# 3-W Mono Class-D Audio Amplifier With SmartGain™ AGC/DRC

**Check for Samples: TPA2029D1**

## FEATURES

- **Filter-Free Class-D Architecture**
- **3 W Into 4 Ω at 5 V (10% THD+N)**
- **880 mW Into 8 Ω at 3.6 V (10% THD+N)**
- **Power Supply Range: 2.5 V to 5.5 V**
- **3 Selectable AGC functions**
- **Low Supply Current: 1.8 mA**
- **Low Shutdown Current: 0.2 µA**
- **High PSRR: 80 dB**
- **Fast Start-up Time: 5 ms**
- **AGC Enable/Disable Function**
- **Limiter Enable/Disable Function**
- **Short-Circuit and Thermal Protection**
- **Space-Saving Package**
  - **1.63 mm × 1.63 mm WCSP (YZF)**

## APPLICATIONS

- **Wireless or Cellular Handsets and PDAs**
- **Portable Navigation Devices**
- **Portable DVD Player**
- **Notebook PCs**
- **Portable Radio**
- **Portable Games**
- **Educational Toys**
- **USB Speakers**

## DESCRIPTION

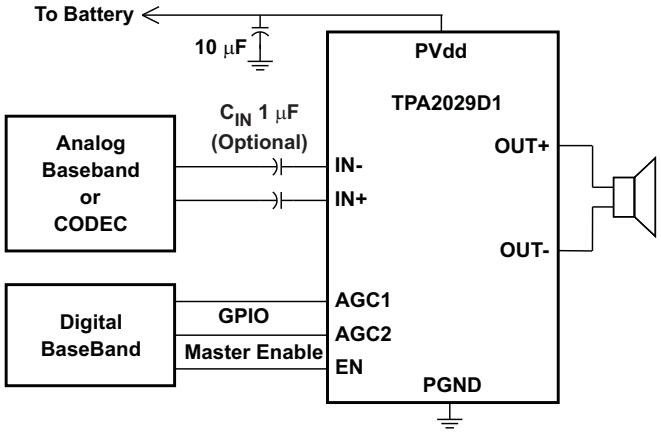
The TPA2029D1 is a mono, filter-free Class-D audio power amplifier with dynamic range compression (DRC) and automatic gain control (AGC). It is available in a 1.63 mm x 1.63 mm WCSP package.

The DRC/AGC function in the TPA2029D1 can be enabled and disabled. The DRC/AGC function is configured to automatically prevent distortion of the audio signal and enhance quiet passages that are normally not heard. The DRC/AGC is also configured to protect the speaker from damage at high power levels and compress the dynamic range of music to fit within the dynamic range of the speaker. The TPA2029D1 is capable of driving 3 W at 5 V into 4Ω load or 880 mW at 3.6 V into 8Ω load. The device features an enable pin and also provides thermal and short circuit protection.

In addition to these features, a fast start-up time and small package size make the TPA2029D1 an ideal choice for Notebook PCs, PDAs and other portable applications.

TPA2029D1 is available with different default AGC/DRC settings for various system requirements. See Table 2 for more detail.

### SIMPLIFIED APPLICATION DIAGRAM

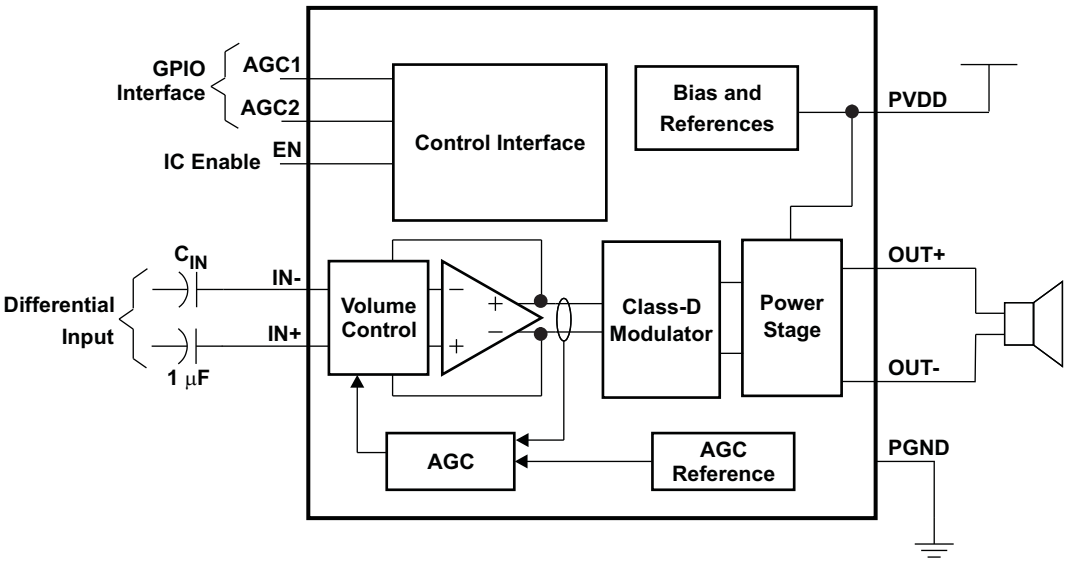



Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.

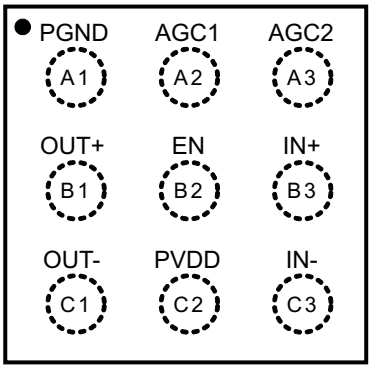
SmartGain is a trademark of Texas Instruments.

These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

## FUNCTIONAL BLOCK DIAGRAM




**DEVICE PINOUT**
**WCSP (YZF) PACKAGE**
**(TOP VIEW)**



## PIN FUNCTIONS

| PIN | | I/O/P | DESCRIPTION |
|---|---|---|---|
| NAME | WCSP | | |
| IN+ | B3 | I | Positive audio input |
| IN– | C3 | I | Negative audio input |
| EN | B2 | I | Enable terminal (active high) |
| AGC2 | A3 | I | AGC select function pin 2 |
| AGC1 | A2 | I | AGC select function pin 1 |
| OUT+ | B1 | O | Positive differential output |
| OUT– | C1 | O | Negative differential output |
| PVDD | C2 | P | Power supply |
| PGND | A1 | P | Power ground |

## ABSOLUTE MAXIMUM RATINGS(1)

over operating free-air temperature range (unless otherwise noted).

| | | | VALUE / UNIT |
|---|---|---|---|
| $V_{DD}$ | Supply voltage | PVDD | –0.3 V to 6 V |
| | Input voltage | EN, INR+, INR–, INL+, INL– | –0.3 V to $V_{DD}$+0.3 V |
| | | AGC1, AGC2 | –0.3 V to 6 V |
| | Continuous total power dissipation | | See Dissipation Ratings Table |
| $T_A$ | Operating free-air temperature range | | –40°C to 85°C |
| $T_J$ | Operating junction temperature range | | –40°C to 150°C |
| $T_{stg}$ | Storage temperature range | | –65°C to 150°C |
| ESD | Electro-Static Discharge Tolerance, all pins | Human Body Model (HBM) | 2 KV |
| | | Charged Device Model (CDM) | 500 V |
| $R_{LOAD}$ | Minimum load resistance | | 3.6 Ω |

(1) Stresses beyond those listed under "absolute maximum ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under "recommended operating conditions" is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

## DISSIPATION RATINGS TABLE(1)

| PACKAGE | $T_A \le 25°C$ | DERATING FACTOR | $T_A = 70°C$ | $T_A = 85°C$ |
|---|---|---|---|---|
| 9-ball WCSP | 1.19 W | 9.52 mW/°C | 0.76 W | 0.62 W |

(1) Dissipations ratings are for a 2-side, 2-plane PCB.

### AVAILABLE OPTIONS(1)

| $T_A$ | PACKAGED DEVICES(2) | PART NUMBER | SYMBOL |
|---|---|---|---|
| –40°C to 85°C | 9-pin, 1.63 mm × 1.63 mm WCSP | TPA2029D1YZFR | QWI |
| | | TPA2029D1YZFT | QWI |

(1) For the most current package and ordering information, see the Package Option Addendum at the end of this document, or see the TI Web site at www.ti.com

(2) The YZF packages are only available taped and reeled. The suffix R indicates a reel of 3000; the suffix T indicates a reel of 250.

## RECOMMENDED OPERATING CONDITIONS

| | | | MIN | MAX | UNIT |
|---|---|---|---|---|---|
| $V_{DD}$ | Supply voltage | PVDD | 2.5 | 5.5 | V |
| $V_{IH}$ | High-level input voltage | EN, AGC1, AGC2 | 1.3 | | V |
| $V_{IL}$ | Low-level input voltage | EN, AGC1, AGC2 | | 0.6 | V |
| $T_A$ | Operating free-air temperature | | –40 | 85 | °C |

## ELECTRICAL CHARACTERISTICS

at $T_A$ = 25°C, $V_{DD}$ = 3.6 V, EN = 1.3 V, and $R_L$ = 8 Ω + 33 µH (unless otherwise noted).

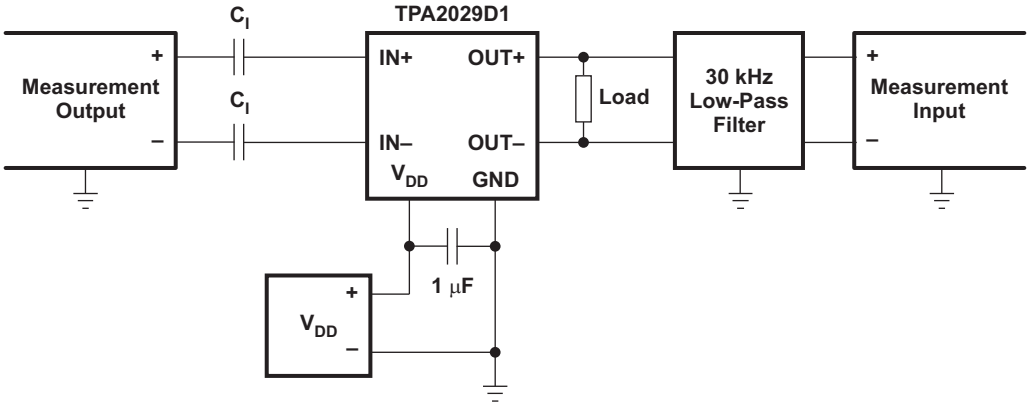
| PARAMETER | | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|
| $V_{DD}$ | Supply voltage range | | 2.5 | 3.6 | 5.5 | V |
| $I_{SDZ}$ | Shutdown quiescent current | EN = 0.35 V, $V_{DD}$ = 2.5 V | | 0.1 | 1 | µA |
| | | EN = 0.35 V, $V_{DD}$ = 3.6 V | | 0.2 | 1 | |
| | | EN = 0.35 V, $V_{DD}$ = 5.5 V | | 0.3 | 1 | |
| $I_{DD}$ | Supply current | $V_{DD}$ = 2.5 V | | 1.6 | 4.5 | mA |
| | | $V_{DD}$ = 3.6 V | | 1.8 | 4.7 | |
| | | $V_{DD}$ = 5.5 V | | 2.1 | 5.5 | |
| $f_{SW}$ | Class D Switching Frequency | | 275 | 300 | 325 | kHz |
| $I_{IH}$ | High-level input current | $V_{DD}$ = 5.5 V, EN = 5.8 V | | | 1 | µA |
| $I_{IL}$ | Low-level input current | $V_{DD}$ = 5.5 V, EN = –0.3 V | –1 | | | µA |
| $t_{START}$ | Start-up time | 2.5 V ≤ $V_{DD}$ ≤ 5.5 V no pop, $C_{IN}$ ≤ 1 µF | | 5 | | ms |
| POR | Power on reset ON threshold | | | 2 | 2.3 | V |
| | Power on reset hysteresis | | | 0.2 | | V |
| CMRR | Input common mode rejection | $R_L$ = 8 Ω, $V_{icm}$ = 0.5 V and $V_{icm}$ = $V_{DD}$ – 0.8 V, differential inputs shorted | | –75 | | dB |
| $V_{oo}$ | Output offset voltage | $V_{DD}$ = 3.6 V, $A_V$ = 6 dB, $R_L$ = 8 Ω, inputs ac grounded | | 1.5 | 10 | mV |
| $Z_O$ | Output Impedance in shutdown mode | EN = 0.35 V | | 2 | | kΩ |
| | Gain accuracy | Compression and limiter disabled, Gain = 0 to 30 dB | –0.5 | | 0.5 | dB |
| PSRR | Power supply rejection ratio | $V_{DD}$ = 2.5 V to 4.7 V | | –80 | | dB |

## OPERATING CHARACTERISTICS

at $T_A$ = 25°C, $V_{DD}$ = 3.6V, EN = 1.3 V, $R_L$ = 8 Ω +33 µH, and $A_V$ = 6 dB (unless otherwise noted).

| PARAMETER | | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|---|---|---|---|---|---|---|
| $k_{SVR}$ | power-supply ripple rejection ratio | $V_{DD}$ = 3.6 Vdc with ac of 200 $mV_{PP}$ at 217 Hz | | –70 | | dB |
| THD+N | Total harmonic distortion + noise | $f_{aud\_in}$ = 1 kHz; $P_O$ = 550 mW; $V_{DD}$ = 3.6 V | | 0.1% | | |
| | | $f_{aud\_in}$ = 1 kHz; $P_O$ = 1.25 W; $V_{DD}$ = 5 V | | 0.1% | | |
| | | $f_{aud\_in}$ = 1 kHz; $P_O$ = 710 mW; $V_{DD}$ = 3.6 V | | 1% | | |
| | | $f_{aud\_in}$ = 1 kHz; $P_O$ = 1.4 W; $V_{DD}$ = 5 V | | 1% | | |
| $N_r$ | Output integrated noise | Av = 6 dB | | 42 | | µV |
| | | Av = 6 dB floor, A-weighted | | 30 | | µV |
| f | Frequency response | Av = 6 dB | 20 | | 20000 | Hz |
| $P_{O(max)}$ | Maximum output power | THD+N = 10%, $V_{DD}$ = 5 V, $R_L$ = 8 Ω | | 1.72 | | W |
| | | THD+N = 10%, $V_{DD}$ = 3.6 V, $R_L$ = 8 Ω | | 880 | | mW |
| | | THD+N = 1%, $V_{DD}$ = 5 V, $R_L$ = 8 Ω | | 1.4 | | W |
| | | THD+N = 1% , $V_{DD}$ = 3.6 V, $R_L$ = 8 Ω | | 710 | | mW |
| | | THD+N = 10% , $V_{DD}$ = 5 V, $R_L$ = 4 Ω | | 3 | | W |
| η | Efficiency | THD+N = 1%, $V_{DD}$ = 3.6 V, $R_L$ = 8 Ω, $P_O$= 0.71 W | | 91% | | |
| | | THD+N = 1%, $V_{DD}$ = 5 V, $R_L$ = 8 Ω, $P_O$ = 1.4 W | | 93% | | |

**Figure 1. TEST SET-UP FOR GRAPHS**




(1) All measurements were taken with a 1-µF $C_I$ (unless otherwise noted.)

(2) A 33-µH inductor was placed in series with the load resistor to emulate a small speaker for efficiency measurements.

(3) The 30-kHz low-pass filter is required, even if the analyzer has an internal low-pass filter. An RC low-pass filter (1 kΩ 4.7 nF) is used on each output for the data sheet graphs.

## TYPICAL CHARACTERISTICS

with $C_{(DECOUPLE)}$ = 1 µF, $C_I$ = 1 µF.
All THD + N graphs are taken with outputs out of phase (unless otherwise noted).
All data is taken on left channel.

### Table of Graphs

| | | FIGURE |
|---|---|---|
| Quiescent supply current | vs Supply voltage | Figure 2 |
| Total harmonic distortion + noise | vs Frequency | Figure 3 |
| Total harmonic distortion + noise | vs Frequency | Figure 4 |
| Total harmonic distortion + noise | vs Output power | Figure 5 |
| Supply ripple rejection ratio | vs Frequency | Figure 6 |
| Efficiency | vs Output power (per channel) | Figure 7 |
| Total power dissipation | vs Total output power | Figure 8 |
| Total supply current | vs Total output power | Figure 9 |
| Output power | vs Supply voltage | Figure 10 , Figure 11 |
| Shutdown time | | Figure 12 |
| Startup time | | Figure 13 |

**QUIESCENT SUPPLY CURRENT**
**vs**
**SUPPLY VOLTAGE**

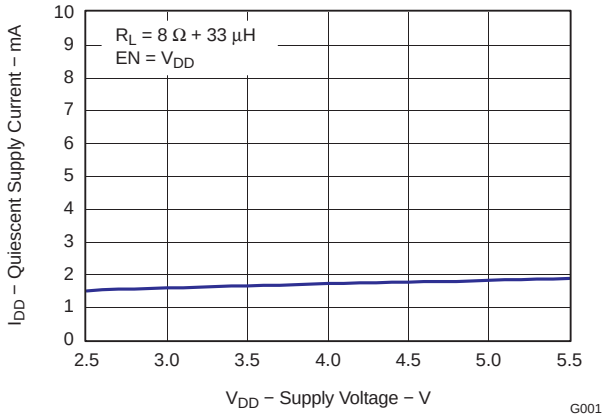



**Figure 2.**

**TOTAL HARMONIC DISTORTION + NOISE**
**vs**
**FREQUENCY**

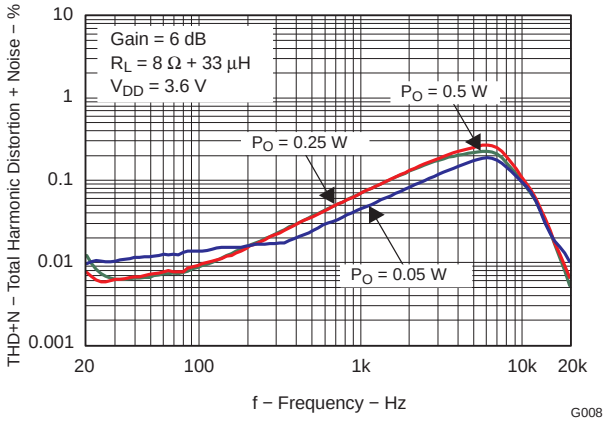



**Figure 3.**

**TOTAL HARMONIC DISTORTION + NOISE vs FREQUENCY**

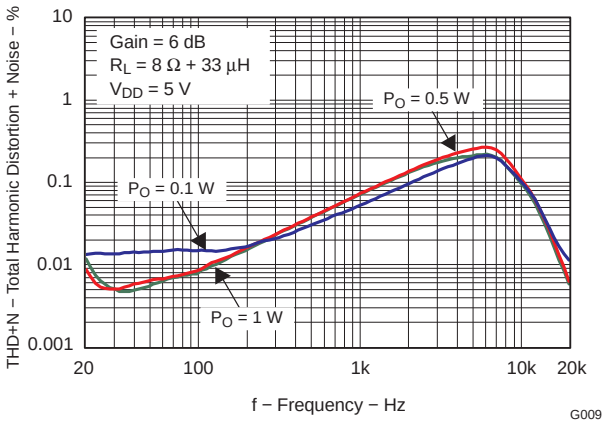



**Figure 4.**

**TOTAL HARMONIC DISTORTION + NOISE vs OUTPUT POWER**

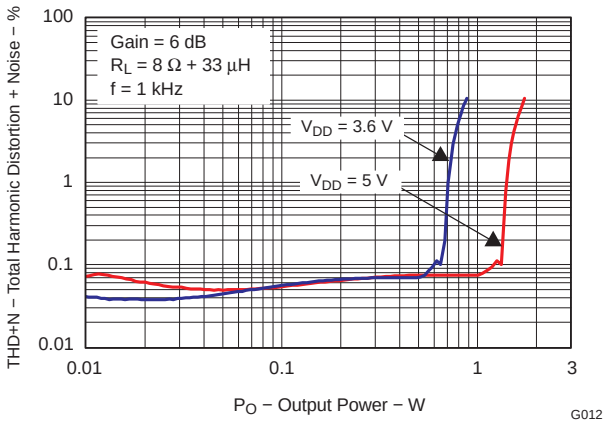



**Figure 5.**

**SUPPLY RIPPLE REJECTION RATIO**

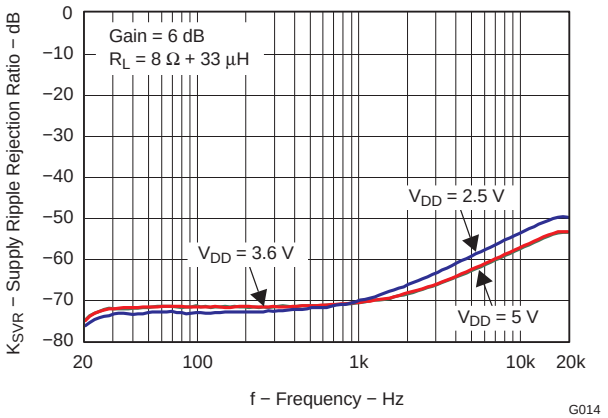



**Figure 6.**

**EFFICIENCY vs OUTPUT POWER (PER CHANNEL)**

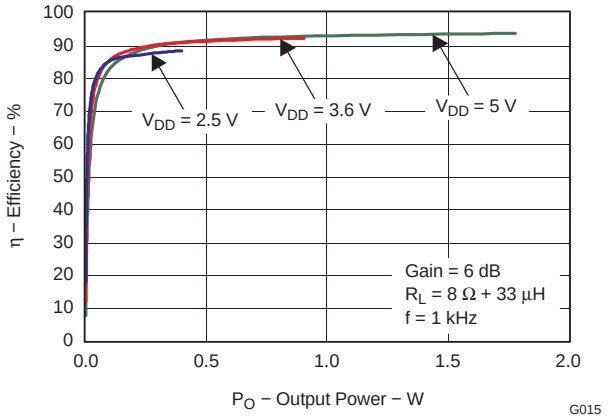



**Figure 7.**

**TOTAL POWER DISSIPATION vs TOTAL OUTPUT POWER**

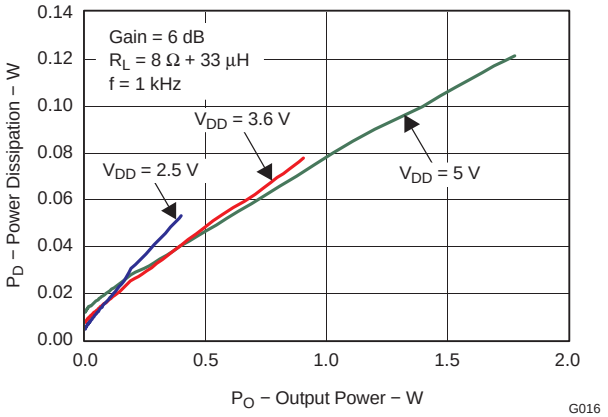



**Figure 8.**

**TOTAL SUPPLY CURRENT vs TOTAL OUTPUT POWER**

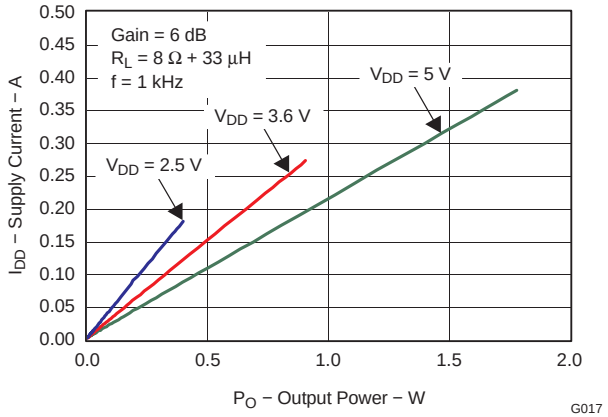



**Figure 9.**

**OUTPUT POWER vs SUPPLY VOLTAGE**

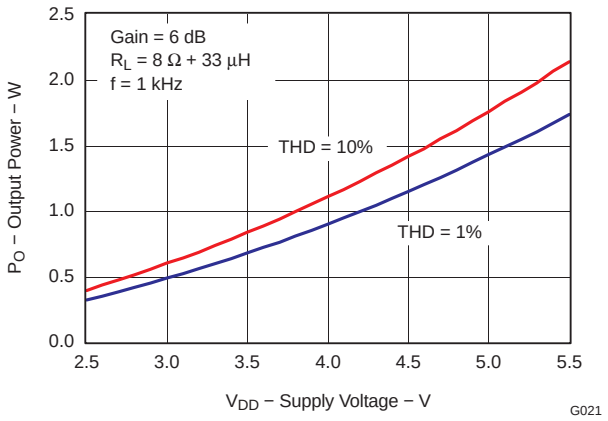



**Figure 10.**

**OUTPUT POWER vs SUPPLY VOLTAGE**

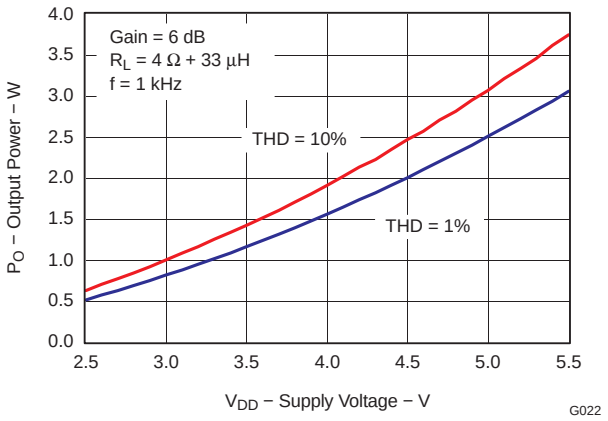



**Figure 11.**

**VOLTAGE vs SHUTDOWN TIME**

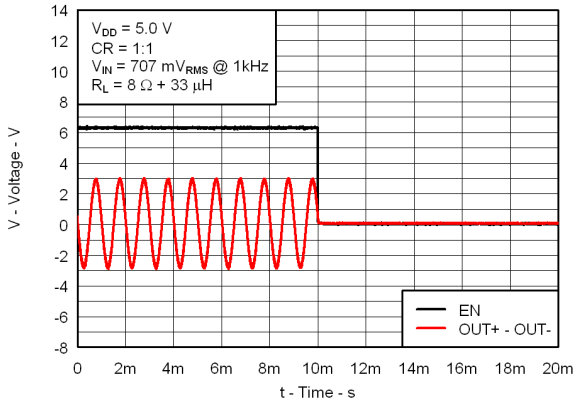



**Figure 12.**

**VOLTAGE vs STARTUP TIME**

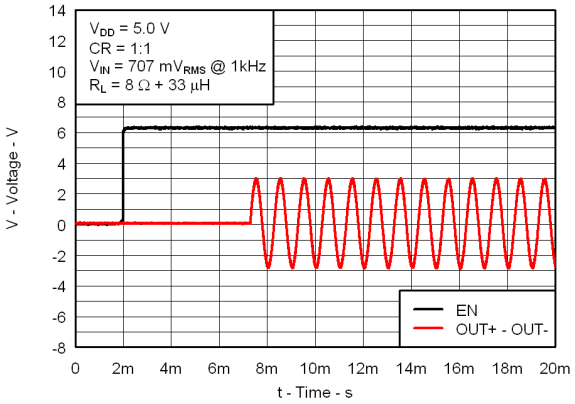



**Figure 13.**

**Nominal Input Impedance - Per Leg**

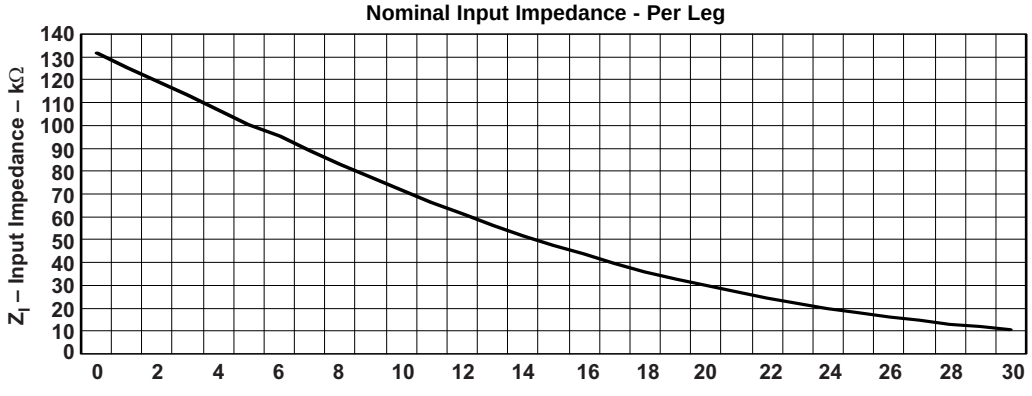


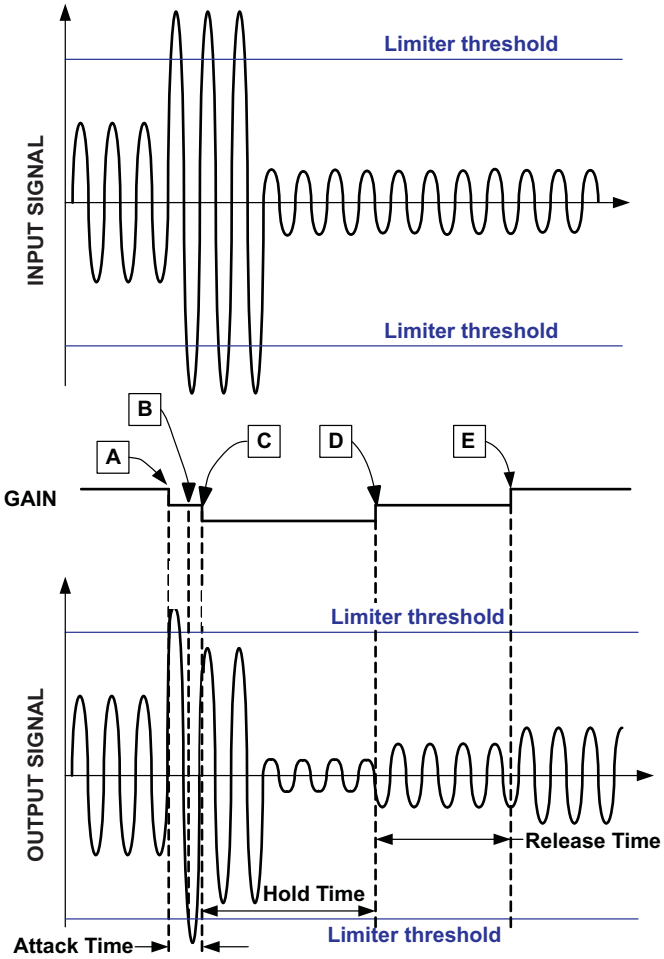

**Figure 14.**

## APPLICATION INFORMATION

### AUTOMATIC GAIN CONTROL

The Automatic Gain Control (AGC) feature provides continuous automatic gain adjustment to the amplifier through an internal PGA. This feature enhances the perceived audio loudness and at the same time prevents speaker damage from occurring (Limiter function).

The AGC works by detecting the audio input envelope. The gain changes depending on the amplitude, the limiter level, the compression ratio, and the attack and release time. The gain changes constantly as the audio signal increases and/or decreases to create the compression effect. The gain step size for the AGC is 0.5 dB. If the audio signal has near-constant amplitude, the gain does not change. Figure 15 shows how the AGC works.




A. Gain decreases with no delay; attack time is reset. Release time and hold time are reset.

B. Signal amplitude above limiter level, but gain cannot change because attack time is not over.

C. Attack time ends; gain is allowed to decrease from this point forward by one step. Gain decreases because the amplitude remains above limiter threshold. All times are reset

D. Gain increases after release time finishes and signal amplitude remains below desired level. All times are reset after the gain increase.

E. Gain increases after release time is finished again because signal amplitude remains below desired level. All times are reset after the gain increase.

**Figure 15. Input and Output Audio Signal vs Time**

Since the number of gain steps is limited the compression region is limited as well. The following figure shows how the gain changes vs. the input signal amplitude in the compression region.

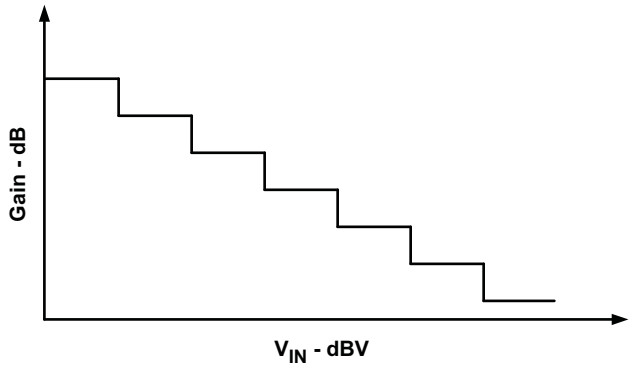



**Figure 16. Input Signal Voltage vs Gain**

Thus the AGC performs a mapping of the input signal vs. the output signal amplitude.

Pins AGC1 and AGC 2 are used to enable/disable the limiter, compression, and noise gate function. Table 1 shows each function.

**Table 1. FUNCTION DEFINITION FOR AGC1 AND AGC2**

| AGC1 | AGC2 | Function |
|---|---|---|
| 0 | 0 | AGC Function disabled |
| 0 | 1 | AGC Limiter Function enabled |
| 1 | 0 | AGC, Limiter, and Compression Functions enabled |
| 1 | 1 | AGC, Limiter, Compression, and Noise Gate Functions enabled |

The default values for the TPA2029D1 AGC function are given in Table 2. The default values can be changed at the factory during production. Refer to the TI representative for assistance with different default value requests.

**Table 2. AGC DEFAULT VALUES**

| AGC Parameters | TPA2029D1 |
|---|---|
| **Attack Time** | **14.084 ms / 6 dB step** |
| Release Time | 822 ms/ 6 dB step |
| Hold Time | off |
| Fixed Gain | 9 dB |
| NoiseGate Threshold | 4 mV |
| Output Limiter Level | 9 dBV |
| Max Gain | 30 dB |
| Compression Ratio | 2:1 |

## DECOUPLING CAPACITOR ($C_S$)

The TPA2029D1 is a high-performance Class-D audio amplifier that requires adequate power supply decoupling to ensure the efficiency is high and total harmonic distortion (THD) is low. For higher frequency transients, spikes, or digital hash on the line, a good low equivalent-series-resistance (ESR) 1-µF ceramic capacitor (typically) placed as close as possible to the device PVDD lead works best. Placing this decoupling capacitor close to the TPA2029D1 is important for the efficiency of the Class-D amplifier, because any resistance or inductance in the trace between the device and the capacitor can cause a loss in efficiency. For filtering lower-frequency noise signals, a 4.7 µF or greater capacitor placed near the audio power amplifier would also help, but it is not required in most applications because of the high PSRR of this device.

## INPUT CAPACITORS ($C_I$)

The input capacitors and input resistors form a high-pass filter with the corner frequency, $f_C$, determined in Equation 1.

$$f_C = \frac{1}{(2\pi \times R_I \times C_I)} \tag{1}$$

The value of the input capacitor is important to consider as it directly affects the bass (low frequency) performance of the circuit. Speakers in wireless phones cannot usually respond well to low frequencies, so the corner frequency can be set to block low frequencies in this application. Not using input capacitors can increase output offset. Equation 2 is used to solve for the input coupling capacitance. If the corner frequency is within the audio band, the capacitors should have a tolerance of ±10% or better, because any mismatch in capacitance causes an impedance mismatch at the corner frequency and below.

$$C_I = \frac{1}{(2\pi \times R_I \times f_C)} \tag{2}$$

## COMPONENT LOCATION

Place all the external components very close to the TPA2029D1. Placing the decoupling capacitor, $C_S$, close to the TPA2029D1 is important for the efficiency of the Class-D amplifier. Any resistance or inductance in the trace between the device and the capacitor can cause a loss in efficiency.

## EFFICIENCY AND THERMAL INFORMATION

The maximum ambient temperature depends on the heat-sinking ability of the PCB system. The derating factor for the packages are shown in the dissipation rating table. Converting this to $\theta_{JA}$ for the WCSP package:

$$\theta_{JA} = \frac{1}{\text{Derating Factor}} = \frac{1}{0.0095} = 105^{o}\text{C/W} \tag{3}$$

Given $\theta_{JA}$ of 100°C/W, the maximum allowable junction temperature of 150°C, and the maximum internal dissipation of 0.4 W for 3 W output power into 4-Ω load, 5-V supply, from Figure 7, the maximum ambient temperature can be calculated with the following equation.

$$T_A\text{Max} = T_J\text{Max} - \theta_{JA}P_{DMAX} = 150 - 105\ (0.4) = 108^{\circ}\text{C} \tag{4}$$

Equation 4 shows that the calculated maximum ambient temperature is 108°C at maximum power dissipation with a 5-V supply and 4-Ω a load. The TPA2029D1 is designed with thermal protection that turns the device off when the junction temperature surpasses 150°C to prevent damage to the IC. Also, using speakers more resistive than 8-Ω dramatically increases the thermal performance by reducing the output current and increasing the efficiency of the amplifier.

## OPERATION WITH DACS AND CODECS

In using Class-D amplifiers with CODECs and DACs, sometimes there is an increase in the output noise floor from the audio amplifier. This occurs when mixing of the output frequencies of the CODEC/DAC mix with the switching frequencies of the audio amplifier input stage. The noise increase can be solved by placing a low-pass filter between the CODEC/DAC and audio amplifier. This filters off the high frequencies that cause the problem and allow proper performance. See the functional block diagram.

## FILTER FREE OPERATION AND FERRITE BEAD FILTERS

A ferrite bead filter can often be used if the design is failing radiated emissions without an LC filter and the frequency sensitive circuit is greater than 1 MHz. This filter functions well for circuits that just have to pass FCC and CE because FCC and CE only test radiated emissions greater than 30 MHz. When choosing a ferrite bead, choose one with high impedance at high frequencies, and low impedance at low frequencies. In addition, select a ferrite bead with adequate current rating to prevent distortion of the output signal.

Use an LC output filter if there are low frequency (< 1 MHz) EMI sensitive circuits and/or there are long leads from amplifier to speaker. Figure 17 shows typical ferrite bead and LC output filters.

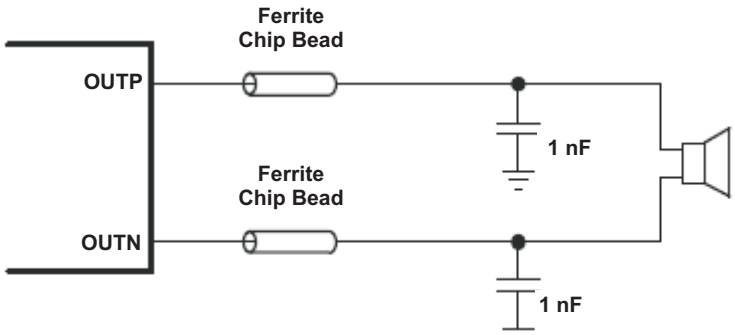



**Figure 17. Typical Ferrite Bead Filter (Chip bead example: TDK: MPZ1608S221A)**

## PACKAGE INFORMATION

### Package Dimensions

The package dimensions for this YZF package are shown in the table below. See the package drawing at the end of this data sheet for more details.

**Table 3. YZF Package Dimensions**

| Packaged Devices | D | E |
|---|---|---|
| TPA2029D1YZF | Min = 1594µm<br>Max = 1654µm | Min = 1594µm<br>Max = 1654µm |

## REVISION HISTORY

**Changes from Revision December 2011 (*) to Revision A** **Page**

- Added Figure 14 ..... 8

## PACKAGING INFORMATION

| Orderable Device | Status (1) | Package Type | Package Drawing | Pins | Package Qty | Eco Plan (2) | Lead/Ball Finish | MSL Peak Temp (3) | Op Temp (°C) | Top-Side Markings (4) | Samples |
|---|---|---|---|---|---|---|---|---|---|---|---|
| TPA2029D1YZFR | ACTIVE | DSBGA | YZF | 9 | 3000 | Green (RoHS & no Sb/Br) | SNAGCU | Level-1-260C-UNLIM | -40 to 85 | QWI | Samples |
| TPA2029D1YZFT | ACTIVE | DSBGA | YZF | 9 | 250 | Green (RoHS & no Sb/Br) | SNAGCU | Level-1-260C-UNLIM | -40 to 85 | QWI | Samples |

(1) The marketing status values are defined as follows:
**ACTIVE:** Product device recommended for new designs.
**LIFEBUY:** TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.
**NRND:** Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.
**PREVIEW:** Device has been announced but is not in production. Samples may or may not be available.
**OBSOLETE:** TI has discontinued the production of the device.

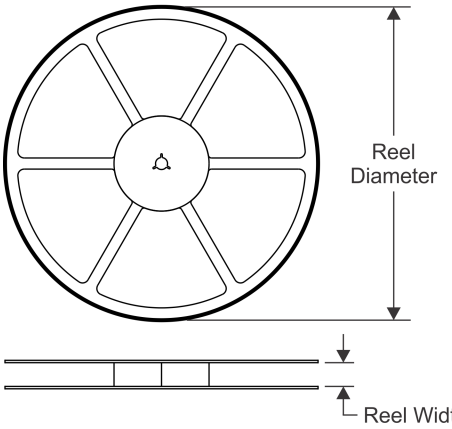
(2) Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check http://www.ti.com/productcontent for the latest availability information and additional product content details.
**TBD:** The Pb-Free/Green conversion plan has not been defined.
**Pb-Free (RoHS):** TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.
**Pb-Free (RoHS Exempt):** This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.
**Green (RoHS & no Sb/Br):** TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

(3) MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

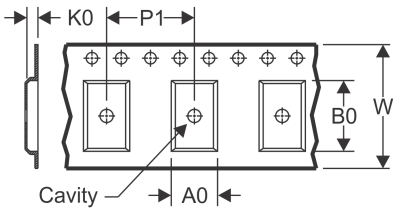
(4) Multiple Top-Side Markings will be inside parentheses. Only one Top-Side Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Top-Side Marking for that device.

## TAPE AND REEL INFORMATION

**REEL DIMENSIONS**

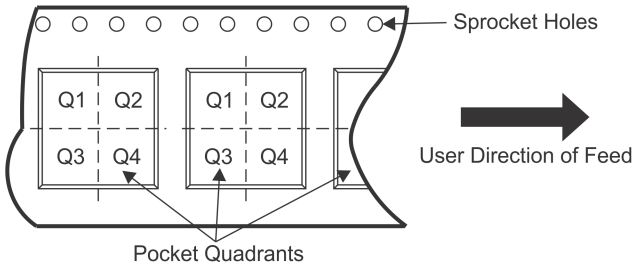



**TAPE DIMENSIONS**




| | |
|---|---|
| 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 |

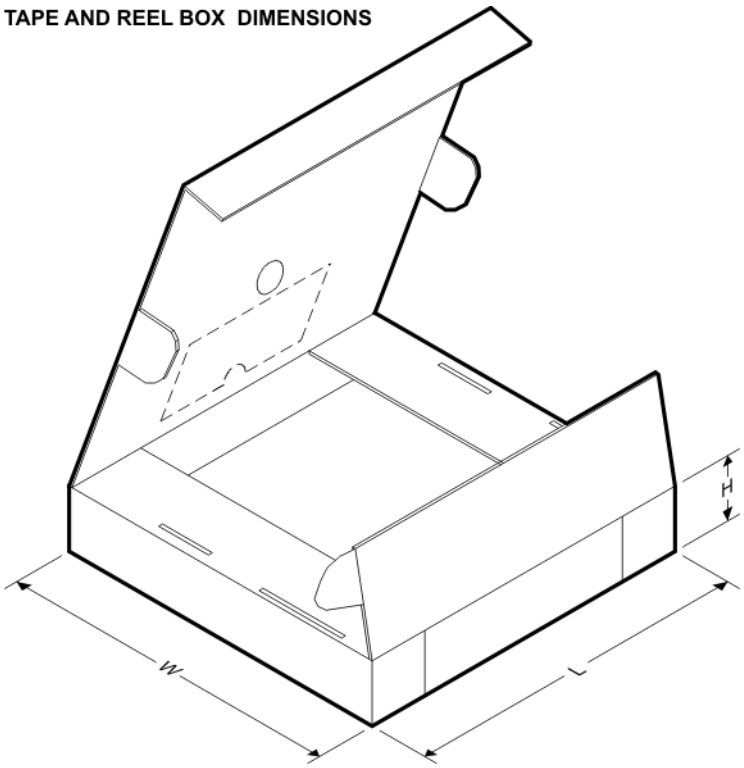
**QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE**




*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 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TPA2029D1YZFR | DSBGA | YZF | 9 | 3000 | 180.0 | 8.4 | 1.71 | 1.71 | 0.81 | 4.0 | 8.0 | Q1 |
| TPA2029D1YZFT | DSBGA | YZF | 9 | 250 | 180.0 | 8.4 | 1.71 | 1.71 | 0.81 | 4.0 | 8.0 | Q1 |

**TAPE AND REEL BOX DIMENSIONS**




*All dimensions are nominal

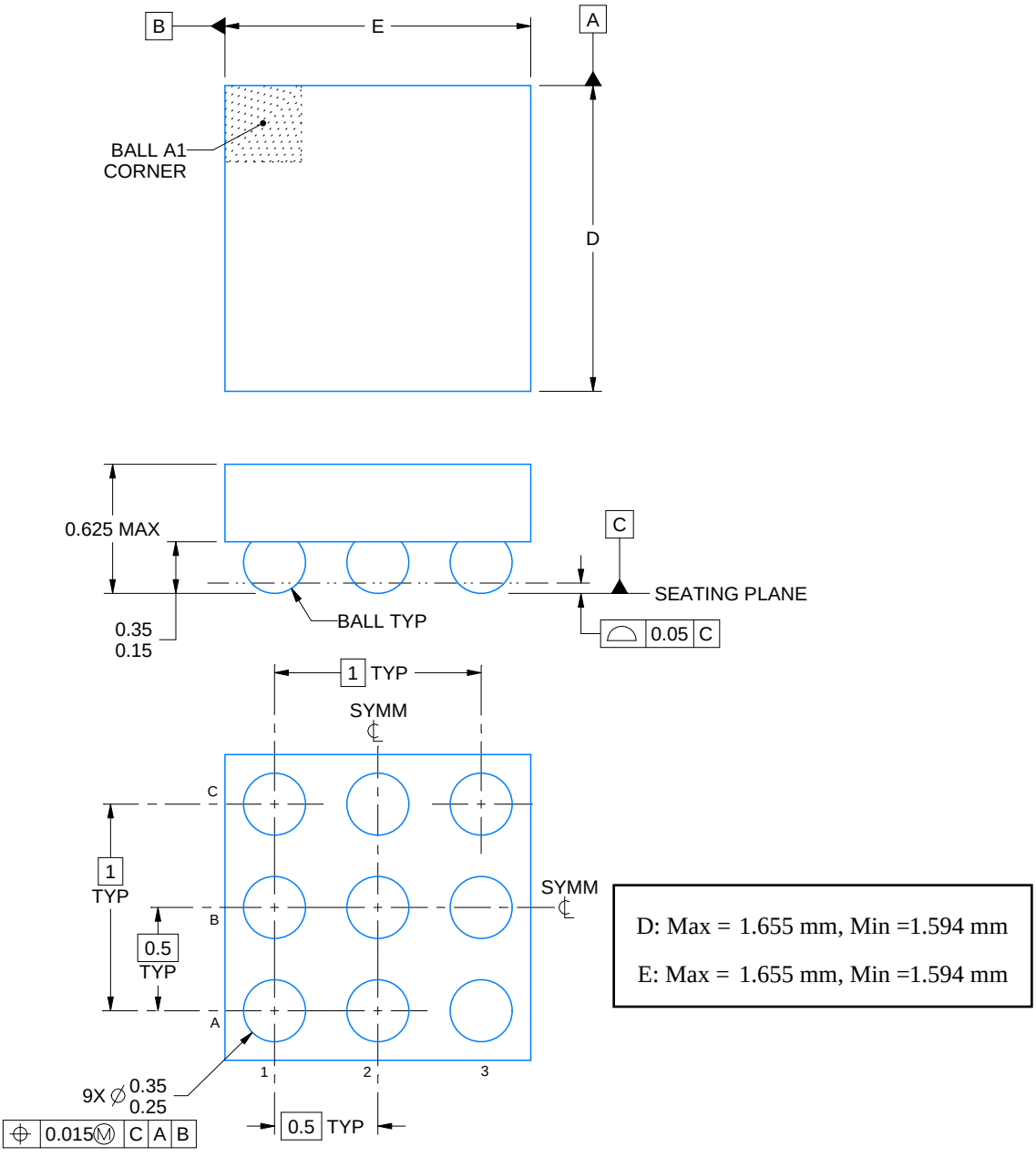
| Device | Package Type | Package Drawing | Pins | SPQ | Length (mm) | Width (mm) | Height (mm) |
|---|---|---|---|---|---|---|---|
| TPA2029D1YZFR | DSBGA | YZF | 9 | 3000 | 210.0 | 185.0 | 35.0 |
| TPA2029D1YZFT | DSBGA | YZF | 9 | 250 | 210.0 | 185.0 | 35.0 |

# PACKAGE OUTLINE

## YZF0009

## DSBGA - 0.625 mm max height

DIE SIZE BALL GRID ARRAY

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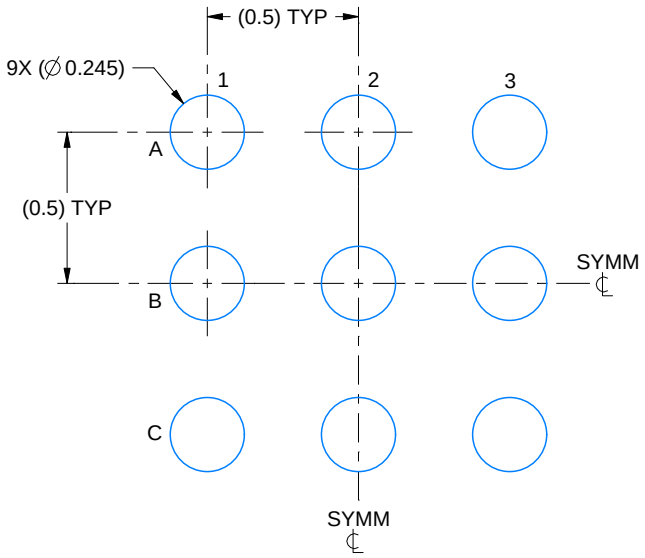
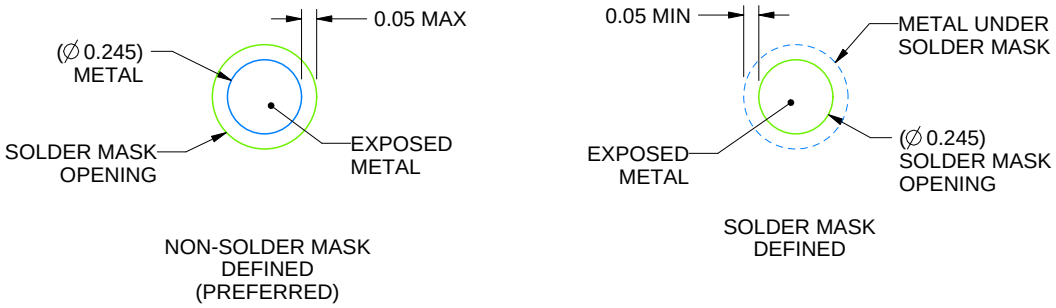
NOTES:

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.




LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE: 40X




SOLDER MASK DETAILS
NOT TO SCALE

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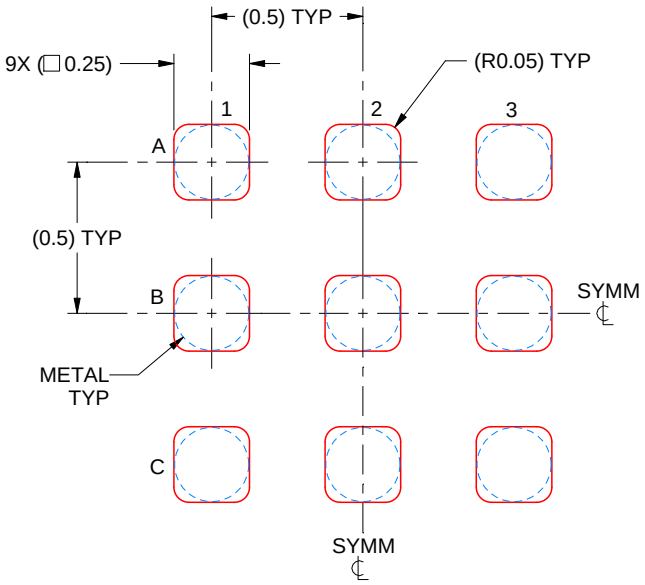
NOTES: (continued)

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).




SOLDER PASTE EXAMPLE
BASED ON 0.1 mm THICK STENCIL
SCALE: 40X

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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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