

FAN7544

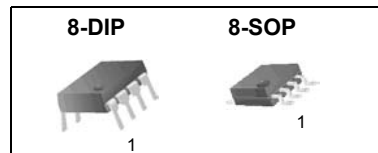
Simple Ballast Controller

Features

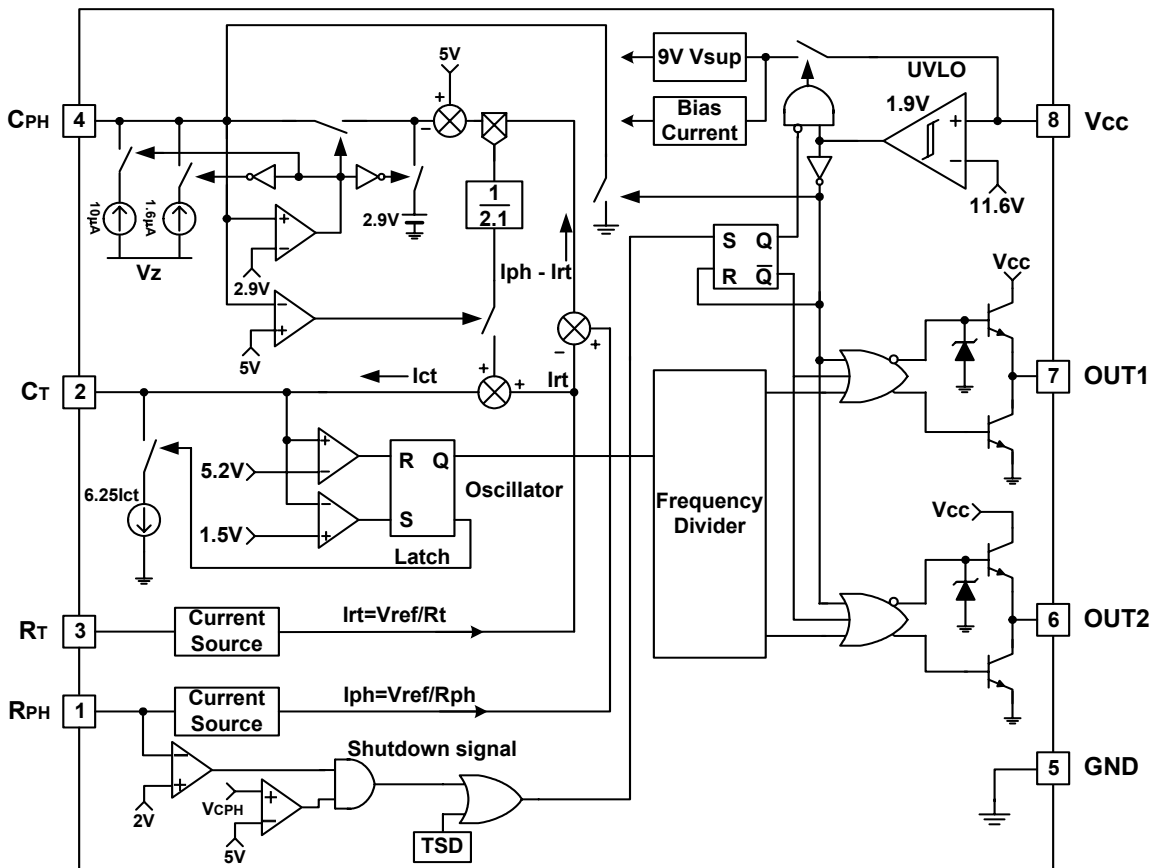
- Low Start-up and Operating Current : 140µA, 6.5mA
- Under Voltage Lock Out With 1.9V of Hysteresis
- 600mA of Totem Pole Output with High State Clamp
- Trimmed 1.5% Internal Bandgap Reference
- Programmable Preheat Time & Frequency
- Programmable Run Frequency
- High Accuracy Oscillator

Descriptions

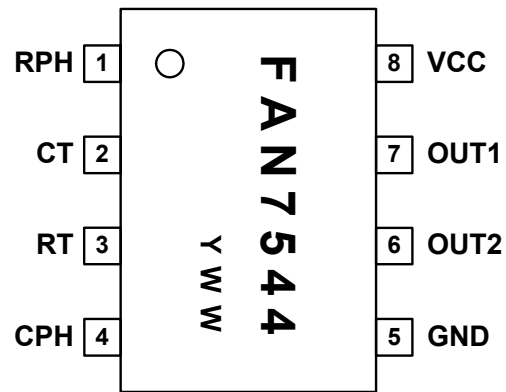
The FAN7544 provides simple and high performance electronic ballast control functions. The FAN7544 is optimized for electronic ballast requiring a minimum board area, by reducing component counts and lowering power dissipation. The features include programmable preheating time and frequency and programmable run frequency. The initial preheating time and frequency can be adjusted according to the types of lamps using the CPH, CT and RPH. Output gate driver circuit clamps power MOSFET gate voltage to the supply voltage.



Internal Block Diagram



Pin Assignments



YWW : Work Week Code

Pin Definitions

Pin Number	Pin Name	Pin Function Description
1	RPH	Preheat frequency set resistor
2	CT	Oscillator frequency set capacitor
3	RT	Oscillator frequency set resistor
4	CPH	Preheat time set capacitor
5	GND	Ground
6	OUT2	Gate drive output 2
7	OUT1	Gate drive output 1
8	VCC	Supply voltage

Absolute Maximum Ratings

Parameter	Symbol	Value	Unit
Supply Voltage	V _{CC}	30	V
Peak Drive Output Current	I _{OH} , I _{OL}	±600	mA
Output Drive Clamping Diode Current	I _{clamp}	±10	mA
CPH, CT, RT, and RPH Pins Input Voltage	V _{IN}	-0.3 to 6	V
Operating Temperature Range	T _{opr}	-25 to 125	°C
Storage Temperature Range	T _{stg}	-65 to 150	°C
Power Dissipation	8-DIP	0.8	W
	8-SOP	0.5	
Thermal Resistance (Junction-to-Air)	8-DIP	100	°C/W
	8-SOP	165	

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

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

Electrical Characteristics

Unless otherwise specified, for typical values $V_{CC}=15V$, $T_a=25^{\circ}C$, For Min/Max values T_a is the operating ambient temperature range with $-25^{\circ}C \leq T_a \leq 125^{\circ}C$ and $12.7V \leq V_{CC} \leq 30V$

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
UNDER VOLTAGE LOCK OUT SECTION						
Start Threshold Voltage	$V_{TH(st)}$	V_{CC} Increasing	10.5	11.6	12.7	V
UVLO Hysteresis	$HY(st)$	-	1.4	1.9	2.4	V
SUPPLY CURRENT SECTION						
Start Up Supply Current	I_{ST}	$V_{CC} < V_{TH(st)}$	-	0.14	0.2	mA
Operating Supply Current	I_{CC}	Output not switching	-	6.5	10	mA
Dynamic Operating Supply Current	I_{DCC}	50kHz, $C_L = 1nF$	-	8	12	mA
OSCILLATOR SECTION						
CPH Pin Charging Current 1	I_{CPHL}	$V_{CPH}=2V$	1.3	1.6	1.9	μA
CPH Pin Charging Current 2	I_{CPHH}	$V_{CPH}=4V$	7	10	13	μA
CPH Pin Clamp Voltage	V_{CLAMP}	-	4.8	5.6	6.4	V
Preheating Frequency	f_{PH}	$V_{CPH}=0V$, $R_{PH}=47k\Omega$, $C_T=470pF$	70	81.5	93	kHz
Preheating Dead Time	t_{pd}	$V_{CPH}=0V$, $R_{PH}=47k\Omega$, $C_T=470pF$	0.8	1.3	1.8	μs
Operating Frequency	f_{OS}	$V_{CPH}=Open$, $R_T=80k\Omega$, $C_T=470pF$	45.5	50	54.5	kHz
Operating Dead Time	t_{OD}	$V_{CPH}=Open$, $R_T=80k\Omega$, $C_T=470pF$	1.6	2.0	2.4	μs
CT Threshold Voltage ^(note1)	ΔV_{CT}	$T_a=25^{\circ}C$	3.2	3.7	4.2	V
CT Charging Current	I_{CHG}	-	170	220	270	μA
CT Discharging Current	I_{DIS}	-	0.9	1.15	1.4	mA
Temperature Stability ^(Note1)	$\Delta f/\Delta T$	$-25^{\circ}C \leq T_a \leq 125^{\circ}C$, $V_{CC} = 25V$	-	1	3	%
Voltage Stability	$\Delta f/\Delta V$	$12.7V \leq V_{CC} \leq 30V$, $T_a=25^{\circ}C$	-	-	3	%
OUTPUT SECTION						
Gate Driver Source Current ^(note1)	$I_{OSOURCE}$	$V_{OUT}=0V$	-	500	-	mA
Gate Driver Sink Current ^(note1)	I_{OSINK}	$V_{OUT}=14.6V$	-	500	-	mA
Rising Time ^(Note1)	t_r	$C_L=1nF$, $V_{CC}=15V$, $T_a=25^{\circ}C$	-	130	170	ns
Falling Time ^(Note1)	t_f	$C_L=1nF$, $V_{CC}=15V$, $T_a=25^{\circ}C$	-	50	100	ns
Maximum Output Voltage	V_{omax}	$V_{CC} = 25V$	13	15	17	V
Output Voltage With UVLO Activated	V_{omin}	$V_{CC} = 5V$, $I_O = 100\mu A$	-	-	1	V
PROTECTION SECTION						
Shutdown Sink Current ^(note1)	I_{SD}	$R_{PH}=47k\Omega$	-	0.6	-	mA
Latch Mode Quiescent Current	I_{LATCH}	$V_{CC} = 15V$	-	0.36	0.57	mA
Thermal Shutdown Junction Temperature ^(Note1)	T_{SD}	-	-	150	-	$^{\circ}C$

Note:

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

Typical Characteristics

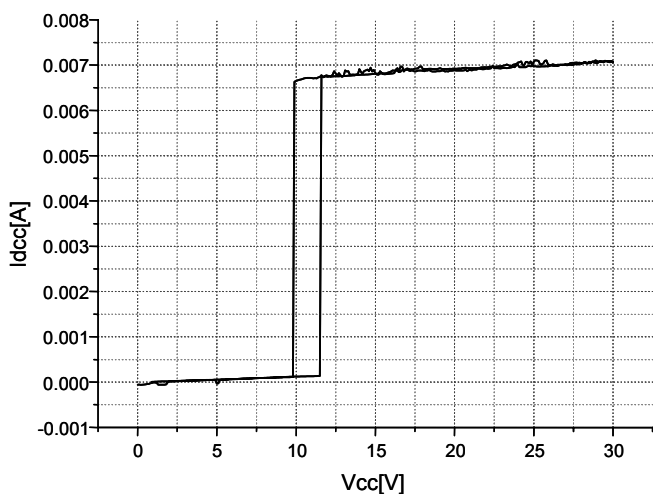


Figure 1. UVLO

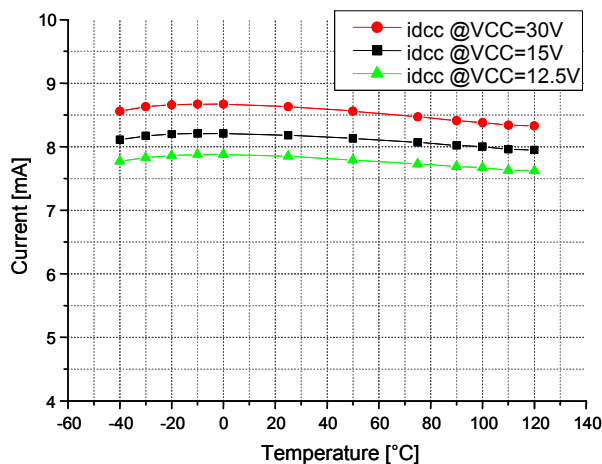


Figure 2. Dynamic Operating Current

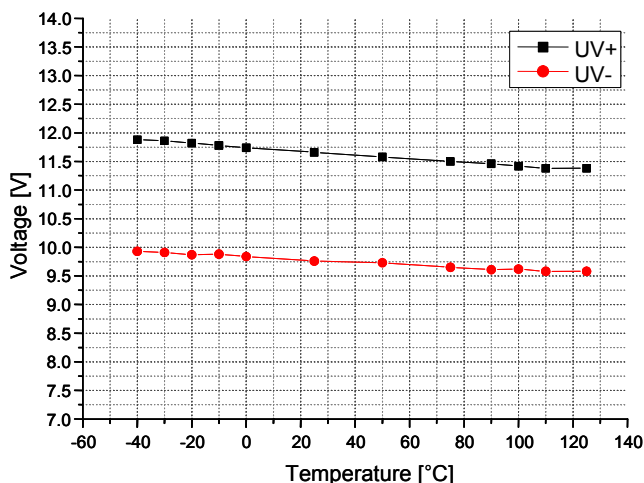


Figure 3. UVLO Hysteresis

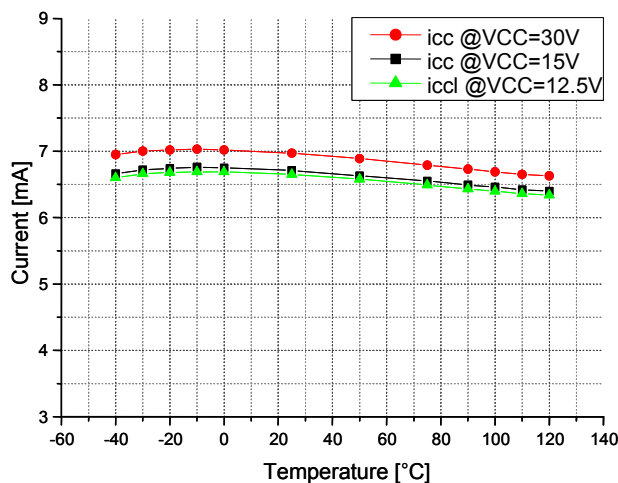


Figure 4. Operating Current

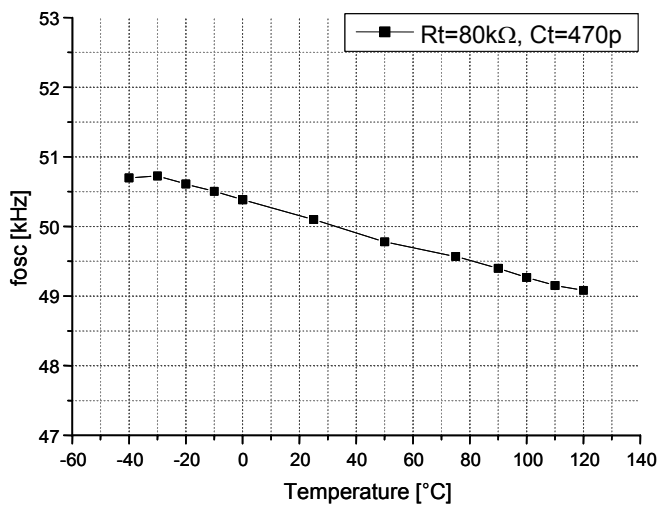


Figure 5. Switching Frequency

Typical Characteristics(Con't)

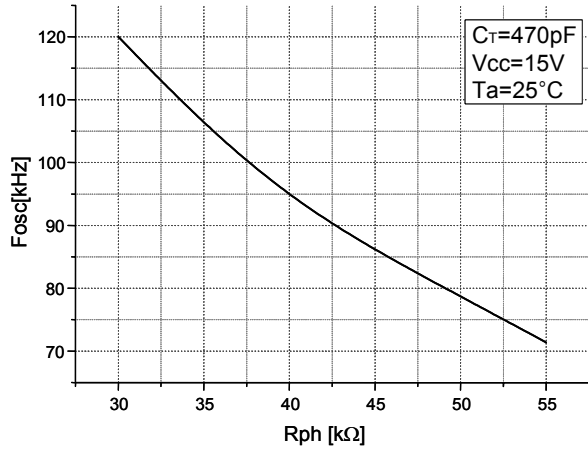


Figure 6. Preheating Frequency, $C_T=470\text{pF}$

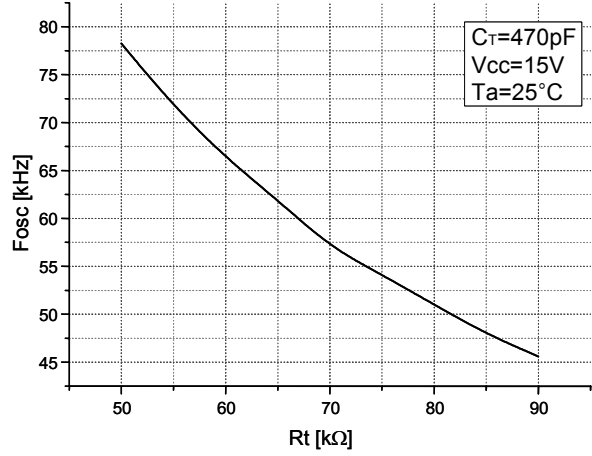


Figure 7. Switching Frequency, $C_T=470\text{pF}$

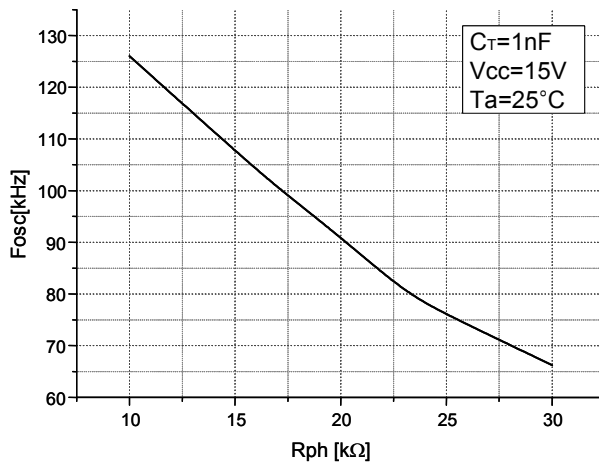


Figure 8. Preheating Frequency, $C_T=1\text{nF}$

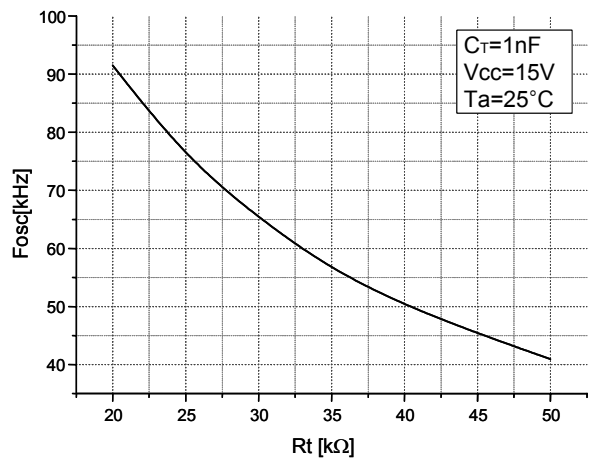


Figure 9. Switching Frequency, $C_T=1\text{nF}$

Application Information

Start-up Circuit

The start-up current is supplied to the IC through the start up resistor (Rst). In order to reduce the power dissipation in Rst, the Rst is connected to the full wave rectified output voltage.

The following equations can be used to calculate the size of Rst

$$R_{st} < \frac{V_{in(ac)} \times \sqrt{2} - V_{th(st),max}}{I_{st,max}} \quad P_{Rst} = \frac{(V_{in(ac_max)} \cdot \sqrt{2} - V_{cc})^2}{R_{st}} \leq 0.5W$$

$$= \frac{85 \times \sqrt{2} - 12.5}{0.2 \times 10^{-3}} = 539k\Omega \quad R_{st} \geq 2 \times (V_{in(ac_max)} \cdot \sqrt{2} - V_{cc})^2 \quad \therefore 260K \leq R_{st} \leq 539K$$

$$R_{st} \geq 260K$$

The size of supply capacitor (Cs) is normally decided in terms of the start up time and operating current built up by 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 also charges the supply capacitor. If the size of CQ is increased, the VCC voltage on the Cs is also increased.

Under Voltage Lock Out(UVLO)

UVLO mode of the FAN7544 is designed to maintain an ultra low supply current of less than 140uA, and to guarantee that the IC is fully functional before two output drivers are activated.

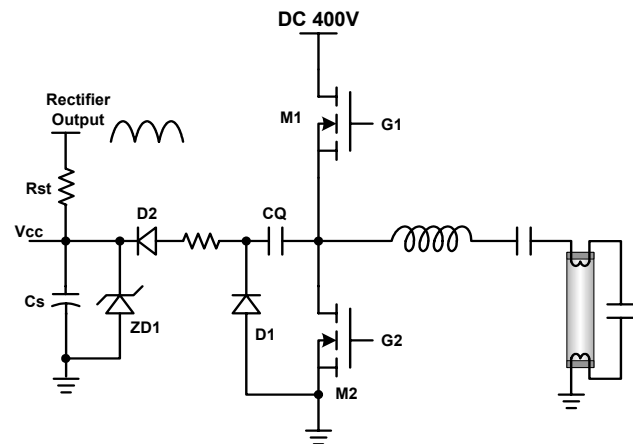


Figure 10. Start-up Circuit

Oscillator

The gate drive output frequency is as half as that of the triangular waveform on timing capacitor (CT) at pin #2. In normal operating mode, the timing capacitor charging current is $4 \times I_{rt} (=V_{ref}/RT)$. The discharging current is 5.25 times of the charging current ($5.25 \times 4 \times I_{rt}$). The charging period of the timing capacitor is the on time of the MOSFET. During the discharging period, both of the MOSFETs are off.

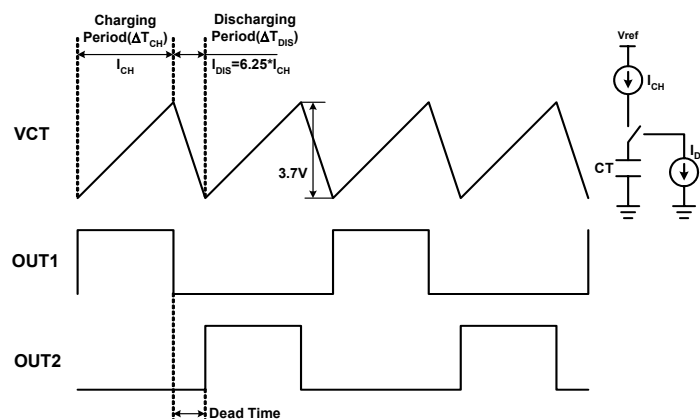
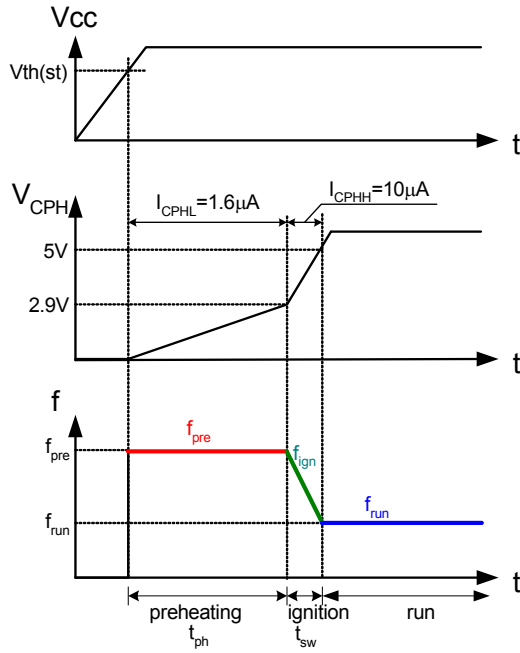


Figure 11. CT & Output Waveforms

Operating Mode



$0V < V_{CPH} < 2.9V$; **Preheating Frequency**

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

$2.9V \leq V_{CPH} < 5V$; **Frequency Sweep**

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

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

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

Figure 12. Timing Diagram

The FAN7544 has three operating mode as was shown in the figure 12.

1) Preheating Mode

The preheating mode is defined as the IC's internal status is in when the lamp filaments are being heated to correct emission temperature. This is necessary for maximizing lamp life and reducing the required ignition voltage. As soon as the Vcc exceeds the UVLO high threshold, the preheating time set-up capacitor, CPH starts to be charged by the internal 1.6µA current source until the VCPH reaches 2.9V. From 0V to 2.9V of the VCPH after the VCPH start to be charged, the switching frequency throughout the preheating mode is determined by CT and RPH and the preheating time is decided by the CPH and the 1.6µA current source. ($\Delta T_{PRE} = CPH \times 2.9V / 1.6\mu A$)

2) Ignition mode

The ignition mode is defined as the IC's internal status is in when a high voltage is established across the lamp necessary for igniting the lamp. When the VCPH exceeds 2.9V, the FAN7544 enters the ignition mode, and moves to the run mode when the VCPH exceeds 5V. In this period, the internal 10µA current source charges the external preheating timing capacitor(CPH) in order to increase noise immunity with sharp slop of the VCPH. The ignition time is decided CPH and internal 10µA current source($\Delta T_{IGN} = CPH \times \Delta V_{CPH2} / I_{CPHH}$). In this mode, the switching frequency is determined by CT, RPH and RT because the ICT is decided by the following equation.

$$I_{CT} = I_{RT} + \frac{I_{RPH} - I_{RT}}{2.1}(5V - V_{CPH})$$

3) Run Mode

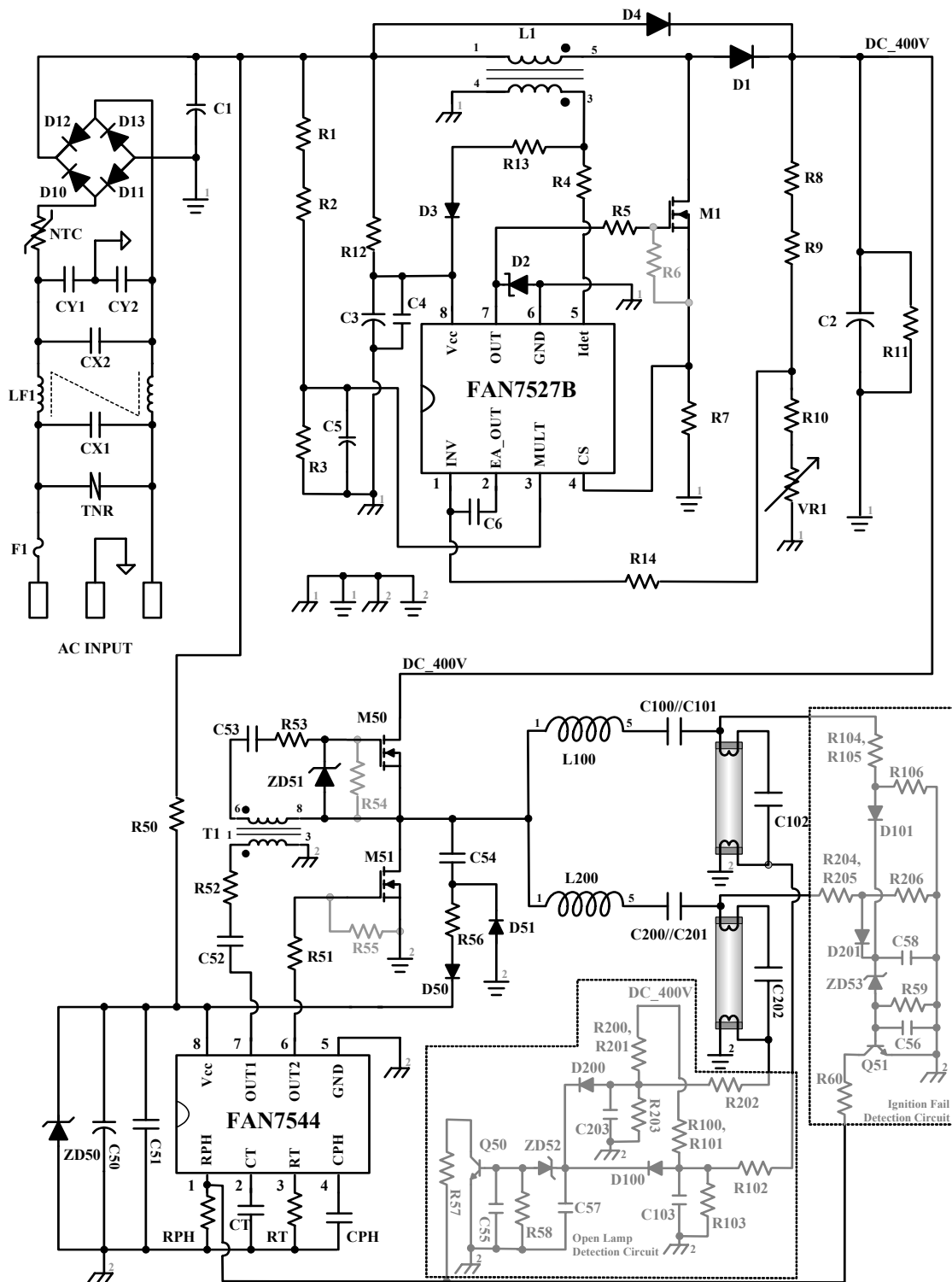
After the lamp has successfully ignited, the FAN7544 enters run mode. The run mode is defined as the IC's internal status is in when the lamp is being driven with a normal power level after the lamp is discharged. The run mode switching frequency is determined by the timing resistor RT and timing capacitor CT. As soon as the VCPH exceeds 5V, the protection masking mode is disable and the IC can enter the protection mode.

Protection Mode

If the voltage at the RPH pin decreases below 2V during the run mode, the FAN7544 enters the protection mode and all gate drive outputs(OUT1 & OUT2) are latched off in the low state and the VCPH is decreased to 0V. To exit the protection mode, the Vcc must go down below the UVLO low threshold.

Application Circuit

<32W×2 Lamps Ballast>



Components List (for Wide-Range 32W× 2Lamps 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
PFC PART			
R1, R2, R8	910kΩ	Ceramic, 1206	-
R3	22kΩ	Ceramic, 1206	-
R4	25.5kΩ	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, 5A, Power Mosfet	FQP5N50C, FQPF5N50C	Fairchild
Ballast PART			
R50	390kΩ	1W	-
R51, R53	39Ω	Ceramic, 1206	-
R52, R57, R60	0Ω	Ceramic, 1206	-
R54, R55	47kΩ	Ceramic, 1206	-
R56	5.6Ω	1W	-
R58, R59	62kΩ	Ceramic, 0805	-
RPH	51kΩ	Ceramic, 1206	-
RT	82kΩ	Ceramic, 1206	-
R100, R104, R200, R204	820kΩ	Ceramic, 1206	-
R101, R105, R201, R205	300kΩ	Ceramic, 1206	-

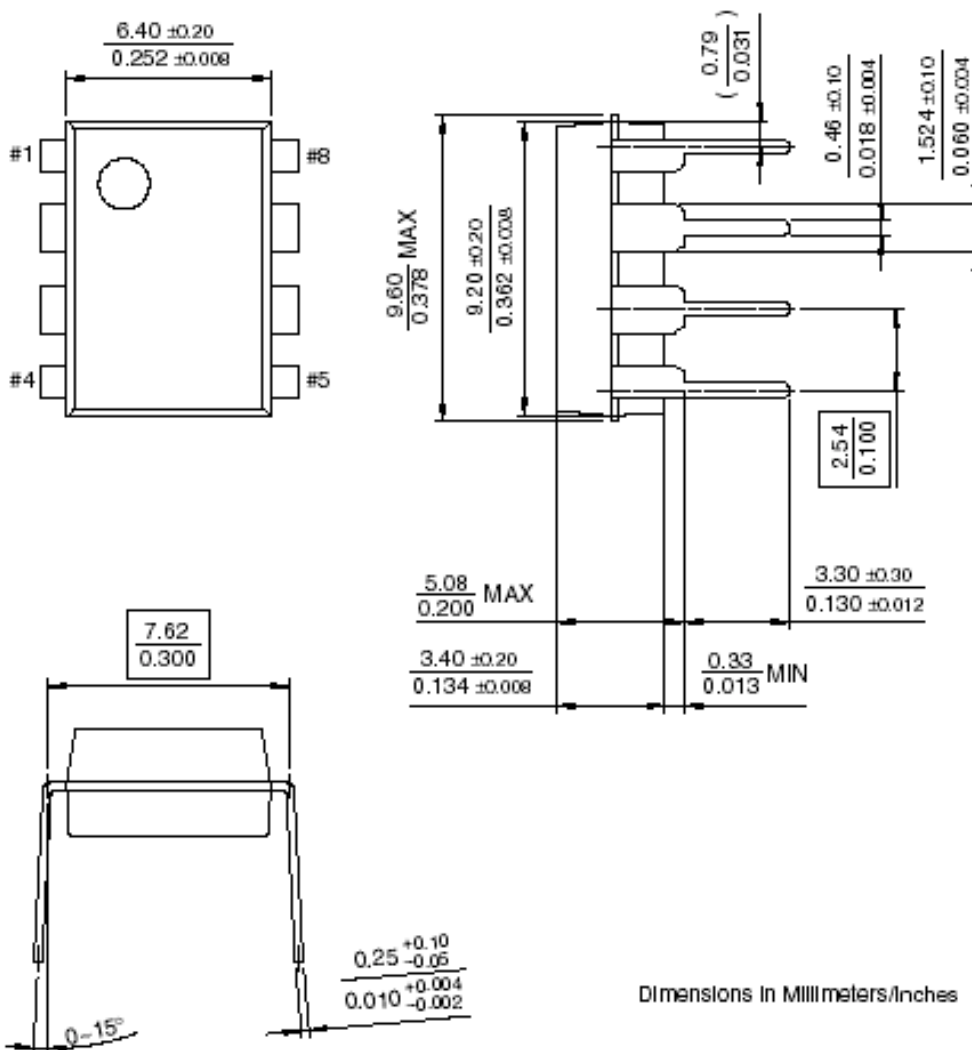
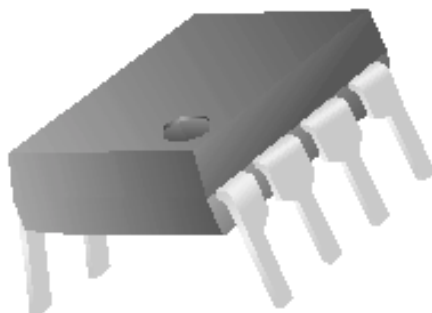
Part number	Value	Note	Manufacturer
R102, R202	5.1k Ω	Ceramic, 1206	-
R103, R203	50k Ω	Ceramic, 1206	-
R106, R206	30k Ω	Ceramic, 1206	-
C50	4.7 μ F, 50V	Electrolytic	-
C51	105	Ceramic, 0805	-
C52, C53	104	Ceramic, 1206	-
C54	1nF, 630V	Miller-Cap	-
C55, C56, C57, C58	104	Ceramic, 0805	-
CT	471	Ceramic, 0805	-
CPH	474	Ceramic, 0805	-
C100, C101, C200, C201	6.8nF, 630V	Miller-Cap	-
C102, C202	4.7nF, 1000V	Miller-Cap	-
L100, L200	3.2mH(120T)	EE2820	-
T1	4mH(50T:50T)	EE1614	-
	4mH(50T:100T)		C53: 0 Ω , ZD51 : Open
Q50	NPN transistor	KST2222A	Fairchild
M50, M51	500V, 5A, Power Mosfet	FQP5N500C, FQPF5N50C	Fairchild
D50, D51, D100, D101, D200, D201	Small Signal Diode	FDLL4148	Fairchild
ZD50, ZD51	15V, 1W Zener Diode	1N4744A	Fairchild
ZD52, ZD53	15V, Zener Diode	MMSZ5245B	Fairchild

Mechanical Dimensions (Continued)

Package

Dimensions in millimeters/inches

8-DIP-300



Dimensions in Millimeters/Inches

Ordering Information

Product Number	Package	Operating Temperature	Packing
FAN7544N	8DIP	-25°C ~ +125°C	Tube
FAN7544M	8SOP		
FAN7544MX	8SOP		Tape & Reel

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