



# THE DATASHEET OF LM2682MMX/NOPB



## LM2682 Switched Capacitor Voltage Doubling Inverter

Check for Samples: [LM2682](#)

### FEATURES

- Inverts Then Doubles Input Supply Voltage
- Small VSSOP Package and SOIC Package
- 90Ω Typical Output Impedance
- 94% Typical Power Efficiency at 10 mA

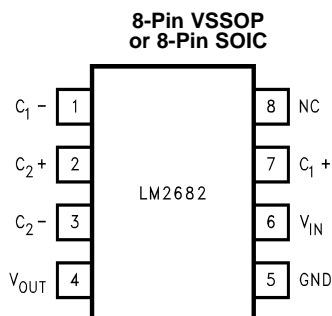
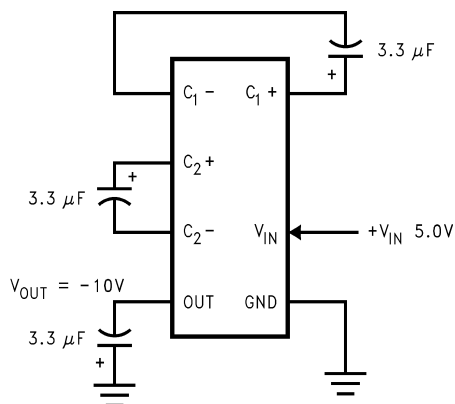
### APPLICATIONS

- LCD Contrast Biasing
- GaAs Power Amplifier Biasing
- Interface Power Supplies
- Handheld Instrumentation
- Laptop Computers and PDAs

### DESCRIPTION

The LM2682 is a CMOS charge-pump voltage inverter capable of converting positive voltage in the range of +2.0V to +5.5V to the corresponding doubled negative voltage of -4.0V to -11.0V respectively. The LM2682 uses three low cost capacitors to provide 10 mA of output current without the cost, size, and EMI related to inductor based circuits. With an operating current of only 150 μA and an operating efficiency greater than 90% with most loads, the LM2682 provides ideal performance for battery powered systems. The LM2682 offers a switching frequency of 6 kHz.

### Typical Operating Circuit and Pin Configuration



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.



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### Absolute Maximum Ratings<sup>(1)</sup>

|                                  |       |                 |
|----------------------------------|-------|-----------------|
| Input Voltage ( $V_{IN}$ )       |       | +5.8V           |
| $V_{IN}$ dV/dT                   |       | 1V/ $\mu$ sec   |
| $V_{OUT}$                        |       | -11.6V          |
| $V_{OUT}$ Short-Circuit Duration |       | Continuous      |
| Storage Temperature              |       | -65°C to +150°C |
| Lead Temperature Soldering       |       | +300°C          |
| Power Dissipation <sup>(2)</sup> | VSSOP | 300 mW          |
|                                  | SOIC  | 470 mW          |
| $T_{JMAX}$                       |       | +150°C          |

- (1) Absolute Maximum Ratings are those values beyond which damage to the device may occur. Operating Ratings indicate conditions for which the device is intended to be functional, but do not ensure specific performance limits. For ensured specifications and test conditions, see the Electrical Characteristics.
- (2) The maximum power dissipation must be de-rated at elevated temperatures (only needed for  $T_A > 85^\circ\text{C}$ ) and is limited by  $T_{JMAX}$  (maximum junction temperature),  $\theta_{J-A}$  (junction to ambient thermal resistance) and  $T_A$  (ambient temperature).  $\theta_{J-A}$  is  $140^\circ\text{C/W}$  for the SOIC-8 package and  $220^\circ\text{C/W}$  for the VSSOP-8 package. The maximum power dissipation at any temperature is:  $P_{DissMAX} = (T_{JMAX} - T_A)/\theta_{J-A}$  up to the value listed in the Absolute Maximum Ratings.

### Operating Ratings

|                                   |                  |                 |
|-----------------------------------|------------------|-----------------|
| ESD Susceptibility <sup>(1)</sup> | Human Body Model | 2 kV            |
|                                   | Machine Model    | 200V            |
| Ambient Temp. Range               |                  | -40°C to +85°C  |
| Junction Temp. Range              |                  | -40°C to +125°C |

- (1) The human body model is a 100 pF capacitor discharged through a 1.5 k $\Omega$  resistor into each pin. The machine model is a 200pF capacitor discharged directly into each pin.

## LM2682

### Electrical Characteristics

$V_{IN} = 5\text{V}$  and  $C_1 = C_2 = C_3 = 3.3\mu\text{F}$  unless otherwise specified. Limits with **bold typeface** apply over the full operating ambient temperature range, -40°C to +85°C, limits with standard typeface apply for  $T_A = 25^\circ\text{C}$ .

| Symbol           | Parameter                     | Conditions                               | Min        | Typical <sup>(1)</sup> | Max                      | Units         |
|------------------|-------------------------------|--|------------|------------------------|--------------------------|---------------|
| $V_{IN}$         | Supply Voltage Range          | $R_L = 2\text{ k}\Omega$                 | <b>2.0</b> |                        | <b>5.5</b>               | V             |
| $I_{IN}$         | Supply Current                | Open Circuit, No Load                    |            | 150                    | <b>300</b><br><b>400</b> | $\mu\text{A}$ |
| $R_{OUT}$        | $V_{OUT}$ Source Resistance   | $I_L = 10\text{ mA}$                     |            | 90                     | 150<br><b>200</b>        | $\Omega$      |
|                  |                               | $I_L = 5\text{ mA}, V_{IN} = 2\text{ V}$ |            | 110                    | <b>250</b>               | $\Omega$      |
| $f_{OSC}$        | Oscillator Frequency          | See <sup>(2)</sup>                       |            | 12                     | <b>30</b>                | kHz           |
| $f_{SW}$         | Switching Frequency           | See <sup>(2)</sup>                       |            | 6                      | <b>15</b>                | kHz           |
| $\eta_{POWER}$   | Power Efficiency              | $R_L = 2\text{ k}\Omega$ <sup>(3)</sup>  | 90         | 93                     |                          | %             |
| $\eta_{VOLTAGE}$ | Voltage Conversion Efficiency |  |            | 99.9                   |                          | %             |

- (1) Typical numbers are at 25°C and represent the most likely norm.
- (2) The output switches operate at one half of the oscillator frequency,  $f_{OSC} = 2f_{SW}$ .
- (3) The minimum specification is specified by design and is not tested.

**Table 1. PIN DESCRIPTIONS**

| Pin Number | Symbol    | Description                            |
|------------|-----------|--|
| 1          | $C_{1-}$  | Capacitor $C_1$ negative terminal      |
| 2          | $C_{2+}$  | Capacitor $C_2$ positive terminal      |
| 3          | $C_{2-}$  | Capacitor $C_2$ negative terminal      |
| 4          | $V_{OUT}$ | Negative output voltage ( $-2V_{IN}$ ) |
| 5          | GND       | Device ground                          |
| 6          | $V_{IN}$  | Power supply voltage                   |
| 7          | $C_{1+}$  | Capacitor $C_1$ positive terminal      |
| 8          | NC        | No Connection                          |

### Typical Performance Characteristics

$V_{IN} = 5V$  and  $T_A = 25^\circ C$  unless otherwise noted.

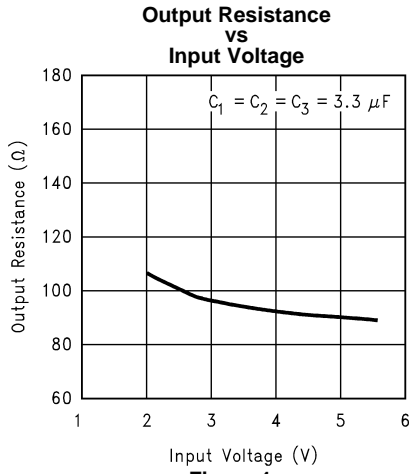


Figure 1.

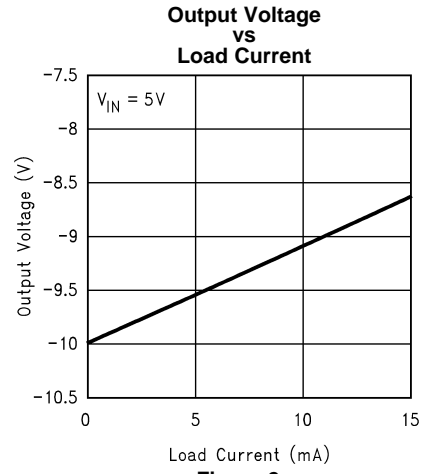


Figure 2.

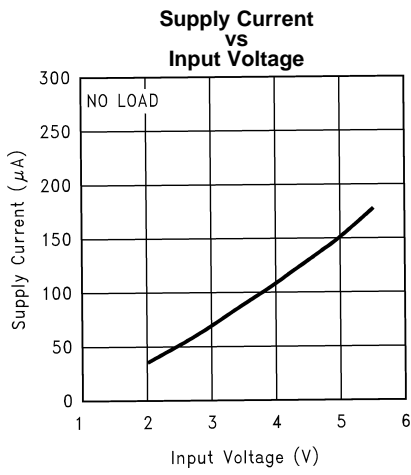


Figure 3.

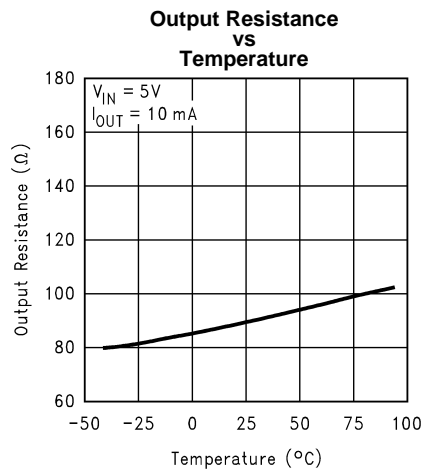


Figure 4.

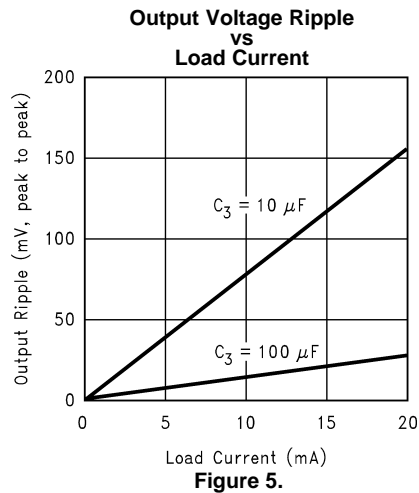
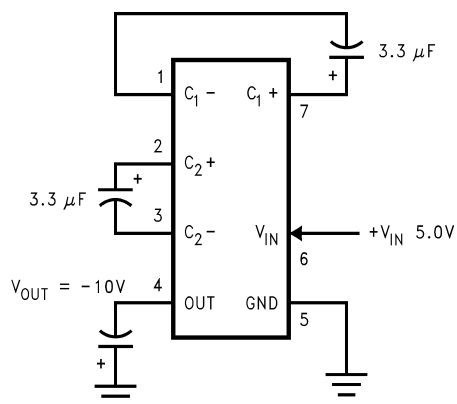
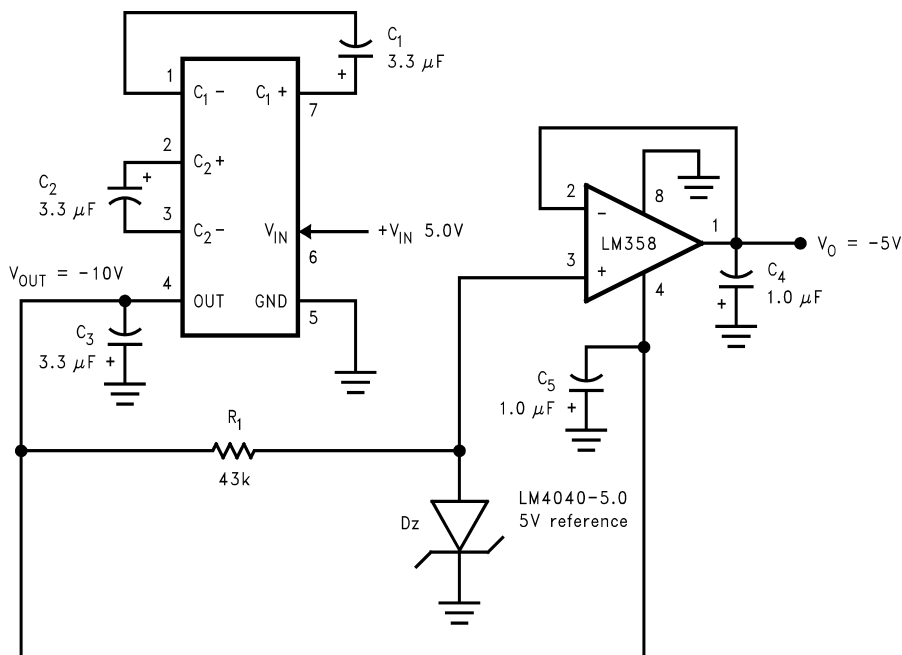


Figure 5.

**BASIC APPLICATION CIRCUITS**



**Figure 6. Doubling Voltage Inverter**



**Figure 7. +5V to -5V Regulated Voltage Converter**

## APPLICATION INFORMATION

### VOLTAGE DOUBLING INVERTER

The main application of the LM2682 is to generate a negative voltage that is twice the positive input voltage. This circuit requires only three external capacitors and is connected as shown in [Figure 6](#). It is important to keep in mind that the efficiency of the circuit is determined by the output resistance. A derivation of the output resistance is shown below:

$$R_{OUT} = 2(R_{SW1} + R_{SW2} + ESR_{C1} + R_{SW3} + R_{SW4} + ESR_{C2}) + 2(R_{SW1} + R_{SW2} + ESR_{C1} + R_{SW3} + R_{SW4} + ESR_{C2}) + 1/(f_{OSC} \times C1) + 1/(f_{OSC} \times C2) + ESR_{C3}$$

Using the assumption that all four switches have the same ON resistance our equation becomes:

$$R_{OUT} = 16R_{SW} + 4ESR_{C1} + 4ESR_{C2} + ESR_{C3} + 1/(f_{OSC} \times C1) + 1/(f_{OSC} \times C2)$$

Output resistance is typically 90Ω with an input voltage of +5V, an operating temperature of 25°C, and using low ESR 3.3 μF capacitors. This equation shows the importance of capacitor selection. Large value, low ESR capacitors will reduce the output resistance significantly but will also require a larger overall circuit. Smaller capacitors will take up less space but can lower efficiency greatly if the ESR is large. Also to be considered is that C1 must be rated at 6 VDC or greater while C2 and C3 must be rated at 12 VDC or greater.

The amount of output voltage ripple is determined by the output capacitor C3 and the output current as shown in this equation:

$$V_{RIPPLE\ P-P} = I_{OUT} \times (2 \times ESR_{C3} + 1/[2 \times (f_{OSC} \times C3)])$$

Once again a larger capacitor with smaller ESR will give better results.

### +5V TO -5V REGULATED VOLTAGE CONVERTER

Another application in which the LM2682 can be used is for generating a -5V regulated supply from a +5V unregulated supply. This involves using an op-amp and a reference and is connected as shown in [Figure 7](#). The LM358 op-amp was chosen for its low cost and versatility and the LM4040-5.0 reference was chosen for its low bias current requirement. Of course other combinations may be used at the designer's discretion to fit accuracy, efficiency, and cost requirements. With this configuration the circuit is well regulated and is still capable of providing nearly 10 mA of output current. With a 9 mA load the circuit can typically maintain 5% regulation on the output voltage with the input varying anywhere from 4.5V to the maximum of 5.5V. With less load the results are even better. Voltage ripple concerns are reduced in this case since the ripple at the output of the LM2682 is reduced at the output by the PSRR of the op-amp used.

## PARALLELING DEVICES

Any number of devices can be paralleled to reduce the output resistance. As shown in Figure 8, each device must have its own pumping capacitors, C1 and C2, but only one shared output capacitor is required. The effective output resistance is the output resistance of one device divided by the number of devices used in parallel. Paralleling devices also gives the capability of increasing the maximum output current. The maximum output current now becomes the maximum output current for one device multiplied by the number of devices used in parallel. For example, if you parallel two devices you can get 20 mA of output current and have half the output resistance of one device supplying 10 mA.

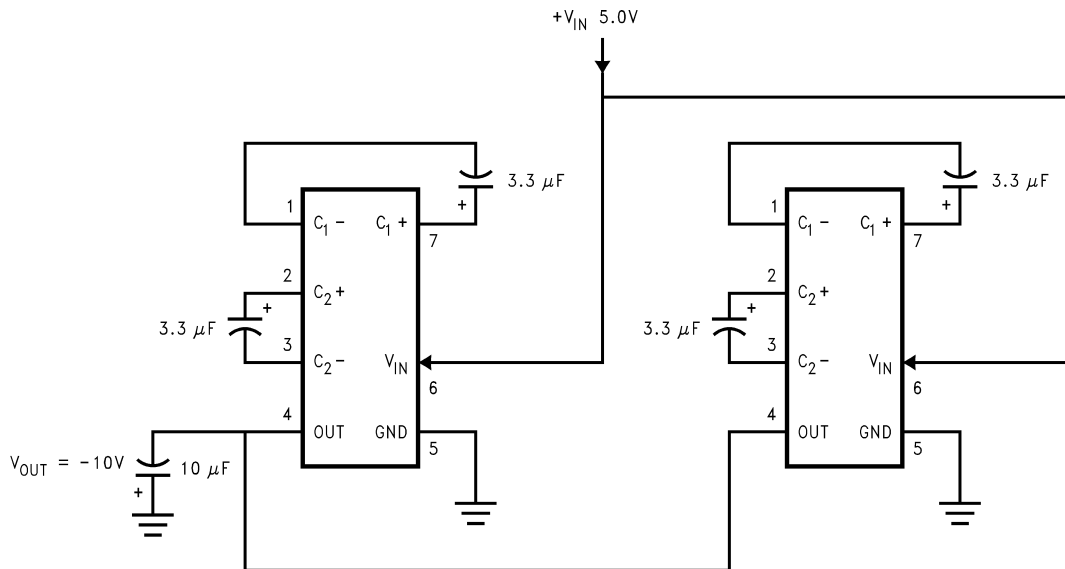


Figure 8. Paralleling Devices

## REVISION HISTORY

| Changes from Revision A (May 2013) to Revision B           | Page              |
|--|-------------------|
| • Changed layout of National Data Sheet to TI format ..... | <a href="#">7</a> |

**PACKAGING INFORMATION**

| Orderable Device | Status<br>(1) | Package Type | Package Drawing | Pins | Package Qty | Eco Plan<br>(2)         | Lead/Ball Finish<br>(6) | MSL Peak Temp<br>(3) | Op Temp (°C) | Device Marking<br>(4/5) | Samples                 |
|------------------|---------------|--------------|-----------------|------|-------------|-------------------------|-------------------------|----------------------|--------------|-------------------------|-------------------------|
| LM2682MM/NOPB    | ACTIVE        | VSSOP        | DGK             | 8    | 1000        | Green (RoHS & no Sb/Br) | CU SN                   | Level-1-260C-UNLIM   | -40 to 85    | S11A                    | <a href="#">Samples</a> |
| LM2682MMX/NOPB   | ACTIVE        | VSSOP        | DGK             | 8    | 3500        | Green (RoHS & no Sb/Br) | CU SN                   | Level-1-260C-UNLIM   | -40 to 85    | S11A                    | <a href="#">Samples</a> |

(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.

**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.

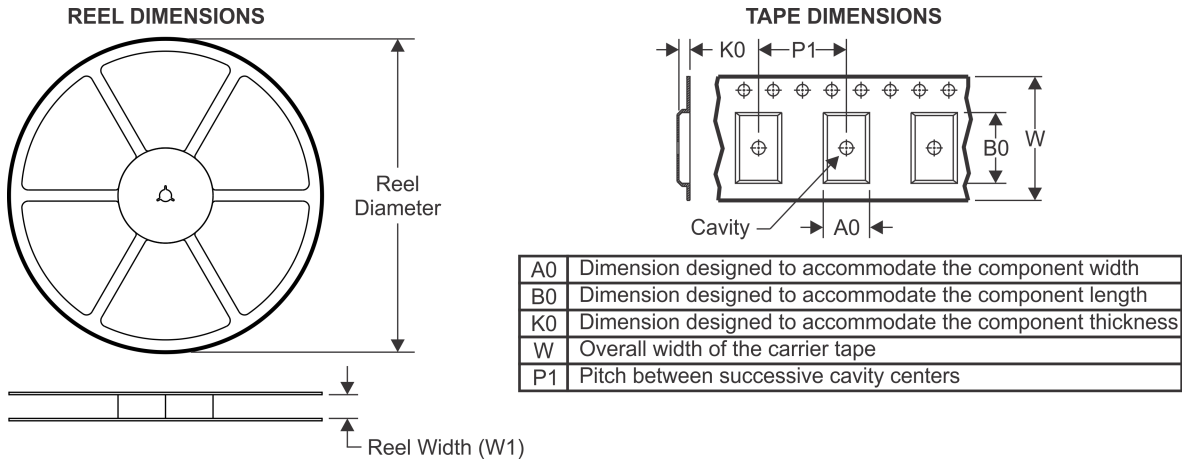
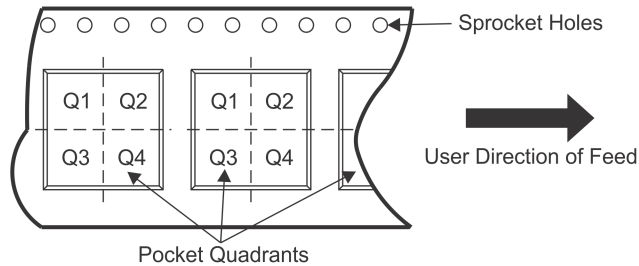
(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(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 |
|----------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| LM2682MM/NOPB  | VSSOP        | DGK             | 8    | 1000 | 178.0              | 12.4               | 5.3     | 3.4     | 1.4     | 8.0     | 12.0   | Q1            |
| LM2682MMX/NOPB | VSSOP        | DGK             | 8    | 3500 | 330.0              | 12.4               | 5.3     | 3.4     | 1.4     | 8.0     | 12.0   | Q1            |

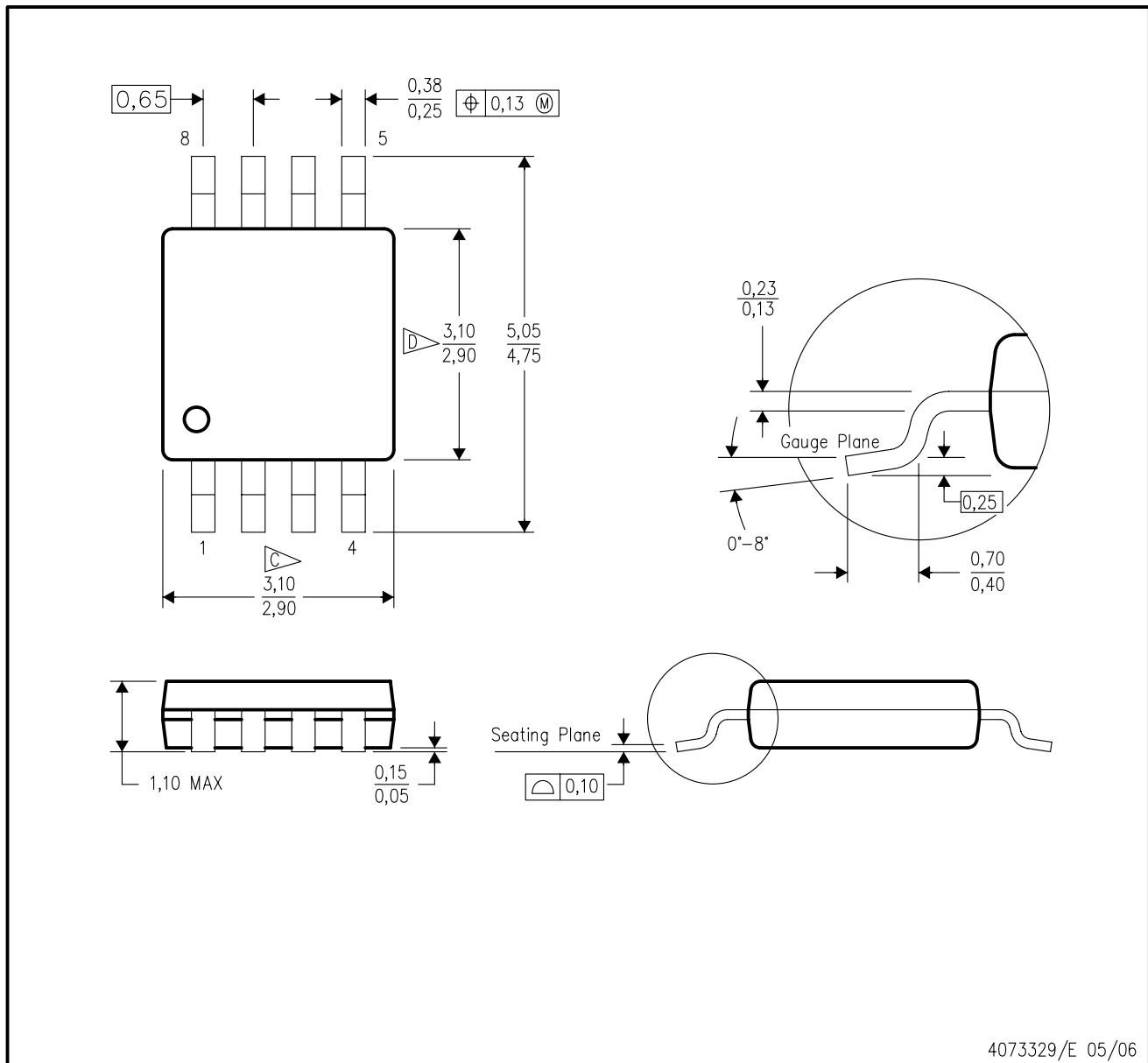
**TAPE AND REEL BOX DIMENSIONS**


\*All dimensions are nominal

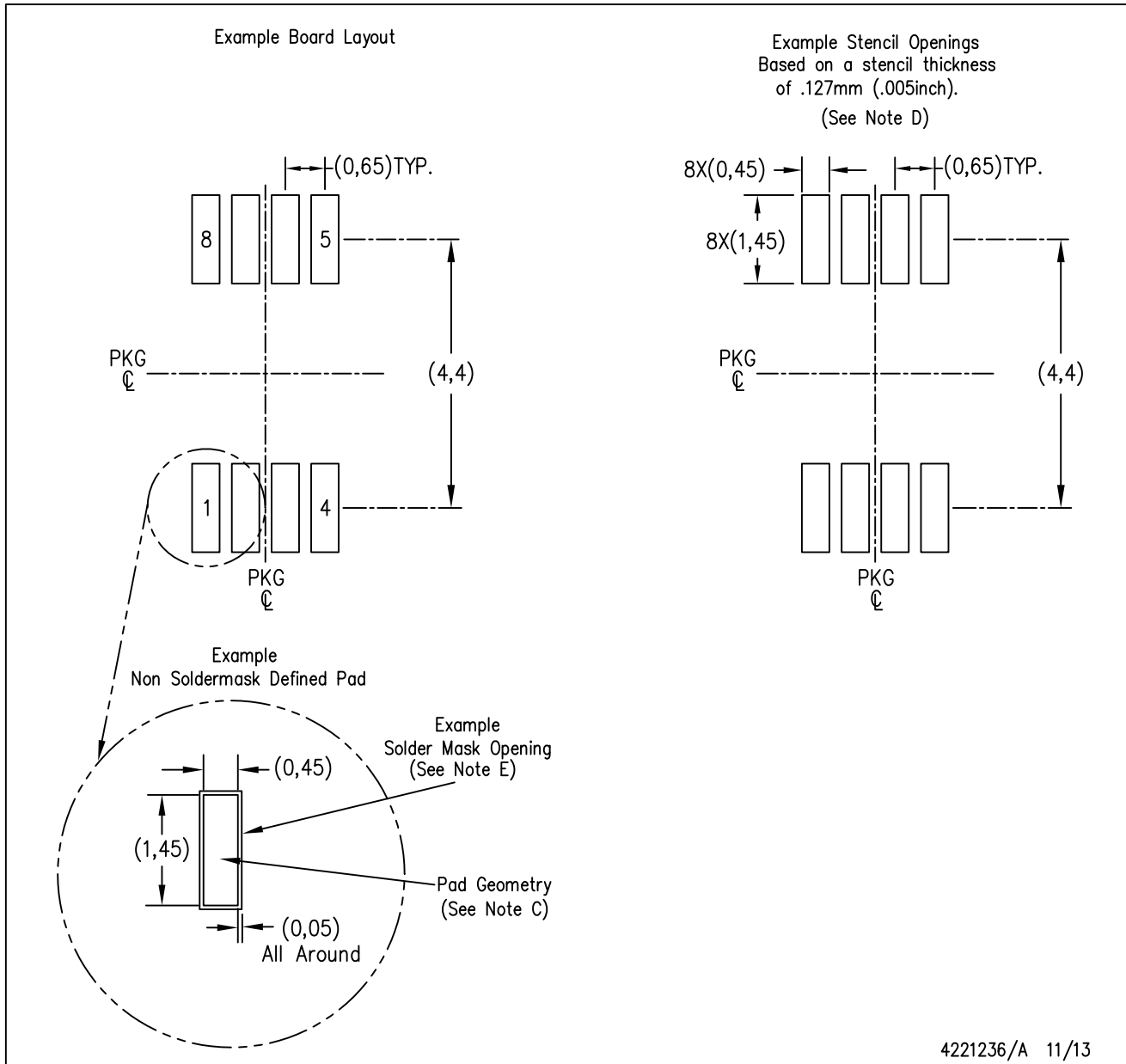
| Device         | Package Type | Package Drawing | Pins | SPQ  | Length (mm) | Width (mm) | Height (mm) |
|----------------|--------------|-----------------|------|------|-------------|------------|-------------|
| LM2682MM/NOPB  | VSSOP        | DGK             | 8    | 1000 | 210.0       | 185.0      | 35.0        |
| LM2682MMX/NOPB | VSSOP        | DGK             | 8    | 3500 | 367.0       | 367.0      | 35.0        |

DGK (S-PDSO-G8)

PLASTIC SMALL-OUTLINE PACKAGE



- NOTES:
- A. All linear dimensions are in millimeters.
  - B. This drawing is subject to change without notice.
  - C. Body length does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.15 per end.
  - D. Body width does not include interlead flash. Interlead flash shall not exceed 0.50 per side.
  - E. Falls within JEDEC MO-187 variation AA, except interlead flash.



- NOTES:
- A. All linear dimensions are in millimeters.
  - B. This drawing is subject to change without notice.
  - C. Publication IPC-7351 is recommended for alternate designs.
  - D. 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 other stencil recommendations.
  - E. Customers should contact their board fabrication site for solder mask tolerances between and around signal pads.

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### Applications



|                               |  |
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