

Resonant Lamp Ballast Controller

FEATURES

- Controls Different Types of Lamps: Cold Cathode Fluorescent, Neon, and Gas Discharge
- Zero Voltage Switching (ZVS) of Push-Pull Drivers
- Accurate Control of Lamp Current
- Variable Lamp Intensity Control
- 1µA Disable Current
- 4.5V to 24V Operation
- Open Lamp Detection Circuitry

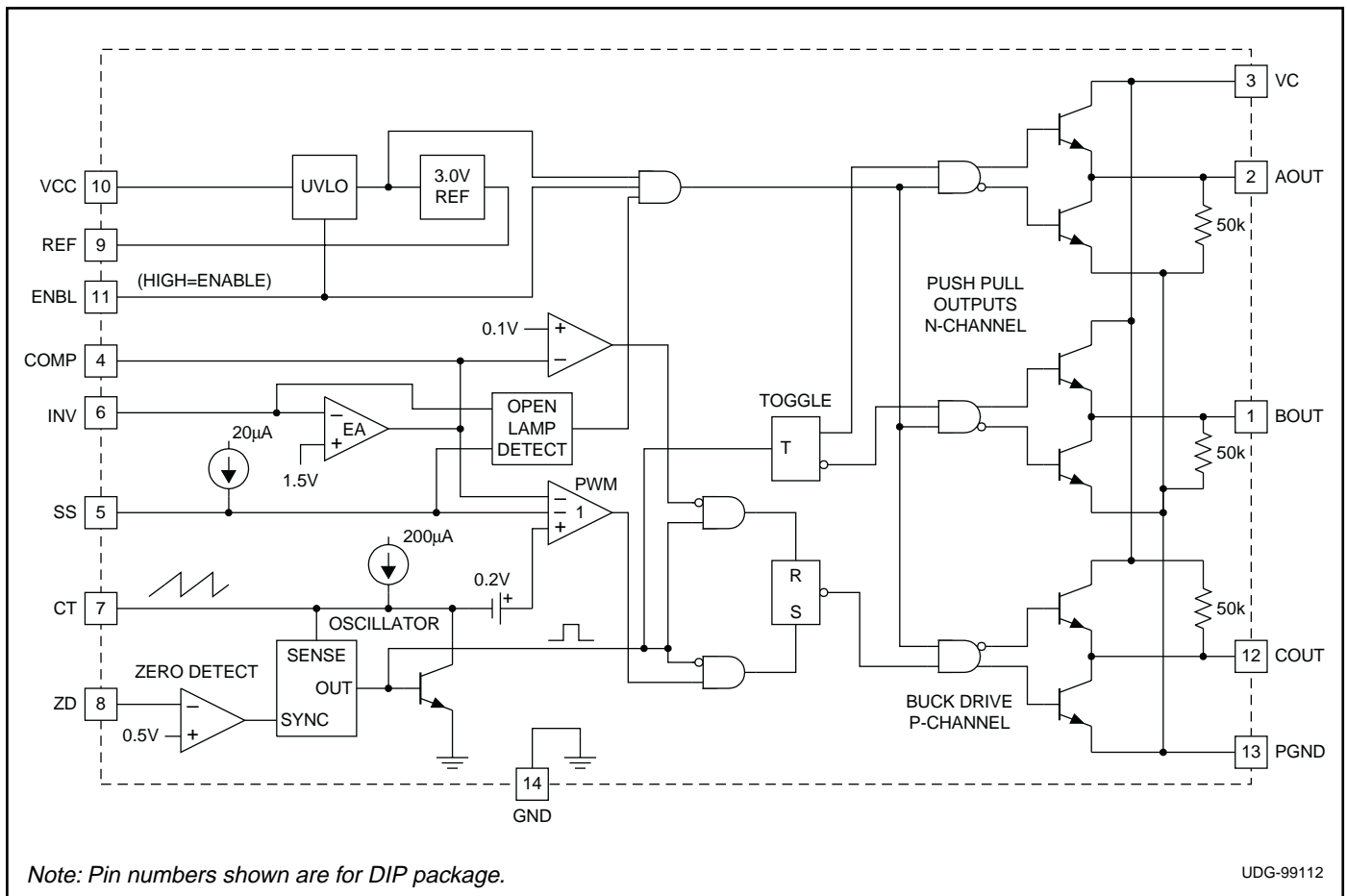
DESCRIPTION

The UC3872 is a resonant lamp ballast controller optimized for driving cold cathode fluorescent, neon, and other gas discharge lamps. The resonant power stage develops a sinusoidal lamp drive voltage, and minimizes switching loss and EMI generation. Lamp intensity adjustment is accomplished with a buck regulator, which is synchronized to the external power stage's resonant frequency. Suitable for automotive and battery powered applications, the UC3872 draws only 1µA when disabled.

Soft start and open lamp detect circuitry have been incorporated to minimize component stresses. Open lamp detection is enabled at the completion of a soft start cycle. The chip is optimized for smooth duty cycle control to 100%.

Other features include a precision 1.2% reference, undervoltage lockout, and accurate minimum and maximum frequency control.

BLOCK DIAGRAM



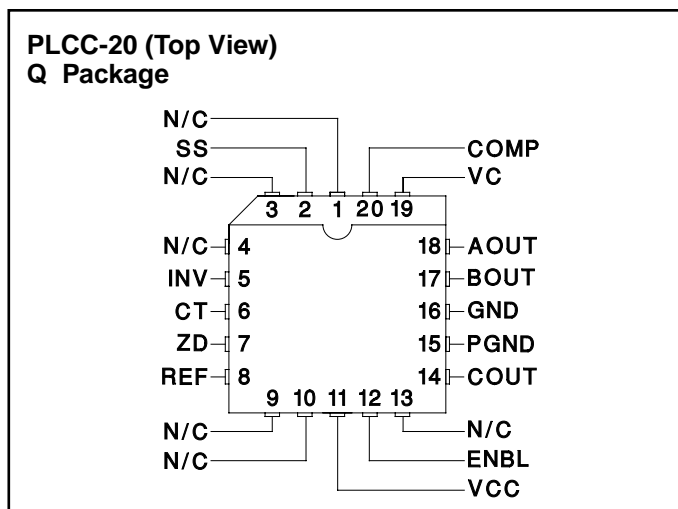
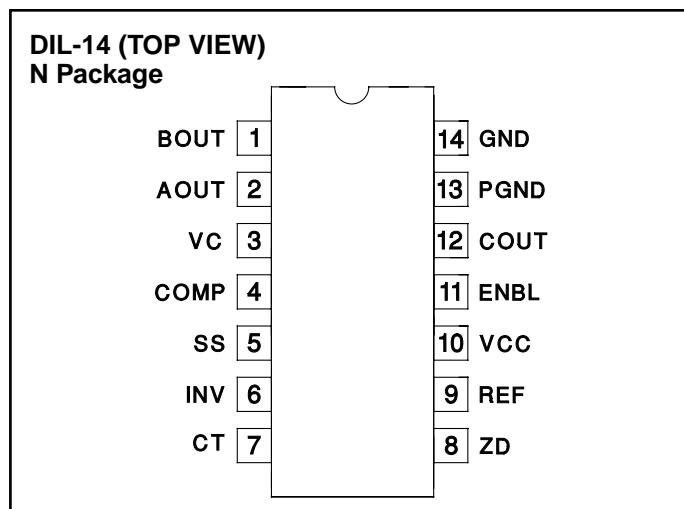
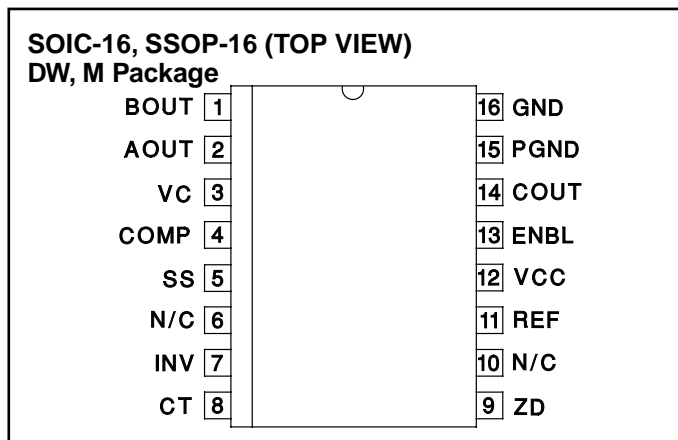
ABSOLUTE MAXIMUM RATINGS

| | |
|--------------------------------|-----------------|
| Analog Inputs | -0.3 to +10V |
| VCC, VC Voltage | +24V |
| ZD Input Current | |
| High Impedance Source | +10mA |
| ZD Input Voltage | |
| Low Impedance Source | +24V |
| Power Dissipation at TA = 25°C | 1W |
| Storage Temperature | -65°C to +150°C |
| Lead Temperature | 300°C |

Note 1: Currents are positive into, negative out of the specified terminal.

Note 2: Consult Packaging Section of Databook for thermal limitations and considerations of package.

CONNECTION DIAGRAMS



ELECTRICAL CHARACTERISTICS: Unless otherwise stated, these parameters apply for $T_J = -55^\circ\text{C}$ to $+125^\circ\text{C}$ for the UC1872, -40°C to $+85^\circ\text{C}$ for the UC2872, 0°C to $+70^\circ\text{C}$ for the UC3872; $V_{CC} = 5\text{V}$, $V_C = 15\text{V}$, $V_{ENBL} = 5\text{V}$, $C_T = 1\text{nF}$, $Z_D = 1\text{V}$.

| PARAMETER | TEST CONDITIONS | MIN | TYP | MAX | UNITS |
|-----------------------------------|-----------------------------------------|-------|-------|-------|---------------|
| Reference Section | | | | | |
| Output Voltage | $T_J = 25^\circ\text{C}$ | 2.963 | 3.000 | 3.037 | V |
| | Over Temperature | 2.940 | 3.000 | 3.060 | V |
| Line Regulation | $V_{CC} = 4.75\text{V}$ to 18V | | | 10 | mV |
| Load Regulation | $I_O = 0$ to -5mA | | | 10 | mV |
| Oscillator Section | | | | | |
| Free Running Frequency | $T_J = 25^\circ\text{C}$ | 57 | 68 | 78 | kHz |
| Maximum Synchronization Frequency | $T_J = 25^\circ\text{C}$ | 160 | 200 | 240 | kHz |
| Charge Current | $V_{CT} = 1.5\text{V}$ | 180 | 200 | 220 | μA |
| Voltage Stability | | | | 2 | % |
| Temperature Stability | | | 4 | 8 | % |
| Zero Detect Threshold | | 0.46 | 0.5 | 0.56 | V |
| Error Amp Section | | | | | |
| Input Voltage | $V_O = 2\text{V}$ | 1.445 | 1.475 | 1.505 | V |
| Input Bias Current | | | -0.4 | -2 | μA |
| Open Loop Gain | $V_O = 0.5$ to 3V | 65 | 90 | | dB |
| Output High | $V_{INV} = 1.3\text{V}$ | 3.1 | 3.5 | 3.9 | V |

ELECTRICAL CHARACTERISTICS: Unless otherwise stated, these parameters apply for $T_J = -55^\circ\text{C}$ to $+125^\circ\text{C}$ for the UC1872, -40°C to $+85^\circ\text{C}$ for the UC2872, -0°C to $+70^\circ\text{C}$ for the UC3872; $V_{CC} = 5\text{V}$, $V_C = 15\text{V}$, $V_{ENBL} = 5\text{V}$, $C_T = 1\text{nF}$, $Z_D = 1\text{V}$.

| PARAMETER | TEST CONDITIONS | MIN | TYP | MAX | UNITS |
|--------------------------------------|--------------------------------------------------------|------|------|--------------------|---------------|
| Error Amp Section (cont.) | | | | | |
| Output Low | $V_{INV} = 1.7\text{V}$ | | 0.1 | 0.2 | V |
| Output Source Current | $V_{INV} = 1.3\text{V}$, $V_O = 2\text{V}$ | -350 | -500 | | μA |
| Output Sink Current | $V_{INV} = 1.7\text{V}$, $V_O = 2\text{V}$ | 10 | 20 | | mA |
| Common Mode Range | | 0 | | $V_{IN}-1\text{V}$ | V |
| Unity Gain Bandwidth | $T_J = 25^\circ\text{C}$ (Note 4) | | 1 | | MHz |
| Open Lamp Detect Section | | | | | |
| Soft Start Threshold | $V_{INV} = 0\text{V}$ | 2.9 | 3.4 | 3.8 | V |
| Open Lamp Detect Threshold | $V_{SS} = 4.2\text{V}$ | 0.6 | 1.0 | 1.4 | V |
| Soft Start Current | $V_{SS} = 2\text{V}$ | 10 | 20 | 40 | μA |
| Output Section | | | | | |
| Output Low Level | $I_{OUT} = 0$, Outputs A and B | | 0.05 | 0.2 | V |
| | $I_{OUT} = 10\text{mA}$ | | 0.1 | 0.4 | V |
| | $I_{OUT} = 100\text{mA}$ | | 1.5 | 2.2 | V |
| Output High Level | $I_{OUT} = 0$, Output C | 13.9 | 14.9 | | V |
| | $I_{OUT} = -10\text{mA}$ | 13.5 | 14.3 | | V |
| | $I_{OUT} = -100\text{mA}$ | 12.5 | 13.5 | | V |
| Rise Time | $T_J = 25^\circ\text{C}$, $C_I = 1\text{nF}$ (Note 4) | | 30 | 80 | ns |
| Fall Time | $T_J = 25^\circ\text{C}$, $C_I = 1\text{nF}$ (Note 4) | | 30 | 80 | ns |
| Output Dynamics | | | | | |
| Out A and B Duty Cycle | | 48 | 49.9 | 50 | % |
| Out C Max Duty Cycle | $V_{INV} = 1\text{V}$ | 100 | | | % |
| Out C Min Duty Cycle | $V_{INV} = 2\text{V}$ | | | 0 | % |
| Under Voltage Lockout Section | | | | | |
| Startup Threshold Voltage | | 3.7 | 4.2 | 4.5 | V |
| Hysteresis | | 120 | 200 | 280 | mV |
| Enable Section | | | | | |
| Input High Threshold | | 2 | | | V |
| Input Low Threshold | | | | 0.8 | V |
| Input Current | $V_{ENBL} = 5\text{V}$ | | 150 | 400 | μA |
| Supply Current Section | | | | | |
| VCC Supply Current | $V_{CC} = 24\text{V}$ | | 6 | 14 | mA |
| VC Supply Current | $V_C = 24\text{V}$ | | 5 | 12 | mA |
| ICC Disabled | $V_{CC} = 24\text{V}$, $V_{ENBL} = 0\text{V}$ | | 1 | 10 | μA |

Note 3: Unless otherwise specified, all voltages are with respect to ground. Currents are positive into, and negative out of the specified terminal.

Note 4: Guaranteed by design. Not 100% tested in production.

PIN DESCRIPTIONS

AOUT, BOUT: These outputs provide complementary drive signals for the push-pull N-channel MOSFETs. Each one is high for 50% of the time, switching states each time a zero-detect is sensed.

COMP: COMP is the output terminal of the error amplifier. Compensation components are normally connected between COMP and INV. Connecting a capacitor from this pin to ground limits turn on current and blanks the open lamp detect signal allowing the lamp to start.

COUT: This output directly drives the bulk regulator P-channel MOSFET. COUT turn-on is synchronized to each zero-detect, and therefore switches at twice the frequency of AOUT and BOUT. The modulator controlling COUT is designed to provide smooth control up to 100% duty cycle.

CT: A capacitor connected between this pin and GND ground sets the synchronization frequency range. The capacitor is charged with approximately 200 μ A, creating a linear ramp which is used by COUT's (buck regulator driver) PWM comparator.

ENBL: When ENBL is driven high the device is enabled. When ENBL is pulled low, the IC is shut down and typically draws 1 μ A.

GND: This pin is the ground reference point for the internal reference and all thresholds.

INV: This pin is the inverting input to the error amplifier and the input for the open lamp detect circuitry. If the voltage at INV is below the 1V open lamp detect threshold, the outputs are disabled.

PGND: This pin is the high current ground connection for the three output drivers.

REF: This pin is connected to the 3V reference voltage which is used for the internal logic. Bypass REF to ground with a 0.01 μ F ceramic capacitor for proper operation.

VC: VC is the power supply voltage connection for the output drivers. Bypass it to ground with a 0.1 μ F ceramic capacitor for proper operation.

VCC: VCC is the positive supply voltage for the chip. Its operating range is from 4.2V to 24V. Bypass VCC to ground with a 0.1 μ F ceramic capacitor for proper operation.

ZD: The zero-detect input senses when the transformer's primary center tap voltage falls to zero to synchronize the sawtooth voltage waveform on CT. The threshold is approximately 0.5V, providing a small amount of offset such that with propagation delay, zero-volt switching occurs. A resistor (typically 10k) should be connected between ZD and the primary center tap to limit input current at turn off.

APPLICATION INFORMATION

Figure 1 shows a complete application circuit using the UC3872 Resonant Lamp Ballast Controller. The IC provides all drive, control and housekeeping functions. The buck output voltage (transformer center-tap) provides the zero crossing and synchronization signals.

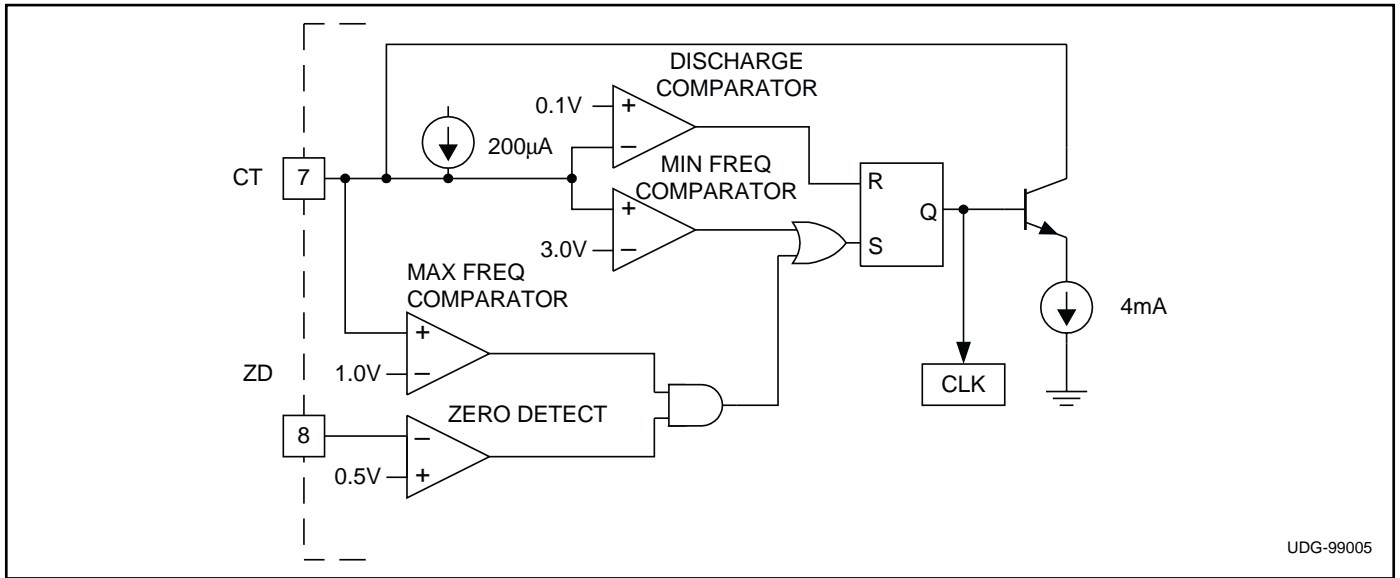
The buck modulator drives a P-channel MOSFET directly, and operates over a 0-100% duty-cycle range. The modulation range includes 100%, allowing operation with minimal headroom.

The oscillator and synchronization circuitry are shown in Figure 2. The oscillator is designed to synchronize over a 3:1 frequency range. In an actual application however, the frequency range is only about 1.5:1. A zero detect comparator senses the primary center-tap voltage, generating a synchronization pulse when the resonant wave-

form falls to zero. The actual threshold is 0.5 volts, providing a small amount of anticipation to offset propagation delay.

The synchronization pulse width is the time required for the 4mA current sink to discharge the timing capacitor to 0.1 volts. This pulse width limits the minimum linear control range of the buck regulator. The 200 μ A current source charges the capacitor to a maximum of 3 volts. A comparator blanks the zero detect signal until the capacitor voltage exceeds 1 volt, preventing multiple synchronization pulse generation and setting the maximum frequency. If the capacitor voltage reaches 3 volts (a zero detection has not occurred) an internal clock pulse is generated to limit the minimum frequency.

APPLICATIONS INFORMATION



UDG-99005

Figure 2. UC3872 oscillator section.

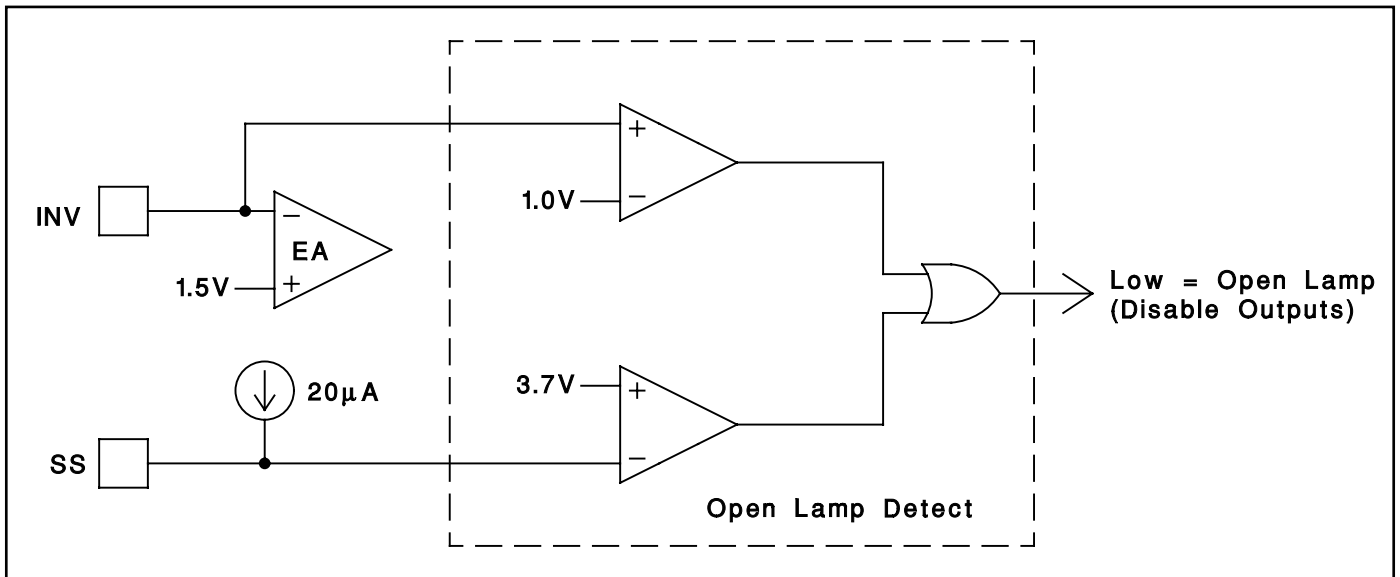


Figure 3. UC3872 open lamp detect circuitry.

PACKAGING INFORMATION

| Orderable Device | Status ⁽¹⁾ | Package Type | Package Drawing | Pins | Package Qty | Eco Plan ⁽²⁾ | Lead/Ball Finish | MSL Peak Temp ⁽³⁾ |
|------------------|-----------------------|---------------|-----------------|------|-------------|-------------------------|------------------|------------------------------|
| UC2872DW | ACTIVE | SOIC | DW | 16 | 40 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR |
| UC2872DWG4 | ACTIVE | SOIC | DW | 16 | 40 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR |
| UC2872DWTR | ACTIVE | SOIC | DW | 16 | 2000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR |
| UC2872DWTRG4 | ACTIVE | SOIC | DW | 16 | 2000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR |
| UC2872N | ACTIVE | PDIP | N | 14 | 25 | Green (RoHS & no Sb/Br) | CU NIPDAU | N / A for Pkg Type |
| UC2872NG4 | ACTIVE | PDIP | N | 14 | 25 | Green (RoHS & no Sb/Br) | CU NIPDAU | N / A for Pkg Type |
| UC2872Q | ACTIVE | PLCC | FN | 20 | 46 | Green (RoHS & no Sb/Br) | CU SN | Level-2-260C-1 YEAR |
| UC2872QG3 | ACTIVE | PLCC | FN | 20 | 46 | Green (RoHS & no Sb/Br) | CU SN | Level-2-260C-1 YEAR |
| UC3872DW | ACTIVE | SOIC | DW | 16 | 40 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR |
| UC3872DWG4 | ACTIVE | SOIC | DW | 16 | 40 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR |
| UC3872DWTR | ACTIVE | SOIC | DW | 16 | 2000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR |
| UC3872DWTRG4 | ACTIVE | SOIC | DW | 16 | 2000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR |
| UC3872M | ACTIVE | SSOP/ QSOP | DBQ | 16 | 75 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR |
| UC3872MG4 | ACTIVE | SSOP/ QSOP | DBQ | 16 | 75 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR |
| UC3872MTR | ACTIVE | SSOP/ QSOP | DBQ | 16 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR |
| UC3872MTRG4 | ACTIVE | SSOP/ QSOP | DBQ | 16 | 2500 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-2-260C-1 YEAR |
| UC3872N | ACTIVE | PDIP | N | 14 | 25 | Green (RoHS & no Sb/Br) | CU NIPDAU | N / A for Pkg Type |
| UC3872NG4 | ACTIVE | PDIP | N | 14 | 25 | Green (RoHS & no Sb/Br) | CU NIPDAU | N / A for Pkg Type |

⁽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.

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

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

TAPE AND REEL INFORMATION



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 |
|------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| UC2872DWTR | SOIC | DW | 16 | 2000 | 330.0 | 16.4 | 10.85 | 10.8 | 2.7 | 12.0 | 16.0 | Q1 |
| UC3872DWTR | SOIC | DW | 16 | 2000 | 330.0 | 16.4 | 10.85 | 10.8 | 2.7 | 12.0 | 16.0 | Q1 |
| UC3872MTR | SSOP/QSOP | DBQ | 16 | 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) |
|------------|--------------|-----------------|------|------|-------------|------------|-------------|
| UC2872DWTR | SOIC | DW | 16 | 2000 | 346.0 | 346.0 | 33.0 |
| UC3872DWTR | SOIC | DW | 16 | 2000 | 346.0 | 346.0 | 33.0 |
| UC3872MTR | SSOP/QSOP | DBQ | 16 | 2500 | 346.0 | 346.0 | 29.0 |

IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, modifications, enhancements, improvements, and other changes to its products and services at any time and to discontinue any product or service without notice. Customers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All products are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its hardware products to the specifications applicable at the time of sale in accordance with TI's standard warranty. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by government requirements, testing of all parameters of each product is not necessarily performed.

TI assumes no liability for applications assistance or customer product design. Customers are responsible for their products and applications using TI components. To minimize the risks associated with customer products and applications, customers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any TI patent right, copyright, mask work right, or other TI intellectual property right relating to any combination, machine, or process in which TI products or services are used. Information published by TI regarding third-party products or services does not constitute a license from TI to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of TI information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. Reproduction of this information with alteration is an unfair and deceptive business practice. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

Resale of TI products or services with statements different from or beyond the parameters stated by TI for that product or service voids all express and any implied warranties for the associated TI product or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

TI products are not authorized for use in safety-critical applications (such as life support) where a failure of the TI product would reasonably be expected to cause severe personal injury or death, unless officers of the parties have executed an agreement specifically governing such use. Buyers represent that they have all necessary expertise in the safety and regulatory ramifications of their applications, and acknowledge and agree that they are solely responsible for all legal, regulatory and safety-related requirements concerning their products and any use of TI products in such safety-critical applications, notwithstanding any applications-related information or support that may be provided by TI. Further, Buyers must fully indemnify TI and its representatives against any damages arising out of the use of TI products in such safety-critical applications.

TI products are neither designed nor intended for use in military/aerospace applications or environments unless the TI products are specifically designated by TI as military-grade or "enhanced plastic." Only products designated by TI as military-grade meet military specifications. Buyers acknowledge and agree that any such use of TI products which TI has not designated as military-grade is solely at the Buyer's risk, and that they are solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI products are neither designed nor intended for use in automotive applications or environments unless the specific TI products are designated by TI as compliant with ISO/TS 16949 requirements. Buyers acknowledge and agree that, if they use any non-designated products in automotive applications, TI will not be responsible for any failure to meet such requirements.

Following are URLs where you can obtain information on other Texas Instruments products and application solutions:

Products

| | |
|-----------------------------|--------------------------------------------------------------------|
| Amplifiers | amplifier.ti.com |
| Data Converters | dataconverter.ti.com |
| DSP | dsp.ti.com |
| Clocks and Timers | www.ti.com/clocks |
| Interface | interface.ti.com |
| Logic | logic.ti.com |
| Power Mgmt | power.ti.com |
| Microcontrollers | microcontroller.ti.com |
| RFID | www.ti-rfid.com |
| RF/IF and ZigBee® Solutions | www.ti.com/lprf |

Applications

| | |
|--------------------|--------------------------------------------------------------------------|
| Audio | www.ti.com/audio |
| Automotive | www.ti.com/automotive |
| Broadband | www.ti.com/broadband |
| Digital Control | www.ti.com/digitalcontrol |
| Medical | www.ti.com/medical |
| Military | www.ti.com/military |
| Optical Networking | www.ti.com/opticalnetwork |
| Security | www.ti.com/security |
| Telephony | www.ti.com/telephony |
| Video & Imaging | www.ti.com/video |
| Wireless | www.ti.com/wireless |

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2008, Texas Instruments Incorporated