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## FAN7387

### Self-Oscillated, High-Voltage Gate Driver

#### Features

- Internal Clock Using RCT
- External Sync Function Using RCT
- Dead Time Control Using Resistor
- Shut Down (Disable Mode)
- Internal Shunt Regulator
- UVLO Function, High and Low Side

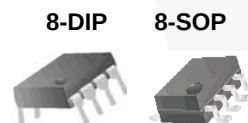
#### Applications

- Half-Bridge Inverter
- SMPS
- Ballast Solution for High-Intensity Discharge (HID) Lamp
- Ballast for Fluorescent Lamp

#### Description

The FAN7387 is a simple control IC for common half-bridge inverters, SMPS, and ballast for fluorescent and HID lamps. The FAN7387 has an oscillating circuit using an external resistor and capacitor.

The frequency variation is very stable across a wide temperature range. The FAN7387 has an external pin for dead-time control and shutdown. Using this resistor, the designer can choose the optimum dead time to reduce power loss on switching devices, such as transistors and MOSFETs.



#### Ordering Information

| Part Number              | Package | Operating Temperature | Packing Method |
|--------------------------|---------|-----------------------|----------------|
| FAN7387MX <sup>(1)</sup> | 8-SOP   | -40 to +125°C         | Tape & Reel    |

#### Note:

1. These device passed wave soldering test by JESD22A-111.

## Typical Applications Diagrams

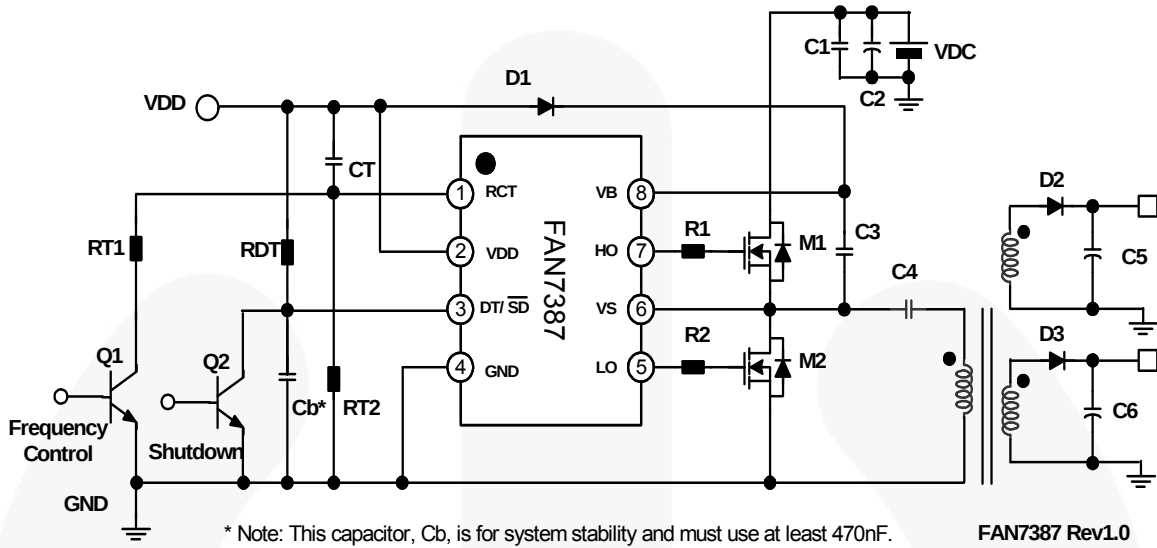


Figure 1. Typical Application Circuit for SMPS (Self Oscillation Method)

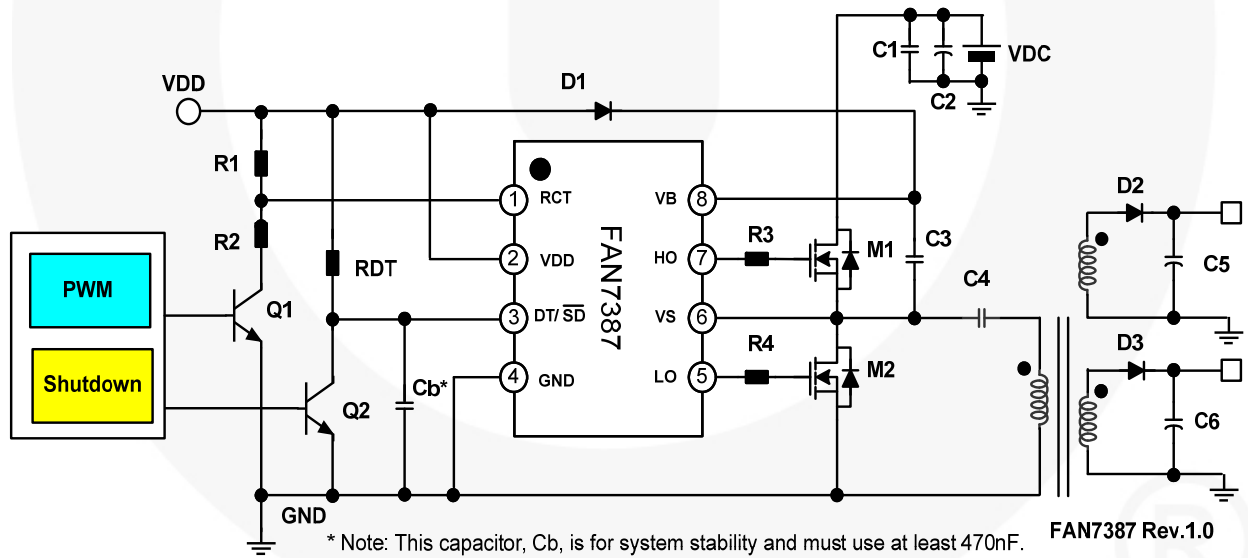


Figure 2. Typical Application Circuit for SMPS by Using External Signal

# Typical Application Diagrams (Continued)

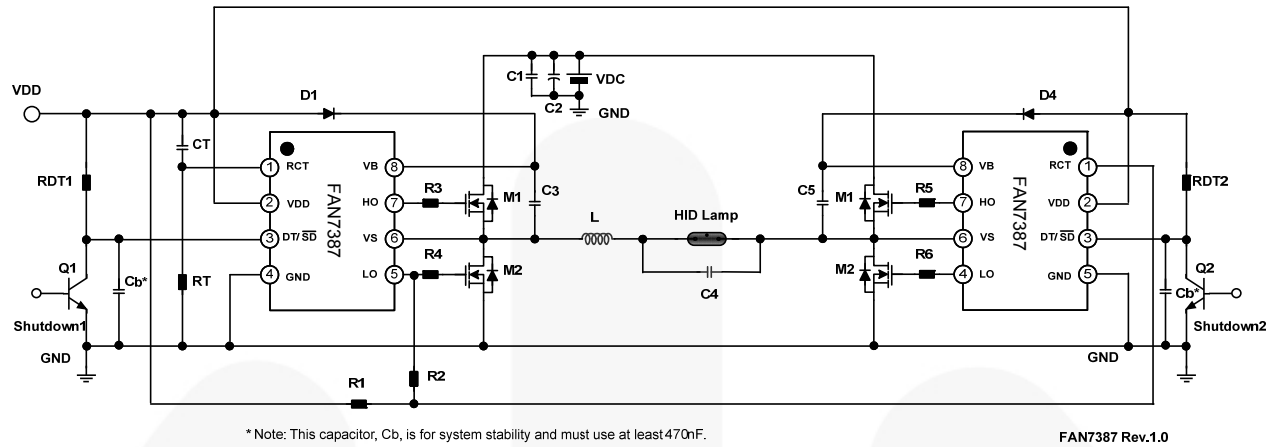


Figure 3. Typical Application Circuit for Full-Bridge Converter

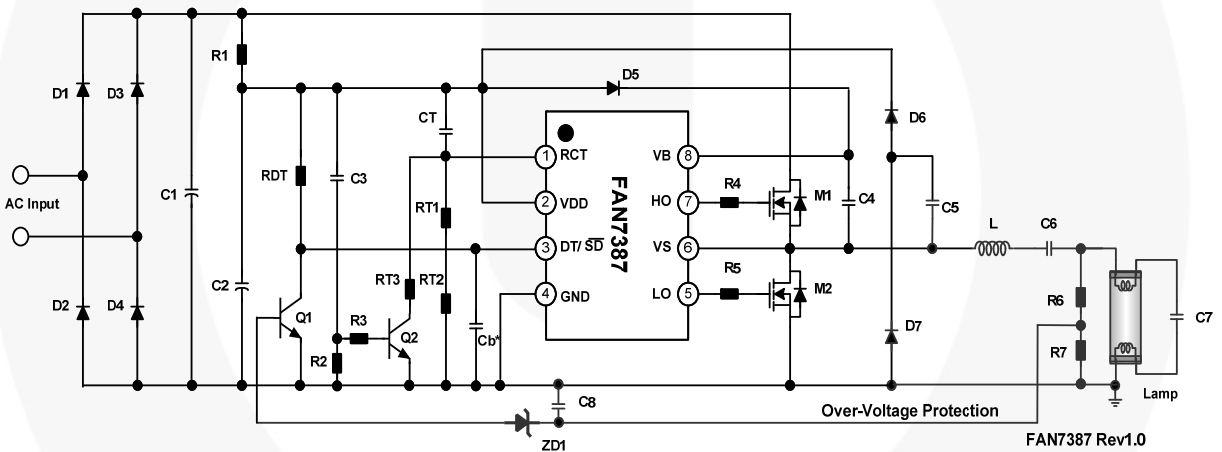
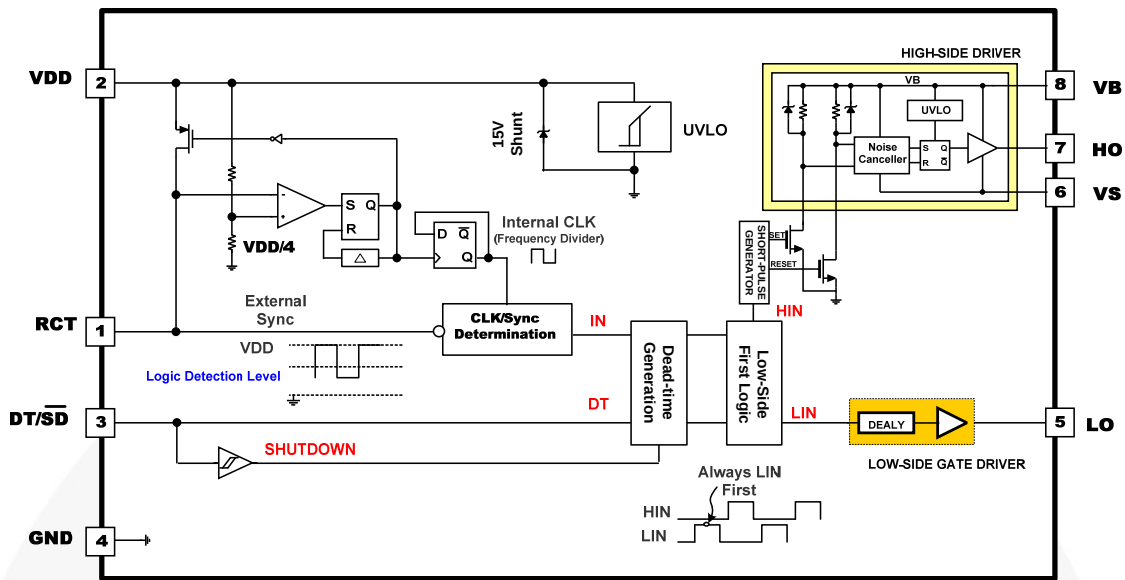


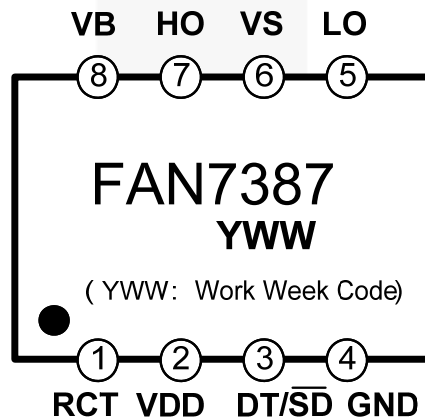
Figure 4. Typical Application Circuit for Fluorescent Lamp Ballast

### Internal Block Diagram



**Figure 5. Functional Block Diagram**

## Pin Configuration



**Figure 6. Pin Configurations (Top View)**

## Pin Definitions

| Pin # | Name  | Description                                      |
|-------|-------|--------------------------------------------------|
| 1     | RCT   | Oscillator frequency set resistor and capacitor. |
| 2     | VDD   | Supply Voltage.                                  |
| 3     | DT/SD | Dead-time control and shutdown (active LOW).     |
| 4     | GND   | Signal Ground.                                   |
| 5     | LO    | Low-Side Output.                                 |
| 6     | VS    | High-Side floating supply return.                |
| 7     | HO    | High-Side output.                                |
| 8     | VB    | High-Side floating supply.                       |

## 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.  $T_A=25^{\circ}\text{C}$  unless otherwise specified.

| Symbol        | Parameter                             | Min. | Typ.  | Max.     | Unit                 |
|---------------|---------------------------------------|------|-------|----------|----------------------|
| $V_B$         | High-Side Floating Supply Voltage     | -0.3 |       | 625.0    | V                    |
| $V_S$         | High-Side Offset Voltage              | -0.3 |       | 600.0    | V                    |
| $V_{RCT}$     | RCT Pins Input Voltage                |      |       | $V_{CL}$ | V                    |
| $I_{CL}$      | Clamping current level <sup>(2)</sup> |      |       | 25       | mA                   |
| $dV_S/dt$     | Allowable Offset Voltage Slew Rate    |      | 50    |          | V/ns                 |
| $T_A$         | Operating Temperature Range           | -40  |       | +125     | $^{\circ}\text{C}$   |
| $T_{STG}$     | Storage Temperature Range             | -65  |       | +150     | $^{\circ}\text{C}$   |
| $P_D$         | Power Dissipation                     |      | 0.625 |          | W                    |
| $\Theta_{JA}$ | Thermal Resistance (Junction-to-Air)  |      | 200   |          | $^{\circ}\text{C/W}$ |

**Note:**

- Do not supply a low-impedance voltage source to the internal clamping Zener diode between the GND and the VDD pin of this device.

## Recommended Operating Ratings

The Recommended Operating Conditions table defines the conditions for actual device operation. Recommended operating conditions are specified to ensure optimal performance to the datasheet specifications. Fairchild does not recommend exceeding them or designing to absolute maximum ratings.

| Symbol   | Parameter                         | Min.             | Max.             | Unit.              |
|----------|-----------------------------------|------------------|------------------|--------------------|
| $V_B$    | High-Side Floating Supply Voltage | $V_S+11$         | $V_S+14$         | V                  |
| $V_S$    | High-Side Offset Voltage          | $6-V_{DD}$       | 600              | V                  |
| $V_{DD}$ | Low-Side Supply Voltage           | 11               | 14               | V                  |
| $V_{HO}$ | High-Side (HO) Output Voltage     | GND              | $V_{DD}$         | V                  |
| $V_{LO}$ | Low-Side (LO) Output Voltage      | GND              | $V_{DD}$         | V                  |
| $V_{IH}$ | Logic "1" Input Voltage of RCT    | $(3/4 V_{DD})+1$ |                  | V                  |
| $V_{IL}$ | Logic "0" Input Voltage of RCT    |                  | $(3/5 V_{DD})-1$ | V                  |
| $R_T$    | Timing Resistor Value of RCT      | 2                |                  | $k\Omega$          |
| $C_T$    | Timing Capacitor Value of RCT     | 100              |                  | pF                 |
| $T_A$    | Ambient Temperature               | -40              | +125             | $^{\circ}\text{C}$ |

## Electrical Characteristics

$V_{BIAS}$  ( $V_{DD}$ ,  $V_B - V_S$ ) = 14.0 V,  $C_L$  = 1 nF,  $R_T$  = 50 k $\Omega$  and  $C_T$  = 330 pF and  $T_A$  = 25°C, unless otherwise specified.

| Symbol                                                           | Parameter                                                                             | Conditions                             | Min. | Typ.         | Max.         | Unit    |
|------------------------------------------------------------------|---------------------------------------------------------------------------------------|----------------------------------------|------|--------------|--------------|---------|
| <b>Low-Side Supply Characteristics (<math>V_{DD}</math>)</b>     |                                                                                       |                                        |      |              |              |         |
| $V_{DD_{UV+}}$                                                   | $V_{DD}$ Supply Under-Voltage Positive-Going Threshold                                | $V_{DD}$ Increasing                    | 9.50 | 11.00        | 12.50        | V       |
| $V_{DD_{UV-}}$                                                   | $V_{DD}$ Supply Under-Voltage Negative-Going Threshold                                | $V_{DD}$ Decreasing                    | 7.5  | 9.0          | 10.5         | V       |
| $V_{DD_{UVH}}$                                                   | $V_{DD}$ Supply Under-Voltage Lockout Hysteresis                                      |                                        |      | 2            |              | V       |
| $V_{CL}$                                                         | Supply Camping Voltage                                                                | $I_{DD}$ = 10 mA                       | 14.8 | 15.4         |              | V       |
| $I_{QDD}$                                                        | Low-Side Quiescent Supply Current                                                     | $R_{DT}$ = 100 k $\Omega$              |      | 220          | 500          | $\mu$ A |
| $I_{ST}$                                                         | Startup Supply Current                                                                | $V_{DD}$ = 9 V                         |      | 50           | 130          | $\mu$ A |
| $I_{LK}$                                                         | Offset Supply Leakage Current                                                         | $V_B = V_S$ = 600 V                    |      |              | 10           | $\mu$ A |
| $I_{PDD}$                                                        | Low-Side Dynamic Operating Supply Current                                             |                                        |      | 0.8          |              | mA      |
| <b>High-Side Supply Characteristics (<math>V_B - V_S</math>)</b> |                                                                                       |                                        |      |              |              |         |
| $V_{BS_{UV+}}$                                                   | $V_{BS}$ Supply Under-Voltage Negative-Going Threshold                                | $V_B - V_S$ Increasing                 | 7.7  | 9.2          | 10.7         | V       |
| $V_{BS_{UV-}}$                                                   | $V_{BS}$ Supply Under-Voltage Negative-Going Threshold                                | $V_B - V_S$ Decreasing                 | 7.1  | 8.6          | 10.1         | V       |
| $V_{BS_{UVH}}$                                                   | $V_{BS}$ Supply Under-Voltage Lockout Hysteresis                                      |                                        |      | 0.6          |              | V       |
| $I_{QBS}$                                                        | High-Side Quiescent Supply Current                                                    |                                        |      | 50           | 130          | $\mu$ A |
| $I_{PBS}$                                                        | High-Side Dynamic Operating Supply Current                                            |                                        |      | 400          | 800          | $\mu$ A |
| <b>Oscillator Characteristics</b>                                |                                                                                       |                                        |      |              |              |         |
| $f_{osc1}$                                                       | Oscillation Frequency 1                                                               | $R_T$ = 50 k $\Omega$ , $C_T$ = 330 pF | 18   | 20           | 22           | kHz     |
| $f_{osc2}$                                                       | Oscillation Frequency 2                                                               | $R_T$ = 1 k $\Omega$ , $C_T$ = 1 nF    | 210  | 250          | 290          | kHz     |
| D                                                                | Duty Cycle                                                                            | Running Mode                           | 47.5 | 49.0         |              | %       |
| $V_{RCT+}$                                                       | Upper Threshold Voltage of RCT                                                        | Running Mode                           |      | $V_{DD}$     |              | V       |
| $V_{RCT-}$                                                       | Lower Threshold Voltage of RCT                                                        | Running Mode                           |      | $V_{DD} / 4$ |              | V       |
| $V_{IH}$                                                         | Logic "1" Input Voltage of RCT                                                        | Running Mode                           |      | $3/4 V_{DD}$ |              | V       |
| $V_{IL}$                                                         | Logic "0" Input Voltage of RCT                                                        | Running Mode                           |      |              | $3/5 V_{DD}$ | V       |
| $t_D$                                                            | Dead-Time                                                                             | $R_{DT}$ = 100 k $\Omega$              | 500  | 600          | 700          | ns      |
| $t_{DMIN}$                                                       | Minimum Dead-Time                                                                     | $V_{DT/SD} = V_{DD}$                   | 300  | 400          | 500          | ns      |
| <b>Output Characteristics</b>                                    |                                                                                       |                                        |      |              |              |         |
| $I_{O+}$                                                         | Output High, Short-Circuit Pulse Current <sup>(3)</sup>                               | $PW \leq 10 \mu s$                     |      | 350          |              | mA      |
| $I_{O-}$                                                         | Output Low, Short-Circuit Pulse Current <sup>(3)</sup>                                | $PW \leq 10 \mu s$                     |      | 650          |              | mA      |
| $V_S$                                                            | Allowable Negative $V_S$ Pin voltage for Input Signal ( $V_{RCT}$ ) Propagation to HO |                                        |      | -9.8         | -7.0         | V       |

Continued on the following page...

**Electrical Characteristics** (Continued)

$V_{BIAS}$  ( $V_{DD}$ ,  $V_B - V_S$ )=14.0 V,  $C_L$ =1 nF,  $R_T$ =50 k $\Omega$  and  $C_T$ =330 pF and  $T_A$ =25°C, unless otherwise specified.

| Symbol                            | Parameter                  | Conditions                                                                               | Min. | Typ. | Max. | Unit    |
|-----------------------------------|----------------------------|------------------------------------------------------------------------------------------|------|------|------|---------|
| <b>Output Characteristics</b>     |                            |                                                                                          |      |      |      |         |
| $t_{ON}$                          | Turn-On Propagation Time   | $V_{DD}=V_{BS}=14$ V, $V_{DT/SD}=V_{DD}$ ,<br>$V_{RCT}=4$ V~ $V_{DD}$ , $f_{OSC}=20$ kHz |      | 550  |      | ns      |
| $t_{OFF}$                         | Turn-Off Propagation Time  | $V_{DD}=V_{BS}=14$ V, $V_{DT/SD}=V_{DD}$ ,<br>$V_{RCT}=4$ V~ $V_{DD}$ , $f_{OSC}=20$ kHz |      | 160  |      | ns      |
| $t_R$                             | Turn-On Rising Time        | $C_L=1000$ pF                                                                            |      | 50   | 120  | ns      |
| $t_F$                             | Turn-Off Falling Time      | $C_L=1000$ pF                                                                            |      | 30   | 70   | ns      |
| <b>Protection Characteristics</b> |                            |                                                                                          |      |      |      |         |
| /SD+                              | Shutdown "1" Input Voltage |                                                                                          | 2.7  |      |      | V       |
| /SD-                              | Shutdown "0" Input Voltage |                                                                                          |      |      | 1    | V       |
| $I_{SD}$                          | Shutdown Current           | $V_{DT/SD}=0$ After Running Mode                                                         |      | 250  |      | $\mu$ A |
| $t_{SD}$                          | Shutdown Propagation Delay |                                                                                          |      | 180  |      | ns      |

**Note:**

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

## Switching Definitions

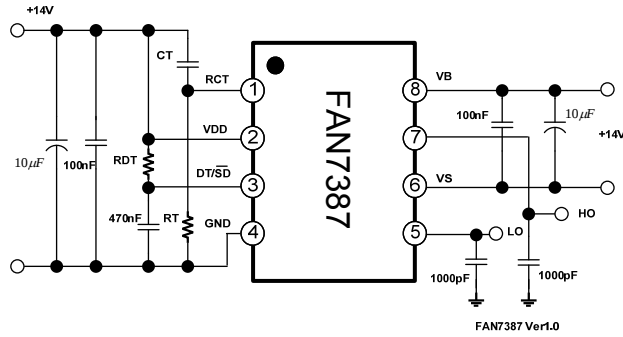


Figure 7. Test Circuit for Self-Oscillation Method

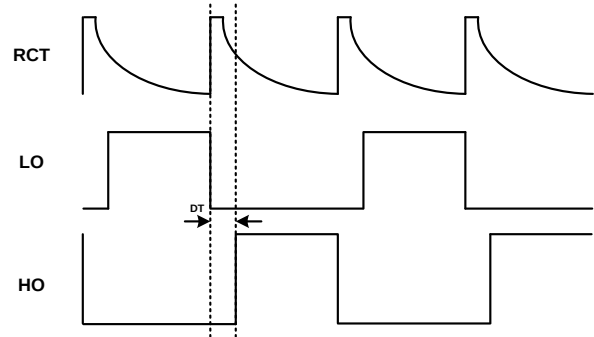


Figure 8. Basic Operating Waveforms of Self-Oscillation

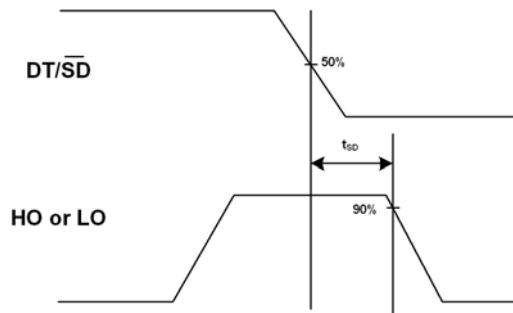


Figure 9. Shutdown Delay Definition

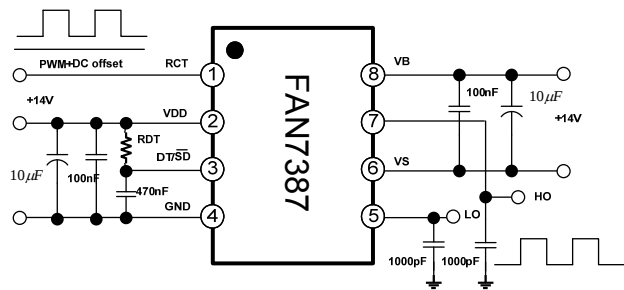


Figure 10. Test Circuit for Forced-Oscillation Method Using External Signal

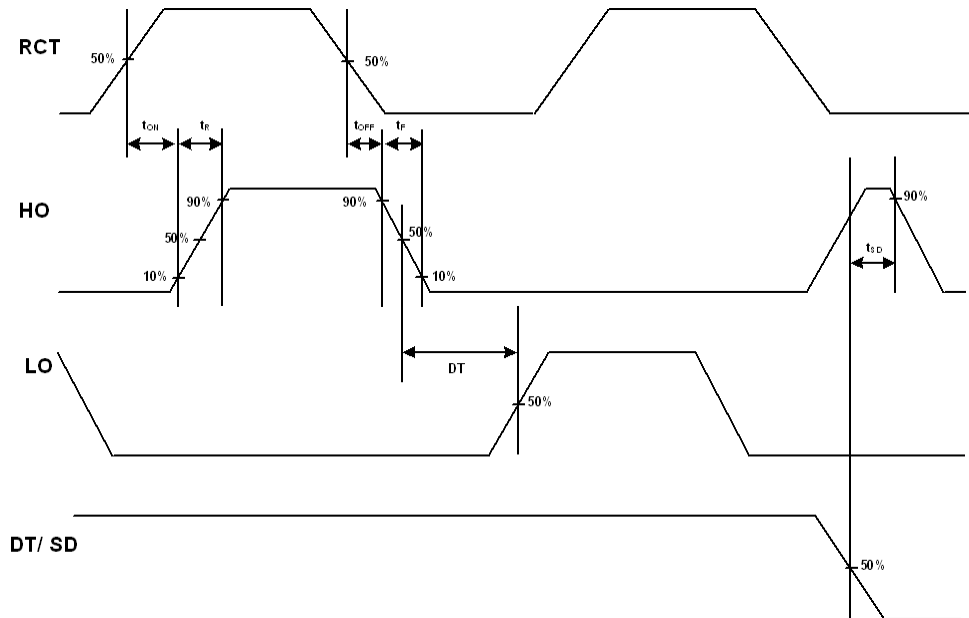


Figure 11. Basic Operation Waveforms of Forced-oscillation Method Using External Signal

## Typical Performance Characteristics

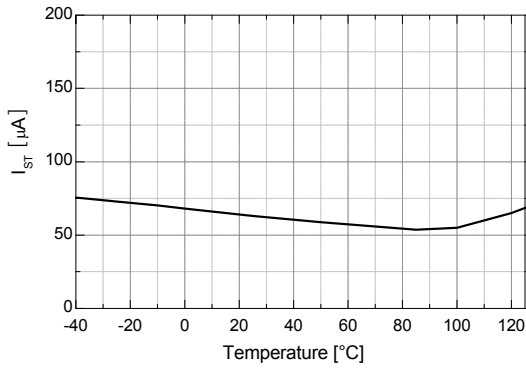


Figure 12. Startup Current vs. Temperature

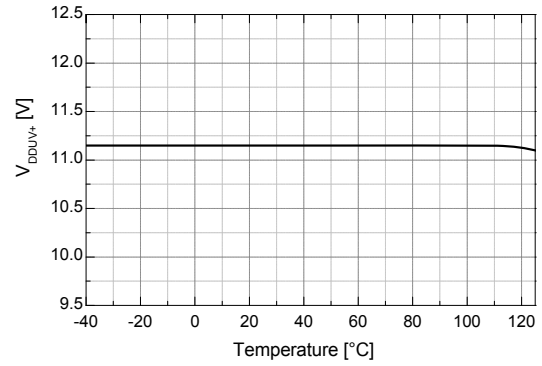


Figure 13.  $V_{DD}$  UVLO+ vs. Temperature

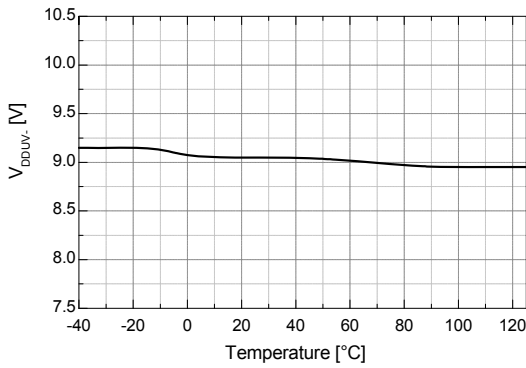


Figure 14.  $V_{DD}$  UVLO- vs. Temperature

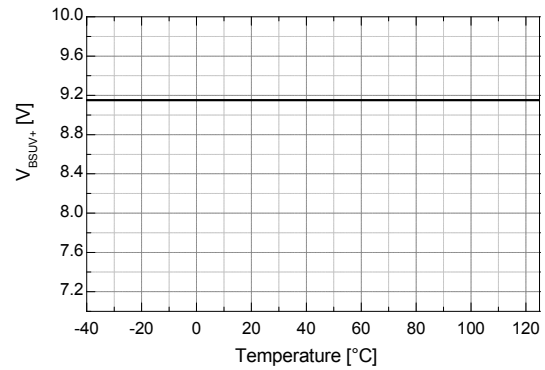


Figure 15.  $V_{BS}$  UVLO+ vs. Temperature

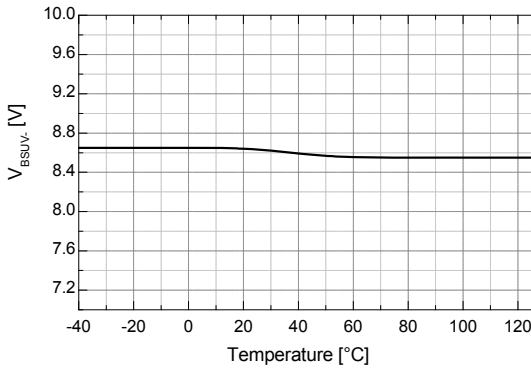


Figure 16.  $V_{BS}$  UVLO- vs. Temperature

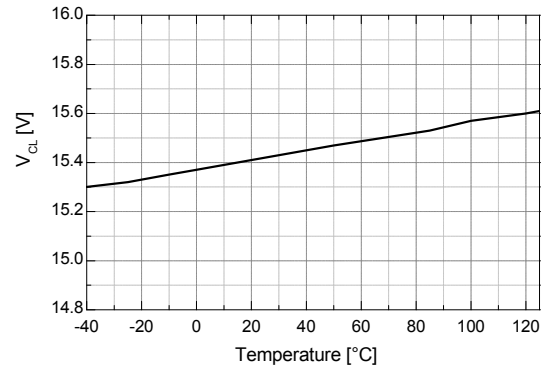


Figure 17.  $V_{CL}$  vs. Temperature

## Typical Performance Characteristics (Continued)

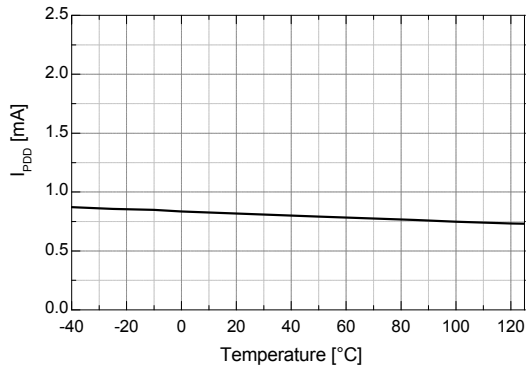


Figure 18.  $I_{PDD}$  vs. Temperature

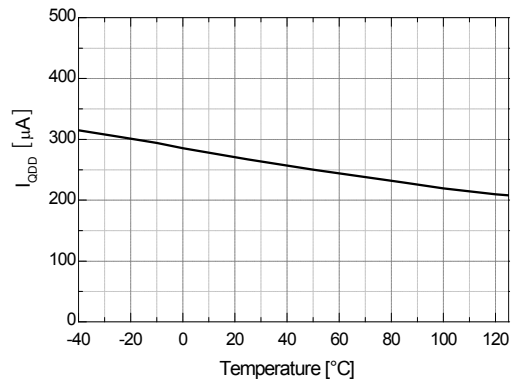


Figure 19.  $I_{QDD}$  vs. Temperature

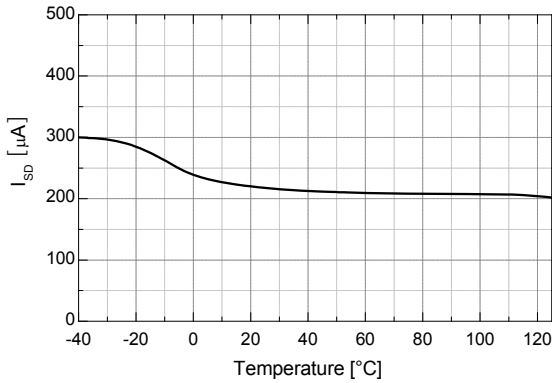


Figure 20.  $I_{SD}$  vs. Temperature

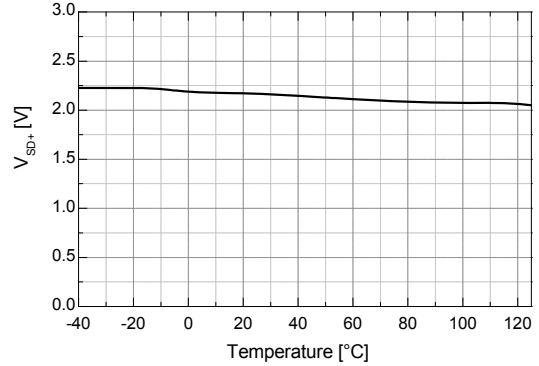


Figure 21.  $V_{SD+}$  vs. Temperature

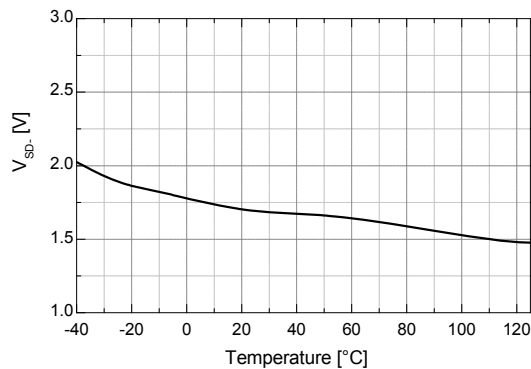


Figure 22.  $V_{SD-}$  vs. Temperature

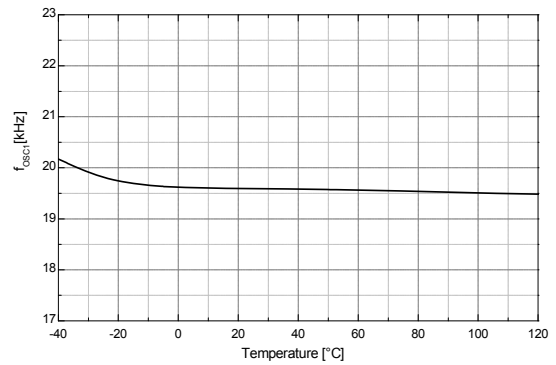


Figure 23. Operating Frequency 1 vs. Temperature

## Typical Performance Characteristics (Continued)

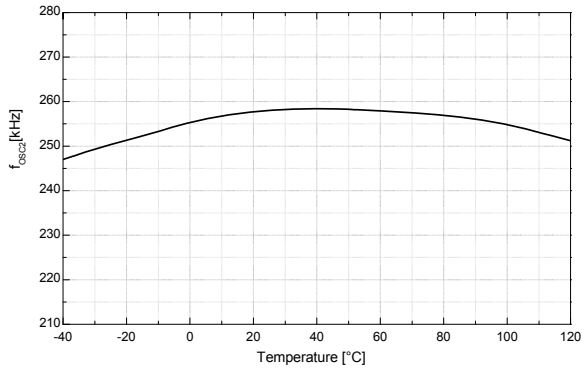


Figure 24. Operating Frequency 2 vs. Temperature

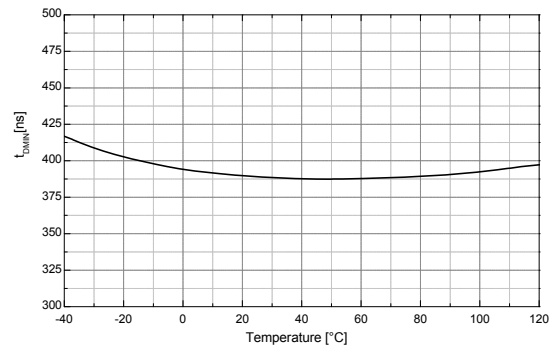


Figure 25.  $t_{D\text{MIN}}$  vs. Temperature

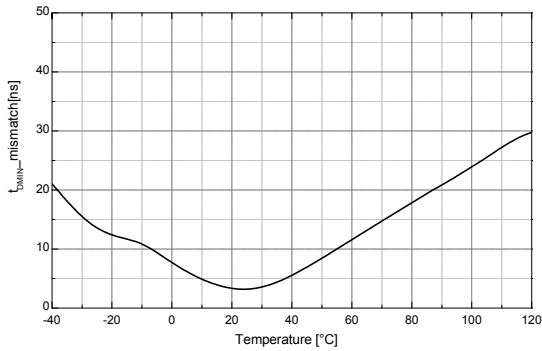


Figure 26. Dead-Time Mismatch vs. Temperature

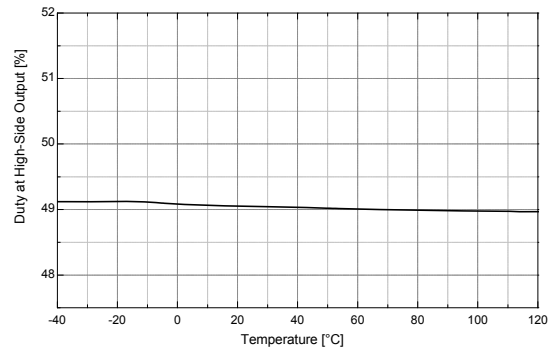


Figure 27. High-Side Duty Ratio vs. Temperature

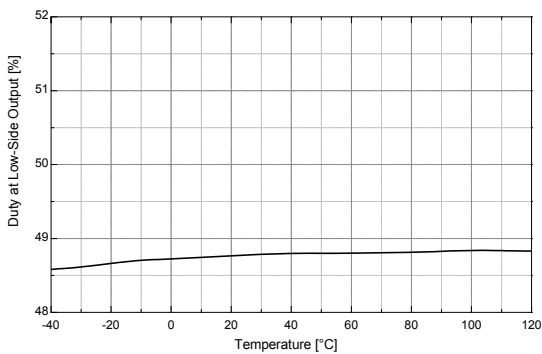


Figure 28. Low-Side Duty Ratio vs. Temperature

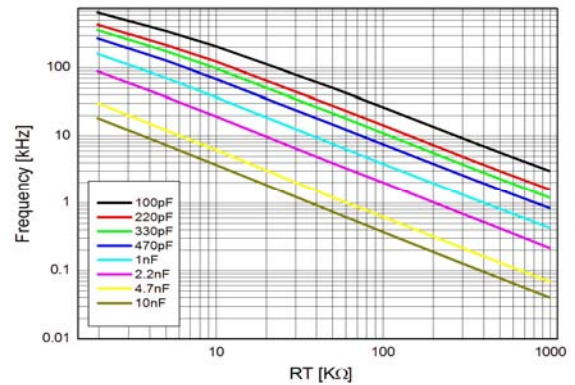


Figure 29. Frequency vs.  $R_T$

## Functional Description

### 1. Under-Voltage Lockout (UVLO) Function

FAN7387 has a UVLO circuit for a low-side and high-side block. When  $V_{DD}$  reaches to the  $V_{DD_{UV+}}$ , the UVLO circuit is released and the FAN7387 operates normally. At UVLO condition, the FAN7387 has a low supply current of less than 130  $\mu A$ . Once UVLO is released, FAN7387 operates normally until  $V_{DD}$  goes below  $V_{DD_{UV-}}$ , the UVLO hysteresis.

FAN7387 also has a high-side gate driver. The supply for the high-side driver is applied between  $V_B$  and  $V_S$ . To prevent malfunction at low supply voltage between  $V_B$  and  $V_S$ , FAN7387 provides an additional UVLO circuit. If  $V_B - V_S$  is under  $V_{BS_{UV+}}$ , the driver holds LOW state to turn off the high-side switch. Once the voltage of  $V_B - V_S$  is higher than  $V_{BS_{UVH}}$ , after  $V_B - V_S$  exceeds  $V_{BS_{UV-}}$ , the operation of driver resumes.

### 2. Oscillator

The running frequency is determined by an external timing resistor ( $R_T$ ) and timing capacitor ( $C_T$ ). The charge time of capacitor  $C_T$  from  $1/4 V_{DD}$  to  $V_{DD}$  determines the running frequency of LO and HO gate driver output. Figure 30 shows connection configuration.

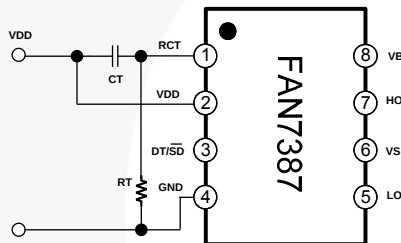


Figure 30. Typical Connection Method

Figure 31 shows the typical waveforms of RCT, LO, and HO. From the circuit analysis, the discharging time of RCT,  $t$ , is given by Equation 1:

$$V_{RCT} = V_{DD} \times \ln\left(\frac{-t}{R_t \times C_t}\right) \quad (1)$$

Equation 1 enables calculation of discharging time,  $t$ , from  $V_{DD}$  to  $1/4 V_{DD}$  by substituting  $V_{RCT(t)}$  with  $1/4 V_{DD}$ .

$$t = 1.38 \times R_t \times C_t \quad (2)$$

The running frequency of IC is determined by  $1/T$  and is approximately given as:

$$f_{\text{running}} = \frac{1}{T} = \frac{1}{2(t + T_{\text{fix}})} \quad (3)$$

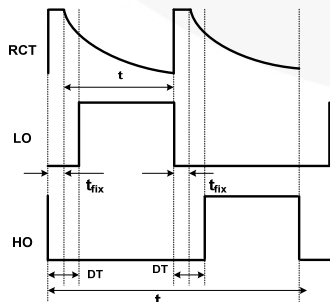


Figure 31. Typical Waveforms of RCT, LO and HO

where,  $t$  is the discharging time of the RCT voltage and  $t_{\text{fix}}$  is constant value about 450 ns of IC.

### 3. Programming Dead-Time Control / Shutdown

A multi-function pin controls dead-time using an external resistor ( $R_{DT}$ ) and protects abnormal condition using an external switch. This pin should be connected to an external capacitor to maintain stable operation.

If the voltage of DT/SD is decreased under 1 V by an external switch, such as the TR or MOSFET, the FAN7387 enters shutdown mode. In this mode, the FAN7387 doesn't have any output signal.

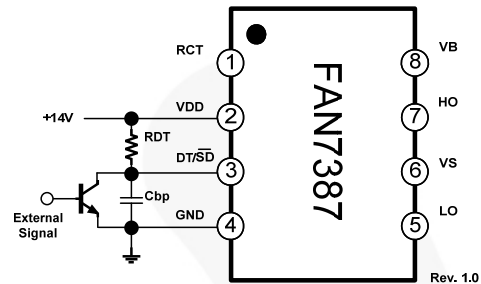


Figure 32. External Shutdown Circuit

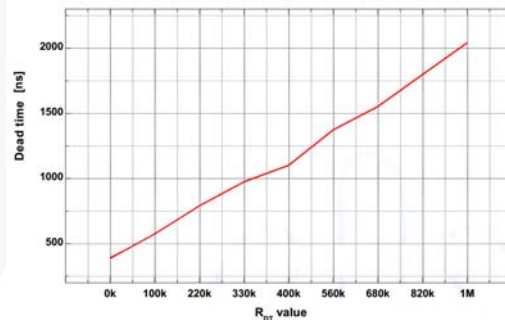


Figure 33. Adjustable Dead Time

### 4. Gate Driver Operation

The FAN7387 has a two operating modes. One is the self-oscillation mode by using external timing resistor ( $R_T$ ) and external timing capacitor ( $C_T$ ) and the other is the forced oscillation mode by external PWM signal comes from U-com and the other devices.

Figure 33 shows operation of the IC using an external PWM circuit with additional resistors ( $R_1$  and  $R_2$ ) for internal limitation of the IC. The input signal range from an external circuit must be within  $3/5 V_{DD}$  and  $3/4 V_{DD}$ . The external signal produces the HO and LO output and HO signal is in-phase with the external input signal.

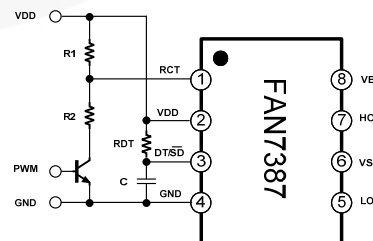
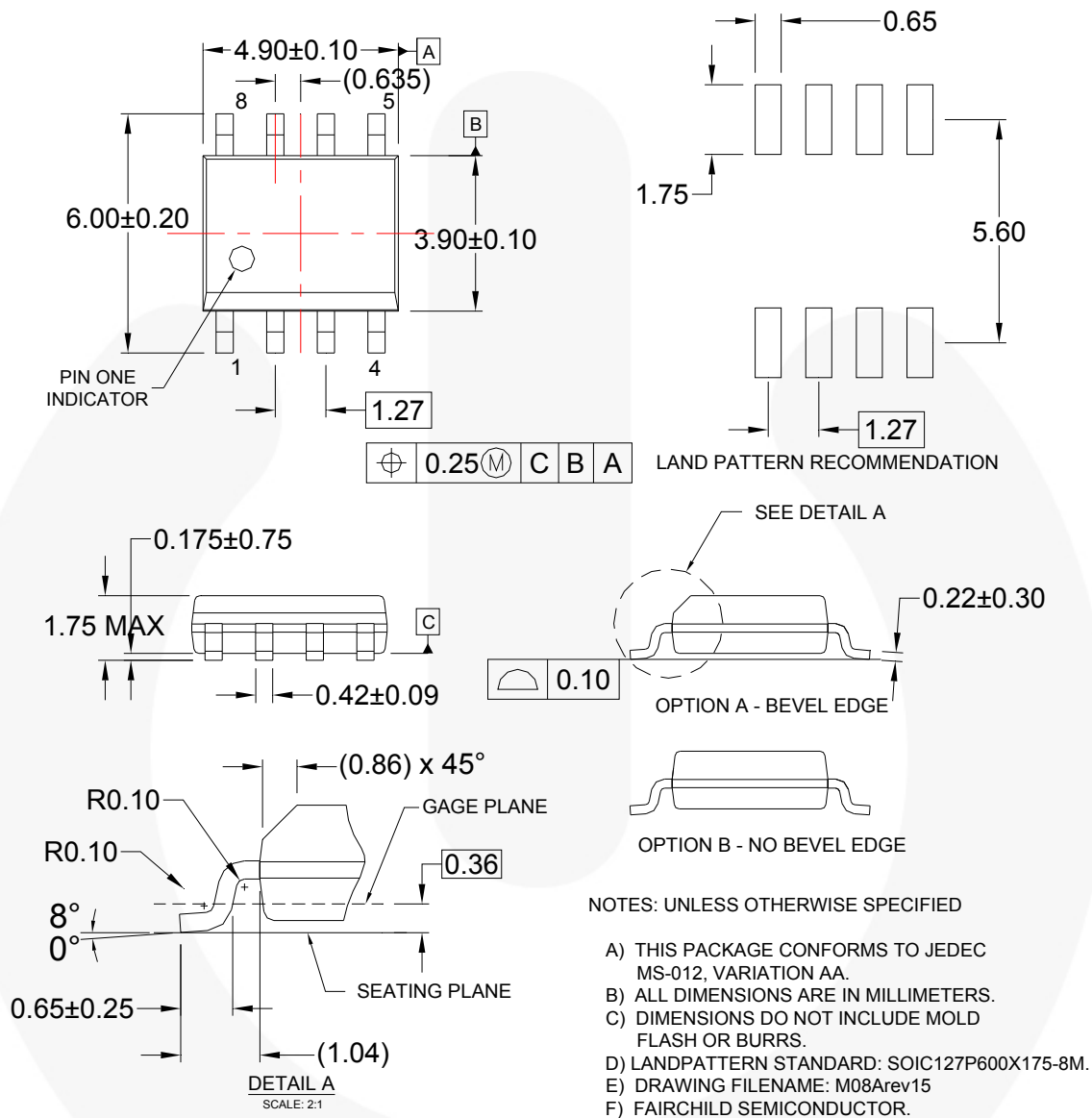


Figure 34. Gate Driver Using External PWM Signal

## Physical Dimensions



### Figure 35. 8-Lead Small Outline Package (SOP)

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