



# FAN7311 LCD Backlight Inverter Drive IC

## Features

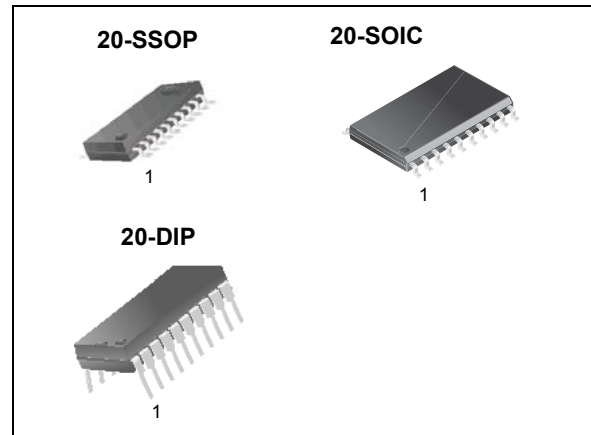
- High-Efficiency Single-Stage Power Conversion
- Wide Input Voltage Range: 5V to 25.5V
- Backlight Lamp Ballast and Soft Dimming
- Reduced Number of Required External Components
- Precision Voltage Reference Trimmed to 2%
- ZVS Full-Bridge Topology
- Soft-Start Capability
- PWM Control at Fixed Frequency
- Analog and Burst Dimming Function
- Programmable Striking Frequency
- Open-Lamp Protection
- Open-Lamp Regulation
- 20-Pin SSOP/SOIC/DIP

## Applications

- LCD TV
- LCD Monitor

## Description

The FAN7311 provides all the control functions for a series parallel resonant converter as well as a pulse width modulation (PWM) controller to develop a supply voltage. Typical operating frequency range is between 30kHz and 250kHz, depending on the cold cathode fluorescent lamp (CCFL) and the transformer's characteristics. The FAN7311 uses a new patent-pending phase-shift control.

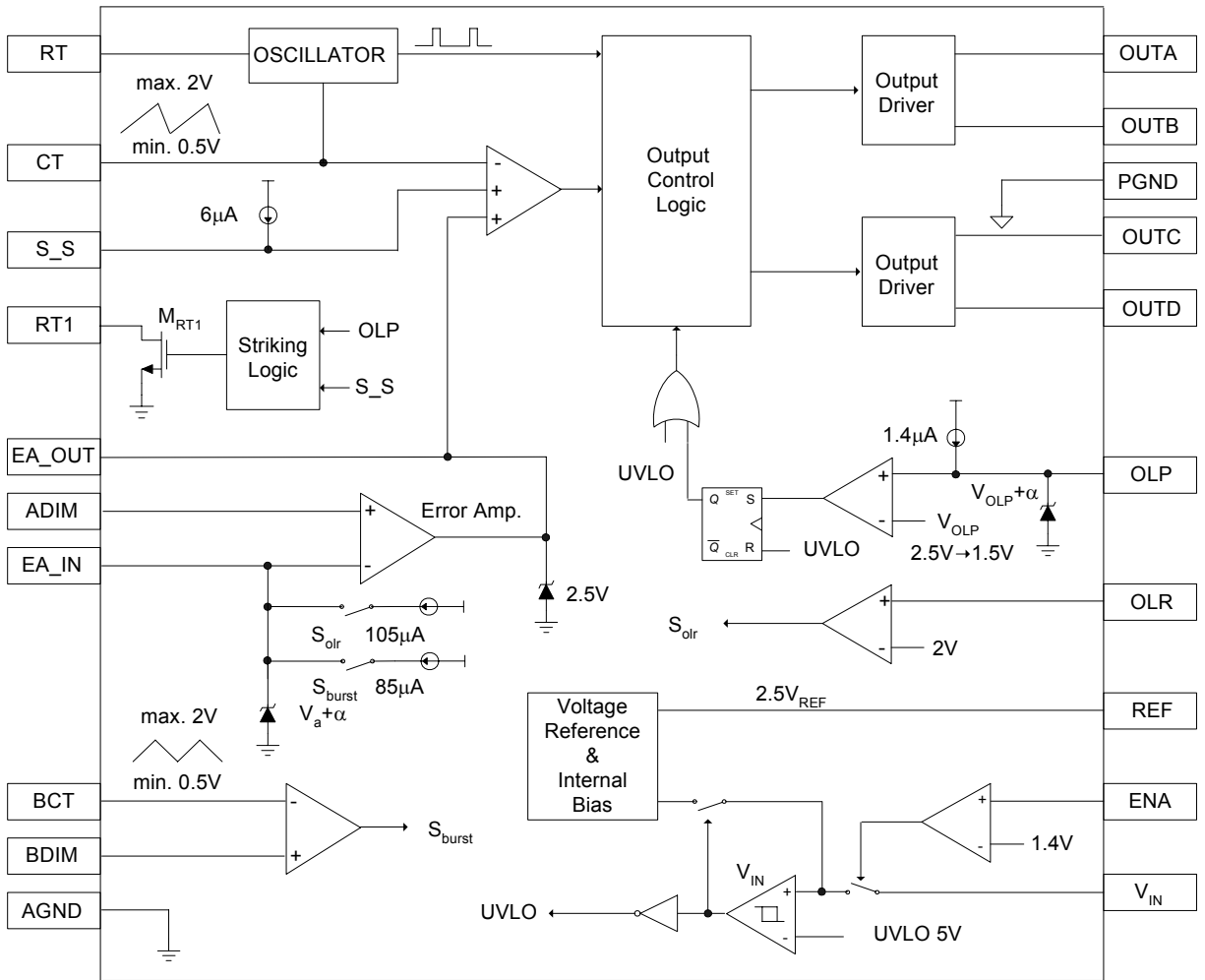


## Ordering Information

Part Number	Package	Pb-Free	Operating Temperature Range	Packing Method
FAN7311G	20-SSOP	Yes	-25°C to 85°C	Rail
FAN7311GX	20-SSOP	Yes		Tape & Reel
FAN7311M	20-SOIC	Yes		Rail
FAN7311MX	20-SOIC	Yes		Tape & Reel
FAN7311N	20-DIP	Yes		Rail

**Protected by U.S. Patent: 5,652,479; 7,158,390.**

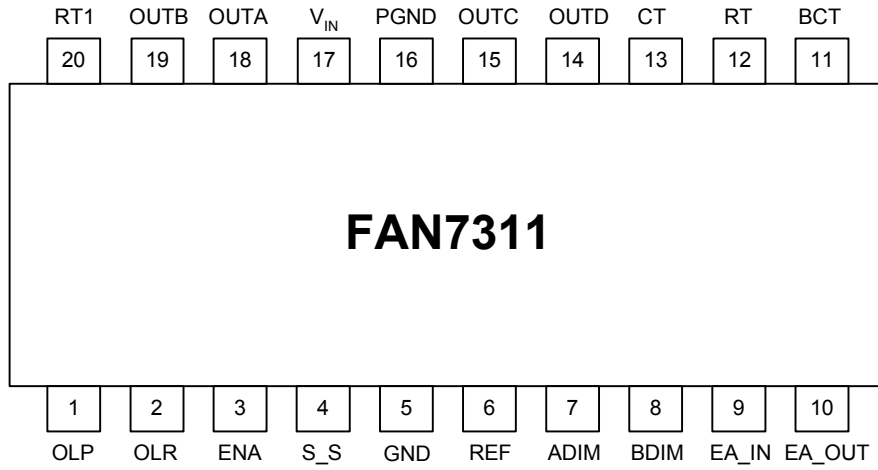
### Internal Block Diagram



FAN7311 Rev.06

Figure 1. Functional Block Diagram of FAN7311

## Pin Assignments



FAN7311 Rev. 05

Figure 2. Pin Configuration (Top View)

## Pin Definitions

Pin #	Name	Description	Pin #	Name	Description
1	OLP	Open-Lamp Protection	11	BCT	Burst Dimming Timing Capacitor
2	OLR	Open-Lamp Regulation	12	RT	Timing Resistor
3	ENA	Enable Input	13	CT	Timing Capacitor
4	S_S	Soft-Start	14	OUTD	NMOSFET Drive Output D
5	GND	Analog Ground	15	OUTC	PMOSFET Drive Output C
6	REF	2.5V Reference Voltage	16	PGND	Power Ground
7	ADIM	Analog Dimming Input	17	V <sub>IN</sub>	Supply Voltage
8	BDIM	Burst Dimming Input	18	OUTA	PMOSFET Drive Output A
9	EA_IN	Error Amplifier Input	19	OUTB	NMOSFET Drive Output B
10	EA_OUT	Error Amplifier Output	20	RT1	Striking Frequency Resistor

## Absolute Maximum Ratings

Stresses exceeding the absolute maximum ratings may damage the device. The device may not function or be operable above the recommended operating conditions and stressing the parts to these levels is not recommended. In addition, extended exposure to stresses above the recommended operating conditions may affect device reliability. The absolute maximum ratings are stress ratings only.

For typical values,  $T_A=25^{\circ}\text{C}$  and  $V_{IN}=12\text{V}$ . For min. and max. values,  $T_A$  is the operating ambient temperature range with  $-25^{\circ}\text{C} \leq T_A \leq 85^{\circ}\text{C}$  and  $5\text{V} \leq V_{IN} \leq 25.5\text{V}$ , unless otherwise specified.

Symbol	Characteristics	Value	Unit
$V_{IN}$	Supply Voltage	5 to 25.5	V
$T_A$	Operating Temperature Range	-25 to 85	$^{\circ}\text{C}$
$T_J$	Junction Temperature	150	$^{\circ}\text{C}$
$T_{STG}$	Storage Temperature Range	-65 to 150	$^{\circ}\text{C}$
$\theta_{JA}$	Thermal Resistance Junction-to-Ambient (still air) <sup>(1)</sup>		$^{\circ}\text{C/W}$
	20-SSOP	112	
	20-SOIC	70	
	20-DIP	TBD <sup>(2)</sup>	
$P_D$	Power Dissipation		W
	20-SSOP	1.1	
	20-SOIC	1.8	
	20-DIP	TBD	

### Notes:

1. Thermal resistance test board size: 76.2 \* 114.3 \* 1.6mm (1S0P). JEDEC standard: JESD51-2, JESD51-3.
2. To be determined.

## Electrical Characteristics

For typical values,  $T_A=25^{\circ}\text{C}$  and  $V_{IN}=12\text{V}$ . For min. and max. values,  $T_A$  is the operating ambient temperature range with  $-25^{\circ}\text{C} \leq T_A \leq 85^{\circ}\text{C}$  and  $5\text{V} \leq V_{IN} \leq 25.5\text{V}$ , unless otherwise specified. Specifications from  $-25^{\circ}\text{C}$  to  $85^{\circ}\text{C}$  are guaranteed by design based on final characterization results.

Symbol	Characteristics	Test Condition	Min.	Typ.	Max.	Unit
<b>REFERENCE SECTION (Recommend X7R Capacitor)</b>						
$\Delta V_{ref}$	Line Regulation	$5 \leq V_{IN} \leq 25.5\text{V}$		2	25	mV
V25	2.5V Regulation Voltage		2.45	2.50	2.55	V
<b>OSCILLATOR SECTION (MAIN)</b>						
$f_{osc}$	Oscillation Frequency	$T_A = 25^{\circ}\text{C}$ , $CT = 270\text{pF}$ , $RT = 18\text{k}\Omega$	110.4	115.0	119.6	kHz
		$CT = 270\text{pF}$ , $RT = 18\text{k}\Omega$	108	115	122	
$V_{cth}$	CT High Voltage			2.0		V
$V_{ctl}$	CT Low Voltage			0.5		V
<b>OSCILLATOR SECTION (BURST)</b>						
$f_{oscB}$	Oscillation Frequency	$T_A = 25^{\circ}\text{C}$ , $CTB = 10\text{nF}$ , $RT=18\text{k}\Omega$	209.25	225.00	240.75	Hz
		$CTB = 10\text{nF}$ , $RT=18\text{k}\Omega$	206.25	225.00	241.75	
$V_{bcth}$	BCT High Voltage			2		V
$V_{bctl}$	BCT Low Voltage			0.5		V
<b>ERROR AMP SECTION</b>						
$A_v$	Open Loop Gain <sup>(3)</sup>			80		dB
$G_{BW}$	Unit Gain Bandwidth <sup>(3)</sup>			1.5		MHz
$V_{eh}$	Feedback Output High Voltage	$EA\_IN = 0\text{V}$	2.00	2.27	2.54	V
$I_{sin}$	Output Sink Current	$EA\_OUT = 1.5\text{V}$			-1	mA
$I_{sur}$	Output Source Current	$EA\_OUT = 1.5\text{V}$	1			mA
$I_{olr}$	$EA\_IN$ Driving Current on OLR		75	105	135	$\mu\text{A}$
$I_{burst}$	$EA\_IN$ Driving Current on Burst Dimming		61	85	109	$\mu\text{A}$
$V_{fbh}$	Feedback High Voltage on Burst Dimming	$R(EA\_IN) = 60\text{k}\Omega$	$V_a+0.1$	$V_a+0.4$	$V_a+0.7$	V
<b>SOFT-START SECTION</b>						
$I_{SS}$	Soft-Start Current	$S\_S=1\text{V}$	4	6	8	$\mu\text{A}$
$V_{ssh}$	Soft-Start Clamping Voltage <sup>(3)</sup>			4		V
<b>PROTECTION SECTION</b>						
$V_{olp0}$	Open-Lamp Protection Voltage 0	Start at open lamp	2.2	2.5	2.8	V
$V_{olp1}$	Open-Lamp Protection Voltage 1	Normal -> open lamp	1.3	1.5	1.7	V
$V_{olr}$	Open-Lamp Regulation Voltage		1.75	2.00	2.25	V
$I_{olp}$	Open-Lamp Protection Charging Current		0.7	1.4	2.1	$\mu\text{A}$
<b>UNDER-VOLTAGE LOCKOUT SECTION</b>						
$V_{th}$	Start Threshold Voltage				5	V
$I_{st}$	Startup Current	$V_{IN} = V_{th}-0.2$		130	180	$\mu\text{A}$
$I_{op}$	Operating Supply Current	$V_{IN} = 12\text{V}$		1.5	4.0	mA
$I_{sb}$	Stand-by Current	$V_{IN} = 12\text{V}$		200	370	$\mu\text{A}$

### Note:

3. These parameters, although guaranteed, are not 100% tested in production.

**Electrical Characteristics** (Continued)

For typical values,  $T_A=25^\circ\text{C}$  and  $V_{IN}=12\text{V}$ . For min. and max. values,  $T_A$  is the operating ambient temperature range with  $-25^\circ\text{C} \leq T_A \leq 85^\circ\text{C}$  and  $5\text{V} \leq V_{IN} \leq 25.5\text{V}$ , unless otherwise specified. Specifications from  $-25^\circ\text{C}$  to  $85^\circ\text{C}$  are guaranteed by design based on final characterization results.

Symbol	Characteristics	Test Condition	Min.	Typ.	Max.	Unit
<b>ON/OFF SECTION</b>						
$V_{on}$	On State Input Voltage		2		5	V
$V_{off}$	Off Stage Input Voltage				0.7	V
<b>OUTPUT SECTION</b>						
$V_{pdhv}$	PMOS Gate High Voltage	$V_{IN} = 12\text{V}$		$V_{IN}$		V
$V_{phlv}$	PMOS Gate Low Voltage	$V_{IN} = 12\text{V}$	$V_{IN}-10.5$	$V_{IN}-8.5$	$V_{IN}-6.5$	V
$V_{ndhv}$	NMOS Gate Drive Voltage	$V_{IN} = 12\text{V}$	6.5	8.5	10.5	V
$V_{ndhv}$	NMOS Gate Drive Voltage	$V_{IN} = 12\text{V}$		0		V
$V_{puv}$	PMOS Gate Voltage With UVLO Activated	$V_{IN} = V_{th}-0.2$	$V_{IN}-0.3$			V
$V_{nuv}$	NMOS Gate Voltage With UVLO Activated	$V_{IN} = V_{th}-0.2$			0.3	V
$t_r$	Rising Time <sup>(4)</sup>	$V_{IN} = 12\text{V}, C_L=2\text{nF}$		200	500	ns
$t_f$	Falling Time <sup>(4)</sup>	$V_{IN} = 12\text{V}, C_L=2\text{nF}$		200	500	ns
<b>MAX./MIN. OVERLAP</b>						
	Min. Overlap Between Diagonal Switches <sup>(4)</sup>	$f_{osc} = 100\text{kHz}$		0		%
	Max. Overlap Between Diagonal Switches <sup>(4)</sup>	$f_{osc} = 100\text{kHz}$		100		%
<b>DELAY TIME</b>						
	PDR_A/NDR_B <sup>(4)</sup>	$RT = 18\text{k}\Omega$		450		ns
	PDR_C/NDR_D <sup>(4)</sup>	$RT = 18\text{k}\Omega$		450		ns

**Note:**

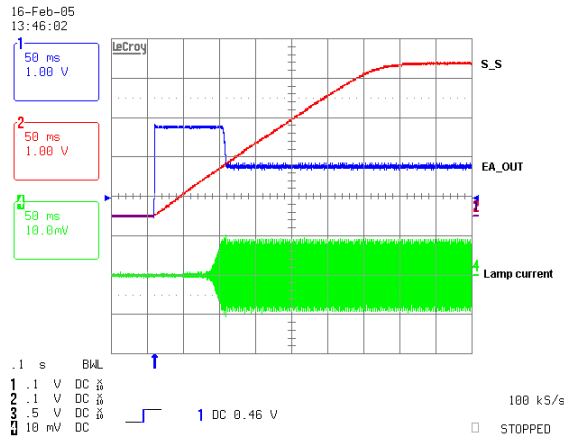
4. These parameters, although guaranteed, are not 100% tested in production.

## Function Description

**UVLO:** The under-voltage lockout circuit guarantees stable operation of the IC's control circuit by stopping and starting it as a function of the  $V_{IN}$  value. The UVLO circuit turns on the control circuit when  $V_{IN}$  exceeds 5V. When  $V_{IN}$  is lower than 5V, the IC's standby current is less than 200 $\mu$ A.

**ENA:** Applying voltage higher than 2V to the ENA pin enables operation of the IC. Applying voltage lower than 0.7V to the ENA pin disables operation of the inverter.

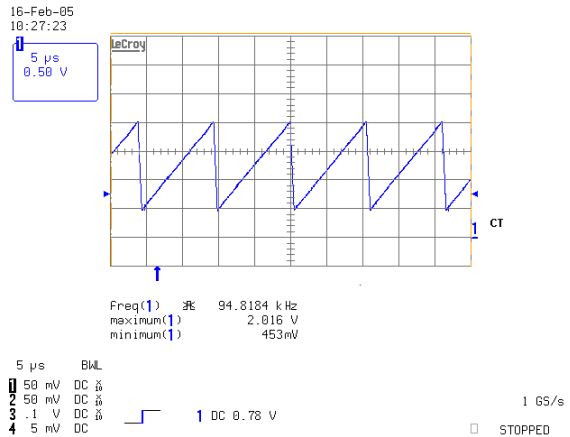
**Soft-Start:** The soft-start function requires that the S\_S pin is connected through a capacitor to GND. A soft-start circuit ensures a gradual increase in the input and output power. The capacitor connected to the S\_S pin determines the rate at which the duty ratio rises. It is charged by a 6 $\mu$ A current source.



**Figure 3. Soft-Start During Initial Operation**

**Main Oscillator:** The timing capacitors (CTs) are charged by the reference current source, which is formed by the timing resistor (RT). The timing resistor's voltage is regulated at 1.25V. The sawtooth waveform charges up to 2V. Once this voltage is reached, the capacitors begin discharging down to 0.5V. Next, the timing capacitors start charging again and a new switching cycle begins. The main frequency can be programmed by adjusting the RT and CT values. The main frequency can be calculated as shown below.

$$f_{op} = \frac{19}{32 \cdot RT \cdot CT} \quad (1)$$



**Figure 4. Main Oscillator Waveform**

**Burst Oscillator & Burst Dimming:** The timing capacitors (BCTs) are charged by the reference current source, which is formed by the timing resistor (RT). The timing resistor's voltage is regulated at 1.25V. The sawtooth waveform charges up to 2V. Once this voltage is reached, the capacitors begin discharging down to 0.5V. Next, the timing capacitors start charging again and a new switching cycle begins. The burst dimming frequency can be programmed by adjusting the RT and BCT values. The burst dimming frequency can be calculated as shown in Equation 2.

$$f_{burst} = \frac{3.75}{96 \cdot RT \cdot CT} \quad (2)$$

To avoid visible flicker, the burst dimming frequency should be greater than 120Hz.

By comparing the input of BDIM pin with the 0.5~2V triangular wave of the burst oscillator, the PWM pulses for burst dimming. The PWM pulse controls EA\_OUT's voltage by summing 85 $\mu$ A into the EA\_IN pin.

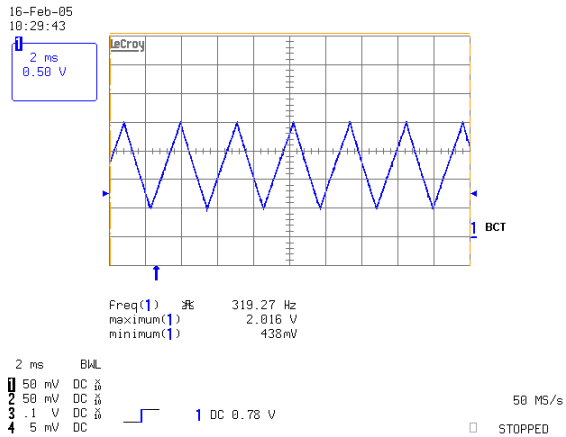


Figure 5. Burst Oscillator Waveform

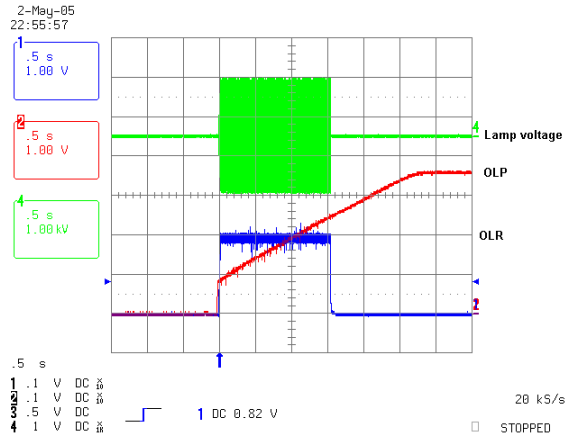


Figure 7. OLR Voltage During Striking Mode

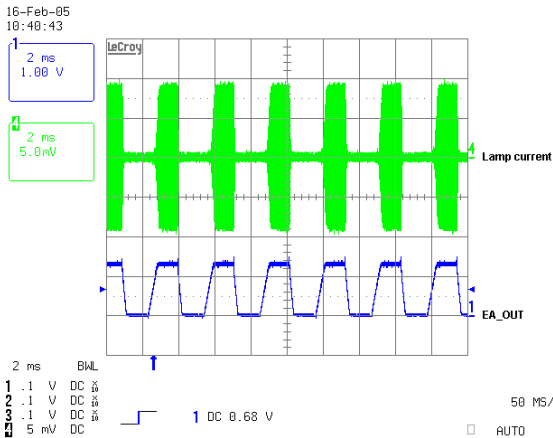


Figure 6. Burst Dimming

**Open Lamp Regulation and Open-Lamp Protection:** It is necessary to suspend power stage operation if an open lamp occurs, because the power stage has high gain. When a voltage higher than 2V is applied to the OLR pin, the part enters regulation mode and controls the EA\_OUT voltage. This limits the lamp voltage by summing 105µA into the feedback node. At the same time, the OLP capacitor, connected to the OLP pin, is charged by the 1.4µA internal current source. Once it reaches 2.5V, the IC enters shut down where all output is high.

**Output Drives:** The four output drives are designed so that switches A and B, C and D never turn on simultaneously. The OUTA-OUTB pair is intended to drive one half-bridge in the external power stage. The OUTC-OUTD pair drives the other half-bridge.

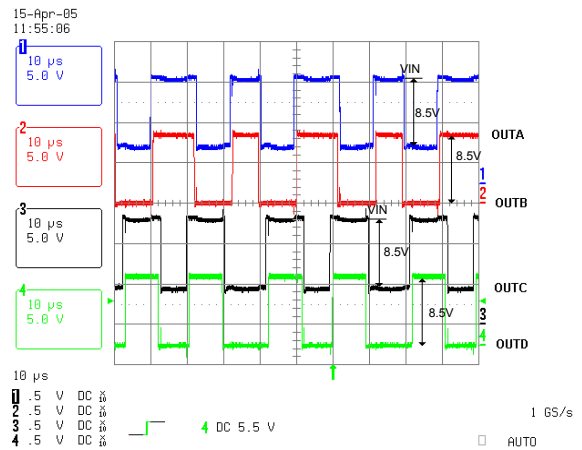
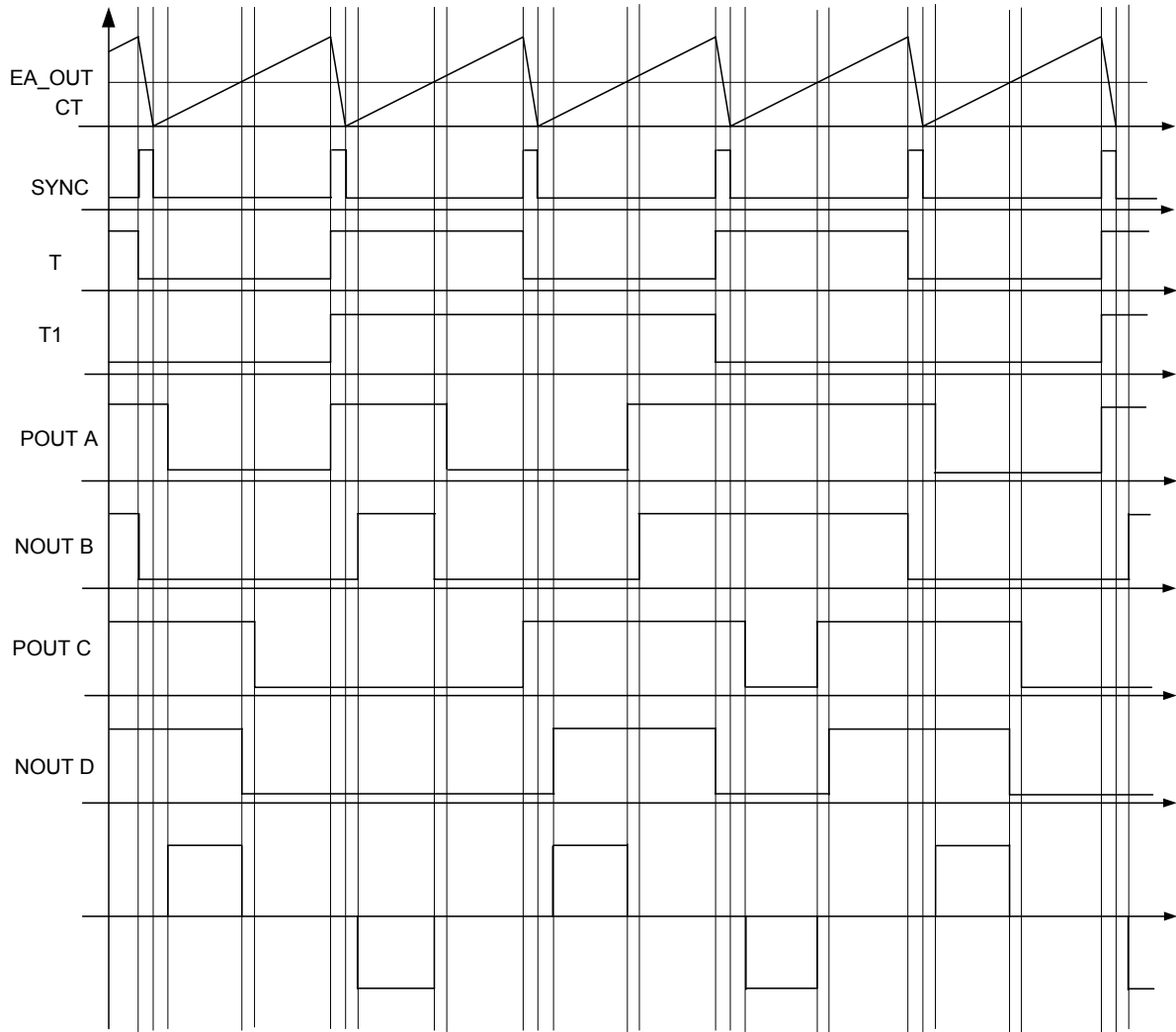


Figure 8. Phase-Shift Control Waveforms



### Timing Diagram

The FAN7311 uses the improved phase-shift control full-bridge to drive CCFL. As a result, the temperature difference between the left and the right leg is almost zero. The detail timing is shown below.



FAN7311 Rev.04

Figure 9. Phase-Shift Control Waveforms

## Typical Application Circuits

Application	Lamps	Input Voltage
19-inch LCD Monitor	4	13V

### 1. Schematic

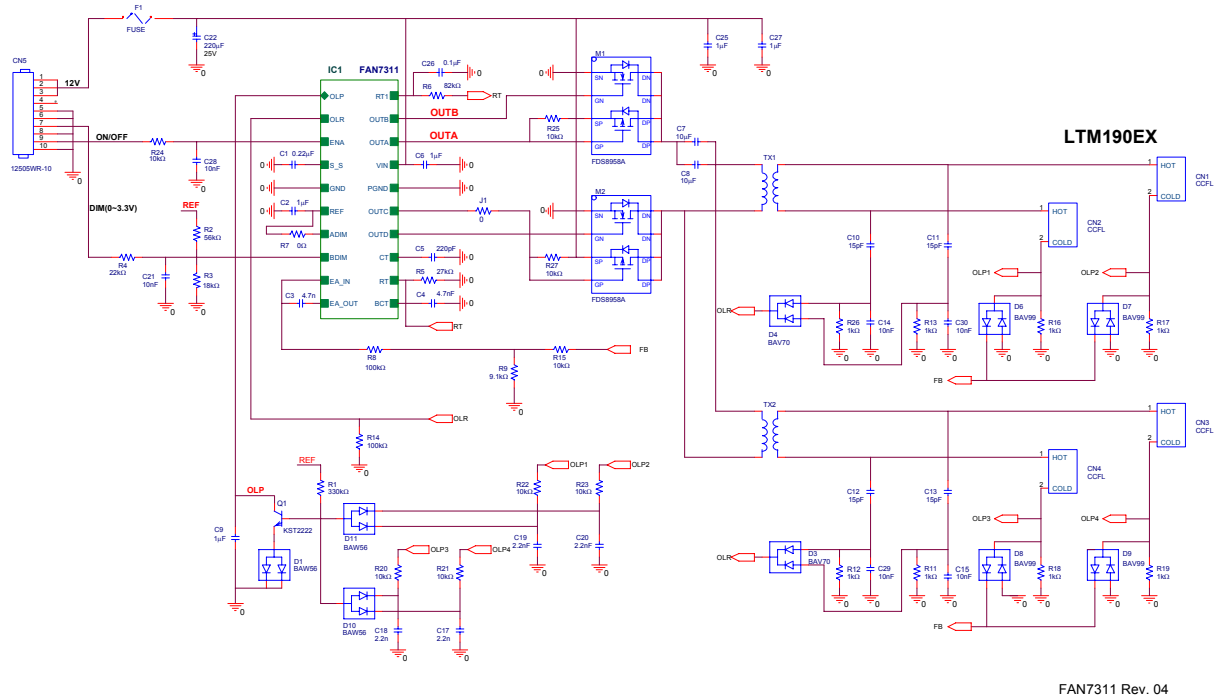


Figure 10. Typical Application Circuit

### 2. Transformer Schematic Diagram

- Supported by Namyang electronics (<http://www.namyangelec.co.kr>)

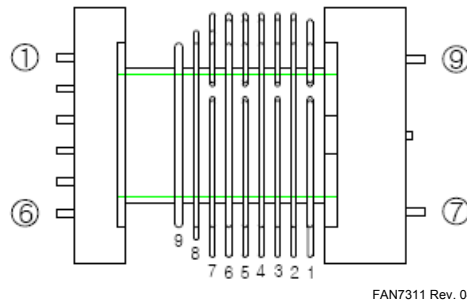


Figure 11. Transformer Schematic

### 3. Core & Bobbin

- Core: EFD2124
- Material: PL7
- Bobbin: EFE2124

#### 4. Winding Specification

Pin No.	Wire	Turns	Inductance	Leakage Inductance	Remarks
5 --> 2	1 UEW 0.45 $\phi$	19	115 $\mu$ H	21.5 $\mu$ H	1KHz, 1V
7 --> 9	1 UEW 0.04 $\phi$	2300	1.5 H	280mH	1KHz, 1V

#### 5. BOM of the Application Circuit

Part Ref.	Value	Description / Vendor	Part Ref.	Value	Description / Vendor
<b>Fuse</b>			C5	220pF	50V 1608 J
F1	24V 3A	Fuse	C6	1 $\mu$ F	50V 2012 K
<b>Resistor (SMD)</b>			C7	10 $\mu$ F	16V 3216
R1	330k $\Omega$	1608 J	C8	10 $\mu$ F	16V 3216
R2	56k $\Omega$	1608 F	C9	1 $\mu$ F	16V 1608 K
R3	18k $\Omega$	1608 F	C10	15pF	3KV 3216
R4	22k $\Omega$	1608 F	C11	15pF	3KV 3216
R5	27k $\Omega$	1608 F	C12	15pF	3KV 3216
R6	82k $\Omega$	1608 F	C13	15pF	3KV 3216
R8	100k $\Omega$	1608 F	C14	10nF	50V 1608 K
R9	9.1k $\Omega$	1608 F	C15	10nF	50V 1608 K
R11	1k $\Omega$	1608 F	C17	2.2nF	50V 1608 Z
R12	1k $\Omega$	1608 F	C18	2.2nF	50V 1608 Z
R13	1k $\Omega$	1608 F	C19	2.2nF	50V 1608 Z
R14	100k $\Omega$	1608 F	C20	2.2nF	50V 1608 Z
R15	10k $\Omega$	1608 F	C21	10nF	50V 1608 Z
R16	1k $\Omega$	1608 F	C25	1 $\mu$ F	50V 2012 K
R17	1k $\Omega$	1608 F	C26	0.1 $\mu$ F	16V 1608 K
R18	1k $\Omega$	1608 F	C27	1 $\mu$ F	50V 2012 K
R19	1k $\Omega$	1608 F	C28	10nF	50V 1608 Z
R20	10k $\Omega$	1608 J	C29	10nF	50V 1608 K
R21	10k $\Omega$	1608 J	C30	10nF	50V 1608 K
R22	10k $\Omega$	1608 J	<b>Diode / TR (SMD)</b>		
R23	10k $\Omega$	1608 J	D1	BAW56	Fairchild Semiconductor
R24	10k $\Omega$	1608 J	D3	BAV70	Fairchild Semiconductor
R25	10k $\Omega$	1608 J	D4	BAV70	Fairchild Semiconductor
R26	1k $\Omega$	1608 F	D6	BAV99	Fairchild Semiconductor
R27	10k $\Omega$	1608 J	D7	BAV99	Fairchild Semiconductor
<b>Capacitor (SMD)</b>			D8	BAV99	Fairchild Semiconductor
C1	0.22 $\mu$ F	16V 1608 K	D9	BAV99	Fairchild Semiconductor
C2	1 $\mu$ F	50V 2012 K	D10	BAW56	Fairchild Semiconductor
C3	4.7nF	50V 1608 K	D11	BAW56	Fairchild Semiconductor
C4	4.7nF	50V 1608 K	Q1	KST2222	Fairchild Semiconductor

**5. BOM of the Application Circuit (Continued)**

Part Ref.	Value	Description / Vendor	Part Ref.	Value	Description / Vendor
<b>Electrolytic capacitor</b>			<b>Wafer (SMD)</b>		
C22	220μF	25V	CN1	35001WR-02A	
<b>MOSFET (SMD)</b>			CN2	35001WR-02A	
M1	FDS8958A	Fairchild semiconductor	CN3	35001WR-02A	
M2	FDS8958A	Fairchild semiconductor	CN4	35001WR-02A	
<b>Transformer (SMD)</b>			CN5	12505WR-10	
TX1	EFD2124	<b>Supported by Namyang electronics (<a href="http://www.namyangelec.co.kr">http://www.namyangelec.co.kr</a>)</b>			
TX2	EFD2124				

### Mechanical Dimensions

#### 20-SSOP

Dimensions are in millimeters unless otherwise specified.

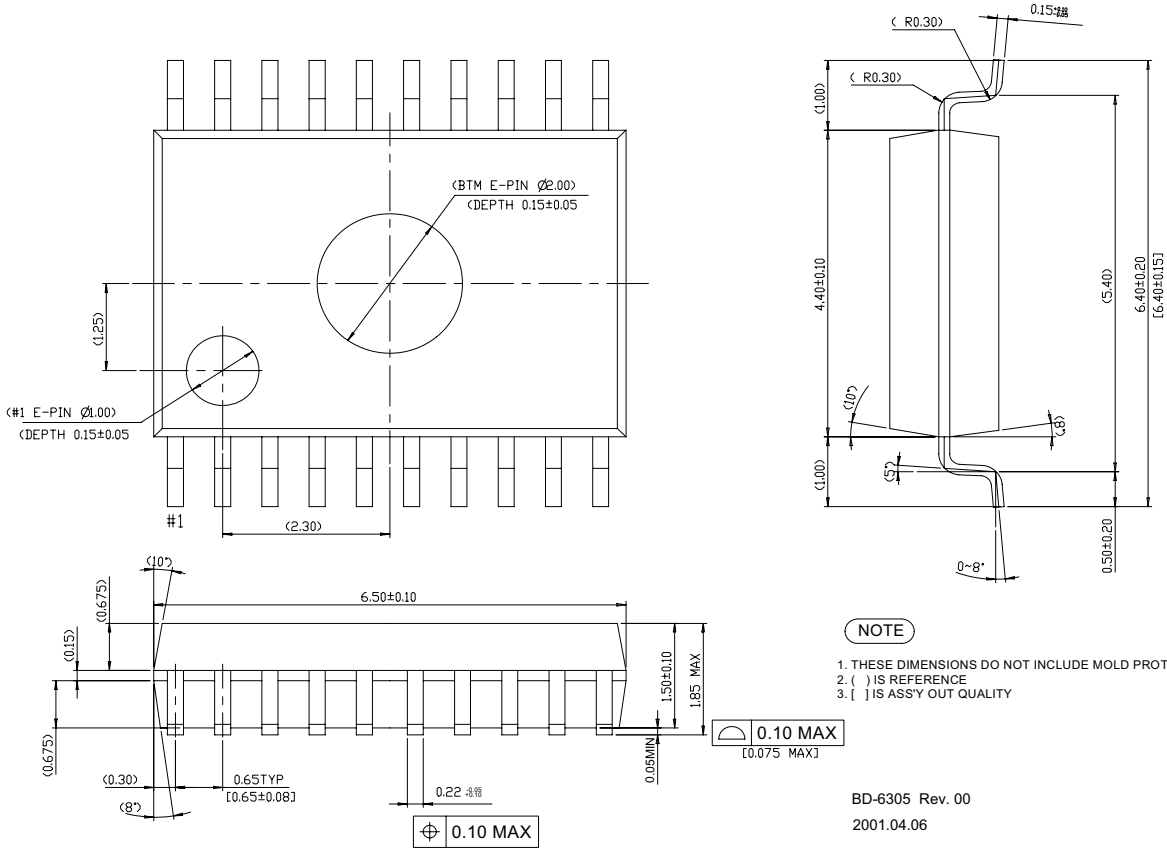
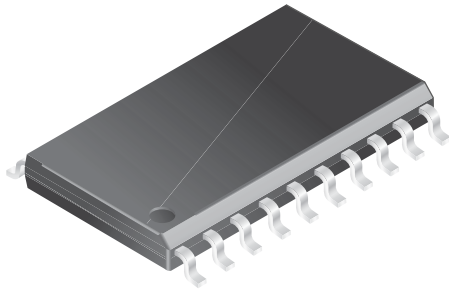


Figure 12. 20-Lead Shrink Small Outline Package (SSOP)

## Mechanical Dimensions (Continued)

### 20-SOIC

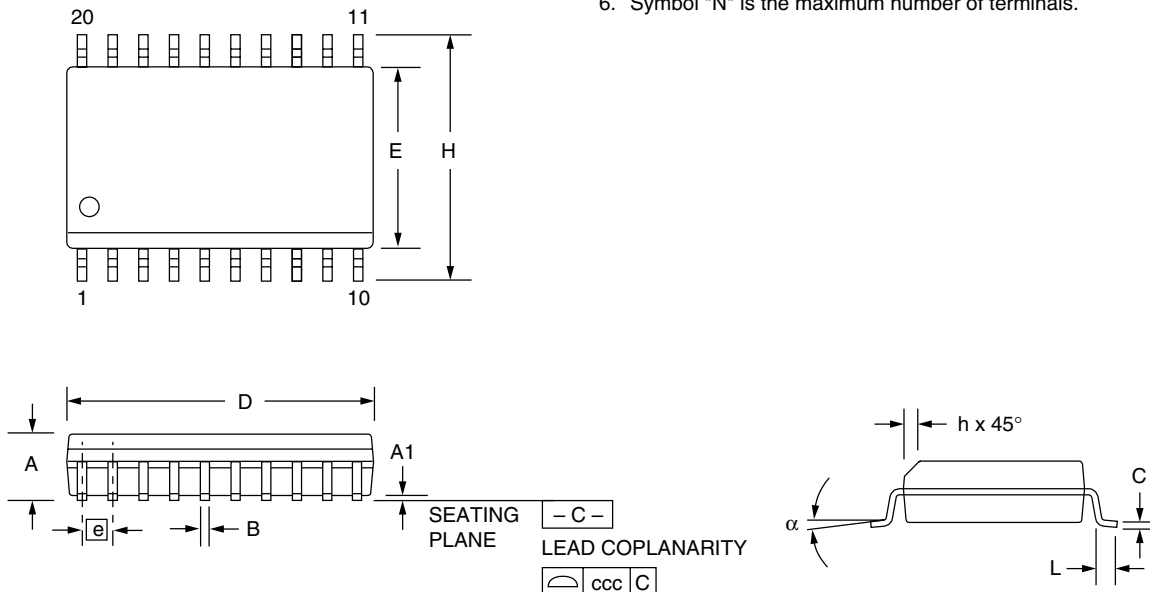
Dimensions are in millimeters unless otherwise specified.



Symbol	Inches		Millimeters		Notes
	Min.	Max.	Min.	Max.	
A	.093	.104	2.35	2.65	
A1	.004	.012	0.10	0.30	
B	.013	.020	0.33	0.51	
C	.009	.013	0.23	0.32	5
D	.496	.512	12.60	13.00	2
E	.291	.299	7.40	7.60	2
e	.050 BSC		1.27 BSC		
H	.394	.419	10.00	10.65	
h	.010	.029	0.25	0.75	
L	.016	.050	0.40	1.27	3
N	20		20		6
$\alpha$	0°	8°	0°	8°	
ccc	—	.004	—	0.10	

#### Notes:

1. Dimensioning and tolerancing per ANSI Y14.5M-1982.
2. "D" and "E" do not include mold flash. Mold flash or protrusions shall not exceed .010 inch (0.25mm).
3. "L" is the length of terminal for soldering to a substrate.
4. Terminal numbers are shown for reference only.
5. "C" dimension does not include solder finish thickness.
6. Symbol "N" is the maximum number of terminals.



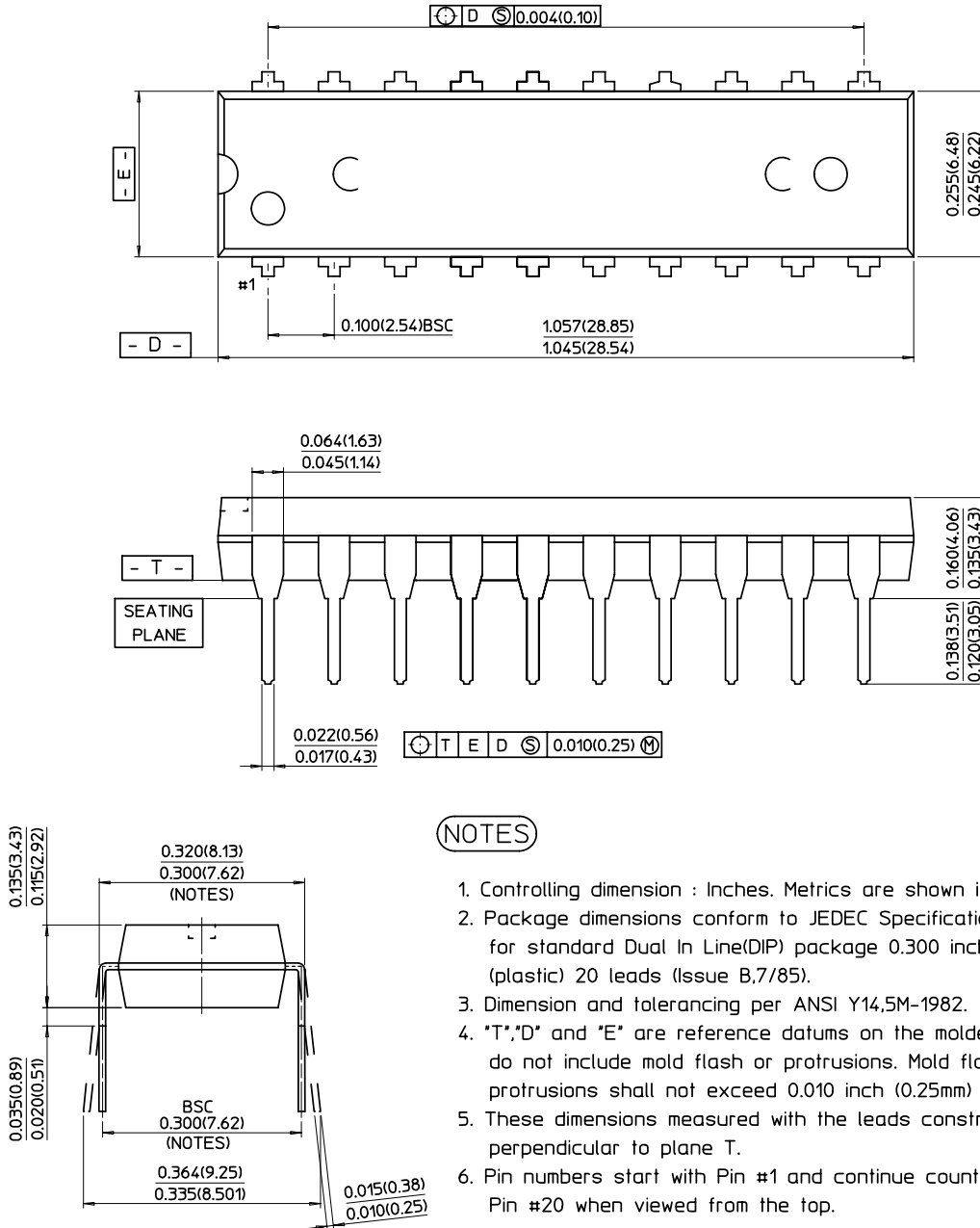
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Figure 13. 20-Lead Small Outline Integrated Circuit (SOIC)

## Mechanical Dimensions (Continued)

### 20-DIP

Dimensions are in millimeters unless otherwise specified.



### NOTES

1. Controlling dimension : Inches. Metrics are shown in parentheses.
2. Package dimensions conform to JEDEC Specification MS-001-AE for standard Dual In Line(DIP) package 0.300 inch row spacing (plastic) 20 leads (Issue B.7/85).
3. Dimension and tolerancing per ANSI Y14.5M-1982.
4. "T","D" and "E" are reference datums on the molded body and do not include mold flash or protrusions. Mold flash or protrusions shall not exceed 0.010 inch (0.25mm) on any side.
5. These dimensions measured with the leads constrained to be perpendicular to plane T.
6. Pin numbers start with Pin #1 and continue counterclockwise to Pin #20 when viewed from the top.

BD5256 REV. 00  
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Figure 14. 20-Lead Dual In-Line Package (DIP)

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Build it Now™	HiSeC™	OPTOPLANAR™	Stealth™	
CoolFET™	I <sup>2</sup> C™	PACMAN™	SuperFET™	
CROSSVOLT™	i-Lo™	POP™	SuperSOT™-3	
DOME™	ImpliedDisconnect™	Power247™	SuperSOT™-6	
EcoSPARK™	IntelliMAX™	PowerEdge™	SuperSOT™-8	
E <sup>2</sup> CMOS™	ISOPLANAR™	PowerSaver™	SyncFET™	
EnSigna™	LittleFET™	PowerTrench®	TCM™	
FACT®	MICROCOUPLER™	QFET®	TinyBoost™	
FAST®	MicroFET™	QS™	TinyBuck™	
FASTr™	MicroPak™	QT Optoelectronics™	TinyPWM™	
FPS™	MICROWIRE™	Quiet Series™	TinyPower™	
FRFET™	MSX™	RapidConfigure™	TinyLogic®	
	MSXPro™	RapidConnect™	TINYOPTO™	
Across the board. Around the world.™		μSerDes™	TruTranslation™	
The Power Franchise®		ScalarPump™	UHC®	
Programmable Active Droop™				

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As used herein:

1. Life support devices or systems are devices or systems which, (a) are intended for surgical implant into the body, or (b) support or sustain life, or (c) whose failure to perform when properly used in accordance with instructions for use provided in the labeling, can be reasonably expected to result in significant injury to the user.
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.

### PRODUCT STATUS DEFINITIONS

#### Definition of Terms

Datasheet Identification	Product Status	Definition
Advance Information	Formative or In Design	This datasheet contains the design specifications for product development. Specifications may change in any manner without notice.
Preliminary	First Production	This datasheet contains preliminary data, and supplementary data will be published at a later date. Fairchild Semiconductor reserves the right to make changes at any time without notice to improve design.
No Identification Needed	Full Production	This datasheet contains final specifications. Fairchild Semiconductor reserves the right to make changes at any time without notice to improve design.
Obsolete	Not In Production	This datasheet contains specifications on a product that has been discontinued by Fairchild semiconductor. The datasheet is printed for reference information only.

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