

# TWL6041 8-Channel Low-Power Audio Codec for Portable Applications

## 1 Device Overview

### 1.1 Features

- Four Audio Digital-to-Analog Converter (DAC) Channels
- Stereo Capless Headphone Drivers
  - Up to 104-dB DR
  - Power Tune for Performance and Power Consumption Tradeoff
- Stereo 8 Ω, 1.5 W per Channel Speaker Drivers also with 4-Ω Support Capability
- Differential Earpiece Driver
- Stereo Line-Out
- Two Audio Analog-to-Digital Converter (ADC) Channels
  - 96-dBA SNR
- Four Audio Inputs:
  - Three Differential Microphone Inputs
  - Stereo Line-In and FM Input
- Two Vibrator and Haptics Feedback Channels
  - Differential H-bridge Drivers
- Two Low-Noise Analog Microphone Bias Outputs
- Two Digital Microphone Bias Outputs
- Analog Low-Power Loop from Line-in to Headphone and Speaker Outputs
- Dual Phase-Locked Loops (PLLs) for Flexible Clock Support:
  - 32-kHz Sleep Clock Input for System Low-Power Playback Mode
  - 12-, 19.2-, 26-, and 38.4-MHz System Clock Input
- Accessory Plug and Unplug Detection, Accessory Button Press Detection
- Integrated Power Supplies:
  - Negative Charge Pump for Capless Headphone Driver
  - Two Low Dropout Voltage Regulators (LDOs) for High Power Supply Rejection Ration (PSRR)
- I<sup>2</sup>C Control
- Thermal Protection:
  - Host Interrupt
- Power Supplies:
  - Analog: 2.1 V
  - Digital I/O: 1.8 V
  - Battery: 2.3 V–5.5 V
- Package 3.8-mm × 3.8-mm 81-Pin WCSP

### 1.2 Applications

- Mobile and Smart Phones
- MP3 Players
- Handheld Devices

### 1.3 Description

The TWL6041 is an audio codec with a high level of integration providing analog audio codec functions for portable applications, as shown in [Figure 1-1](#). The device contains multiple audio analog inputs and outputs, as well as microphone biases and accessory detection. The device is connected to the OMAP™ 4 host processor through a proprietary PDM interface for audio data communication enabling partitioning with optimized power consumption and performance. Multichannel audio data is multiplexed to a single wire for downlink (PDML) and uplink (PDMUL).

The OMAP4 device provides the TWL6041 device with five PDM audio-input channels (DL0–DL4). Channels DL0–DL3 are connected to four parallel DAC channels multiplexed to stereo headphone (HSL, HSR), stereo speaker (HFL, HFR), and earpiece (EAR) or stereo line outputs (AUXL, AUXR).

The stereo headphone path has a low-power (LP) mode operating from a 32-kHz sleep clock to enable more than 100 hours of MP3 playback time. Very-high dynamic range of 104 dBA is achieved when using the system clock input and DAC path high-performance (HP) mode. Class-AB headphone drivers provide a 1-Vrms output and are ground centered for capless connection to a headphone, thus enabling system size and cost reduction. The earpiece driver is a differential class-AB driver with 2-Vrms capability to a typical 32-Ω load or 1.4-Vrms to a typical 16-Ω load.



An IMPORTANT NOTICE at the end of this data sheet addresses availability, warranty, changes, use in safety-critical applications, intellectual property matters and other important disclaimers. PRODUCTION DATA.

Stereo speaker path has filterless class-D outputs with 1.5-W capability per channel. Additionally, the 4- $\Omega$  load is supported. For output-power maximization, supply connection to an external boost is supported. Speaker drivers also support hearing aid coil loads.

For vibrator and haptic feedback support, the TWL6041 device has two PWM channels with independent input signals from DL4 or I<sup>2</sup>C. Vibra drivers are differential H-bridge outputs, enabling fast acceleration and deceleration of vibra motor. An external driver for a hearing aid coil or a piezo speaker requiring high voltage can be connected to line outputs.

The TWL6041 supports three differential microphone inputs (MMIC, HMIC, and SMIC) and a stereo line-input (AFML, AFMR) multiplexed to two parallel ADCs. The PDM output from the ADCs is transmitted to the OMAP4 processor through UL0 and UL1. AFML, AFMR inputs can also be looped to analog outputs (LB0, LB1).

Two LDOs provide a voltage of 2.1 V to bias analog microphones (MBIAS and HBIAS). The maximum output current is 2 mA for each analog bias, allowing up to two microphones on one bias. Two LDOs provide a voltage of 1.8 V to 1.85 V to bias digital microphones (DBIAS1 and DBIAS2). One bias generator can bias several digital microphones at the same time, with a total maximum output current of 10 mA.

The TWL6041 device has an integrated negative charge pump and two LDOs (HS LDO and LS LDO) for high PSRR. The only external supply needed is 2.1 V, which is available from the 2.1-V DC-DC of TWL6030/6032 power-management IC (PMIC) in the OMAP4 system. By powering audio from low-noise 2.1-V DC-DC of low power consumption, high dynamic range and high output swing at the headset output are achieved. All other supply inputs can be directly connected to battery or system 1.8-V I/O.

Two integrated PLLs enable operation from a 12-, 19.2-, 26-, and 38.4-MHz system clock (MCLK) or, in LP playback mode, from a 32-kHz sleep clock (CLK32K). The frequency plan is based on a 48-kS/s audio data rate for all channels, and the host processor uses sample-rate converters to interface with different sample rates (for example, 44.1 kHz). In the specific case of low-power audio playback, the TWL6041 supports the 44.1-kS/s and 48-kS/s rates. Transitions between sample rates or input clocks are seamless.

Accessory plug and unplug detections are supported (PLUGDET). Some headsets have a manual switch for submitting send/end signal to the terminal through the microphone input pin. This feature is supported by a periodic accessory button press detection to minimize current consumption in sleep mode. Detection cycle properties can be programmed according to system requirements.

The TWL6041BSRS, when connected to OMAP4 and OMAP5 platform, includes SRS Audio Effects, SRS pre-processing solutions and SRS TruMedia as standard feature for Android™ ICS.

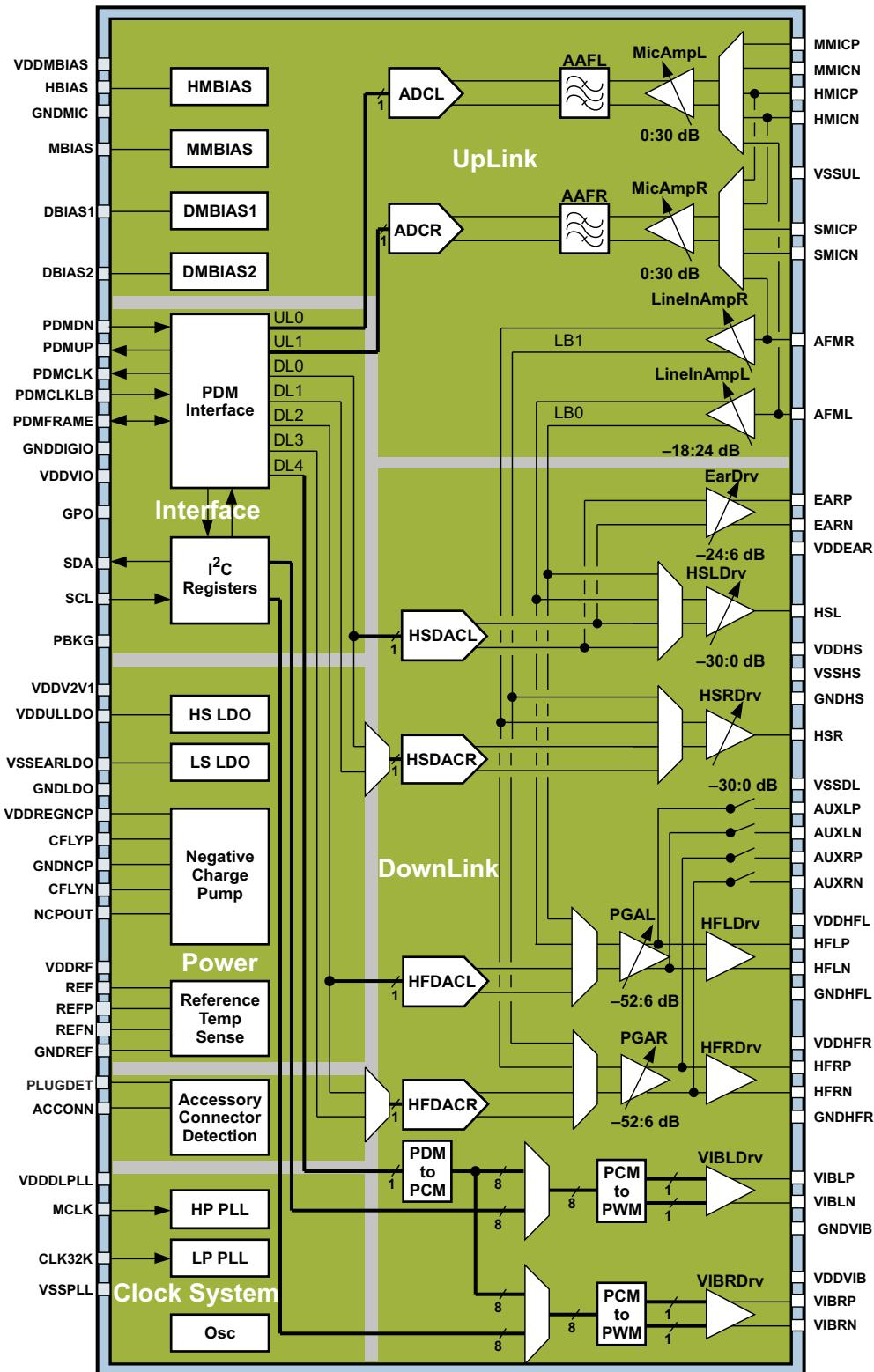
**Table 1-1. Device Information<sup>(1)</sup>**

PART NUMBER	PACKAGE	BODY SIZE (NOM)
TWL6041B	YFF (81)	3.56 mm x 3.56 mm

(1) For more information, see [Section 3, Mechanical Packaging and Orderable Information](#).

## 1.4 Functional Block Diagram

Figure 1-1 shows a simplified block diagram of the device.



SWCS056-001

**Figure 1-1. Simplified Block Diagram**

For the complete TWL60xx data sheet (SWCS056), contact your TI sales representative.

## 2 Revision History

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

<b>Changes from Revision C (June 2012) to Revision D</b>	<b>Page</b>
• Changed document to standard TI format .....	<a href="#">1</a>

### 3 Mechanical Packaging and Orderable Information

#### 3.1 Packaging 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)
<a href="#">TWL6041BYFFR</a>	Active	Production	DSBGA (YFF)   81	3000   LARGE T&R	Yes	SNAGCU	Level-1-260C-UNLIM	-40 to 85	TWL6041B
TWL6041BYFFR.A	Active	Production	DSBGA (YFF)   81	3000   LARGE T&R	Yes	SNAGCU	Level-1-260C-UNLIM	-40 to 85	TWL6041B
<a href="#">TWL6041BYFFT</a>	Active	Production	DSBGA (YFF)   81	250   SMALL T&R	Yes	SNAGCU	Level-1-260C-UNLIM	-40 to 85	TWL6041B
TWL6041BYFFT.A	Active	Production	DSBGA (YFF)   81	250   SMALL T&R	Yes	SNAGCU	Level-1-260C-UNLIM	-40 to 85	TWL6041B

<sup>(1)</sup> **Status:** For more details on status, see our [product life cycle](#).

<sup>(2)</sup> **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.

<sup>(3)</sup> **RoHS values:** Yes, No, RoHS Exempt. See the [TI RoHS Statement](#) for additional information and value definition.

<sup>(4)</sup> **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.

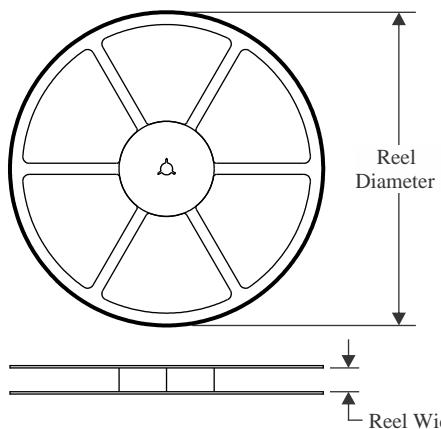
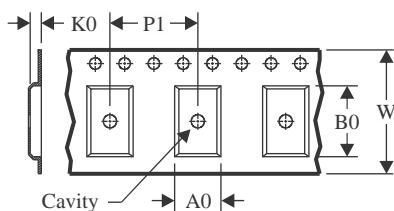
<sup>(5)</sup> **MSL rating/Peak reflow:** The moisture sensitivity level ratings and peak solder (reflow) temperatures. In the event that a part has multiple moisture sensitivity ratings, only the lowest level per JEDEC standards is shown. Refer to the shipping label for the actual reflow temperature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

<sup>(6)</sup> **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.

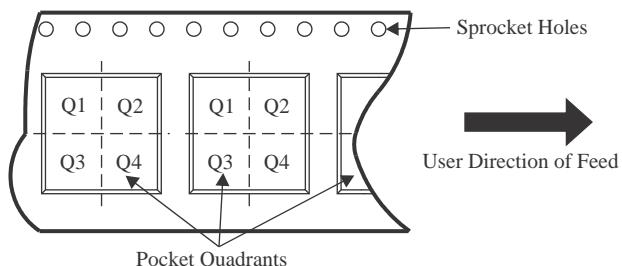
Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "~" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

**Important Information and Disclaimer:** The information provided on this page represents TI's knowledge and belief as of the date that it is provided. TI bases its knowledge and belief on information provided by third parties, and makes no representation or warranty as to the accuracy of such information. Efforts are underway to better integrate information from third parties. TI has taken and continues to take reasonable steps to provide representative and accurate information but may not have conducted destructive testing or chemical analysis on incoming materials and chemicals. TI and TI suppliers consider certain information to be proprietary, and thus CAS numbers and other limited information may not be available for release.

In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

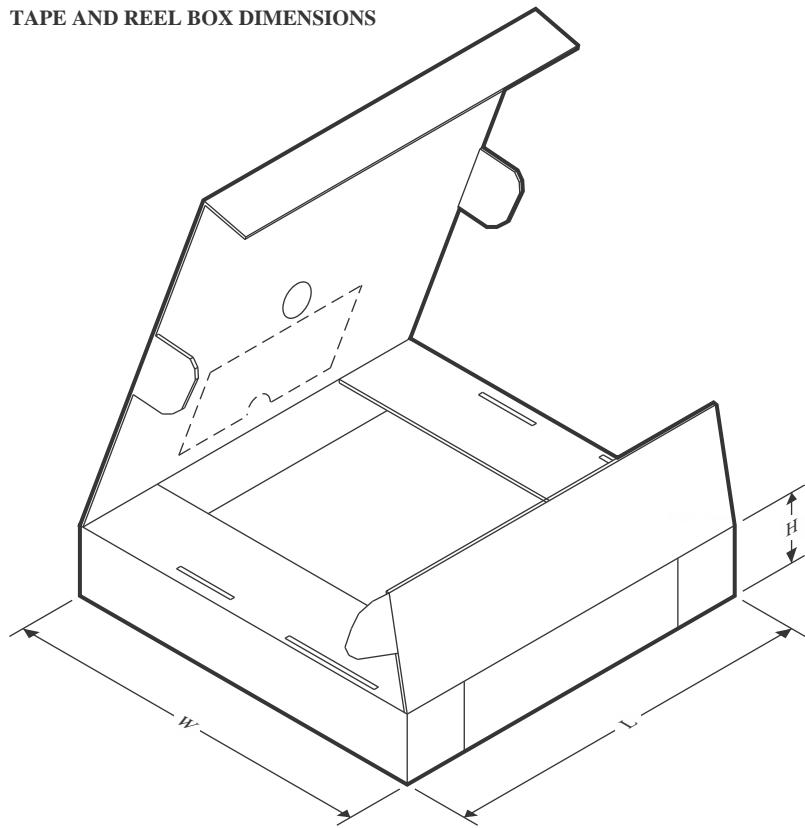
**TAPE AND REEL INFORMATION**
**REEL DIMENSIONS**

**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
TWL6041BYFFR	DSBGA	YFF	81	3000	330.0	12.4	3.86	3.86	0.69	8.0	12.0	Q1
TWL6041BYFFT	DSBGA	YFF	81	250	180.0	12.4	3.86	3.86	0.69	8.0	12.0	Q1

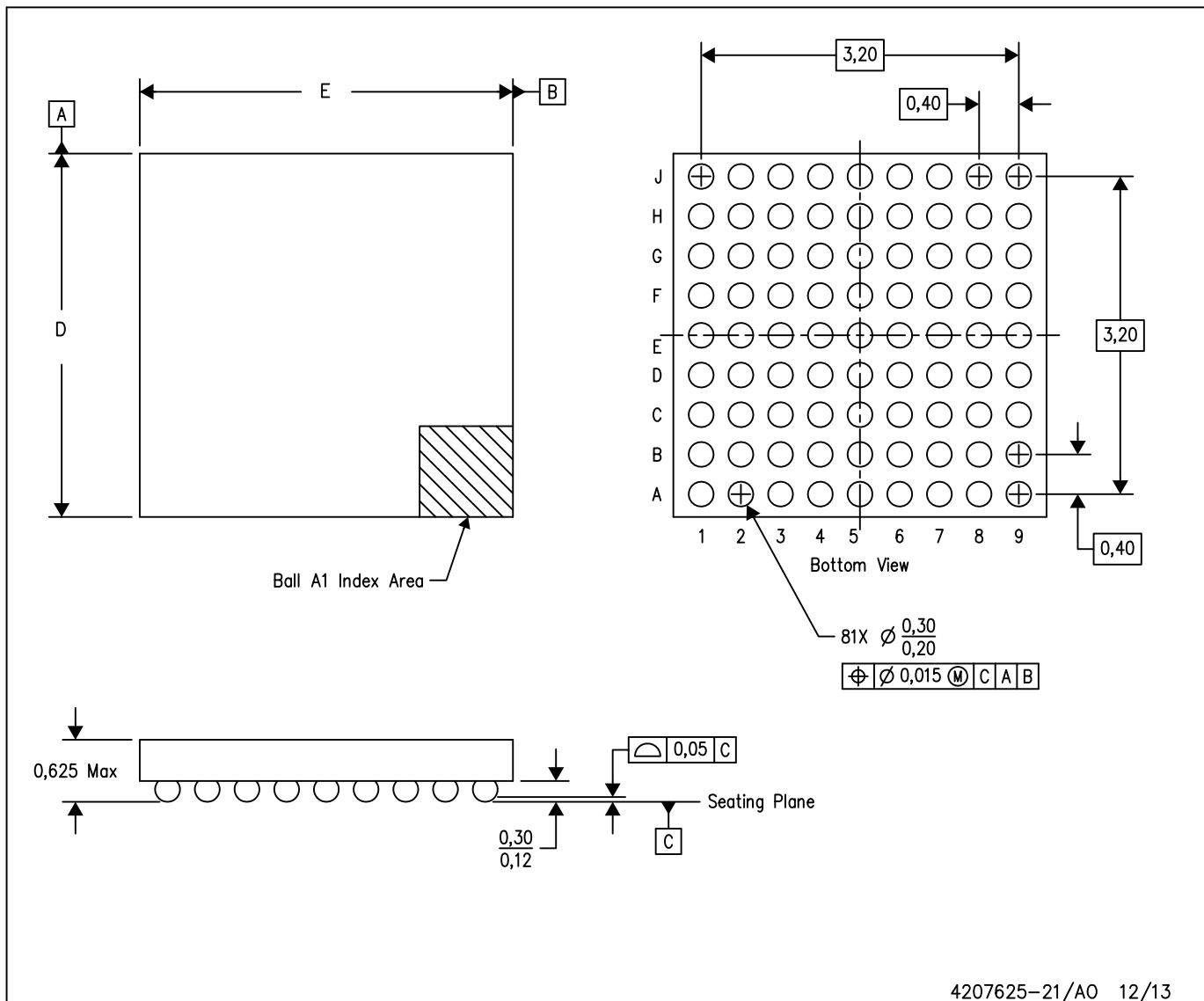
**TAPE AND REEL BOX DIMENSIONS**


\*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
TWL6041BYFFR	DSBGA	YFF	81	3000	335.0	335.0	25.0
TWL6041BYFFT	DSBGA	YFF	81	250	182.0	182.0	20.0

YFF (R-XBGA-N81)

DIE-SIZE BALL GRID ARRAY



NOTES:

- A. All linear dimensions are in millimeters. Dimensioning and tolerancing per ASME Y14.5M-1994.
- B. This drawing is subject to change without notice.
- C. NanoFree™ package configuration.

NanoFree is a trademark of Texas Instruments.

## IMPORTANT NOTICE AND DISCLAIMER

TI PROVIDES TECHNICAL AND RELIABILITY DATA (INCLUDING DATASHEETS), DESIGN RESOURCES (INCLUDING REFERENCE DESIGNS), APPLICATION OR OTHER DESIGN ADVICE, WEB TOOLS, SAFETY INFORMATION, AND OTHER RESOURCES "AS IS" AND WITH ALL FAULTS, AND DISCLAIMS ALL WARRANTIES, EXPRESS AND IMPLIED, INCLUDING WITHOUT LIMITATION ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

These resources are intended for skilled developers designing with TI products. You are solely responsible for (1) selecting the appropriate TI products for your application, (2) designing, validating and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, regulatory or other requirements.

These resources are subject to change without notice. TI grants you permission to use these resources only for development of an application that uses the TI products described in the resource. Other reproduction and display of these resources is prohibited. No license is granted to any other TI intellectual property right or to any third party intellectual property right. TI disclaims responsibility for, and you fully indemnify TI and its representatives against any claims, damages, costs, losses, and liabilities arising out of your use of these resources.

TI's products are provided subject to [TI's Terms of Sale](#), [TI's General Quality Guidelines](#), or other applicable terms available either on [ti.com](#) or provided in conjunction with such TI products. TI's provision of these resources does not expand or otherwise alter TI's applicable warranties or warranty disclaimers for TI products. Unless TI explicitly designates a product as custom or customer-specified, TI products are standard, catalog, general purpose devices.

TI objects to and rejects any additional or different terms you may propose.

Copyright © 2025, Texas Instruments Incorporated

Last updated 10/2025