# FAN7544

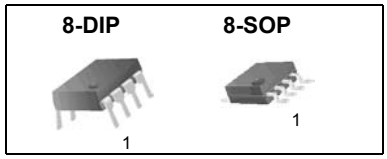
## Simple Ballast Controller

### Features

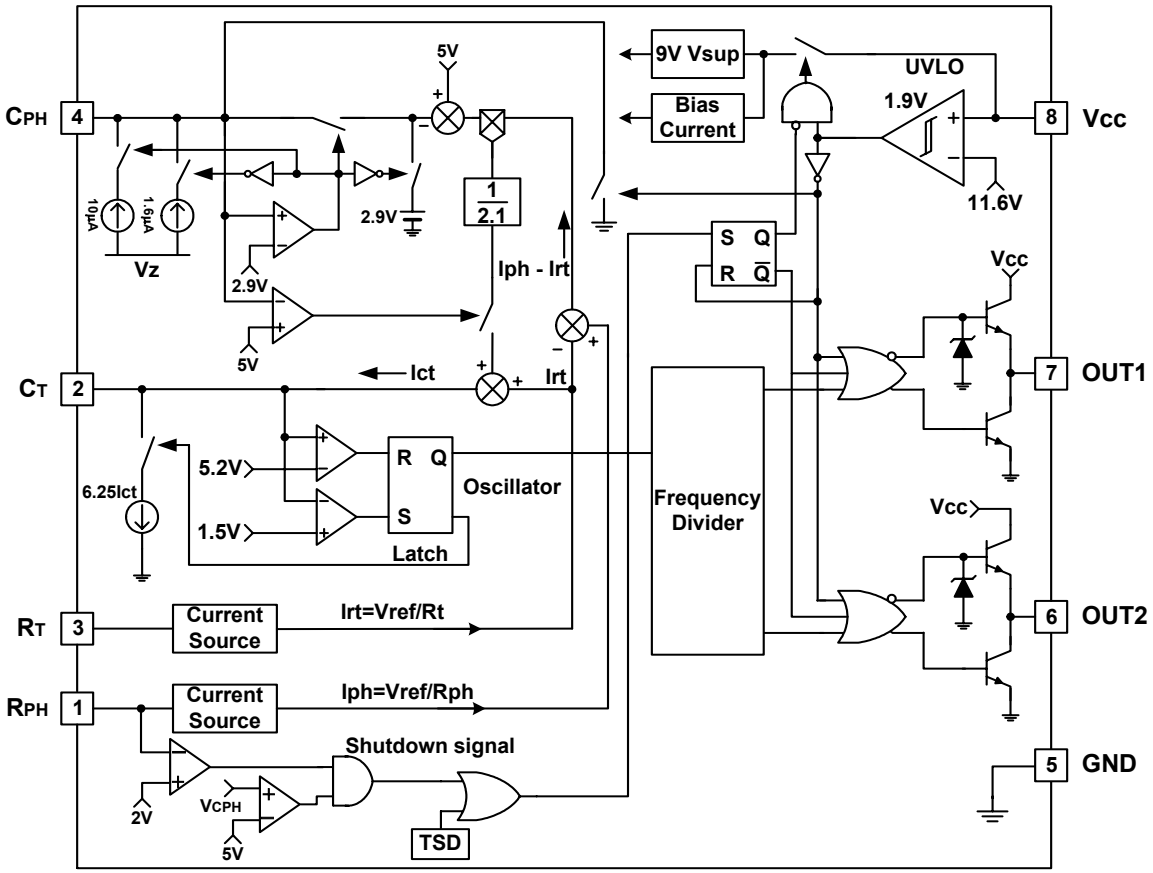
- Low Start-up and Operating Current : 140μA, 6.5mA
- Under Voltage Lock Out With 1.9V of Hysteresis
- 600mA of Totem Pole Output with High State Clamp
- Trimmed 1.5% Internal Bandgap Reference
- Programmable Preheat Time & Frequency
- Programmable Run Frequency
- High Accuracy Oscillator

### 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.

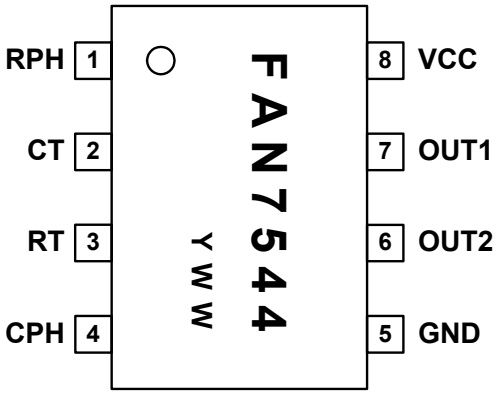



### Internal Block Diagram




Rev. 1.0.0

## Pin Assignments




YWW : Work Week Code

## Pin Definitions

| Pin Number | Pin Name | Pin Function Description |
|---|---|---|
| 1 | RPH | Preheat frequency set resistor |
| 2 | $C_T$ | 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 | $V_{CC}$ | 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 | | Iclamp | ±10 | mA |
| CPH, CT, RT, and RPH Pins Input Voltage | | $V_{IN}$ | -0.3 to 6 | V |
| Operating Temperature Range | | Topr | -25 to 125 | °C |
| Storage Temperature Range | | Tstg | -65 to 150 | °C |
| Power Dissipation | 8-DIP | Pd | 0.8 | W |
| | 8-SOP | | 0.5 | |
| Thermal Resistance (Junction-to-Air) | 8-DIP | Rθja | 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 Vcc=15V, Ta=25°C, For Min/Max values Ta is the operating ambient temperature range with -25°C ≤ Ta ≤ 125°C and 12.7V ≤ $V_{CC}$ ≤ 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, RPH=47kΩ, CT=470pF | 70 | 81.5 | 93 | kHz |
| Preheating Dead Time | tpd | $V_{CPH}$=0V, RPH=47kΩ, CT=470pF | 0.8 | 1.3 | 1.8 | μs |
| Operating Frequency | $f_{OS}$ | $V_{CPH}$=Open, RT=80kΩ, CT=470pF | 45.5 | 50 | 54.5 | kHz |
| Operating Dead Time | $t_{OD}$ | $V_{CPH}$=Open, RT=80kΩ, CT=470pF | 1.6 | 2.0 | 2.4 | μs |
| CT Threshold Voltage(note1) | $\Delta V_{CT}$ | Ta=25°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°C ≤ Ta ≤ 125°C, $V_{CC}$ = 25V | - | 1 | 3 | % |
| Voltage Stability | $\Delta f/\Delta V$ | 12.7V ≤ $V_{CC}$ ≤ 30V, Ta=25°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) | tr | $C_L$=1nF, Vcc=15V, Ta=25°C | - | 130 | 170 | ns |
| Falling Time (Note1) | tf | $C_L$=1nF, Vcc=15V, Ta=25°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, $I_O$ = 100μA | - | - | 1 | V |
| **PROTECTION SECTION** | | | | | | |
| Shutdown Sink Current(note1) | $I_{SD}$ | RPH=47kΩ | - | 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 | - | °C |

**Note:**

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

## Typical Characteristics

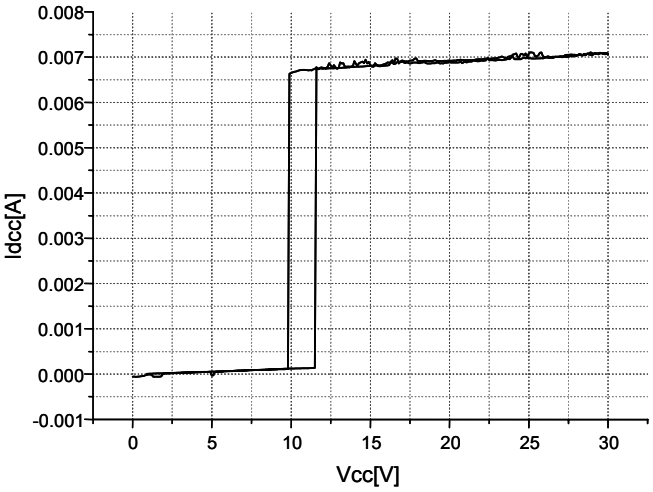



Figure 1. UVLO

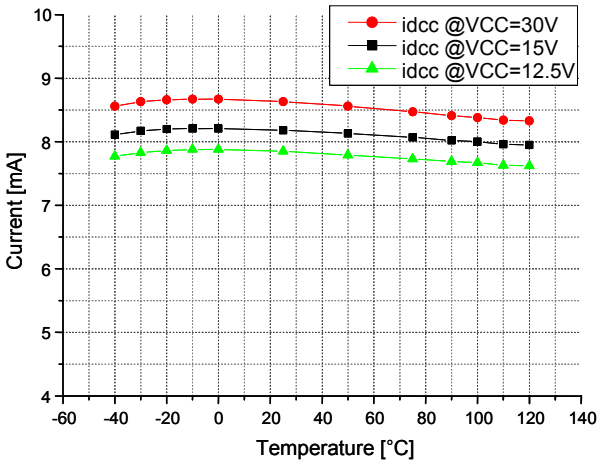



Figure 2. Dynamic Operating Current

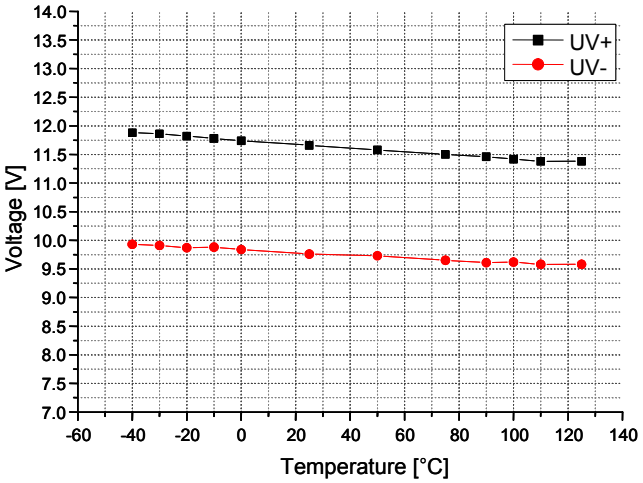



Figure 3. UVLO Hysteresis

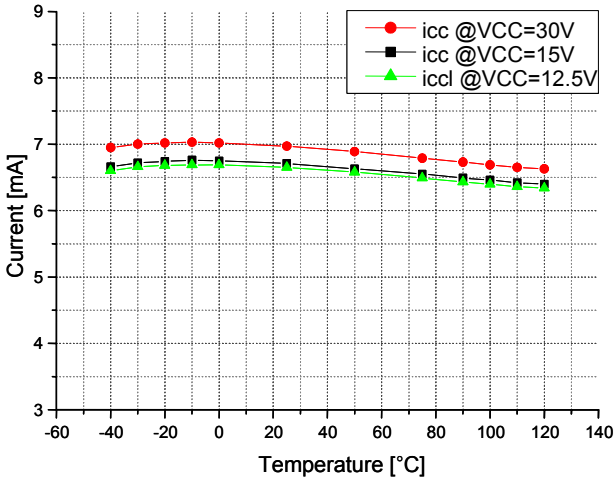



Figure 4. Operating Current

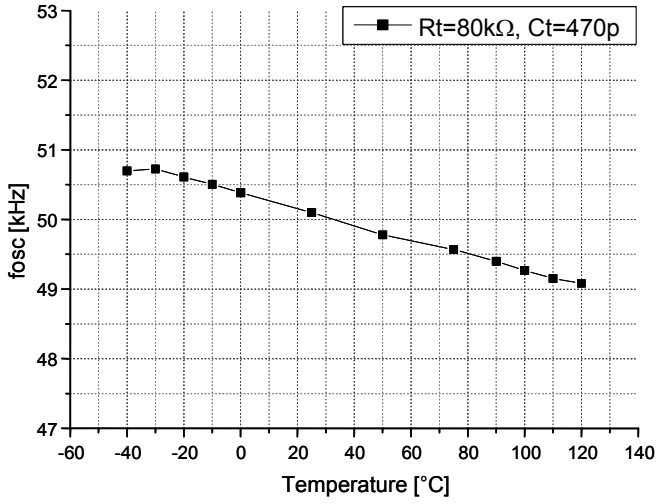



Figure 5. Switching Frequency

## Typical Characteristics(Con't)

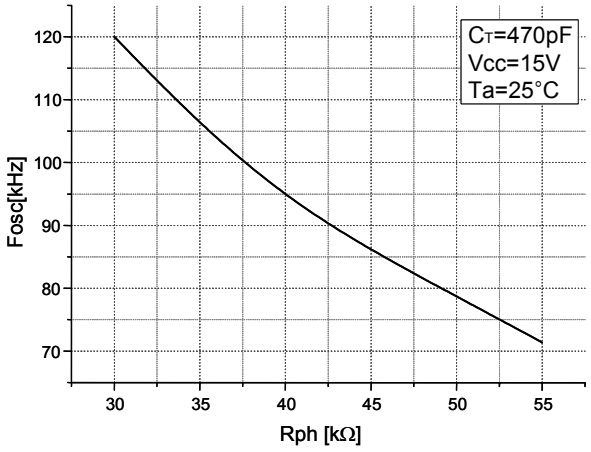



Figure 6. Preheating Frequency, $C_T$=470pF

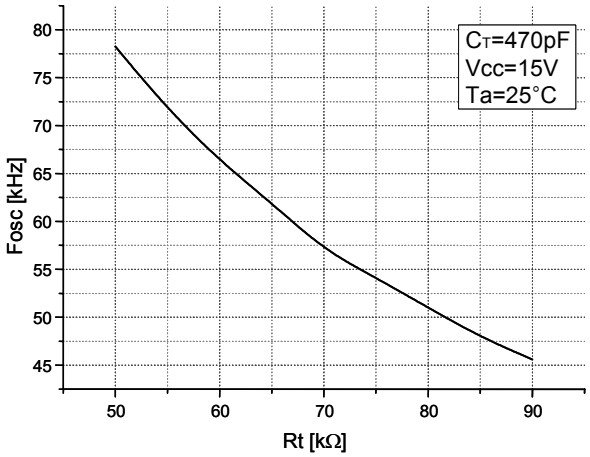



Figure 7. Switching Frequency, $C_T$=470pF

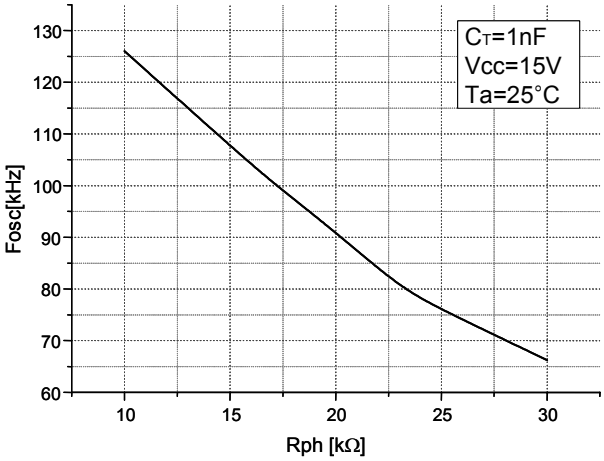



Figure 8. Preheating Frequency, $C_T$=1nF

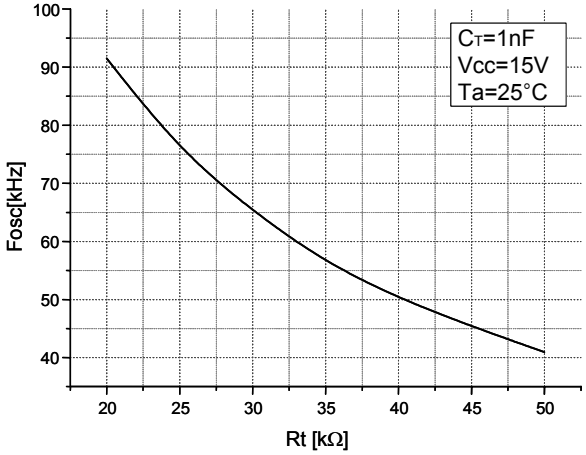



Figure 9. Switching Frequency, $C_T$=1nF

# 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

$$Rst < \frac{Vin(ac) \times \sqrt{2} - Vth(st),max}{Ist,max}$$

$$= \frac{85 \times \sqrt{2} - 12.5}{0.2 \times 10^{-3}} = 539k\Omega$$

$$P_{RSt} = \frac{(Vin(ac\_max) \cdot \sqrt{2} - Vcc)^2}{R_{St}} \le 0.5W$$

$$R_{St} \ge 2 \times (Vin(ac\_max) \cdot \sqrt{2} - Vcc)^2$$

$$R_{St} \ge 260K$$

$$\therefore 260K \le R_{St} \le 539K$$

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 $V_{CC}$ voltage on the Cs is also increased.

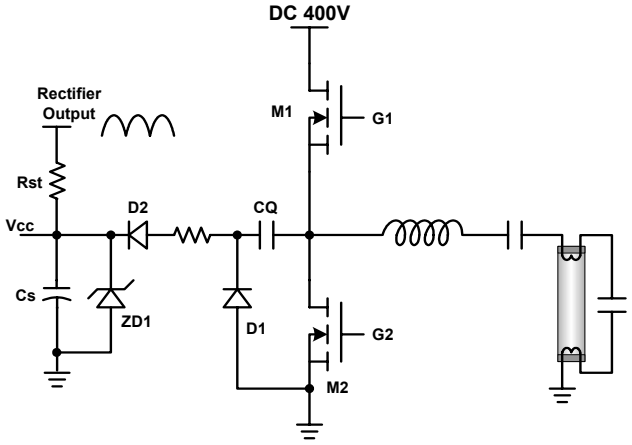



**Figure 10. Start-up Circuit**

## 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.

## 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×Irt(=Vref/RT). The discharging current is 5.25 times of the charging current (5.25×4×Irt). The charging period of the timing capacitor is the on time of the MOSFET. During the discharging period, both of the MOSFETs are off.

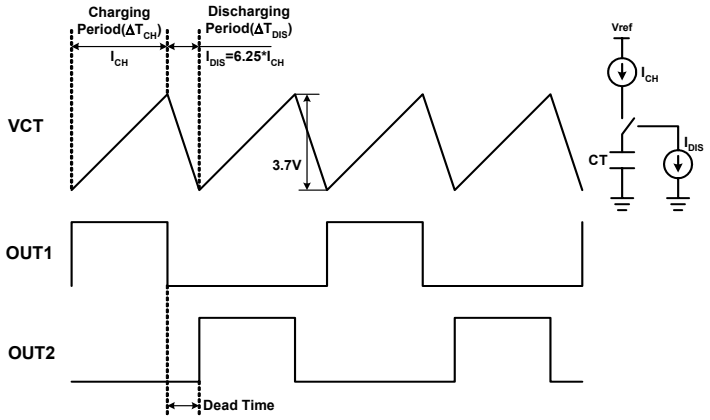
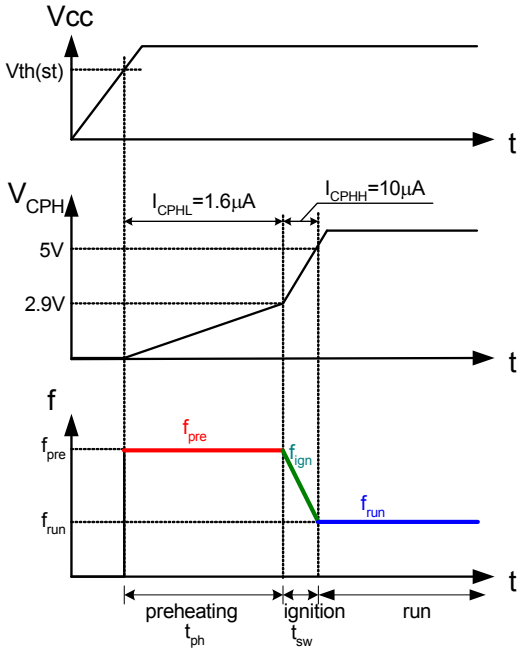



**Figure 11. CT & Output Waveforms**

## Operating Mode




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

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

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

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

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

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

**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 $V_{CPH}$ reaches 2.9V. From 0V to 2.9V of the $V_{CPH}$ after the $V_{CPH}$ 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×2.9V/1.6μA)

### 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 $V_{CPH}$ exceeds 2.9V, the FAN7544 enters the ignition mode, and moves to the run mode when the $V_{CPH}$ 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 $V_{CPH}$. The ignition time is decided CPH and internal 10μA current source($\Delta T_{IGN}$=CPH×$\Delta V_{CPH2}$/$I_{CPHH}$). In this mode, the switching frequency is determined by CT, RPH and RT because the $I_{CT}$ is decided by the following equation.

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

### 3) Run Mode

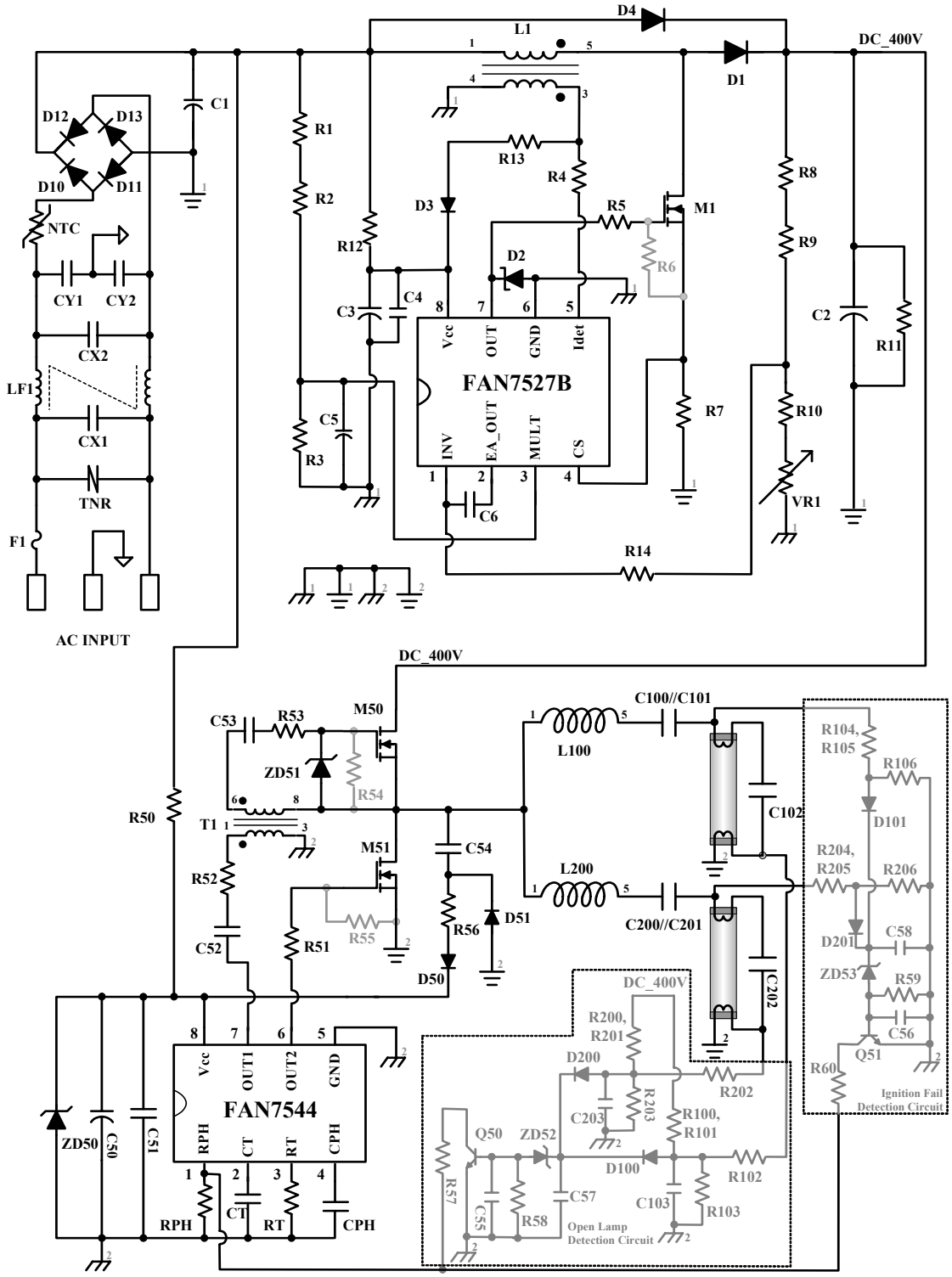
After the lamp has successfully ignited, the FAN7544 enters run mode. The run mode is defined as the IC's internal status is in when the lamp is being driven with a normal power level after the lamp is discharged. The run mode switching frequency is determined by the timing resistor RT and timing capacitor 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 | Ceriamic, 1206 | - |
| R3 | 22kΩ | Ceriamic, 1206 | - |
| R4 | 25.5kΩ | Ceriamic, 1206 | - |
| R5 | 10Ω | Ceriamic, 1206 | - |
| R6 | 22kΩ | Ceriamic, 1206 | - |
| R7 | 0.47Ω | 1W | - |
| R9 | 100kΩ | Ceriamic, 1206 | - |
| R10 | 2.2kΩ | Ceriamic, 1206 | - |
| R11 | 220kΩ | 1W | - |
| R12 | 150kΩ | 1W | |
| R13 | 4.7Ω | Ceriamic, 1206 | |
| R14 | 0Ω | Ceriamic, 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 | Ceriamic, 1206 | - |
| R52, R57, R60 | 0Ω | Ceriamic, 1206 | - |
| R54, R55 | 47kΩ | Ceriamic, 1206 | - |
| R56 | 5.6Ω | 1W | - |
| R58, R59 | 62kΩ | Ceriamic, 0805 | - |
| RPH | 51kΩ | Ceriamic, 1206 | |
| RT | 82kΩ | Ceriamic, 1206 | - |
| R100, R104, R200, R204 | 820kΩ | Ceriamic, 1206 | - |
| R101, R105, R201, R205 | 300kΩ | Ceriamic, 1206 | - |

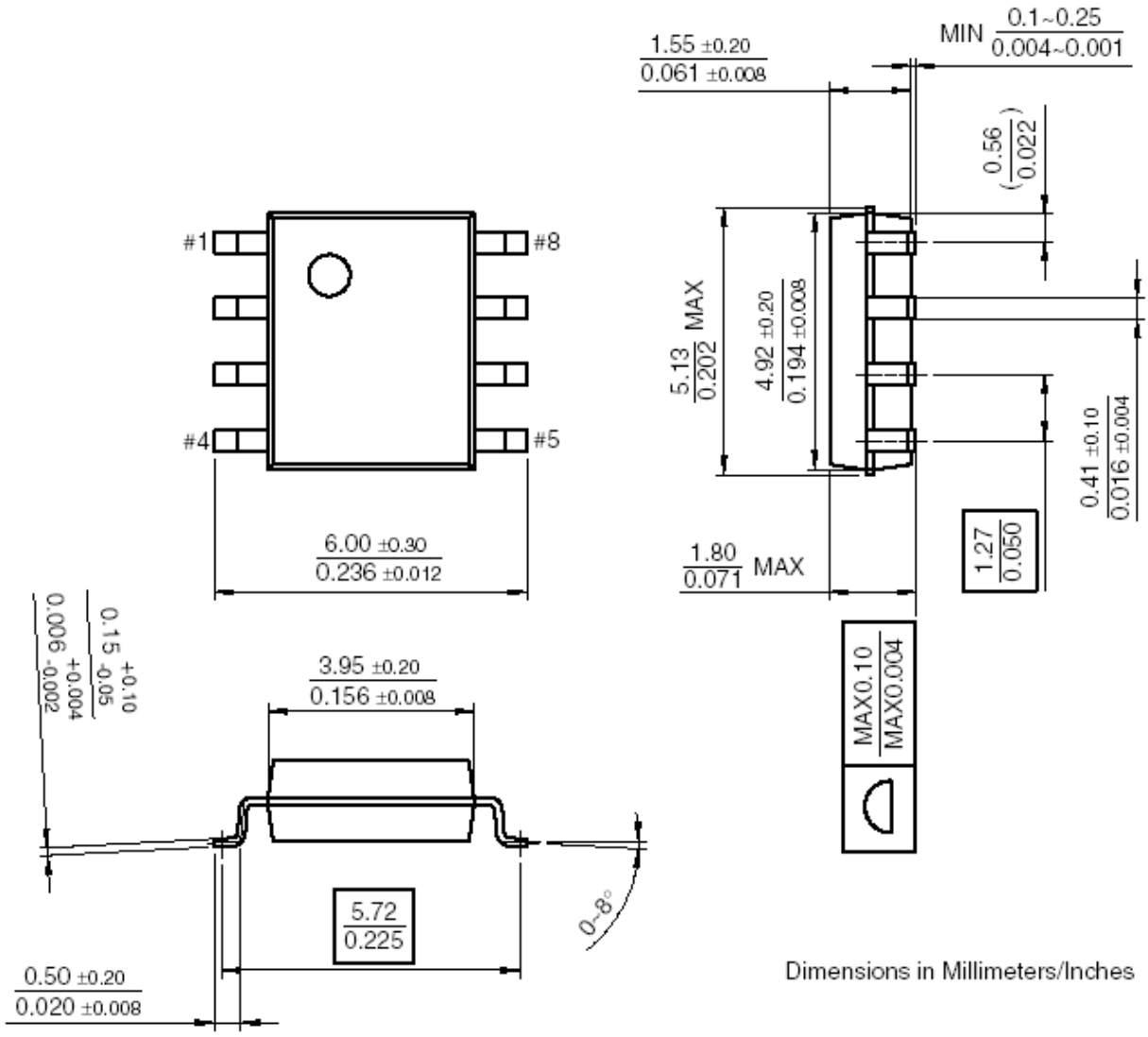
| Part number | Value | Note | Manufacturer |
|---|---|---|---|
| R102, R202 | 5.1kΩ | Ceriamic, 1206 | - |
| R103, R203 | 50kΩ | Ceriamic, 1206 | - |
| R106, R206 | 30kΩ | Ceriamic, 1206 | |
| C50 | 4.7μF, 50V | Electrolytic | - |
| C51 | 105 | Ceriamic, 0805 | - |
| C52, C53 | 104 | Ceramic, 1206 | - |
| 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: 0Ω, 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

### Package

**Dimensions in millimeters/inches**

# 8-SOP-225



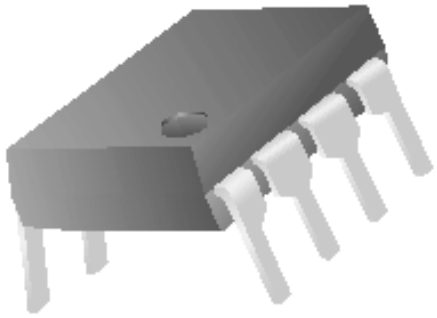

Dimensions in Millimeters/Inches

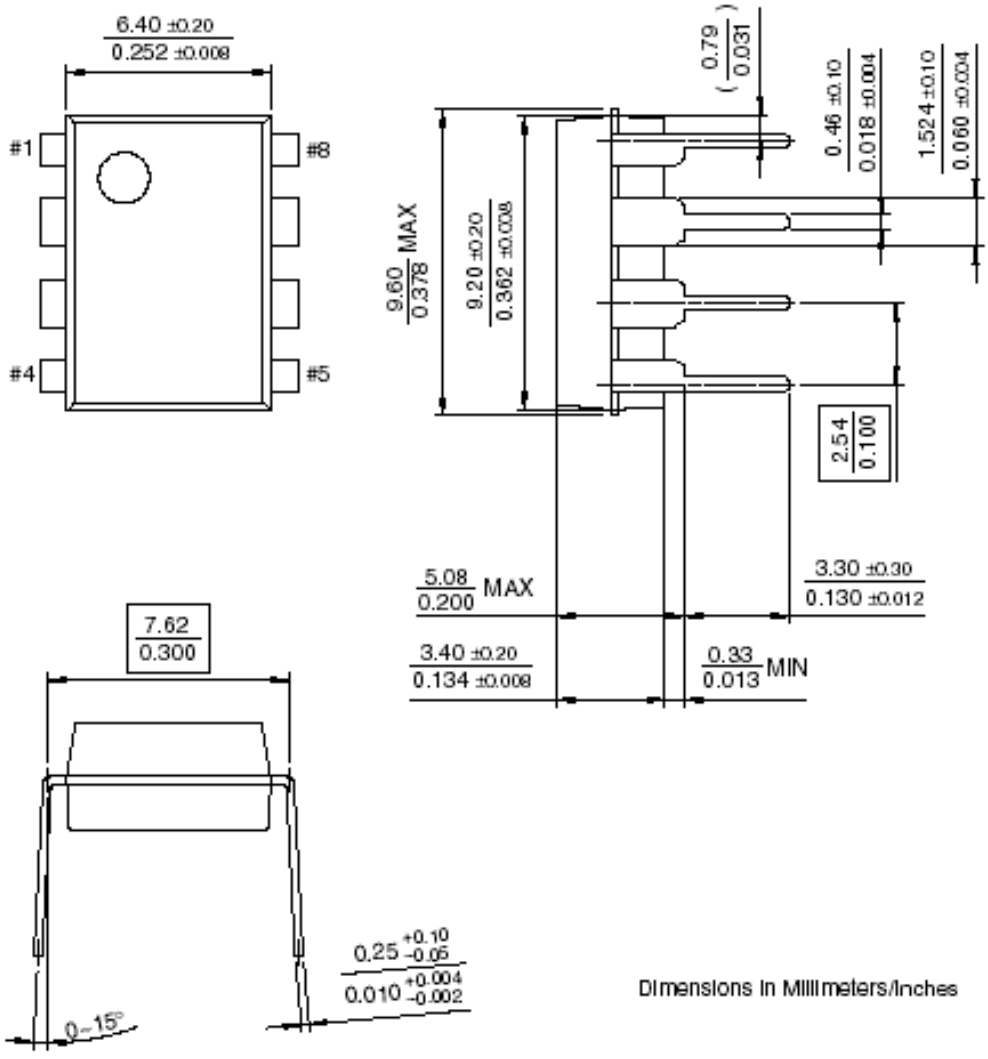
## Mechanical Dimensions (Continued)

**Package**

**Dimensions in millimeters/inches**

# 8-DIP-300





## Ordering Information

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