National Semiconductor

June 1996

LM2825 SIMPLE SWITCHER®
1A DC-DC Converter in 24-Pin DIP Package

General Description

The LM2825 is a complete 1A DC-DC Buck converter packaged in a 24-lead molded Dual-In-Line integrated circuit package.

Contained within the package are all the active and passive components for a high efficiency step-down (buck) switching regulator. Available in fixed output voltages of 3.3V and 5V, these devices can provide up to 1A of load current with fully guaranteed electrical specifications over the full operating temperature range.

Self-contained, this converter is also fully protected from output fault conditions, such as excessive load current, short circuits, or excessive temperatures.

Highlights

- Integrated circuit reliability
- MTBF over 20 million hours
- Radiated EMI meets Class B stipulated by CISPR 22
- High power density, 35 W/in^3
- 24-pin DIP package profile (1.25 x 0.54 x 0.26 inches)
- Package weight 6 grams
- No external components required

Features

- Minimum design time required
- 3.3V and 5V fixed output versions
- Guaranteed 1A output current
- Wide input voltage range, up to 40V
- Low-power standby mode, I_Q typically 65 μA
- High efficiency, typically 80%
- $\pm$4% output voltage tolerance
- Excellent line and load regulation
- TTL shutdown capability/programmable Soft-start
- Thermal shutdown and current limit protection

Applications

- Simple high-efficiency step-down (buck) regulator
- On-card switching regulators
- Efficient pre-regulator for linear regulators
- Distributed power systems
- DC/DC module replacement

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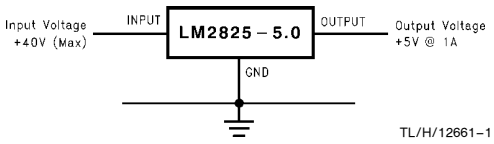
Standard Application



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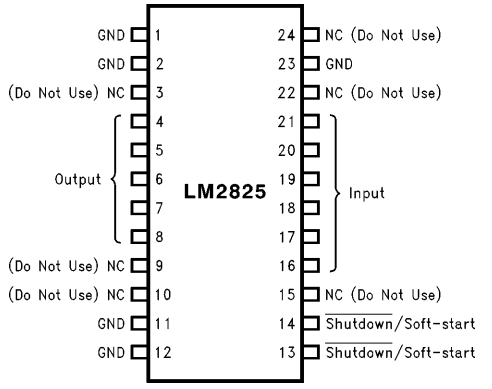
Radiated EMI

Radiated emission of electromagnetic fields is measured at 10m distance. The emission levels are within the Class B limits stipulated by CISPR 22.

30. . . .230 MHz	30 dB μV/m
230. . . .1000 MHz	37 dB μV/m
1. . . .10 GHz	46 dB μV/m

Connection Diagram



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Note: "NC (Do not use)" pins: See *Figure 5*.

Top View

Order Information

Order Number LM2825N-3.3 or LM2825N-5.0
See NS Package Number NA24F

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Absolute Maximum Ratings (Note 1)

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/Distributors for availability and specifications.

Maximum Input Supply (V_{IN})	+45V
SD/SS Pin Input Voltage (Note 2)	6V
Output Voltage to Ground (steady state)	−1V
Power Dissipation	Internally Limited
Storage Temperature Range	−40°C to +125°C
ESD Susceptibility	
Human Body Model (Note 3)	2 kV
Lead Temperature (Soldering 10 sec.)	260°C

Operating Ratings

Ambient Temperature Range	$0°C \le T_A \le +70°C$
Junction Temperature Range	$0°C \le T_J \le +125°C$
Input Supply Voltage (3.3V version)	4.75V to 40V
Input Supply Voltage (5V version)	7V to 40V

LM2825-3.3 Electrical Characteristics

Specifications with standard type face are for T_A = 25°C, and those with **boldface type** apply over **full Operating Temperature Range**. (Note 4) Test Circuit *Figure 2*.

Symbol	Parameter	Conditions	LM2825-3.3		Units (Limits)
			Typical (Note 5)	Limit (Note 6)	
V_{OUT}	Output Voltage	$4.75V \le V_{IN} \le 40V$, $0.1A \le I_{LOAD} \le 1A$	3.3	3.168/**3.135** 3.432/**3.465**	V V(min) V(max)
	Line Regulation	$4.75V \le V_{IN} \le 40V$ I_{LOAD} = 100 mA	1.5		mV
	Load Regulation	$0.1A \le I_{LOAD} \le 1A$ V_{IN} = 12V	8		mV
	Output Ripple Voltage	V_{IN} = 12V, I_{LOAD} = 1A	40		mV p-p
η	Efficiency	V_{IN} = 12V, I_{LOAD} = 1A	78		%

LM2825-5.0 Electrical Characteristics

Specifications with standard type face are for T_A = 25°C, and those with **boldface type** apply over **full Operating Temperature Range**. (Note 4) Test Circuit *Figure 2*.

Symbol	Parameter	Conditions	LM2825-5.0		Units (Limits)
			Typical (Note 5)	Limit (Note 6)	
V_{OUT}	Output Voltage	$7V \le V_{IN} \le 40V$, $0.1A \le I_{LOAD} \le 1A$	5.0	4.800/**4.750** 5.200/**5.250**	V V(min) V(max)
	Line Regulation	$7V \le V_{IN} \le 40V$ I_{LOAD} = 100 mA	2.7		mV
	Load Regulation	$0.1A \le I_{LOAD} \le 1A$ V_{IN} = 12V	8		mV
	Output Ripple Voltage	V_{IN} = 12V, I_{LOAD} = 1A	40		mV p-p
η	Efficiency	V_{IN} = 12V, I_{LOAD} = 1A	80		%

All Output Voltage Versions Electrical Characteristics

Specifications with standard type face are for T_A = 25°C, and those with **boldface type** apply over **full Operating Range.** Unless otherwise specified, V_{IN} = 12V, I_{LOAD} = 100 mA.

Symbol	Parameter	Conditions	LM2825-XX		Units (Limits)
			Typical (Note 5)	Limit (Note 6)	
I_{CL}	DC Output Current Limit	V_{IN} = 12V, R_L = 0Ω	1.4	 1.2 2.4	A A(min) A(max)
I_Q	Operating Quiescent Current	SD/SS Pin = 3V (Note 7)	5	 10	mA mA(max)
I_{STBY}	Standby Quiescent Current	SD/SS Pin = 0V (Note 7)	65	 200	μA μA(max)
f_O	Oscillator Frequency	(Note 8)	150		kHz
θ_{JA}	Thermal Resistance	Junction to Ambient (Note 9)	30		°C/W
SHUTDOWN/SOFT-START CONTROL Test Circuit *Figure 2*					
V_{SD}	Shutdown Threshold Voltage	 Low (Shutdown Mode) High (Soft-start Mode)	1.3	 **0.6** **2.0**	V V(max) V(min)
V_{SS}	Soft-start Voltage	V_{OUT} = 20% of Nominal Output Voltage V_{OUT} = 100% of Nominal Output Voltage	2 3		V
I_{SD}	Shutdown Current	$V_{\overline{SHUTDOWN}}$ = 0.5V (Note 7)	5	 10	μA μA(max)
I_{SS}	Soft-start Current	$V_{SOFT-START}$ = 2.5V (Note 7)	1.6	 5	μA μA(max)

Note 1: Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. Operating Ratings indicate conditions for which the device is intended to be functional, but do not guarantee specific performance limits. For guaranteed specifications and test conditions, see the Electrical Characteristics.

Note 2: Voltage internally clamped. If clamp voltage is exceeded, limit current to a maximum of 5 mA.

Note 3: The human body model is a 100 pF capacitor discharged through a 1.5k resistor into each pin.

Note 4: When the LM2825 is used as shown in *Figure 2* test circuit, system performance will be as shown in Electrical Characteristics.

Note 5: Typical numbers are at 25°C and represent the most likely norm.

Note 6: All limits guaranteed at room temperature (standard type face) and at **temperature extremes (bold type face).** All room temperature limits are 100% production tested. All limits at **temperature extremes** are guaranteed via correlation using standard Statistical Quality Control (SQC) methods. All limits are used to calculate Average Outgoing Quality Level (AOQL).

Note 7: I_{LOAD} = 0A.

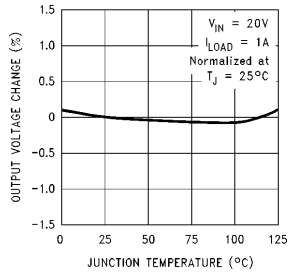
Note 8: The switching frequency is reduced when the second stage current limit is activated. The amount of reduction is determined by the severity of current overload.

Note 9: Junction to ambient thermal resistance (no external heat sink) for the DIP-24 package with the leads soldered to a printed circuit board with (1 oz.) copper area of approximately 2 in^2.

Typical Performance Characteristics

(Circuit of *Figure 2*) Unless otherwise specified, $V_{IN} = 12V$, $I_{LOAD} = 100$ mA

Normalized Output Voltage



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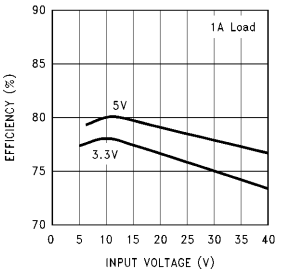
Efficiency



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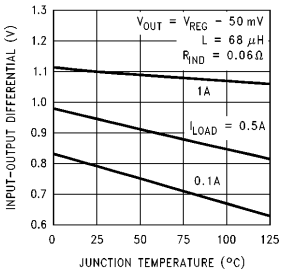
Dropout Voltage



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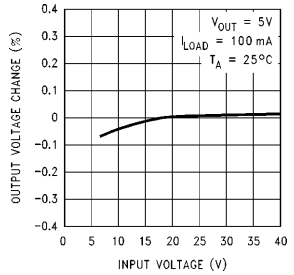
Line Regulation



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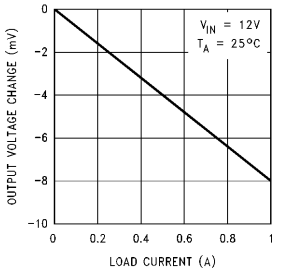
Load Regulation



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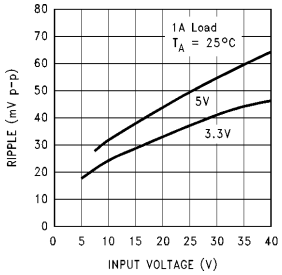
Output Ripple Voltage



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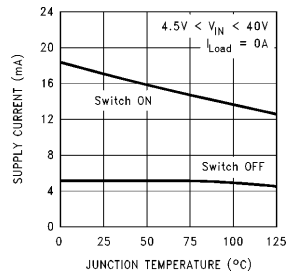
Operating Quiescent Current



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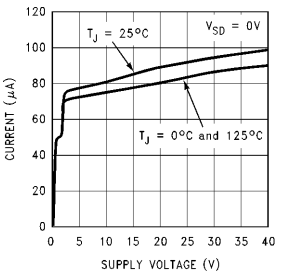
Shutdown Quiescent Current



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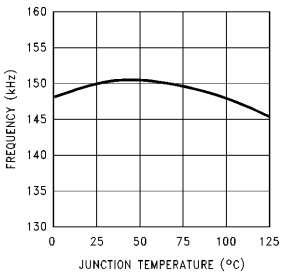
Switching Frequency



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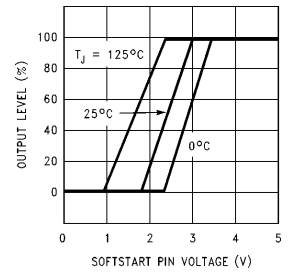
Soft-start



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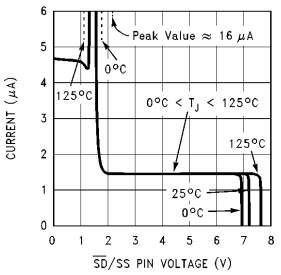
$\overline{\text{Shutdown}}$/Soft-start Current



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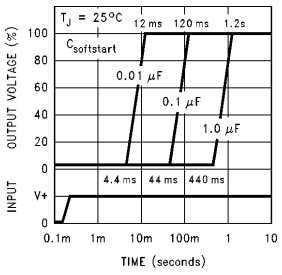
Soft-start Response



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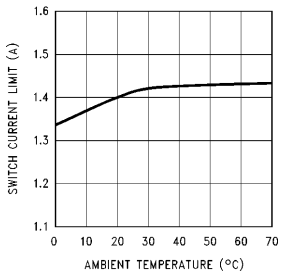
Typical Performance Characteristics

(Circuit of *Figure 2*) Unless otherwise specified, V_{IN} = 12V, I_{LOAD} = 100 mA (Continued)

Switch Current Limit



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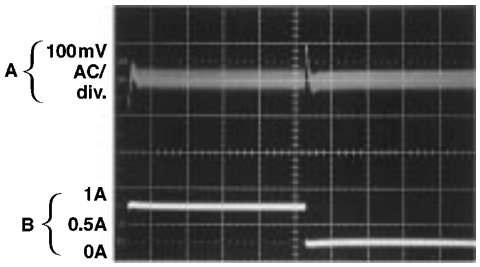
Load Transient Response for Continuous Mode
V_{IN} = 20V, V_{OUT} = 5V, I_L = 250 mA to 750 mA



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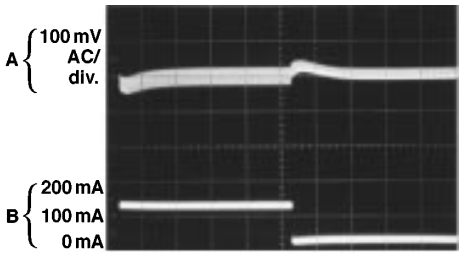
A: Output Voltage 100 mV/div (AC)
B: 250 mA to 750 mA Load Pulse
Horizontal Time Base: 200 μs/div

Load Transient Response for Discontinuous Mode
V_{IN} = 20V, V_{OUT} = 5V, I_L = 40 mA to 140 mA



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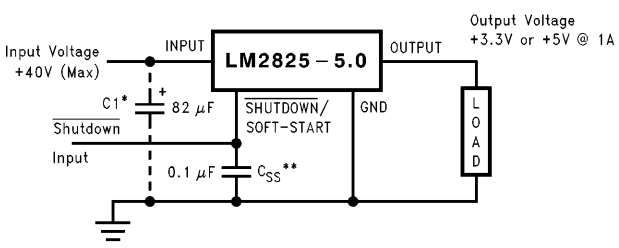
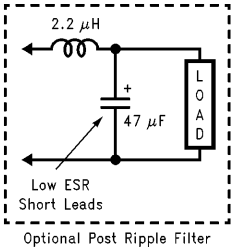
A: Output Voltage 100 mV/div (AC)
B: 40 mA to 140 mA Load Pulse
Horizontal Time Base: 200 μs/div

FIGURE 1. Typical Load Transient Response

Test Circuit





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*Optional—Required if package is more than 6″ away from main filter or bypass capacitor.
**Optional Soft-start Capacitor

V_{IN} = 40V (max)
V_{OUT} = 3.3V or 5V
I_{LOAD} = 1A

FIGURE 2. Standard Test Circuit

Application Information

OPTIONAL EXTERNAL COMPONENTS

SOFT-START CAPACITOR

C_{SS}: A capacitor on this pin provides the regulator with a Soft-start feature (slow start-up). The current drawn from the source starts out at a low average level with narrow pulses, and ramps up in a controlled manner as the pulses expand to their steady-state width. This reduces the startup current considerably, and delays and slows down the output voltage rise time.

It is especially useful in situations where the input power source is limited in the amount of current it can deliver, since you avoid loading down this type of power supply.

Under some operating conditions, a Soft-start capacitor is required for proper operation. *Figure 3* indicates the input voltage and ambient temperature conditions for which a Soft-start capacitor may be required.

This curve is typical for full 1A loads and can be used as a guideline. As the output current decreases, the operating area requiring a Soft-start capacitor decreases. Capacitor values between 0.1 μF and 1 μF are recommended. Tantalum or ceramic capacitors are appropriate for this application.

INPUT CAPACITOR

C_{IN}: An optional input capacitor is required if the package is more than 6″ away from the main filter or bypass capacitor. A low ESR aluminum or tantalum bypass capacitor is recommended between the input pin and ground to prevent large voltage transients from appearing at the input. In addition, to be conservative, the RMS current rating of the input capacitor should be selected to be at least ½ the DC load current. With a 1A load, a capacitor with a RMS current rating of at least 500 mA is recommended.

The voltage rating should be approximately 1.25 times the maximum input voltage. With a nominal input voltage of 12V, an aluminum electrolytic capacitor (Panasonic HFQ series or Nichicon PL series or equivalent) with a voltage rating greater than 15V ($1.25 \times V_{IN}$) would be needed.

Solid tantalum input capacitors should only be used where the input source is impedance current limited. High dV/dt applied at the input can cause excessive charge current through low ESR tantalum capacitors. This high charge current can result in shorting within the capacitor. It is recommended that they be surge current tested by the manufacturer.The TPS series available from AVX, and the 593D series from Sprague are both surge current tested.

Use caution when using ceramic capacitors for input bypassing, because it may cause ringing at the V_{IN} pin.

SHUTDOWN

The circuit shown in *Figure 4* shows 2 circuits for the $\overline{\text{Shutdown}}$/Soft-start feature using different logic signals for shutdown and using a 0.1 μF Soft-start capacitor.

THERMAL CONSIDERATIONS

The LM2825 is available in a 24-pin through hole DIP. The package is molded plastic with a copper lead frame. When the package is soldered to the PC board, the copper and the board are the heat sink for the LM2825.

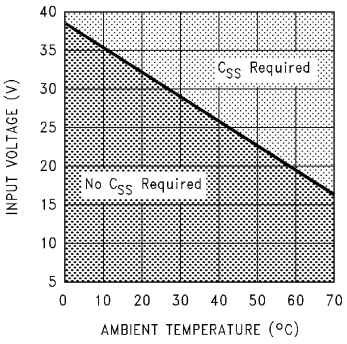

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FIGURE 3. Usage of the Soft-start Capacitor

Application Information (Continued)

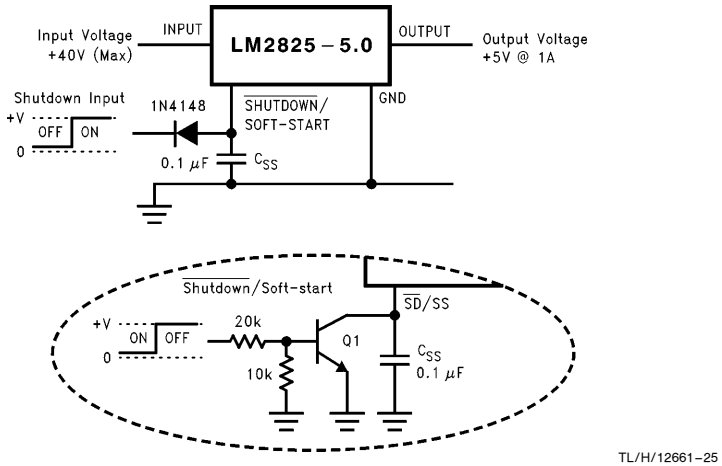

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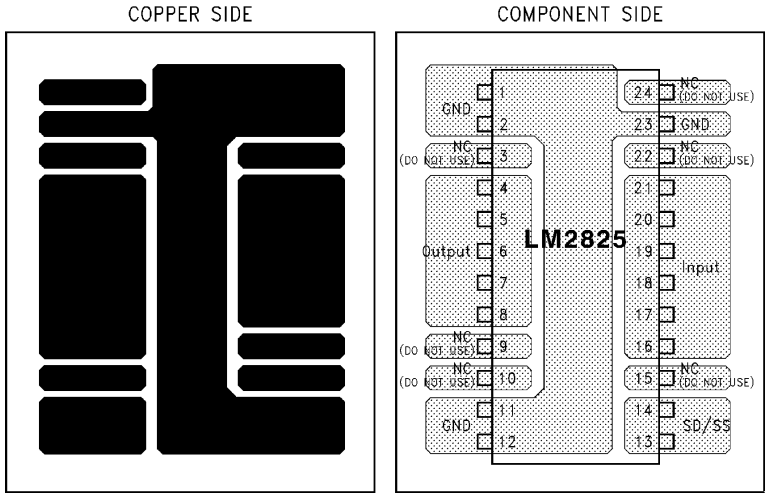
FIGURE 4. Typical Circuits Using Shutdown/Soft-Start Features

TYPICAL THROUGH HOLE PC BOARD LAYOUT (2X SIZE), SINGLE SIDED, THROUGH HOLE PLATED



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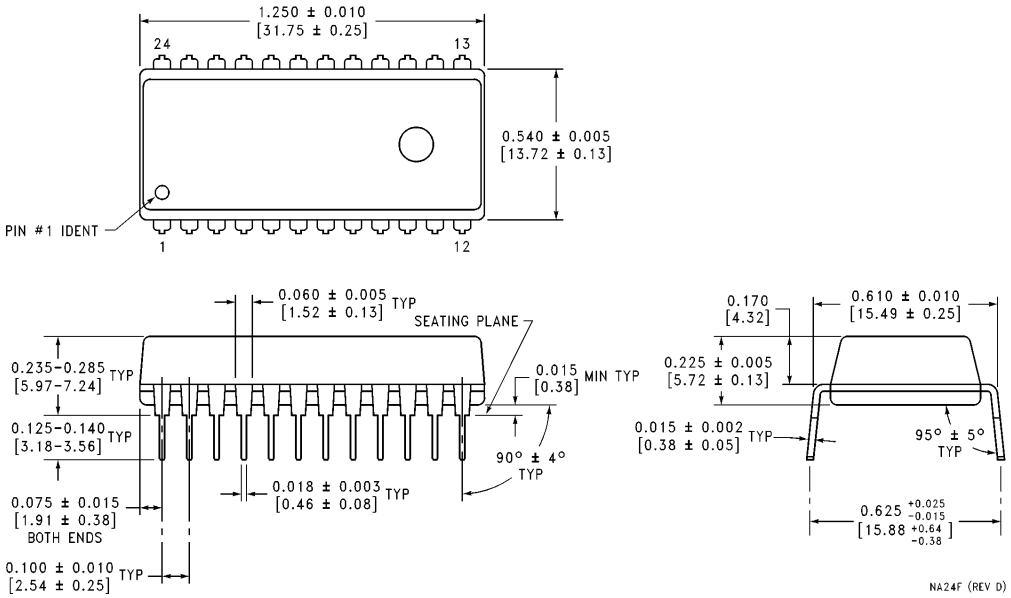
Note: Holes are not shown.

"No Connect Pins" are connected to copper pads for thermal reasons only and must remain electrically isolated.

FIGURE 5. 2X Printed Circuit Board Layout

Physical Dimensions inches (millimeters) unless otherwise noted



24-Lead (0.600″ Wide) Molded Dual-In-Line Package
Order Number LM2825N-3.3 or LM2825N-5.0
NS Package Number NA24F

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2. A critical component is any component of a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.

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