mm x 2.0 mm Package Outline (Continued)

### 4-Lead Very Thin Land Grid Array (AUA) - 2.5x2.0 mm Body [VLGA]

**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 Terminals	N	4		
Terminal Pitch	e	1.65 BSC		
Terminal Pitch	e1	1.25 BSC		
Overall Height	A	0.79	0.84	0.89
Standoff	A1	0.00	0.02	0.05
Substrate Thickness (with Terminals)	A3	0.20 REF		
Overall Length	D	2.50 BSC		
Overall Width	E	2.00 BSC		
Terminal Width	b1	0.60	0.65	0.70
Terminal Length	L	0.60	0.65	0.70
Terminal 1 Index Chamfer	CH	-	0.225	-

**Notes:**

1. Pin 1 visual index feature may vary, but must be located within the hatched area.
2. Package is saw singulated
3. Dimensioning and tolerancing per ASME Y14.5M

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

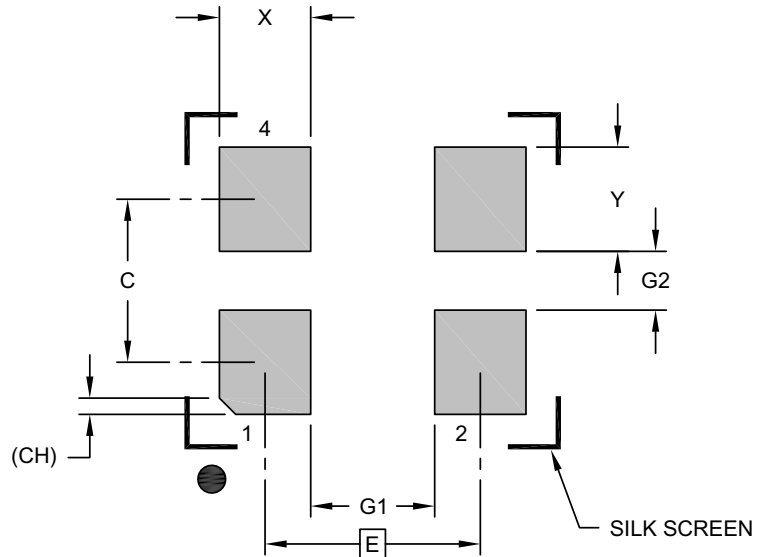
REF: Reference Dimension, usually without tolerance, for information purposes only.

Microchip Technology Drawing C04-1202A Sheet 2 of 2

## 4-Lead VLGA 2.5 mm x 2.0 mm Recommended Land Pattern

### 4-Lead Very Thin Land Grid Array (AUA) - 2.5x2.0 mm Body [VLGA]

**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	1.65 BSC		
Contact Spacing	C		1.25	
Contact Width (X4)	X			0.70
Contact Pad Length (X6)	Y			0.80
Space Between Contacts (X4)	G1	0.95		
Space Between Contacts (X3)	G2	0.45		
Contact 1 Index Chamfer	CH	0.13 X 45° REF		

**Notes:**

1. Dimensioning and tolerancing per ASME Y14.5M  
BSC: Basic Dimension. Theoretically exact value shown without tolerances.

Microchip Technology Drawing C04-3202A

# DSC61XX

## 4-Lead CDFN 3.2 mm x 2.5 mm Package Outline and Recommended Land Pattern

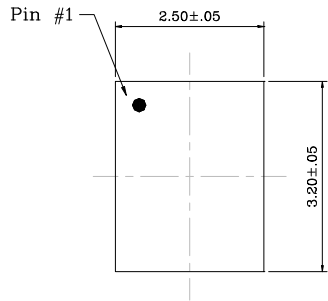
**Note:** For the most current package drawings, please see the Microchip Packaging Specification located at <http://www.microchip.com/packaging>

### TITLE

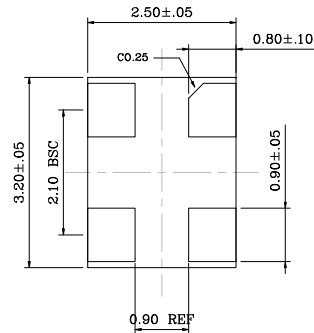
4 LEAD CDFN 3.2x2.5mm COL PACKAGE OUTLINE & RECOMMENDED LAND PATTERN

**DRAWING #** CDFN3225-4LD-PL-1

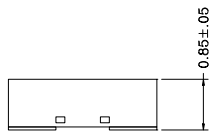
**UNIT** MM



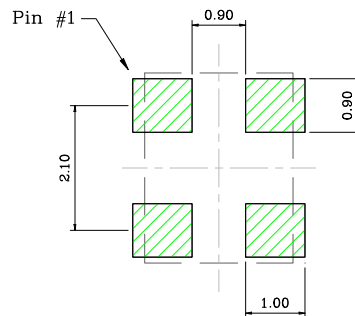
Top View



Bottom View



Side View



Recommended Land Pattern

### NOTE:

1. Green shaded rectangles in Recommended Land Pattern are solder stencil opening.

## APPENDIX A: REVISION HISTORY

### Revision A (September 2016)

- Initial release of DSC61XX Microchip data sheet DS20005624A.

# DSC61XX

---

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	X	X	X	X - XXX.XXXX	X
Device	Pin 1 Definition	Output Drive Strength	Package	Temperature Range	Frequency Stability	Revision	Frequency	Tape and Reel
<b>Device:</b> DSC61XX: Ultra-Low Power MEMS Oscillator								
<b>Pin Definition:</b>								
	<b>Selection</b>	<b>Pin 1</b>	<b>Internal Pull Register</b>					
	0	OE	Pull-up					
	1	STDBY	Pull-up					
	2	FS	Pull-up					
	4	OE	None					
	5	STDBY	None					
	6	FS	None					
	8	KHz Output	None					
<b>Output Drive Strength:</b>								
	1	Standard						
	2	High						
<b>Packages:</b>								
	C	= 4-Lead 3.2 mm x 2.5 mm DFN						
	J	= 4-Lead 2.5 mm x 2.0 mm VFLGA						
	M	= 4-Lead 2.0 mm x 1.6 mm VFLGA						
	H	= 4-Lead 1.6 mm x 1.2 mm VFLGA						
<b>Temperature Range:</b>								
	E	= -20°C to +70°C (Extended Commercial)						
	I	= -40°C to +85°C (Industrial)						
<b>Frequency Stability:</b>								
	1	= ± 50 ppm						
	2	= ± 25 ppm						
<b>Revision:</b>								
	A	= Revision A						
<b>Frequency:</b>								
	xxx.xxxx	= User-Defined Frequency between 001.0000 MHz and 100.0000 MHz						
	xxxkxxx	= User-Defined Frequency between 002.000 kHz and 999.999 kHz						
	xxxx	= Frequency configuration code when pin 1 = FS. Configure the part online through ClockWorks						
<b>Tape and Reel:</b>								
	Blank	= Bulk						
	T	= Tape and Reel						
<b>Examples:</b>								
a) DSC6112JI2A-100.0000: Ultra-Low Power MEMS Oscillator, Pin1= Standby with internal Pull-Up, High Output Drive Strength, 4-Lead 2.5 mm x 2.0 mm VFLGA, Industrial Temperature (-40°C to +85°C), ±25 ppm, Revision A, 100 MHz Frequency, Bulk.								
b) DSC6101HE1A-016.0000T: Ultra-Low Power MEMS Oscillator, Pin1= OE with Internal Pull-Up, Standard Output Drive Strength, 4-Lead 1.6 mm x1.2 mm VFLGA, Extended Commercial Temperature (-20°C to +70°C), ±50 ppm, Revision A, 16 MHz Frequency, Tape and Reel.								
c) DSC6183ME1A-032k768: Ultra-Low Power MEMS Oscillator, Pin1= 32.768 KHz Clock Output, Low Output Drive Strength, 4-Lead 2.0 mm x1.6 mm VFLGA, Extended Commercial Temperature (-20°C to +70°C), ±50 ppm, Revision A, Bulk								
d) DSC6121CI2A-001A: Ultra-Low Power MEMS Oscillator, Pin1= FS with internal Pull-up, Standard Output Drive Strength, 4-Lead 3.2 mm x 2.5 mm CDFN, Industrial Temperature (-40 to 85°C), ±25 ppm, Revision A, Frequency code = 001A (configured through ClockWorks), Bulk								
<b>Note 1:</b> Tape and Reel identifier only appears in the catalog part number description. This identifier is used for ordering purposes and is not printed on the device package. Check with your Microchip Sales Office for package availability with the Tape and Reel option.								

**Note 1:** Please visit Microchip ClockWorks® Configurator Website to configure the part number for customized frequency. <http://clockworks.microchip.com/timing/>.

# DSC61XX

---

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 unless otherwise stated.

*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

The Microchip name and logo, the Microchip logo, AnyRate, dsPIC, FlashFlex, flexPWR, Heldo, JukeBlox, KeeLoq, KeeLoq logo, Klear, LANCheck, LINK MD, MediaLB, MOST, MOST logo, MPLAB, OptoLyzer, PIC, PICSTART, PIC32 logo, RightTouch, SpyNIC, SST, SST Logo, SuperFlash and UNI/O are registered trademarks of Microchip Technology Incorporated in the U.S.A. and other countries.

ClockWorks, The Embedded Control Solutions Company, ETHERSYNCH, Hyper Speed Control, HyperLight Load, IntelliMOS, mTouch, Precision Edge, and QUIET-WIRE are registered trademarks of Microchip Technology Incorporated in the U.S.A.

Analog-for-the-Digital Age, Any Capacitor, AnyIn, AnyOut, BodyCom, chipKIT, chipKIT logo, CodeGuard, dsPICDEM, dsPICDEM.net, Dynamic Average Matching, DAM, ECAN, EtherGREEN, In-Circuit Serial Programming, ICSP, Inter-Chip Connectivity, JitterBlocker, KlearNet, KlearNet logo, MiWi, motorBench, MPASM, MPF, MPLAB Certified logo, MPLIB, MPLINK, MultiTRAK, NetDetach, Omniscient Code Generation, PICDEM, PICDEM.net, PICkit, PICtail, PureSilicon, RightTouch logo, REAL ICE, Ripple Blocker, Serial Quad I/O, SQL, SuperSwitcher, SuperSwitcher II, Total Endurance, TSHARC, USBCheck, VariSense, ViewSpan, WiperLock, Wireless DNA, and ZENA are trademarks of Microchip Technology Incorporated in the U.S.A. and other countries.

SQTP is a service mark of Microchip Technology Incorporated in the U.S.A.

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

GestIC is a 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.

© 2016, Microchip Technology Incorporated, Printed in the U.S.A., All Rights Reserved.

ISBN: 978-1-5224-0961-8



# 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

**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: 905-695-1980  
Fax: 905-695-2078

### 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

06/23/16