

X4 SRAM Nonvolatile Controller Unit

Features

- Power monitoring and switching for 3-volt battery-backup applications
- Write-protect control
- 2-input decoder for control of up to 4 banks of SRAM
- 3-volt primary cell inputs
- Less than 10ns chip-enable propagation delay
- 5% or 10% supply operation

General Description

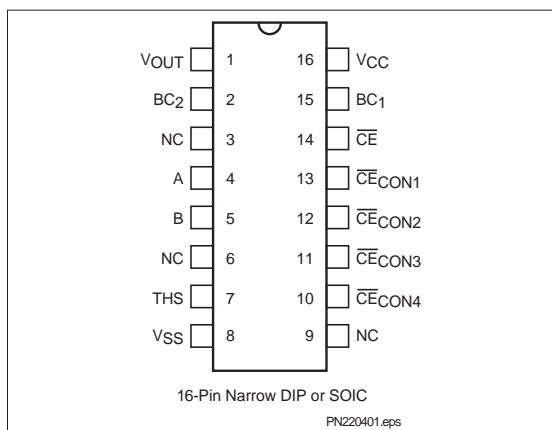
The CMOS bq2204A SRAM Nonvolatile Controller Unit provides all necessary functions for converting up to four banks of standard CMOS SRAM into nonvolatile read/write memory.

A precision comparator monitors the 5V VCC input for an out-of-tolerance condition. When out-of-tolerance is detected, the four conditioned chip-enable outputs are forced inactive to write-protect up to four banks of SRAM.

During a power failure, the external SRAMs are switched from the VCC supply to one of two 3V backup supplies. On a subsequent power-up, the SRAMs are write-protected until a power-valid condition exists.

During power-valid operation, a two-input decoder transparently selects one of up to four banks of SRAM.

Pin Connections



Pin Names

| | |
|---|-----------------------------------|
| VOUT | Supply output |
| BC ₁ –BC ₂ | 3 volt primary backup cell inputs |
| THS | Threshold select input |
| $\overline{\text{CE}}$ | chip-enable active low input |
| $\overline{\text{CE}}_{\text{CON1}}$ – $\overline{\text{CE}}_{\text{CON4}}$ | Conditioned chip-enable outputs |
| A–B | Decoder inputs |
| NC | No connect |
| VCC | +5 volt supply input |
| VSS | Ground |

Functional Description

Up to four banks of CMOS static RAM can be battery-backed using the VOUT and conditioned chip-enable output pins from the bq2204A. As VCC slews down during a power failure, the conditioned chip-enable outputs $\overline{\text{CE}}_{\text{CON1}}$ through $\overline{\text{CE}}_{\text{CON4}}$ are forced inactive independent of the chip-enable input $\overline{\text{CE}}$.

This activity unconditionally write-protects the external SRAM as VCC falls below an out-of-tolerance threshold VPFD. VPFD is selected by the threshold select input pin, THS. If THS is tied to VSS, the power-fail detection occurs at 4.62V typical for 5% supply operation.

If THS is tied to VCC, power-fail detection occurs at 4.37V typical for 10% supply operation. The THS pin must be tied to VSS or VCC for proper operation.

If a memory access is in process to any of the four external banks of SRAM during power-fail detection, that memory cycle continues to completion before the memory is write-protected. If the memory cycle is not terminated within time t_{WPT} , all four chip-enable outputs are unconditionally driven high, write-protecting the controlled SRAMs.

bq2204A

As the supply continues to fall past V_{PFD} , an internal switching device forces V_{OUT} to one of the two external backup energy sources. $\overline{CECON1}$ through $\overline{CECON4}$ are held high by the V_{OUT} energy source.

During power-up, V_{OUT} is switched back to the 5V supply as V_{CC} rises above the backup cell input voltage sourcing V_{OUT} . Outputs $\overline{CECON1}$ through $\overline{CECON4}$ are held inactive for time t_{CER} (120ms maximum) after the power supply has reached V_{PFD} , independent of the \overline{CE} input, to allow for processor stabilization.

During power-valid operation, the \overline{CE} input is passed through to one of the four \overline{CECON} outputs with a propagation delay of less than 10ns. The \overline{CE} input is output on one of the four \overline{CECON} output pins depending on the level of the decode inputs at A and B as shown in the Truth Table.

The A and B inputs are usually tied to high-order address pins so that a large nonvolatile memory can be designed using lower-density memory devices. Nonvolatility and decoding are achieved by hardware hookup as shown in Figure 1.

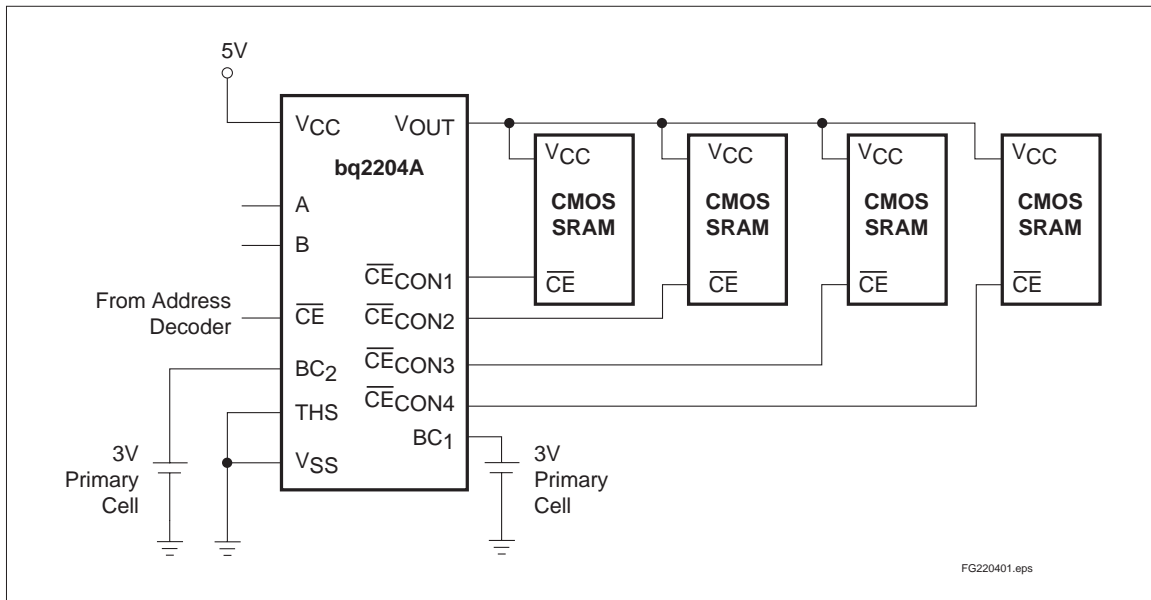


Figure 1. Hardware Hookup (5% Supply Operation)

Energy Cell Inputs—BC₁, BC₂

Two backup energy source inputs are provided on the bq2204A. The BC₁ and BC₂ inputs accept a 3V primary battery (non-rechargeable), typically some type of lithium chemistry. If no primary cell is to be used on either BC₁ or BC₂, the unused input should be tied to V_{SS}.

V_{CC} falling below V_{PF}D starts the comparison of BC₁ and BC₂. The BC input comparison continues until V_{CC} rises above V_{SO}. Power to V_{OUT} begins with BC₁ and switches to BC₂ only when V_{BC1} is less than V_{BC2} minus V_{BSO}. The controller alternates to the higher BC voltage only when the difference between the BC input voltages is greater than V_{BSO}. Alternating the backup batteries allows one-at-a-time battery replacement and efficient use of both backup batteries.

To prevent battery drain when there is no valid data to retain, V_{OUT} and $\overline{\text{CE}}_{\text{CON1-4}}$ are internally isolated from BC₁ and BC₂ by either of the following conditions:

- Initial connection of a battery to BC₁ or BC₂, or
- Presentation of an isolation signal on $\overline{\text{CE}}$.

A valid isolation signal requires $\overline{\text{CE}}$ low as V_{CC} crosses both V_{PF}D and V_{SO} during a power-down. See Figure 2. Between these two points in time, $\overline{\text{CE}}$ must be brought to the point of (0.48 to 0.52)*V_{CC} and held for at least 700ns. The isolation signal is invalid if $\overline{\text{CE}}$ exceeds 0.54*V_{CC} at any point between V_{CC} crossing V_{PF}D and V_{SO}.

The appropriate battery is connected to V_{OUT} and $\overline{\text{CE}}_{\text{CON1-4}}$ immediately on subsequent application and removal of V_{CC}.

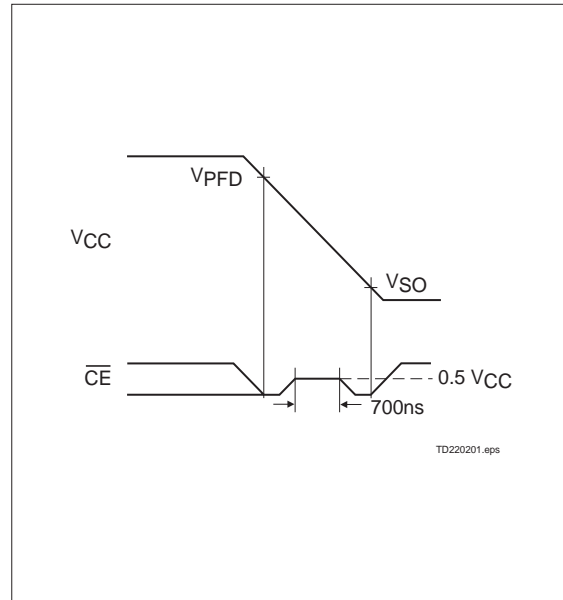


Figure 2. Battery Isolation Signal

Truth Table

| Input | | | Output | | | |
|------------------------|---|---|--------------------------------------|--------------------------------------|--------------------------------------|--------------------------------------|
| $\overline{\text{CE}}$ | A | B | $\overline{\text{CE}}_{\text{CON1}}$ | $\overline{\text{CE}}_{\text{CON2}}$ | $\overline{\text{CE}}_{\text{CON3}}$ | $\overline{\text{CE}}_{\text{CON4}}$ |
| H | X | X | H | H | H | H |
| L | L | L | L | H | H | H |
| L | H | L | H | L | H | H |
| L | L | H | H | H | L | H |
| L | H | H | H | H | H | L |

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Absolute Maximum Ratings

| Symbol | Parameter | Value | Unit | Conditions |
|---------------------|---|--------------|------|--|
| V _{CC} | DC voltage applied on V _{CC} relative to V _{SS} | -0.3 to +7.0 | V | |
| V _T | DC voltage applied on any pin excluding V _{CC} relative to V _{SS} | -0.3 to +7.0 | V | V _T ≤ V _{CC} + 0.3 |
| T _{OPR} | Operating temperature | 0 to 70 | °C | Commercial |
| | | -40 to +85 | °C | Industrial "N" |
| T _{STG} | Storage temperature | -55 to +125 | °C | |
| T _{BIAS} | Temperature under bias | -40 to +85 | °C | |
| T _{SOLDER} | Soldering temperature | 260 | °C | For 10 seconds |
| I _{OUT} | V _{OUT} current | 200 | mA | |

Note: Permanent device damage may occur if **Absolute Maximum Ratings** are exceeded. Functional operation should be limited to the Recommended DC Operating Conditions detailed in this data sheet. Exposure to conditions beyond the operational limits for extended periods of time may affect device reliability.

Recommended DC Operating Conditions (T_A = T_{OPR})

| Symbol | Parameter | Minimum | Typical | Maximum | Unit | Notes |
|--|---------------------|---------|---------|-----------------------|------|-----------------------------------|
| V _{CC} | Supply voltage | 4.75 | 5.0 | 5.5 | V | THS = V _{SS} |
| | | 4.50 | 5.0 | 5.5 | V | THS = V _{CC} |
| V _{SS} | Supply voltage | 0 | 0 | 0 | V | |
| V _{IL} | Input low voltage | -0.3 | - | 0.8 | V | |
| V _{IH} | Input high voltage | 2.2 | - | V _{CC} + 0.3 | V | |
| V _{BC1} , V _{BC2} | Backup cell voltage | 2.0 | - | 4.0 | V | V _{CC} < V _{BC} |
| THS | Threshold select | -0.3 | - | V _{CC} + 0.3 | V | |

Note: Typical values indicate operation at T_A = 25°C, V_{CC} = 5V or V_{BC}.

DC Electrical Characteristics ($T_A = T_{OPR}$, $V_{CC} = 5V \pm 10\%$)

| Symbol | Parameter | Minimum | Typical | Maximum | Unit | Conditions/Notes |
|--------|-----------------------------|----------------|-----------|---------|---------|---|
| ILI | Input leakage current | - | - | ± 1 | μA | $V_{IN} = V_{SS}$ to V_{CC} |
| VOH | Output high voltage | 2.4 | - | - | V | $I_{OH} = -2.0mA$ |
| VOHB | VOH, BC supply | $V_{BC} - 0.3$ | - | - | V | $V_{BC} > V_{CC}$, $I_{OH} = -10\mu A$ |
| VOL | Output low voltage | - | - | 0.4 | V | $I_{OL} = 4.0mA$ |
| ICC | Operating supply current | - | 3 | 6 | mA | No load on outputs. |
| VPFD | Power-fail detect voltage | 4.55 | 4.62 | 4.75 | V | $THS = V_{SS}$ |
| | | 4.30 | 4.37 | 4.50 | V | $THS = V_{CC}$ |
| VSO | Supply switch-over voltage | - | V_{BC} | - | V | |
| ICCDR | Data-retention mode current | - | - | 100 | nA | V_{OUT} data-retention current to additional memory not included. |
| VBC | Active backup cell voltage | - | V_{BC1} | - | V | $V_{BC1} > V_{BC2} + V_{BSO}$ |
| | | - | V_{BC2} | - | V | $V_{BC2} > V_{BC1} + V_{BSO}$ |
| VBSO | Battery switch-over voltage | 0.25 | 0.4 | 0.6 | V | |
| IOUT1 | V_{OUT} current | - | - | 160 | mA | $V_{OUT} > V_{CC} - 0.3V$ |
| IOUT2 | V_{OUT} current | - | 100 | - | μA | $V_{OUT} > V_{BC} - 0.2V$ |

Note: Typical values indicate operation at $T_A = 25^\circ C$, $V_{CC} = 5V$ or V_{BC} .

Capacitance ($T_A = 25^\circ C$, $F = 1MHz$, $V_{CC} = 5.0V$)

| Symbol | Parameter | Minimum | Typical | Maximum | Unit | Conditions |
|--------|--------------------|---------|---------|---------|------|---------------------|
| CIN | Input capacitance | - | - | 8 | pF | Input voltage = 0V |
| COUT | Output capacitance | - | - | 10 | pF | Output voltage = 0V |

Note: This parameter is sampled and not 100% tested.

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AC Test Conditions

| Parameter | Test Conditions |
|--|-----------------------------------|
| Input pulse levels | 0V to 3.0V |
| Input rise and fall times | 5ns |
| Input and output timing reference levels | 1.5V (unless otherwise specified) |

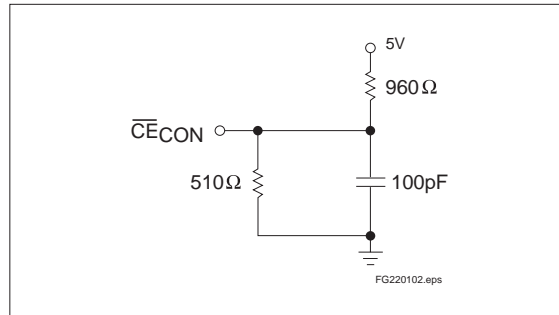


Figure 3. Output Load

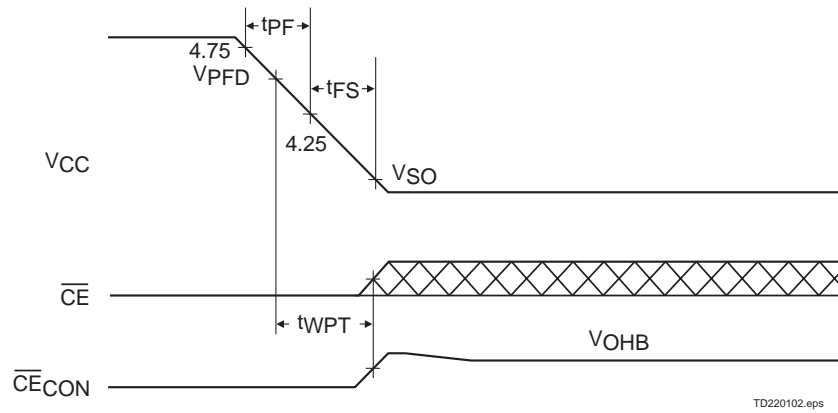
Power-Fail Control ($T_A = T_{OPR}$)

| Symbol | Parameter | Minimum | Typical | Maximum | Unit | Notes |
|--------|--|---------|---------|---------|------|--|
| tPF | V _{CC} slew, 4.75V to 4.25V | 300 | - | - | μs | |
| tFS | V _{CC} slew, 4.25V to V _{SO} | 10 | - | - | μs | |
| tPU | V _{CC} slew, 4.25V to 4.75V | 0 | - | - | μs | |
| tCED | chip-enable propagation delay | - | 7 | 10 | ns | |
| tAS | A,B set up to \overline{CE} | 0 | - | - | ns | |
| tCER | chip-enable recovery | 40 | 80 | 120 | ms | Time during which SRAM is write-protected after V _{CC} passes V _{PFD} on power-up. |
| tWPT | Write-protect time | 40 | 100 | 150 | μs | Delay after V _{CC} slews down past V _{PFD} before SRAM is write-protected. |

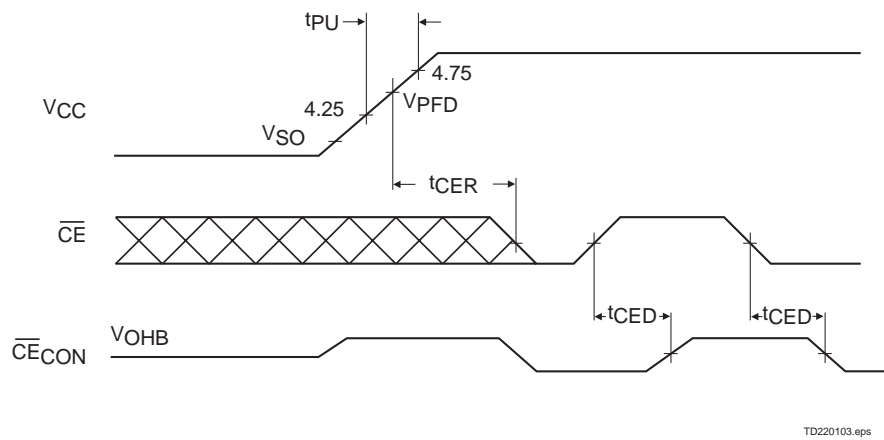
Note: Typical values indicate operation at $T_A = 25^\circ\text{C}$, $V_{CC} = 5\text{V}$.

Caution: Negative undershoots below the absolute maximum rating of -0.3V in battery-backup mode may affect data integrity.

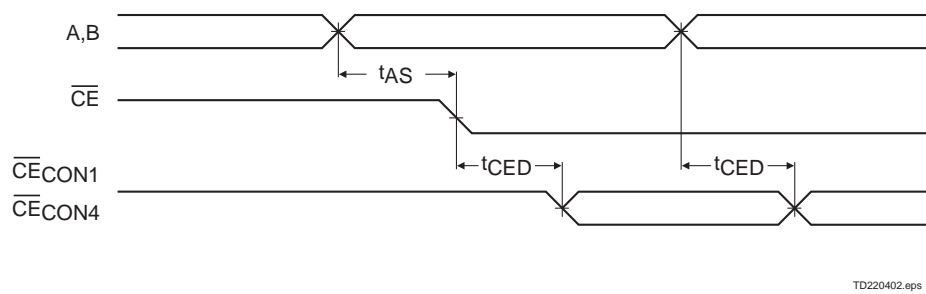
Power-Down Timing



Power-Up Timing



Address-Decode Timing



bq2204A

Data Sheet Revision History

| Change No. | Page No. | Description of Change | Nature of Change |
|------------|----------|--|------------------|
| 1 | All | bq2204A replaces bq2204. | |
| 1 | 1, 4-5 | 10% tolerance requires the THS pin to be tied to VCC, not VOUT. | |
| 1 | 3 | Energy cell input selection process alternates between BC ₁ and BC ₂ . | |

Note: Change 1 = Dec. 1992 changes from Sept. 1991

PACKAGING INFORMATION

| Orderable Device | Status ⁽¹⁾ | Package Type | Package Drawing | Pins | Package Qty | Eco Plan ⁽²⁾ | Lead/ Ball Finish | MSL Peak Temp ⁽³⁾ | Samples (Requires Login) |
|------------------|-----------------------|--------------|-----------------|------|-------------|----------------------------|----------------------|------------------------------|-----------------------------|
| BQ2204APN | ACTIVE | PDIP | N | 16 | 25 | Pb-Free (RoHS) | CU NIPDAU | N / A for Pkg Type | |
| BQ2204ASN | ACTIVE | SOIC | D | 16 | 40 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR | |
| BQ2204ASN-N | ACTIVE | SOIC | D | 16 | 40 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR | |
| BQ2204ASN-NG4 | ACTIVE | SOIC | D | 16 | 40 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR | |
| BQ2204ASNG4 | ACTIVE | SOIC | D | 16 | 40 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR | |
| BQ2204ASNTR | ACTIVE | SOIC | D | 16 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR | |
| BQ2204ASNTRG4 | ACTIVE | SOIC | D | 16 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR | |

⁽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⁾ 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.

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

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PACKAGE OPTION ADDENDUM

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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 |

TAPE AND REEL INFORMATION

*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 |
|-------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| BQ2204ASNTR | SOIC | D | 16 | 2500 | 330.0 | 16.4 | 6.5 | 10.3 | 2.1 | 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) |
|-------------|--------------|-----------------|------|------|-------------|------------|-------------|
| BQ2204ASNTR | SOIC | D | 16 | 2500 | 367.0 | 367.0 | 38.0 |

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