

## Direct PWM Variable Speed Fan Motor Driver

### Features

- **Single Phase Full Wave Fan Driver**
- **Low Supply Current**
- **Built-In Variable Speed Function**
- **Include Hall Bias Circuit**
- **Built-In Lock Protection and Auto Restart Function**
- **FG Output and RD Output Signal available**
- **Built-In Current Limit Circuit**
- **Built-In Thermal Protection Circuit**
- **TSSOP-16 Package**
- **Lead Free and Green Devices Available (RoHS Compliant)**

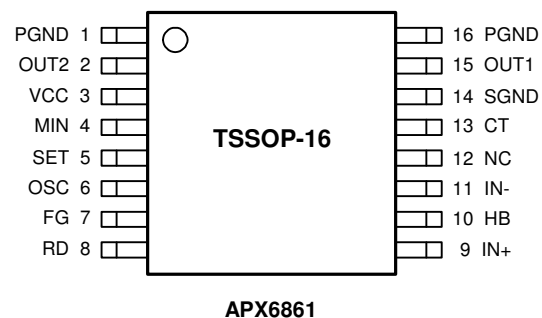
### General Description

The APX6861 is a high efficient direct PWM drive IC with single phase and CMOS drive. Such IC design is suitable for variable speed control FAN of personal computer's power supply radiation and CPU cooler. The device is built-in lock protection. When fan is locked, the device will enter the lockup protection mode. It is also with rotation detection output and thermal shut-down function. In normal operation, supply current is 3mA. The APX6861 is available in TSSOP-16 package.

### Applications

- **CPU Cooler**
- **Variable Speed Control Fan**

### Pin Configuration



ANPEC reserves the right to make changes to improve reliability or manufacturability without notice, and advise customers to obtain the latest version of relevant information to verify before placing orders.

|                                                                                                      |                                                                                                                                                                                                                |
|------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>APX6861</p>      | <p>Package Code<br/> O: TSSOP - 16<br/> Operating Ambient Temperature Range<br/> I : -40 to 90 °C<br/> Handling Code<br/> TR : Tape &amp; Reel<br/> Assembly Material<br/> G: Halogen and Lead Free Device</p> |
| <p>APX6861 O :</p>  | <p>XXXXXX - Date Code</p>                                                                                                                                                                                      |

### Absolute Maximum Ratings (Note 1)

| Symbol                               | Parameter                                          | Ratings    | Unit |
|--------------------------------------|----------------------------------------------------|------------|------|
| V <sub>CC</sub>                      | VCC Pin Supply Voltage                             | -0.3 to 18 | V    |
| I <sub>OUT</sub>                     | OUT1/OUT2 Pin Output Current                       | 0 to 1     | A    |
| V <sub>OUT1</sub> /V <sub>OUT2</sub> | OUT1/OUT2 Pin Output Voltage                       | -0.3 to 18 | V    |
| I <sub>HB</sub>                      | HB Pin Output Current                              | 0 to 10    | mA   |
| V <sub>SET</sub> / V <sub>MIN</sub>  | SET/MIN Pin Input Voltage                          | -0.3 to 18 | V    |
| V <sub>RD</sub> / V <sub>FG</sub>    | RD/FG Output Voltage                               | -0.3 to 18 | V    |
| I <sub>RD</sub> / I <sub>FG</sub>    | RD/FG Sink Current                                 | 0 to 10    | mA   |
| R <sub>TH,JA</sub>                   | Thermal Resistance-Junction to Ambient<br>TSSOP-16 | 147        | °C/W |
| P <sub>D</sub>                       | Power Dissipation                                  | 0.85       | W    |
| T <sub>J</sub>                       | Junction Temperature                               | -40 to 150 | °C   |
| T <sub>STG</sub>                     | Storage Temperature                                | -55 to 150 | °C   |
| T <sub>SDR</sub>                     | Maximum Lead Soldering Temperature, 10 Seconds     | 260        | °C   |

## Recommended Operating Conditions

| Symbol           | Parameter                              | Rating    | Unit |
|------------------|----------------------------------------|-----------|------|
| V <sub>CC</sub>  | VCC Pin Supply Voltage                 | 3.5 to 15 | V    |
| V <sub>SET</sub> | SET Pin Input Voltage Range            | 0 to 6    | V    |
| V <sub>MIN</sub> | MIN Pin Input Voltage Range            | 0 to 6    | V    |
| V <sub>ICM</sub> | Common-Mode Hall Input Voltage Range   | 0.2 to 3  | V    |
| T <sub>A</sub>   | Ambient Temperature <sup>(Note2)</sup> | -40 to 90 | °C   |

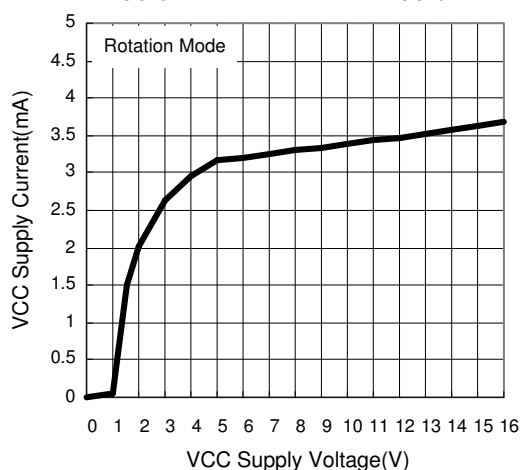
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**Electrical Characteristics** ( $V_{CC} = 12V$ ,  $T_A = 25^\circ C$ , unless otherwise specified)

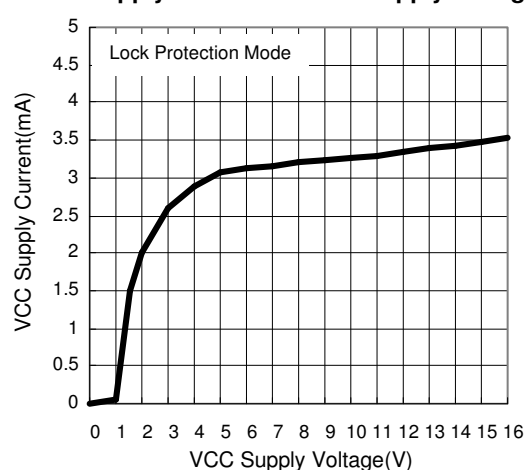
| Symbol                             | Parameter                            | Test Conditions                                      | APX6861 |      |      | Unit |
|------------------------------------|--------------------------------------|------------------------------------------------------|---------|------|------|------|
|                                    |                                      |                                                      | Min.    | Typ. | Max. |      |
| SUPPLY CURRENT                     |                                      |                                                      |         |      |      |      |
| V <sub>HB</sub>                    | HB Pin Output Voltage                | I <sub>HB</sub> = 5mA                                | 1.15    | 1.3  | 1.45 | V    |
| I <sub>CC1</sub>                   | Operating Current                    | Rotation Mode                                        | -       | 3    | 6    | mA   |
| I <sub>CC2</sub>                   |                                      | Lock Protection Mode                                 | -       | 3    | 6    | mA   |
| OSCILLATOR                         |                                      |                                                      |         |      |      |      |
| V <sub>OSCH</sub>                  | OSC High Level Voltage               | C <sub>OSC</sub> = 100pF                             | 3.47    | 3.6  | 3.73 | V    |
| V <sub>OSCL</sub>                  | OSC Low Level Voltage                | C <sub>OSC</sub> = 100pF                             | 1.96    | 2.05 | 2.14 | V    |
| F <sub>OSC</sub>                   | OSC Oscillation Frequency            | C <sub>OSC</sub> = 100pF                             | 18      | 25   | 32   | kHz  |
| LOCK PROTECTION                    |                                      |                                                      |         |      |      |      |
| V <sub>CTH</sub>                   | CT Pin High Level Voltage            | C <sub>CT</sub> = 1μF                                | 3.24    | 3.6  | 3.96 | V    |
| V <sub>CTL</sub>                   | CT Pin Low Level Voltage             | C <sub>CT</sub> = 1μF                                | 1.2     | 1.4  | 1.6  | V    |
| I <sub>CT1</sub>                   | CT Charge Current                    | V <sub>CT</sub> = 0V                                 | 1.5     | 2    | 2.5  | μA   |
| I <sub>CT2</sub>                   | CT Discharge Current                 | V <sub>CT</sub> = 3.6V                               | 0.15    | 0.2  | 0.25 | μA   |
| R <sub>CT</sub>                    | CT Charge/Discharge Current Ratio    | R <sub>CT</sub> = I <sub>CT1</sub> /I <sub>CT2</sub> | 8.5     | 10   | 11.5 | -    |
| OUTPUT DRIVERS                     |                                      |                                                      |         |      |      |      |
| V <sub>OL</sub>                    | Output Lower Side Saturation         | I <sub>OUT</sub> = 200mA                             | -       | 0.1  | 0.2  | V    |
| V <sub>OH</sub>                    | Output Upper Side Saturation         | I <sub>OUT</sub> = 200mA                             | -       | 0.25 | 0.5  | V    |
| V <sub>RD</sub> /V <sub>FG</sub>   | RD/FG Pin Low Voltage                | I <sub>FG</sub> = 5mA                                | -       | 0.2  | 0.3  | V    |
| I <sub>RDL</sub> /I <sub>FGL</sub> | RD/FG Pin Leak Current               | V <sub>FG</sub> = 7V                                 | -       | -    | 0.1  | μA   |
| HALL SENSITIVITY                   |                                      |                                                      |         |      |      |      |
| V <sub>HN</sub>                    | Hall Input Sensitivity               | Zero to peak including offset and hysteresis         | -       | 10   | 25   | mV   |
| THERMAL SHUTDOWN                   |                                      |                                                      |         |      |      |      |
|                                    | Over-Temperature Shutdown Threshold  |                                                      | -       | 175  | -    | °C   |
|                                    | Over-Temperature Shutdown Hysteresis |                                                      | -       | 30   | -    |      |
| CURRENT LIMIT                      |                                      |                                                      |         |      |      |      |
| I <sub>LIM</sub>                   | Current Limit Value                  |                                                      | 0.85    | 1    | 1.15 | A    |

## Typical Operating Characteristics

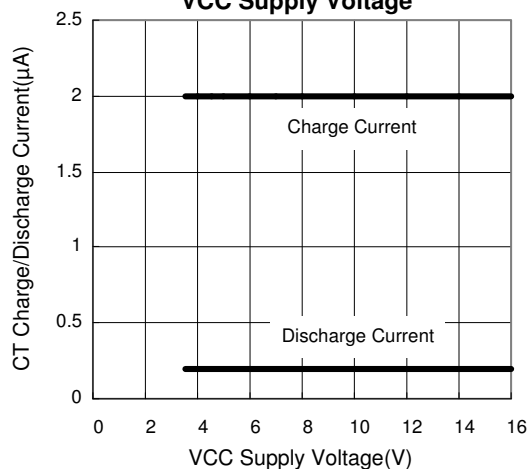
VCC Supply Current vs. VCC Supply Voltage



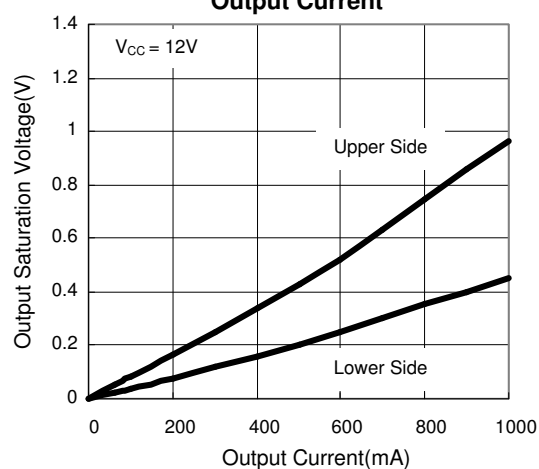
VCC Supply Current vs. VCC Supply Voltage



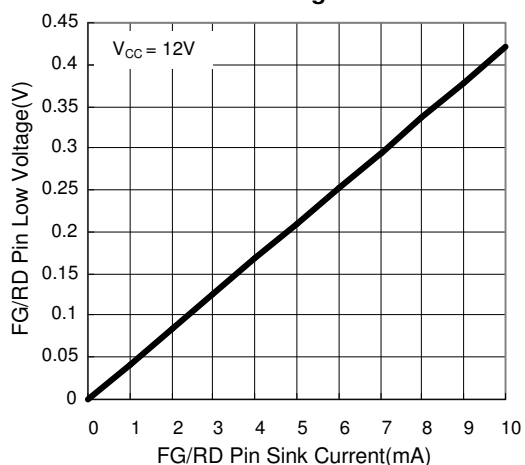
CT Charge/Discharge Current vs. VCC Supply Voltage



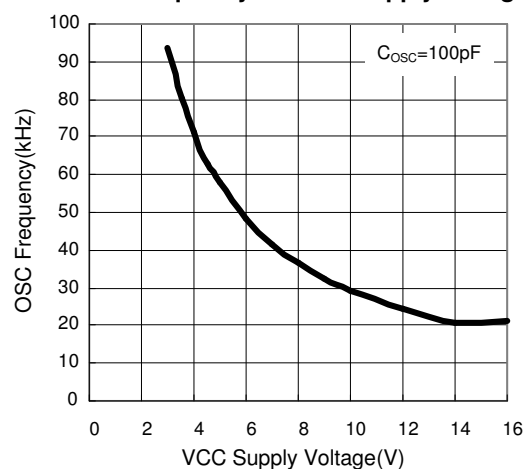
Output Saturation Voltage vs. Output Current



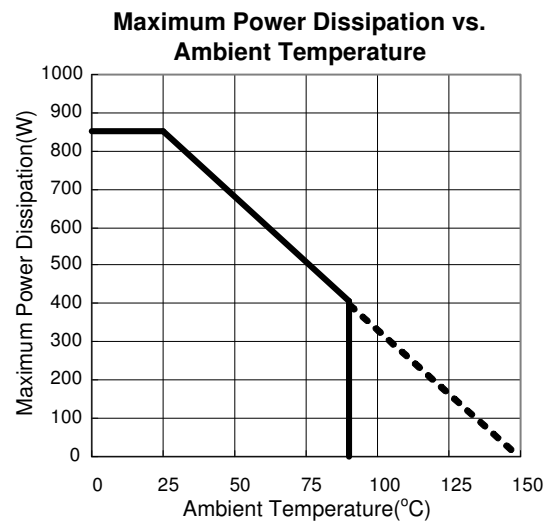
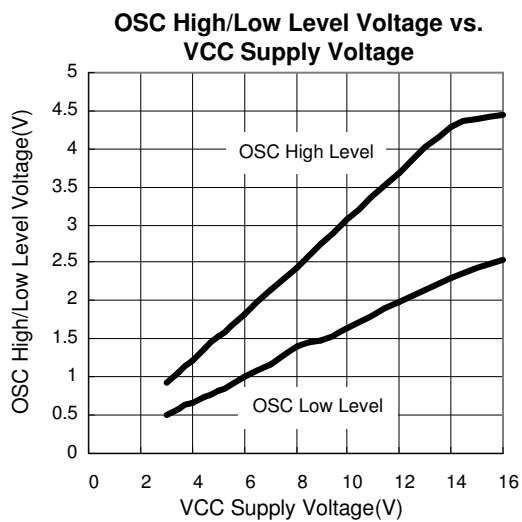
FG/RD Pin Low Voltage vs. Sink Current



OSC Frequency vs. VCC Supply Voltage



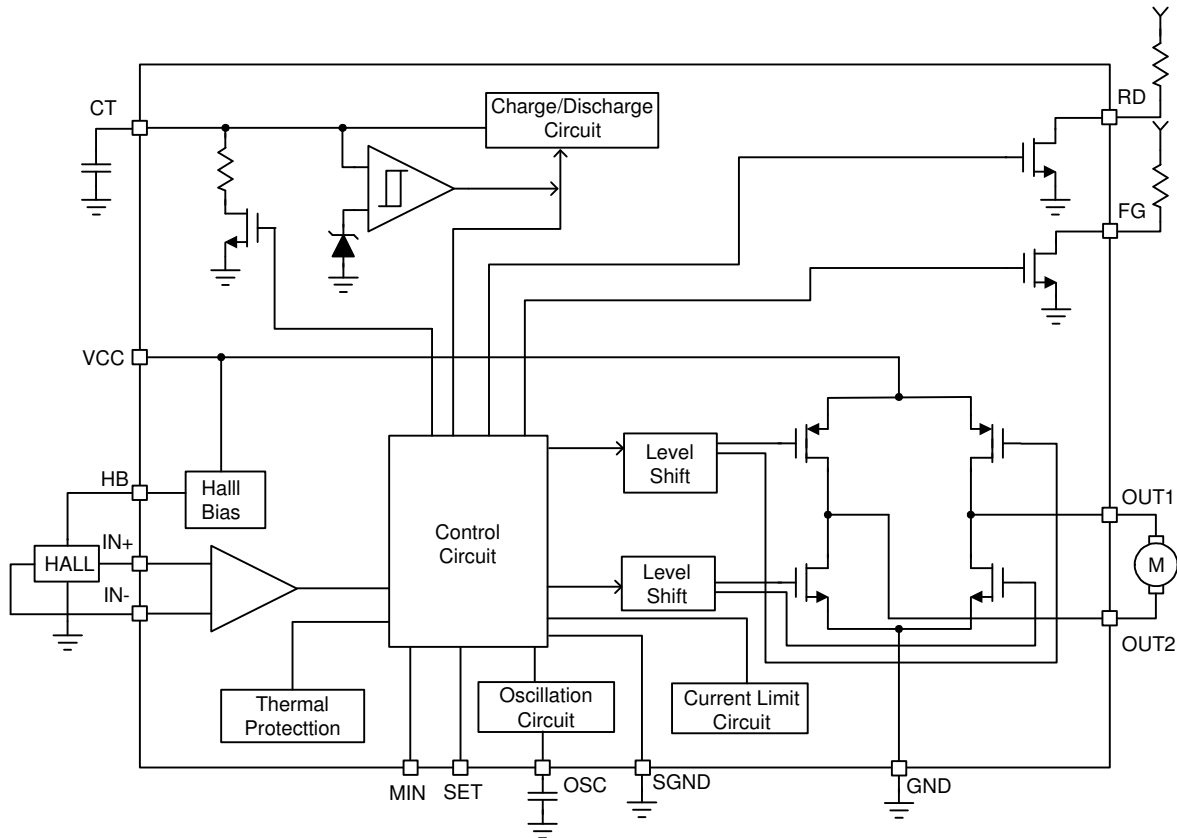
## Typical Operating Characteristics



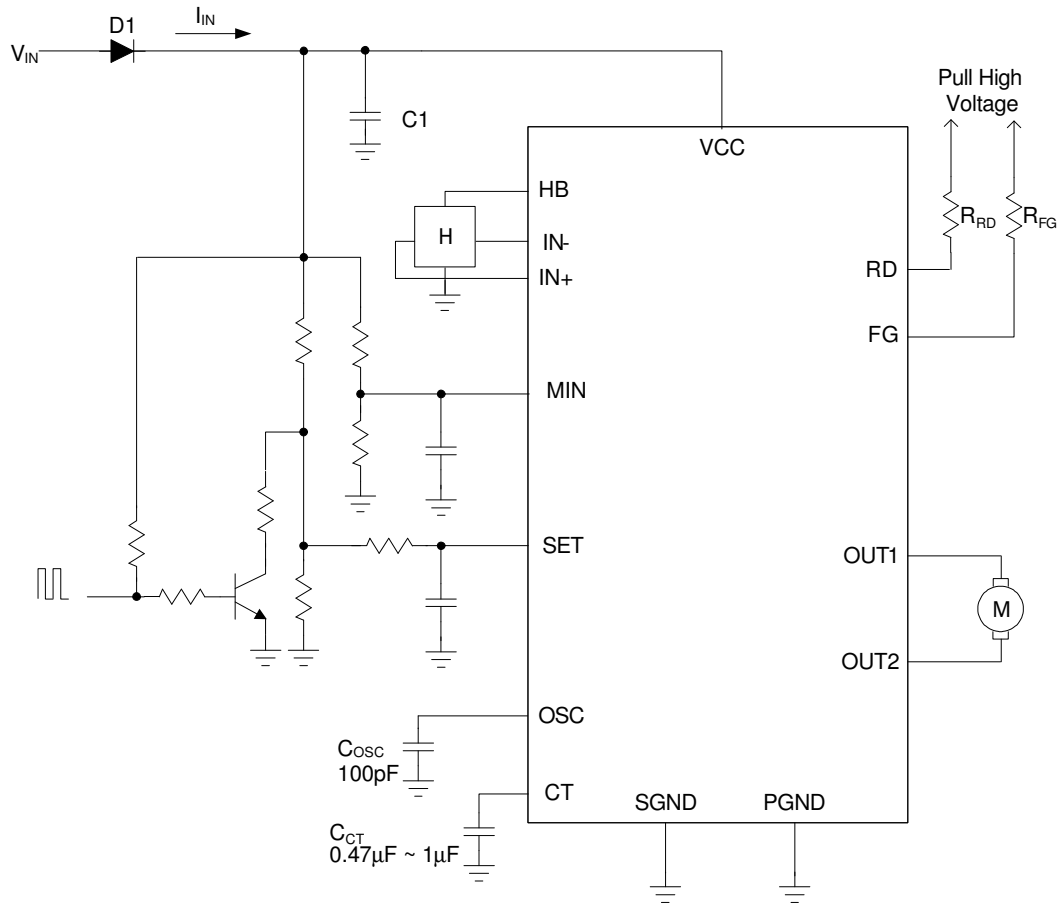
## Pin Descriptions

| PIN |      | FUNCTION                                                                                                               |
|-----|------|------------------------------------------------------------------------------------------------------------------------|
| NO. | NAME |                                                                                                                        |
| 1   | PGND | Power Stage GND.                                                                                                       |
| 2   | OUT2 | H-bridge Output Connection.                                                                                            |
| 3   | VCC  | Supply Voltage Input Pin.                                                                                              |
| 4   | MIN  | Speed Setting. An external voltage into MIN pin to set fan speed.                                                      |
| 5   | SET  | Speed Setting. An external voltage into SET pin to set fan speed.                                                      |
| 6   | OSC  | Oscillation Frequency Setting. Connect a capacitor to GND to set oscillation frequency.                                |
| 7   | FG   | Rotation Speed Output. This is an open-drain output.                                                                   |
| 8   | RD   | Rotation Detection Output. This is an open-drain output.                                                               |
| 9   | IN+  | Hall Input +. Connect to hall element positive output.                                                                 |
| 10  | HB   | Hall Bias. This is a 1.3V constant-voltage output for hall element bias.                                               |
| 11  | IN-  | Hall Input -. Connect to hall element negative output.                                                                 |
| 12  | NC   | No Connection.                                                                                                         |
| 13  | CT   | Shutdown Time and Restart Time Setting. Connect a capacitor to GND to set shutdown time and restart time in lock mode. |
| 14  | SGND | Control Stage GND.                                                                                                     |
| 15  | OUT1 | H-bridge Output Connection.                                                                                            |
| 16  | PGND | Power Stage GND.                                                                                                       |

## Block Diagram



## Typical Application Circuit



## Truth Table

| Input |     |     |    | Output |      |     |     |                                      |
|-------|-----|-----|----|--------|------|-----|-----|--------------------------------------|
| IN-   | IN+ | OSC | CT | OUT1   | OUT2 | FG  | RD  | Mode                                 |
| H     | L   | H   | L  | H      | L    | L   | L   | Rotation (Drive)<br>PWM ON           |
| L     | H   |     |    | L      | H    | OFF | L   |                                      |
| H     | L   | L   |    | OFF    | L    | L   | L   | Rotation (Re-Circulation)<br>PWM OFF |
| L     | H   |     |    | L      | OFF  | OFF | L   |                                      |
| H     | L   | -   | H  | L      | L    | L   | OFF | Lock Mode                            |
| L     | H   |     |    | L      | L    | OFF |     |                                      |

Note 4: OSC-H corresponds to OSC>SET and OSC-L corresponds to OSC<SET.

## Application Information

### Input Protection Diode & Capacitor

The IC should be added a protection diode (D1) to prevent the damage from the power reverse connection. However, the protection diode will cause a voltage drop on the supply voltage. The current rating of the diode must be greater than the maximum output current. For the noise reduction purpose, a capacitor (C1) must connect between VCC and GND. It is the suggestion that C1 should be placed as close as possible to the device VCC pin

### HB Pin & Hall Input

1.3V voltage reference is for hall element bias. Wiring needs to be shortened to prevent carrying of the noise. Hall input amplifier has 20mV hysteresis. Then, we recommend the hall input level to be 60mV or over.

### CT Capacitor

The capacitor that is connected from CT pin to GND determines the shutdown time and restart time.

$$\text{Locked Detection Time} = \frac{C_{CT} \times (V_{CTH} - 0.2V)}{I_{CT1}}$$

$$\text{Restart Time} = \frac{C_{CT} \times (V_{CTH} - V_{CTL})}{I_{CT1}}$$

$$\text{Shutdown Time} = \frac{C_{CT} \times (V_{CTH} - V_{CTL})}{I_{CT2}}$$

where:

$C_{CT}$  = CT pin capacitor

For example:

$V_{CC} = 12V$ ,  $C_{CT} = 1\mu F$

Locked Detection Time = 1.7s

Restart Time = 1.1s

Shutdown Time = 11s

The value of charge capacitor is recommended from 0.47 $\mu F$  to 1 $\mu F$ .

### FG/RD Resistor

The value of the FG/RD resistor could be decided by the following equation:

$$R_{FG} = \frac{V_{DC} - V_{FG}}{I_{FG}}$$

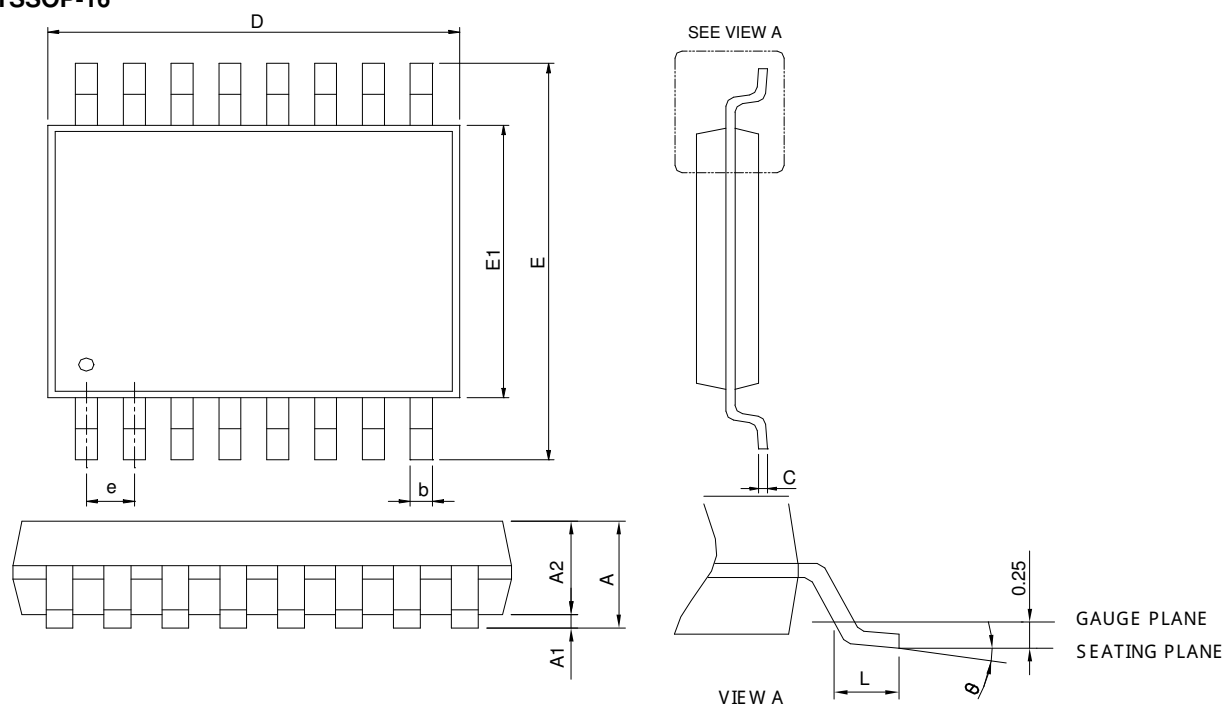
For example:

$V_{DC} = 6V$ ,  $I_{FG} = 5mA$ ,  $V_{FG} = 0.2V$ ,  $R_{FG} = 1.16k\Omega$

The value of resistor in the range of 1k $\Omega$  to 10k $\Omega$  is recommended.

## Package Information

### TSSOP-16



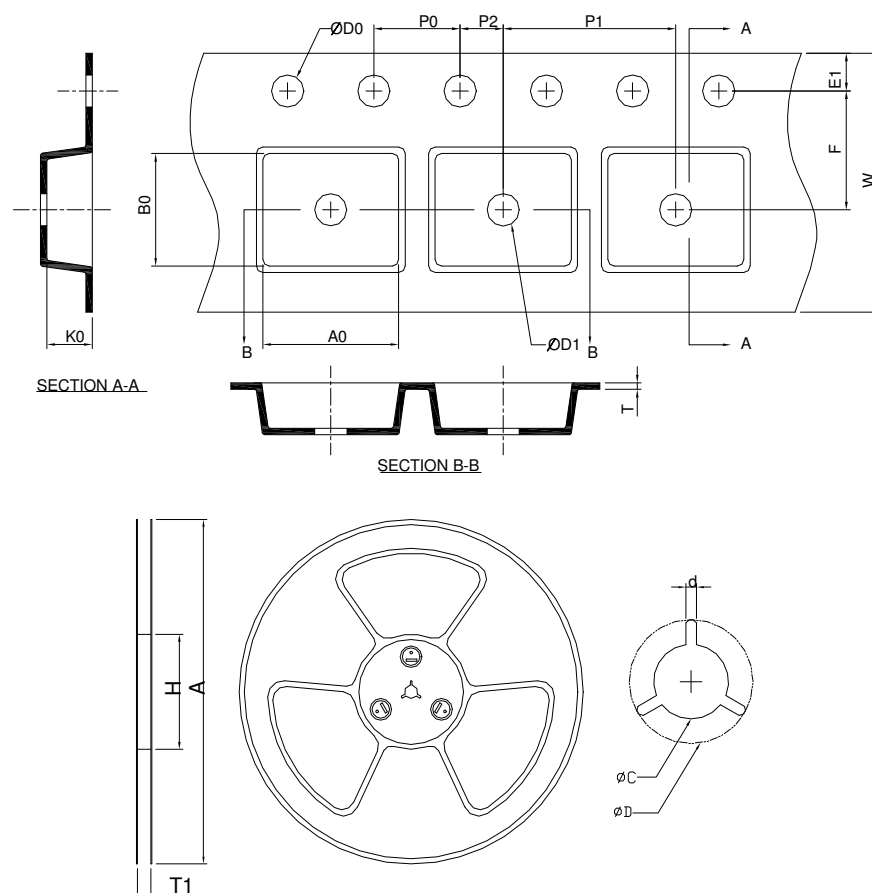
| SYMBOL | TSSOP-16    |      |           |       |
|--------|-------------|------|-----------|-------|
|        | MILLIMETERS |      | INCHES    |       |
|        | MIN.        | MAX. | MIN.      | MAX.  |
| A      |             | 1.20 |           | 0.047 |
| A1     | 0.05        | 0.15 | 0.002     | 0.006 |
| A2     | 0.80        | 1.05 | 0.031     | 0.041 |
| b      | 0.19        | 0.30 | 0.007     | 0.012 |
| c      | 0.09        | 0.20 | 0.004     | 0.008 |
| D      | 4.90        | 5.10 | 0.193     | 0.201 |
| E      | 6.20        | 6.60 | 0.244     | 0.260 |
| E1     | 4.30        | 4.50 | 0.169     | 0.177 |
| e      | 0.65 BSC    |      | 0.026 BSC |       |
| L      | 0.45        | 0.75 | 0.018     | 0.030 |
| θ      | 0°          | 8°   | 0°        | 8°    |

Note : 1. Follow from JEDEC MO-153 AB.

2. Dimension "D" does not include mold flash, protrusions or gate burrs. Mold flash, protrusion or gate burrs shall not exceed 6 mil per side.

3. Dimension "E1" does not include inter-lead flash or protrusions. Inter-lead flash and protrusions shall not exceed 10 mil per side.

## Carrier Tape & Reel Dimensions



| Application | A          | H         | T1                 | C                  | d        | D                 | W         | E1        | F         |
|-------------|------------|-----------|--------------------|--------------------|----------|-------------------|-----------|-----------|-----------|
| TSSOP-16    | 330.0±2.00 | 50 MIN.   | 12.4+2.00<br>-0.00 | 13.0+0.50<br>-0.20 | 1.5 MIN. | 20.2 MIN.         | 12.0±0.30 | 1.75±0.10 | 5.50±0.05 |
|             | P0         | P1        | P2                 | D0                 | D1       | T                 | A0        | B0        | K0        |
|             | 4.00±0.10  | 8.00±0.10 | 2.00±0.05          | 1.5+0.10<br>-0.00  | 1.5 MIN. | 0.6+0.00<br>-0.40 | 6.80±0.20 | 5.40±0.20 | 1.60±0.20 |

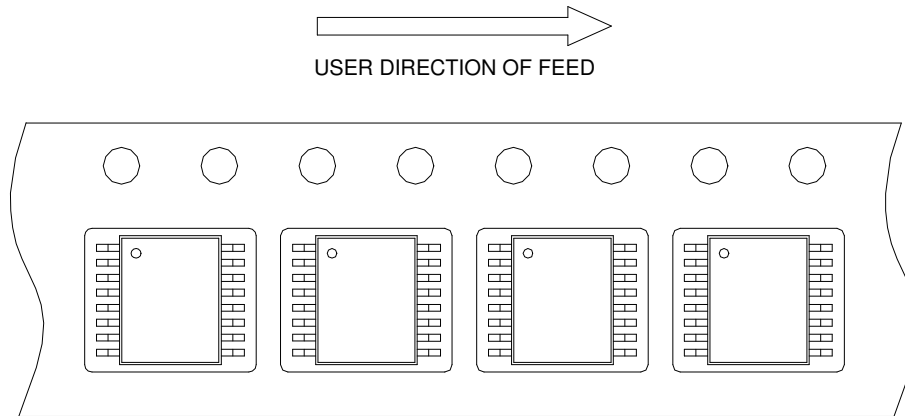
(mm)

## Devices Per Unit

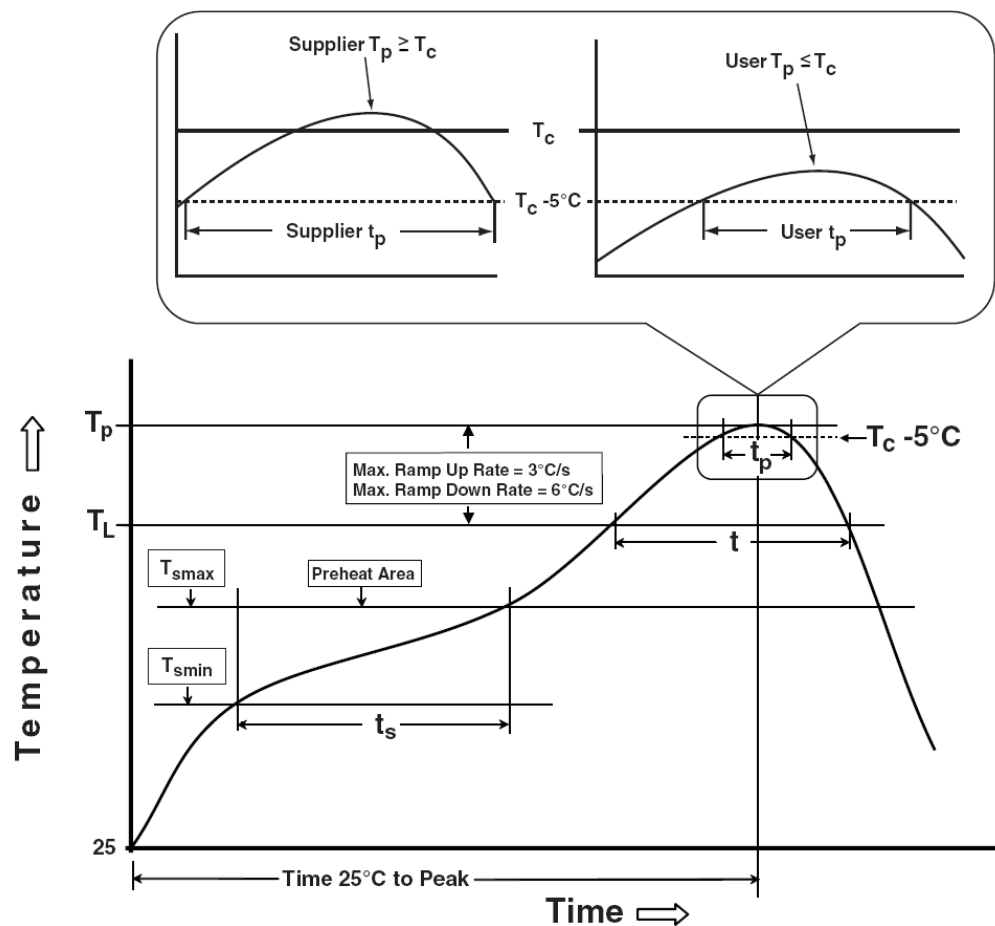
| Package Type | Unit        | Quantity |
|--------------|-------------|----------|
| TSSOP- 16    | Tape & Reel | 2500     |

## Taping Direction Information

TSSOP-16



## Classification Profile



## Classification Reflow Profiles

| Profile Feature                                                                                                  | Sn-Pb Eutectic Assembly            | Pb-Free Assembly                   |
|------------------------------------------------------------------------------------------------------------------|------------------------------------|------------------------------------|
| <b>Preheat &amp; Soak</b>                                                                                        |                                    |                                    |
| Temperature min ( $T_{smin}$ )                                                                                   | 100 °C                             | 150 °C                             |
| Temperature max ( $T_{smax}$ )                                                                                   | 150 °C                             | 200 °C                             |
| Time ( $T_{smin}$ to $T_{smax}$ ) ( $t_s$ )                                                                      | 60-120 seconds                     | 60-120 seconds                     |
| Average ramp-up rate ( $T_{smax}$ to $T_p$ )                                                                     | 3 °C/second max.                   | 3°C/second max.                    |
| Liquidous temperature ( $T_L$ )                                                                                  | 183 °C                             | 217 °C                             |
| Time at liquidous ( $t_L$ )                                                                                      | 60-150 seconds                     | 60-150 seconds                     |
| Peak package body Temperature ( $T_p$ )*                                                                         | See Classification Temp in table 1 | See Classification Temp in table 2 |
| Time ( $t_p$ )** within 5°C of the specified classification temperature ( $T_c$ )                                | 20** seconds                       | 30** seconds                       |
| Average ramp-down rate ( $T_p$ to $T_{smax}$ )                                                                   | 6 °C/second max.                   | 6 °C/second max.                   |
| Time 25°C to peak temperature                                                                                    | 6 minutes max.                     | 8 minutes max.                     |
| * Tolerance for peak profile Temperature ( $T_p$ ) is defined as a supplier minimum and a user maximum.          |                                    |                                    |
| ** Tolerance for time at peak profile temperature ( $t_p$ ) is defined as a supplier minimum and a user maximum. |                                    |                                    |

Table 1. SnPb Eutectic Process – Classification Temperatures ( $T_c$ )

| Package Thickness | Volume mm <sup>3</sup><br><350 | Volume mm <sup>3</sup><br>≥350 |
|-------------------|--------------------------------|--------------------------------|
| <2.5 mm           | 235 °C                         | 220 °C                         |
| ≥2.5 mm           | 220 °C                         | 220 °C                         |

Table 2. Pb-free Process – Classification Temperatures ( $T_c$ )

| Package Thickness | Volume mm <sup>3</sup><br><350 | Volume mm <sup>3</sup><br>350-2000 | Volume mm <sup>3</sup><br>>2000 |
|-------------------|--------------------------------|------------------------------------|---------------------------------|
| <1.6 mm           | 260 °C                         | 260 °C                             | 260 °C                          |
| 1.6 mm – 2.5 mm   | 260 °C                         | 250 °C                             | 245 °C                          |
| ≥2.5 mm           | 250 °C                         | 245 °C                             | 245 °C                          |

## Reliability Test Program

| Test item     | Method             | Description                                |
|---------------|--------------------|--------------------------------------------|
| SOLDERABILITY | JESD-22, B102      | 5 Sec, 245°C                               |
| HOLT          | JESD-22, A108      | 1000 Hrs, Bias @ $T_j=125^{\circ}\text{C}$ |
| PCT           | JESD-22, A102      | 168 Hrs, 100%RH, 2atm, 121°C               |
| TCT           | JESD-22, A104      | 500 Cycles, -65°C~150°C                    |
| HBM           | MIL-STD-883-3015.7 | VHBM ≥ 2KV                                 |
| MM            | JESD-22, A115      | VMM ≥ 200V                                 |
| Latch-Up      | JESD 78            | 10ms, $I_{tr} \geq 100\text{mA}$           |

## Customer Service

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