

SRAM Nonvolatile Controller Unit

Features

- ▶ Power monitoring and switching for 3-volt battery-backup applications
- ▶ Write-protect control
- ▶ 3-volt primary cell inputs
- ▶ Less than 10ns chip-enable propagation delay
- ▶ 5% or 10% supply operation

General Description

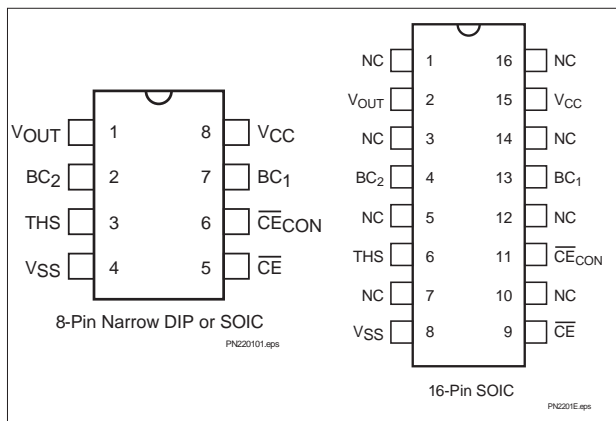
The CMOS bq2201 SRAM Nonvolatile Controller Unit provides all necessary functions for converting a standard CMOS SRAM into nonvolatile read/write memory.

A precision comparator monitors the 5V V_{CC} input for an out-of-tolerance condition. When out of tolerance is detected, a conditioned chip-enable output is forced inactive to write-protect any standard CMOS SRAM.

During a power failure, the external SRAM is switched from the V_{CC} supply to one of two 3V backup supplies. On a subsequent power-up, the SRAM is write-protected until a power-valid condition exists.

The bq2201 is footprint- and timing-compatible with industry standards with the added benefit of a chip-enable propagation delay of less than 10ns.

Pin Connections



Pin Names

| | |
|-----------------------|-----------------------------------|
| V_{OUT} | Supply output |
| BC_1 — BC_2 | 3-volt primary backup cell inputs |
| THS | Threshold select input |
| \overline{CE} | chip-enable active low input |
| \overline{CE}_{CON} | Conditioned chip-enable output |
| V_{CC} | +5-volt supply input |
| V_{SS} | Ground |
| NC | No Connect |

Functional Description

An external CMOS static RAM can be battery-backed using the V_{OUT} and the conditioned chip-enable output pin from the bq2201. As V_{CC} slews down during a power failure, the conditioned chip-enable output \overline{CE}_{CON} is forced inactive independent of the chip-enable input \overline{CE} .

This activity unconditionally write-protects external SRAM as V_{CC} falls to an out-of-tolerance threshold V_{PFD} . V_{PFD} is selected by the threshold select input pin, THS.

If THS is tied to V_{SS} , power-fail detection occurs at 4.62V typical for 5% supply operation. If THS is tied to V_{CC} , power-fail detection occurs at 4.37V typical for 10% supply operation. The THS pin must be tied to V_{SS} or V_{CC} for proper operation.

If a memory access is in process 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} , the \overline{CE}_{CON} output is unconditionally driven high, write-protecting the memory.

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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{CE}_{CON} is held high by the V_{OUT} energy source.

During power-up, V_{OUT} is switched back to the V_{CC} supply as V_{CC} rises above the backup cell input voltage sourcing V_{OUT} . The \overline{CE}_{CON} output is held inactive for time t_{CER} (120 ms maximum) after the 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 fed through to the \overline{CE}_{CON} output with a propagation delay of less than 10ns. Nonvolatility is achieved by hardware hookup, as shown in Figure 1.

Energy Cell Inputs—BC₁, BC₂

Two primary backup energy source inputs are provided on the bq2201. The BC₁ and BC₂ inputs accept a 3V primary battery, 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} .

If both inputs are used, during power failure the V_{OUT} output is fed only by BC₁ as long as it is greater than 2.5V. If the voltage at BC₁ falls below 2.5V, an internal isolation switch automatically switches V_{OUT} from BC₁ to BC₂.

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

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

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

The appropriate battery is connected to V_{OUT} and \overline{CE}_{CON} immediately on subsequent application and removal of V_{CC} .

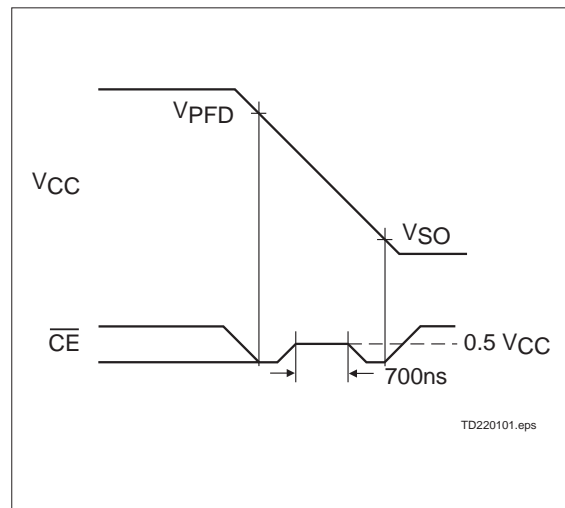


Figure 2. Battery Isolation Signal

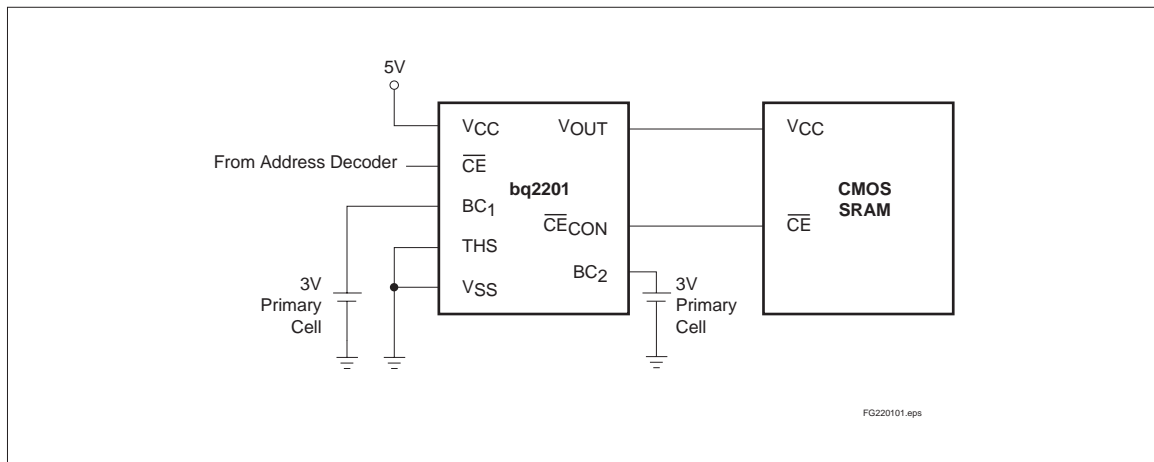


Figure 1. Hardware Hookup (5% Supply Operation)

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 | |
| 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}.

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

| Symbol | Parameter | Minimum | Typical | Maximum | Unit | Conditions/Notes |
|------------|-----------------------------|----------------|-----------|---------|---------|---|
| I_{LI} | Input leakage current | - | - | ± 1 | μA | $V_{IN} = V_{SS}$ to V_{CC} |
| V_{OH} | Output high voltage | 2.4 | - | - | V | $I_{OH} = -2.0mA$ |
| V_{OHB} | V_{OH} , BC supply | $V_{BC} - 0.3$ | - | - | V | $V_{BC} > V_{CC}$, $I_{OH} = -10\mu A$ |
| V_{OL} | Output low voltage | - | - | 0.4 | V | $I_{OL} = 4.0mA$ |
| I_{CC} | Operating supply current | - | 3 | 5 | mA | No load on V_{OUT} and \overline{CE}_{CON} . |
| V_{PFD} | Power-fail detect voltage | 4.55 | 4.62 | 4.75 | V | $THS = V_{SS}$ |
| | | 4.30 | 4.37 | 4.50 | V | $THS = V_{CC}$ |
| V_{SO} | Supply switch-over voltage | - | V_{BC} | - | V | |
| I_{CCDR} | Data-retention mode current | - | - | 100 | nA | V_{OUT} data-retention current to additional memory not included. |
| V_{OUT1} | V_{OUT} voltage | $V_{CC} - 0.2$ | - | - | V | $V_{CC} > V_{BC}$, $I_{OUT} = 100mA$ |
| | | $V_{CC} - 0.3$ | - | - | V | $V_{CC} > V_{BC}$, $I_{OUT} = 160mA$ |
| V_{OUT2} | V_{OUT} voltage | $V_{BC} - 0.3$ | - | - | V | $V_{CC} < V_{BC}$, $I_{OUT} = 100\mu A$ |
| V_{BC} | Active backup cell voltage | - | V_{BC2} | - | V | $V_{BC1} < 2.5V$ |
| | | - | V_{BC1} | - | V | $V_{BC1} > 2.5V$ |
| I_{OUT1} | V_{OUT} current | - | - | 160 | mA | $V_{OUT} > V_{CC} - 0.3V$ |
| I_{OUT2} | 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 ($T_A = 25^\circ\text{C}$, $F = 1\text{MHz}$, $V_{CC} = 5.0\text{V}$)

| Symbol | Parameter | Minimum | Typical | Maximum | Unit | Conditions |
|-----------|--------------------|---------|---------|---------|------|---------------------|
| C_{IN} | Input capacitance | - | - | 8 | pF | Input voltage = 0V |
| C_{OUT} | Output capacitance | - | - | 10 | pF | Output voltage = 0V |

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

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) |
| Output load (including scope and jig) | See Figure 3 |

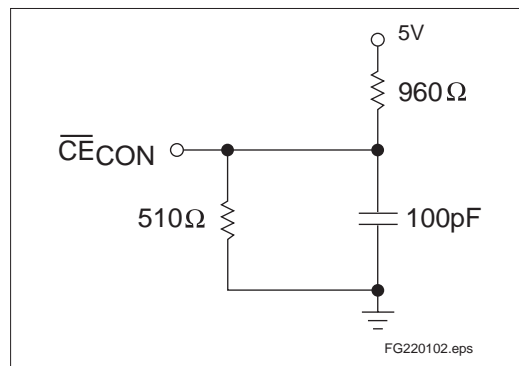


Figure 3. Output Load

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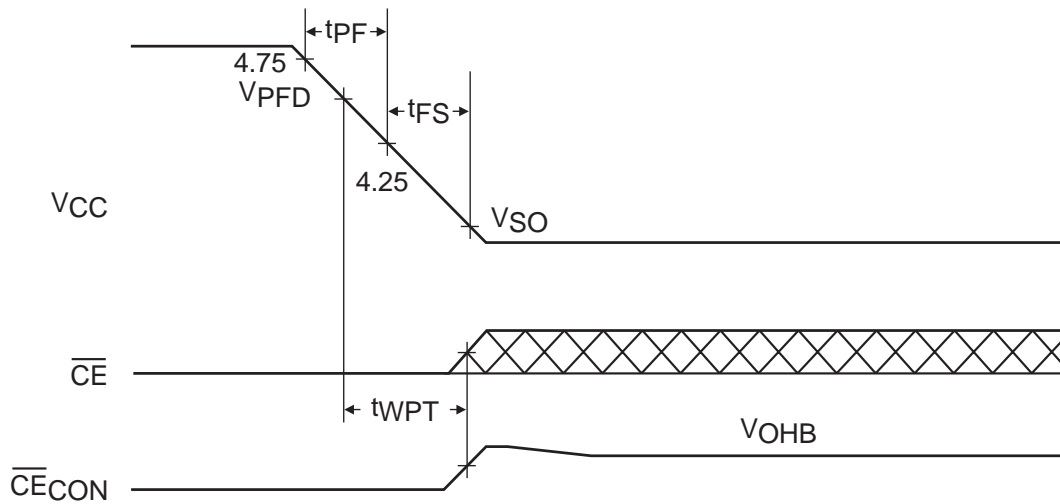
Power-Fail Control ($T_A = T_{OPR}$)

| Symbol | Parameter | Minimum | Typical | Maximum | Unit | Notes |
|-----------|----------------------------------|---------|---------|---------|---------|--|
| t_{PF} | V_{CC} slew, 4.75V to 4.25V | 300 | - | - | μs | |
| t_{FS} | V_{CC} slew, 4.25V to V_{SO} | 10 | - | - | μs | |
| t_{PU} | V_{CC} slew, 4.25V to 4.75V | 0 | - | - | μs | |
| t_{CED} | Chip-enable propagation delay | - | 7 | 10 | ns | |
| t_{CER} | Chip-enable recovery | 40 | 80 | 120 | ms | Time during which SRAM is write-protected after V_{CC} passes V_{PFD} on power-up. |
| t_{WPT} | 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 $T_A = 25^\circ C$.

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

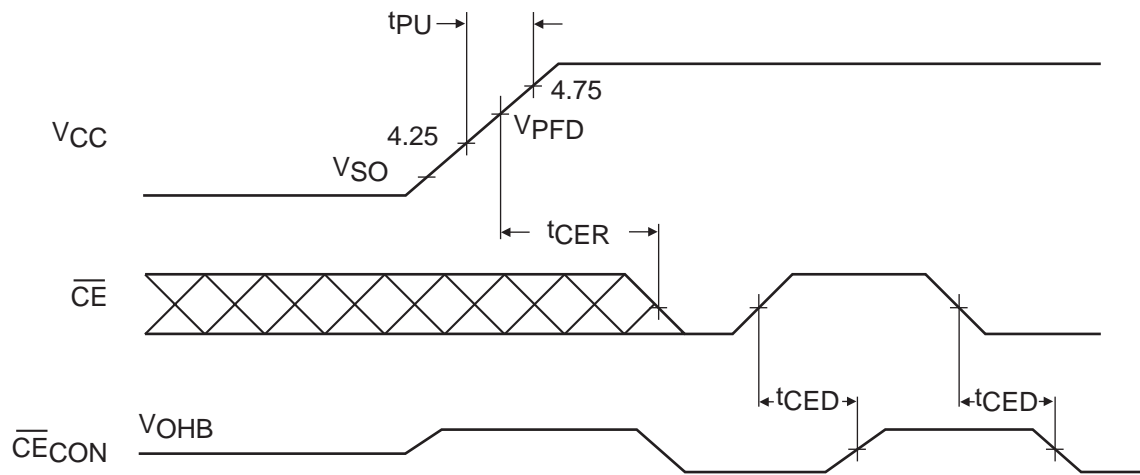
Power-Down Timing



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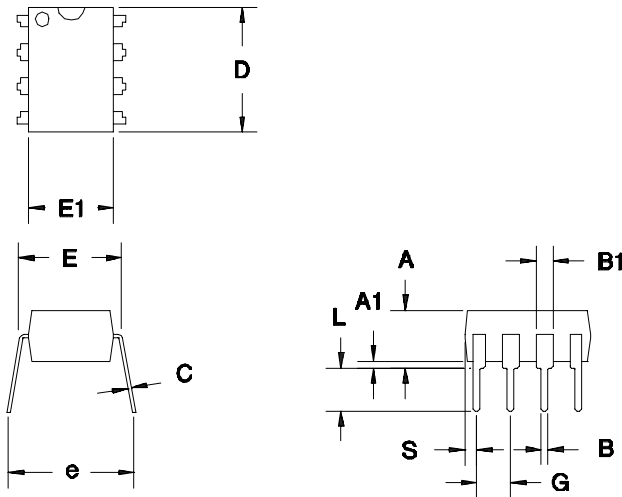
Power-Up Timing



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8-Pin DIP Narrow (PN)

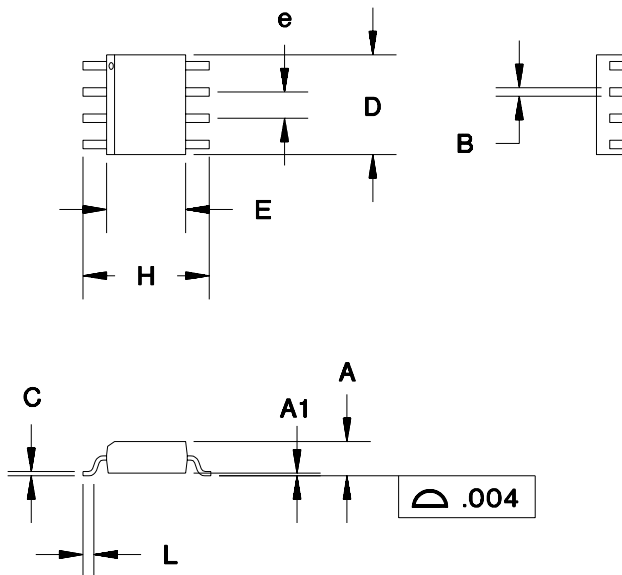


8-Pin DIP Narrow (PN)

| Dimension | Minimum | Maximum |
|-----------|---------|---------|
| A | 0.160 | 0.180 |
| A1 | 0.015 | 0.040 |
| B | 0.015 | 0.022 |
| B1 | 0.055 | 0.065 |
| C | 0.008 | 0.013 |
| D | 0.350 | 0.380 |
| E | 0.300 | 0.325 |
| E1 | 0.230 | 0.280 |
| e | 0.300 | 0.370 |
| G | 0.090 | 0.110 |
| L | 0.115 | 0.150 |
| S | 0.020 | 0.040 |

All dimensions are in inches.

8-Pin SOIC Narrow (SN)

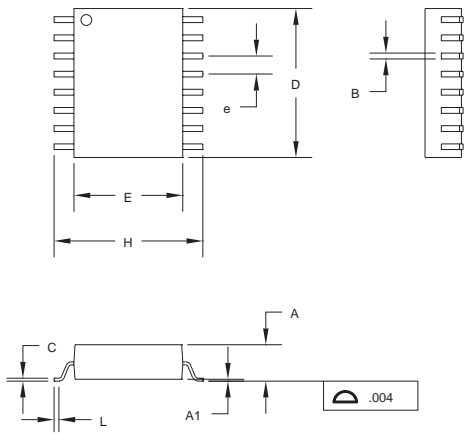


8-Pin SOIC Narrow (SN)

| Dimension | Minimum | Maximum |
|-----------|---------|---------|
| A | 0.060 | 0.070 |
| A1 | 0.004 | 0.010 |
| B | 0.013 | 0.020 |
| C | 0.007 | 0.010 |
| D | 0.185 | 0.200 |
| E | 0.150 | 0.160 |
| e | 0.045 | 0.055 |
| H | 0.225 | 0.245 |
| L | 0.015 | 0.035 |

All dimensions are in inches.

S: 16-Pin SOIC



16-Pin S (SOIC)

| Dimension | Minimum | Maximum |
|-----------|---------|---------|
| A | 0.095 | 0.105 |
| A1 | 0.004 | 0.012 |
| B | 0.013 | 0.020 |
| C | 0.008 | 0.013 |
| D | 0.400 | 0.415 |
| E | 0.290 | 0.305 |
| e | 0.045 | 0.055 |
| H | 0.395 | 0.415 |
| L | 0.020 | 0.040 |

All dimensions are in inches.

bq2201

Data Sheet Revision History

| Change No. | Page No. | Description | Nature of Change |
|------------|----------|------------------------------------|--|
| 1 | | Added industrial temperature range | |
| 2 | 1, 3, 4 | 10% supply operation | Was: THS tied to V_{OUT} Is: THS tied to V_{CC} |
| 3 | 1, 9, 11 | Added 16-pin package option | |

Note: Change 1 = Sept. 1991 B changes from Sept. 1990 A.
Change 2 = Aug. 1997 C changes from Sept. 1991 B.
Change 3 = Oct. 1998 D changes from Aug. 1997 C.

Ordering Information

| | |
|---------------|--|
| bq2201 | |
| | Temperature Range: blank = Commercial (0 to +70°C) N = Industrial (-40 to +85°C) |
| | Package Option: PN = 8-pin narrow plastic DIP SN = 8-pin narrow SOIC S = 16-pin SOIC |
| | Device: bq2201 Nonvolatile SRAM Controller |

PACKAGING INFORMATION

| Orderable Device | Status ⁽¹⁾ | Package Type | Package Drawing | Pins | Package Qty | Eco Plan ⁽²⁾ | Lead/Ball Finish | MSL Peak Temp ⁽³⁾ |
|------------------|-----------------------|--------------|-----------------|------|-------------|-------------------------|------------------|------------------------------|
| BQ2201PN | ACTIVE | PDIP | P | 8 | 50 | Pb-Free (RoHS) | CU NIPDAU | N / A for Pkg Type |
| BQ2201PNE4 | ACTIVE | PDIP | P | 8 | 50 | Pb-Free (RoHS) | CU NIPDAU | N / A for Pkg Type |
| BQ2201SN | ACTIVE | SOIC | D | 8 | 75 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| BQ2201SN-N | ACTIVE | SOIC | D | 8 | 75 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| BQ2201SN-NG4 | ACTIVE | SOIC | D | 8 | 75 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| BQ2201SN-NTR | ACTIVE | SOIC | D | 8 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| BQ2201SN-NTRG4 | ACTIVE | SOIC | D | 8 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| BQ2201SNG4 | ACTIVE | SOIC | D | 8 | 75 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| BQ2201SNTR | ACTIVE | SOIC | D | 8 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| BQ2201SNTRG4 | ACTIVE | SOIC | D | 8 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |

⁽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.

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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 |
|--------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| BQ2201SN-NTR | SOIC | D | 8 | 2500 | 330.0 | 12.4 | 6.4 | 5.2 | 2.1 | 8.0 | 12.0 | Q1 |
| BQ2201SNTR | SOIC | D | 8 | 2500 | 330.0 | 12.4 | 6.4 | 5.2 | 2.1 | 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) |
|--------------|--------------|-----------------|------|------|-------------|------------|-------------|
| BQ2201SN-NTR | SOIC | D | 8 | 2500 | 346.0 | 346.0 | 29.0 |
| BQ2201SNTR | SOIC | D | 8 | 2500 | 346.0 | 346.0 | 29.0 |

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