AFE4950 Ultra-Small, Integrated AFE for Wearable Optical Heart-Rate Monitoring, SpO2 and Electrical Bio-sensing

1 Features

- Supports simultaneous and synchronized acquisition of up to 24 PPG and a single-lead ECG signal.
- Flexible allocation of 8 LED, 4 PD in each phase
- ECG signal chain:
  - 1-lead ECG signal acquisition up to 2 kHz
  - RLD output to drive a third electrode
  - Input noise : 0.7 µV-rms
  - Supports up to ±0.65 V differential DC offset and +/-0.55 V common mode range
  - Programmable INA gain: 11, 21
  - High-pass filter with quick saturation recovery
  - Integrated 300 Hz anti-aliasing low pass filter
  - AC, DC lead-off detect: 2.9 nA to 92.5 nA
  - Low power continuous lead-on detection
- Impedance signal chain
  - Continuous low-power monitoring of impedance between 2 electrodes
  - 7 MΩ range
  - 300 Ω noise on 620 kΩ
- PPG Transmitter:
  - 8-Bit Programmable LED Current with range adjustable from 25 mA to 250 mA
  - Mode to fire two LEDs in parallel
  - Support of 8 LEDs in Common Anode configuration for SpO2, Multi-Wavelength HRM
- PPG Receiver:
  - 2 parallel receivers (two sets of TIA/ filter)
  - Supports 4 Time-Multiplexed Photodiode Inputs to each Receiver
  - 8-bit Ambient Offset subtraction at each TIA input with 256 µA range
  - 8-bit LED Offset Subtraction DAC with 64 µA range
  - Automatic ambient cancellation and dynamic LED DC cancellation at TIA input
  - Ambient rejection close to 100 dB up to 10 Hz
  - Noise filtering with programmable bandwidth
  - Trans-impedance Gain: 3.7 kΩ to 1 MΩ
- Accurate, Continuous Heart-Rate Monitoring:
  - System SNR up to 109-dB at 16 µA PD current
  - Low Current for Continuous Operation on a Wearable Device with a Typical Value: 15-µA for an LED, 20-µA for the Receiver
- External clock and internal oscillator modes
- Acquire data synchronized with system master clock
- FIFO with 256-sample Depth
- SPI, I^{2}C interfaces: Selectable by pin
- 2.6-mm × 2.5-mm DSBGA, 0.4-mm Pitch
- Supplies: Rx:1.7-1.9V (LDO Bypass); 1.9-3.6V (LDO Enabled), Tx:3-5.5V, IO:1.7-RX_SUP

2 Applications

- Optical Heart-Rate Monitoring (HRM) for Wearables, Hearables
- High performance ECG signal acquisition
- Synchronized PPG, ECG for BP estimation
- Heart-rate variability (HRV)
- Pulse oximetry (SpO_2) measurements

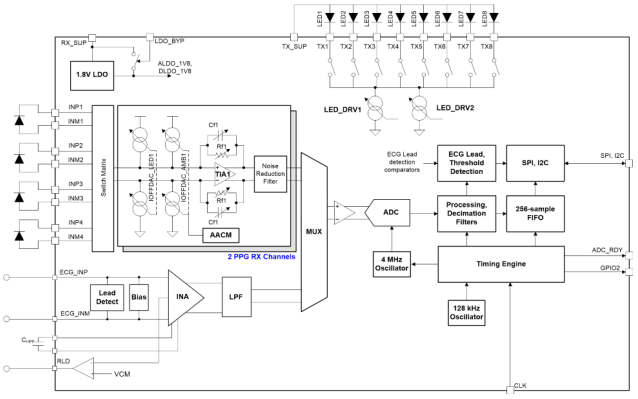
3 Description

The AFE4950 device is an analog front-end (AFE) for synchronized signal acquisition of PPG and ECG signals. The device can also be used for optical bio-sensing applications, such as heart-rate monitoring (HRM) and saturation of peripheral capillary oxygen (SpO2). The ECG signal chain supports 2- and 3-electrode configurations and has an integrated Right leg drive (RLD) buffer. The ECG signal chain can also be used to do a continuous, low-power monitoring of the impedance between pair of electrodes.

Device Information

PART NUMBER	PACKAGE(1)	BODY SIZE (NOM)
AFE4950	DSBGA (36)	2.60 mm × 2.50 mm

(1) For all available packages, see the orderable addendum at the end of the data sheet.



Simplified Schematic

4 Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from Revision A (July 2020) to Revision B (July 2021)	Page
• Changed the *Features* list *AC, DC lead-off detect* value From: *2.6-nA to 85-nA* To: *2.9 nA to 92.5 nA*	1

Changes from Revision * (June 2020) to Revision A (July 2020)	Page
• Changed the data sheet From: *Advanced Information* To: *Production* data	1

5 Device and Documentation Support

5.1 Receiving Notification of Documentation Updates

To receive notification of documentation updates, navigate to the device product folder on ti.com. Click on *Subscribe to updates* to register and receive a weekly digest of any product information that has changed. For change details, review the revision history included in any revised document.

5.2 Support Resources

TI E2E™ support forums are an engineer's go-to source for fast, verified answers and design help — straight from the experts. Search existing answers or ask your own question to get the quick design help you need.

Linked content is provided "AS IS" by the respective contributors. They do not constitute TI specifications and do not necessarily reflect TI's views; see TI's Terms of Use.

5.3 Trademarks

TI E2E™ is a trademark of Texas Instruments.
All trademarks are the property of their respective owners.

5.4 Electrostatic Discharge Caution

This integrated circuit can be damaged by ESD. Texas Instruments recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

5.5 Glossary

TI Glossary	This glossary lists and explains terms, acronyms, and definitions.

Mechanical, Packaging, and Orderable Information

The following pages include mechanical, packaging, and orderable information. This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser-based versions of this data sheet, refer to the left-hand navigation.

PACKAGING INFORMATION

Orderable part number	Status (1)	Material type (2)	Package | Pins	Package qty | Carrier	RoHS (3)	Lead finish/ Ball material (4)	MSL rating/ Peak reflow (5)	Op temp (°C)	Part marking (6)
AFE4950YBGR	Active	Production	DSBGA (YBG) | 36	3000 | LARGE T&R	Yes	SAC396	Level-1-260C-UNLIM	-40 to 85	AFE4950
AFE4950YBGR.A	Active	Production	DSBGA (YBG) | 36	3000 | LARGE T&R	Yes	SAC396	Level-1-260C-UNLIM	-40 to 85	AFE4950
AFE4950YBGT	Active	Production	DSBGA (YBG) | 36	250 | SMALL T&R	Yes	SAC396	Level-1-260C-UNLIM	-40 to 85	AFE4950
AFE4950YBGT.A	Active	Production	DSBGA (YBG) | 36	250 | SMALL T&R	Yes	SAC396	Level-1-260C-UNLIM	-40 to 85	AFE4950

(1) **Status:** For more details on status, see our product life cycle.

(2) **Material type:** When designated, preproduction parts are prototypes/experimental devices, and are not yet approved or released for full production. Testing and final process, including without limitation quality assurance, reliability performance testing, and/or process qualification, may not yet be complete, and this item is subject to further changes or possible discontinuation. If available for ordering, purchases will be subject to an additional waiver at checkout, and are intended for early internal evaluation purposes only. These items are sold without warranties of any kind.

(3) **RoHS values:** Yes, No, RoHS Exempt. See the TI RoHS Statement for additional information and value definition.

(4) **Lead finish/Ball material:** Parts may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

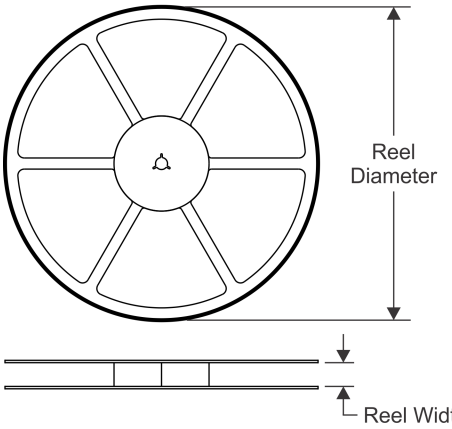
(5) **MSL rating/Peak reflow:** The moisture sensitivity level ratings and peak solder (reflow) temperatures. In the event that a part has multiple moisture sensitivity ratings, only the lowest level per JEDEC standards is shown. Refer to the shipping label for the actual reflow temperature that will be used to mount the part to the printed circuit board.

(6) **Part marking:** There may be an additional marking, which relates to the logo, the lot trace code information, or the environmental category of the part.

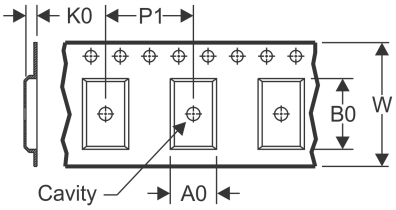
Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "~" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

TAPE AND REEL INFORMATION

REEL DIMENSIONS

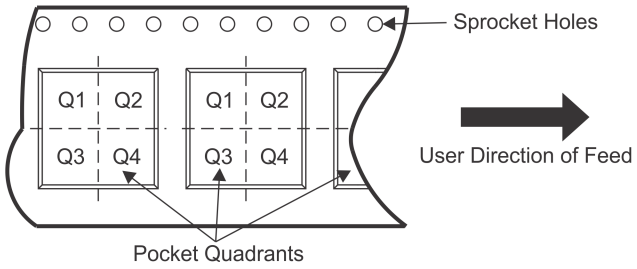


TAPE DIMENSIONS



A0	Dimension designed to accommodate the component width
B0	Dimension designed to accommodate the component length
K0	Dimension designed to accommodate the component thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers

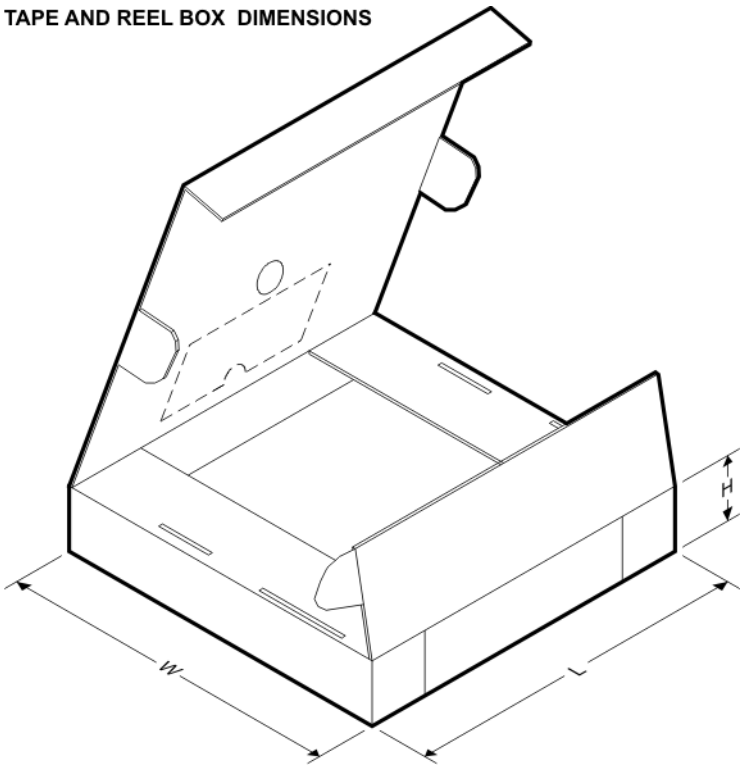
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
AFE4950YBGR	DSBGA	YBG	36	3000	330.0	12.4	2.64	2.8	0.74	8.0	12.0	Q1
AFE4950YBGT	DSBGA	YBG	36	250	330.0	12.4	2.64	2.8	0.74	8.0	12.0	Q1

TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

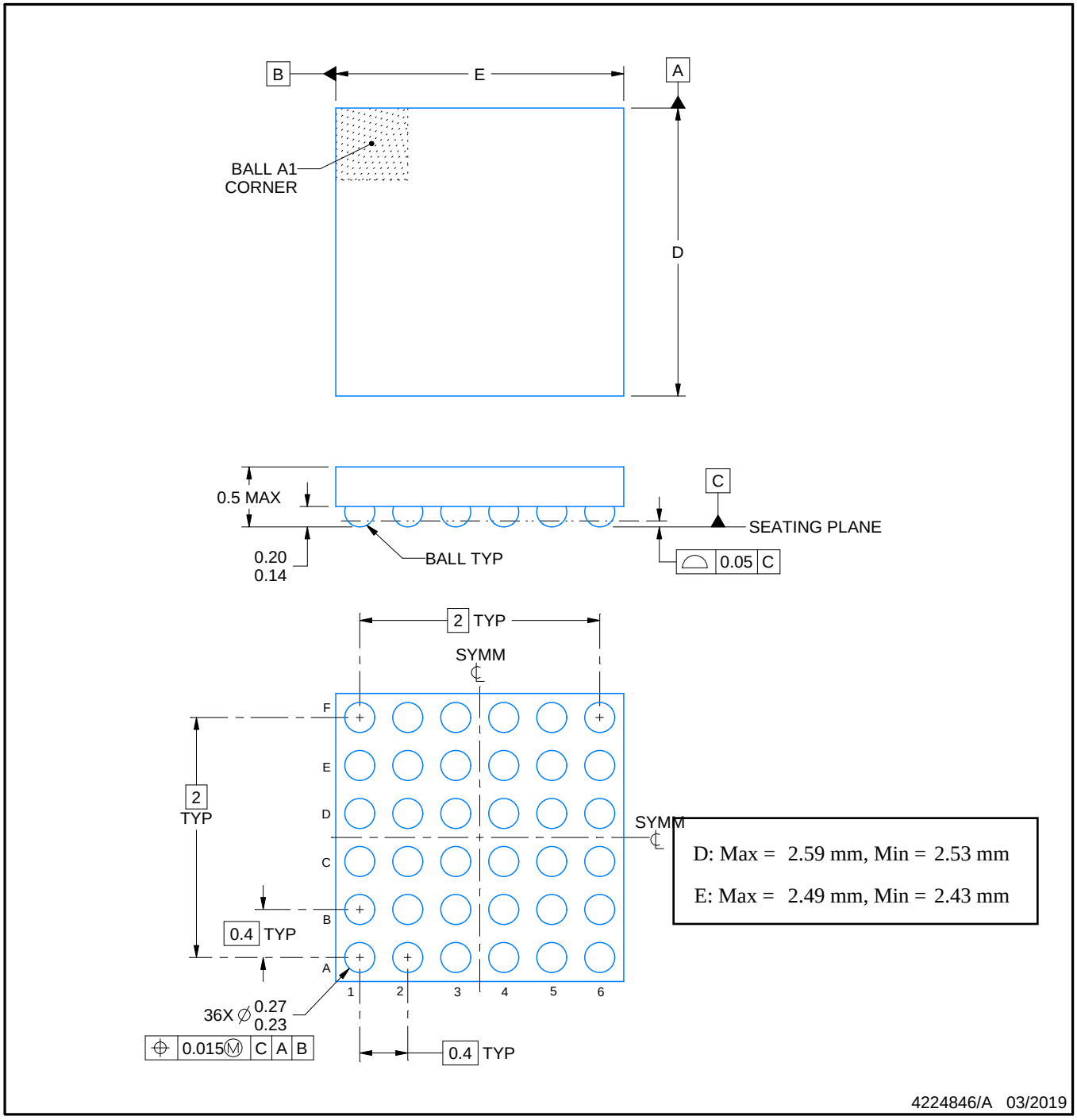
Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
AFE4950YBGR	DSBGA	YBG	36	3000	345.0	365.0	55.0
AFE4950YBGT	DSBGA	YBG	36	250	345.0	365.0	55.0

YBG0036

PACKAGE OUTLINE

DSBGA - 0.5 mm max height

DIE SIZE BALL GRID ARRAY



NOTES:

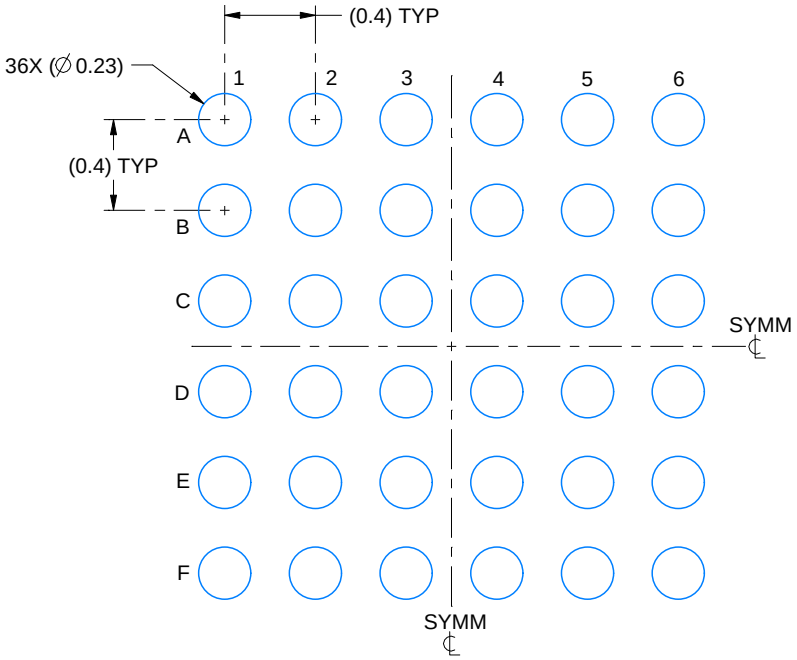
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.

EXAMPLE BOARD LAYOUT

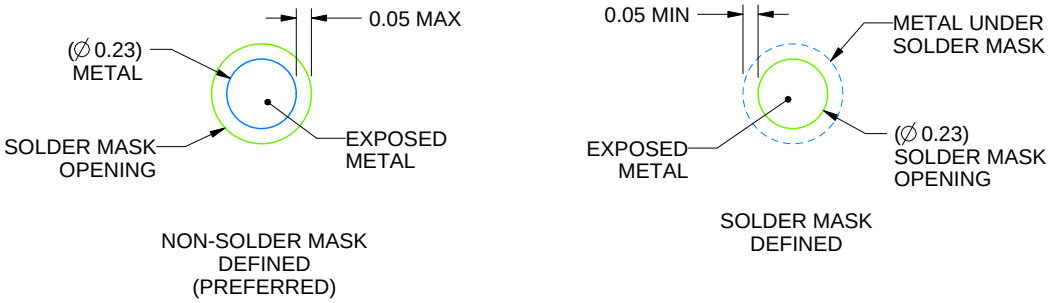
YBG0036

DSBGA - 0.5 mm max height

DIE SIZE BALL GRID ARRAY



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE: 30X



SOLDER MASK DETAILS
NOT TO SCALE

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NOTES: (continued)

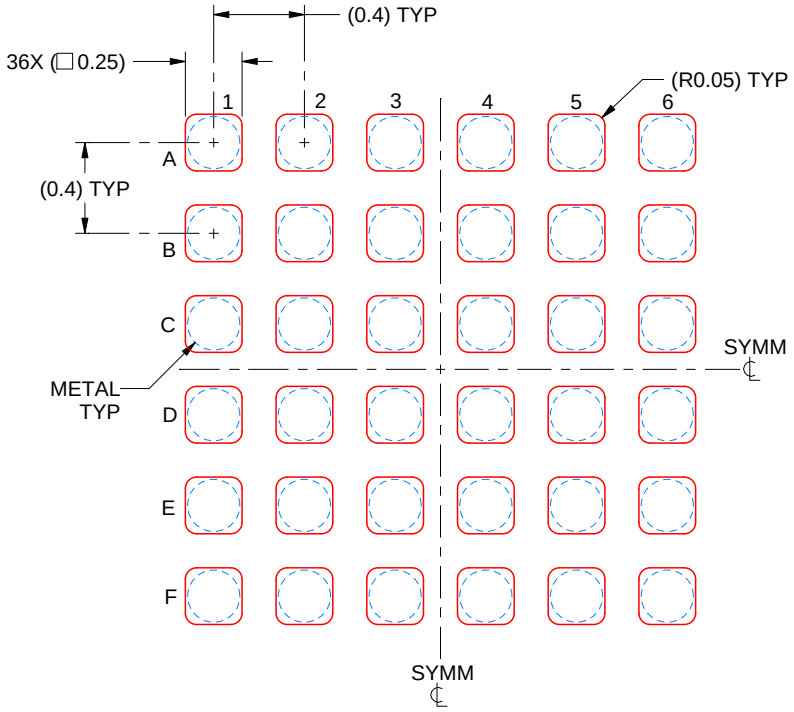
3. Final dimensions may vary due to manufacturing tolerance considerations and also routing constraints.
   See Texas Instruments Literature No. SNVA009 (www.ti.com/lit/snva009).

EXAMPLE STENCIL DESIGN

YBG0036

DSBGA - 0.5 mm max height

DIE SIZE BALL GRID ARRAY



SOLDER PASTE EXAMPLE
BASED ON 0.1 mm THICK STENCIL
SCALE: 30X

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NOTES: (continued)

4. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release.

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