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FAN7532
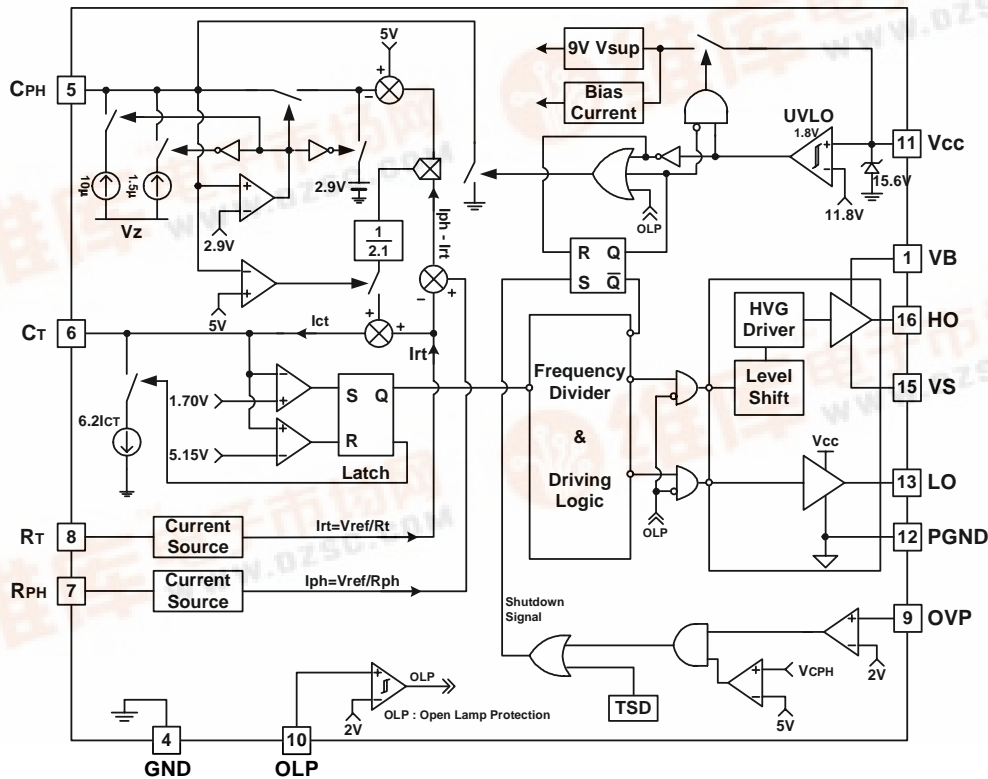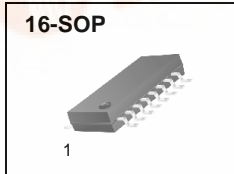## Ballast Control IC

Features

- Floating Channel Designed for Bootstrap Operation to +600V.
- Lower di/dt Gate Driver for Better Noise Immunity
- Driver Current Capability: 250mA/500mA
- Low Start-up and Operating Current: 120µA, 6.4mA
- Under Voltage Lock Out (UVLO) with 1.8V of Hysteresis
- Programmable Preheat Time and Frequency
- Programmable Run Frequency
- Protection from Failure to Strike
- Lamp Filament Sensing and Protection
- Automatic Restart for Lamp Exchange
- High Accuracy Oscillator
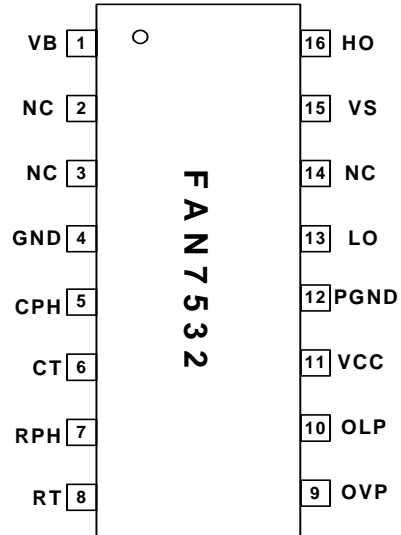- 16-Pin SOP

Typical Application

- General Purpose Ballast IC

Descriptions

The FAN7532 provides simple and high performance electronic ballast control functions. Optimized for an electronic ballast, the FAN7532 requires a minimum board area, and reduces component counts. The FAN7532 is intended to drive two power MOSFETs in the classical half-bridge topology with all the features needed to properly drive and control a fluorescent lamp. The FAN7532 has many comprehensive protection features that work through filament failure, failure of a lamp to strike, and automatic restarts. A dedicated timing section in the FAN7532 allows the user to set the necessary parameters to preheat, ignite, and run the lamp properly.

16-SOP

1

Rev. 1.0.0

Pin Assignments

```
           VB  1   ○         16  HO

           NC  2             15  VS

           NC  3             14  NC

          GND  4    F        13  LO
                    A
                    N
          CPH  5    7        12  PGND
                    5
          CT   6    3        11  VCC
                    2
          RPH  7             10  OLP

          RT   8              9  OVP
```

Pin Definitions

Pin Number	Pin Name	Pin Function Description
1	VB	High Side Floating Supply Voltage
2	N.C.	No Connection
3	N.C.	No Connection
4	GND	Ground
5	CPH	Preheat Time Set Capacitor
6	CT	Oscillator Frequency Set Capacitor
7	RPH	Preheat Frequency Set Resistor
8	RT	Oscillator Frequency Set Resistor
9	OVP	Over Voltage Protection, Latch Mode
10	OLP	Open Lamp Protection, Only Output Disable Mode
11	Vcc	Supply Voltage
12	PGND	Power Ground
13	LO	Low Side Gate Driver Output
14	N.C.	No Connection
15	VS	High Side Floating Supply Return
16	HO	High Side Gate Driver Output

Absolute Maximum Ratings

Parameter		Symbol	Value	Unit
Supply Current (See Caution Below)		I_{CC}	25	mA
High Side Floating Supply Offset Voltage		V_S	V_B-25 to V_B+0.3	V
High Side Floating Supply Voltage		V_B	-0.3 to 625	V
High Side Floating Output Voltage, HO		V_{HO}	V_S-0.3 to V_S+0.3	
Drive Output Source Current		I_{OH}	250	mA
Drive Output Sink Current		I_{OL}	500	mA
CPH, CT, RT, and RPH Pins Input Voltage		V_{IN}	-0.3 to 6	V
Allowable Offset Voltage Slew Rate		dV_S/dt	50	V/ns
Operating Temperature Range		Topr	-25 to 125	°C
Storage Temperature Range		Tstg	-65 to 150	°C
Power Dissipation	16-SOP	Pd	0.94	W
Thermal Resistance (Junction-to-Air)		Rθja	100	°C/W

Caution: You must not supply a low impedance voltage source to the internal clamping zener diode that is between the GND and the V_{CC} pin of this device.

Recommended Operating Conditions

Parameter	Symbol	Value	Unit
Supply Voltage	V_{CC}	11 to V_{CL}	V
High Side Floating Offset Supply Voltage	V_S	600	V
High Side Floating Supply Voltage	V_B	V_S+11 to V_S+20	V
High Side Floating Output Voltage, HO	V_{HO}	V_S to V_B	V

Temperature Characteristics (-25°C ≤ Ta ≤ 125°C)

Parameter	Symbol	Value	Unit
Temperature Stability for Operating Frequency (fos)	Δfos(Typ)	3	%

ESD Level

Parameter	Reference	Pins	Conditions	Level	Unit
Human Body Model (HBM)	GND, CPH, CT, RPH, RT, OVP, OLP, LO	VB, VS, HO	R=1.5kΩ, C=100pF	±1000	V
Machine Model (MM)	GND	LO	C=200pF	+250	

Note: ESD immunity for all pins, except for condition noted above, is guaranteed up to 2000V (Human Body Model) and 300V (Machine Model).

Electrical Characteristics

$V_{CC}=V_{BS}=14V$, Ta=25°C unless otherwise specified.

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
SUPPLY VOLTAGE SECTION						
Start Threshold Voltage	$V_{TH(st)}$	V_{CC} Increasing	11	11.8	12.6	V
UVLO Hysteresis	HY(st)	-	0.8	1.8	2.8	V
Supply Clamping Voltage	V_{CL}	Icc=12mA	14.7	15.6	16.5	V
Start-Up Supply Current	IST	V_{CC} = 10V	-	120	180	µA
Operating Supply Current	ICC	Output Not Switching	-	6.4	9.5	mA
Dynamic Operating Supply Current: (ICC+IQBS)	IDCC	50kHz, C_L =1nF	-	8.2	10.5	mA
OSCILLATOR SECTION						
CPH Pin Charging Current 1	ICPHL	VCPH=2V	1	1.5	2	µA
CPH Pin Charging Current 2	ICPHH	VCPH=4V	7.7	10	12.3	µA
CPH Pin Clamp Voltage	VCLAMP	-	5.1	5.65	6.2	V
Preheating Frequency	fPH	VCPH=0V, RPH=20kΩ, CT=1nF	75	85	95	kHz
Preheating Dead Time	tPD	VCPH=0V, RPH=20kΩ, CT=1nF	0.75	1.20	1.55	µs
Operating Frequency	fOSC	VCPH=Open, RT=18kΩ, CT=1nF	48	50	52	kHz
Operating Dead Time	tOD	VCPH=Open, RT=18kΩ, CT=1nF	1.5	2	2.3	µs
Differential Threshold Voltage on CT	ΔVCT	-	3	3.45	4	V
CT Charging Current	Ich	VCT=1.5V	400	460	510	µA
CT Discharging Current	Idisch	VCT=5.5V	1.95	2.4	2.8	mA
Voltage Stability	Δf/ΔV	12.7V ≤ V_{CC} ≤ V_{CL}	-	-	3	%
OUTPUT SECTION						
Low Side Driver Source Current	ILO1	VLO=Vcc	200	250	-	mA
Low Side Driver Sink Current	ILO2	VLO=GND	400	500	-	mA
High Side Driver Source Current	IHO1	VHO=VB	200	250	-	mA
High Side Driver Sink Current	IHO2	VHO=VS	400	500	-	mA
High/Low Side Rising Time	tr	C_L =1nF	-	90	150	ns
High/Low Side Falling Time	tf	C_L = 1nF	-	40	100	ns
HIGH VOLTAGE SECTION						
Offset Supply Leakage Current	ILK	VB=VS=600V	-	-	10	µA
Quiescent VBS Supply Current	IQBS	-	10	48	90	µA

Electrical Characteristics (Continued)

Vcc=V$_{BS}$=14V, Ta=25°C unless otherwise specified.

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
PROTECTION SECTION						
OVP/OLP Comparator Threshold Voltage	Vth_com	-	1.8	2	2.3	V
OLP Comparator Hysteresis Voltage	Vhy_com	-	0.6	0.92	1.3	V
Latch Mode Quiescent Current	Ilatch	-	-	0.35	0.45	mA
Thermal Shutdown Junction Temperature	T$_{SD}$	-	-	150	-	°C

Typical Characteristics
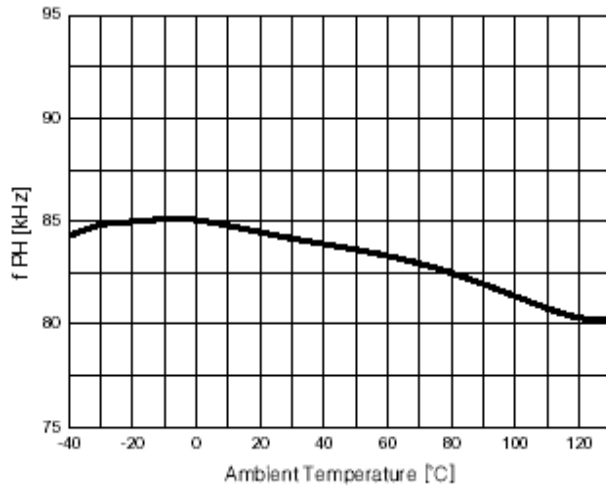
Figure 1. Preheating Frequency vs. Temperature
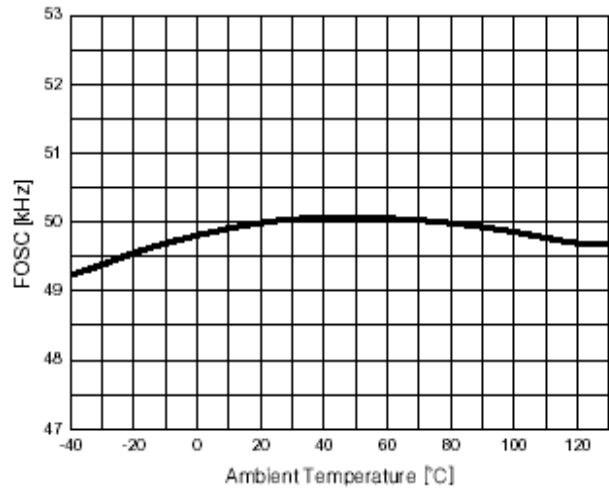
Figure 2. Operating Frequency vs. Temperature
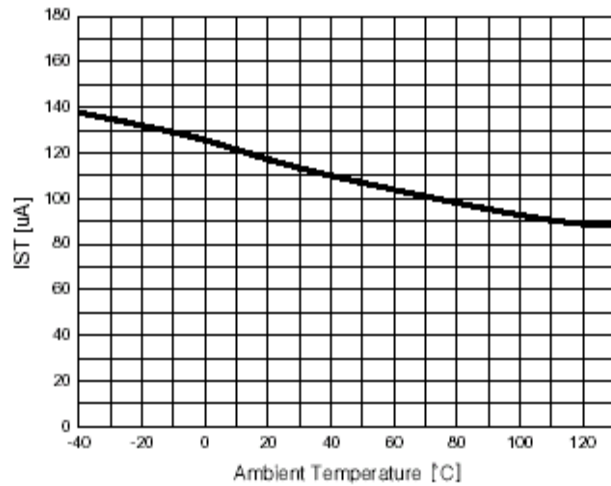
Figure 3. Start-up Current vs. Temperature
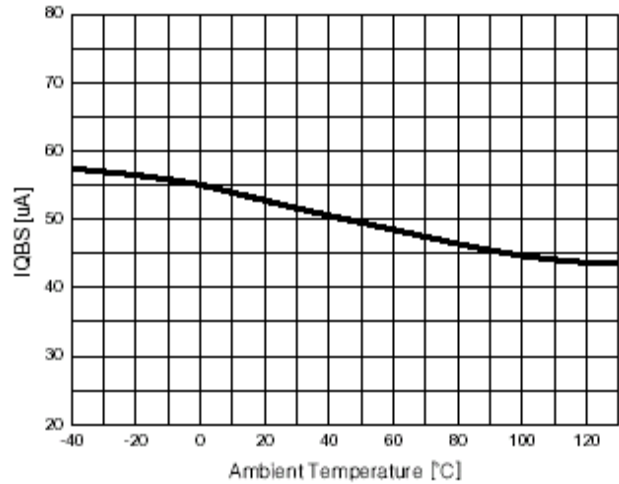
Figure 4. V_{BS} Quiescent Current vs. Temperature
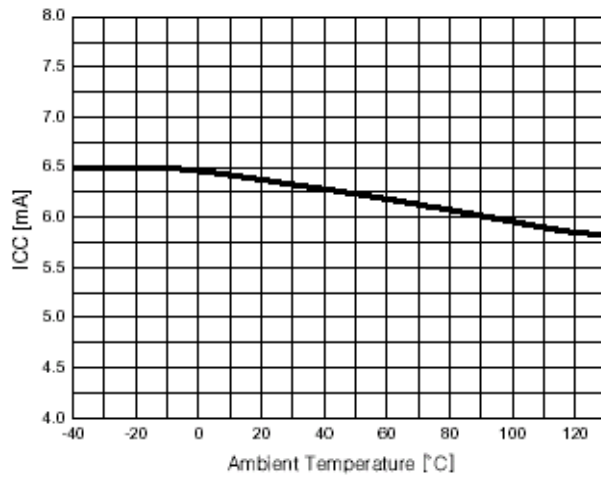
Figure 5. Operating Current vs. Temperature
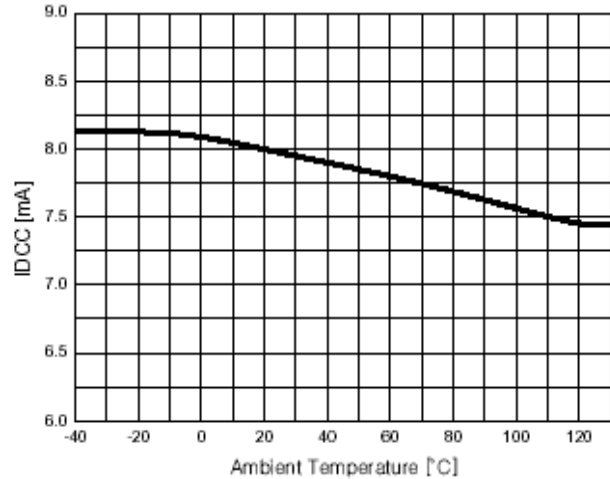
Figure 6. Dynamic Operating Current vs. Temperature

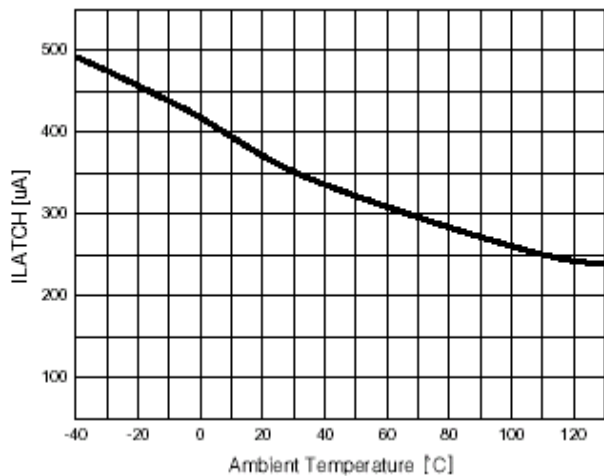## Typical Characteristics (Continued)
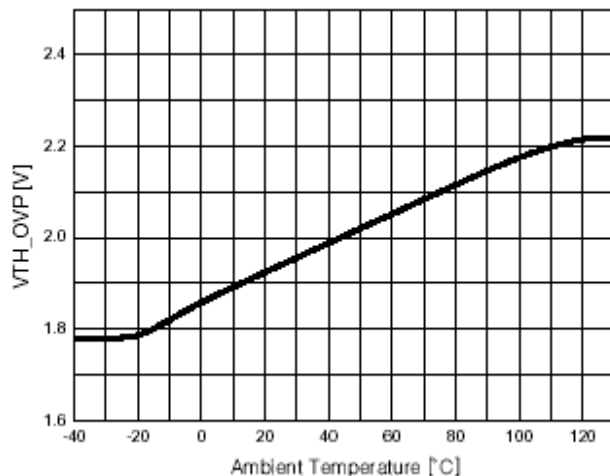

Figure 7. Latch Mode Current vs. Temperature

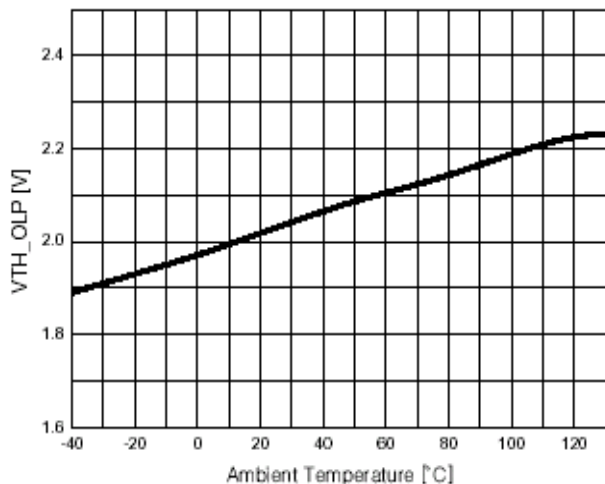Figure 8. OVP Detection Voltage vs. Temperature

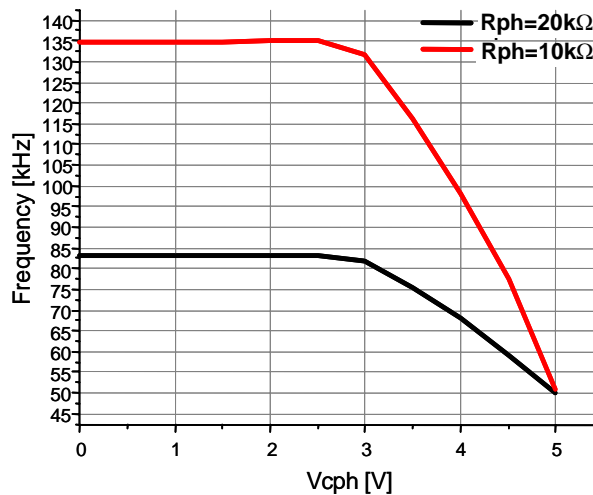Figure 9. OLP Detection Voltage vs. Temperature

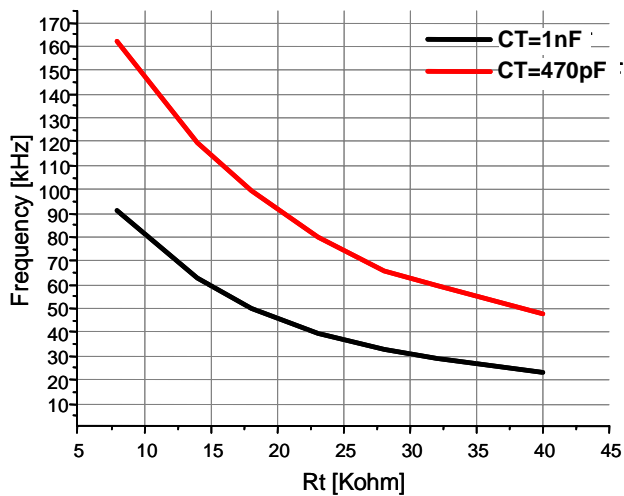Figure 10. Preheating Frequency vs. Rph

Figure 11. Run Frequency vs. Rt and CT

Application Information

Start-up Circuit

The start-up current is supplied to the IC through the start-up resistor (Rst). To reduce the power dissipation in Rst, Rst is connected to the full-wave, rectified output voltage. The size of Rst can be determined by equations (1) and (2).
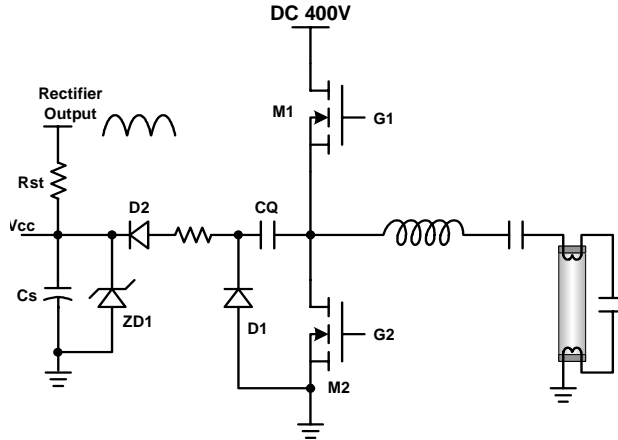

Figure 12. Start-up Circuit

$$R_{st} = \frac{V_{in(ac)} \times \sqrt{2} - V_{th(st), max}}{I_{st, max}} \tag{1}$$

$$= \frac{85 \times \sqrt{2} - 12.4}{0.18 \times 10^{-3}} = 599[k\Omega]$$

$$R_{st} = \frac{(V_{in(ac, max)} \times \sqrt{2} - V_{cc})^2}{R_{st}} \leq 0.5[W] \tag{2}$$

$$R_{st} \geq 2 \times (V_{in(ac, max)} \times \sqrt{2} - V_{cc})^2$$

$$R_{st} \geq 260[k\Omega]$$

$$\therefore 260k \leq R_{st} \leq 599k$$

The size of supply capacitor (Cs) is normally determined by the start-up time and the operating current which is built up by the auxiliary operating current source. The turn-off snubber capacitor (CQ) and two diodes (D1, D2) constitute the auxiliary operating current source for the IC. The charging current through the CQ flows into the IC and charges the supply capacitor. If the size of CQ is increased, the V_{cc} voltage on the Cs is also increased.

Under Voltage Lock Out (UVLO)

The UVLO mode of the FAN7532 is designed to maintain an ultra low supply current of less than 120µA, and to guarantee that the IC is fully functional before two output drivers are activated.

Oscillator

The gate drive output frequency is half that of the triangular waveform on timing capacitor (CT) at pin #6. In normal operating mode, the timing capacitor charging current is 4*Irt(=Vref/RT). The discharging current is 6.2 times the charging current (5.2*4*Irt). During the charging period of the timing capacitor (CT), the MOSFET alternatively turns on. During the discharging period of the timing capacitor (CT), both MOSFETs are off.
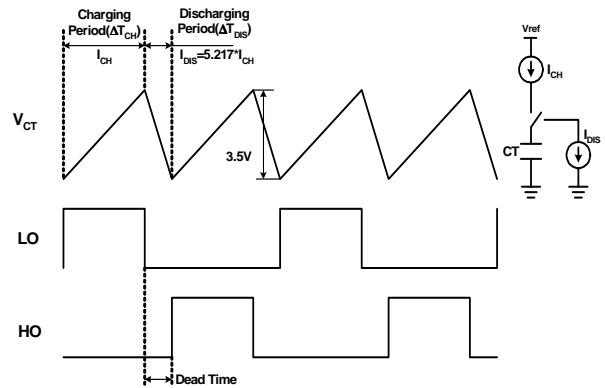

Figure 13. CT & Output Waveforms

Operating Modes

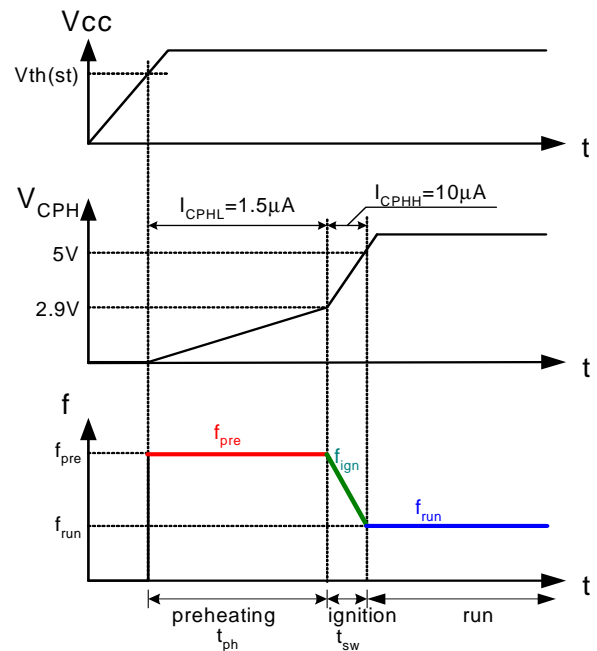The FAN7532 has three operating modes according to VCPH as shown in Figure 14.

Figure 14. Operating Modes

$$0V < V_{CPH} < 2.9V \qquad ; \text{Preheating Frequency}$$

$$i_{CT} = I_{RT} + \frac{I_{PH} - I_{RT}}{(5V - 2.9V)}(5V - 2.9V) = I_{PH}$$

$$2.9V < V_{CPH} < 5V \qquad ; \text{Frequency Sweep}$$

$$i_{CT} = I_{RT} + \frac{I_{PH} - I_{RT}}{(5V - 2.9V)}(5V - V_{CPH})$$

$$V_{CPH} \geq 5V \qquad ; \text{Run Frequency}$$

$$i_{CT} = I_{RT}$$

1) Preheating Mode

The preheating mode is defined as the IC's internal status when the V_{CPH} is between 0V and 2.9V. During preheating, the current that flows through the ballast circuit heats the lamp filaments. This is necessary for maximizing lamp life and reducing the required ignition voltage. When the V_{cc} exceeds the UVLO high threshold, the preheating time set-up capacitor, CPH, starts being charged by the internal 1.5μA current source until the V_{CPH} reaches 2.9V. Until the VCPH reaches 2.9V the switching frequency throughout the pre-heating mode is determined by CT and RPH.
The preheating time is determined by the CPH and the 1.5μA current source. Therefore, the preheating time is determined by equation (3):

$$t_{pre} = CPH \times \frac{V_{CPH}}{I_{charging}} \qquad (3)$$

The preheating frequency is determined by the amount of charging and discharging current to the CT capacitor. The charging and discharging current during preheating mode is decided by equation (4):

$$I_{pre\_ch} = 4 \times \frac{V_{ref}}{R_{ph}} \qquad (4)$$

$$I_{pre\_disch} = 4 \times \frac{V_{ref}}{6.25 \times R_{ph}} \quad \text{Vref = 4V: constant}$$

Additionally, the charging and discharging time of the CT capacitor during preheating mode is decided by equation (5):

$$I_{pre\_ch} = C_T \times \frac{dV_{CT}}{I_{pre\_ch}} \qquad (5)$$

$$t_{pre\_disch} = C_T \times \frac{dV_{CT}}{I_{pre\_disch}} \quad \text{dVct = 3.45V: constant}$$

Finally, the FAN7532's preheating frequency in the preheating period is determined by equation (6):

$$f_{pre} = \frac{1}{2 \times (t_{pre\_ch} + t_{pre\_disch})} \qquad (6)$$

2) Ignition Mode

The ignition mode is defined as the IC's internal status when V_{CPH} is approximately between 2.9V and 5V. During ignition, the operating frequency is decreased to a pre-determined value.
At the same time, a very high voltage for igniting the lamp is established across the lamp. When the V_{CPH} exceeds 2.9V, the FAN7532 enters the ignition mode. Once V_{CPH} exceeds 5V, the device enters the run mode described in the following section.
In the ignition period, the internal 10mA current source charges the external preheating timing capacitor (CPH) in order to increase noise immunity with the sharp slope of the V_{CPH}. The ignition time is determined by the CPH and internal 10mA current source (DTIGN=CPH*DVCPH/ICPHH).

- In this mode, the switching frequency is determined by CT, RPH and RT. Therefore, the charging and discharging currents change according to V_{CPH} are determined by equation (7):

$$I_{CT} = I_{RT} + \frac{I_{RPH} - I_{RT}}{2 \cdot 1}(5V - V_{CPH}) \qquad (7)$$

3) Run Mode

After the lamp has successfully ignited, the FAN7532 enters run mode. The run mode is defined as the IC's internal status when V_{CPH} is higher than 5V. In this mode, the lamp is being driven with a normal power level after the lamp is discharged. The run mode switching frequency is determined by the timing resistor RT and the timing capacitor CT. When the V_{CPH} exceeds 5V, the protection-masking mode is disabled and the IC can enter the protection mode. The running frequency is determined by the amount of charging and discharging current to CT capacitor.
The charging and discharging currents during preheating mode are decided by the equation (8):

$$I_{run\_ch} = 2 \times \frac{V_{ref}}{R_t} \qquad (8)$$

$$I_{run\_disch} = 2 \times \frac{V_{ref}}{6.25 \times R_t} \quad \text{Vref = 4V: constant}$$

The charging and discharging time of the CT capacitor during preheating mode is determined by the equation (9):

$$t_{run\_ch} = C_T \times \frac{dV_{CT}}{I_{run\_ch}} \qquad (9)$$

$$t_{run\_disch} = C_T \times \frac{dV_{CT}}{I_{run\_disch}} \quad dVct = 3.45V: constant$$

Finally, the preheating frequency in the preheating period using the FAN7532 is determined by the equation (10):

$$f_{run} = \frac{1}{2 \times (t_{run\_ch} + t_{run\_disch})} \qquad (10)$$

Protection Modes

The FAN7532 has two types of protection modes.

1) Over Voltage Protection (OVP) Mode

The OVP pin is normally connected to the external components that detect lamp voltage between a lamp's cathodes. This voltage is always maintained under 2V in normal operation. If the lamp enters the end of lamp life or abnormal condition, the lamp will not turn on even if there is enough voltage supplied between two cathodes. Normally, this condition means that one of the cathodes is broken, deactivated, or the lamp is deeply blackened around the cathodes. In this state, the ballast constantly generates very high voltage between two cathodes to ignite according to a specific procedure in the control IC. When the voltage of OVP pin exceeds 2V, the IC instantly enters the protection mode. To exit this mode, the V_{cc} must be recycled below the UVLO low threshold.
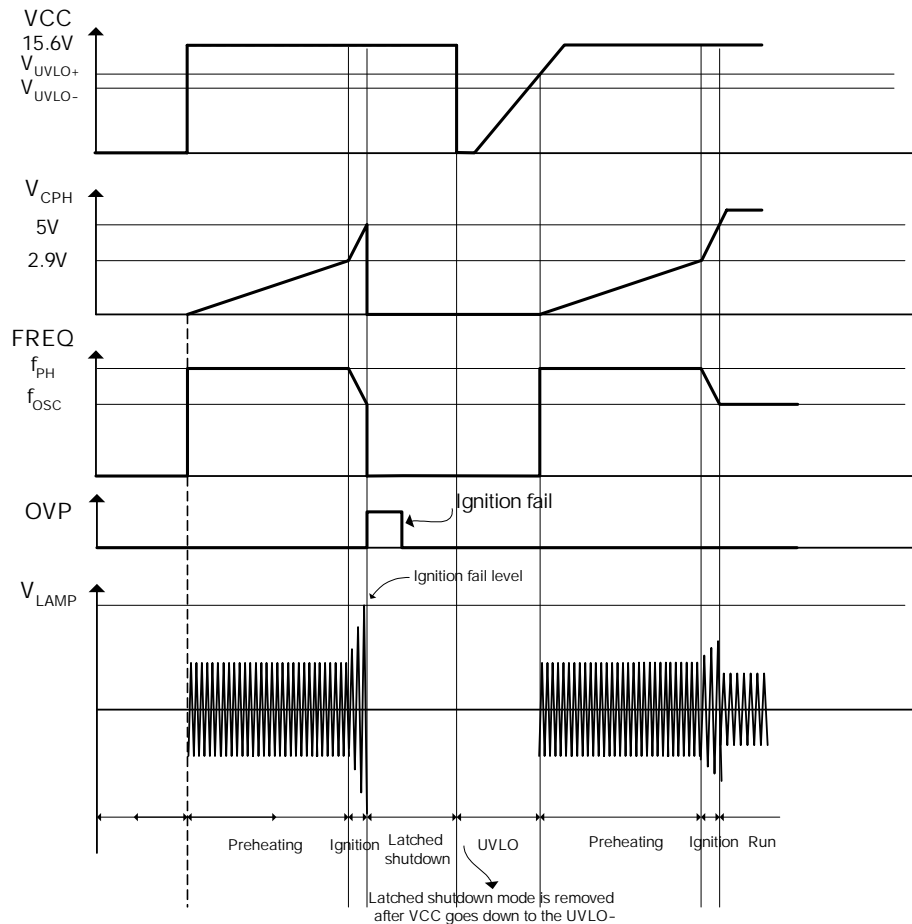

Figure 15. Timing Diagram (OVP) Mode

2) Open Lamp Protection (OLP) Mode

After the lamp has successfully ignited, the FAN7532 enters run mode. In this mode, if one of the cathodes isn't correctly connected to the ballast, the ballast should stop operation for safety until the lamp is changed and a new one is connected between the lamp and the ballast. As soon as the voltage of

OLP pin exceeds 2V, the IC enters the protection mode instantly. However, the FAN7532 outputs are only disabled in this mode. To exit protection mode, the lamp must be replaced or correctly connected to the ballast.
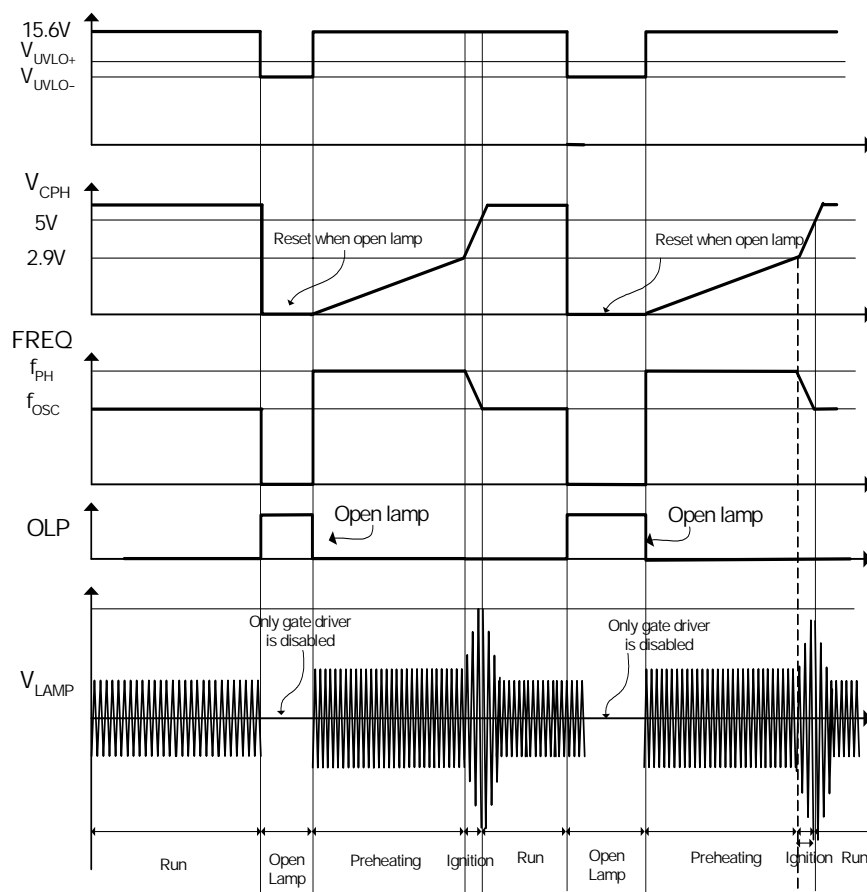
Figure 16. Timing Diagram (OLP Mode)

PCB Layout Guides

Component selection and placement on the PCB is very important when using power control ICs. Bypass the V_{CC} to GND as close to the IC terminals as possible with a low ESR/ESL capacitor, as shown in Figure 17. This bypassed capacitor can reduce the noise from the power supply parts such as a startup resistor and a charge pump. The GND lead should be directly connected to the low side power MOSFET using an individual PCB trace. In addition, the ground return path of the timing components (CPH, CT, RPH, RT) and V_{CC} decoupling capacitor should be connected directly to the IC GND lead and not via separate traces or jumpers to other ground traces on the board. These connection techniques prevent high current ground loops from interfering with sensitive timing component operations and allow the entire control circuit to reduce common-mode noise due to output switching.
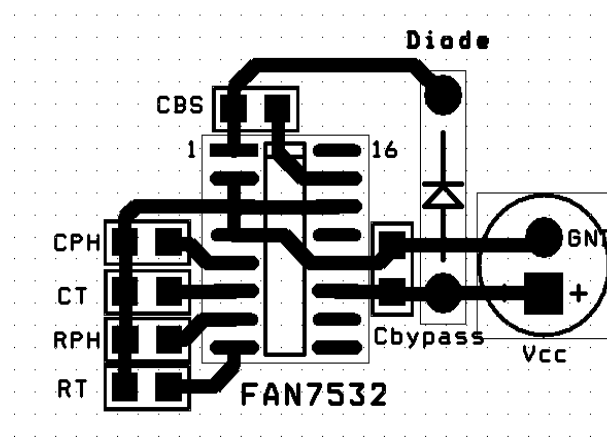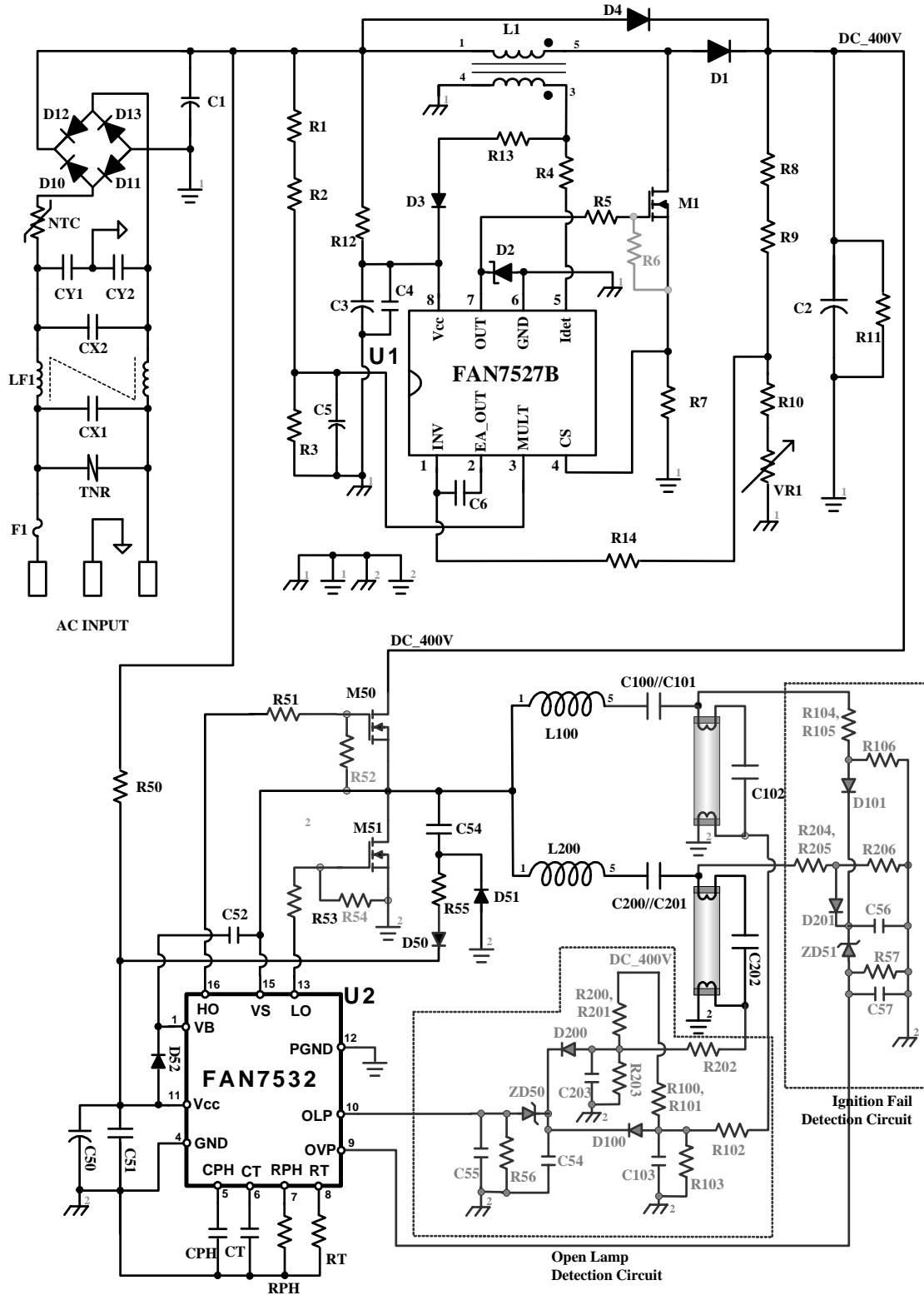
Figure 17. PCB Layout

Typical Application Circuit

Components List (for Wide-Range 32W× 2 Lamps Application)

Part number	Value	Note	Manufacturer
INPUT PART			
F1	250V, 3A	Fuse	-
CX1	47nF, 275Vac	Box-Cap	-
CX2	150nF, 275Vac	Box-Cap	-
CY1, CY2	2200pF, 3000V	Y-Cap	-
TNR	470V	471	-
NTC	10Ω	10D09	-
D10, D11, D12, D13	400V, 1A	1N4004	Fairchild
LF1	45mH		
PFC PART			
R1, R2, R8	910kΩ	Ceramic, 1206	-
R3	22kΩ	Ceramic, 1206	-
R4	22kΩ	Ceramic, 1206	-
R5	10Ω	Ceramic, 1206	-
R6	22kΩ	Ceramic, 1206	-
R7	0.47Ω	1W	-
R9	100kΩ	Ceramic, 1206	-
R10	2.2kΩ	Ceramic, 1206	-
R11	220kΩ	1W	-
R12	150kΩ	1W	
R13	4.7Ω	Ceramic, 1206	
R14	0Ω	Ceramic, 1206	
VR1	10kΩ	Variable Resistor	-
C1	0.22μF, 630V	Miller-Cap	-
C2	47μF, 450V	Electrolytic	-
C3	10μF, 50V	Electrolytic	-
C4	105	Ceramic, 0805	-
C5	102	Ceramic, 0805	-
C6	105	Ceramic, 0805	-
L1	0.9mH(80T:6T)	EI2820	
D1, D4	600V, 1A, Ultrafast	UF4005	Fairchild
D2	Schottky Diode	MBR0540	Fairchild
D3	Small Signal Diode	FDLL4148	Fairchild
M1	500V, 6A, Power MOSFET	FQP6N50C, FQPF6N50C	Fairchild
U1	PFC IC	FAN7527B	Fairchild

Components List (Continued)

Ballast PART			
Part number	**Value**	**Note**	**Manufacturer**
R50	390kΩ	1W	-
R51, R53	39Ω	Ceramic, 1206	-
R52, R54	47kΩ	Ceramic, 1206	-
R55	5.6Ω	1W	-
R56, R57	68kΩ	Ceramic, 0805	-
RPH	27kΩ	Ceramic, 1206	1%
RT	18kΩ	Ceramic, 1206	1%
R100, R104, R200, R204	910kΩ	Ceramic, 1206	-
R101, R105, R201, R205	300kΩ	Ceramic, 1206	-
R102, R202	5.1kΩ	Ceramic, 1206	-
R103, R203	68kΩ	Ceramic, 1206	-
R106, R206	30kΩ	Ceramic, 1206	
C50	10μF, 50V	Electrolytic	-
C51	105	Ceramic, 0805	-
C52	104	Ceramic, 1206	-
C53	681, 630V	Miller-Cap	-
C54, C55, C56, C57,C103,C203	104	Ceramic, 0805	-
CT	1nF	Ceramic, 0805	5%
CPH	680nF	Ceramic, 0805	-
C100, C101, C200, C201	6.8nF, 630V	Miller-Cap	-
C102, C202	3.3nF, 1000V	Miller-Cap	-
L100, L200	3.2mH(120T)	EE2820	-
M50, M51	500V, 5A, Power MOSFET	FQP5N50C, FQPF5N50C	Fairchild
ZD50,ZD51	Zener Diode	1N5245	Fairchild
D50,D51,D52	600V,1A,Ultrafast	UF4005	Fairchild
D100, D101, D200, D201	Small Signal Diode	FDLL4148	Fairchild
U2	Ballast IC	FAN7532	Fairchild

Mechanical Dimensions

Package

Dimensions in millimeters/inches

16-SOP-225

#1 #16

#8 #9

6.00 ±0.30
0.236 ±0.012

3.95 ±0.20
0.156 ±0.008

0.20 +0.10 -0.05
0.008 +0.004 -0.002

5.72
0.225

0.70 ±0.20
0.0275 ±0.008

0-8°

MIN 0.05
0.002

1.55 ±0.10
0.061 ±0.004

0.51
(0.020)

10.30 MAX
0.405

9.90 ±0.20
0.39 ±0.008

0.406 +0.10 -0.05
0.016 +0.004 -0.002

1.27
0.050

1.80 MAX
0.071

MAX0.10
MAX0.004
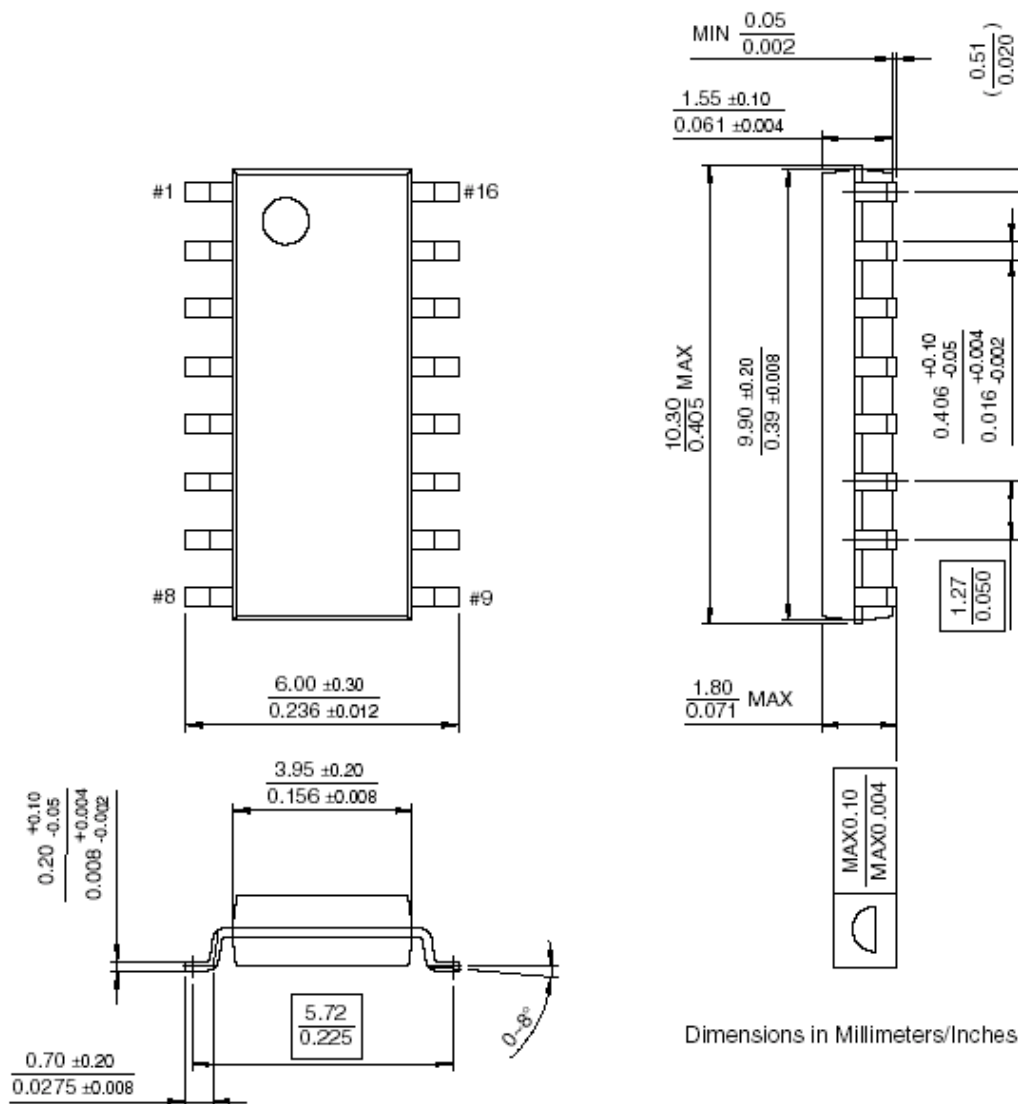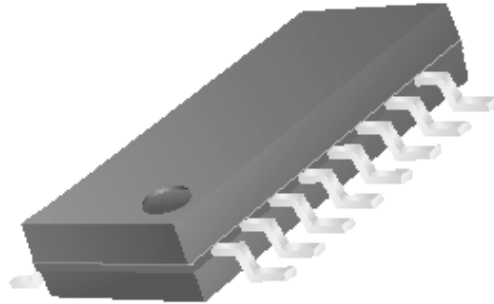
Dimensions in Millimeters/Inches

Ordering Information

Product Number	Package	Operating Temperature	Packing
FAN7532M	16-SOP	-25°C ~ +125°C	Tube
FAN7532MX			Tape & Reel