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Change Summary

CHANGES

No	Applicable Section	Description	Page(s)
1	Features	Change input voltage range to '1.8V to 5.5V'	1
2	Pin Description	Update Pin No.3 DIM-ENA description: analog dimming control voltage range to '0.8V to 1.4V'	2
3	Recommended Operating Range	a. Change VCC-Input Voltage b. Fill in Thermal Impedance	2
4	Electrical Characteristics	a. Update General Test Conditions b. Update Input Voltage Range c. Update Internal Reference Voltage d. Update Driver Output Switching Frequency e. Update Disable Threshold & Over-voltage protection Threshold f. Update Analog Dimming Voltage Range	3
5	Functional Description	Update the voltage range in Functional Information according to the change in Electrical Characteristics	5
6	Throughout datasheet	Miscellaneous changes	---

REVISION HISTORY

Revision No.	Description of change	Release Date
0.50	Initial release	09/17/04
0.60	***1. Features:*** a. Change 'input voltage range' from 1.5V-5.5V to 1.6V-5.5V; b. Delete 'Under-voltage protection'. ***2. Ordering Information:*** a. Change part number to OZ9950MN due to the package change from TSOP to MSOP; b. Add 'OZ9950IMN' package. ***3. Pin Diagram:*** Change pin sequence due to package change. ***4. Pin Description:*** Change pin sequence due to package change. ***5. Absolute Max Ratings:*** Update 'Operating Temp.' ***6. Recommended Operating Range:*** Change 'VCC-Input Voltage' range. ***7. Electrical Characteristic:*** a. Change 'Supply input voltage range' Min limit; b. Delete 'Driver output voltage'; c. Change 'Over-voltage protection' Typ limit; d. Delete 'Under-voltage protection'; e. Delete note (1).f. Changed supply current parameter from 0.9mA to 1.2mA. ***8. Functional Description:*** Change pin numbers in the functional description due to package change. ***9. Reference Application Circuit:*** Change pin sequence due to package change. ***10. Package Information:*** Change package from TSOP to MSOP	06/10/05
0.90	***1. Features:*** Delete 'Over-temperature protection'. ***2. General Description:*** Delete 'and Over-temperature' in 2nd sentence. ***3. Functional Information:*** Modify functional information. ***4. Reference Application Circuit:*** Modify reference application circuit	10/28/05
0.91	***1. Ordering Information:*** Added OZ9950GN. ***2. Package Information:*** Added 8-SOP package drawings.	02/16/06

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OZ9950

White LED Controller

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FEATURES

- High efficiency DC-DC step up converter for the white LED drivers
- 1.8 V to 5.5 V input voltage range
- PWM or Analog dimming control
- Over-voltage protection
- Soft Start
- Low standby current
- Small inductor & capacitor values

APPLICATIONS

- PDA
- Cellular phones
- Color displaying backlights

ORDERING INFORMATION

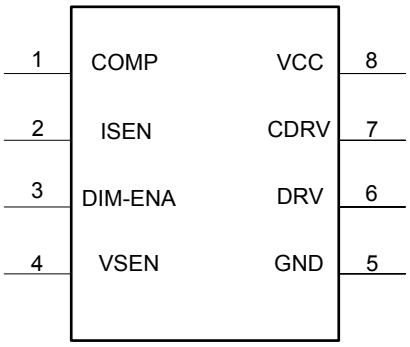
Part Number	Temp Range	Package
OZ9950MN	-20°C to 85°C	8-pin MSOP, Lead-Free
OZ9950IMN	-40°C to 85°C	8-pin MSOP, Lead-Free
OZ9950GN	-20°C to 85°C	8-pin SOP, Lead-Free

GENERAL DESCRIPTION

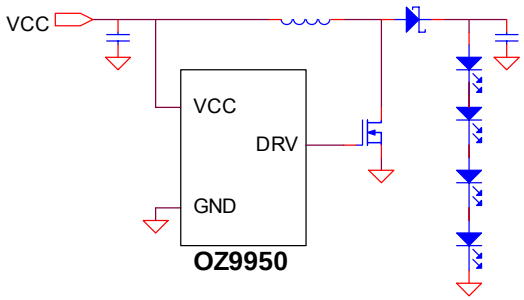
OZ9950 is a high efficiency, DC-DC step up converter that allows a series connection of White LEDs resulting in uniform brightness. The step-up converter topology works in a discontinuous mode to allow the use of a small inductor and ease of loop stability that results in a high efficiency and low cost module. An external Pulse Width Modulation (PWM) signal or external voltage can be used for the dimming control function. The IC provides the user with an over-voltage protection feature. A soft start feature is provided to minimize in-rush current during start-up. OZ9950 operates with a standby current of approximately 0.2uA.

Applications include PDAs, cellular phones, and color display backlights.

PIN DIAGRAM



TYPICAL OPERATING CIRCUIT



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PIN DESCRIPTION

Pin No.	Names	Description
1	COMP	Soft start / compensation
2	ISEN	Sense input for load current
3	DIM-ENA	Shut down input, active low. Dimming Control: 1) For analog dimming control apply 0.8V to 1.4V DC voltage or 2) For external PWM pulse for digital dimming control
4	VSEN	Over-voltage protection
5	GND	Ground
6	DRV	Driver output for external NMOS switch
7	CDRV	Decoupling capacitor of an internal LDO
8	VCC	Battery voltage.

ABSOLUTE MAXIMUM RATINGS(1)

Input Voltage	7V
GNDA	+/- 0.3V
Signal Inputs	-0.3V to (VCC + 0.3)V

Operating Temp.	OZ9950	OZ9950I
	-20°C to +85°C	-40°C to +85°C

Operating Junction Temp.	125°C
Storage Temp.	-55°C to 150°C

RECOMMENDED OPERATING RANGE

VCC - Input Voltage	1.8V to 5.5V
Thermal Impedance (θ_{J-A}) 8-pin MSOP	101°C/W

Note (1): The "Absolute Maximum Ratings" are those values beyond which the safety of the device cannot be guaranteed. The device should not be operated at these limits. The "Electrical Characteristics" table defines the conditions for actual device operation. Exposure to absolute maximum rated conditions for extended periods may affect device reliability.

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ELECTRICAL CHARACTERISTICS

Parameter	Symbol	Test Conditions		Limits		Unit
		VCC =1.8V to 5.5V unless specified	Min	Typ	Max	
SUPPLY						
Input Voltage Range			1.8		5.5	V
Supply current		DIM-ENA=High			1.2	mA
Quiescent Current		VCC=5V DIM-ENA= GND	-	0.2	-	μA
INTERNAL REFERENCE VOLTAGE						
ISEN		VCC = 3.3V, Temp = 25°C	178	196	213	mV
Temperature Coefficient			-	250	-	Ppm/°C
DRIVER OUTPUT						
Switching Frequency		VCC = 3.3V Temp = 25°C	230	280	330	KHz
THRESHOLD						
Enable			0.8			V
Disable					0.4	V
Over-voltage protection	VSEN		0.95	1	1.05	V
DIMMING						
Analog Dimming Voltage Range			0.8	-	1.4	V

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FUNCTIONAL BLOCK DIAGRAM

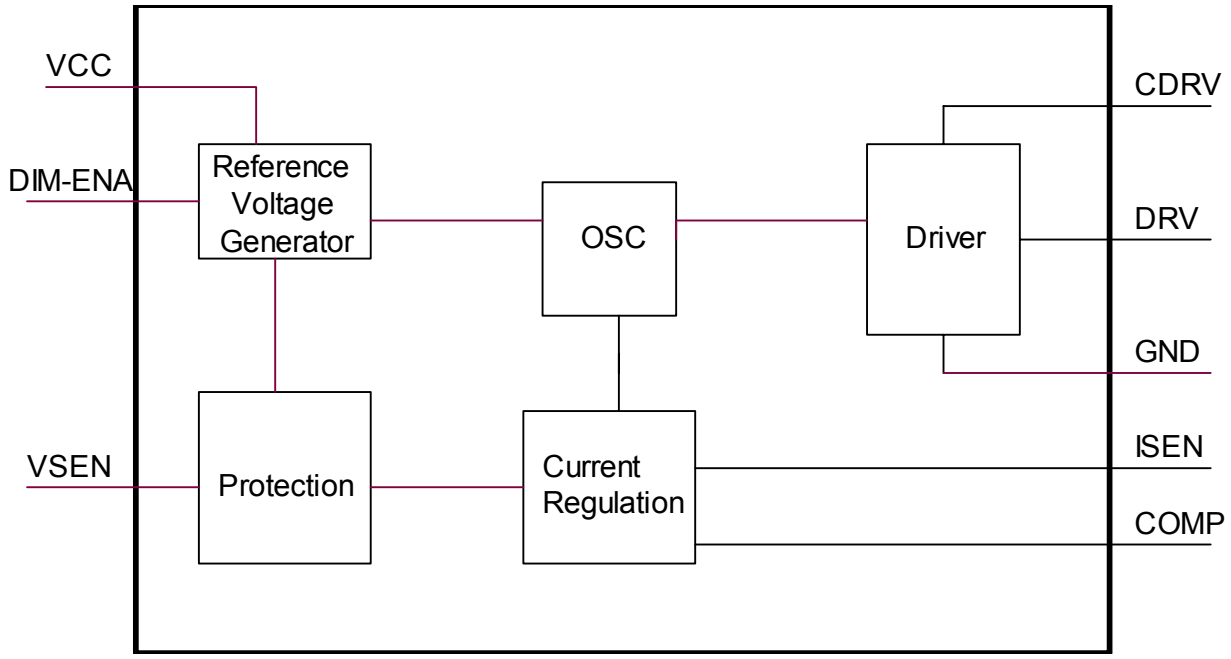

Figure 1

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FUNCTIONAL DESCRIPTION

Refer to the Functional Block Diagram in Figure 1, Page 4.

The Reference Voltage Generator Block generates voltages that are used for all internal blocks. This ensures that the IC is functional at a supply voltage of 1.8V.

A soft-start feature is provided to prevent high peak input current during start-up.

The Oscillator (OSC) Block generates a constant frequency for OZ9950 operation.

The Current Regulation Block consists of a tranconductance operational amplifier (OTA) that regulates the LED current.

The Driver Block provides a PWM drive signal to drive the external N-Channel MOSFET.

The Protection Block provides the circuitry for over-voltage and over-temperature protection.

FUNCTIONAL INFORMATION

Refer to the Typical Application Circuit in Figure 2, Page 7.

1. ENABLE

OZ9950 is enabled when the voltage to DIM-ENA (Pin 3) is greater than 0.8V. A voltage of less than 0.4V disables the IC.

2. SOFT START

To avoid in-rush current to the load during turn-on, a soft-start function is implemented to provide reliable load operation. The soft start function is initiated when the voltage at DIM-ENA is greater than 0.8V. The soft-start time is determined by capacitor C3 connected to COMP (Pin 1).

3. LED CURRENT REGULATION

Once the IC is enabled, the LED current reaches the pre-set level and is sensed by resistor R9 connected to ISEN (Pin 2), the circuit begins to regulate LED current. The operating frequency is fixed thus minimizing EMI.

An external resistor (R9) connected from ISEN (pin 2) to GND sets the white LED current. The value of this resistor can be calculated from the following equation:

$$I_{LED} = \frac{0.20}{Rsense}$$

4. DIMMING CONTROL

OZ9950 allows for both analog and PWM dimming control.

A. Analog Dimming

Analog dimming control is achieved by varying the DC voltage level applied to DIM-ENA (Pin 3). The voltage range of ~0.8V (minimum brightness) to ~1.4V (maximum brightness) controls the panel brightness.

In addition, a voltage greater than 1.4V to DIM-ENA pin will output maximum current from OZ9950.

B. PWM Dimming

PWM dimming control is achieved by applying an external LPWM signal of 100Hz to 300Hz with a peak of greater than approximately 1.4V to Vcc and a valley of less than approximately 0.4V to DIM-ENA (pin 3). Varying the LPWM duty cycle controls the panel brightness.

The output current will remain at the maximum level, when a voltage greater than 1.4V is applied to pin DIM-ENA

5. PROTECTION FEATURES

A. Over-Voltage Protection

In the event of an open-circuit, the over-voltage protection feature will be activated when the voltage at VSEN pin exceeds 1V. If this condition exists for a duration of approximately 64usec, the DRV (Pin 6) output will be pulled low to prevent the external power MOSFTET from switching. Toggle DIM-ENA to restart the IC.

6. MINIMUM OFF-TIME

Limiting the drive duty cycle of the external NMOS switch provides short-circuit protection. The maximum duty cycle of DRV (Pin 6) output is limited at approximately 80%.

7. INDUCTOR SELECTION

The LED driver is designed to operate in discontinuous mode to allow the use of a smaller inductor and capacitor. Proper selection of

inductor is necessary to ensure that the converter still operates in this mode at the lowest VCC and maximum load.

A. Inductor Selection

$$L_{crit} = \frac{1}{2} \times \frac{Vout \times D \times (1-D)^2 \times T}{I_{LED}(\max)}$$

where $D_{\max} = 1 - \frac{Vcc(\min)}{Vout(\max)}$

$$T = 4u\sec$$

The selected inductor has to be smaller than this value to ensure that the converter works in discontinuous mode.

B. Inductor Peak Current

$$I_{PEAK} = \frac{Vcc \times Ton}{L} \quad (Amps)$$

where

$$Ton = T \times \left[\frac{(Vout - Vcc) \times 2 \times L \times I_{LED}}{T \times Vcc^2} \right]^{1/2}$$

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REFERENCE APPLICATION CIRCUIT

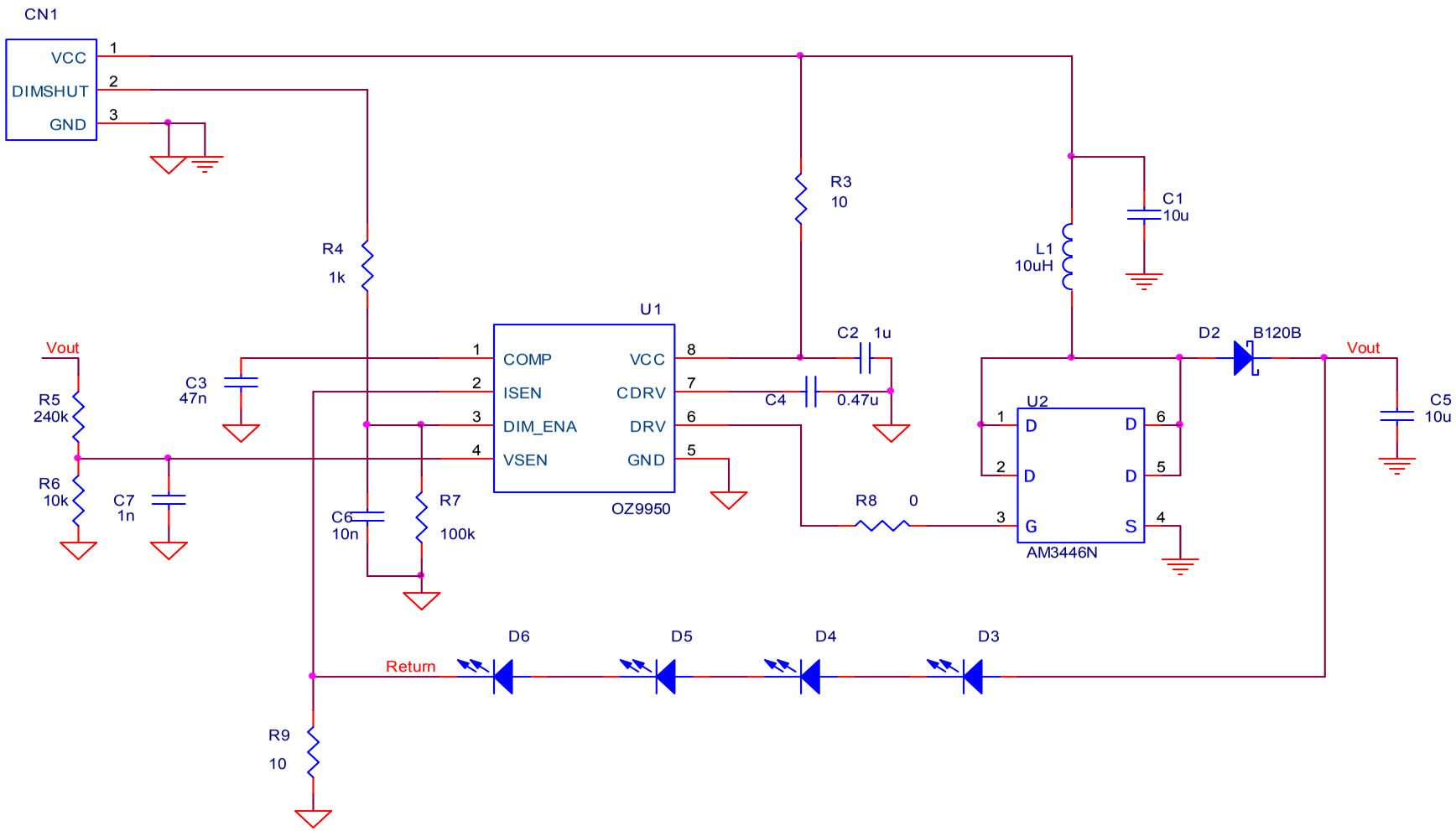

Figure 2

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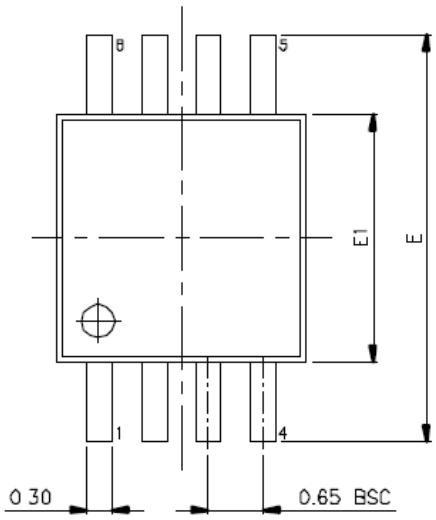
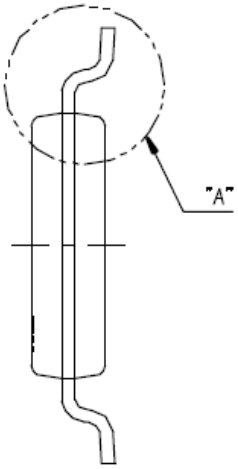
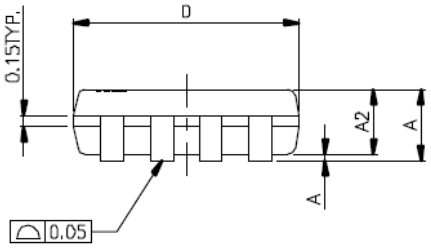
PACKAGE INFORMATION – 8-PIN MSOP: OZ9950M (118mil)

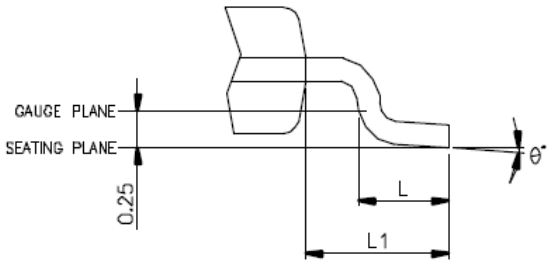






SYMBOLS	MIN.	NOM.	MAX.
A	–	–	1.10
A1	0.00	–	0.15
A2	0.75	0.85	0.95
D		3.00 BSC	
E		4.90 BSC	
E1		3.00 BSC	
L	0.40	0.60	0.80
L1		0.95 REF	
θ°	0	–	8

UNIT : MM



NOTES:
1. JEDEC OUTLINE : MO-187 AA
2. DIMENSION 'D' DOES NOT INCLUDE MOLD FLASH, PROTRUSIONS OR GATE BURRS. MOLD FLASH, PROTRUSIONS OR GATE BURRS SHALL NOT EXCEED 0.15 PER SIDE.
3. DIMENSION 'E1' DOES NOT INCLUDE INTERLEAD FLASH OR PROTRUSION. INTERLEAD FLASH OR PROTRUSION SHALL NOT EXCEED 0.25 PER SIDE.
4. DIMENSION '0.22' DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL BE 0.08 MM TOTAL IN EXCESS OF THE '0.22' DIMENSION AT MAXIMUM MATERIAL CONDITION. DAMBAR CANNOT BE LOCATED ON THE LOWER RADIUS OF THE FOOT. MINIMUM SPAC BETWEEN PROTRUSION AND ADJACENT LEAD IS 0.07 MM
5. DIMENSIONS 'D' AND 'E1' TO BE DETERMINED AT DATUM PLANE H .

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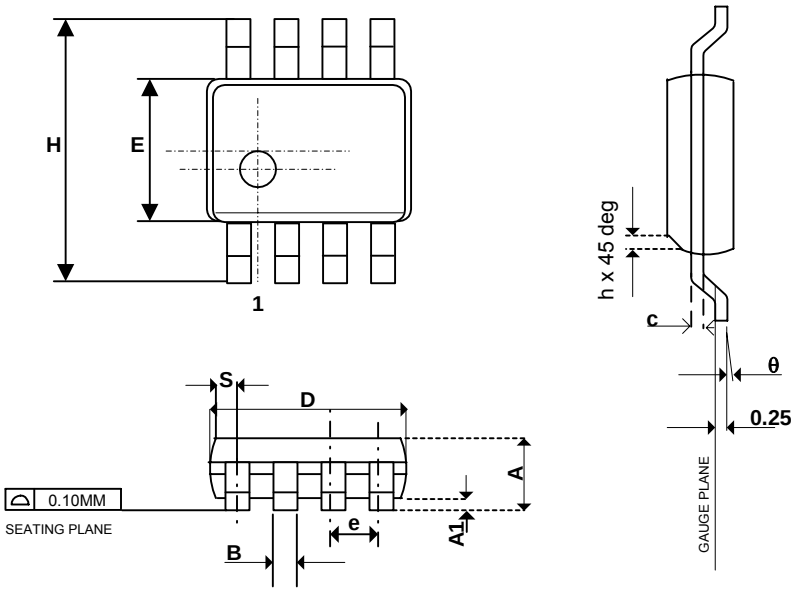
PACKAGE INFORMATION – 8-PIN SOP: OZ9950GN (150mil)



DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	0.053	0.069	1.35	1.75
A1	0.004	0.010	0.10	0.25
B	0.013	0.020	0.33	0.51
c	0.008	0.010	0.19	0.25
E	0.150	0.157	3.80	4.00
e	0.050 BSC.		1.27 BSC.	
H	0.228	0.244	5.80	6.20
h	0.010	0.020	0.25	0.50
S	0.0155	0.0255	0.394	0.648
θ	0°	8°	0°	8°
D	-	-	4.80	5.00
JEDEC	MS-012AA			

Notes:
1. Controlling dimensions are in millimeter (mm).
2. Pin #1 count orientation shall be in counterclockwise direction as viewed in live-bug position.

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