National Semiconductor

August 2000

LM2622
600kHz/1.3MHz Step-up PWM DC/DC Converter

General Description

The LM2622 is a step-up DC/DC converter with a 1.6A, 0.2Ω internal switch and pin selectable operating frequency. With the ability to convert 3.3V to multiple outputs of 8V, -8V, and 23V, the LM2622 is an ideal part for biasing TFT displays. The LM2622 can be operated at switching frequencies of 600kHz and 1.3MHz allowing for easy filtering and low noise. An external compensation pin gives the user flexibility in setting frequency compensation, which makes possible the use of small, low ESR ceramic capacitors at the output. The LM2622 is available in a low profile 8-lead MSOP package.

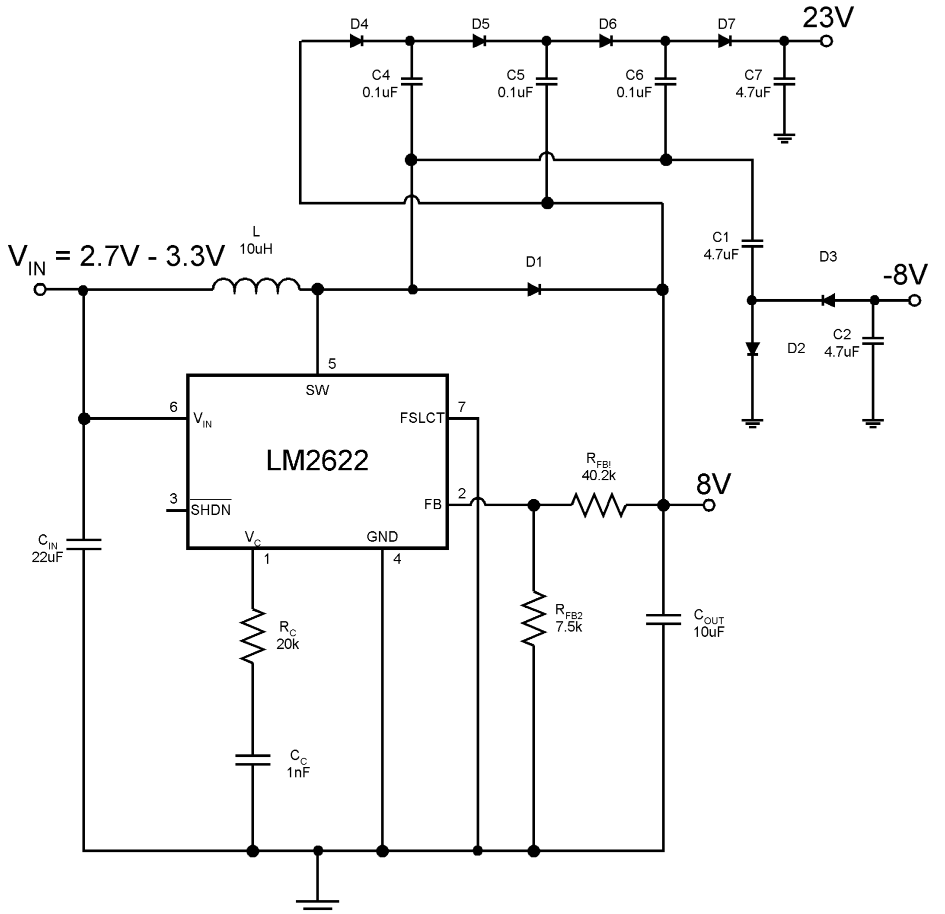
Features

- 1.6A, 0.2Ω, internal switch
- Operating voltage as low as 2.0V
- 600kHz/1.3MHz pin selectable frequency operation
- Over temperature protection
- 8-Lead MSOP package

Applications

- TFT Bias Supplies

Typical Application Circuit



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600 kHz Operation

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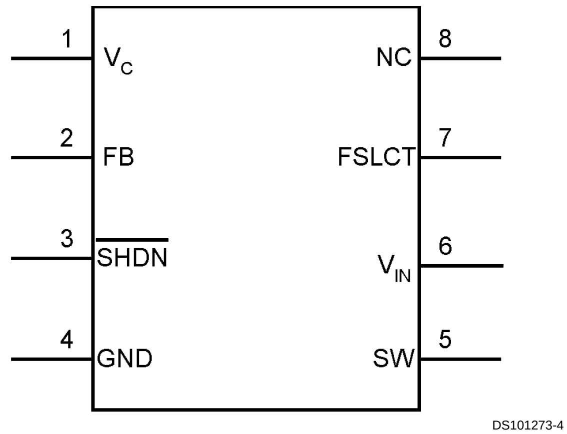
Connection Diagram

Top View



8-Lead Plastic MSOP
NS Package Number MUA08A

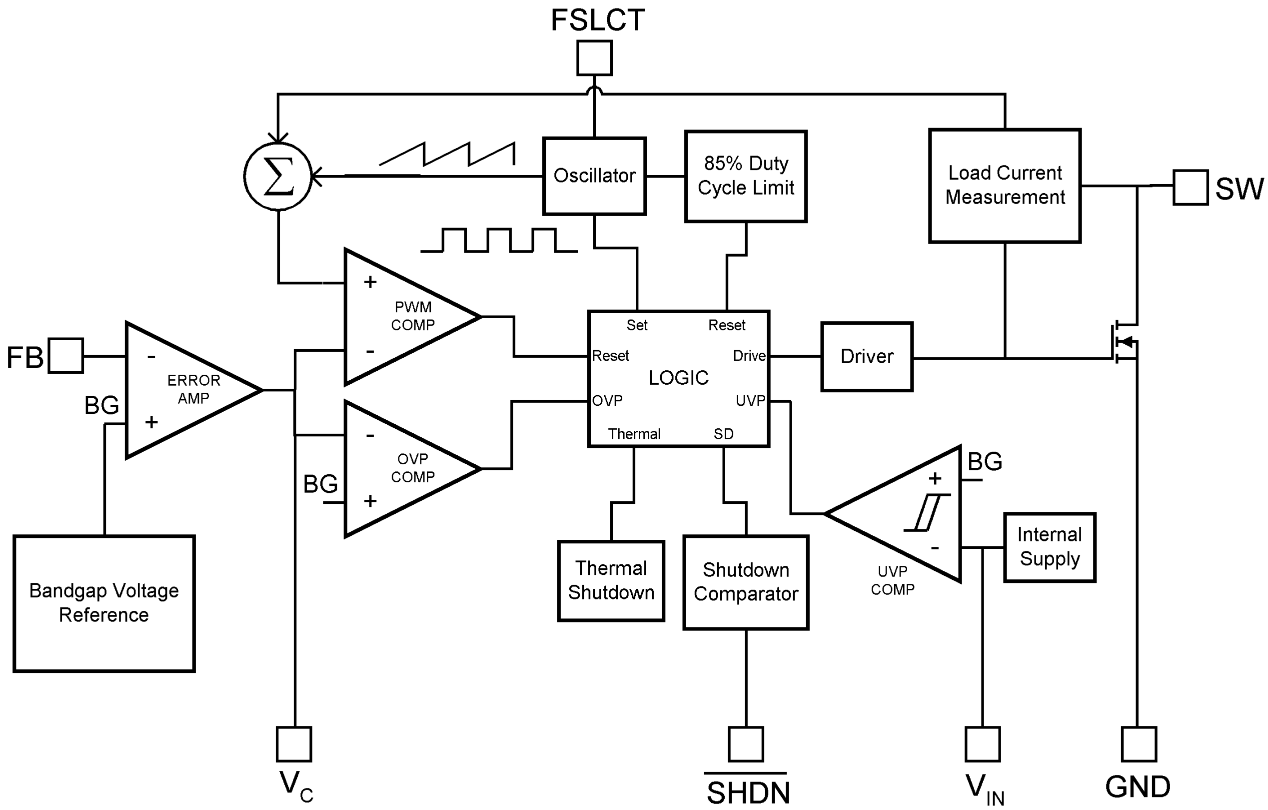
Ordering Information

Order Number	Package Type	NSC Package Drawing	Supplied As	Package ID
LM2622MM-ADJ	MSOP-8	MUA08A	1000 Units, Tape and Reel	S18B
LM2622MMX-ADJ	MSOP-8	MUA08A	3500 Units, Tape and Reel	S18B

Pin Description

Pin	Name	Function
1	V_C	Compensation network connection. Connected to the output of the voltage error amplifier.
2	FB	Output voltage feedback input.
3	$\overline{SHDN}$	Shutdown control input, active low.
4	GND	Analog and power ground.
5	SW	Power switch input. Switch connected between SW pin and GND pin.
6	V_{IN}	Analog power input.
7	FSLCT	Switching frequency select input. V_{IN} = 1.3MHz. Ground = 600kHz.
8	NC	Connect to ground.

Block Diagram



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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.

V_{IN}	12V
SW Voltage	18V
FB Voltage	7V
V_C Voltage	7V
$\overline{SHDN}$ Voltage	7V
FSLCT	12V
Maximum Junction Temperature	150˚C
Power Dissipation(Note 2)	Internally Limited
Lead Temperature	300˚C
Vapor Phase (60 sec.)	215˚C
Infrared (15 sec.)	220˚C
ESD Susceptibility (Note 3)	
Human Body Model (Note 4)	2kV
Machine Model	200V

Operating Conditions

Operating Junction Temperature Range (Note 5)	−40˚C to +125˚C
Storage Temperature	−65˚C to +150˚C
Supply Voltage	2V to 12V

Electrical Characteristics

Specifications in standard type face are for T_J = 25˚C and those with **boldface type** apply over the full **Operating Temperature Range** (T_J = −40˚C to +125˚C)Unless otherwise specified. V_{IN} =2.0V and I_L = 0A, unless otherwise specified.

Symbol	Parameter	Conditions	Min (Note 5)	Typ (Note 6)	Max (Note 5)	Units
I_Q	Quiescent Current	FB = 0V (Not Switching)		1.3	**2.0**	mA
		$V_{\overline{SHDN}}$ = 0V		5	**10**	µA
V_{FB}	Feedback Voltage		**1.2285**	1.26	**1.2915**	V
I_{CL}(Note 7)	Switch Current Limit	V_{IN} = 2.7V (Note 8)	**1.0**	1.65	**2.3**	A
$\Delta V_O/\Delta I_{LOAD}$	Load Regulation	V_{IN} = 3.3V		6.7		mV/A
$\%V_{FB}/\Delta V_{IN}$	Feedback Voltage Line Regulation	2.0V ≤ V_{IN} ≤ 12.0V		0.013	**0.1**	%/V
I_B	FB Pin Bias Current (Note 9)			0.5	**20**	nA
V_{IN}	Input Voltage Range		**2**		**12**	V
g_m	Error Amp Transconductance	ΔI = 5µA	**40**	135	**290**	µmho
A_V	Error Amp Voltage Gain			135		V/V
D_{MAX}	Maximum Duty Cycle		**78**	85		%
f_S	Switching Frequency	FSLCT = Ground	**480**	600	**720**	kHz
		FSLCT = V_{IN}	**1**	1.25	**1.5**	MHz
$I_{\overline{SHDN}}$	Shutdown Pin Current	$V_{\overline{SHDN}}$ = V_{IN}		0.01	**0.1**	µA
		$V_{\overline{SHDN}}$ = 0V		−0.5	**-1**	
I_L	Switch Leakage Current	V_{SW} = 18V		0.01	**3**	µA
R_{DSON}	Switch R_{DSON}	V_{IN} = 2.7V, I_{SW} = 1A		0.2	**0.4**	Ω
Th_{SHDN}	$\overline{SHDN}$ Threshold	Output High	**0.9**	0.6		V
		Output Low		0.6	**0.3**	V
UVP	On Threshold		**1.8**	1.92	**2.0**	V
	Off Threshold		**1.7**	1.82	**1.9**	V

Electrical Characteristics (Continued)

Specifications in standard type face are for T_J = 25˚C and those with **boldface type** apply over the full **Operating Temperature Range** (T_J = −40˚C to +125˚C)Unless otherwise specified. V_{IN} =2.0V and I_L = 0A, unless otherwise specified.

Symbol	Parameter	Conditions	Min (Note 5)	Typ (Note 6)	Max (Note 5)	Units
θ_{JA}	Thermal Resistance	Junction to Ambient(Note 10)		235		˚C/W
		Junction to Ambient(Note 11)		225		
		Junction to Ambient(Note 12)		220		
		Junction to Ambient(Note 13)		200		
		Junction to Ambient(Note 14)		195		

Note 1: Absolute maximum ratings are limits beyond which damage to the device may occur. Operating Ratings are conditions for which the device is intended to be functional, but device parameter specifications may not be guaranteed. For guaranteed specifications and test conditions, see the Electrical Characteristics.

Note 2: The maximum allowable power dissipation is a function of the maximum junction temperature, T_J(MAX), the junction-to-ambient thermal resistance, θ_{JA}, and the ambient temperature, T_A. See the Electrical Characteristics table for the thermal resistance of various layouts. The maximum allowable power dissipation at any ambient temperature is calculated using: P_D (MAX) = ($T_{J(MAX)}$ − T_A)/θ_{JA}. Exceeding the maximum allowable power dissipation will cause excessive die temperature, and the regulator will go into thermal shutdown.

Note 3: The human body model is a 100 pF capacitor discharged through a 1.5kΩ resistor into each pin. The machine model is a 200pF capacitor discharged directly into each pin.

Note 4: ESD susceptibility using the human body model is 500V for V_C.

Note 5: All limits guaranteed at room temperature (standard typeface) and at temperature extremes (bold typeface). 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 6: Typical numbers are at 25˚C and represent the most likely norm.

Note 7: Duty cycle affects current limit due to ramp generator.

Note 8: Current limit at 0% duty cycle. See TYPICAL PERFORMANCE section for Switch Current Limit vs. V_{IN}

Note 9: Bias current flows into FB pin.

Note 10: Junction to ambient thermal resistance (no external heat sink) for the MSO8 package with minimal trace widths (0.010 inches) from the pins to the circuit. See ″Scenario 'A'″ in the Power Dissipation section.

Note 11: Junction to ambient thermal resistance for the MSO8 package with minimal trace widths (0.010 inches) from the pins to the circuit and approximately 0.0191 sq. in. of copper heat sinking. See ″Scenario 'B'″ in the Power Dissipation section.

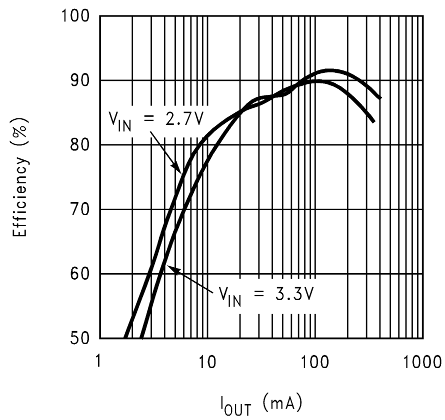
Note 12: Junction to ambient thermal resistance for the MSO8 package with minimal trace widths (0.010 inches) from the pins to the circuit and approximately 0.0465 sq. in. of copper heat sinking. See ″Scenario 'C'″ in the Power Dissipation section.

Note 13: Junction to ambient thermal resistance for the MSO8 package with minimal trace widths (0.010 inches) from the pins to the circuit and approximately 0.2523 sq. in. of copper heat sinking. See ″Scenario 'D'″ in the Power Dissipation section.

Note 14: Junction to ambient thermal resistance for the MSO8 package with minimal trace widths (0.010 inches) from the pins to the circuit and approximately 0.0098 sq. in. of copper heat sinking on the top layer and 0.0760 sq. in. of copper heat sinking on the bottom layer, with three 0.020 in. vias connecting the planes. See ″Scenario 'E'″ in the Power Dissipation section.

Typical Performance Characteristics

Efficiency vs. Load Current (V_{IN} = 3.3V, f_S = 600 kHz)



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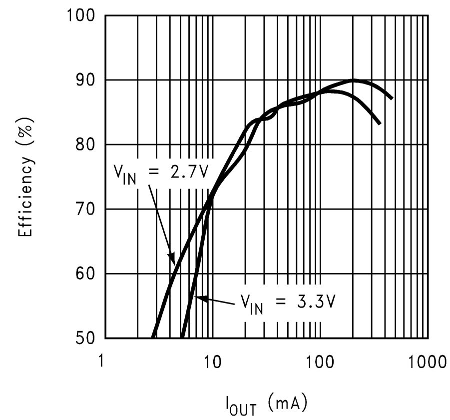
Efficiency vs. Load Current (V_{IN} = 3.3V, f_S = 1.3 MHz)



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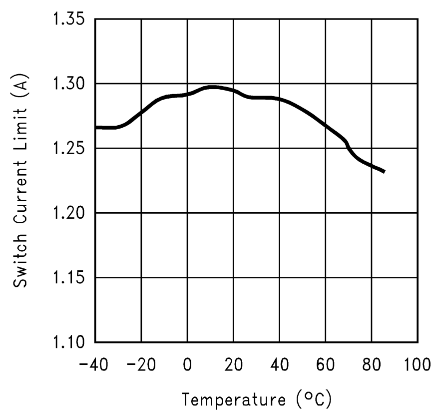
Switch Current Limit vs. Temperature (V_{IN} = 3.3V, V_{OUT} = 8V)



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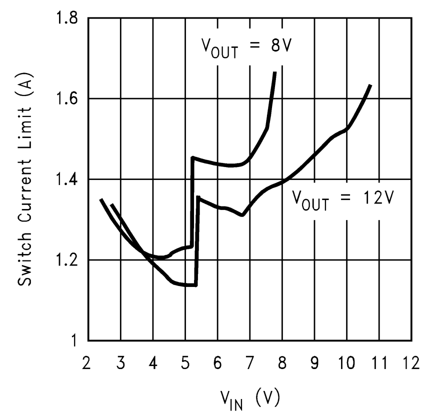
Switch Current Limit vs. V_{IN}



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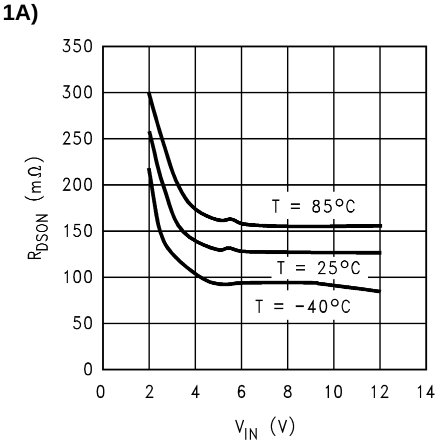
R_{DSON} vs. V_{IN} (I_{SW} = 1A)



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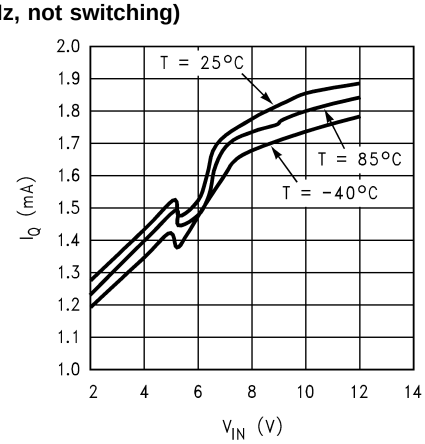
I_Q vs. V_{IN} (600 kHz, not switching)



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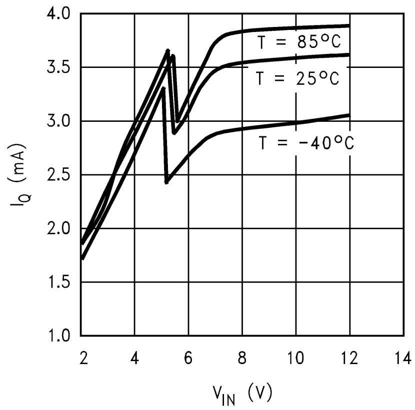
Typical Performance Characteristics (Continued)

I_Q vs. V_{IN}
(600 kHz, switching)



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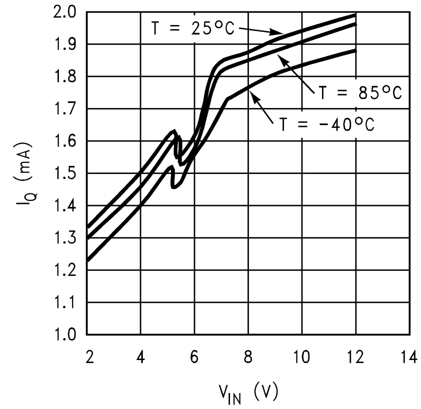
I_Q vs. V_{IN}
(1.3 MHz, not switching)



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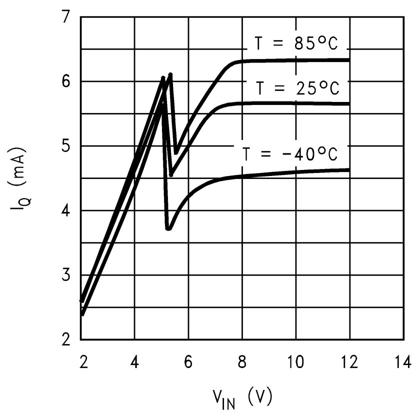
I_Q vs. V_{IN}
(1.3 MHz, switching)



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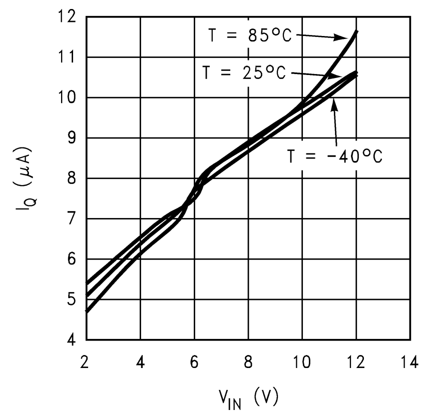
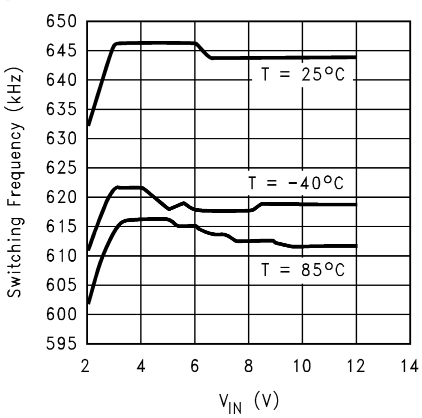
I_Q vs. V_{IN}
(In shutdown)



DS101273-18

Frequency vs. V_{IN}
(600 kHz)



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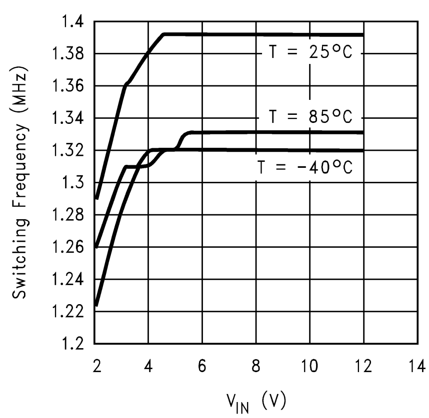
Frequency vs. V_{IN}
(1.3 MHz)



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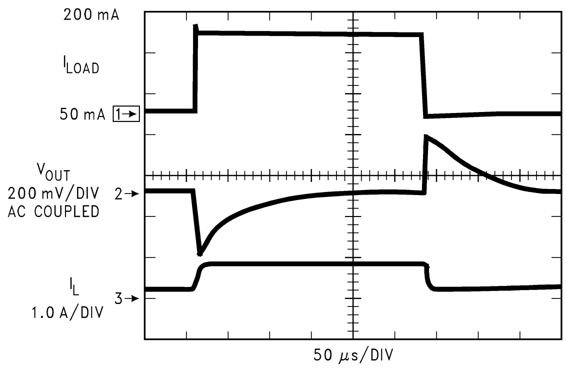
Typical Performance Characteristics (Continued)

Load Transient Response (600 kHz operation)



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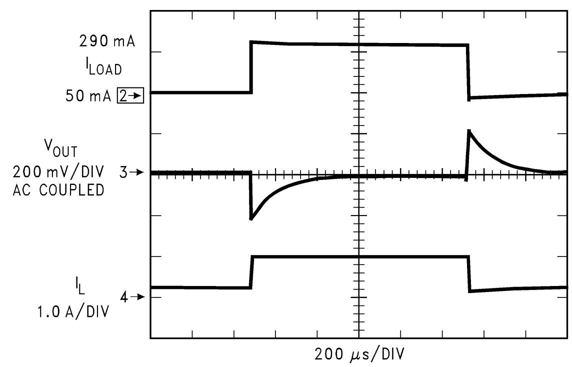
Test circuit is shown in *Figure 4*.

Load Transient Response (1.3 MHz operation)



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Test circuit is shown in *Figure 5*

Operation

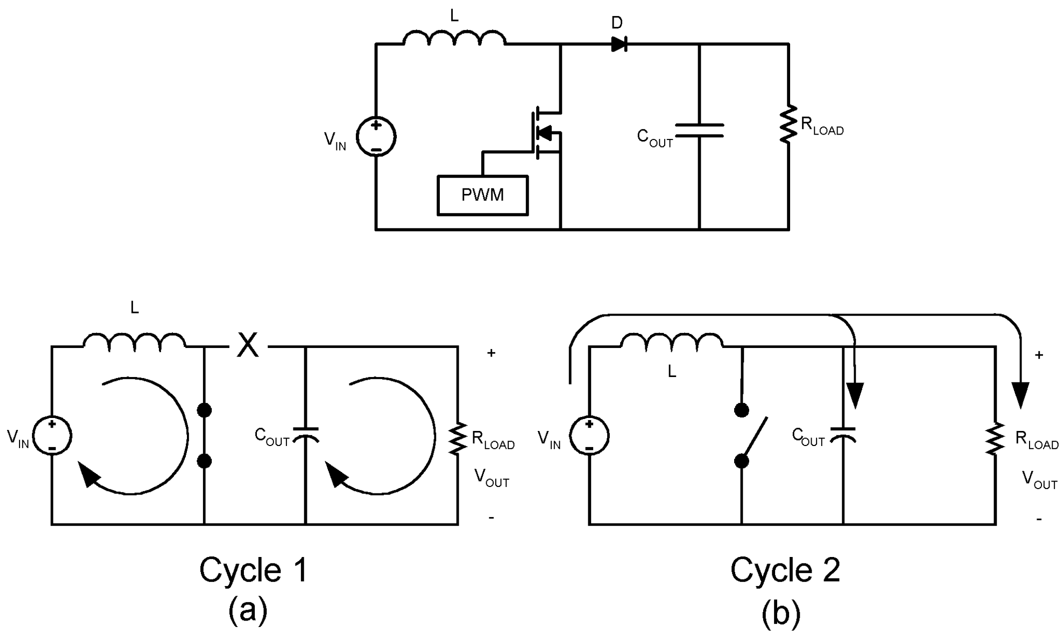

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FIGURE 1. Simplified Boost Converter Diagram
(a) First Cycle of Operation (b) Second Cycle Of Operation

Continuous Conduction Mode

The LM2622 is a current-mode, PWM boost regulator. A boost regulator steps the input voltage up to a higher output voltage. In continuous conduction mode (when the inductor current never reaches zero at steady state), the boost regulator operates in two cycles.

In the first cycle of operation, shown in *Figure 1* (a), the transistor is closed and the diode is reverse biased. Energy is collected in the inductor and the load current is supplied by C_{OUT}.

The second cycle is shown in *Figure 1* (b). During this cycle, the transistor is open and the diode is forward biased. The energy stored in the inductor is transferred to the load and output capacitor.

The ratio of these two cycles determines the output voltage. The output voltage is defined as:

$$V_{OUT} = \frac{V_{IN}}{1 - D}$$

where D is the duty cycle of the switch.

Operation (Continued)

Compensation

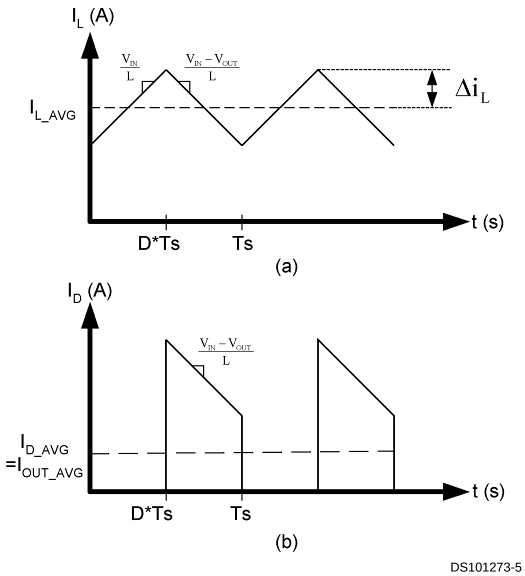


FIGURE 2. (a) Inductor current. (b) Diode current.

The LM2622 is a current mode PWM boost converter. The signal flow of this control scheme has two feedback loops, one that senses switch current and one that senses output voltage.

To keep a current programmed control converter stable above duty cycles of 50%, the inductor must meet certain criteria. The inductor, along with input and output voltage, will determine the slope of the current through the inductor (see *Figure 2* (a)). If the slope of the inductor current is too great, the circuit will be unstable above duty cycles of 50%. A 10µH inductor is recommended for 600 kHz operation, while a 4.7µH inductor may be used for 1.3 MHz operation. If the duty cycle is approaching the maximum of 85%, it may be necessary to increase the inductance by as much as 2X.

The LM2622 provides a compensation pin (COMP) to customize the voltage loop feedback. It is recommended that a series combination of R_C and C_C be used for the compensation network, as shown in *Figure 3*. For any given application, there exists a unique combination of R_C and C_C that will optimize the performance of the LM2622 circuit in terms of its transient response. The series combination of R_C and C_C introduces pole-zero pair according to the following equations:

$$z_1 = \frac{1}{2\pi R_C C_C} \text{Hz}$$

$$p_1 = \frac{1}{2\pi (R_C + R_o) C_C} \text{Hz}$$

where R_O is the output impedance of the error amplifier, 1MegΩ. For most applications, performance can be optimized by choosing values within the range 5kΩ ≤ R_C ≤ 20kΩ and 680pF ≤ C_C ≤ 4.7nF. Refer to the applications section for recommended values for specific circuits and conditions.

Application Information

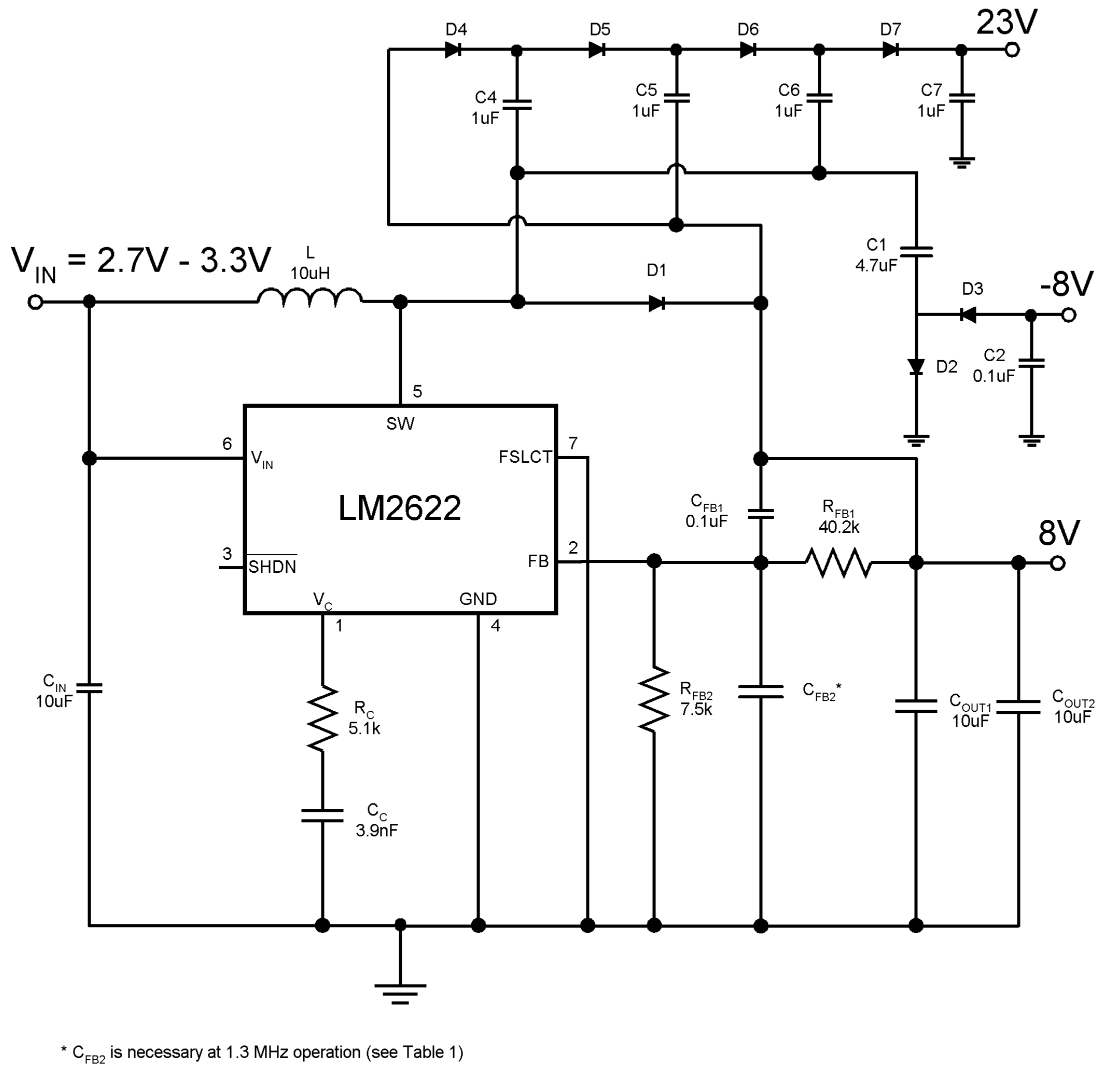


FIGURE 3. Triple Output TFT Bias (600 kHz operation)

Triple Output TFT Bias

The circuit in *Figure 3* shows how the LM2622 can be configured to provide outputs of 8V, −8V, and 23V, convenient for biasing TFT displays. The 8V output is regulated, while the −8V and 23V outputs are unregulated.

The 8V output is generated by a typical boost topology. The basic operation of the boost converter is described in the OPERATION section. The output voltage is set with R_{FB1} and R_{FB2} by:

$$R_{FB1} = R_{FB2} \frac{V_{OUT} - 1.26}{1.26} \Omega$$

C_{FB} is placed across R_{FB1} to act as a pseudo soft-start. The compensation network of R_C and C_C are chosen to optimally stabilize the converter. The inductor also affects the stability. When operating at 600 kHz, a 10uH inductor is recommended to insure the converter is stable at duty cycles greater than 50%. Refer to the COMPENSATION section for more information.

The -8V output is derived from a diode inverter. During the second cycle, when the transistor is open, D2 conducts and C1 charges to 8V minus a diode drop (≅0.4V if using a Schottky). When the transistor opens in the first cycle, D3 conducts and C1's polarity is reversed with respect to the output at C2, producing -8V.

The 23V output is realized with a series of capacitor charge pumps. It consists of four stages: the first stage includes C4, D4, and the LM2622 switch; the second stage uses C5, D5, and D1; the third stage includes C6, D6, and the LM2622 switch; the final stage is C7 and D7. In the first stage, C4 charges to 8V when the LM2622 switch is closed, which causes D5 to conduct when the switch is open. In the second stage, the voltage across C5 is VC4 + VD1 - VD5 = VC4 ≅ 8V when the switch is open. However, because C5 is referenced to the 8V output, the voltage at C5 is 16V when referenced to ground. In the third stage, the 16V at C5 appears across C6 when the switch is closed. When the switch opens, C6 is referenced to the 8V output minus a diode drop, which raises the voltage at C6 with respect to ground to about 24V. Hence, in the fourth stage, C7 is charged to 24V when the switch is open. From the first stage to the last,

Application Information (Continued)

there are three diode drops that make the output voltage closer to 24 - 3xVDIODE (about 22.8V if a 0.4V forward drop is assumed).

TABLE 1. Components For Circuits in *Figure 3*

Component	600 kHz	1.3 MHz
L	10µH	4.7µH
COUT1	10µF	22µF
COUT2	10µF	NOT USED
CC	3.9nF	1.5nF
CFB1	0.1µF	15nF
CFB2	NOT USED	560pF
CIN	10µF	22µF
C1	4.7µF	4.7µF
C2	0.1µF	0.1µF
C4	1µF	1µF
C5	1µF	1µF
C6	1µF	1µF
C7	1µF	1µF
RFB1	40.2kΩ	91kΩ
RFB2	7.5kΩ	18kΩ
RC	5.1kΩ	10kΩ
D1	MBRM140T3	MBRM140T3
D2	BAT54S	BAT54S
D3		
D4	BAT54S	BAT54S
D5		
D6	BAT54S	BAT54S
D7		

Application Information (Continued)

600 kHz Operation

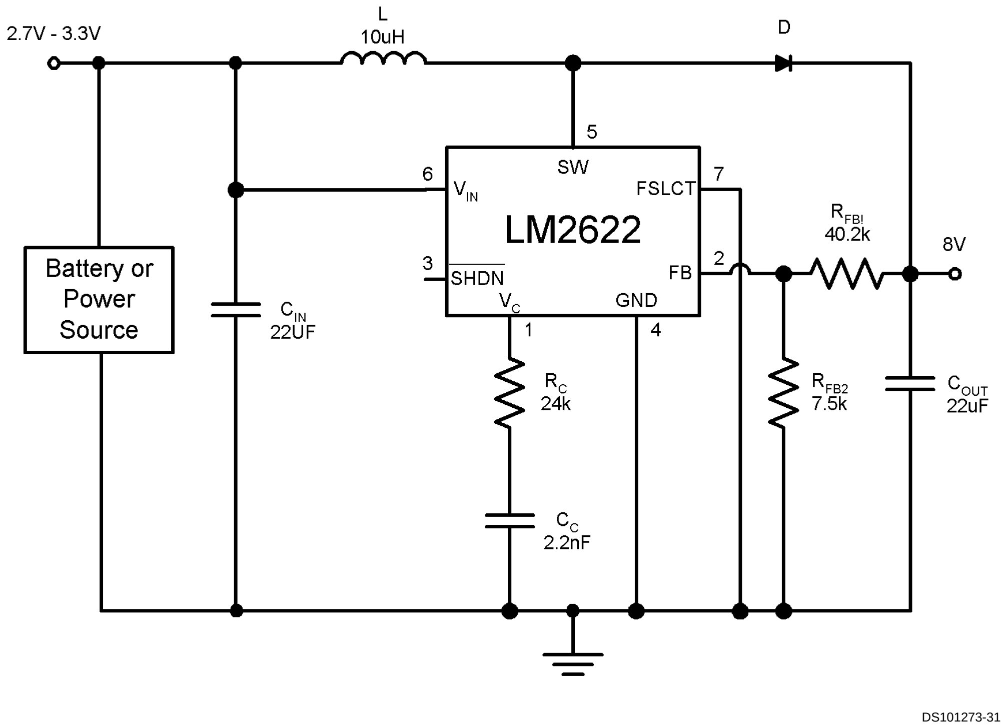


FIGURE 4. 600 kHz operation

1.3 MHz Operation

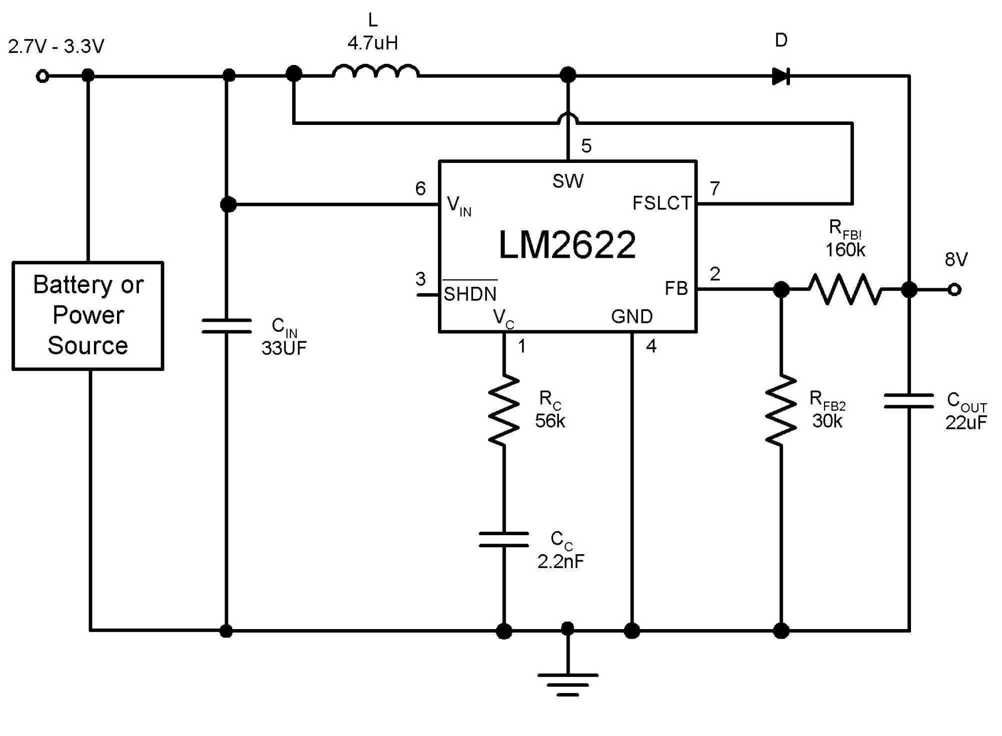


FIGURE 5. 1.3 MHz operation

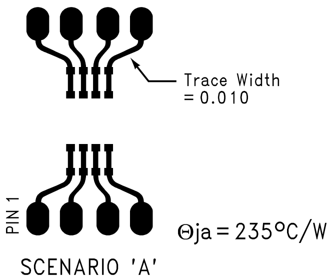
Application Information (Continued)

Power Dissipation

The output power of the LM2622 is limited by its maximum power dissipation. The maximum power dissipation is determined by the formula

$$P_D = (T_{jmax} - T_A)/\theta_{JA}$$

where T_{jmax} is the maximum specdfied junction temperature (125˚C), T_A is the ambient temperature, and θ_{JA} is the thermal resistance of the package. θ_{JA} is dependant on the layout of the board as shown below.



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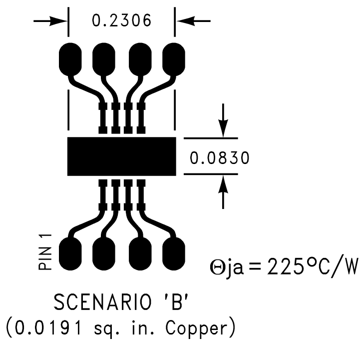

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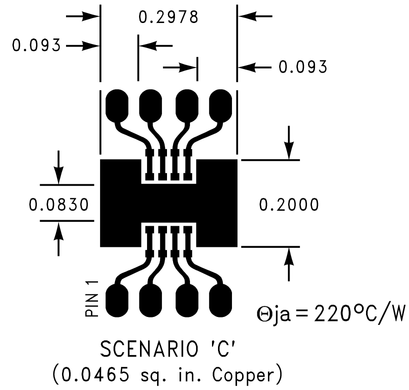

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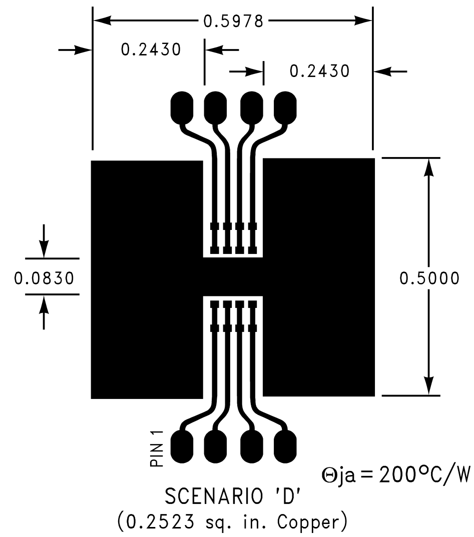

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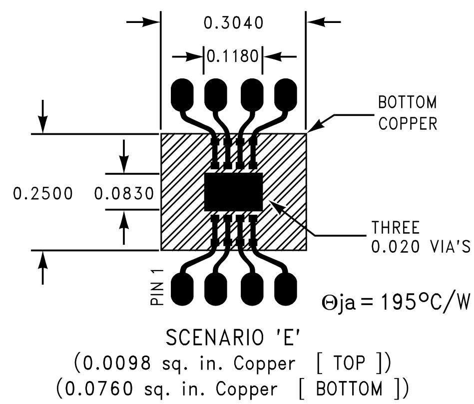

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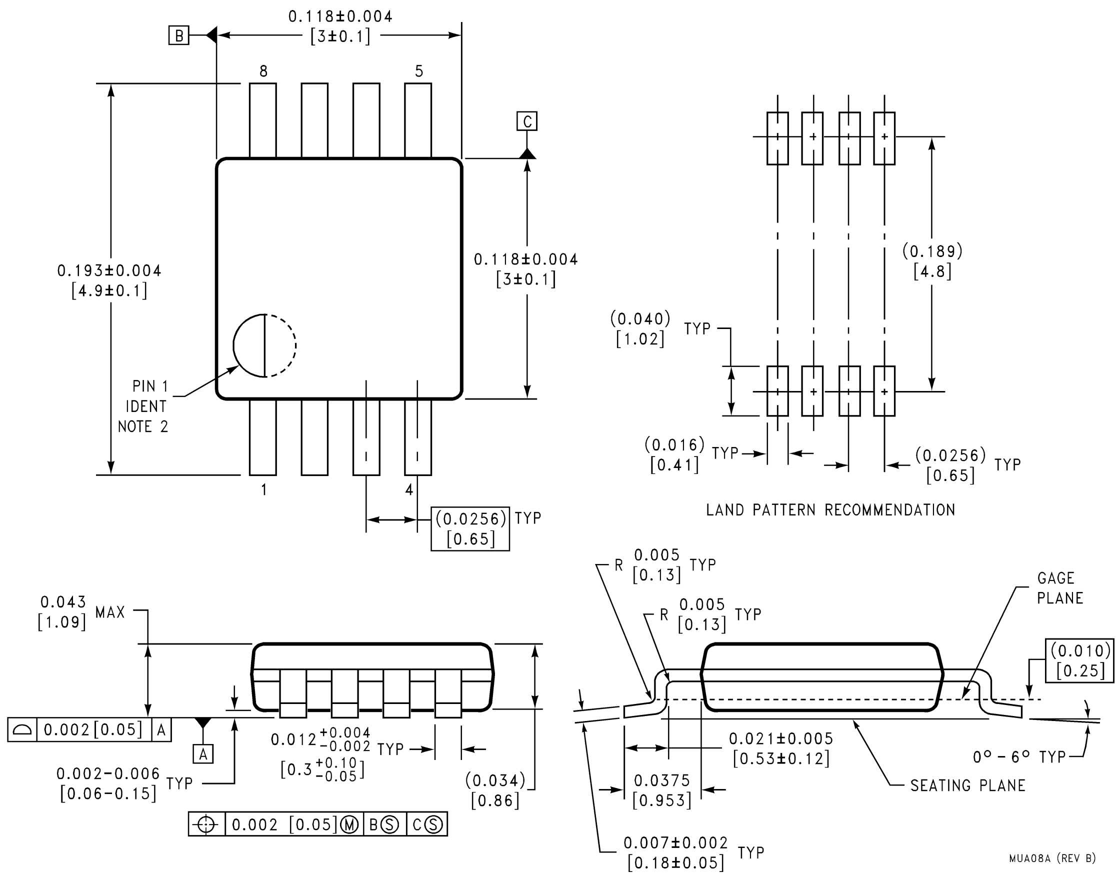
Physical Dimensions inches (millimeters) unless otherwise noted



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