

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/ μ s 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

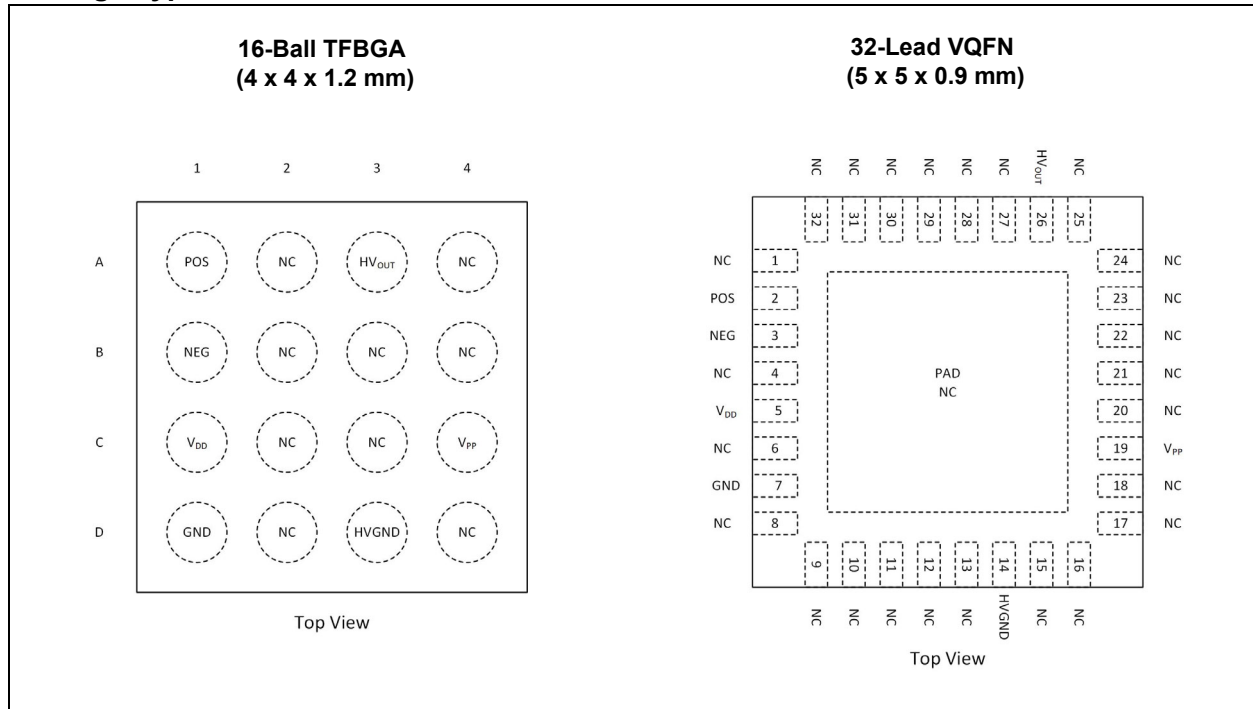
HV56266 is a single-channel MEMS amplifier with external gain-set resistors. The amplifier uses two supplies - a low voltage 5V supply at V_{DD} and a high voltage 100V-300V supply at V_{PP} .

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/ μ s slew rate and a bandwidth of 10 kHz with a gain of 90V/V.

The HV56266 device is available in two packages:

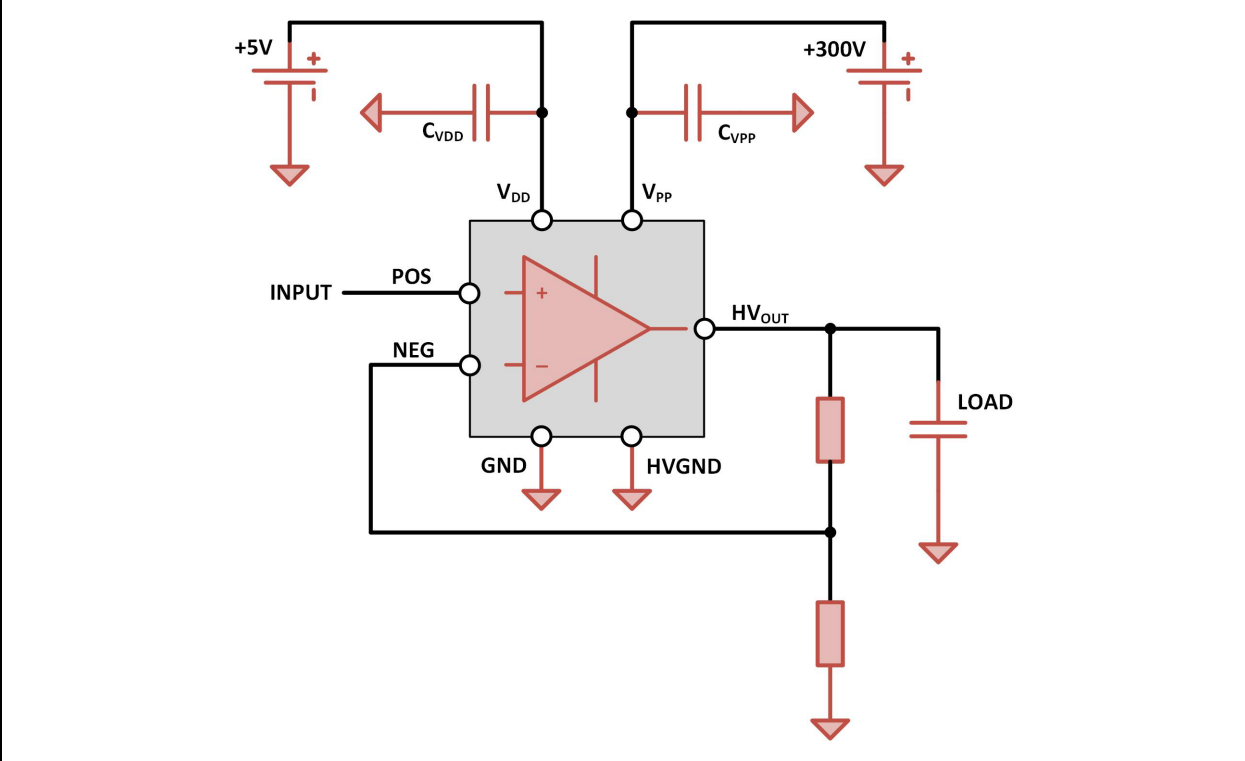
- 16-ball 4 x 4 x 1.2 mm TFBGA.
- 32-lead 5 x 5 x 0.9 mm VQFN.

Package Types

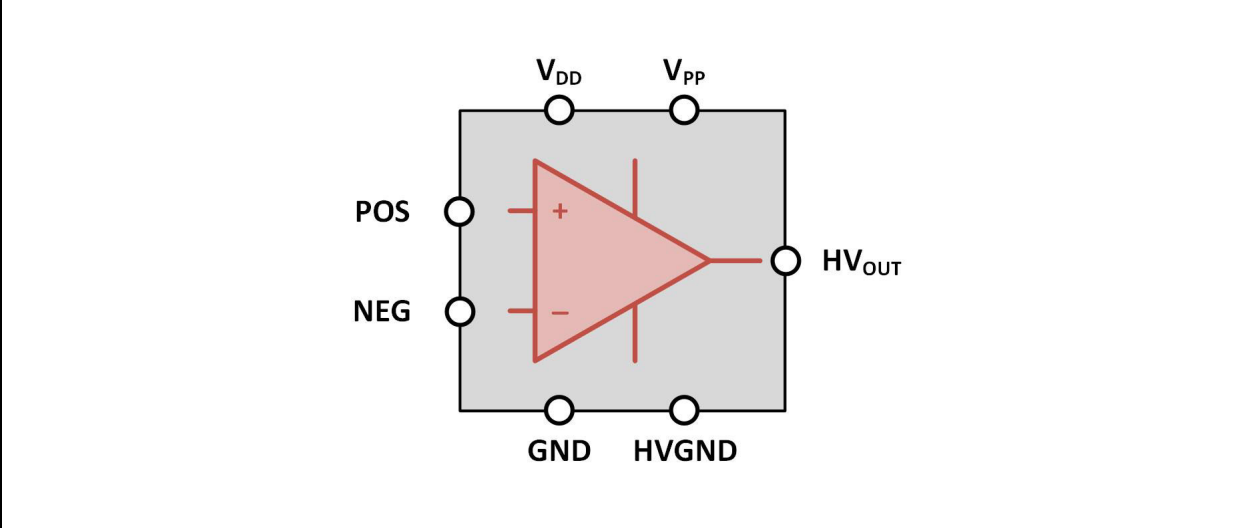


HV56266

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, $T_A = T_J = 25^\circ\text{C}$, $V_{DD} = 5\text{V}$, $V_{PP} = 300\text{V}$, $C_{VPP} = 0.1\ \mu\text{F}$, $C_{VDD} = 1\ \mu\text{F}$, $C_{LOAD} = 15\ \text{pF}$, $R_{F1} = 3.09\ \text{M}\Omega$, $R_{F2} = 34.8\ \text{k}\Omega$. **Boldface** specifications apply over $T_A = T_J = -40^\circ\text{C}$ 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	$V_{O,\text{pk-pk}}$	VPP-10	—	—	V	POS = 0-3.3V sine wave at 1 kHz
Closed Loop Gain Range	A_V	30	—	90	V/V	Note 2
Load Capacitance Range	C_{LOAD}	0	—	15	pF	Note 2
Total Feedback Resistance Range	$R_{F,\text{tot}}$	3	—	7	M Ω	$R_{F1} + R_{F2}$, (Note 2)

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

2: Specification is for design guidance only.

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ELECTRICAL CHARACTERISTICS (CONTINUED)

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

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	$^\circ\text{C}$	
Storage Temperature Range	T_A	-55	—	+165	$^\circ\text{C}$	
Package Thermal Resistance						
Thermal Resistance, 32-Lead VQFN	θ_{JA}	—	32.3	—	$^\circ\text{C/W}$	
Thermal Resistance, 16-Ball BGA	θ_{JA}	—	113	—	$^\circ\text{C/W}$	

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.

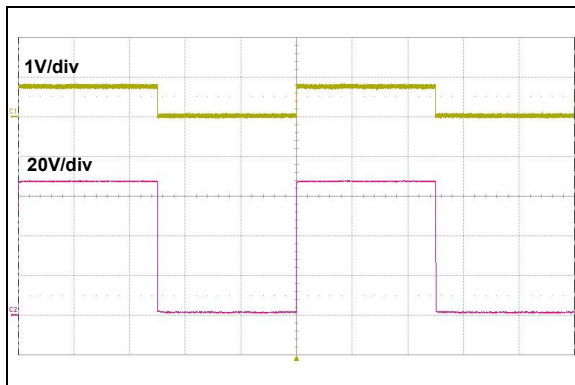


FIGURE 2-1: Typical Small-Signal Pulse Response (POS = 0~750 mV pulse, 100 Hz, CL = 15 pF).

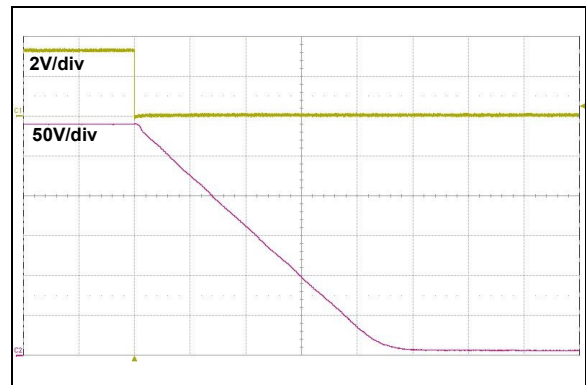


FIGURE 2-4: Typical Fall Time (POS = 0~3.3V pulse, 100 Hz, CL = 15 pF).

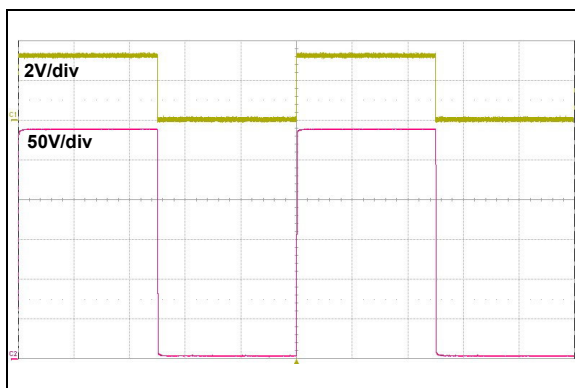


FIGURE 2-2: Typical Large-Signal Pulse Response (POS = 0~3.3V pulse, 100 Hz, CL = 15 pF).

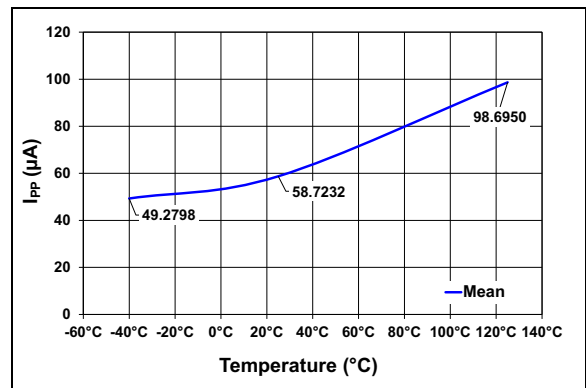


FIGURE 2-5: I_{PP} Current vs. Temperature (Mean).

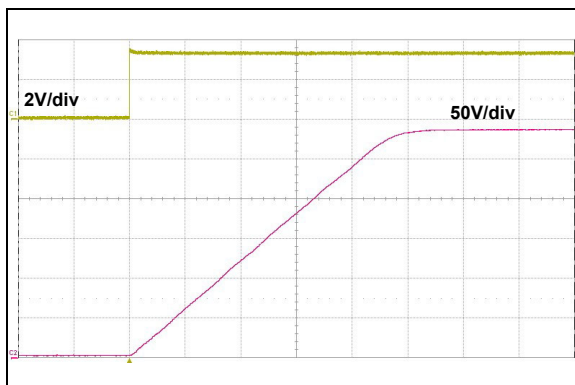


FIGURE 2-3: Typical Rise Time (POS = 0~3.3V pulse, 100 Hz, CL = 15 pF).

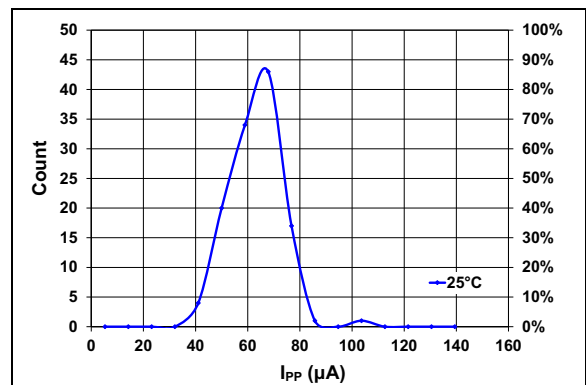


FIGURE 2-6: Distribution of I_{PP} Current at T_A = 25°C.

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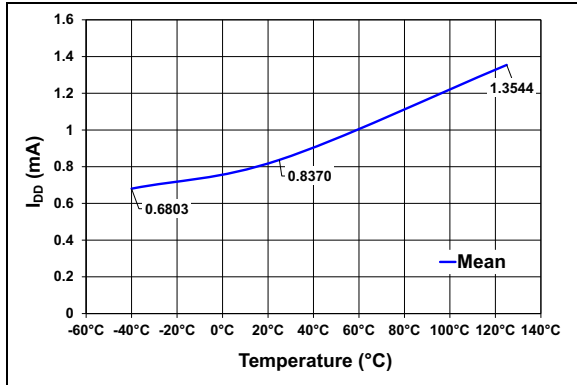


FIGURE 2-7: I_{DD} Current vs. Temperature (Mean).

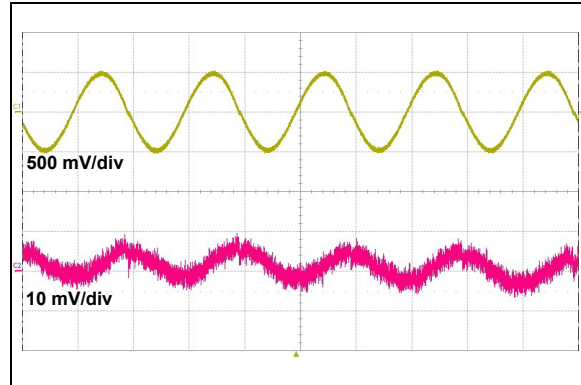


FIGURE 2-10: Typical Power Supply Rejection from V_{PP} .

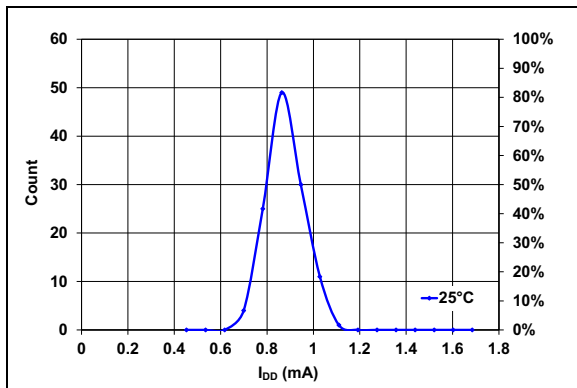


FIGURE 2-8: Distribution of I_{DD} Current at $T_A = 25^\circ\text{C}$.

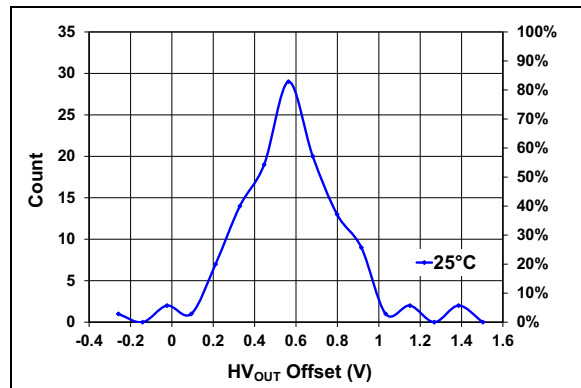


FIGURE 2-11: Distribution of HV_{OUT} Offset at $T_A = 25^\circ\text{C}$.

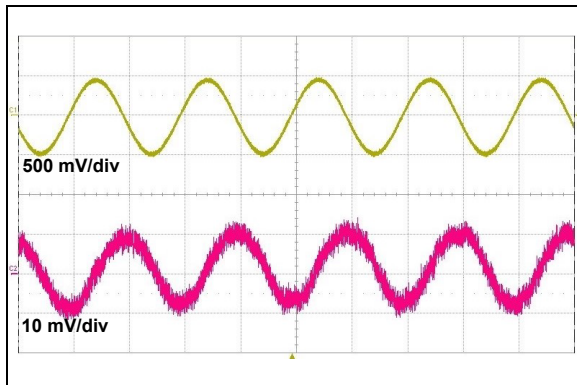


FIGURE 2-9: Typical Power Supply Rejection from V_{DD} .

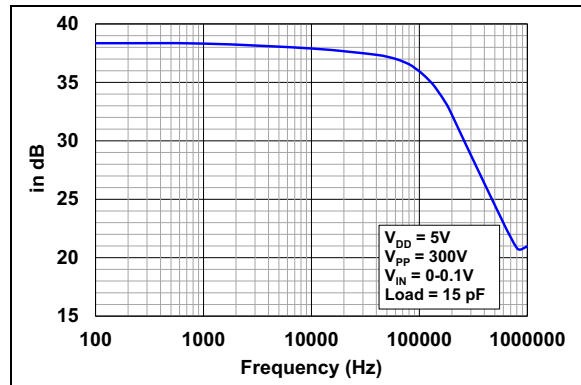


FIGURE 2-12: Typical Frequency Response of Gain at 90V/V at $T_A = 25^\circ\text{C}$.

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 ($\geq 1 \mu\text{F}$).
C4	19	V _{PP}	100V-300V nominal power supply. Bypass with a low ESR ceramic capacitor ($\geq 0.1 \mu\text{F}$).
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.

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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

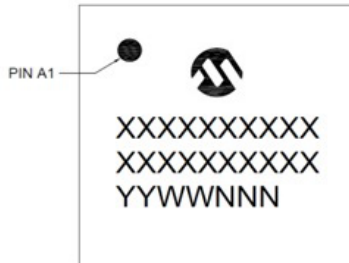
TABLE 4-2: ACCEPTABLE POWER-OFF SEQUENCE

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

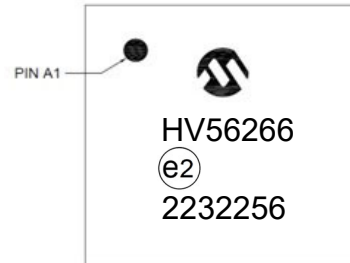
5.0 PACKAGE INFORMATION

5.1 Package Marking Information

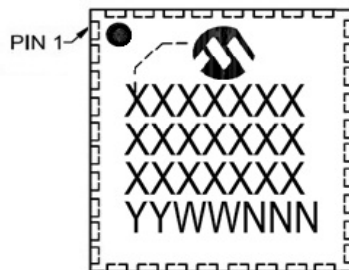
16-Ball TFBGA (4 x 4 x 1.2 mm)



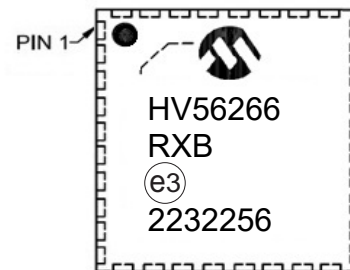
Example



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



Example



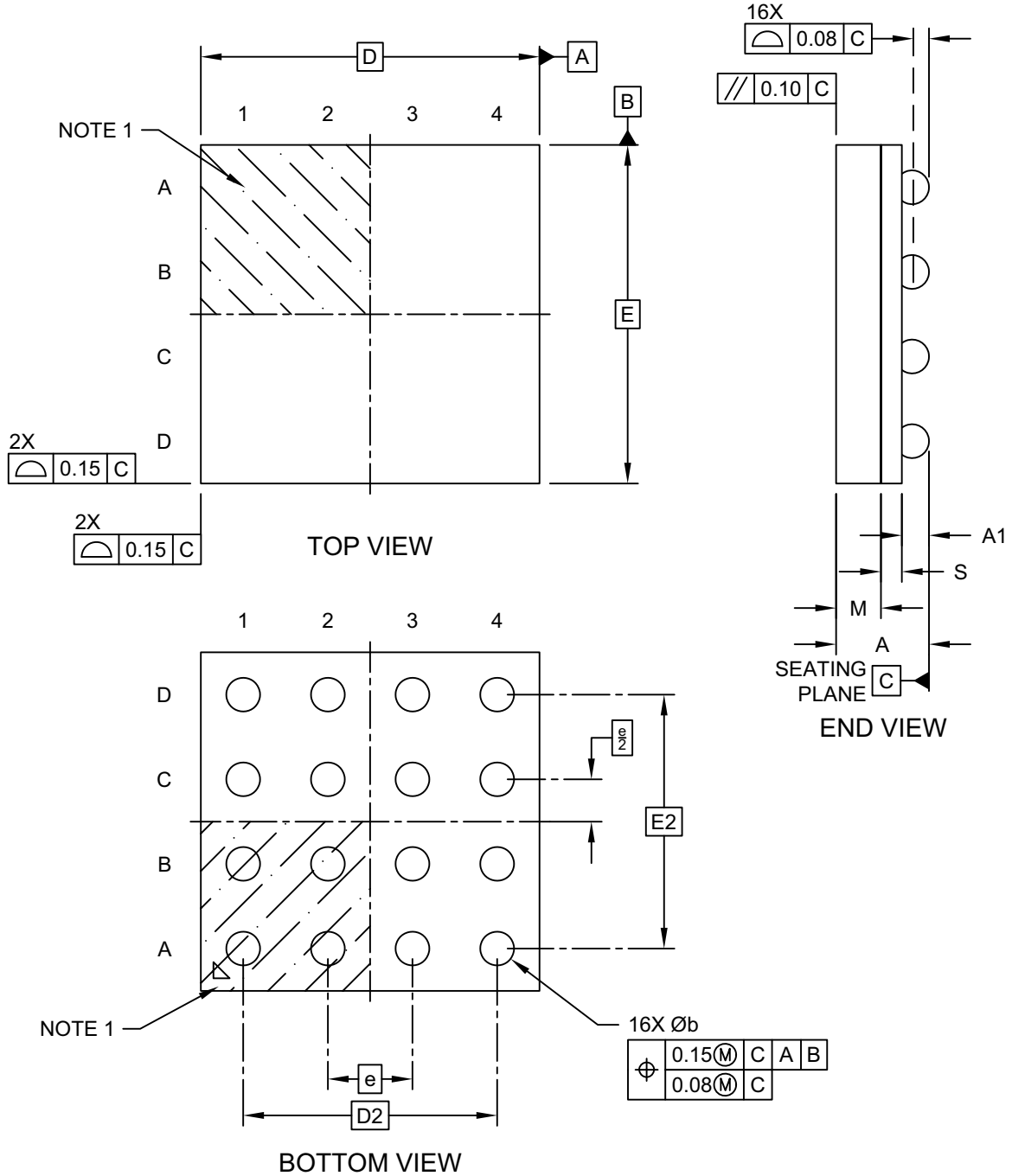
Legend:	XX...X	Product Code or Customer-specific information
	Y	Year code (last digit of calendar year)
	YY	Year code (last 2 digits of calendar year)
	WW	Week code (week of January 1 is week '01')
	NNN	Alphanumeric traceability code
	(e3)	Pb-free JEDEC designator for Matte Tin (Sn)
	*	This package is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

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

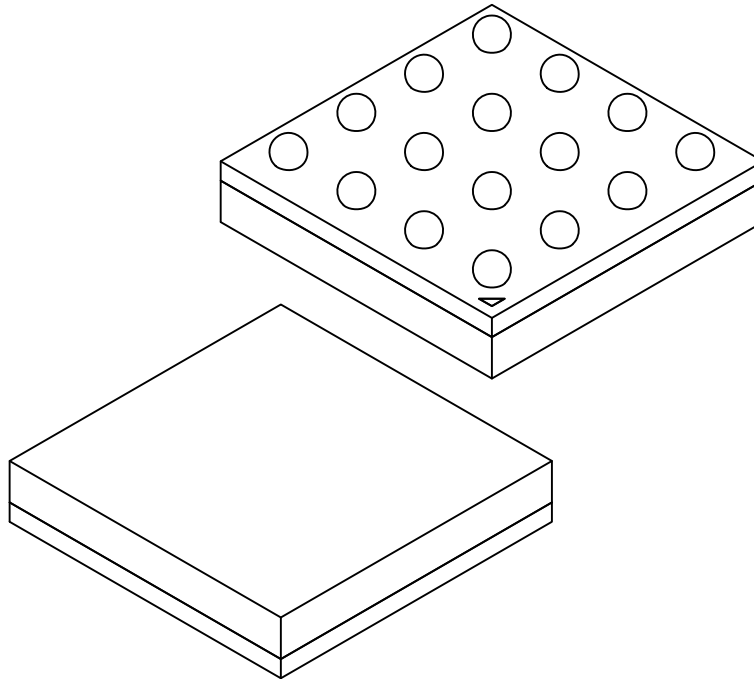
Note: For the most current package drawings, please see the Microchip Packaging Specification located at <http://www.microchip.com/packaging>



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

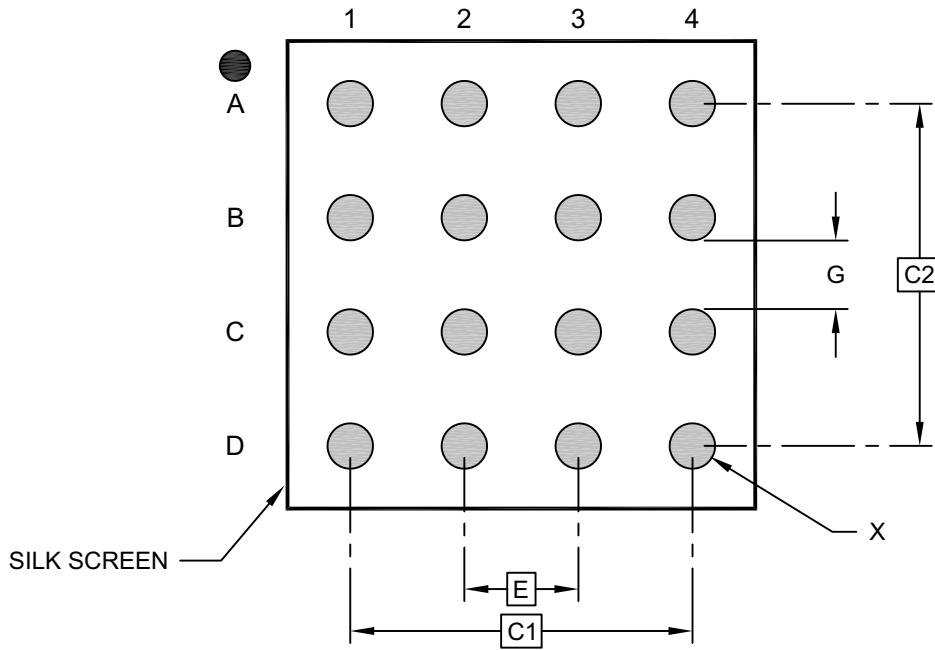
Notes:

- Pin 1 visual index feature may vary, but must be located within the hatched area.
- 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.

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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

Dimension Limits	Units	MILLIMETERS		
		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:

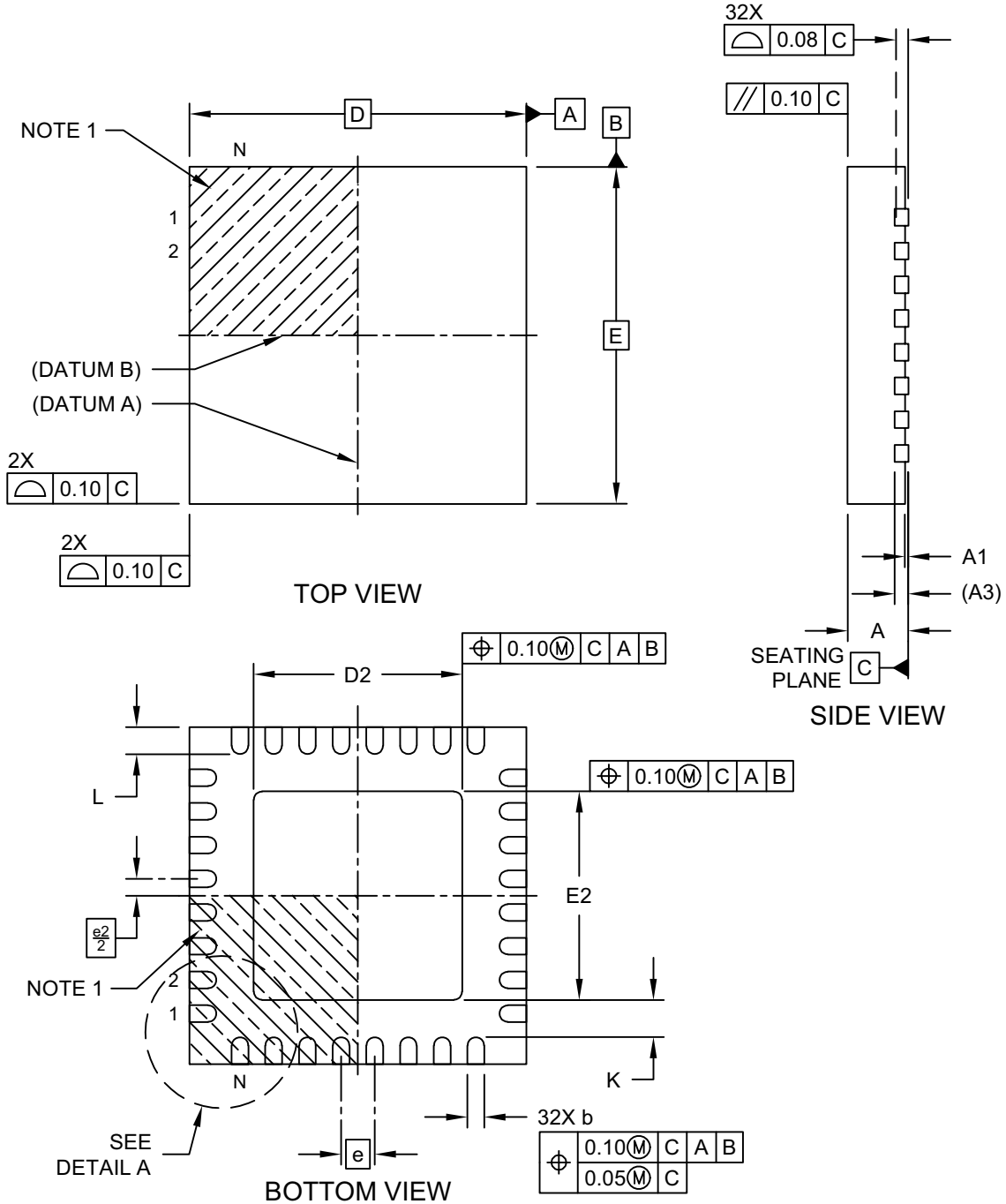
1. Dimensioning and tolerancing per ASME Y14.5M

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>

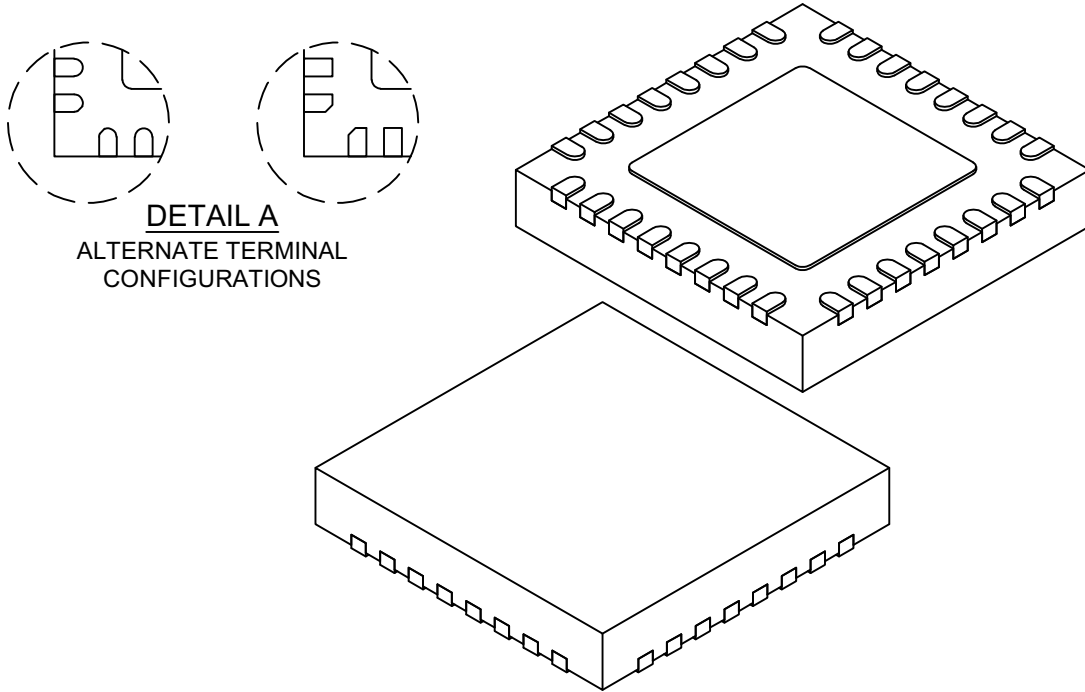


Microchip Technology Drawing C04-21395-RXB Rev C Sheet 1 of 2

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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>



Dimension Limits	Units	MILLIMETERS		
		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	-	-

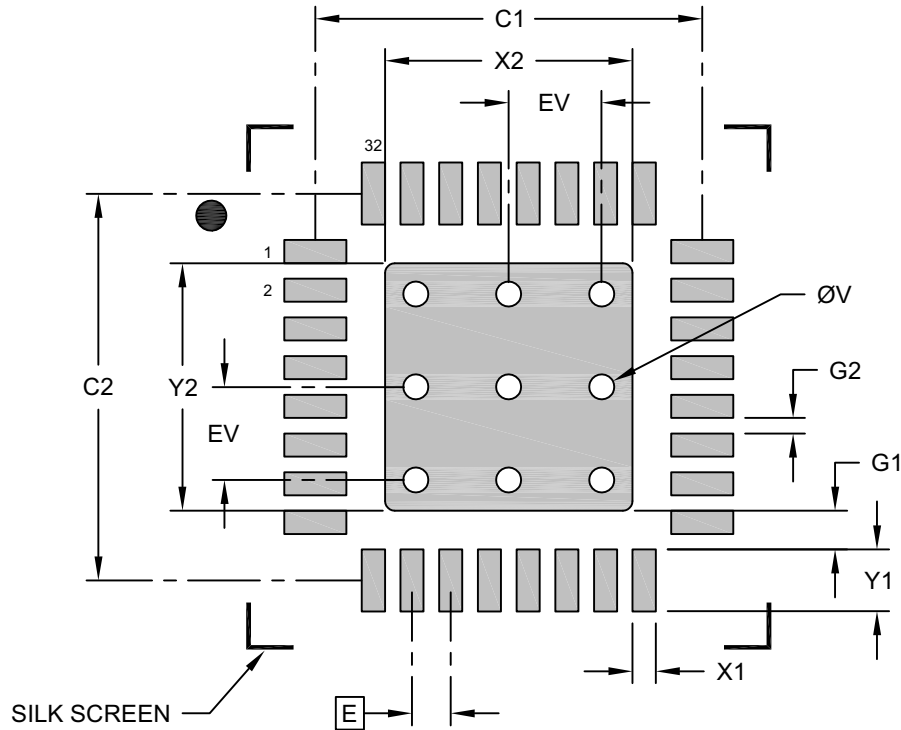
Notes:

- 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 C04-21395-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

Dimension Limits	Units	MILLIMETERS		
		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:

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

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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.

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

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