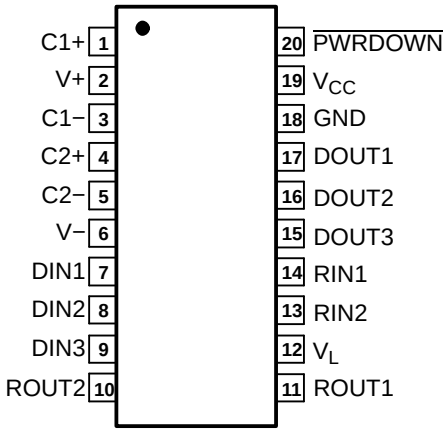
# MAX3386E
# RS-232 TRANSCEIVER WITH SPLIT SUPPLY PIN FOR LOGIC SIDE

SLLS659 – MAY 2006

## FEATURES

- **$V_L$ Pin for Compatibility With Mixed-Voltage Systems Down to 1.8 V on Logic Side**
- **Enhanced ESD Protection on RIN Inputs and DOUT Outputs**
  - **– ±15-kV Human-Body Model**
  - **– ±15-kV IEC 61000-4-2, Air-Gap Discharge**
  - **– ±8-kV IEC 61000-4-2, Contact Discharge**
- **Low 300-μA Supply Current**
- **Specified 250-kbps Data Rate**
- **1-μA Low-Power Shutdown**
- **Meets EIA/TIA-232 Specifications Down to 3 V**

**TSSOP OR SSOP PACKAGE**
**TOP VIEW**




## APPLICATIONS

- **Hand-Held Equipment**
- **PDAs**
- **Cell Phones**
- **Battery-Powered Equipment**
- **Data Cables**

## DESCRIPTION/ORDERING INFORMATION

The MAX3386E is a three-driver and two-receiver RS-232 interface device, with split supply pins for mixed-signal operations. All RS-232 inputs and outputs are protected to ±15 kV using the IEC 61000-4-2 Air-Gap Discharge method, ±8 kV using the IEC 61000-4-2 Contact Discharge method, and ±15 kV using the Human-Body Model.

The charge pump requires only four small 0.1-μF capacitors for operation from a 3.3-V supply. The MAX3386E is capable of running at data rates up to 250 kbps, while maintaining RS-232-compliant output levels.

The MAX3386E has a unique $V_L$ pin that allows operation in mixed-logic voltage systems. Both driver in (DIN) and receiver out (ROUT) logic levels are pin programmable through the $V_L$ pin. The MAX3386E is available in a space-saving thin shrink small-outline package (TSSOP).

**ORDERING INFORMATION**

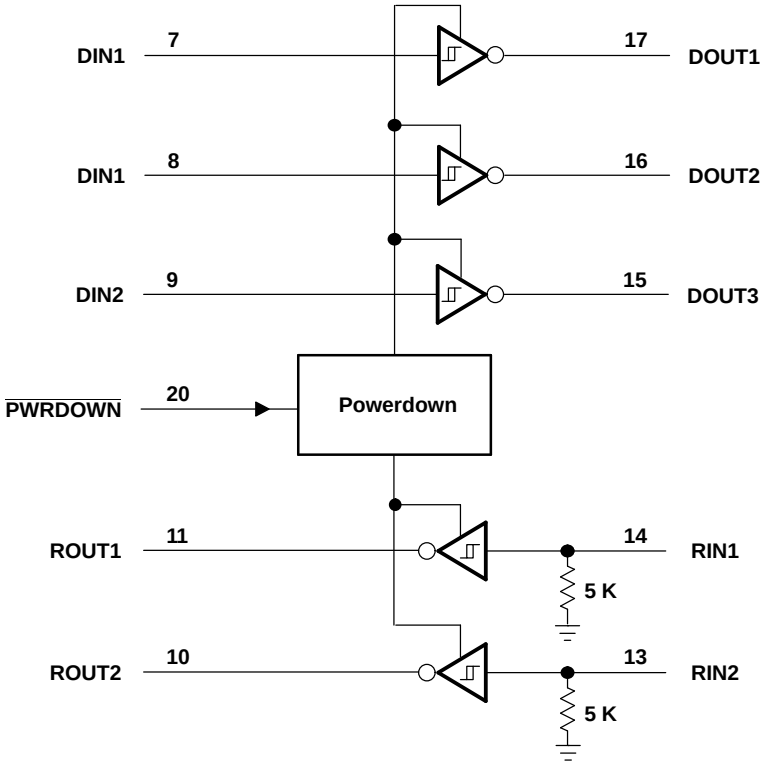
| $T_A$ | PACKAGE(1) | ORDERABLE PART NUMBER | TOP-SIDE MARKING |
|---|---|---|---|
| 0°C to 70°C | TSSOP | MAX3386ECPWR | MP386EC |
| | SSOP | MAX3386ECDBR | MAX3386EC |
| –40°C to 85°C | TSSOP | MAX3386EIPWR | MP386EI |
| | SSOP | MAX3386EIDBR | MAX3386EI |

(1) Package drawings, standard packing quantities, thermal data, symbolization, and PCB design guidelines are available at www.ti.com/sc/package.

**TRUTH TABLE (SHUTDOWN FUNCTION)**

| $\overline{\text{PWRDWN}}$ | DRIVER OUTPUTS | RECEIVER OUTPUTS | CHARGE PUMP |
|---|---|---|---|
| L | High-Z | High-Z | Inactive |
| H | Active | Active | Active |

## FUNCTIONAL BLOCK DIAGRAM




## TERMINAL FUNCTIONS

| TERMINAL | | DESCRIPTION |
|---|---|---|
| NAME | NO. | |
| C1+ | 1 | Positive terminal of the voltage-doubler charge-pump capacitor |
| V+ | 2 | 5.5-V supply generated by the charge pump |
| C1– | 3 | Negative terminal of the voltage-doubler charge-pump capacitor |
| C2+ | 4 | Positive terminal of the inverting charge-pump capacitor |
| C2– | 5 | Negative terminal of the inverting charge-pump capacitor |
| V– | 6 | –5.5-V supply generated by the charge pump |
| DIN1<br>DIN2<br>DIN3 | 7<br>8<br>9 | Driver inputs |
| ROUT2<br>ROUT1 | 10<br>11 | Receiver outputs. Swing between 0 and $V_L$. |
| $V_L$ | 12 | Logic-level supply. All CMOS inputs and outputs are referenced to this supply. |
| RIN2<br>RIN1 | 13<br>14 | RS-232 receiver inputs |
| DOUT3<br>DOUT2<br>DOUT1 | 15<br>16<br>17 | RS-232 driver outputs |
| GND | 18 | Ground |
| $V_{CC}$ | 19 | 3-V to 5.5-V supply voltage |
| $\overline{\text{PWRDWN}}$ | 20 | Powerdown input<br>L = Powerdown<br>H = Normal operation |

## Absolute Maximum Ratings(1)

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

| | | | MIN | MAX | UNIT |
|---|---|---|---|---|---|
| | $V_{CC}$ to GND | | –0.3 | 6 | V |
| | $V_L$ to GND | | –0.3 | $V_{CC}$ + 0.3 | V |
| | V+ to GND | | –0.3 | 7 | V |
| | V– to GND | | 0.3 | – 7 | V |
| | V+ + \|V–\|(2) | | | 13 | V |
| $V_I$ | Input voltage | DIN, $\overline{PWRDWN}$ to GND | –0.3 | 6 | V |
| | | RIN to GND | | ±25 | |
| $V_O$ | Output voltage | DOUT to GND | | ±13.2 | V |
| | | ROUT | –0.3 | $V_L$ + 0.3 | |
| | Short-circuit duration DOUT to GND | | | Continuous | |
| | Continuous power dissipation | $T_A$ = 70°C, 20-pin TSSOP (derate 7 mW/°C above 70°C) | | 559 | mW |
| $T_J$ | Junction temperature | | | 150 | °C |
| $T_{stg}$ | Storage temperature range | | –65 | 150 | °C |
| | Lead temperature (soldering, 10 s) | | | 300 | °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 in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.
(2) V+ and V– can have maximum magnitudes of 7 V, but their absolute difference cannot exceed 13 V.

## Recommended Operating Conditions

| | | | | MIN | MAX | UNIT |
|---|---|---|---|---|---|---|
| $V_{CC}$ | Supply voltage | | | 3 | 5.5 | V |
| $V_L$ | Supply voltage | | | 1.65 | $V_{CC}$ | V |
| | Input logic threshold low | DIN, $\overline{PWRDWN}$ | $V_L$ = 3 V or 5.5 V | | 0.8 | V |
| | | | $V_L$ = 2.3 V | | 0.6 | |
| | | | $V_L$ = 1.65 V | | 0.5 | |
| | Input logic threshold high | DIN, $\overline{PWRDWN}$ | $V_L$ = 5.5 V | 2.4 | | V |
| | | | $V_L$ = 3 V | 2.0 | | |
| | | | $V_L$ = 2.7 V | 1.4 | | |
| | | | $V_L$ = 1.95 V | 0.9 | | |
| | Operating temperature | | MAX3386ECPWR | 0 | 70 | °C |
| | | | MAX3386EIPWR | –40 | 85 | |
| | Receiver input voltage | | | –25 | 25 | V |

## Electrical Characteristics

over operating free-air temperature range, $V_{CC}$ = $V_L$ = 3 V to 5.5 V, C1–C4 = 0.1 µF (tested at 3.3 V ± 10%), C1 = 0.047 µF, C2–C4 = 0.33 µF (tested at 5 V ± 10%) (unless otherwise noted)

| PARAMETER | TEST CONDITIONS | MIN | TYP(1) | MAX | UNIT |
|---|---|---|---|---|---|
| **DC Characteristics ($V_{CC}$ = 3.3 V or 5 V, $T_A$ = 25°C)** | | | | | |
| Powerdown supply current | $\overline{PWRDWN}$ = GND, All inputs at $V_{CC}$ or GND | | 1 | 10 | µA |
| Supply current | $\overline{PWRDWN}$ = $V_{CC}$, No load | | 0.3 | 1 | mA |

(1) Typical values are at $V_{CC}$ = $V_L$ = 3.3 V, $T_A$ = 25°C.

## ESD Protection

| PARAMETER | TEST CONDITIONS | TYP | UNIT |
|---|---|---|---|
| RIN, DOUT | Human-Body Model | ±15 | kV |
| | IEC 61000-4-2 Air-Gap Discharge | ±15 | |
| | IEC 61000-4-2 Contact Discharge | ±8 | |

## RECEIVER SECTION

### Electrical Characteristics

over operating free-air temperature range, $V_{CC}$ = $V_L$ = 3 V to 5.5 V, C1–C4 = 0.1 µF (tested at 3.3 V ± 10%), C1 = 0.047 µF, C2–C4 = 0.33 µF (tested at 5 V ± 10%), $T_A$ = $T_{MIN}$ to $T_{MAX}$ (unless otherwise noted)

| PARAMETER | | TEST CONDITIONS | | MIN | TYP(1) | MAX | UNIT |
|---|---|---|---|---|---|---|---|
| $I_{off}$ | Output leakage current | ROUT, receivers disabled | | | ±0.05 | ±10 | µA |
| $V_{OL}$ | Output voltage low | $I_{OUT}$ = 1.6 mA | | | | 0.4 | V |
| $V_{OH}$ | Output voltage high | $I_{OUT}$ = –1 mA | | $V_L$ – 0.6 | $V_L$ – 0.1 | | V |
| $V_{IT–}$ | Input threshold low | $T_A$ = 25°C | $V_L$ = 5 V | 0.8 | 1.2 | | V |
| | | | $V_L$ = 3.3 V | 0.6 | 1.5 | | |
| $V_{IT+}$ | Input threshold high | $T_A$ = 25°C | $V_L$ = 5 V | | 1.8 | 2.4 | V |
| | | | $V_L$ = 3.3 V | | 1.5 | 2.4 | |
| $V_{hys}$ | Input hysteresis | | | | 0.5 | | V |
| | Input resistance | $T_A$ = 25°C | | 3 | 5 | 7 | kΩ |

(1) Typical values are at $V_{CC}$ = $V_L$ = 3.3 V, $T_A$ = 25°C

### Switching Characteristics

over operating free-air temperature range, $V_{CC}$ = $V_L$ = 3 V to 5.5 V, C1–C4 = 0.1 µF (tested at 3.3 V ± 10%), C1 = 0.047 µF, C2–C4 = 0.33 µF (tested at 5 V ± 10%), $T_A$ = $T_{MIN}$ to $T_{MAX}$ (unless otherwise noted)

| PARAMETER | | TEST CONDITIONS | TYP(1) | UNIT |
|---|---|---|---|---|
| $t_{PHL}$ | Receiver propagation delay | Receiver input to receiver output, $C_L$ = 150 pF | 0.15 | µs |
| $t_{PLH}$ | | | 0.15 | |
| $t_{PHL}$ – $t_{PLH}$ | Receiver skew | | 50 | ns |
| $t_{en}$ | Receiver output enable time | From $\overline{PWRDWN}$ | 200 | ns |
| $t_{dis}$ | Receiver output disable time | From $\overline{PWRDWN}$ | 200 | ns |

(1) Typical values are at $V_{CC}$ = $V_L$ = 3.3 V, $T_A$ = 25°C.

## DRIVER SECTION

### Electrical Characteristics

over operating free-air temperature range, $V_{CC}$ = $V_L$ = 3 V to 5.5 V, C1–C4 = 0.1 µF (tested at 3.3 V ± 10%), C1 = 0.047 µF, C2–C4 = 0.33 µF (tested at 5 V ± 10%), $T_A$ = $T_{MIN}$ to $T_{MAX}$ (unless otherwise noted)

| PARAMETER | | TEST CONDITIONS | MIN | TYP(1) | MAX | UNIT |
|---|---|---|---|---|---|---|
| $V_{OH}$ | Output voltage swing | All driver outputs loaded with 3 kΩ to ground | ±5 | ±5.4 | | V |
| $r_o$ | Output resistance | $V_{CC}$ = V+ = V– = 0, Driver output = ±2 V | 300 | 10M | | Ω |
| $I_{OS}$ | Output short-circuit current | $V_{T\_OUT}$ = 0 | | | ±60 | mA |
| $I_{OZ}$ | Output leakage current | $V_{T\_OUT}$ = ±12 V, Driver disabled, $V_{CC}$ = 0 or 3 V to 5.5 V | | | ±25 | µA |
| | Driver input hysteresis | | | | 0.5 | V |
| | Input leakage current | DIN, $\overline{PWRDWN}$ | | ±0.01 | ±1 | µA |

(1) Typical values are at $V_{CC}$ = $V_L$ = 3.3 V, $T_A$ = 25°C

### Timing Requirements

over operating free-air temperature range, $V_{CC}$ = $V_L$ = 3 V to 5.5 V, C1–C4 = 0.1 µF (tested at 3.3 V ± 10%), C1 = 0.047 µF, C2–C4 = 0.33 µF (tested at 5 V ± 10%), $T_A$ = $T_{MIN}$ to $T_{MAX}$ (unless otherwise noted)

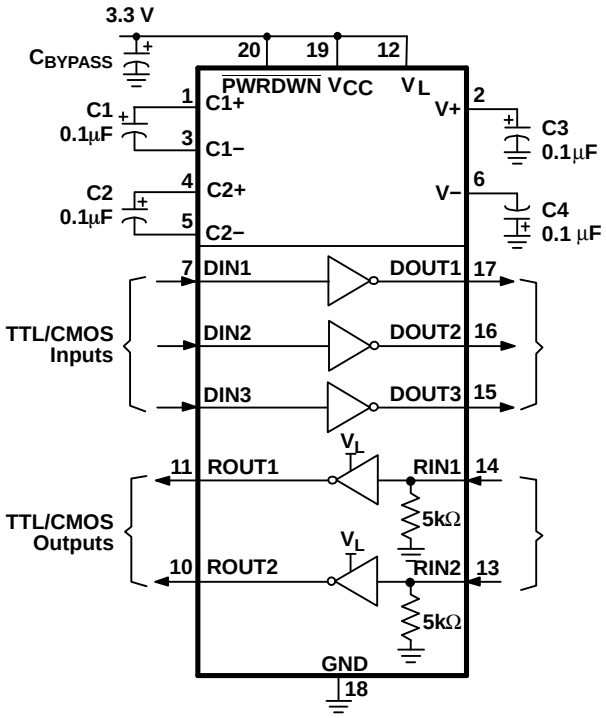
| PARAMETER | | | | MIN | TYP(1) | MAX | UNIT |
|---|---|---|---|---|---|---|---|
| | Maximum data rate | $R_L$ = 3 kΩ, $C_L$ = 1000 pF, One driver switching | | 250 | | | kbps |
| | Time-to-exit powerdown | $\|V_{T\_OUT}\|$ > 3.7 V | | | 100 | | µs |
| $\|t_{PHL} – t_{PLH}\|$ | Driver skew(2) | | | | 100 | | ns |
| | Transition-region slew rate | $V_{CC}$ = 3.3 V, $T_A$ = 25°C, $R_L$ = 3 kΩ to 7 kΩ, Measured from 3 V to –3 V or –3 V to 3 V | $C_L$ = 150 pF to 1000 pF | 6 | | 30 | V/µs |
| | | | $C_L$ = 150 pF to 2500 pF | 4 | | 30 | |

(1) Typical values are at $V_{CC}$ = $V_L$ = 3.3 V, $T_A$ = 25°C.
(2) Driver skew is measured at the driver zero crosspoint.

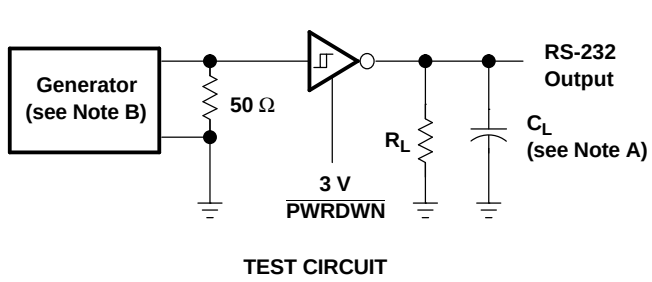
### ESD Protection

| PARAMETER | TEST CONDITIONS | TYP | UNIT |
|---|---|---|---|
| RIN, DOUT | Human-Body Model | ±15 | kV |
| | IEC 61000-4-2 Air-Gap Discharge | ±15 | |
| | IEC 61000-4-2 Contact Discharge | ±8 | |

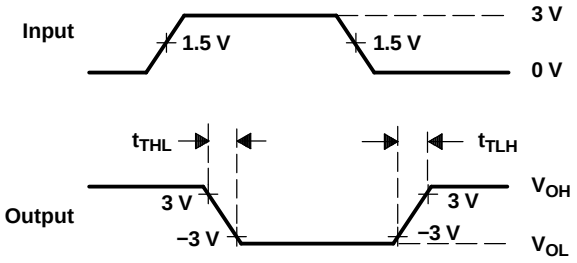
## APPLICATION INFORMATION



## PARAMETER MEASUREMENT INFORMATION




TEST CIRCUIT

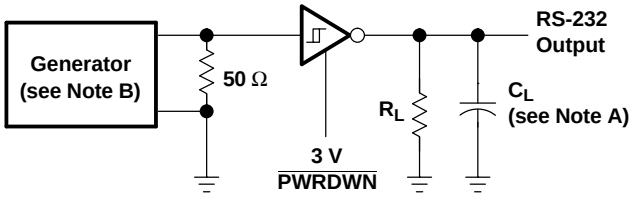



VOLTAGE WAVEFORMS

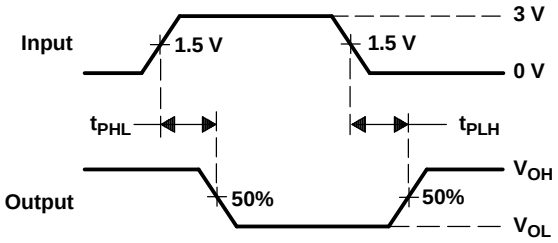
$$SR(tr) = \frac{6\ V}{t_{THL} \text{ or } t_{TLH}}$$

NOTES: A. $C_L$ includes probe and jig capacitance.
B. The pulse generator has the following characteristics: PRR = 250 kbit/s, $Z_O$ = 50 Ω, 50% duty cycle, $t_r \le 10$ ns, $t_f \le 10$ ns.

**Figure 1. Driver Slew Rate**



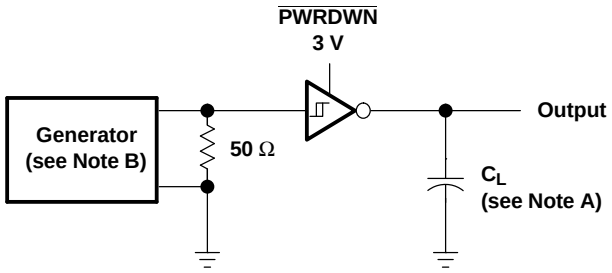

TEST CIRCUIT



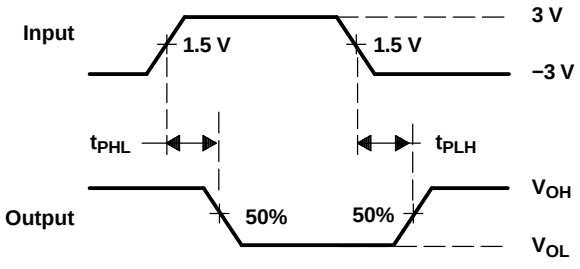

VOLTAGE WAVEFORMS

NOTES: A. $C_L$ includes probe and jig capacitance.
B. The pulse generator has the following characteristics: PRR = 250 kbit/s, $Z_O$ = 50 Ω, 50% duty cycle, $t_r \le 10$ ns, $t_f \le 10$ ns.

**Figure 2. Driver Pulse Skew**




TEST CIRCUIT

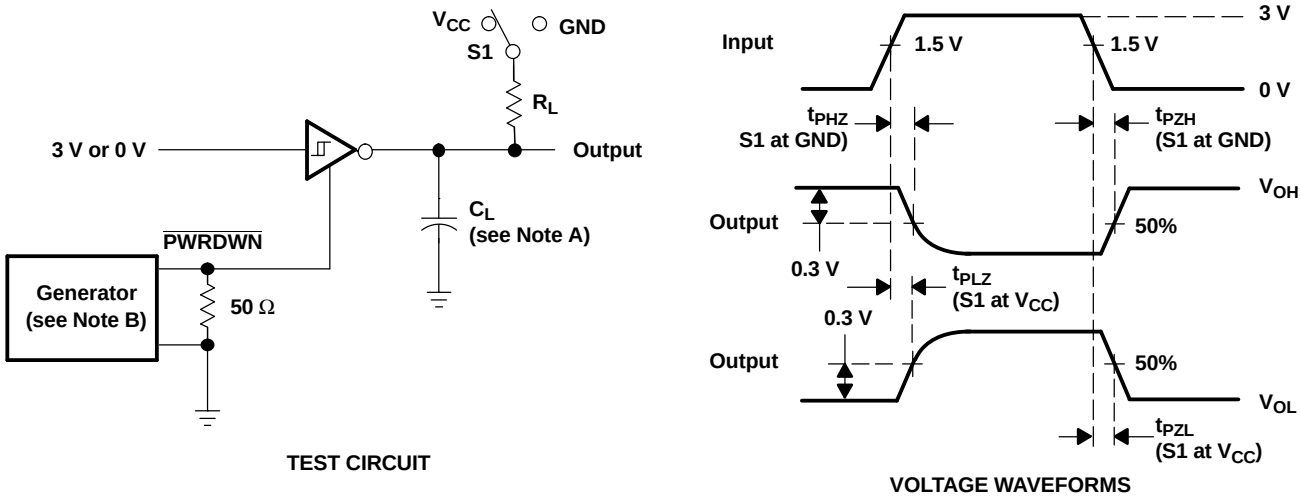



VOLTAGE WAVEFORMS

NOTES: A. $C_L$ includes probe and jig capacitance.
B. The pulse generator has the following characteristics: $Z_O$ = 50 Ω, 50% duty cycle, $t_r \le 10$ ns, $t_f \le 10$ ns.

**Figure 3. Receiver Propagation Delay Times**

## PARAMETER MEASUREMENT INFORMATION




NOTES: A. $C_L$ includes probe and jig capacitance.
B. The pulse generator has the following characteristics: $Z_O$ = 50 Ω, 50% duty cycle, $t_r \le 10$ ns, $t_f \le 10$ ns.

**Figure 4. Receiver Enable and Disable Times**

## PACKAGING INFORMATION

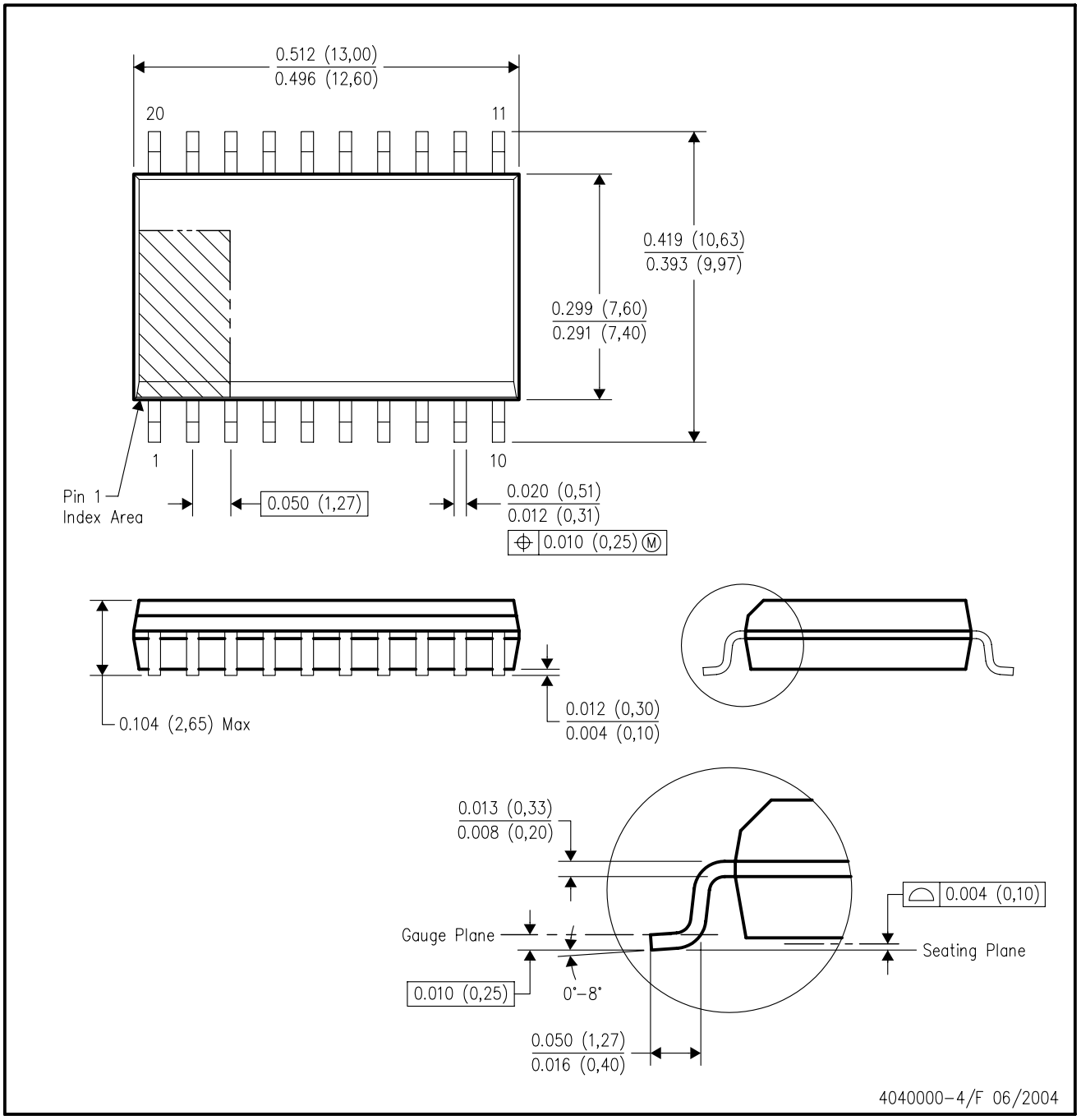
| Orderable Device | Status (1) | Package Type | Package Drawing | Pins | Package Qty | Eco Plan (2) | Lead/Ball Finish | MSL Peak Temp (3) |
|---|---|---|---|---|---|---|---|---|
| MAX3386ECDW | ACTIVE | SOIC | DW | 20 | 25 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| MAX3386ECDWG4 | ACTIVE | SOIC | DW | 20 | 25 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| MAX3386ECDWR | ACTIVE | SOIC | DW | 20 | 2000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| MAX3386ECDWRG4 | ACTIVE | SOIC | DW | 20 | 2000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| MAX3386ECPW | ACTIVE | TSSOP | PW | 20 | 70 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| MAX3386ECPWG4 | ACTIVE | TSSOP | PW | 20 | 70 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| MAX3386ECPWR | ACTIVE | TSSOP | PW | 20 | 2000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| MAX3386ECPWRG4 | ACTIVE | TSSOP | PW | 20 | 2000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| MAX3386EIDW | ACTIVE | SOIC | DW | 20 | 25 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| MAX3386EIDWG4 | ACTIVE | SOIC | DW | 20 | 25 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| MAX3386EIDWR | ACTIVE | SOIC | DW | 20 | 2000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| MAX3386EIDWRG4 | ACTIVE | SOIC | DW | 20 | 2000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| MAX3386EIPW | ACTIVE | TSSOP | PW | 20 | 70 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| MAX3386EIPWG4 | ACTIVE | TSSOP | PW | 20 | 70 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| MAX3386EIPWR | ACTIVE | TSSOP | PW | 20 | 2000 | Green (RoHS & no Sb/Br) | CU NIPDAU | Level-1-260C-UNLIM |
| MAX3386EIPWRG4 | ACTIVE | TSSOP | PW | 20 | 2000 | 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.

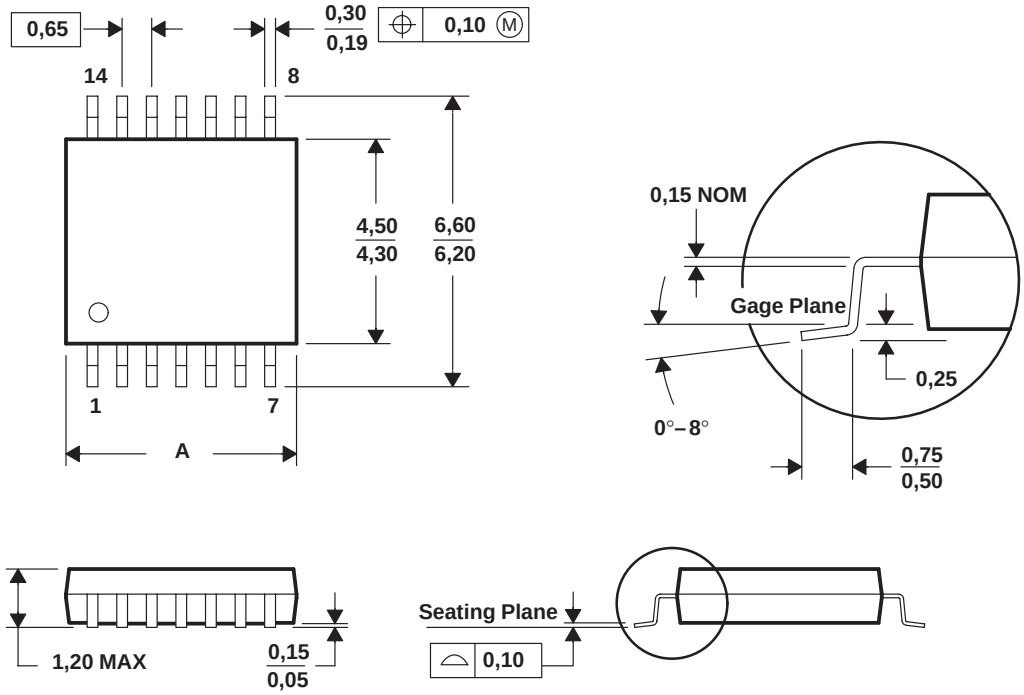
## DW (R–PDSO–G20) PLASTIC SMALL–OUTLINE PACKAGE




NOTES:
A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. Body dimensions do not include mold flash or protrusion not to exceed 0.006 (0,15).
D. Falls within JEDEC MS–013 variation AC.

**PW (R-PDSO-G**)** **PLASTIC SMALL-OUTLINE PACKAGE**

**14 PINS SHOWN**




| DIM \ PINS ** | 8 | 14 | 16 | 20 | 24 | 28 |
|---|---|---|---|---|---|---|
| A MAX | 3,10 | 5,10 | 5,10 | 6,60 | 7,90 | 9,80 |
| A MIN | 2,90 | 4,90 | 4,90 | 6,40 | 7,70 | 9,60 |

**4040064/F 01/97**

NOTES: A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. Body dimensions do not include mold flash or protrusion not to exceed 0,15.
D. Falls within JEDEC MO-153

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