HV56266

Single +300V High Voltage Operational Amplifier

Features

- Single High Voltage Amplifier
- 100V-300V Supply Voltage
- 295V Maximum Output Voltage Swing
- Wide Adjustable Gain
- 30V/V (minimum) to 90V/V (maximum)
- 900 kHz Gain Bandwidth Product
- Minimum Slew Rate of 3 V/µs with 15 pF Load
- AEC-Q100 Qualified
- 5 x 5 mm VQFN Package for Automotive Applications
- 4 x 4 mm BGA Package for Commercial Applications

Application

- MEMS Driver
- Laser Beam Steering
- Haptic Driver

General Description

HV56266 is a single-channel MEMS amplifier with external gain-set resistors. The amplifier uses two supplies - a low voltage 5V supply at V_{DD} and a high voltage 100V-300V supply at V_{PP}.

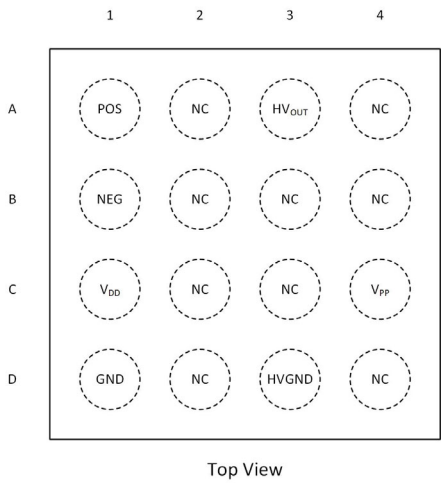
The amplifier is designed to be stable with a maximum of 15 pF capacitive load with closed-loop gain in the range of 30V/V and 90V/V. This high voltage output is capable of minimum 3 V/µs slew rate and a bandwidth of 10 kHz with a gain of 90V/V.

The HV56266 device is available in two packages:

- 16-ball 4 x 4 x 1.2 mm TFBGA.
- 32-lead 5 x 5 x 0.9 mm VQFN.

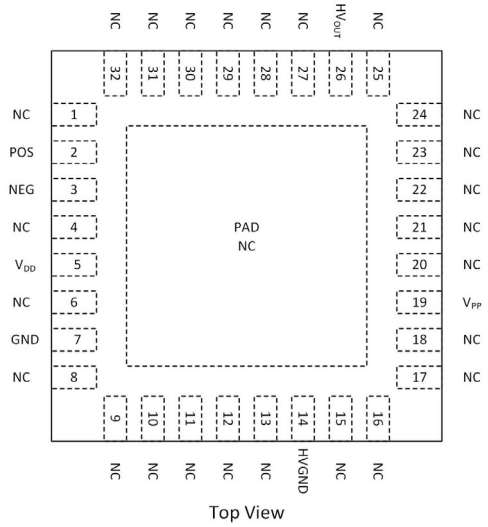
Package Types

16-Ball TFBGA
(4 x 4 x 1.2 mm)



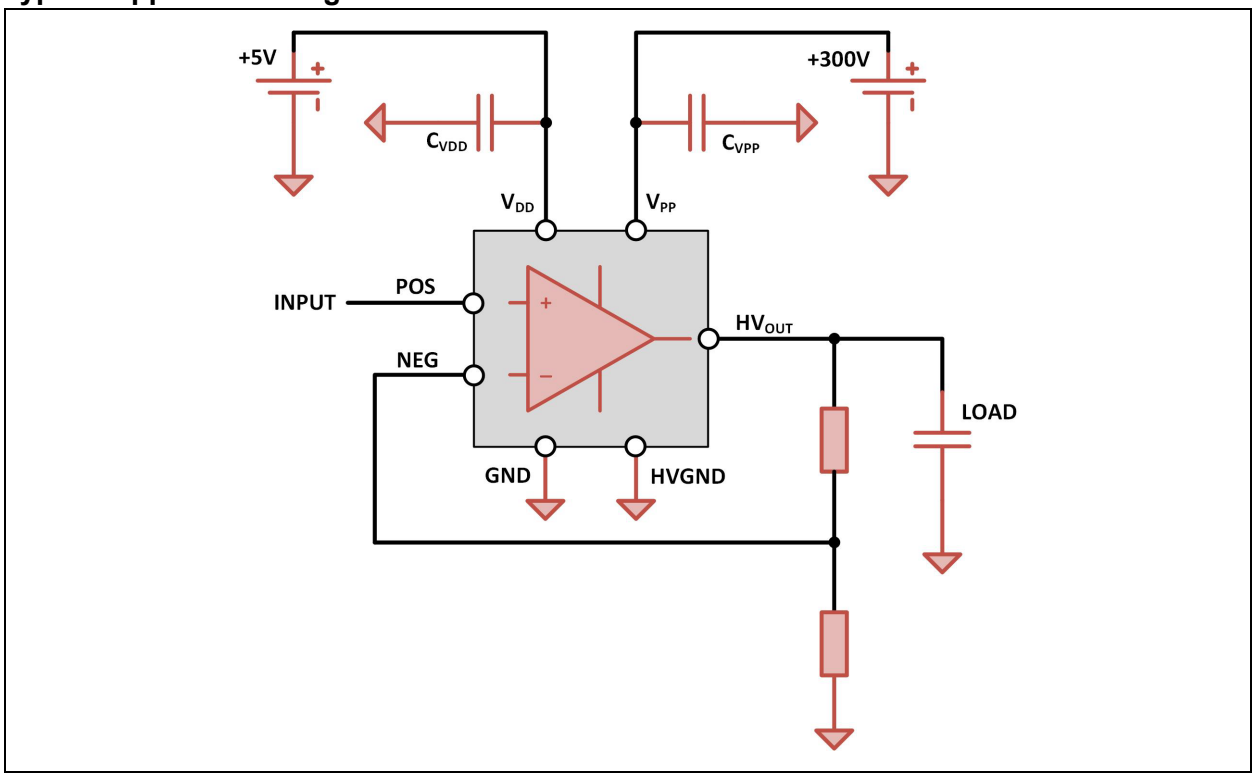
Top View

32-Lead VQFN
(5 x 5 x 0.9 mm)

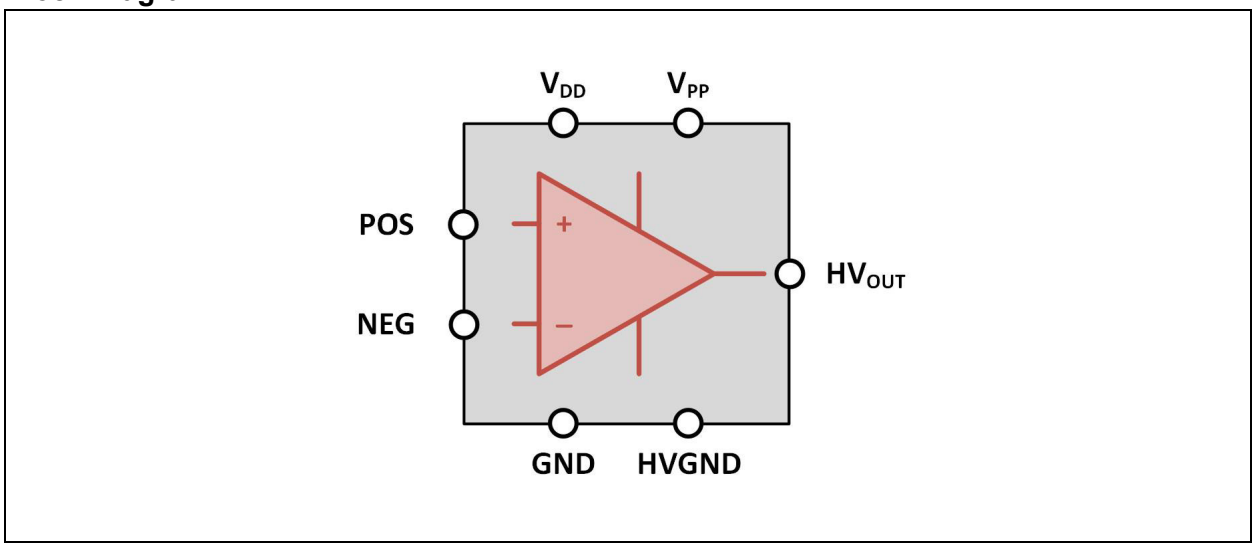


Top View

Typical Application Diagram



Block Diagram



1.0 ELECTRICAL CHARACTERISTICS

Absolute Maximum Ratings †

Supply Voltage (V_{DD}) ..... -0.3V to 6V
High Voltage Supply Voltage (V_{PP}) ..... -0.3V to 315V
Amplifier Inputs (POS, NEG)..... -0.3V to 3.6V
ESD Rating of Low Voltage Pins..... ≥ 2.0 kV HBM
ESD Rating of High Voltage Pins (V_{PP}, HV_{OUT}) ..... ≥ 2.0 kV HBM

† **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 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.

OPERATING SUPPLY VOLTAGES

Electrical Specifications: Unless otherwise specified all specifications apply over the T_A range of -40 to +125°C.

Parameter	Sym.	Min.	Typ.	Max.	Units	Conditions
High Voltage Supply	V_{PP}	+100	—	+300	V	Note 1
Low Voltage Supply	V_{DD}	4.5	—	5.5	V	
Amplifier Inputs	POS, NEG	0	—	3.3	V	

Note 1: Specifications are production tested at room temperature with temperature guard-bands built into the limits.

ELECTRICAL CHARACTERISTICS

Unless otherwise specified, $T_A = T_J = 25°C$, $V_{DD} = 5V$, $V_{PP} = 300V$, $C_{VPP} = 0.1\ \mu F$, $C_{VDD} = 1\ \mu F$, $C_{LOAD} = 15\ pF$, $R_{F1} = 3.09\ M\Omega$, $R_{F2} = 34.8\ k\Omega$. **Boldface** specifications apply over $T_A = T_J = -40°C$ to +125°C.

Parameter	Symbol	Min.	Typ.	Max.	Units	Conditions
Power Supplies						
VPP Supply Current	I_{PP}	**—**	**—**	**200**	µA	POS = GND
VDD Supply Current	I_{DD}	**—**	**—**	**2.1**	mA	POS = GND
Amplifier Specifications						
HVOUT Maximum Swing	V_{OH}	**VPP-5**	**—**	**—**	V	POS = 3.4V
HVOUT Minimum Swing	V_{OL}	**—**	**—**	**3.5**	V	POS = GND
Input Current for Input Pins	I_{IN}	—	—	50	nA	POS = NEG = 3.3V; **(Note 1)**
HVOUT Rising Slew Rate	SR_{rising}	3	—	—	V/µs	POS = 0V to 3.3V step; measured using 10%-90% rise time.
HVOUT Falling Slew Rate	$SR_{falling}$	3	—	—	V/µs	POS = 3.3V to 0V step; measured using 10%-90% fall time
HVOUT Peak-Peak Swing @1 kHz	$V_{O,pk-pk}$	**VPP-10**	—	—	V	POS = 0-3.3V sine wave at 1 kHz
Closed Loop Gain Range	Av	30	—	90	V/V	**Note 2**
Load Capacitance Range	C_{LOAD}	0	—	15	pF	**Note 2**
Total Feedback Resistance Range	$R_{F,tot}$	3	—	7	MΩ	$R_{F1} + R_{F2}$, **(Note 2)**

Note 1: Specification is obtained by characterization and not 100% tested in production.
2: Specification is for design guidance only.

ELECTRICAL CHARACTERISTICS (CONTINUED)

Unless otherwise specified, $T_A = T_J = 25°C$, $V_{DD} = 5V$, $V_{PP} = 300V$, $C_{VPP} = 0.1\ \mu F$, $C_{VDD} = 1\ \mu F$, $C_{LOAD} = 15\ pF$, $R_{F1} = 3.09\ M\Omega$, $R_{F2} = 34.8\ k\Omega$. **Boldface** specifications apply over $T_A = T_J = -40°C$ to $+125°C$.

Parameter	Symbol	Min.	Typ.	Max.	Units	Conditions
Closed Loop Gain Bandwidth Product	GBW	900	**—**	**—**	kHz	**Note 1**
V_{DD} Power Supply Rejection Ratio	$PSRR_{VDD}$	—	30	—	dB	Measured @ 1 kHz; **(Note 1)**
V_{PP} Power Supply Rejection Ratio	$PSRR_{VPP}$	—	35	—	dB	Measured @ 1 kHz; **(Note 1)**
HVOUT Offset	OUT_{OS}	**-2.5**	—	**+2.5**	V	Measured using linear curve fit on a 5 point measurement
Rise Time and Fall Time Rate	$\Delta V/\Delta t$	2.4	—	—	V/µs	POS = 0.1 to 0.75V step; measured using 10%-90% HV_{OUT}

Note 1: Specification is obtained by characterization and not 100% tested in production.

2: Specification is for design guidance only.

TEMPERATURE SPECIFICATIONS

Parameter	Symbol	Min.	Typ.	Max.	Units	Conditions
Temperature Ranges						
Operating Junction Temperature Range	T_J	-40	—	+125	°C	
Storage Temperature Range	T_A	-55	—	+165	°C	
Package Thermal Resistance						
Thermal Resistance, 32-Lead VQFN	θ_{JA}	—	32.3	—	°C/W	
Thermal Resistance, 16-Ball BGA	θ_{JA}	—	113	—	°C/W	

2.0 TYPICAL PERFORMANCE CURVES

Note: The graphs and tables provided below are a statistical summary based on a limited number of samples and are provided for informational purposes only. The performance characteristics listed herein are not tested or guaranteed. In some graphs or tables, the data presented may be outside the specified operating range (e.g. outside specified power supply range) and therefore outside the warranted range.

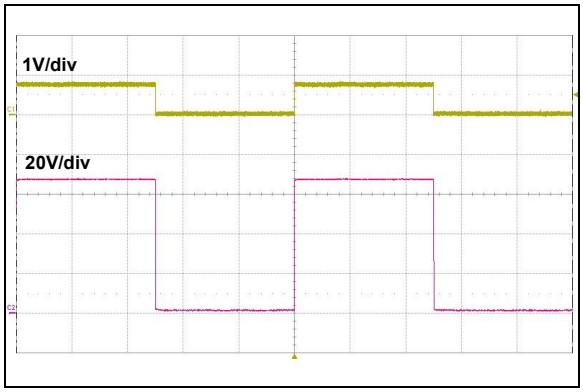


FIGURE 2-1: *Typical Small-Signal Pulse Response (POS = 0~750 mV pulse, 100 Hz, CL = 15 pF).*

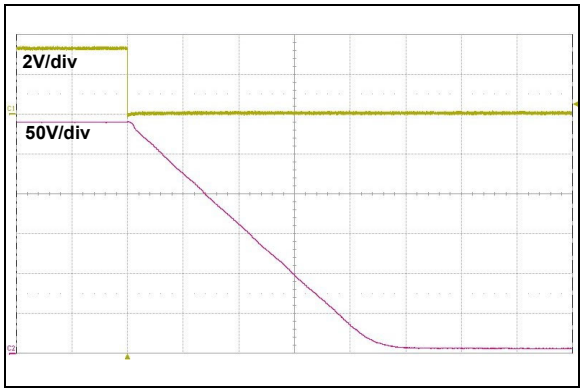


FIGURE 2-4: *Typical Fall Time (POS = 0~3.3V pulse, 100 Hz, CL = 15 pF).*

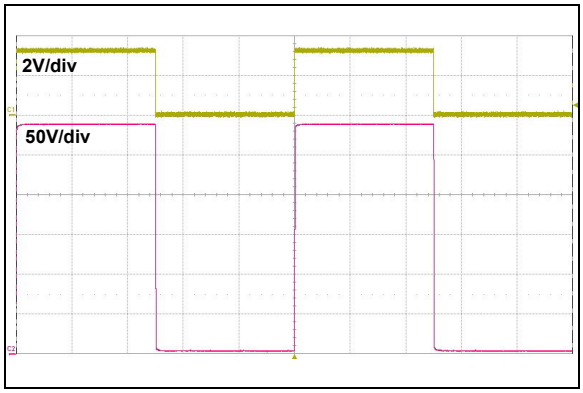


FIGURE 2-2: *Typical Large-Signal Pulse Response (POS = 0~3.3V pulse, 100 Hz, CL = 15 pF).*

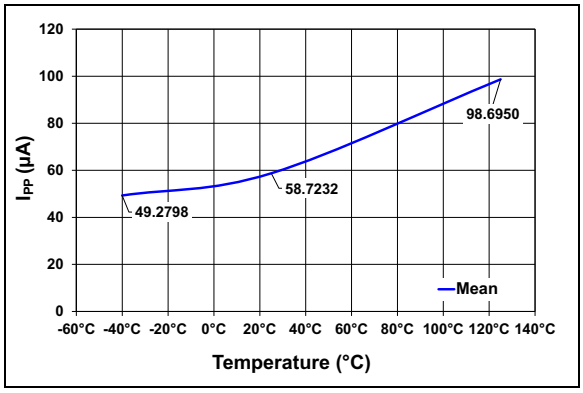


FIGURE 2-5: *I_{PP} Current vs. Temperature (Mean).*

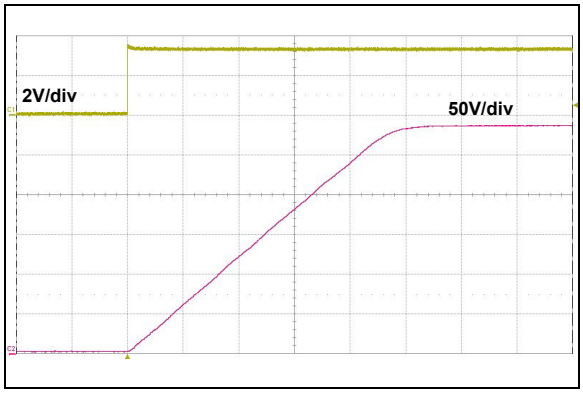


FIGURE 2-3: *Typical Rise Time (POS = 0~3.3V pulse, 100 Hz, CL = 15 pF).*

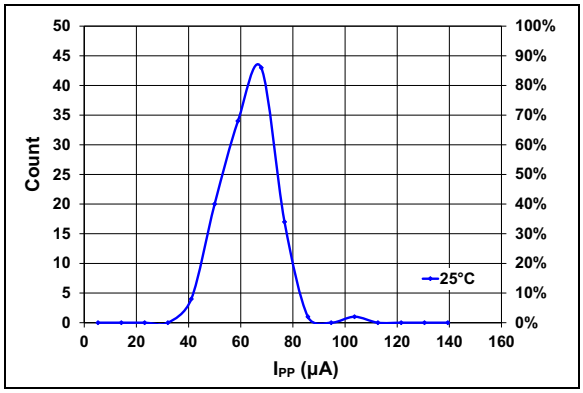


FIGURE 2-6: *Distribution of I_{PP} Current at T_A = 25°C.*

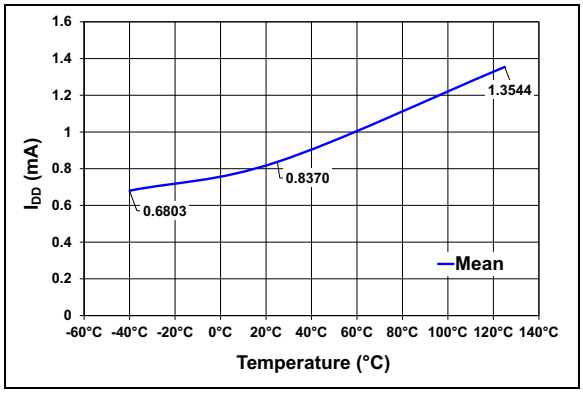


FIGURE 2-7: *I_{DD} Current vs. Temperature (Mean).*

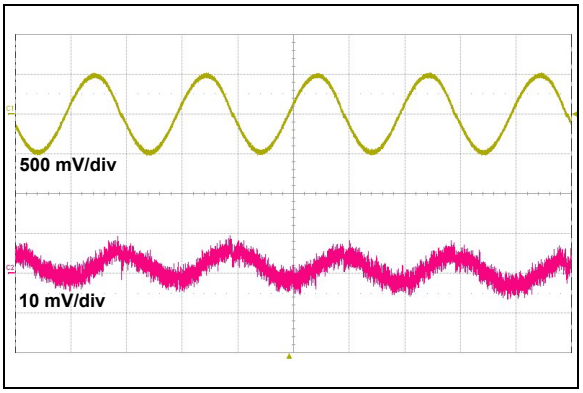


FIGURE 2-10: *Typical Power Supply Rejection from V_{PP}.*

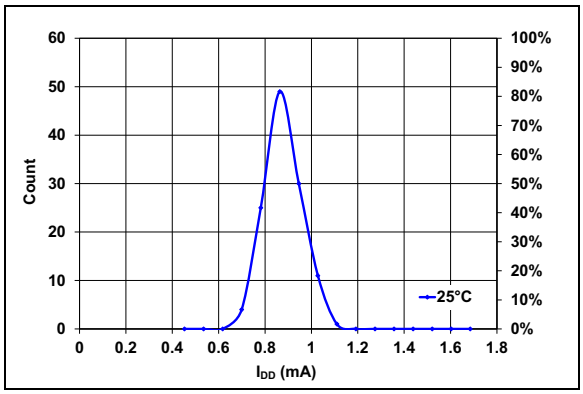


FIGURE 2-8: *Distribution of I_{DD} Current at T_A = 25°C.*

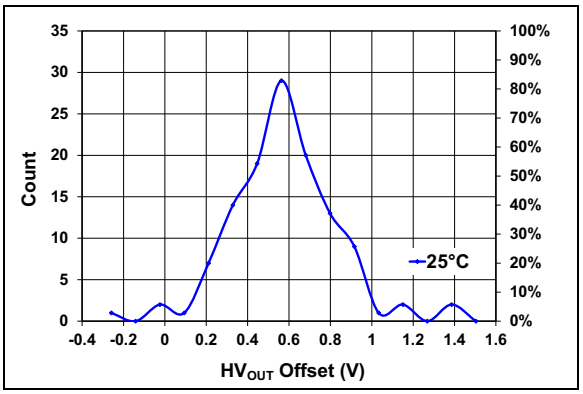


FIGURE 2-11: *Distribution of HV_{OUT} Offset at T_A = 25°C.*

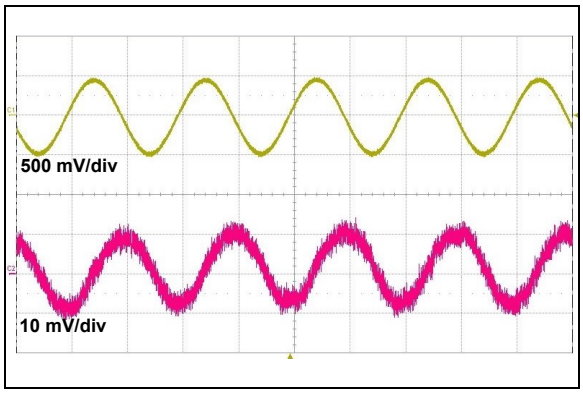


FIGURE 2-9: *Typical Power Supply Rejection from V_{DD}.*

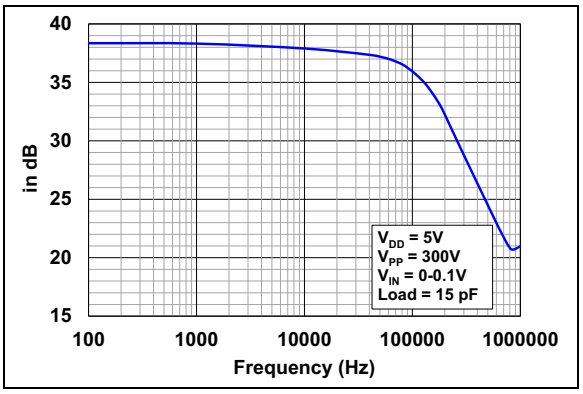


FIGURE 2-12: *Typical Frequency Response of Gain at 90V/V at T_A = 25°C.*

3.0 PINS DESCRIPTION

The description of the pins are listed in Table 3-1.

TABLE 3-1: PIN FUNCTION TABLE

Pin Number (TFBGA)	Pin Number (VQFN)	Pin Name	Description
A1	2	POS	Noninverting Input of the Amplifier. 0V-3.3V input range.
A2, A4, B2, B3, B4, C2, C3, D2, D4	1, 4, 6, 8, 9, 10, 11, 12, 13, 15, 16, 17, 18, 20, 21, 22, 23, 24, 25, 27, 28, 29, 30, 31, 32, Thermal pad	NC	Not connected
A3	26	HV_{OUT}	Amplifier output. Connect feedback resistor between OUT and NEG.
B1	3	NEG	Inverting Input of the Amplifier. 0V-3.3V input range.
C1	5	V_{DD}	5V nominal power supply. Bypass with a low ESR ceramic capacitor (≥1 µF).
C4	19	V_{PP}	100V-300V nominal power supply. Bypass with a low ESR ceramic capacitor (≥0.1 µF).
D1	7	GND	Analog Ground. All input signals should be referenced to this pin.
D3	14	HVGND	High Voltage ground. Connect to GND on the PCB.

4.0 DEVICE DESCRIPTION

4.1 Power-On/Off Sequence

TABLE 4-1: ACCEPTABLE POWER-ON SEQUENCE

Steps	Description
1	Connect Ground
2	Apply V_{DD}
3	Apply V_{PP}
4	Apply input signal

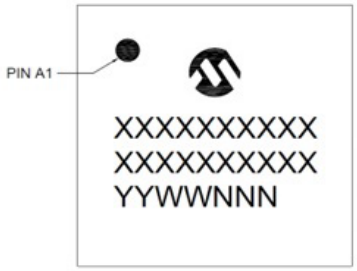
TABLE 4-2: ACCEPTABLE POWER-OFF SEQUENCE

Steps	Description
1	Set input to ground
2	Disconnect V_{PP}
3	Disconnect V_{DD}
4	Disconnect ground

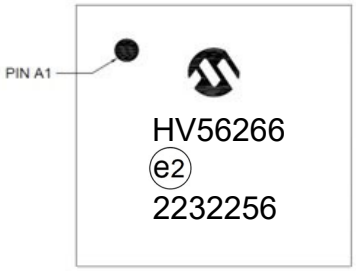
5.0 PACKAGE INFORMATION

5.1 Package Marking Information

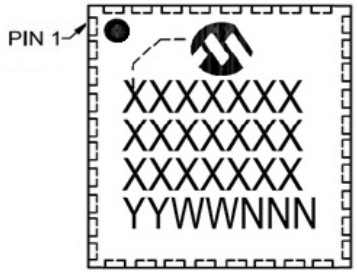
16-Ball TFBGA (4 x 4 x 1.2 mm)



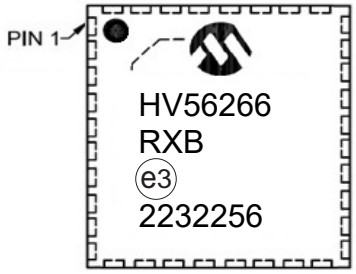
Example



32-Lead VQFN (5 x 5 x 0.9 mm)



Example

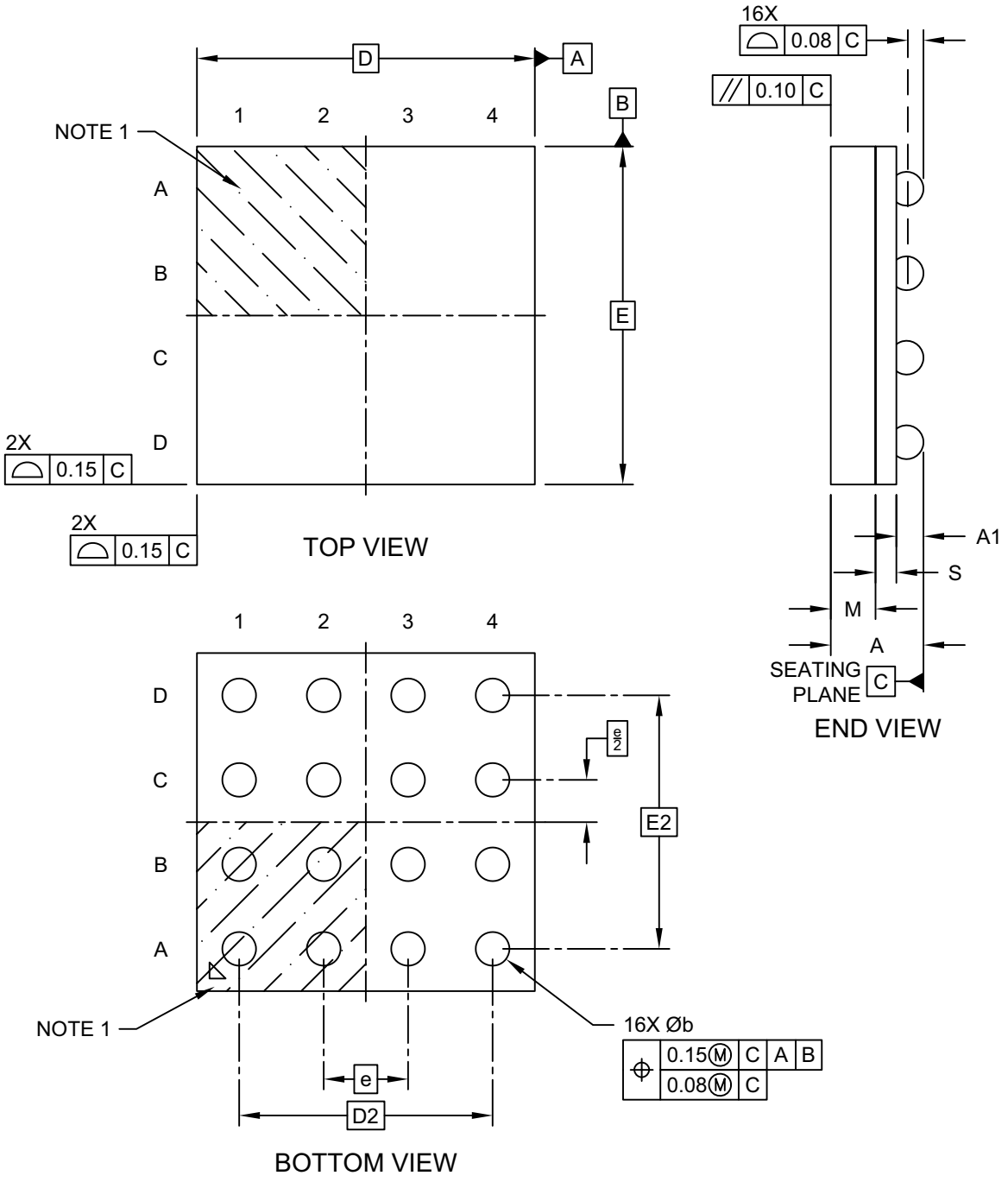


Legend:	XX...X	Product Code or Customer-specific information
	Y	Year code (last digit of calendar year)
	YY	Year code (last 2 digits of calendar year)
	WW	Week code (week of January 1 is week ‘01’)
	NNN	Alphanumeric traceability code
	(e3)	Pb-free JEDEC designator for Matte Tin (Sn)
	*	This package is Pb-free. The Pb-free JEDEC designator ((e3)) can be found on the outer packaging for this package.

Note: In the event the full Microchip part number cannot be marked on one line, it will be carried over to the next line, thus limiting the number of available characters for customer-specific information. Package may or may not include the corporate logo.

16-Ball Thin Fine-Pitch Ball Grid Array Package (2PW) - 4x4x1.2 mm Body [TFBGA]

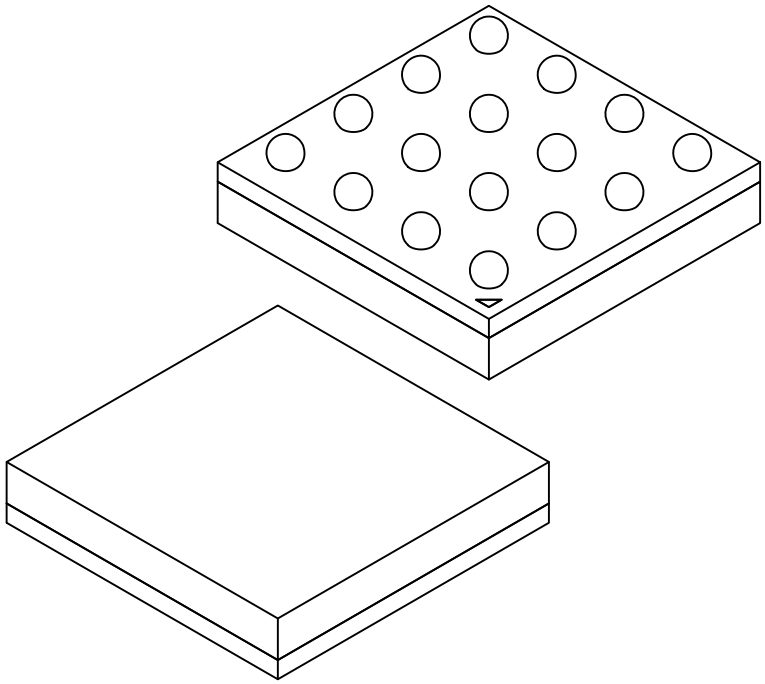
Note: For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging



Microchip Technology Drawing C04-549 Rev B Sheet 1 of 2

16-Ball Thin Fine-Pitch Ball Grid Array Package (2PW) - 4x4x1.2 mm Body [TFBGA]

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		16	
Pitch	e		1.00 BSC	
Overall Height	A	1.00	1.096	1.20
Ball Height	A1	0.27	0.32	0.37
Mold Thickness	M		0.53 REF	
Substrate Thickness	S		0.246 REF	
Overall Length	D		4.00 BSC	
Ball Array Length	D2		3.00 BSC	
Overall Width	E		4.00 BSC	
Ball Array Width	E2		3.00 BSC	
Ball Diameter	b	0.38	0.43	0.48

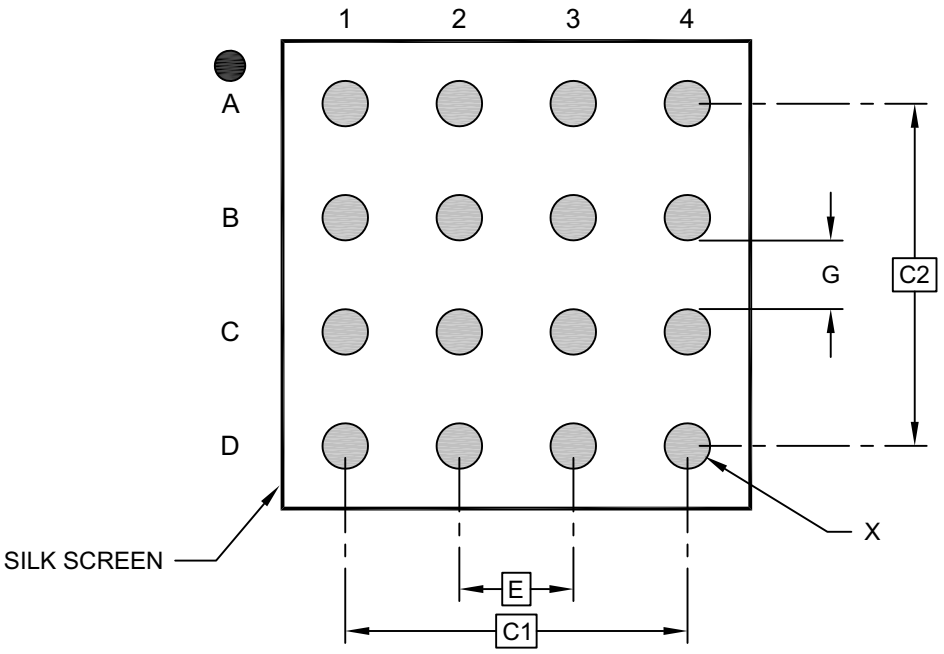
Notes:

1. Pin 1 visual index feature may vary, but must be located within the hatched area.
2. 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 C04-549 Rev B Sheet 2 of 2

16-Ball Thin Fine-Pitch Ball Grid Array Package (2PW) - 4x4x1.2 mm Body [TFBGA]

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



RECOMMENDED LAND PATTERN

Units		MILLIMETERS		
Dimension Limits		MIN	NOM	MAX
Contact Pitch	E		1.00 BSC	
Contact Pad Spacing	C1		3.00 BSC	
Contact Pad Spacing	C2		3.00 BSC	
Contact Pad Width (Xnn)	X			0.40
Contact Pad to Contact Pad (Xnn)	G	0.60		

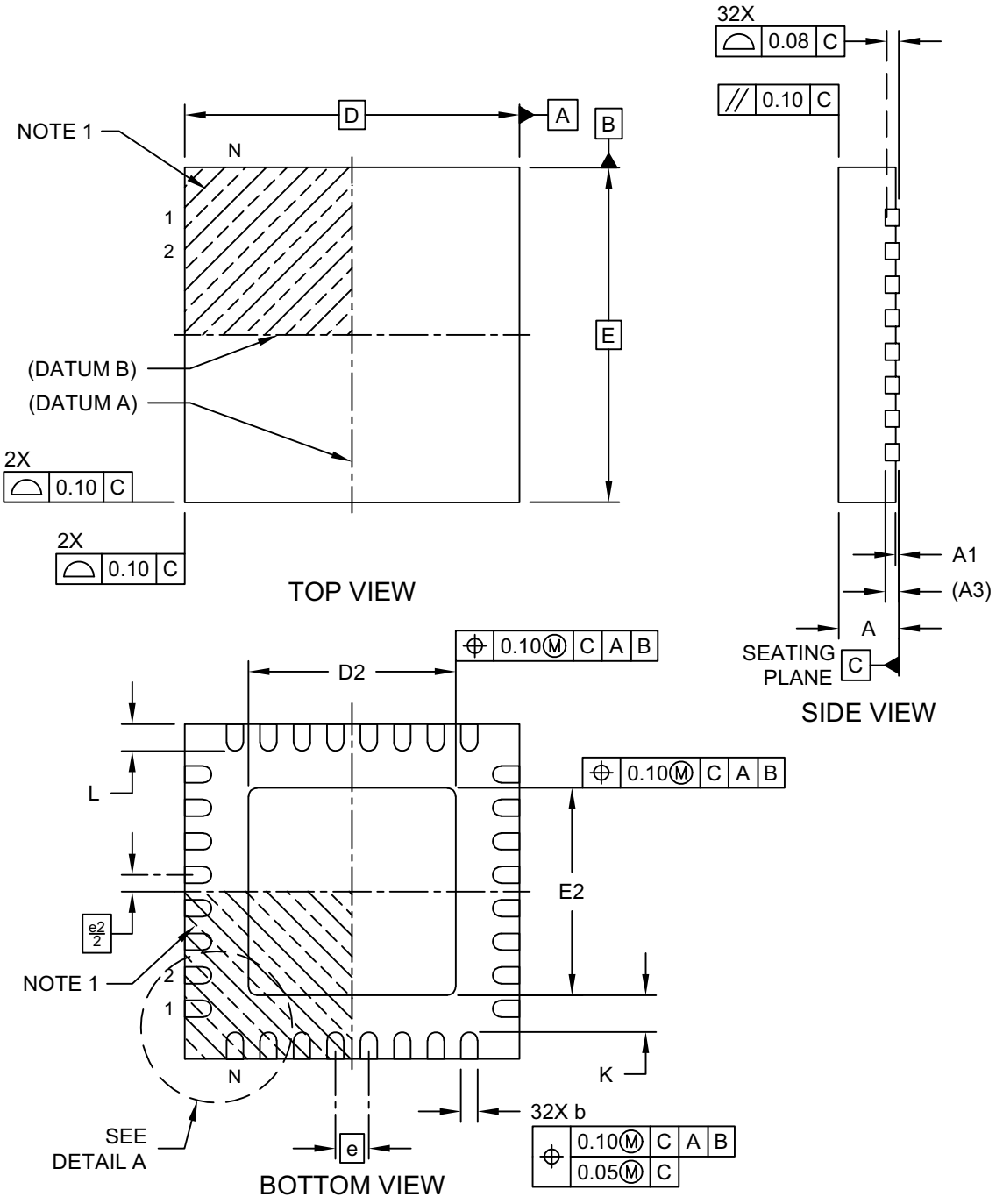
Notes:

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

Microchip Technology Drawing C04-2549 Rev B

32-Lead Very Thin Plastic Quad Flat, No Lead Package (RXB) - 5x5x0.9 mm Body [VQFN] With 3.1x3.1 mm Exposed Pad; Atmel Legacy Global Package Code ZMF

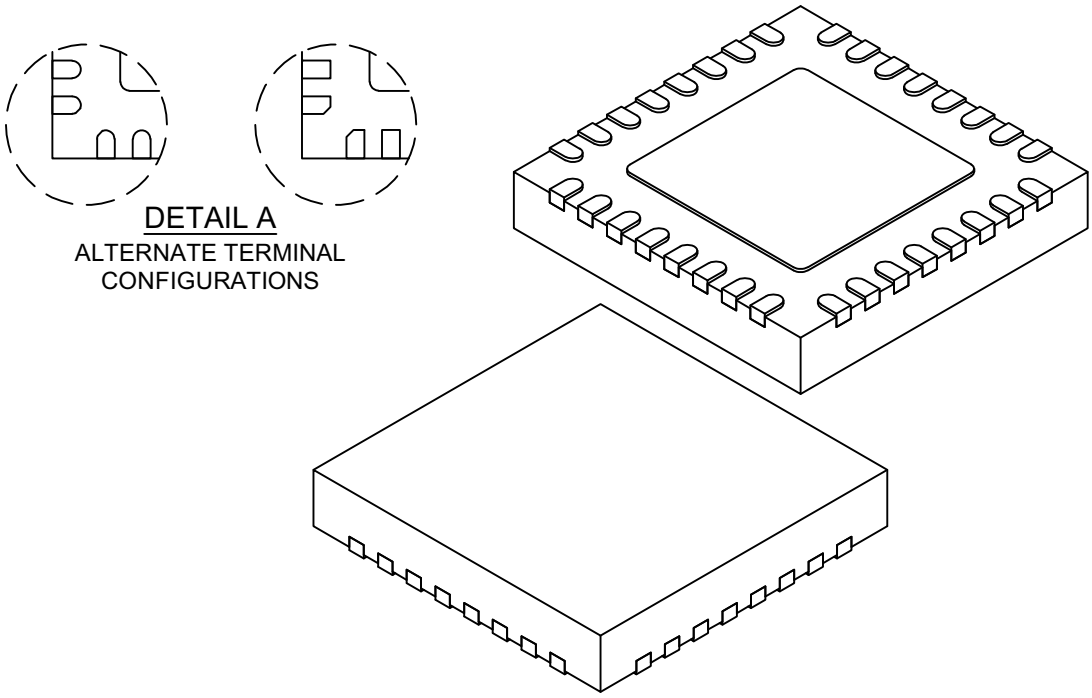
Note:	For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging



Microchip Technology Drawing C04-21395-RXB Rev C Sheet 1 of 2

32-Lead Very Thin Plastic Quad Flat, No Lead Package (RXB) - 5x5x0.9 mm Body [VQFN] With 3.1x3.1 mm Exposed Pad; Atmel Legacy Global Package Code ZMF

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		32	
Pitch	e		0.50 BSC	
Overall Height	A	0.80	0.85	0.90
Standoff	A1	0.00	0.02	0.05
Terminal Thickness	A3		0.203 REF	
Overall Length	D		5.00 BSC	
Exposed Pad Length	D2	3.00	3.10	3.20
Overall Width	E		5.00 BSC	
Exposed Pad Width	E2	3.00	3.10	3.20
Terminal Width	b	0.18	0.25	0.30
Terminal Length	L	0.30	0.40	0.50
Terminal-to-Exposed-Pad	K	0.20	-	-

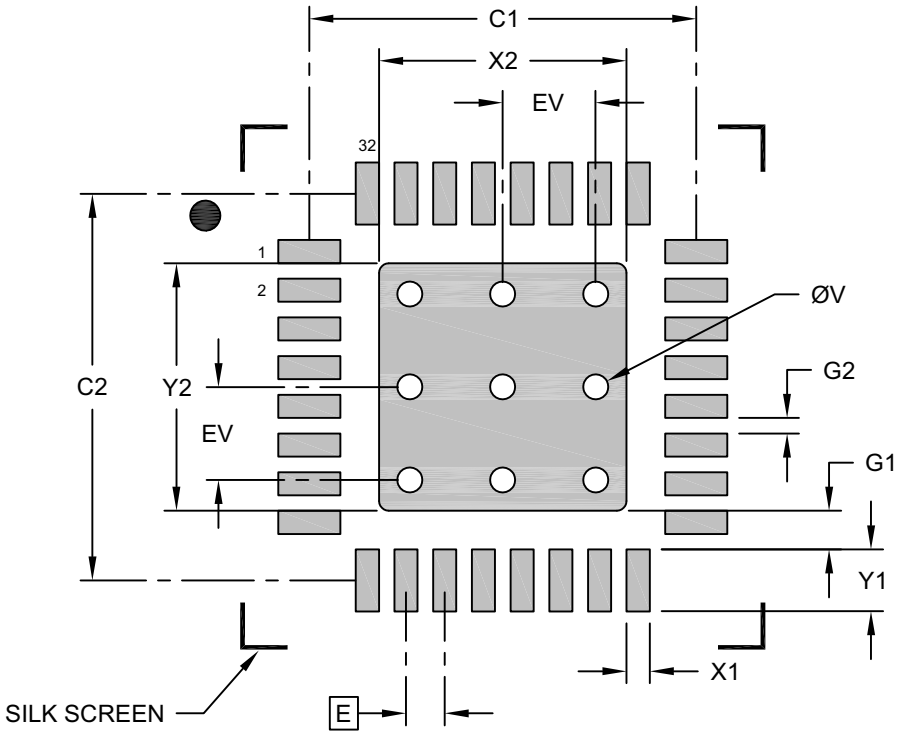
Notes:

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 C04-21395-RXB Rev C Sheet 2 of 2

32-Lead Very Thin Plastic Quad Flat, No Lead Package (RXB) - 5x5x0.9 mm Body [VQFN] With 3.1x3.1 mm Exposed Pad; Atmel Legacy Global Package Code ZMF

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



RECOMMENDED LAND PATTERN

Units		MILLIMETERS		
Dimension Limits		MIN	NOM	MAX
Contact Pitch	E		0.50 BSC	
Center Pad Width	X2			3.20
Center Pad Length	Y2			3.20
Contact Pad Spacing	C1		5.00	
Contact Pad Spacing	C2		5.00	
Contact Pad Width (X32)	X1			0.30
Contact Pad Length (X32)	Y1			0.80
Contact Pad to Center Pad (X32)	G1	0.20		
Contact Pad to Contact Pad (X28)	G2	0.20		
Thermal Via Diameter	V		0.33	
Thermal Via Pitch	EV		1.20	

Notes:

1. Dimensioning and tolerancing per ASME Y14.5M
   BSC: Basic Dimension. Theoretically exact value shown without tolerances.
2. For best soldering results, thermal vias, if used, should be filled or tented to avoid solder loss during reflow process

Microchip Technology Drawing C04-23395-RXB Rev C

NOTES:

APPENDIX A: REVISION HISTORY

Revision B (March 2023)

- Updated quantity per reel for TFBGA package in **Section "Product Identification System"**.

Revision A (December 2022)

- Initial release of this document.

NOTES:

PRODUCT IDENTIFICATION SYSTEM

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

PART NO.	[X](1)	X	/XX	-XXX
Device	Tape and Reel Option	Temperature Range	Package	Qualification

Device:	HV56266: Single +300V High Voltage Operational Amplifier	
Tape and Reel Option:	Blank T	= Standard packaging (tube or tray) = Tape and Reel(1)
Temperature Range:	I E	= -40°C to +85°C (Industrial) = -40°C to +125°C (Extended)
Package:	2PW RXB	= 16-Ball 4 x 4 x 1.2 mm TFBGA = 32-Lead 5 x 5 x 0.9 mm VQFN
Qualification:	Blank VAO	= Standard Part = Automotive AEC-Q100 Qualified

Examples:

a) HV56266T-E/2PW: Single +300V High Voltage Op Amp, 4000/Reel, Extended Temperature, 16-Ball TFBGA package

b) HV56266T-E/RXB-VAO: Single +300V High Voltage Op Amp, 5000/Reel, Extended Temperature, Automotive Grade, 32-Lead VQFN package

Note 1: 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.

NOTES:

Note the following details of the code protection feature on Microchip products:

- Microchip products meet the specifications contained in their particular Microchip Data Sheet.
- Microchip believes that its family of products is secure when used in the intended manner, within operating specifications, and under normal conditions.
- Microchip values and aggressively protects its intellectual property rights. Attempts to breach the code protection features of Microchip product is strictly prohibited and may violate the Digital Millennium Copyright Act.
- Neither Microchip nor any other semiconductor manufacturer can guarantee the security of its code. Code protection does not mean that we are guaranteeing the product is "unbreakable" Code protection is constantly evolving. Microchip is committed to continuously improving the code protection features of our products.

For information regarding Microchip's Quality Management Systems, please visit www.microchip.com/quality.

Trademarks

ISBN: 978-1-6683-2162-1

Worldwide Sales and Service

AMERICAS

Corporate Office
2355 West Chandler Blvd.
Chandler, AZ 85224-6199
Tel: 480-792-7200
Fax: 480-792-7277
Technical Support:
http://www.microchip.com/support
Web Address:
www.microchip.com

Atlanta
Duluth, GA
Tel: 678-957-9614
Fax: 678-957-1455

Austin, TX
Tel: 512-257-3370

Boston
Westborough, MA
Tel: 774-760-0087
Fax: 774-760-0088

Chicago
Itasca, IL
Tel: 630-285-0071
Fax: 630-285-0075

Dallas
Addison, TX
Tel: 972-818-7423
Fax: 972-818-2924

Detroit
Novi, MI
Tel: 248-848-4000

Houston, TX
Tel: 281-894-5983

Indianapolis
Noblesville, IN
Tel: 317-773-8323
Fax: 317-773-5453
Tel: 317-536-2380

Los Angeles
Mission Viejo, CA
Tel: 949-462-9523
Fax: 949-462-9608
Tel: 951-273-7800

Raleigh, NC
Tel: 919-844-7510

New York, NY
Tel: 631-435-6000

San Jose, CA
Tel: 408-735-9110
Tel: 408-436-4270

Canada - Toronto
Tel: 905-695-1980
Fax: 905-695-2078

ASIA/PACIFIC

Australia - Sydney
Tel: 61-2-9868-6733

China - Beijing
Tel: 86-10-8569-7000

China - Chengdu
Tel: 86-28-8665-5511

China - Chongqing
Tel: 86-23-8980-9588

China - Dongguan
Tel: 86-769-8702-9880

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

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

China - Hong Kong SAR
Tel: 852-2943-5100

China - Nanjing
Tel: 86-25-8473-2460

China - Qingdao
Tel: 86-532-8502-7355

China - Shanghai
Tel: 86-21-3326-8000

China - Shenyang
Tel: 86-24-2334-2829

China - Shenzhen
Tel: 86-755-8864-2200

China - Suzhou
Tel: 86-186-6233-1526

China - Wuhan
Tel: 86-27-5980-5300

China - Xian
Tel: 86-29-8833-7252

China - Xiamen
Tel: 86-592-2388138

China - Zhuhai
Tel: 86-756-3210040

ASIA/PACIFIC

India - Bangalore
Tel: 91-80-3090-4444

India - New Delhi
Tel: 91-11-4160-8631

India - Pune
Tel: 91-20-4121-0141

Japan - Osaka
Tel: 81-6-6152-7160

Japan - Tokyo
Tel: 81-3-6880- 3770

Korea - Daegu
Tel: 82-53-744-4301

Korea - Seoul
Tel: 82-2-554-7200

Malaysia - Kuala Lumpur
Tel: 60-3-7651-7906

Malaysia - Penang
Tel: 60-4-227-8870

Philippines - Manila
Tel: 63-2-634-9065

Singapore
Tel: 65-6334-8870

Taiwan - Hsin Chu
Tel: 886-3-577-8366

Taiwan - Kaohsiung
Tel: 886-7-213-7830

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

Thailand - Bangkok
Tel: 66-2-694-1351

Vietnam - Ho Chi Minh
Tel: 84-28-5448-2100

EUROPE

Austria - Wels
Tel: 43-7242-2244-39
Fax: 43-7242-2244-393

Denmark - Copenhagen
Tel: 45-4485-5910
Fax: 45-4485-2829

Finland - Espoo
Tel: 358-9-4520-820

France - Paris
Tel: 33-1-69-53-63-20
Fax: 33-1-69-30-90-79

Germany - Garching
Tel: 49-8931-9700

Germany - Haan
Tel: 49-2129-3766400

Germany - Heilbronn
Tel: 49-7131-72400

Germany - Karlsruhe
Tel: 49-721-625370

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

Germany - Rosenheim
Tel: 49-8031-354-560

Israel - Ra'anana
Tel: 972-9-744-7705

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

Italy - Padova
Tel: 39-049-7625286

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

Norway - Trondheim
Tel: 47-7288-4388

Poland - Warsaw
Tel: 48-22-3325737

Romania - Bucharest
Tel: 40-21-407-87-50

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

Sweden - Gothenberg
Tel: 46-31-704-60-40

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

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