

1.8-V PHASE LOCK LOOP CLOCK DRIVER

SCAS688D—JUNE 2005—REVISED JULY 2007

FEATURES

- 1.8-V Phase Lock Loop Clock Driver for Double Data Rate (DDR II) Applications
- Spread Spectrum Clock Compatible
- Operating Frequency: 10 MHz to 400 MHz
- Low Current Consumption: <135 mA
- Low Jitter (Cycle-Cycle): ± 30 ps
- Low Output Skew: 35 ps
- Low Period Jitter: ± 20 ps
- Low Dynamic Phase Offset: ± 15 ps
- Low Static Phase Offset: ± 50 ps
- Distributes One Differential Clock Input to Ten Differential Outputs
- 52-Ball μ BGA (MicroStar™ Junior BGA, 0,65-mm pitch) and 40-Pin MLF
- External Feedback Pins (FBIN, $\overline{\text{FBIN}}$) are Used to Synchronize the Outputs to the Input Clocks
- Meets or Exceeds JESD82-8 PLL Standard for PC2-3200/4300
- Fail-Safe Inputs

DESCRIPTION

The CDCU877 is a high-performance, low-jitter, low-skew, zero-delay buffer that distributes a differential clock input pair (CK, $\overline{\text{CK}}$) to ten differential pairs of clock outputs (Y_n , $\overline{Y_n}$) and to one differential pair of feedback clock outputs (FBOUT, $\overline{\text{FBOUT}}$). The clock outputs are controlled by the input clocks (CK, $\overline{\text{CK}}$), the feedback clocks (FBIN, $\overline{\text{FBIN}}$), the LVCMOS control pins (OE, OS), and the analog power input (AV_{DD}). When OE is low, the clock outputs, except FBOUT/ $\overline{\text{FBOUT}}$, are disabled while the internal PLL continues to maintain its locked-in frequency. OS (output select) is a program pin that must be tied to GND or V_{DD} . When OS is high, OE functions as previously described. When OS and OE are both low, OE has no effect on $Y_7/\overline{Y_7}$, they are free running. When AV_{DD} is grounded, the PLL is turned off and bypassed for test purposes.

When both clock inputs (CK, $\overline{\text{CK}}$) are logic low, the device enters in a low power mode. An input logic detection circuit on the differential inputs, independent from input buffers, detects the logic low level and performs in a low power state where all outputs, the feedback, and the PLL are off. When the clock inputs transition from being logic low to being differential signals, the PLL turns back on, the inputs and the outputs are enabled, and the PLL obtains phase lock between the feedback clock pair (FBIN, $\overline{\text{FBIN}}$) and the clock input pair (CK, $\overline{\text{CK}}$) within the specified stabilization time.

The CDCU877 is able to track spread spectrum clocking (SSC) for reduced EMI. This device operates from -40°C to 85°C .

ORDERING INFORMATION

| T_A | 52-BALL BGA ⁽¹⁾ | 40-Pin MLF |
|---------------|----------------------------|-------------|
| -40°C to 85°C | CDCU877ZQL | CDCU877RHA |
| | CDCU877AZQL | CDCU877ARHA |
| | CDCU877GQL | CDCU877RTB |
| | CDCU877AGQL | CDCU877ARTB |

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



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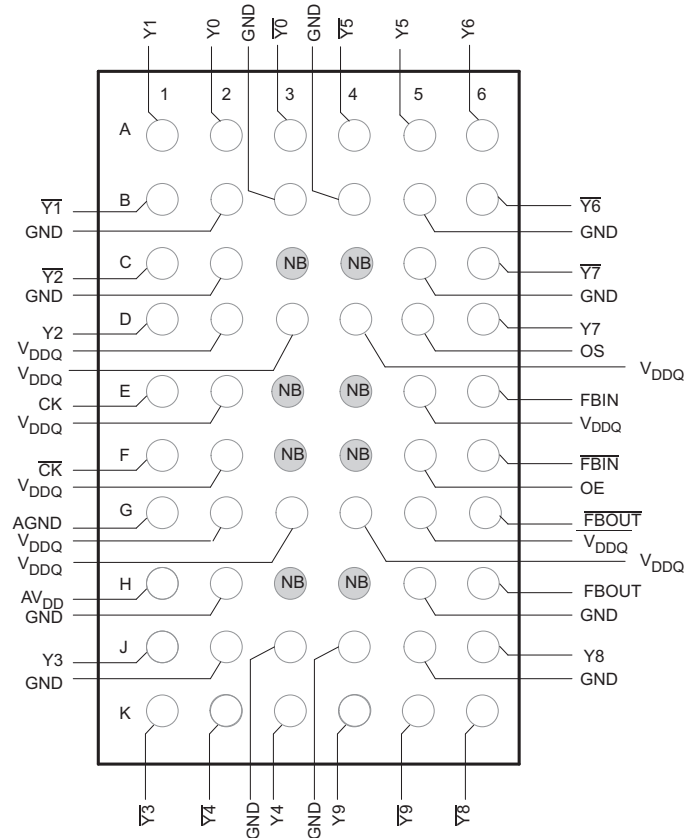
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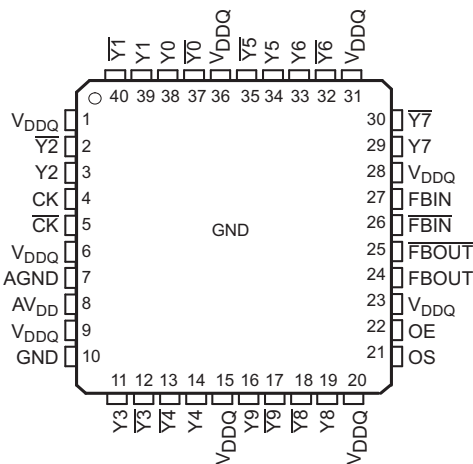
These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

**MicroStar Junior (ZQL) Package
(TOP VIEW)**



- A. NC = No Connection
- B. NB = No Ball

**RHA/RTB Package (MLF Package)
(TOP VIEW)**



40-pin HP-VFQFP-N (6,0 x 6,0 mm Body Size,
0,5 mm Pitch, M0#220, Variation VJJD-2,
E2 = D2 = 2,9 mm ± 0,15 mm) Package Pinouts

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TERMINAL FUNCTIONS

| TERMINAL | | | I/O | DESCRIPTION |
|---------------------------------------------|------------------------------------------------------|------------------------------------------|-----|----------------------------------------------------------------------|
| NAME | GQL/ZQL | RHA/RTB | | |
| AGND | G1 | 7 | | Analog ground |
| AV _{DD} | H1 | 8 | | Analog power |
| CK | E1 | 4 | I | Clock input with a (10 kΩ to 100 kΩ) pulldown resistor |
| $\overline{\text{CK}}$ | F1 | 5 | I | Complementary clock input with a (10 kΩ to 100 kΩ) pulldown resistor |
| FBIN | E6 | 27 | I | Feedback clock input |
| $\overline{\text{FBIN}}$ | F6 | 26 | I | Complementary feedback clock input |
| FBOU _T | H6 | 24 | O | Feedback clock output |
| $\overline{\text{FBOU}}\overline{\text{T}}$ | G6 | 25 | O | Complementary feedback clock output |
| OE | F5 | 22 | I | Output enable (asynchronous) |
| OS | D5 | 21 | I | Output select (tied to GND or V _{DD}) |
| GND | B2, B3, B4, B5, C2, C5, H2, H5, J2, J3, J4, J5 | 10 | | Ground |
| V _{DDQ} | D2, D3, D4, E2, E5, F2, G2, G3, G4, G5 | 1, 6, 9, 15, 20, 23, 28, 31, 36 | | Logic and output power |
| Y[0:9] | A2, A1, D1, J1, K3, A5, A6, D6, J6, K4 | 3, 11, 14, 16, 19, 29, 33, 34, 38, 39 | O | Clock outputs |
| $\overline{\text{Y}}[0:9]$ | A3, B1, C1, K1, K2, A4, B6, C6, K6, K5 | 2, 12, 13, 18, 17, 30, 32, 35, 37, 40 | O | Complementary clock outputs |

FUNCTION TABLE

| INPUTS | | | | | OUTPUTS | | | | |
|---------------|----|----|----|------------------------|-----------------------------|------------------------------------------------------------|-------------------|---------------------------------------------|--------------|
| AVDD | OE | OS | CK | $\overline{\text{CK}}$ | Y | $\overline{\text{Y}}$ | FBOU _T | $\overline{\text{FBOU}}\overline{\text{T}}$ | PLL |
| GND | H | X | L | H | L | H | L | H | Bypassed/Off |
| GND | H | X | H | L | H | L | H | L | Bypassed/Off |
| GND | L | H | L | H | L _Z | L _Z | L | H | Bypassed/Off |
| GND | L | L | H | L | L _Z Y7 Active | L _Z $\overline{\text{Y}}\overline{7}$ Active | H | L | Bypassed/Off |
| 1.8 V Nominal | L | H | L | H | L _Z | L _Z | L | H | On |
| 1.8 V Nominal | L | L | H | L | L _Z Y7 Active | L _Z $\overline{\text{Y}}\overline{7}$ Active | H | L | On |
| 1.8 V Nominal | H | X | L | H | L | H | L | H | On |
| 1.8 V Nominal | H | X | H | L | H | L | H | L | On |
| 1.8 V Nominal | X | X | L | L | L _Z | L _Z | L _Z | L _Z | Off |
| X | X | X | H | H | Reserved | | | | |

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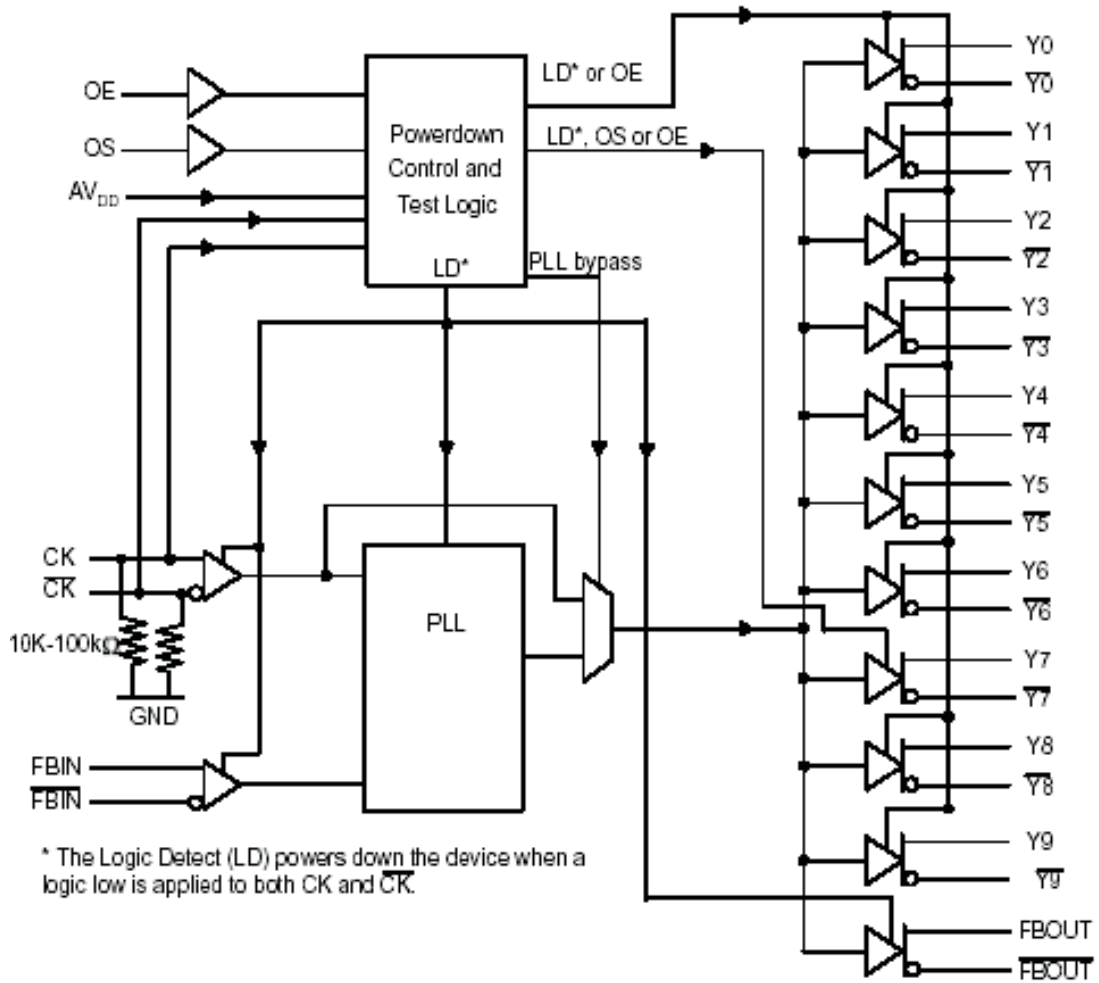


Figure 1. LOGIC DIAGRAM (POSITIVE LOGIC)

Absolute Maximum Ratings⁽¹⁾

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

| | | | MIN | MAX | UNIT |
|------------------|---------------------------------------------------------|---------------------------------------------------------|------|------------------------|------|
| V _{CC} | Supply voltage range | V _{DDQ} or AV _{DD} | -0.5 | 2.5 | V |
| V _I | Input voltage range ⁽²⁾⁽³⁾ | | -0.5 | V _{DDQ} + 0.5 | V |
| V _O | Output voltage range ⁽²⁾⁽³⁾ | | -0.5 | V _{DDQ} + 0.5 | V |
| I _{IK} | Input clamp current | V _I < 0 or V _I > V _{DDQ} | | ±50 | mA |
| I _{OK} | Output clamp current | V _O < 0 or V _O > V _{DDQ} | | ±50 | mA |
| I _O | Continuous output current | V _O = 0 to V _{DDQ} | | ±50 | mA |
| | Continuous current through each V _{DDQ} or GND | | | ±100 | mA |
| T _{stg} | Storage temperature range | | -65 | 150 | °C |

- (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.
- (2) The input and output voltage ratings may be exceeded if the input and output clamp-current ratings are observed.
- (3) This value is limited to 2.5 V maximum.

Recommended Operating Conditions

| | | | MIN | NOM | MAX | UNIT |
|-----------------|-------------------------------------------------------------|---------------------|------------------------------|------------------|------------------------------|------|
| V _{CC} | Output supply voltage, V _{DDQ} | | 1.7 | 1.8 | 1.9 | V |
| | Supply Voltage, AV _{DD} ⁽¹⁾ | | | V _{DDQ} | | V |
| V _{IL} | Low-level input voltage ⁽²⁾ | OE, OS | | | 0.35 x V _{DDQ} | V |
| V _{IH} | High-level input voltage ⁽²⁾ | CK, \overline{CK} | 0.65 x V _{DDQ} | | | V |
| I _{OH} | High-level output current (see Figure 2) | | | | -9 | mA |
| I _{OL} | Low-level output current (see Figure 2) | | | | 9 | mA |
| V _{IX} | Input differential-pair cross voltage | | (V _{DDQ} /2) - 0.15 | | (V _{DDQ} /2) + 0.15 | V |
| V _I | Input voltage level | | -0.3 | | V _{DDQ} + 0.3 | V |
| V _{ID} | Input differential voltage ⁽²⁾ (see Figure 9) | DC | 0.3 | | V _{DDQ} + 0.4 | V |
| | | AC | 0.6 | | V _{DDQ} + 0.4 | V |
| T _A | Operating free-air temperature | | -40 | | 85 | °C |

- (1) The PLL is turned off and bypassed for test purposes when AV_{DD} is grounded. During this test mode, V_{DDQ} remains within the recommended operating conditions and no timing parameters are specified.
- (2) V_{ID} is the magnitude of the difference between the input level on CK and the input level on \overline{CK} , see Figure 9 for definition. The CK and \overline{CK} , V_{IH} and V_{IL} limits define the dc low and high levels for the logic detect state.

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Electrical Characteristics

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

| PARAMETER | | TEST CONDITIONS | AV _{DD} , V _{DDQ} | MIN | TYP ⁽¹⁾ | MAX | UNIT |
|---------------------|--------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------|-----------------------------------------|------------------------|--------------------|------|------|
| V _{IK} | Input | I _I = 18 mA | 1.7 | | | -1.2 | V |
| V _{OH} | High-level output voltage | I _{OH} = -100 μA | 1.7 to 1.9 | V _{DDQ} - 0.2 | | | V |
| | | I _{OH} = -9 mA | 1.7 | 1.1 | | | |
| V _{OL} | Low-level output voltage | I _{OL} = 100 μA | | | | 0.1 | V |
| | | I _{OL} = 9 mA | 1.7 | | | 0.6 | |
| I _{O(DL)} | Low-level output current, disabled | V _{O(DL)} = 100 mV, OE = L | 1.7 | 100 | | | μA |
| V _{OD} | Differential output voltage ⁽¹⁾ | | 1.7 | 0.5 | | | V |
| I _I | Input current | CK, \overline{CK} | 1.9 | | | ±250 | μA |
| | | OE, OS, FBIN, \overline{FBIN} | 1.9 | | | ±10 | |
| I _{DD(LD)} | Supply current, static (I _{DDQ} + I _{ADD}) | CK and \overline{CK} = L | 1.9 | | | 500 | μA |
| I _{DD} | Supply current, dynamic (I _{DDQ} + I _{ADD}) (see Note ⁽²⁾ for CPD calculation) | CK and \overline{CK} = 270 MHz. All outputs are open (not connected to a PCB) | 1.9 | | | 135 | mA |
| | | All outputs are loaded with 2 pF and 120-Ω termination resistor | 1.9 | | | 235 | |
| C _I | Input capacitance | CK, \overline{CK} | V _I = V _{DD} or GND | 1.8 | 2 | 3 | pF |
| | | FBIN, \overline{FBIN} | | 1.8 | 2 | 3 | |
| C _{I(Δ)} | Change in input current | CK, \overline{CK} | V _I = V _{DD} or GND | 1.8 | | 0.25 | pF |
| | | FBIN, \overline{FBIN} | | 1.8 | | 0.25 | |

(1) V_{OD} is the magnitude of the difference between the true and complimentary outputs. See Figure 9 for a definition.

(2) Total I_{DD} = I_{DDQ} + I_{ADD} = f_{CK} × C_{PD} × V_{DDQ}, solving for C_{PD} = (I_{DDQ} + I_{ADD})/(f_{CK} × V_{DDQ}) where f_{CK} is the input frequency, V_{DDQ} is the power supply, and C_{PD} is the power dissipation capacitance.

Timing Requirements

over recommended operating free-air temperature range (unless otherwise noted)⁽¹⁾

| PARAMETER | | TEST CONDITIONS | MIN | MAX | UNIT |
|-----------------|-------------------------------------------------|---------------------------------------------------|-----|-----|------|
| f _{CK} | Clock frequency (operating) ⁽¹⁾⁽²⁾ | AV _{DD} , V _{DD} = 1.8 V ±0.1 V | 10 | 400 | MHz |
| | Clock frequency (application) ⁽¹⁾⁽³⁾ | | 160 | 340 | MHz |
| t _{DC} | Duty cycle, input clock | | 40% | 60% | |
| t _L | Stabilization time ⁽⁴⁾ | | | 12 | μs |

(1) The PLL must be able to handle spread spectrum induced skew.

(2) Operating clock frequency indicates a range over which the PLL must be able to lock, but in which it is not required to meet the other timing parameters (used for low speed system debug).

(3) Application clock frequency indicates a range over which the PLL must meet all timing parameters.

(4) Stabilization time is the time required for the integrated PLL circuit to obtain phase lock of its feedback signal to its reference signal after power up. During normal operation, the stabilization time is also the time required for the integrated PLL circuit to obtain phase lock of its feedback signal to its reference signal when CK and \overline{CK} go to a logic low state, enter the power-down mode and later return to active operation. CK and \overline{CK} may be left floating after they have been driven low for one complete clock cycle.

Switching Characteristics

over recommended operating free-air temperature range (unless otherwise noted) (see ⁽¹⁾) AV_{DD} , $V_{DD} = 1.8 \text{ V} \pm 0.1 \text{ V}$

| PARAMETER | | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|----------------------------------|-------------------------------------------------------|----------------------------------------------------------------------|---------------------|-----|---------------------|------|
| t_{en} | Enable time, OE to any Y/\bar{Y} | See Figure 11 | | | 8 | ns |
| t_{dis} | Disable time, OE to any Y/\bar{Y} | See Figure 11 | | | 8 | ns |
| $t_{jit(cc+)}$ $t_{jit(cc-)}$ | Cycle-to-cycle period jitter ⁽²⁾ | 160 MHz to 190 MHz, see Figure 4 | 0 | | 40 | ps |
| | | | 0 | | -40 | |
| $t_{jit(cc+)}$ $t_{jit(cc-)}$ | Cycle-to-cycle period jitter ⁽²⁾ | 160 MHz to 340 MHz, see Figure 4 | 0 | | 30 | ps |
| | | | 0 | | -30 | |
| $t_{(w)}$ | Static phase offset time ⁽³⁾ | See Figure 5 | -50 | | 50 | ps |
| $t_{(w)dyn}$ | Dynamic phase offset time | See Figure 10 | -15 | | 15 | ps |
| $t_{sk(o)}$ | Output clock skew | See Figure 6 | | | 35 | ps |
| $t_{jit(per)}$ | Period jitter ⁽⁴⁾⁽²⁾ | 160 MHz to 190 MHz, see Figure 7 | -30 | | 30 | ps |
| | | 190 MHz to 340 MHz, see Figure 7 | -20 | | 20 | |
| $t_{jit(hper)}$ | Half-period jitter ⁽⁴⁾⁽²⁾ | 160 MHz to 190 MHz, see Figure 8 | -115 | | 115 | ps |
| | | 190 MHz to 250 MHz, see Figure 8 | -70 | | 70 | |
| | | 250 MHz to 300 MHz, see Figure 8 | -40 | | 40 | |
| | | 300 MHz to 340 MHz, see Figure 8 | -60 | | 60 | |
| SR | Slew rate, OE | See Figure 3 and Figure 9 | 0.5 | | | V/ns |
| | Input clock slew rate | See Figure 3 and Figure 9 | 1 | 2.5 | 4 | |
| | Output clock slew rate ⁽⁵⁾⁽⁶⁾ (no load) | See Figure 3 and Figure 9 | 1.5 | 2.5 | 3 | |
| V_{OX} | Output differential-pair cross voltage ⁽⁷⁾ | CDCU877, See Figure 2 | $(V_{DDQ}/2) - 0.1$ | | $(V_{DDQ}/2) + 0.1$ | V |
| | | CDCU877A ⁽⁸⁾ , See Figure 2 (0 - 85°C) | $(V_{DDQ}/2) - 0.1$ | | $(V_{DDQ}/2) + 0.1$ | |
| | SSC modulation frequency | | 30 | | 33 | kHz |
| | SSC clock input frequency deviation | | 0% | | -0.5% | |
| | PLL loop bandwidth | | 2 | | | MHz |

- (1) There are two different terminations that are used with the following tests. The load/board in [Figure 2](#) is used to measure the input and output differential-pair cross voltage only. The load/board in [Figure 3](#) is used to measure all other tests. For consistency, equal length cables must be used.
- (2) This parameter is specified by design and characterization.
- (3) Phase static offset time does not include jitter.
- (4) Period jitter, half-period jitter specifications are separate specifications that must be met independently of each other.
- (5) The output slew rate is determined from the IBIS model with a 120- Ω load only.
- (6) To eliminate the impact of input slew rates on static phase offset, the input skew rates of reference clock input CK and \bar{CK} and feedback clock inputs FBIN and \bar{FBIN} are recommended to be nearly equal. The 2.5-V/ns skew rates are shown as a recommended target. Compliance with these typical values is not mandatory if it can adequately shown that alternative characteristics meet the requirements of the registered DDR2 DIMM application.
- (7) Output differential-pair cross voltage specified at the DRAM clock input or the test load.
- (8) V_{OX} of CDCU877A is on average 30 mV lower than that of CDCU877 for the same application.

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PARAMETER MEASUREMENT INFORMATION

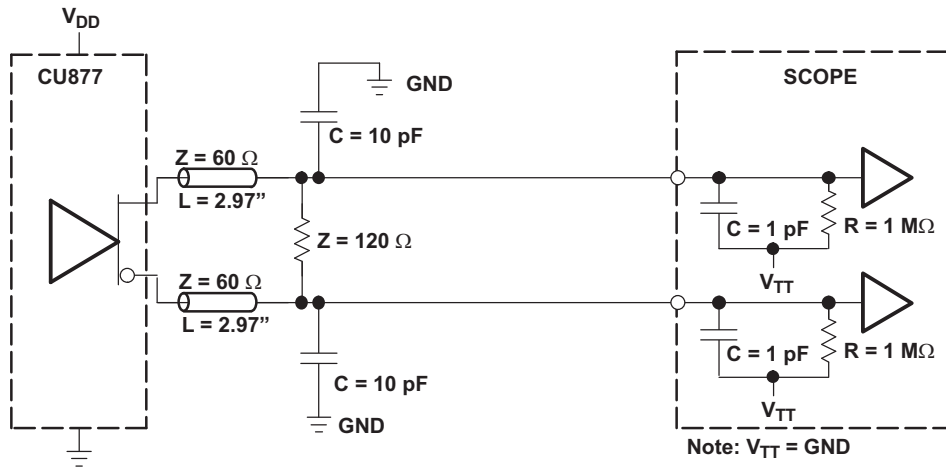


Figure 2. Output Load Test Circuit 1

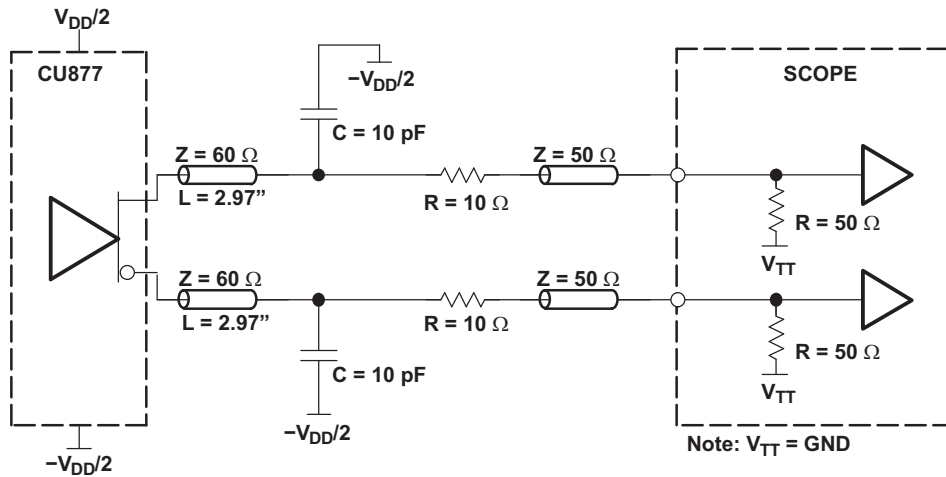


Figure 3. Output Load Test Circuit 2

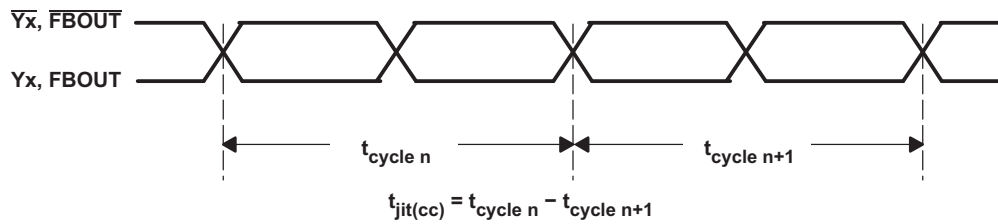


Figure 4. Cycle-To-Cycle Period Jitter

PARAMETER MEASUREMENT INFORMATION (continued)

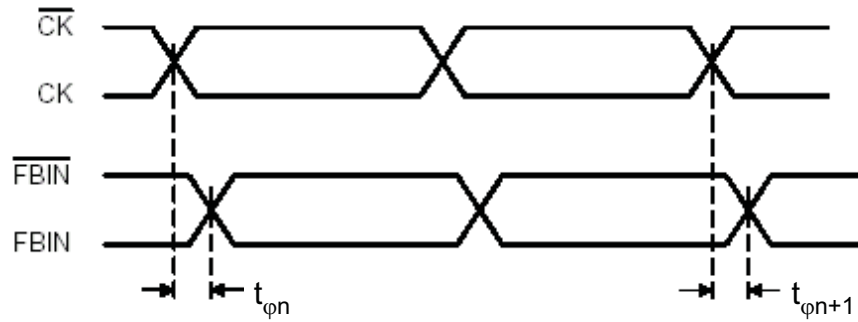


Figure 5. Static Phase Offset

$$t_{\phi} = \frac{\sum_{n=1}^N t_{\phi n}}{N}$$

(N is the large number of samples)

(N > 1000 samples)

(1)

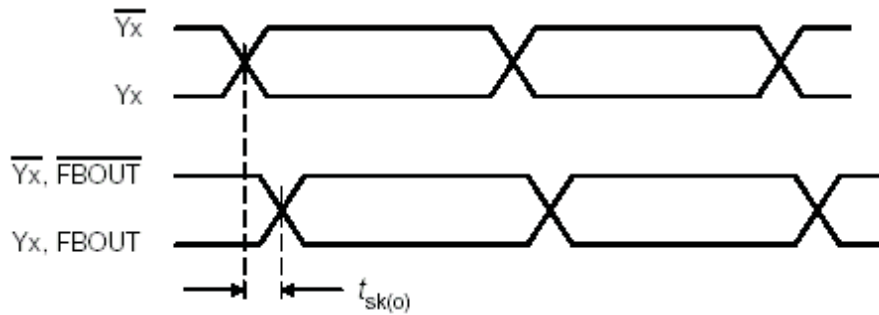


Figure 6. Output Skew

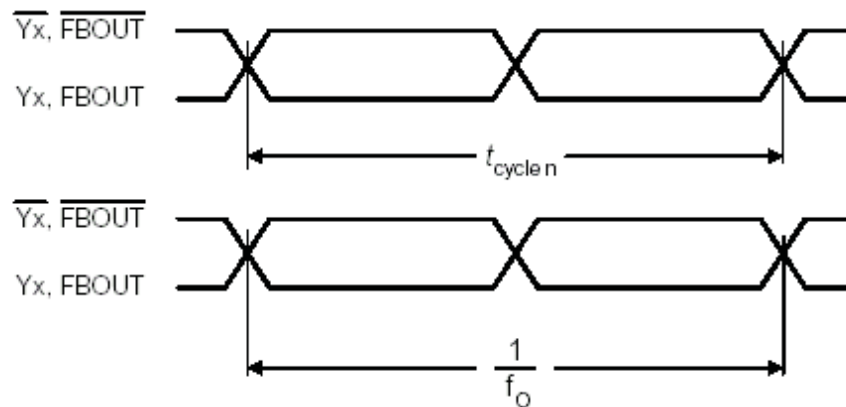


Figure 7. Period Jitter

$$t_{jit(per)} = t_{cycle\ n} - \frac{1}{f_o}$$

(f_o average input frequency measured at CK/CK-bar)

(2)

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PARAMETER MEASUREMENT INFORMATION (continued)

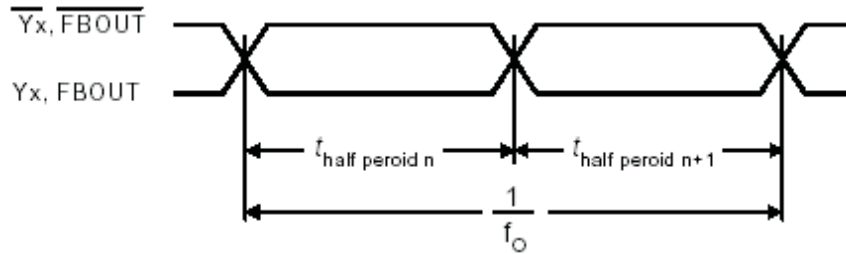


Figure 8. Half-Period Jitter

$$t_{\text{jit(hper)}} = t_{\text{half period } n} - \frac{1}{2 \times f_o}$$

n = any half cycle

(f_o average input frequency measured at CK/\overline{CK})

(3)

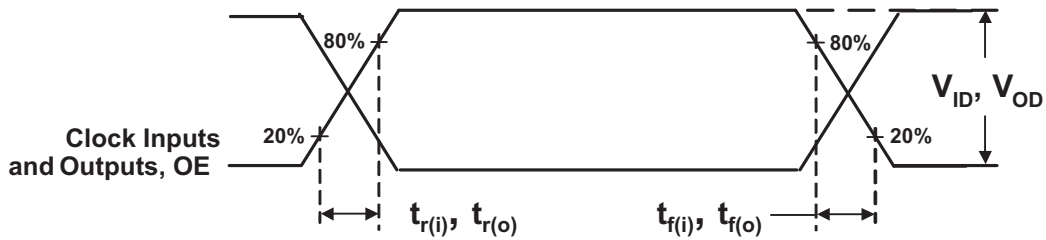


Figure 9. Input and Output Slew Rates

$$slrr_{(i/o)} = \frac{V_{80\%} - V_{20\%}}{t_{r(i/o)}}$$

$$slrf_{(i/o)} = \frac{V_{80\%} - V_{20\%}}{t_{f(i/o)}}$$

(4)

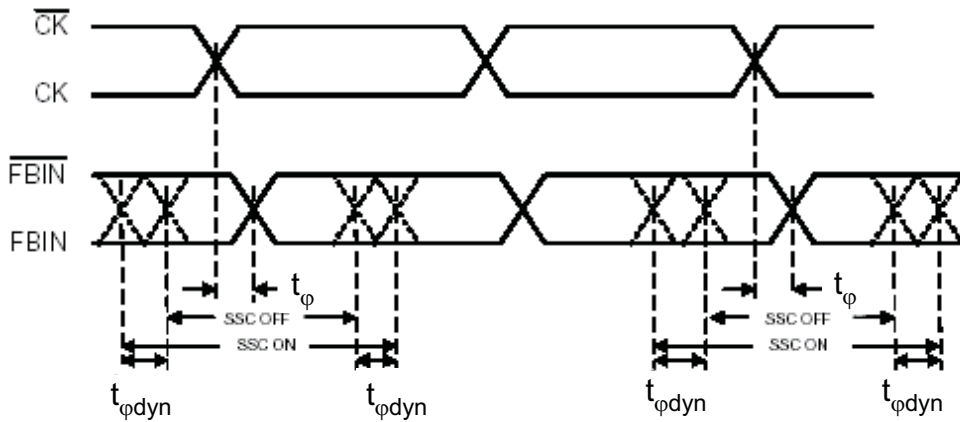


Figure 10. Dynamic Phase Offset

PARAMETER MEASUREMENT INFORMATION (continued)

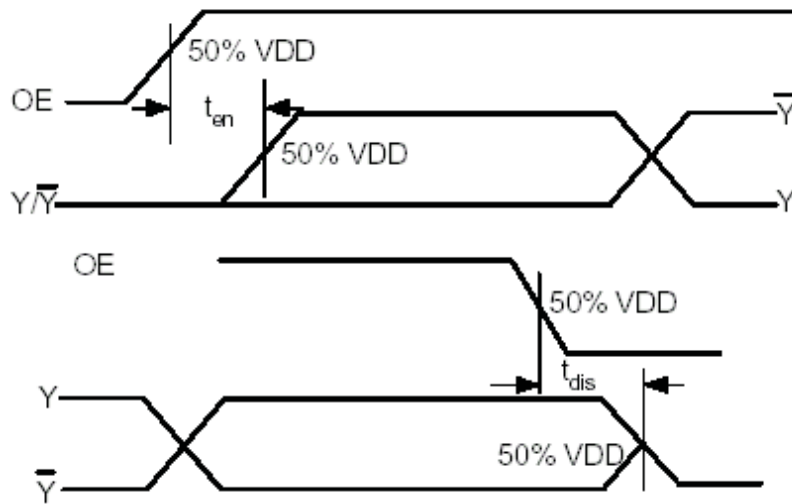
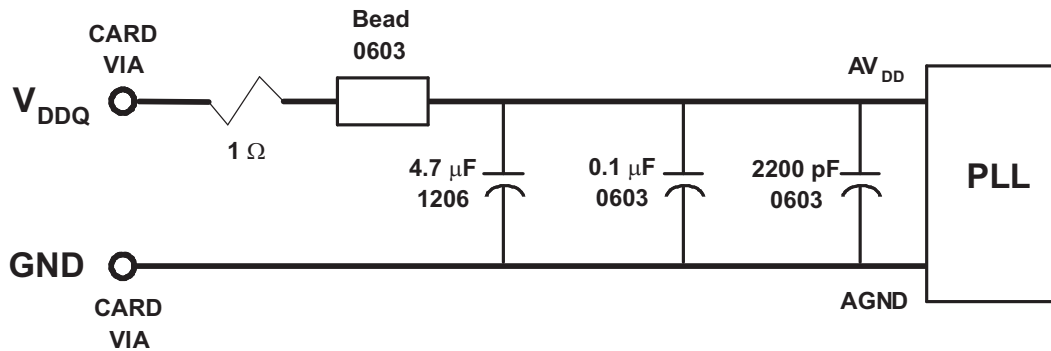


Figure 11. Time Delay Between OE and Clock Output (Y, \bar{Y})

RECOMMENDED AV_{DD} FILTERING



- Place the 2200-pF capacitor close to the PLL.
- Use a wide trace for the PLL analog power and ground. Connect PLL and capacitors to AGND trace and connect trace to one GND via (farthest from the PLL).
- Recommended bead: Fair-Rite PN 2506036017Y0 or equivalent (0.8 Ω dc maximum, 600 Ω at 100 MHz).

Figure 12. Recommended AV_{DD} Filtering

PACKAGING INFORMATION

| Orderable Device | Status (1) | Package Type | Package Drawing | Pins | Package Qty | Eco Plan (2) | Lead/Ball Finish (6) | MSL Peak Temp (3) | Op Temp (°C) | Device Marking (4/5) | Samples |
|------------------|---------------|----------------------|-----------------|------|-------------|-------------------------|-------------------------|----------------------|--------------|-------------------------|-------------------------|
| CDCU877ARHAR | ACTIVE | VQFN | RHA | 40 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-3-260C-168 HR | -40 to 85 | CDCU877A | Samples |
| CDCU877ARHARG4 | ACTIVE | VQFN | RHA | 40 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-3-260C-168 HR | -40 to 85 | CDCU877A | Samples |
| CDCU877ARHAT | ACTIVE | VQFN | RHA | 40 | 250 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-3-260C-168 HR | -40 to 85 | CDCU877A | Samples |
| CDCU877AZQLR | ACTIVE | BGA MICROSTAR JUNIOR | ZQL | 52 | 1000 | Green (RoHS & no Sb/Br) | SNAGCU | Level-2-260C-1 YEAR | -40 to 85 | CDCU877A | Samples |
| CDCU877AZQLT | ACTIVE | BGA MICROSTAR JUNIOR | ZQL | 52 | 250 | Green (RoHS & no Sb/Br) | SNAGCU | Level-2-260C-1 YEAR | -40 to 85 | CDCU877A | Samples |
| CDCU877GQLT | LIFEBUY | BGA MICROSTAR JUNIOR | GQL | 52 | 250 | TBD | SNPB | Level-2-235C-1 YEAR | -40 to 85 | CDCU877 | |
| CDCU877RHAR | ACTIVE | VQFN | RHA | 40 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-3-260C-168 HR | -40 to 85 | CDCU877 | Samples |
| CDCU877RHARG4 | ACTIVE | VQFN | RHA | 40 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-3-260C-168 HR | -40 to 85 | CDCU877 | Samples |
| CDCU877RHAT | ACTIVE | VQFN | RHA | 40 | 250 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-3-260C-168 HR | -40 to 85 | CDCU877 | Samples |
| CDCU877RHATG4 | ACTIVE | VQFN | RHA | 40 | 250 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-3-260C-168 HR | -40 to 85 | CDCU877 | Samples |
| CDCU877RTBR | ACTIVE | VQFN | RHA | 40 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-3-260C-168 HR | -40 to 85 | CDCU877 | Samples |
| CDCU877ZQLR | LIFEBUY | BGA MICROSTAR JUNIOR | ZQL | 52 | 1000 | Green (RoHS & no Sb/Br) | SNAGCU | Level-2-260C-1 YEAR | -40 to 85 | CDCU877 | |

(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.

OBSELETE: TI has discontinued the production of the device.

(2) **RoHS:** TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".

RoHS Exempt: TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.

Green: TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of ≤ 1000 ppm threshold. Antimony trioxide based flame retardants must also meet the ≤ 1000 ppm threshold requirement.

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

(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device Markings will be inside parentheses. Only one Device 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 Device Marking for that device.

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

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TAPE AND REEL INFORMATION

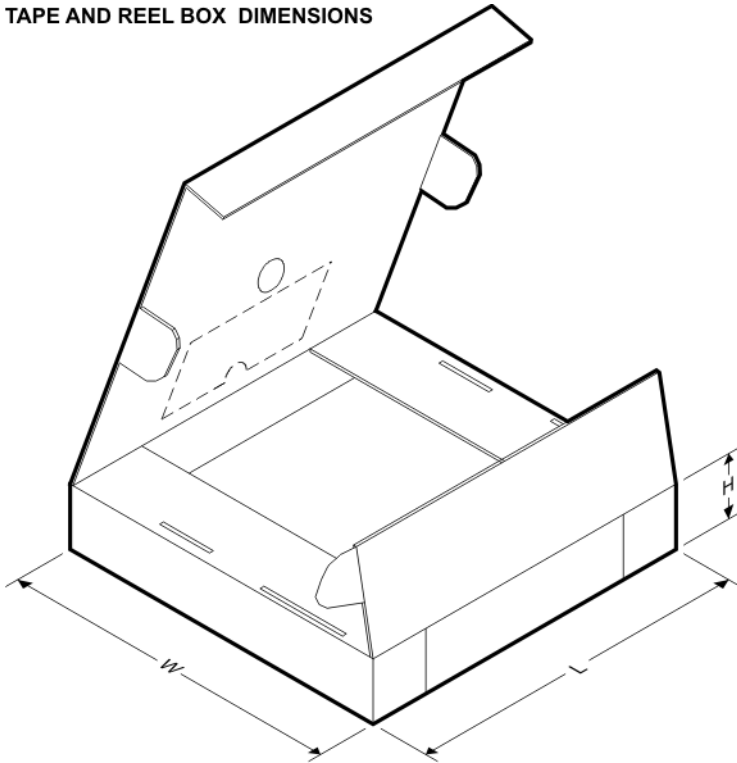


QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*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 |
|--------------|----------------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| CDCU877ARHAR | VQFN | RHA | 40 | 2500 | 330.0 | 16.4 | 6.3 | 6.3 | 1.1 | 12.0 | 16.0 | Q2 |
| CDCU877ARHAT | VQFN | RHA | 40 | 250 | 180.0 | 16.4 | 6.3 | 6.3 | 1.1 | 12.0 | 16.0 | Q2 |
| CDCU877AZQLR | BGA MICROSTAR JUNIOR | ZQL | 52 | 1000 | 330.0 | 16.4 | 4.8 | 7.3 | 1.5 | 8.0 | 16.0 | Q1 |
| CDCU877AZQLT | BGA MICROSTAR JUNIOR | ZQL | 52 | 250 | 180.0 | 16.4 | 4.8 | 7.3 | 1.5 | 8.0 | 16.0 | Q1 |
| CDCU877GQLT | BGA MICROSTAR JUNIOR | GQL | 52 | 250 | 180.0 | 16.4 | 4.8 | 7.3 | 1.5 | 8.0 | 16.0 | Q1 |
| CDCU877RHAR | VQFN | RHA | 40 | 2500 | 330.0 | 16.4 | 6.3 | 6.3 | 1.1 | 12.0 | 16.0 | Q2 |
| CDCU877RHAT | VQFN | RHA | 40 | 250 | 180.0 | 16.4 | 6.3 | 6.3 | 1.1 | 12.0 | 16.0 | Q2 |
| CDCU877ZQLR | BGA MICROSTAR JUNIOR | ZQL | 52 | 1000 | 330.0 | 16.4 | 4.8 | 7.3 | 1.5 | 8.0 | 16.0 | Q1 |

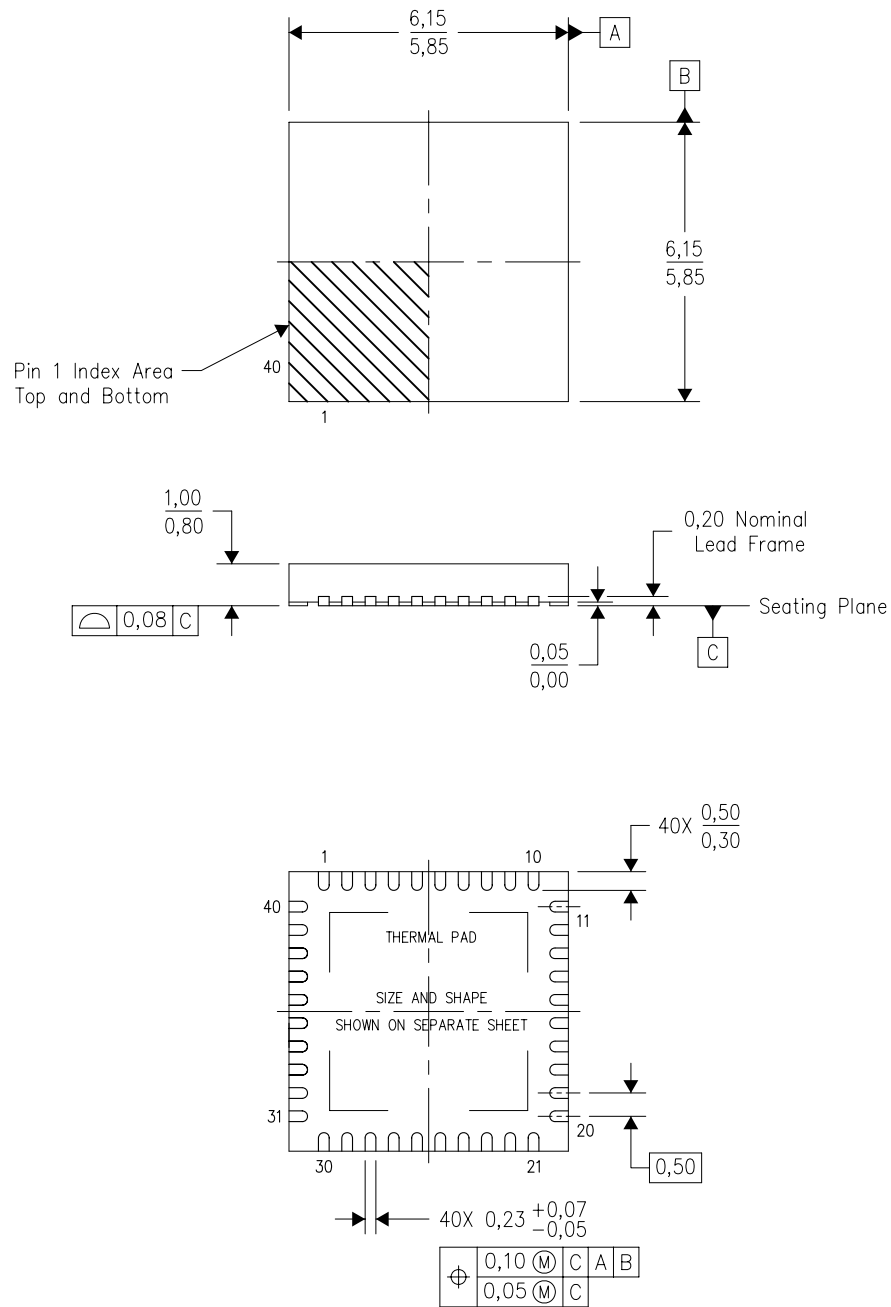
TAPE AND REEL BOX DIMENSIONS


*All dimensions are nominal

| Device | Package Type | Package Drawing | Pins | SPQ | Length (mm) | Width (mm) | Height (mm) |
|--------------|----------------------|-----------------|------|------|-------------|------------|-------------|
| CDCU877ARHAR | VQFN | RHA | 40 | 2500 | 367.0 | 367.0 | 38.0 |
| CDCU877ARHAT | VQFN | RHA | 40 | 250 | 210.0 | 185.0 | 35.0 |
| CDCU877AZQLR | BGA MICROSTAR JUNIOR | ZQL | 52 | 1000 | 350.0 | 350.0 | 43.0 |
| CDCU877AZQLT | BGA MICROSTAR JUNIOR | ZQL | 52 | 250 | 213.0 | 191.0 | 55.0 |
| CDCU877GQLT | BGA MICROSTAR JUNIOR | GQL | 52 | 250 | 213.0 | 191.0 | 55.0 |
| CDCU877RHAR | VQFN | RHA | 40 | 2500 | 367.0 | 367.0 | 38.0 |
| CDCU877RHAT | VQFN | RHA | 40 | 250 | 210.0 | 185.0 | 35.0 |
| CDCU877ZQLR | BGA MICROSTAR JUNIOR | ZQL | 52 | 1000 | 350.0 | 350.0 | 43.0 |

RHA (S-PVQFN-N40)

PLASTIC QUAD FLATPACK NO-LEAD



Bottom View

4204276/E 06/11

- NOTES:
- All linear dimensions are in millimeters. Dimensioning and tolerancing per ASME Y14.5M-1994.
 - This drawing is subject to change without notice.
 - QFN (Quad Flatpack No-Lead) Package configuration.
 - The package thermal pad must be soldered to the board for thermal and mechanical performance.
 - See the additional figure in the Product Data Sheet for details regarding the exposed thermal pad features and dimensions.
 - Package complies to JEDEC MO-220 variation VJJD-2.

THERMAL PAD MECHANICAL DATA

RHA (S-PVQFN-N40)

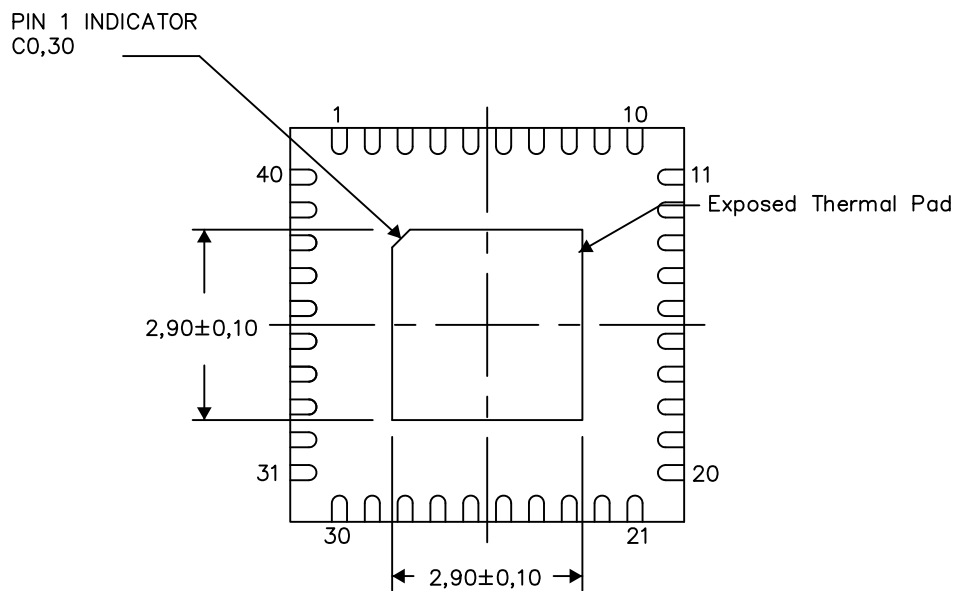
PLASTIC QUAD FLATPACK NO-LEAD

THERMAL INFORMATION

This package incorporates an exposed thermal pad that is designed to be attached directly to an external heatsink. The thermal pad must be soldered directly to the printed circuit board (PCB). After soldering, the PCB can be used as a heatsink. In addition, through the use of thermal vias, the thermal pad can be attached directly to the appropriate copper plane shown in the electrical schematic for the device, or alternatively, can be attached to a special heatsink structure designed into the PCB. This design optimizes the heat transfer from the integrated circuit (IC).

For information on the Quad Flatpack No-Lead (QFN) package and its advantages, refer to Application Report, QFN/SON PCB Attachment, Texas Instruments Literature No. SLUA271. This document is available at www.ti.com.

The exposed thermal pad dimensions for this package are shown in the following illustration.



Bottom View

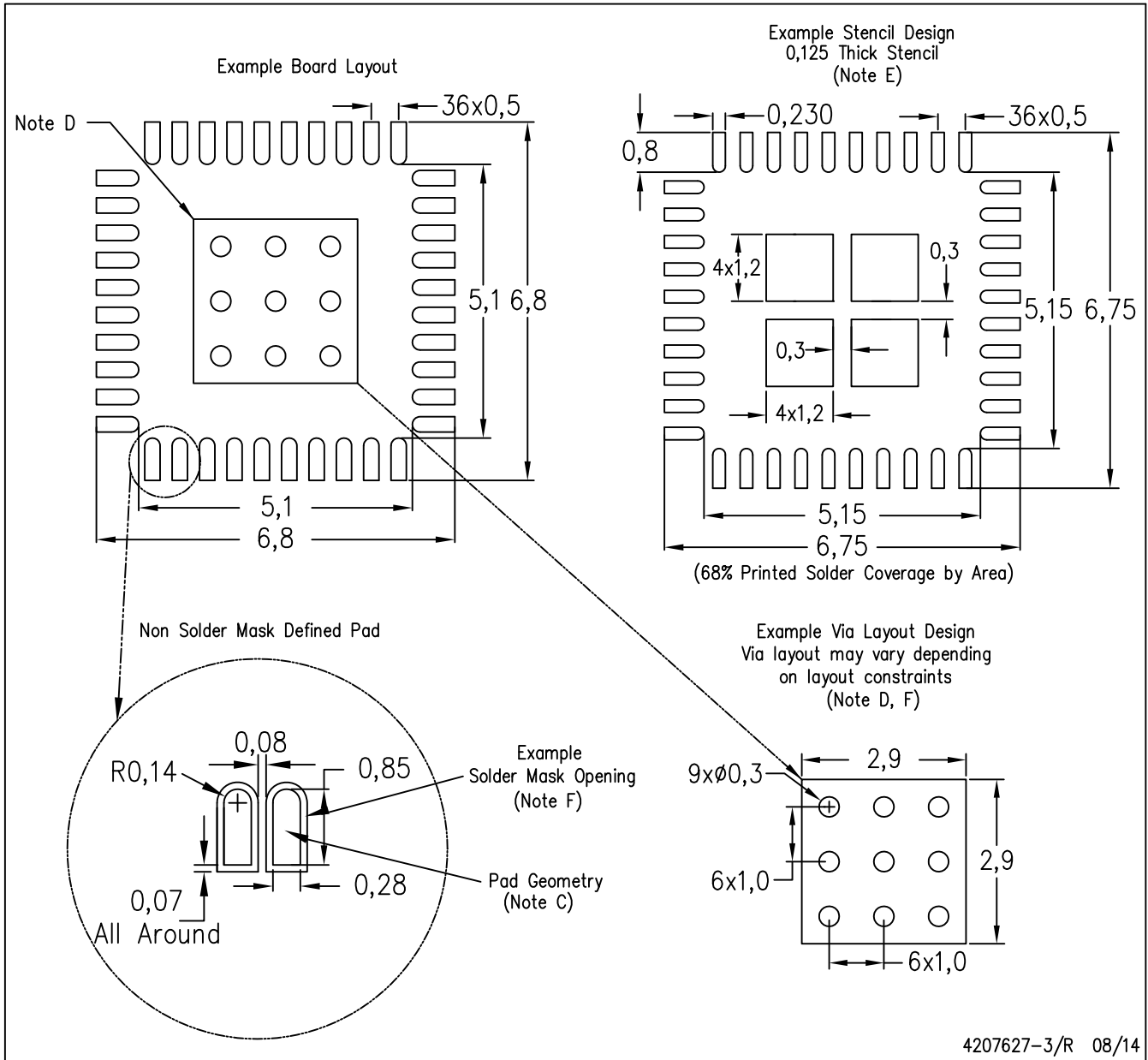
Exposed Thermal Pad Dimensions

4206355-3/X 08/14

NOTES: A. All linear dimensions are in millimeters

RHA (S-PVQFN-N40)

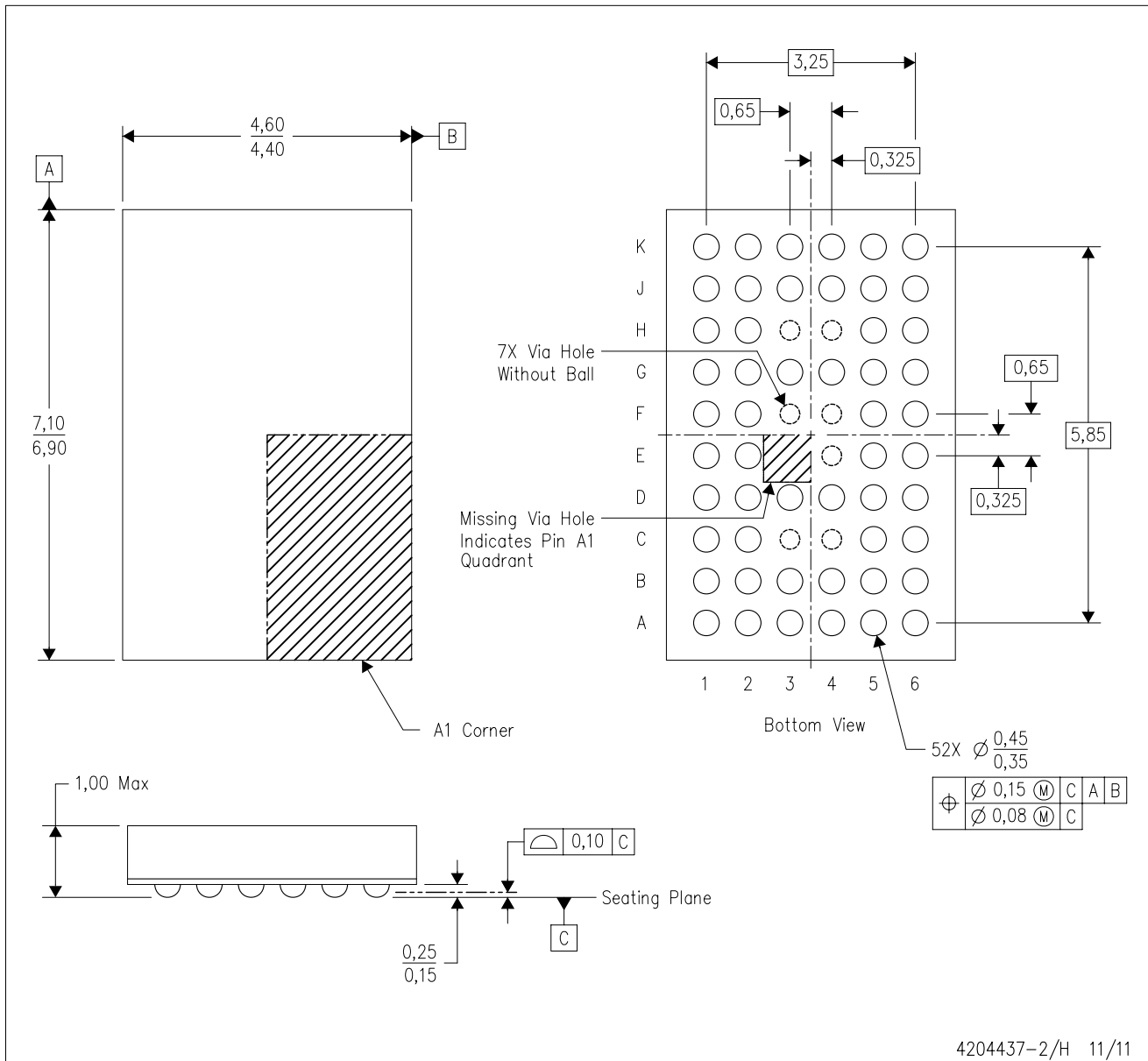
PLASTIC QUAD FLATPACK NO-LEAD



- NOTES:
- All linear dimensions are in millimeters.
 - This drawing is subject to change without notice.
 - Publication IPC-7351 is recommended for alternate designs.
 - This package is designed to be soldered to a thermal pad on the board. Refer to Application Note, Quad Flat-Pack Packages, Texas Instruments Literature No. SLUA271, and also the Product Data Sheets for specific thermal information, via requirements, and recommended board layout. These documents are available at www.ti.com <<http://www.ti.com>>.
 - Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Refer to IPC 7525 for stencil design considerations.
 - Customers should contact their board fabrication site for recommended solder mask tolerances and via tenting recommendations for vias placed in the thermal pad.

ZQL (R-PBGA-N52)

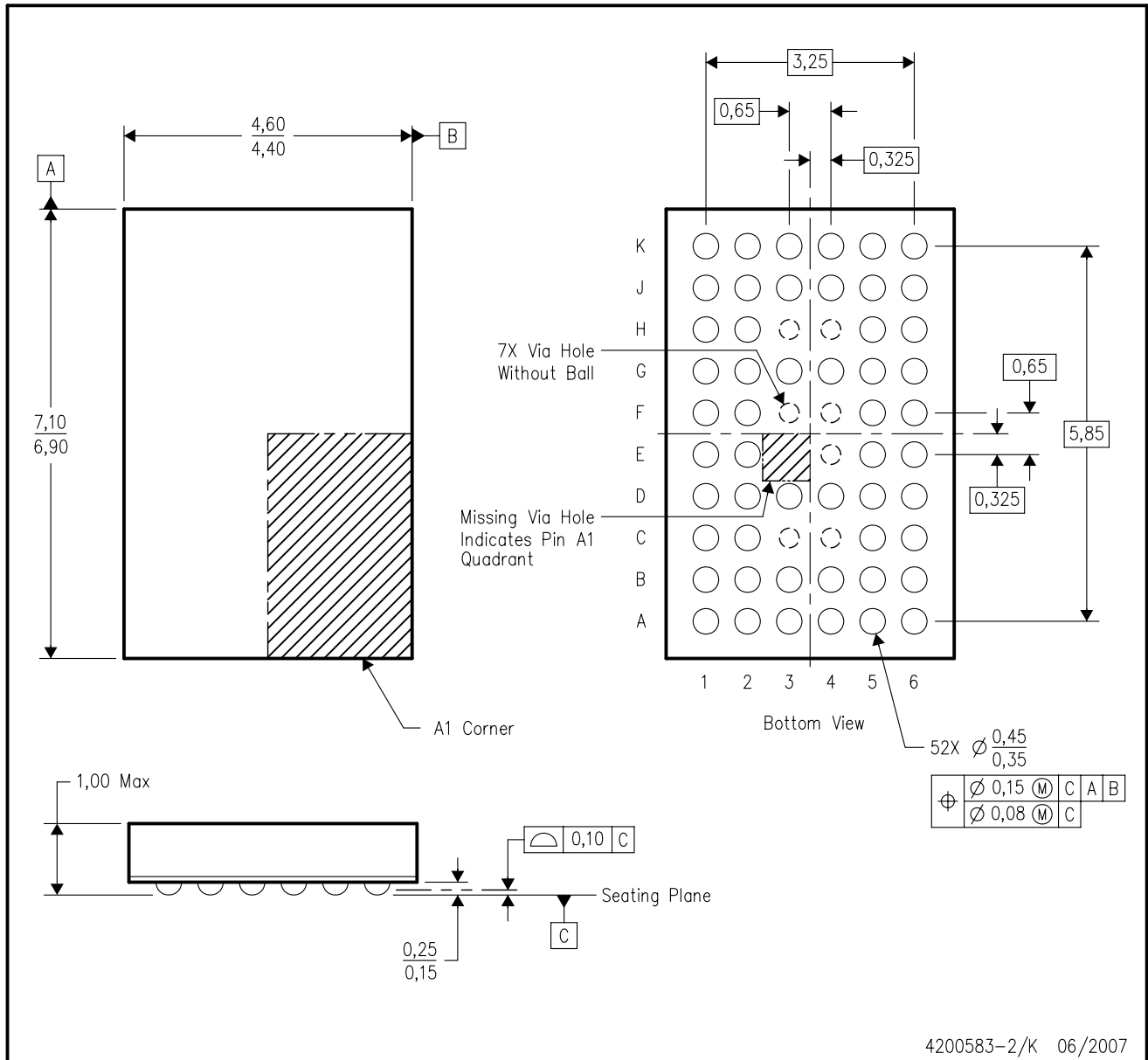
PLASTIC BALL GRID ARRAY



- NOTES:
- All linear dimensions are in millimeters. Dimensioning and tolerancing per ASME Y14.5M-1994.
 - This drawing is subject to change without notice.
 - Falls within JEDEC MO-285 variation BA-2.
 - This package is Pb-free. Refer to the 52 GQL package (drawing 4200583) for tin-lead (SnPb).

GQL (R-PBGA-N52)

PLASTIC 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. Falls within JEDEC MO-285 variation BA-2.
 - D. This package is tin-lead (SnPb). Refer to the 52 ZQL package (drawing 4204437) for lead-free.

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