

## Change Summary

### CHANGES

No	Applicable Section	Description	Page(s)
1	Footer	Added patent numbers	0

### REVISION HISTORY

Revision No.	Description of change	Release Date
0.90	Initial release	09/09/04
1.0	<p>Features: <b>1.</b> Add 'Built-in intelligence to ignite positive impedance CCFLs'; <b>2.</b> Add 'Shutdown delay for input brownout condition'; <b>3.</b> Delete 'Tight parameter tolerance'</p> <p>General Description: <b>1.</b> Add 'OZ9936 drives all types of CCFLs and is able to ignite positive impedance CCFLs. OZ9936 provides a shutdown delay feature for input brownout condition.' after 'OZ9936 operates at a constant...'. <b>2.</b> Move the paragraph 'The OZ9936 provides two drive...' to the 2<sup>nd</sup> paragraph</p> <p>Electrical Specifications: <b>a.</b> Update 'Supply Current' Max limits; <b>b.</b> Update 'Soft Start Current Source' Typ &amp; Max limits; <b>c.</b> Update 'Under Voltage Lockout' Min, Typ &amp; Max limits; <b>d.</b> Update 'ENA_SST_CMP Pin – Low' Max limit; <b>e.</b> Update Operating Frequency on DRV1 &amp; DRV2 Pin' Min, Typ &amp; Max limits &amp; Temperature Coefficient; <b>f.</b> Update 'Duty Cycle on DRV1 &amp; DRV2 (active high)' Max limit; <b>g.</b> Update 'Ignition Time' Min &amp; Max limits; <b>h.</b> Add 'Open Lamp Shutdown Delay Time' parameters; <b>i.</b> Update 'V1(ENA_SST_CMP Pin) Threshold' Min limit; <b>j.</b> Update 'Drivers' Typ &amp; Max limits; <b>k.</b> Update 'Analog Dimming Control' Min, Typ &amp; Max limits; <b>l.</b> Update 'External PWM Dimming Control' Min, Typ &amp; Max limits and add temperature coefficient.</p> <p>Functional Description: Modify No. 7. Open Lamp Protection.</p> <p>Throughout data sheet: Miscellaneous corrections.</p>	03/09/05

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## LCD Monitor CCFL Inverter Controller

### FEATURES

- Built-in intelligence to ignite positive impedance CCFLs
- Low cost LCD monitor inverter solution
- Constant operating frequency
- Built-in intelligence for ignition and normal operation of CCFLs
- Built-in open-lamp protection and over-voltage protection
- Optimized soft-start function
- Supports both analog and external PWM dimming control
- Shutdown delay for input brownout condition
- Higher reliability and longer CCFL life
- Supports multiple CCFLs
- Minimum external components

OZ9936 operates at a constant operating frequency that eliminates any undesired interference between the controller and LCD panel. OZ9936 drives all types of CCFLs and is able to ignite positive impedance CCFLs. OZ9936 provides a shutdown delay feature for input brownout condition.

The control logic provides a regulated ignition voltage and appropriate protection for over-voltage or over-current conditions.

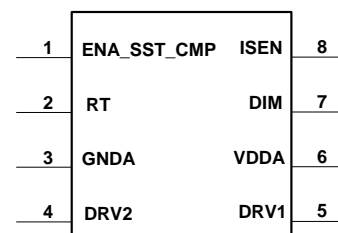
The OZ9936 offers a high level of integration, while maintaining flexibility and high-efficiency operation that reduces component heating. This results in higher reliability and longer CCFL life. The proprietary (patent pending) design technique provides a simpler, lower-cost system solution.

### ORDERING INFORMATION

Part Number	Temp Range	Package
OZ9936G	0°C to 70°C	8-pin SOIC
OZ9936GN	0°C to 70°C	8-pin SOIC, Leadfree
OZ9936IG	-40°C to 85°C	8-pin SOIC
OZ9936IGN	-40°C to 85°C	8-pin SOIC, Leadfree
OZ9936D	0°C to 70°C	8-pin PDIP
OZ9936DN	0°C to 70°C	8-pin PDIP, Leadfree

The CCFL backlight controller is designed for low-cost LCD monitor applications. OZ9936 provides an analog dimming control where the CCFL brightness is controlled by adjusting the current amplitude. In addition, the IC provides a PWM dimming function with an external PWM signal. The controller converts unregulated DC voltages into a nearly sinusoidal lamp voltage and current waveforms.

### PIN DIAGRAM

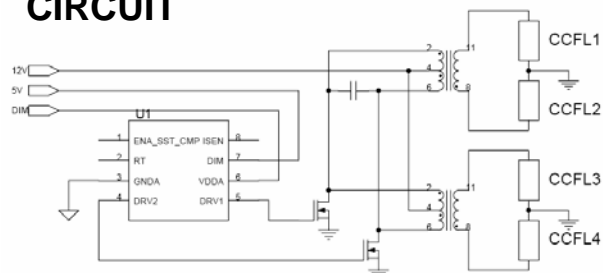


### GENERAL DESCRIPTION

The patent pending OZ9936 is a cost-effective CCFL (Cold Cathode Fluorescent Lamp) Power Management controller designed for driving CCFLs in Liquid Crystal Display (LCD) applications.

The OZ9936 provides two drive signals for most power conversion topologies, such as push-pull, half-bridge, full-bridge or Class-D inverters while maintaining high-efficiency operation. The highly integrated controller provides current and voltage regulation, soft-start operation, over-voltage protection and an external enabling function while maintaining a high-degree of design flexibility. The application requires a minimum number of off-the-shelf components.

### TYPICAL OPERATING CIRCUIT



## PIN DESCRIPTION

Names	Pin No.	Description
ENA_SST_CMP	1	Enable, Soft Start Time and Compensation for Current and Voltage
RT	2	Timing Resistor to Provide Striking and Operating Frequency
GND A	3	Ground
DRV2	4	N MOSFET Drive Output
DRV1	5	N MOSFET Drive Output
VDDA	6	Supply Voltage
DIM	7	Dimming Voltage Adjust Input
ISEN	8	Current Sense Feedback

## ABSOLUTE MAXIMUM RATINGS<sup>(1)</sup>

Input Voltage VDDA	7.0V
GND A	+/- 0.3V
Signal Inputs	-0.3V to VDDA +0.3V

Operating Temp.	OZ9936	OZ9936I
	0°C to +70°C	-40°C to +85°C

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

## RECOMMENDED OPERATING RANGE

VDDA - Input Voltage	4.5V to 5.5V
f <sub>op</sub> - Operating Frequency	30KHz to 150KHz
Thermal Impedance ( $\theta_{J-A}$ )	
- 8-pin PDIP	74°C/W
- 8-pin SOIC	113°C/W

Note <sup>(1)</sup>: 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.

## ELECTRICAL CHARACTERISTICS

Parameter	Symbol	Test Conditions	Limits			Unit
			Min	Typ	Max	
VDDA=5V; RT=100K; CSST=12.1nF, Ta=25 °C						
<b>Supply Current</b>						
Stand By	I <sub>dds</sub>	V <sub>1</sub> =0V; V <sub>8</sub> =0V		350	600	μA
Operating	I <sub>dd</sub>	V <sub>1</sub> =2V; V <sub>8</sub> =0V Capacitance at DRV1 & DRV2=500pF		1.5	3.5	mA
<b>Soft Start Current Source</b>	I <sub>SST</sub>	V <sub>1</sub> =0V; V <sub>8</sub> =0V; V <sub>7</sub> =0V	1.7	3.0	4.3	μA
<b>Under Voltage Lockout</b>	UVLO	V <sub>1</sub> =1.2V; VDDA from 0V to 5V	3.2	3.8	4.4	V
<b>ENA_SST_CMP Pin - Low</b>	V <sub>COMP</sub>		0.77	0.83	0.90	V
<b>Operating Frequency on DRV1 &amp; DRV2 Pin</b>	f <sub>op</sub>	V <sub>1</sub> =1.2V; V <sub>8</sub> =660mV; V <sub>7</sub> =2.8V	48.5	50.0	51.5	kHz
		Température Coefficient		66		ppm/°C
<b>Duty Cycle on DRV1 &amp; DRV2 (active high)</b>						
Maximum		V <sub>1</sub> =3.5V; V <sub>8</sub> =0V; V <sub>7</sub> =0V	43			%
<b>Ignition Time (Open Lamp Time Out)</b>		V <sub>8</sub> =0V; V <sub>7</sub> ≥3.25V	1.8	2.0	2.2	sec
<b>Open Lamp Shutdown Delay Time</b>		I <sub>SEN</sub> <0.75V	2.21	2.60	2.99	sec
<b>V<sub>1</sub> (ENA_SST_CMP Pin) Threshold</b>	ENA		600			mV
<b>Drivers</b>						
DRV1	R <sub>on</sub>	For I <sub>out</sub> = 70 mA; T <sub>amb</sub> =25°C		20	40	Ω
DRV2	R <sub>on</sub>	For I <sub>out</sub> = 70 mA; T <sub>amb</sub> =25°C		20	40	Ω
<b>Analog Dimming Control</b>						
Minimum Lamp Current Reference Voltage			0.40	0.55	0.86	V
Maximum Lamp Current Reference Voltage			1.15	1.235	1.35	V
<b>External PWM Dimming Control</b>						
PWM Dimming Detection Threshold				2.7		V
Lamp Current Reference Voltage	I <sub>SEN</sub>		1.17	1.25	1.32	V
		Température Coefficient		85		ppm/°C

Note: V<sub>x</sub> denotes voltage at Pin<sub>x</sub>

## FUNCTIONAL BLOCK DIAGRAM

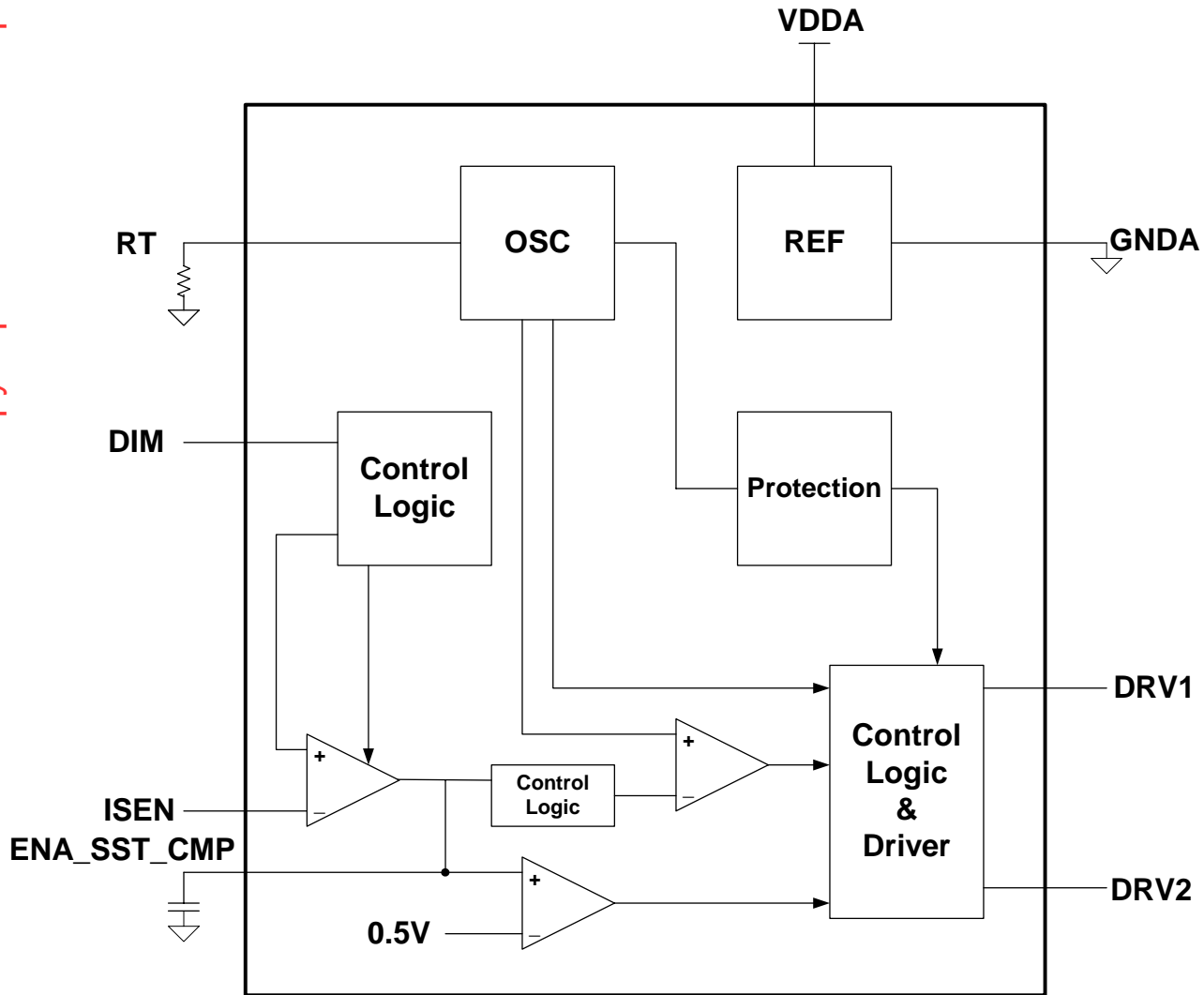


Figure 1

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## FUNCTIONAL DESCRIPTION

### 1. Power Conversion

The power train can be selected from the standard half-bridge, full-bridge, push-pull or Class-D topologies to provide symmetrical drive pulses to the tank circuit that includes the transformer(s), output capacitors and the CCFL/panel load, to yield quasi-sinusoidal CCFL voltage and current waveforms. High-efficiency operation of the OZ9936 yields lower heat dissipation for the inverter system resulting in higher reliability.

To illustrate the controller functions, refer to Figures 1 and 2 on pages 4 and 7, respectively for the following sections. Other topologies can be found in the OZ9936 Application Note.

### 2. Enable

The OZ9936 is enabled when the voltage on Pin 1 is greater than 0.55V.

### 3. Soft Start (SST)

Connecting an external capacitor to Pin 1 provides the SST function. A charging current is provided to capacitor C11. At Start-up, as capacitor C11 charges, the voltage level controls the gradual increase in power to the transformer. This reduces in-rush current and provides reliable operation to the CCFL.

### 4. Ignition

The ignition process requires a higher striking frequency to strike the CCFL. The striking frequency is approximately 1.3 times the normal operating frequency. The striking frequency is determined by external resistor R13 connected to RT (Pin 2).

### 5. Normal Operation

OZ9936 operates in a constant frequency mode. This eliminates any undesired interference between the controller and LCD panel, as the interference is usually associated with variable-frequency design. Interference may result in a poor user experience because of "waterfall" display distortion and other poor display appearance.

Once the CCFL is ignited and current is sensed at Pin 8 (ISEN), the control loop regulates the CCFL current. An external resistor, R13,

connected to RT (Pin 2) determines the operating frequency. The approximate operating frequency is calculated by the following equation.

$$f_{op} = \frac{5.0 \times 10^3}{RT [K\Omega]} \quad [KHz]$$

### 6. Over-Voltage Protection

The control logic protects the transformer from an abnormally high voltage at the secondary output.

The transformer output voltage is sensed through Rectifier Diodes (CR1, CR3, CR5, CR8) and transistor Q5. When the voltage at the emitter of Q5 is less than  $-V_{BE}$  drop, Q5 will conduct and regulate the output voltage to the transformer secondary.

### 7. Open Lamp Protection

When a CCFL is removed or damaged during normal operation, the OZ9936 shuts off the output drives after the shutdown delay timer expires. When the damaged lamp is replaced, toggling the enable pin from low to high resumes normal operation.

OZ9936 provides a shutdown delay feature if the lamp current is not regulated. The inverter module will remain in normal operation for approximately 2 to 3 seconds if the input voltage suddenly drops and subsequently resumes to normal level.

### 8. Aged CCFL Ignition

During the ignition process, the controller senses the voltage at the CCFL. For an open-circuit condition, the power train delivers a regulated voltage at the CCFL for approximately 2.0 seconds. If no current is sensed after approximately 2.0 seconds, the OZ9936 shuts off. Toggling the enable signal from low to floating will resume normal operation. This is to ensure that any aged, slow-turn-on CCFL is provided with sufficient voltage and time to ignite.

### 9. Dimming Control

The OZ9936 provides an analog dimming control function. The input to Pin 7 (DIM) is an analog voltage of 0.5V to 1.25V that corresponds to approximately 40% to 100% of the LCD panel brightness.

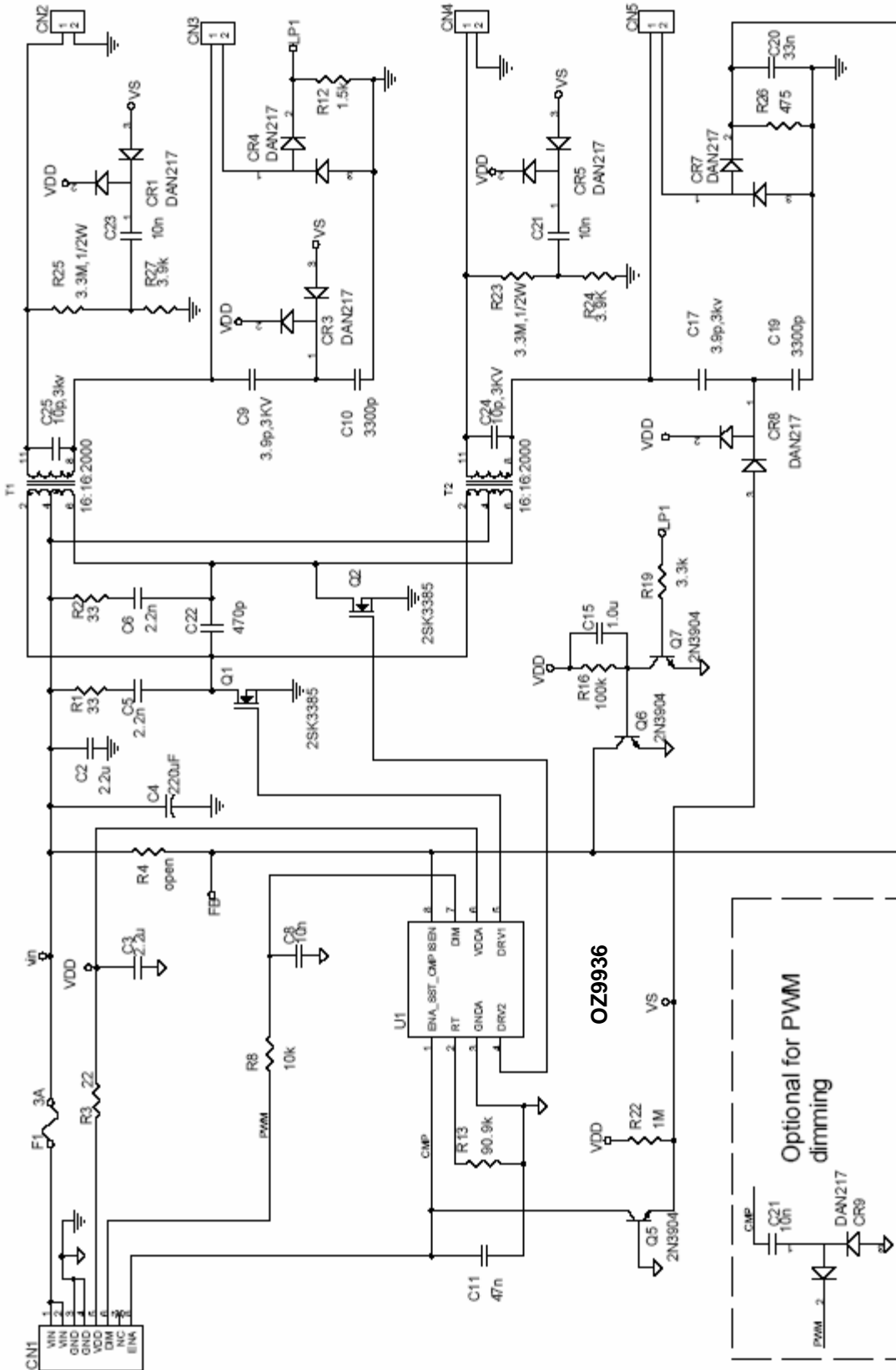
# OZ9936

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For applications that require an external PWM dimming, the OZ9936 accepts a PWM signal to DIM (Pin 7) with a swing voltage of 0V to  $\geq 2.7V$ .

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## REFERENCE APPLICATION CIRCUIT

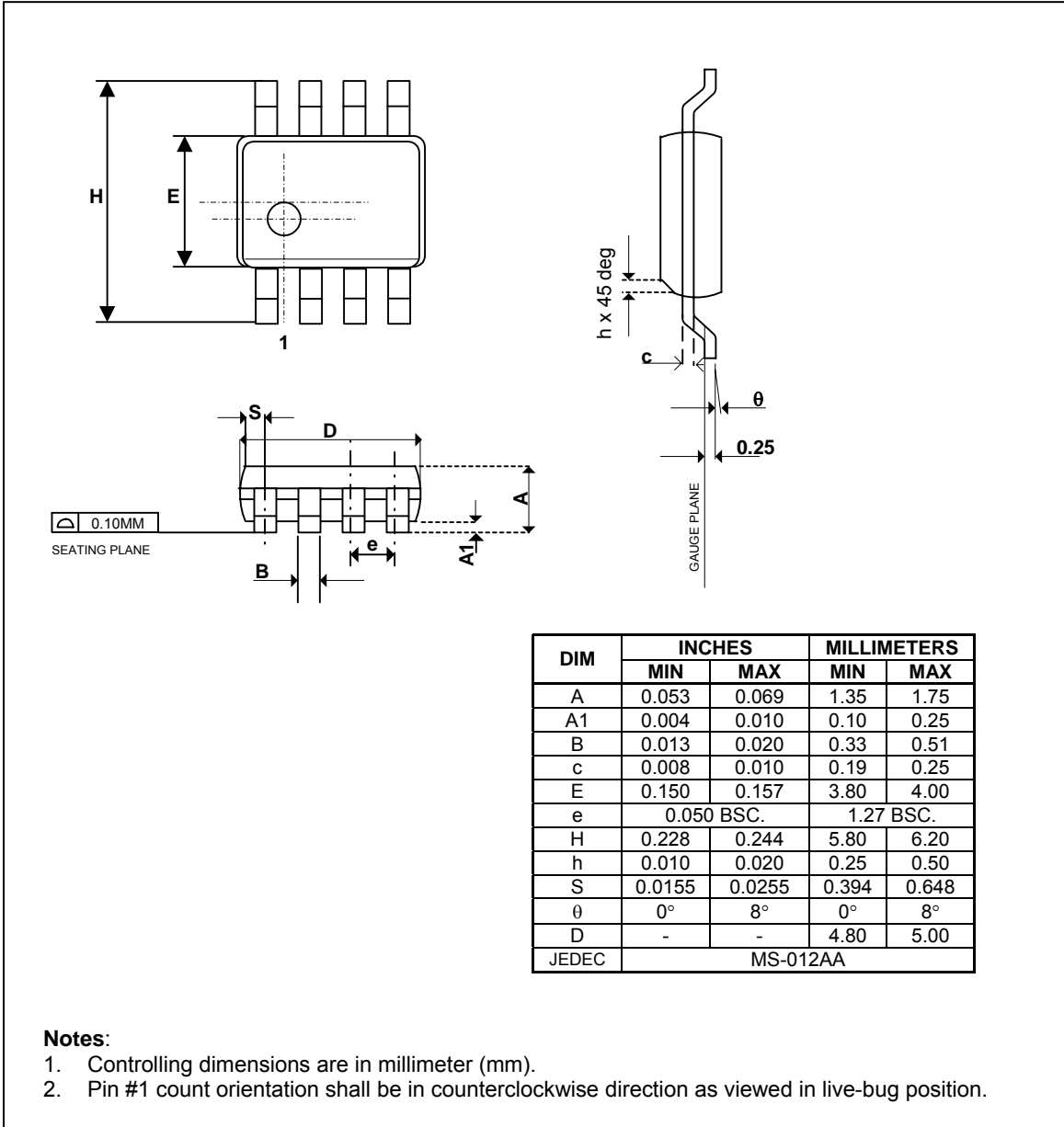


**Figure 2**  
 VIN : 12V +/- 10%  
 VDD: 4.75 -- 5.25V  
 DIM: Analog dimming 0.5v-1.25v, 0.5v for Min B, 1.25v for Max B;  
 External PWM dimming, 0-3.3v Vp-p; 100% Max B; 30% Min B;  
 ENA: 0V Disable; Floating = Enable



# OZ9936

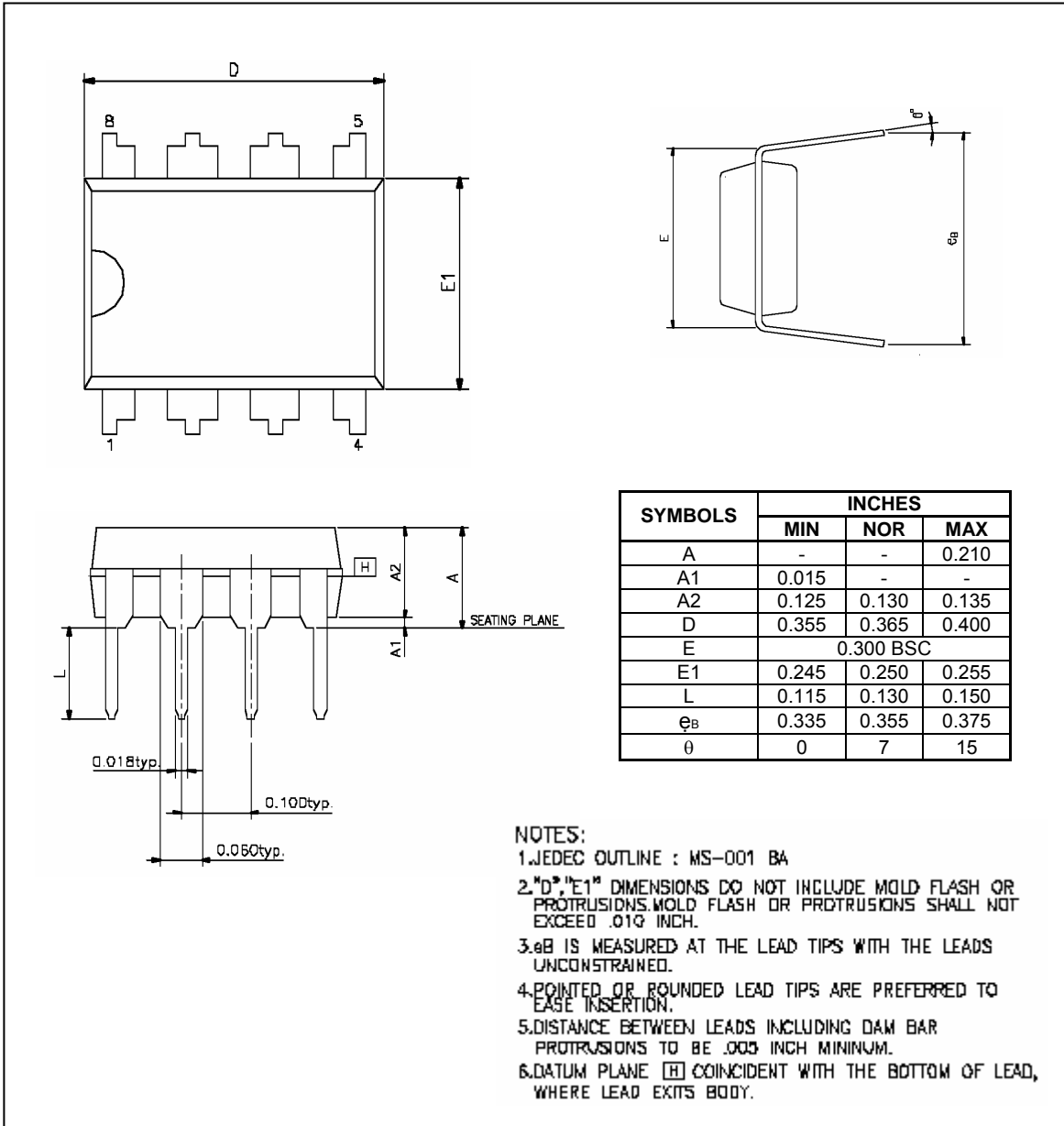
## PACKAGE INFORMATION – 8-PIN SOIC: OZ9936G (150mil)



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## PACKAGE INFORMATION – 8-PIN PDIP: OZ9936D (300mil)



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