

## Change Summary

### CHANGES

No.	Applicable Section	Description	Page(s)
1.	Electrical Characteristics	Update 停protection release threshold in 'Timer & protection' parameter Min & Max limits	3
2.	Throughout datasheet	Miscellaneous changes	---

### REVISION HISTORY

Revision No.	Description of change	Release Date
0.60	Initial release	5/12/2005
0.65	1. Electrical Characteristics: <u>a.</u> Modify general test conditions in line 1; <u>b.</u> Modify 'Driver Frequency – Striking & Normal Operation' Typ limit; <u>c.</u> Modify 'PWM Dimming Control – LCT frequency'. 2. Reference Application Circuit: Modify C14, C9 & R9 values	6/27/2005
1.0	1. Ordering Information: Add OZ9938G, IG, D & DN. 2. Recommended Operating Range: a. Add 'Dimming Range'; b. Fill in 'Thermal Impedance'. 3. Electrical Characteristics: a. Update 'Supply Current' limits; b. Update 'Soft Start' limits; c. Update 'Under Voltage Lockout' limits; d. Update 'Reference Voltage' limits; e. Update 'Driver Frequency' limits; f. Update 'Timer & Protection' limits; g. Update 'Drivers' parameter name & limits; h. Update 'PWM Dimming Control' limits; i. Delete 'Analog Dimming Control'. 4. Function Description: Update formula in NO. 4 Ignition, No. 6 Normal Operation & No. 9 Dimming Control. 5. Package Information: Add DIP package drawing.	9/22/2005

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## LCDFM Inverter Controller

### FEATURES

- Positive PWM dimming polarity
- Constant operating frequency
- Drives positive/negative-impedance lamps during ignition
- High drive current for external MOSFETs
- User-defined ignition time and shutdown delay time
- Multiple mode dimming control
- Built-in intelligence for ignition and normal operation of CCFLs
- Built-in open-lamp protection and over-voltage protection for backlight system
- Optimized soft-start function

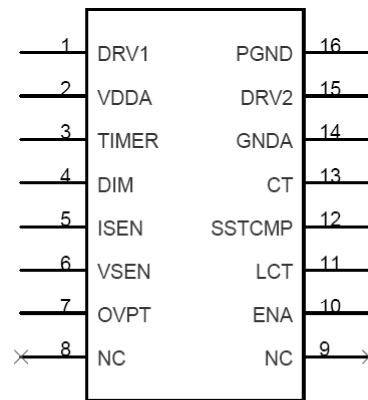
The control logic provides a regulated ignition voltage and appropriate protection features for over-voltage or over-current conditions.

The OZ9938 offers a high level of integration, while maintaining flexibility and high-efficiency operation that reduces external component heating, resulting in higher reliability and longer CCFL life. The proprietary design technique provides a simple, low-cost system solution.

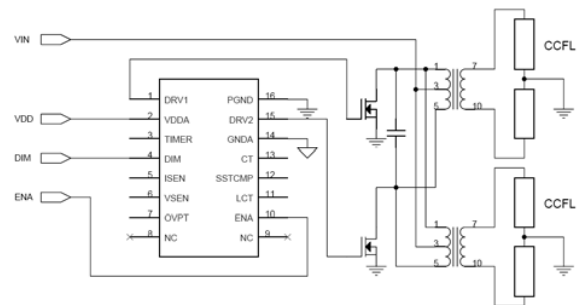
### ORDERING INFORMATION

Part Number	Temp Range	Package
OZ9938G	-20°C to 85°C	16-pin SOIC
OZ9938GN	-20°C to 85°C	16-pin SOIC Lead-Free
OZ9938IG	-40°C to 85°C	16-pin SOIC
OZ9938IGN	-40°C to 85°C	16-pin SOIC Lead-Free
OZ9938D	-20°C to 85°C	16-pin DIP
OZ9938DN	-20°C to 85°C	16-pin DIP Lead-Free

### PIN DIAGRAM



### SIMPLIFIED APPLICATION CIRCUIT



### GENERAL DESCRIPTION

The OZ9938 is a high performance, cost-effective CCFL (Cold Cathode Fluorescent Lamp) controller designed for driving large-size Liquid Crystal Display (LCD) applications requiring 2 to 6 CCFLs.

The controller converts unregulated DC voltages into a nearly sinusoidal lamp voltage and current waveforms.

The OZ9938 provides two drive signals for most power conversion topologies while maintaining high-efficiency operation. The PWM controller provides a soft-start operation, current and voltage regulation, over-voltage and over-current protection, high drive capability and multiple dimming functions (internal PWM or external PWM or analog dimming functions).

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## PIN DESCRIPTION

Pin No.	Names	Description
1	DRV1	Drive output
2	VDDA	Supply voltage input
3	TIMER	Timing capacitor to set striking time and shutdown delay time
4	DIM	Analog dimming or Internal LPWM dimming or external PWM pulse input for dimming function
5	ISEN	Current sense feedback
6	VSEN	Voltage sense feedback
7	OVPT	Over-voltage/ over-current protection threshold setting pin
8	NC	No connection
9	NC	No connection
10	ENA	ON/OFF control of IC
11	LCT	Timing capacitor to set internal PWM dimming frequency and also a pin for analog dimming selection
12	SSTCMP	Capacitor for soft start time and loop compensation
13	CT	Timing resistor and capacitor for operation and striking frequency
14	GND A	Ground for analog signals
15	DRV2	Drive output
16	PGND	Ground for power paths

## 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.	OZ9938	OZ9938I
	-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

VDDA - Input Voltage	4.5V to 5.5V
f <sub>op</sub> - Operating Frequency	20KHz to 150KHz
Analog Dimming Range	0.7V to 2.1V
Thermal Impedance (θ <sub>J-A</sub> )	
- 16-pin SOP	86 °C/W
- 16-pin DIP	56 °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; Ta=25°C R <sub>CT</sub> =39Kohm, C <sub>CT</sub> =470pF R <sub>LCT</sub> =3.3Mohm, C <sub>LCT</sub> =4.7nF				
<b>Supply Current</b>						
Stand By	I <sub>dds</sub>	ENA=0V		2.0	5.0	μA
Operating	I <sub>dd</sub>	Capacitance at DRV1 & DRV2=2nF	1.5	2.0	2.5	mA
<b>Soft Start</b>						
Current Source	ISSTCMP		1.83	2.29	2.75	μA
<b>Under Voltage Lockout</b>						
Lock out	UVLO	VDDA 5V→0V			3.2	V
Resume	UVLO	VDDA 0V→5V	4.0			V
<b>Reference Voltage</b>						
ISEN reference voltage		ISEN=SSTCMP	1.12	1.18	1.23	V
		Temperature Coefficient		360		ppm/°C
VSEN reference voltage during striking		VSEN=SSTCMP	2.78	2.92	3.06	V
		Temperature Coefficient		310		ppm/°C
<b>Driver Frequency</b>						
Striking	f <sub>str</sub>		62.6	65.8	69.0	KHZ
		Temperature Coefficient		290		ppm/°C
Normal operation	F <sub>op</sub>		50.0	52.0	54.0	KHz
		Temperature Coefficient		110		ppm/°C
<b>Timer and Protection</b>						
Striking current Source		ISEN =0V	2.3	2.9	3.5	uA
Open lamp and over voltage protection current Source		SSTCMP > 3.3V or VSEN>OVPT	8.0	10.0	12.0	uA
Protection release threshold			2.60	2.81	3.02	V
<b>Drivers</b>						
DRV1/2 source	R <sub>on</sub>			12	18	Ω
DRV1/2 sink	R <sub>on</sub>			5	9	Ω
Maximum duty cycle			45			%

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## ELECTRICAL CHARACTERISTICS (Continued)

Parameter	Symbol	Test Conditions	Limits			Unit
		VDDA=5V; Ta=25°C R <sub>CT</sub> =39Kohm, C <sub>CT</sub> =470pF R <sub>LCT</sub> =3.3Mohm, C <sub>LCT</sub> =4.7nF	Min	Typ	Max	
<b>PWM Dimming Control</b>						
LCT frequency			194	200	206	Hz
<b>ENA Threshold</b>						
On					2.0	V
Off			1.0			V

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## FUNCTIONAL BLOCK DIAGRAM

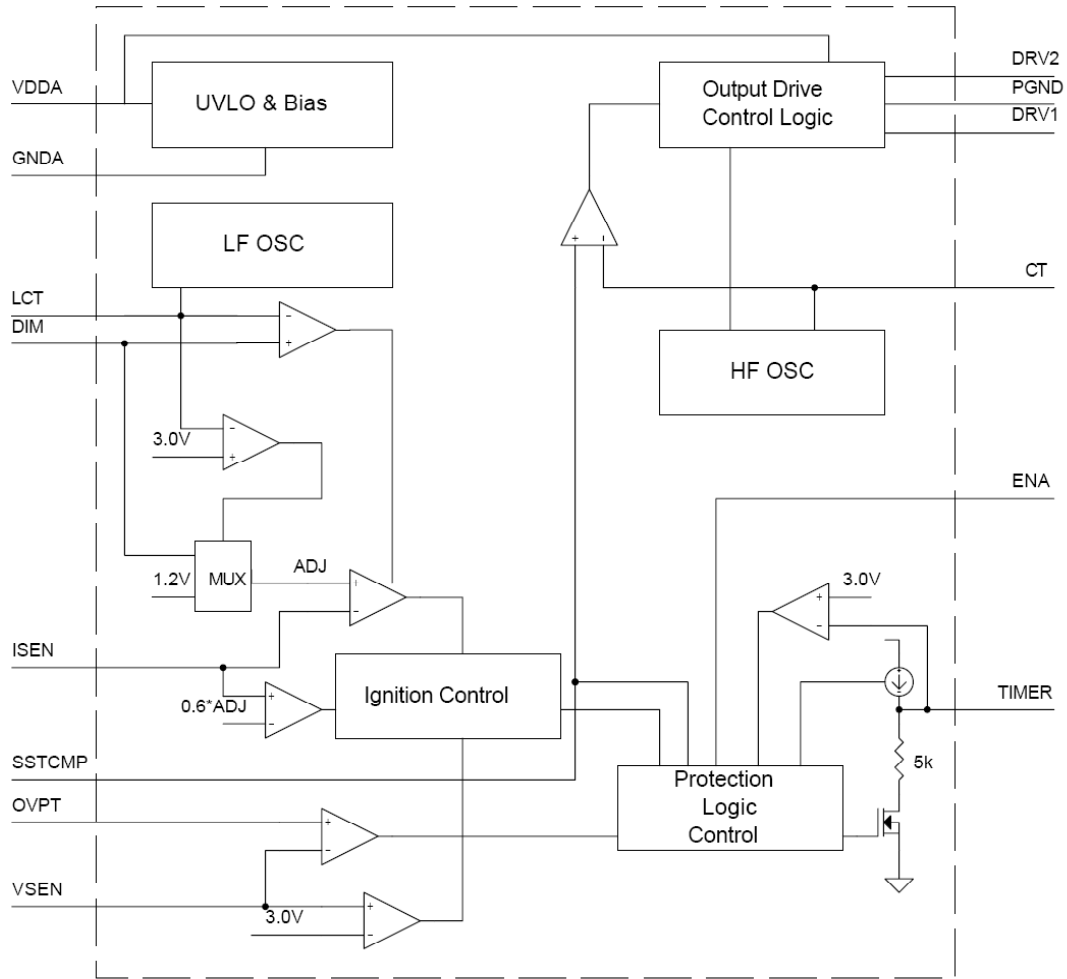


Figure 1

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## FUNCTIONAL DESCRIPTION

### 1. Power Conversion

The OZ9938 controller is designed to suit various power conversion topologies and provides symmetrical drive pulses to the tank circuit that includes the transformer(s), output capacitors and the CCFL/panel load that yields quasi-sinusoidal CCFL voltage and current waveforms. High efficiency operation of the OZ9938 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 5 and 8, respectively for the following sections.

### 2. Enable

Applying a voltage level greater than 2V to ENA (pin 10) enables the IC. A voltage less than 1V will disable the IC.

### 3. Soft-Start (SST)

Utilizing a patented multi-task technique, the soft-start function and the loop compensation function are combined to provide a good start-up characteristic. Connecting an external capacitor to SSTCMP (pin 12) provides the functions. In the start-up mode, current charges capacitor C13 connected to SSTCMP. The voltage at the capacitor controls the gradual increase in power to the transformer and subsequently to the output load. This reduces in-rush current and provides reliable operation to the CCFL.

### 4. Ignition

When the VDDA voltage exceeds the under-voltage lockout threshold, the IC is enabled an internal striking timer is activated.

The approximate striking frequency is calculated by the following equation.

$$f_{st} = \frac{3812 / R_{CT} [K\Omega] + 26}{4 * C_{CT} [pF]} \times 1000 [KHz]$$

### 5. Aged CCFL Ignition

OZ9938 provides a striking timer function to ensure that any aged, slow-turn-on CCFL is provided with sufficient voltage and time to ignite. The transformer output voltage is sensed at VSEN

(Pin 6). When the voltage at VSEN reaches a threshold of approximately 3.0V, the IC regulates the output voltage at the transformer secondary. If the lamps are not ignited when the voltage at TIMER (pin 3) reaches a threshold of approximately 3V, the IC will shutdown and latch

The approximate striking time is calculated by the following equation.

$$T_{str} [Sec] = C_{TIMER} [uF]$$

To resume normal operation, toggle the ENA signal or reset VDDA.

### 6. Normal Operation

Once the lamps are ignited and the voltage at ISEN (pin 5) is >0.7V, the IC enters the normal operation mode and the PWM dimming control is activated.

The operating frequency is determined by resistor (R9) and capacitor (C9) connected to CT (pin 13). The control loop regulates the average current through the lamps by adjusting the duty cycle of the output drives. Constant frequency operation eliminates interference with the inverter and LCD panel that often occurs in a variable frequency inverter system. The peak and valley of the CT waveform are 2V and 0V respectively.

The approximate operating frequency is calculated by the following equation.

$$f_{op} = \frac{9.53 \times 10^5}{R_{CT} [K\Omega] * C_{CT} [pF]} [KHz]$$

### 7. Open Lamp Protection

If a CCFL is removed or damaged during normal operation, the voltage at SSTCMP (pin 12) rises rapidly. When the voltage at SSTCMP reaches a threshold of approximately 2.5V, a current source charges the capacitor (C17) connected to TIMER (pin 3). Once the voltage level at the TIMER pin reaches a threshold of approximately 3V, the drive outputs shut down and latch.

The shutdown delay feature avoids inverter shutdown due to a VIN transient or if a lamp has a positive impedance characteristic.

The approximate shutdown delay time is calculated by the following equation.

$$T_d [Sec] = 0.33 \times C_{TIMER} [uF]$$

To resume operation, toggle the ENA signal or restart VDDA.

External PWM dimming is implemented by setting LCT to a DC voltage between 0.5V to 1.0V using a resistor divider (R8 and R17) between VDDA and GND. Apply the external PWM pulse to DIM (pin 4).

## 8. Over-Voltage and Over-Current Protection

Over-voltage and over-current protection are monitored by the voltage on VSEN (pin 6). During normal operation, if a CCFL is damaged or removed, the voltage at VSEN (pin 6) increases. Once the voltage at VSEN exceeds the user-defined, preset voltage set by OVPT (pin 7), the driver output duty cycle is regulated and the shutdown delay timer is activated. OVPT sets the overall protection threshold voltage that is lower than ~3V (VSEN threshold). Once the voltage at TIMR pin reaches ~3V, the IC will shut down and latch. OVPT voltage setting is determined by a resistor divider (R13 and R16) connected to the OVPT.

The approximate shutdown delay time is calculated by the following equation.

$$T_d [\text{Sec}] = 0.33 X C_{\text{TIMER}} [\mu\text{F}]$$

To resume operation, toggle the PWM signal or restart VDDA.

## 9. Dimming Control

A built-in function enables the user to select one of the following dimming controls: analog, internal LPWM or external PWM signal.

Analog dimming control is activated when the voltage to LCT (pin 11) is greater than 3V. A voltage of 0.5V to 1.25V applied to DIM (pin 4) controls the amplitude of the lamp current.

Internal LPWM dimming control is determined by resistor R8 and capacitor C14 connected to LCT. The low frequency sawtooth waveform is compared with the voltage at DIM to generate the LPWM signal. The peak and valley of the waveform are 1.5V and 0.1V respectively. The frequency is approximated by the following equation:

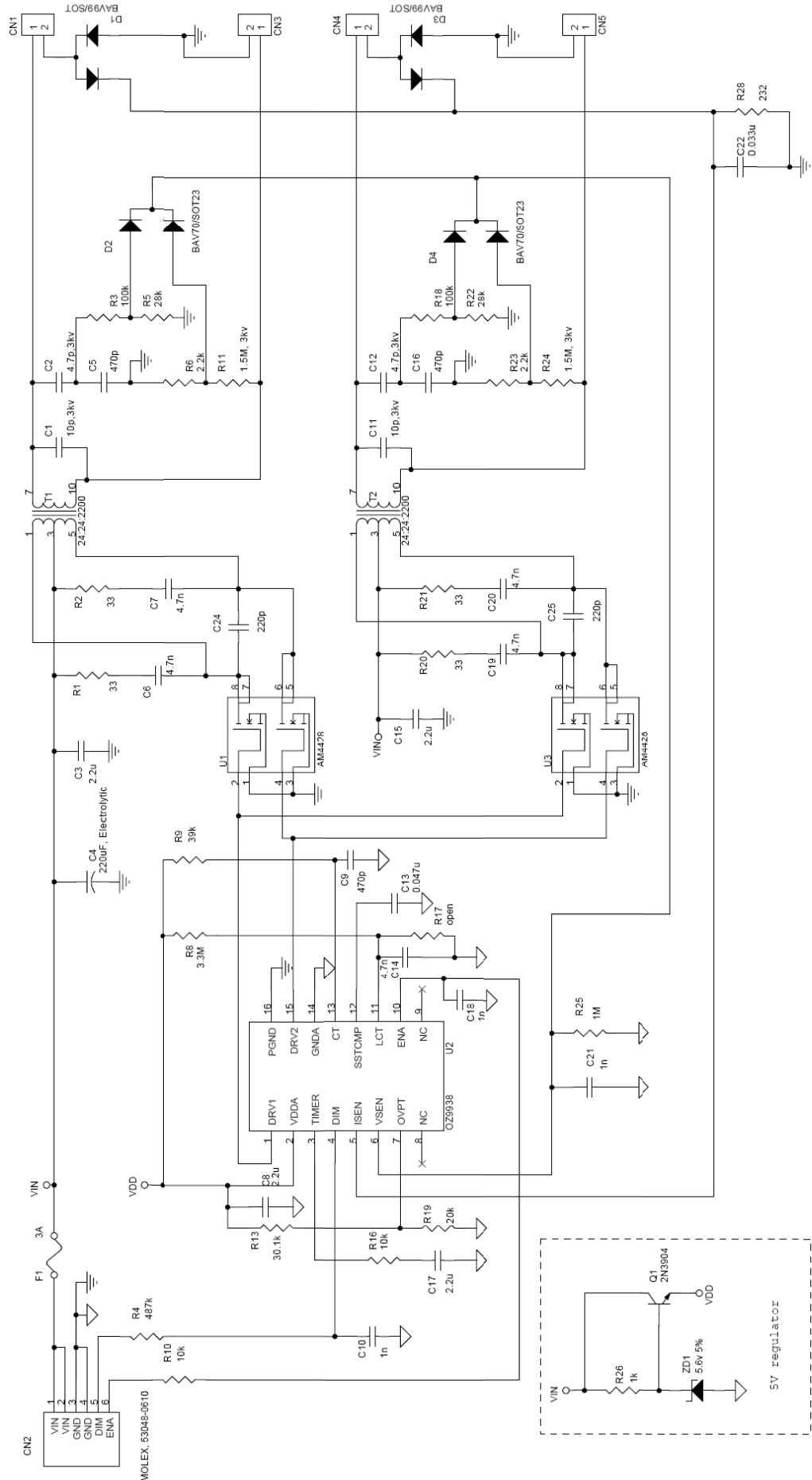
$$f_{\text{LOSC}} = \frac{3102}{R_{\text{LCT}} [\text{M}\Omega] * C_{\text{LCT}} [\text{nF}]} \quad [\text{Hz}]$$

With positive PWM dimming polarity, the LPWM duty cycle will be 100% when DIM pin voltage is higher than 1.5V. LCD panel will have maximum brightness. When DIM pin voltage is lower than 0.1V, the LPWM duty cycle will be 0%. LCD panel will be totally dark.



# OZ9938

## REFERENCE APPLICATION CIRCUIT

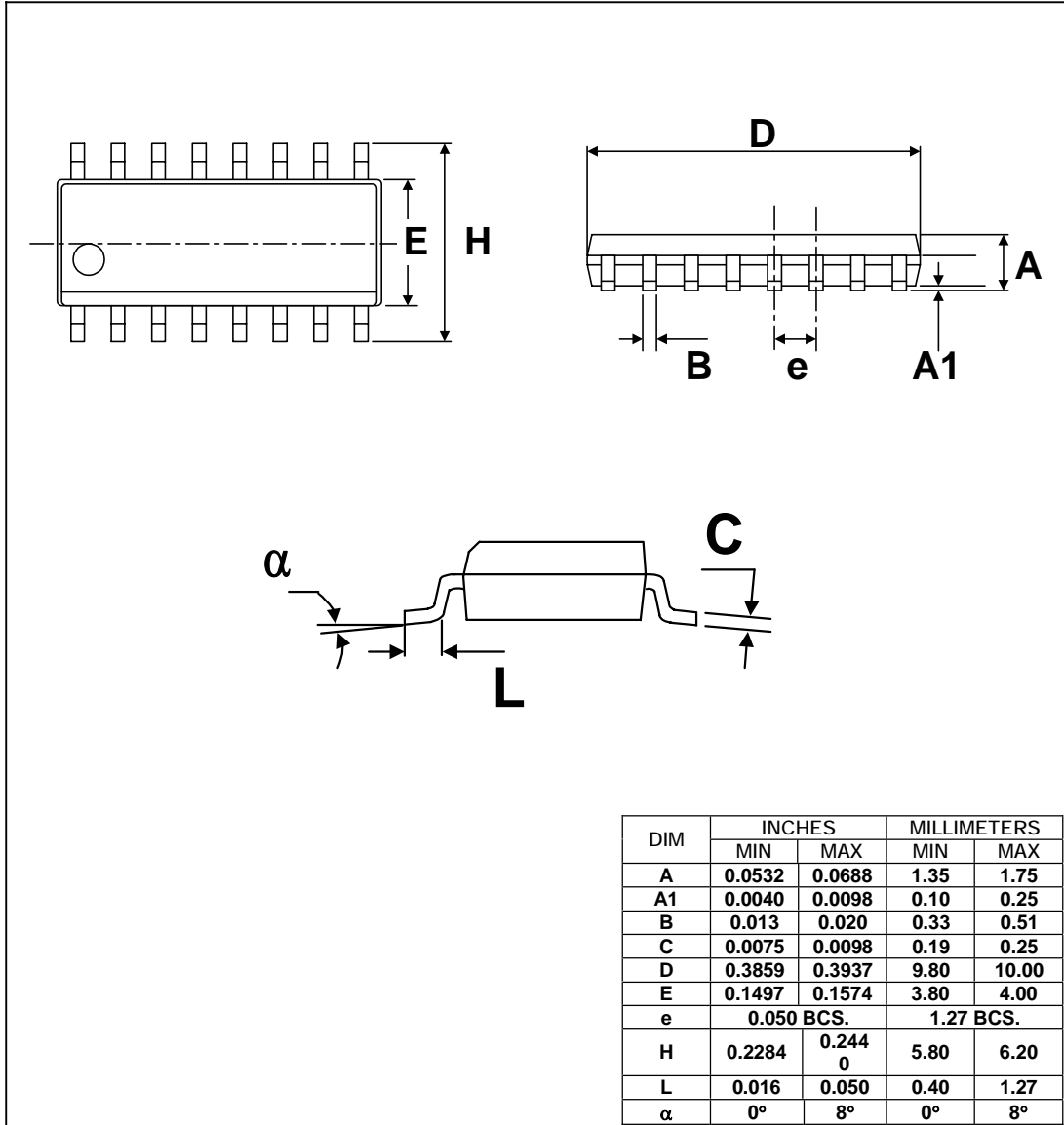


VIN: 10.8V—13.2V  
 ENA: 0V—1.0V, disable; 2.0V—5.0V, Enable  
 DIM: 0.2V—1.6V; 0.2V, minimum brightness; 1.6V, maximum brightness

Figure 2

# OZ9938

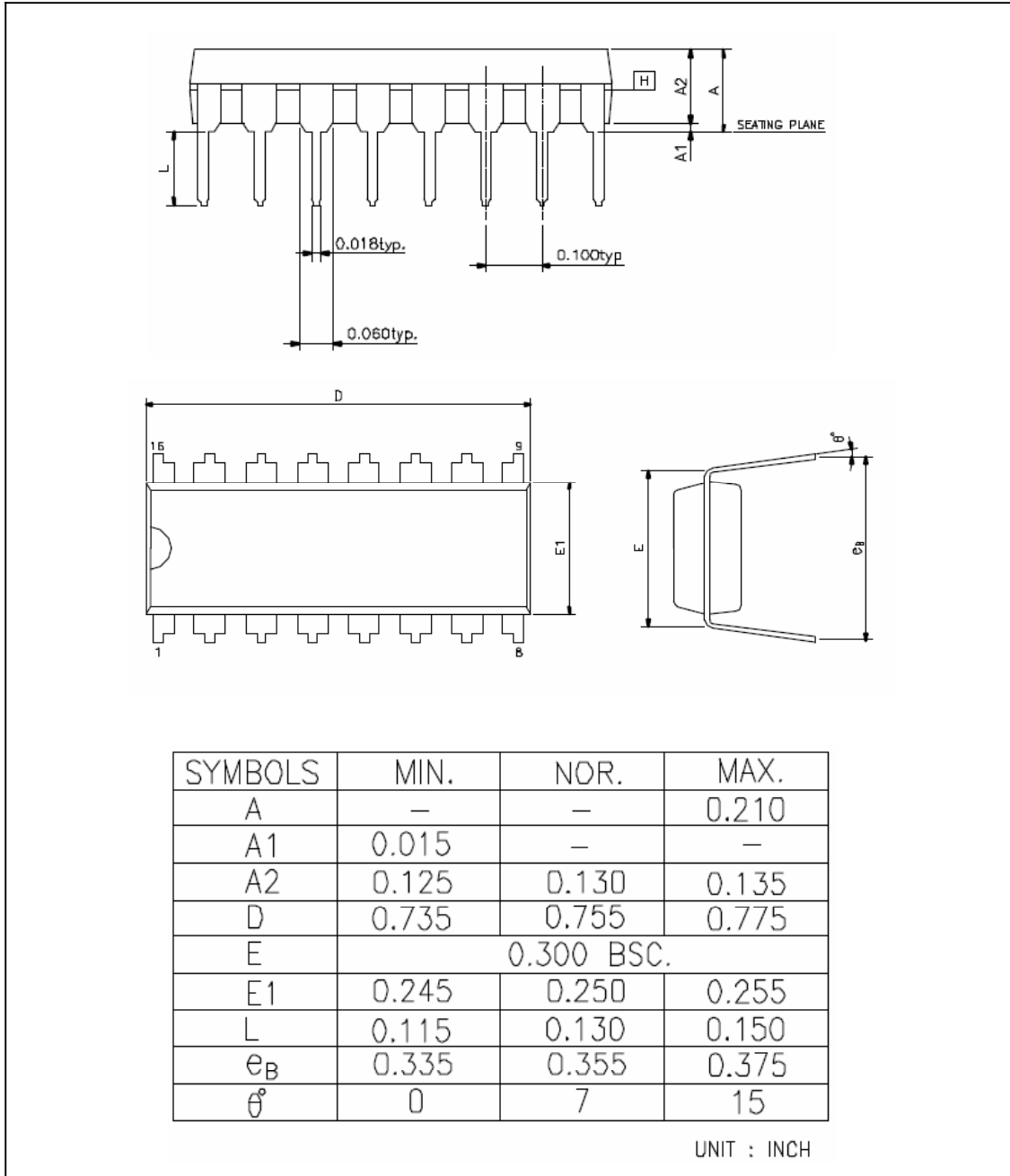
## PACKAGE INFORMATION ? 16-PIN SOP: OZ9938G (150mil)



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## PACKAGE INFORMATION ? 16-PIN DIP: OZ9938D (300mil)



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