

# APX6219



## PWM Stepper Motor Driver

### Features

- Able to Drive Both Windings of Bipolar Stepper Motor
- Up to 750 mA Continuous Output Current for Each Winding
- Up to 28V Output Sustaining Voltage
- Internal PWM Current Control
- Built-in Protection Diode
- Low Output Saturation Voltage
- Internal Thermal Shutdown
- Lead Free Available (RoHS Compliant)

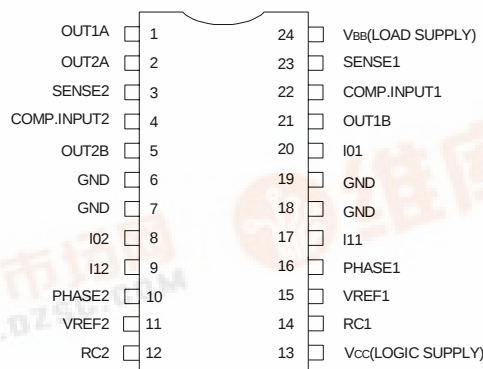
### Applications

- Scanner
- Stepping Motor Control
- Thermal Printer

### General Description

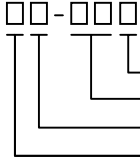
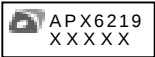
The APX6219 is designed to drive both winding of a two-phase bipolar stepper motor or bidirectionally control 2 DC motors. APX6219 includes two H-bridges capable of continuous output current of  $\pm 750$  mA with peak start up to 1A and operating voltages up to 28V. Motor winding current can be controlled by the internal fixed-frequency, pulse-width modulated (PWM), current-control circuitry. Wide range current control is controlled by means of two logic inputs with a external reference voltage for each bridge. The peak load current limit is set by the user's selection of a reference voltage and current-sensing resistor. Two logic-level select output current limits of 0%,33%, 67%, or 100% of the maximum level. A phase input to each bridge determines load current direction. A thermal shutdown protection circuit disables the outputs if the chip temperature over the safe operation limit. The APX6219 come in SOP-24 package.

### Pin Configuration



SOP-24 (Top View)

## Ordering and Marking Information

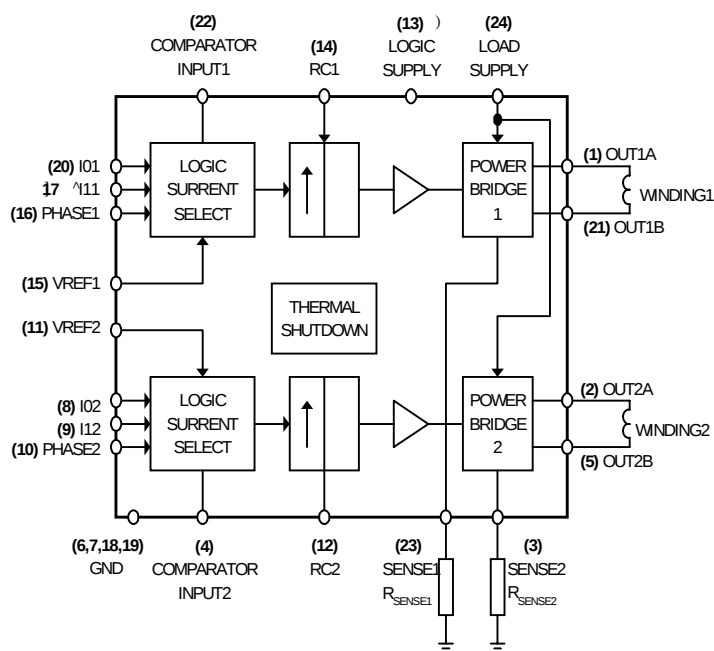
|                                                                                                                                                                           |                                                                                                                                                                                                          |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>APX6219</p>  <p>Lead Free Code<br/>Handling Code<br/>Temp. Range<br/>Package Code</p> | <p>Package Code<br/>K : SOP - 24<br/>Temp. Range<br/>I : -40 °C to 85 °C<br/>Handling Code<br/>TU : Tube      TR : Tape &amp; Reel<br/>Lead Free Code<br/>L : Lead Free      Blank : Original Device</p> |
| <p>APX6219 K :</p>                                                                       | <p>XXXXX - Date Code</p>                                                                                                                                                                                 |

Notes: ANPEC lead-free products contain molding compounds/die attach materials and 100% matte in plate termination finish; which are fully compliant with RoHS and compatible with both SnPb and lead-free soldering operations. ANPEC lead-free products meet or exceed the lead-free requirements of IPC/JEDEC J STD-020C for MSL classification at lead-free peak reflow temperature.

## Pin Description

| PIN       |                   | I/O | Description                                                                                                                                                                                                                                                                                    |    |                              |
|-----------|-------------------|-----|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----|------------------------------|
| NO.       | Name              |     |                                                                                                                                                                                                                                                                                                |    |                              |
| 1,2       | OUTPUT A          | O   | H- bridge Output connection. The output stage is a “H” bridge formed by four transistors and four-protection diode for switching applications.                                                                                                                                                 |    |                              |
| 3,23      | Sense Resistor    | O   | Connection to lower emitters of output stage for insertion of current sensor resistor to check the peak value of output current                                                                                                                                                                |    |                              |
| 4,22      | Comparator Input  | I   | The voltage across the sense resistor is feedback to this input through the low pass filter $R_C C_C$ . The higher power transistors are disabled when the sense voltage exceeds the reference voltage of selected comparator. The current decays for a time set by $R_T C_T$ when this happen |    |                              |
| 5,21      | OUTPUT B          | O   | See pins 1,2                                                                                                                                                                                                                                                                                   |    |                              |
| 6,7,18,19 | Ground            |     | Ground connection                                                                                                                                                                                                                                                                              |    |                              |
| 8,9       | I02/I12           | I   | These pins are logic inputs which select the outputs of the comparators to set the output current level. Current also depends on the sensing resistor and reference voltage.                                                                                                                   |    |                              |
|           |                   |     | I0                                                                                                                                                                                                                                                                                             | I1 | Current level                |
|           |                   |     | H                                                                                                                                                                                                                                                                                              | H  | No current                   |
|           |                   |     | L                                                                                                                                                                                                                                                                                              | H  | Low current 1/3 $I_o$ max    |
|           |                   |     | H                                                                                                                                                                                                                                                                                              | L  | Medium current 2/3 $I_o$ max |
|           |                   |     | L                                                                                                                                                                                                                                                                                              | L  | Maximum current $I_o$ max    |
| 20,17     | I01/I11           | I   | See pins 8,9; current level control for channel2                                                                                                                                                                                                                                               |    |                              |
| 10,16     | PHASE             | I   | This TTL-compatible logic input sets the current flow direction through load. A schmitt trigger with this input provides the noise immunity and a delay circuit prevents output stage short circuits during switching                                                                          |    |                              |
| 11,15     | Reference Voltage | I   | A voltage apply this pin sets the input of a comparator to control the output current                                                                                                                                                                                                          |    |                              |
| 12,14     | $R_T C_T$         | O   | A $R_T C_T$ connection to this pin sets the off time of higher power transistor                                                                                                                                                                                                                |    |                              |
| 13        | $V_{CC}$          |     | Logic supply voltage                                                                                                                                                                                                                                                                           |    |                              |
| 24        | $V_{BB}$          |     | Load supply voltage                                                                                                                                                                                                                                                                            |    |                              |

## Block Diagram



## Absolute Maximum Ratings

| Symbol      | Parameter                                           | Rating               | Unit |
|-------------|-----------------------------------------------------|----------------------|------|
| $V_{BB}$    | Load Supply Voltage                                 | 30                   | V    |
| $I_O$       | Output Current (Peak)                               | $\pm 1$              | A    |
| $I_O$       | Output Current (Continuous)                         | $\pm 750$            | mA   |
| $V_{CC}$    | Logic Supply Voltage                                | 7                    | V    |
| $V_{IN}$    | Logic Input Voltage                                 | -0.3 to $V_{CC}+0.3$ | V    |
| $V_{SENSE}$ | Driver Output Sense Voltage                         | 1.5                  | V    |
| $R_{TH,JA}$ | Thermal Resistance – Junction to Ambient*<br>SOP-24 | 75                   | °C/W |
| $R_{TH,JC}$ | Thermal Resistance – Junction to Case<br>SOP-24     | 15                   | °C/W |
| $P_D$       | Power Dissipation                                   | Internally Limited   | W    |
| $T_J$       | Junction Temperature                                | 0 to 150             | °C   |
| $T_{OP}$    | Operating Temperature Range                         | 0 to 70              | °C   |
| $T_{STG}$   | Storage Temperature Range                           | -65 to +150          | °C   |
| $T_L$       | Lead Temperature (Soldering, 10 second)             | 260                  | °C   |

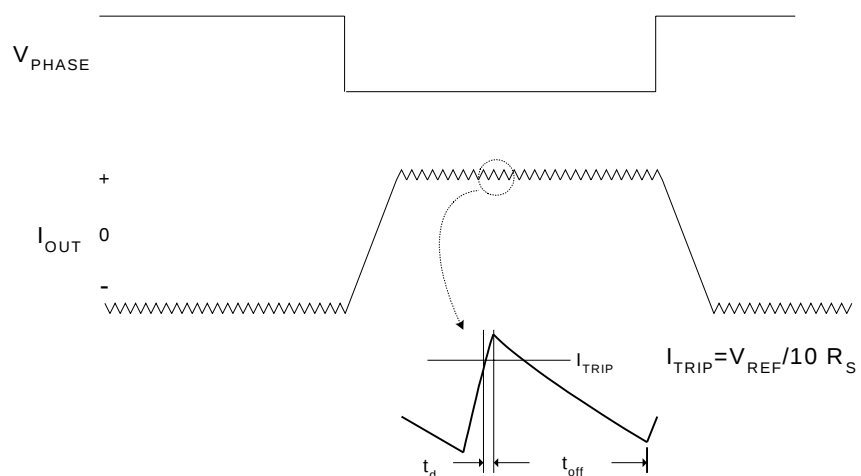
(\*) With minimized copper area.

## Electrical Characteristics

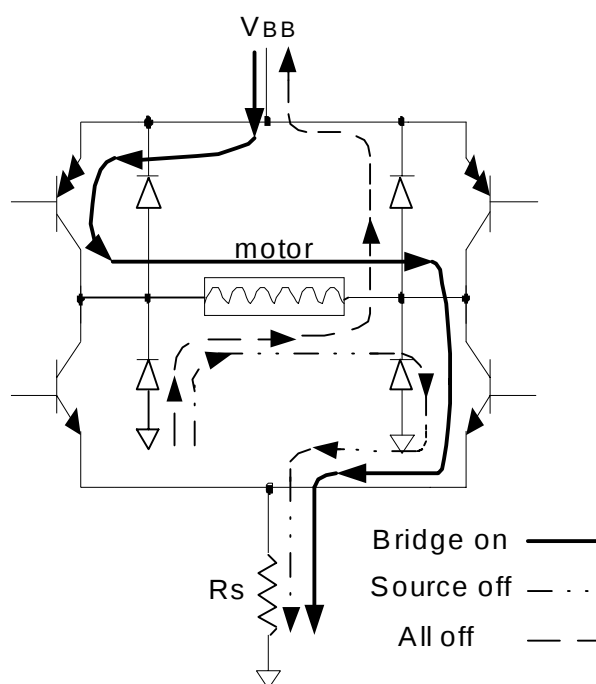
Unless otherwise noted these specifications apply over full temperature,  $V_{BB}=28V$ ,  $V_{CC}=4.75$  to  $5.25V$ ,  $V_{REF}=5V$ ,  $T_J=0$  to  $125^{\circ}C$ . Typical values refer to  $T_J=25^{\circ}C$ .

| Symbol                               | Parameter                               | Test Conditions                                                                                                                                                      | APX6219             |                          |                          | Unit |
|--------------------------------------|-----------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|--------------------------|--------------------------|------|
|                                      |                                         |                                                                                                                                                                      | Min.                | Typ.                     | Max.                     |      |
| Output drivers (OUTA or OUTB)        |                                         |                                                                                                                                                                      |                     |                          |                          |      |
| V <sub>BB</sub>                      | Motor Supply Voltage                    |                                                                                                                                                                      | 10                  |                          | 28                       | V    |
| I <sub>LEAK</sub>                    | Output Leakage Current                  | V <sub>OUT</sub> =V <sub>BB</sub><br>V <sub>OUT</sub> =0                                                                                                             |                     | <1<br><-1                | 50<br>-50                | μA   |
| V <sub>CE(sat)</sub>                 | Output Saturation Voltage               | Sink driver, I <sub>OUT</sub> =+500mA<br>Sink driver, I <sub>OUT</sub> =+750mA<br>Source driver, I <sub>OUT</sub> =-500mA<br>Source driver, I <sub>OUT</sub> =-750mA |                     | 0.4<br>0.8<br>1.1<br>1.4 | 0.7<br>1.1<br>1.4<br>1.7 | V    |
| I <sub>R</sub>                       | Clamp Diode Leakage Current             | V <sub>R</sub> =28V                                                                                                                                                  |                     | <1                       | 50                       | μA   |
| V <sub>F</sub>                       | Clamp Diode Forward Voltage             | Sink diode<br>Source diode I <sub>F</sub> =750mA                                                                                                                     |                     | 1.6<br>1.6               | 2<br>2                   | V    |
| I <sub>BB(on)</sub>                  | Driver Supply Current                   | Both bridges ON, no load                                                                                                                                             |                     | 14                       | 25                       | mA   |
| I <sub>BB(off)</sub>                 | Driver Supply Current                   | Both bridges OFF                                                                                                                                                     |                     | 2                        | 10                       | mA   |
| Control logic                        |                                         |                                                                                                                                                                      |                     |                          |                          |      |
| V <sub>IH</sub>                      | Voltage Input                           | All inputs                                                                                                                                                           | 2.4                 |                          |                          | V    |
| V <sub>IL</sub>                      | Voltage Input                           | All inputs                                                                                                                                                           |                     |                          | 0.8                      | V    |
| I <sub>IH</sub>                      | Input Current                           | V <sub>IN</sub> =2.4V                                                                                                                                                |                     | <1                       | 20                       | μA   |
| I <sub>IL</sub>                      | Input Current                           | V <sub>IN</sub> =0.8V                                                                                                                                                |                     | -5                       | -50                      | μA   |
| V <sub>REF</sub>                     | Reference Voltage                       |                                                                                                                                                                      | 1.5                 |                          | 7.5                      | V    |
| I <sub>CC (on)</sub>                 | Logic Supply Current                    | I0=I1=0.8V, no load                                                                                                                                                  |                     | 47                       | 57                       | mA   |
| I <sub>CC (off)</sub>                | Logic Supply Current                    | I0=I1=2.4V, no load                                                                                                                                                  |                     | 8                        | 14                       | mA   |
| V <sub>REF</sub> /V <sub>SENSE</sub> | Current Limit Threshold (at trip point) | I0=I1=0.8V<br>I0=2.4V,I1=0.8V<br>I0=0.8V,I1=2.4V                                                                                                                     | 9.5<br>13.5<br>25.5 | 10<br>15<br>30           | 10.5<br>16.5<br>34.5     |      |
| T <sub>OFF</sub>                     | Cutoff Time                             | R <sub>T</sub> =56KΩ, C <sub>T</sub> =820pF                                                                                                                          |                     | 45                       |                          | μs   |
| T <sub>D</sub>                       | Turn off Delay                          |                                                                                                                                                                      |                     | 2                        |                          | μs   |
| Protection                           |                                         |                                                                                                                                                                      |                     |                          |                          |      |
| OTS                                  | Over Temperature Shutdown               |                                                                                                                                                                      |                     | 150                      |                          | °C   |
|                                      | Over Temperature Shutdown Hystersis     | Hystersis                                                                                                                                                            |                     | 20                       |                          | °C   |

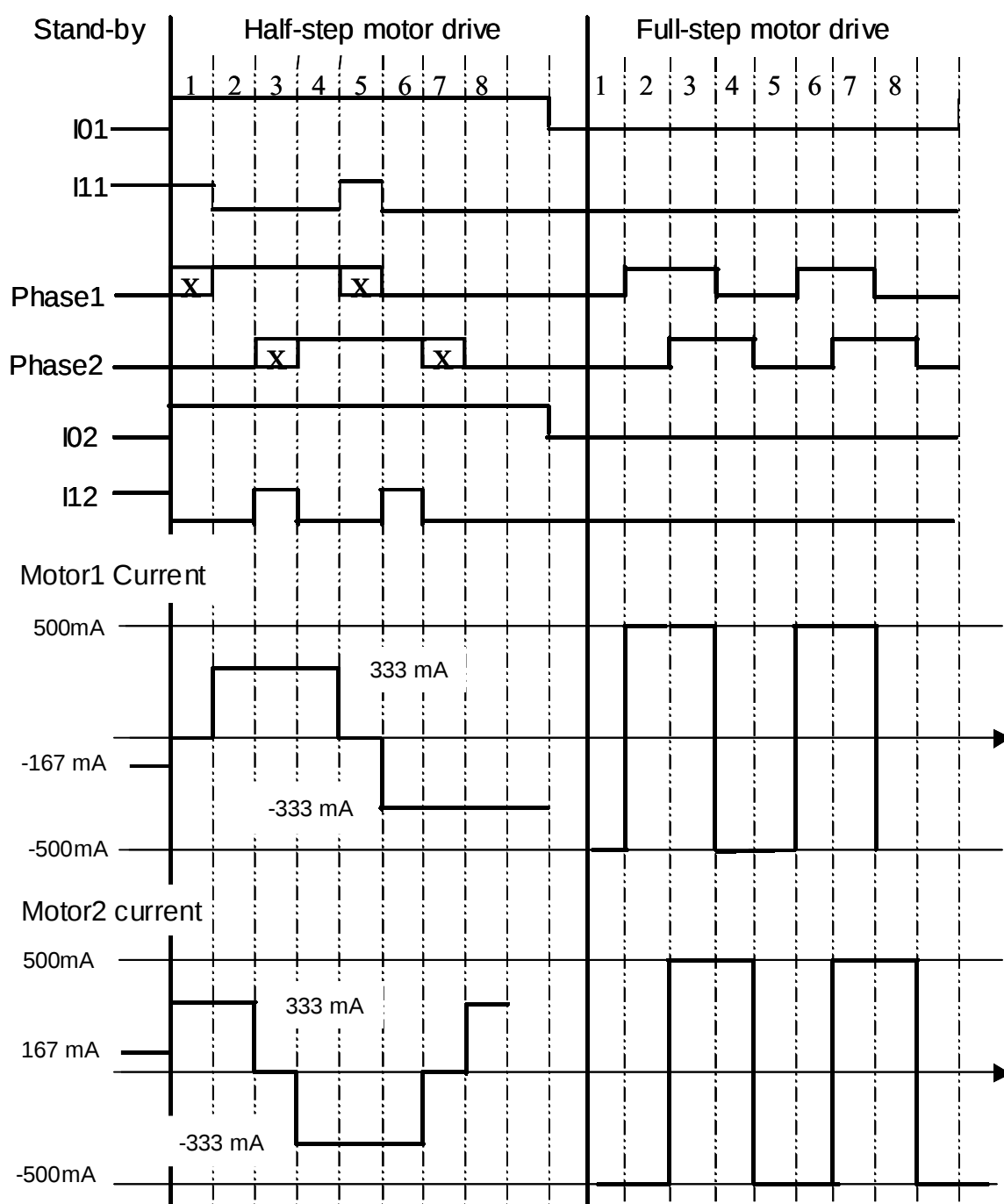
## PWM Output Current Waveform



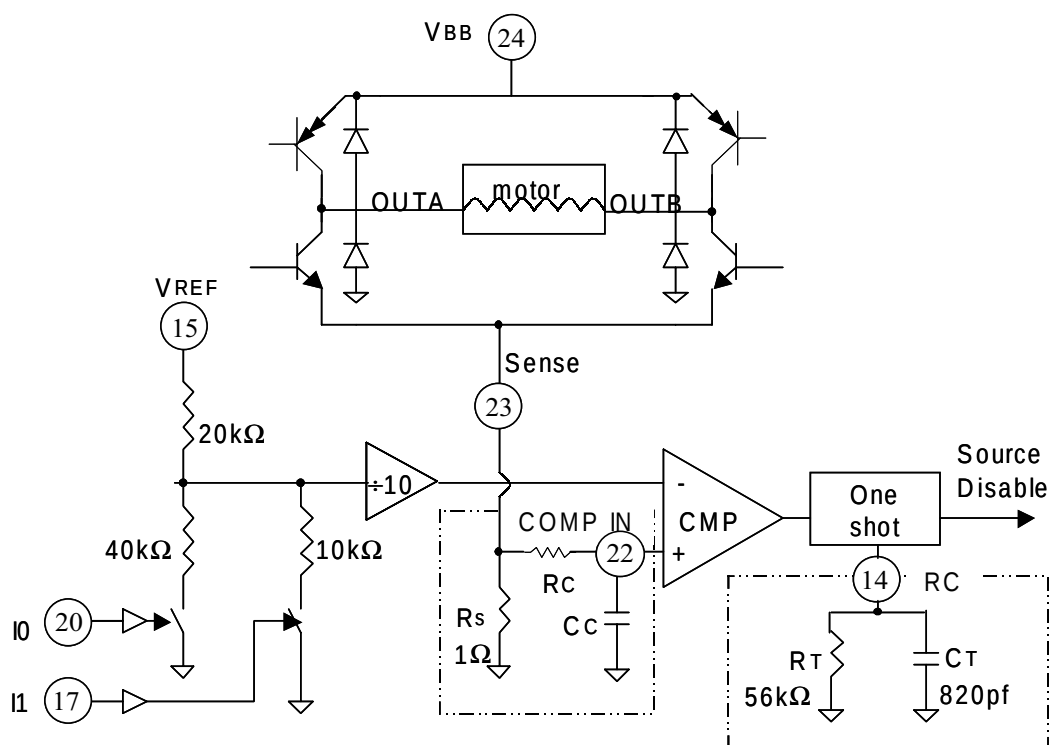
## Load Current Paths



## Principle Operating Sequence



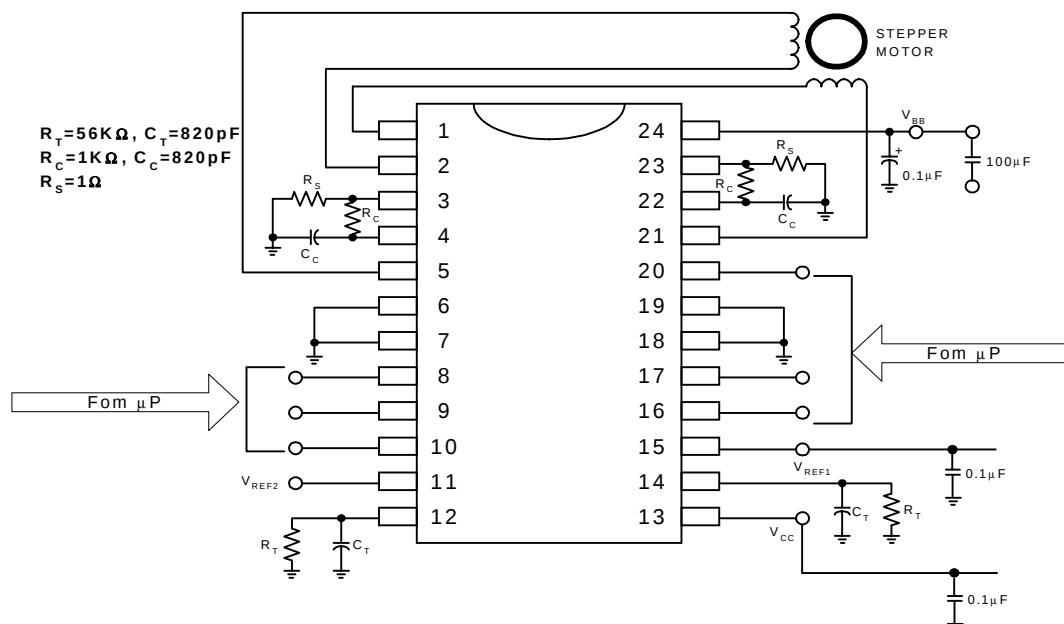
## PWM Current-Control Circuitry



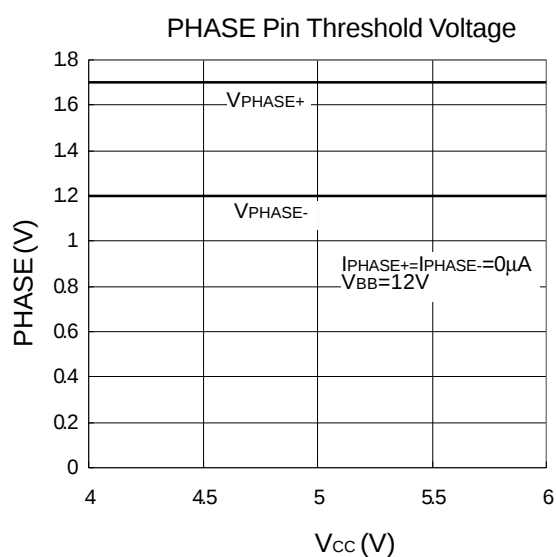
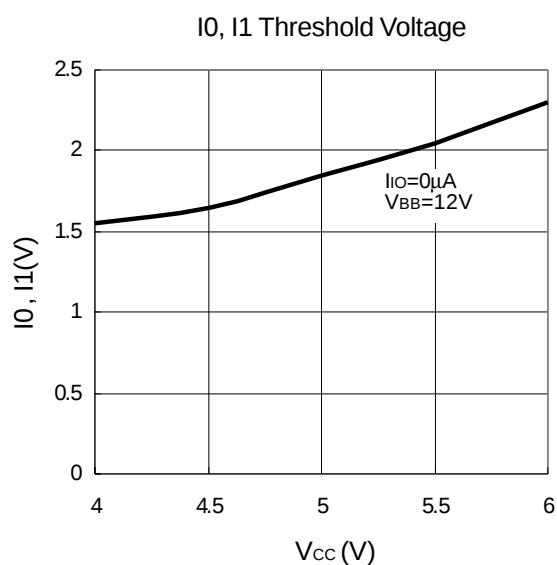
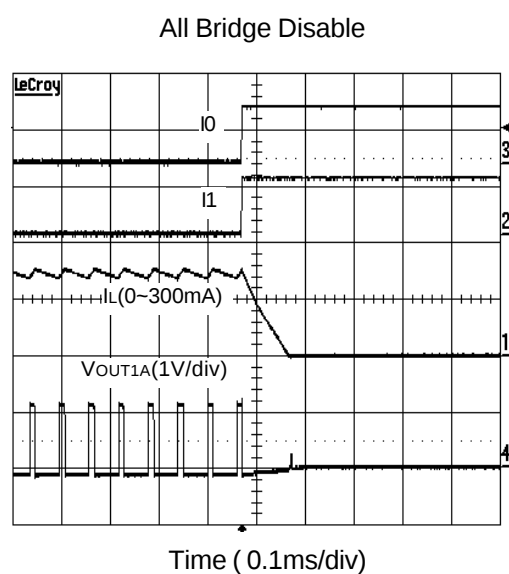
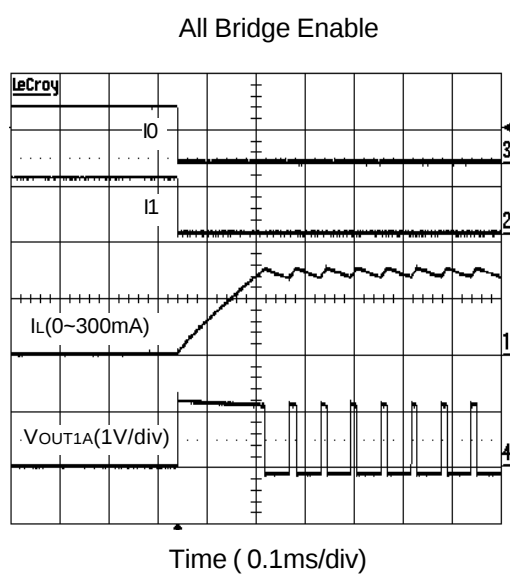
True Table

| Phase | OUTA | OUTB |
|-------|------|------|
| H     | H    | L    |
| L     | L    | H    |

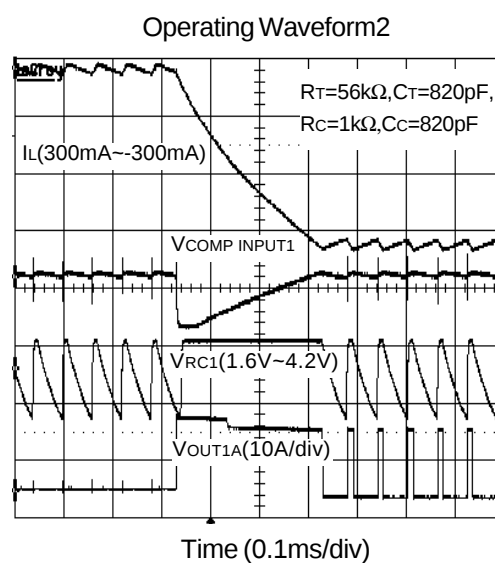
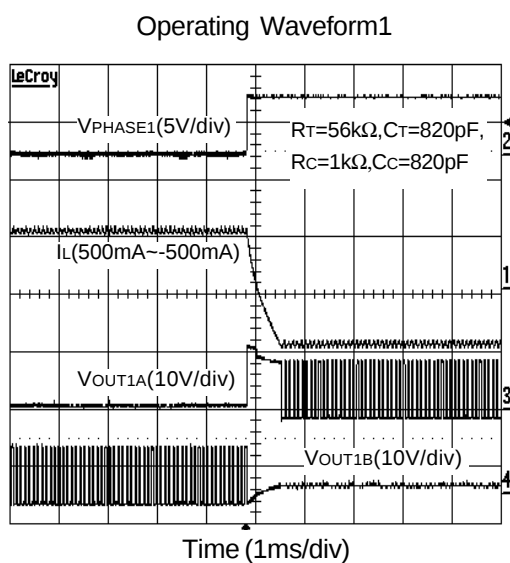
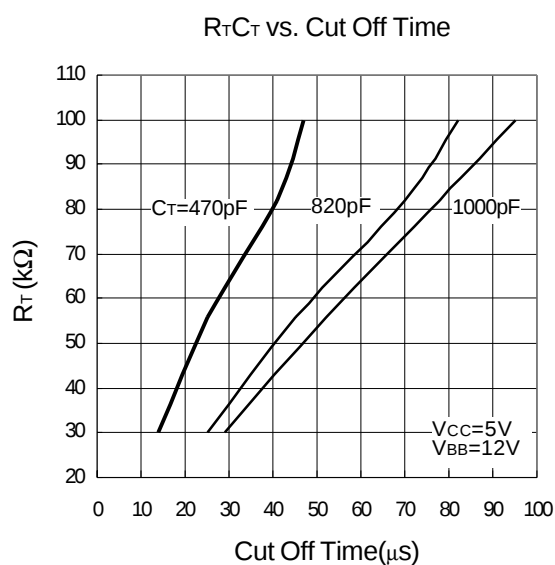
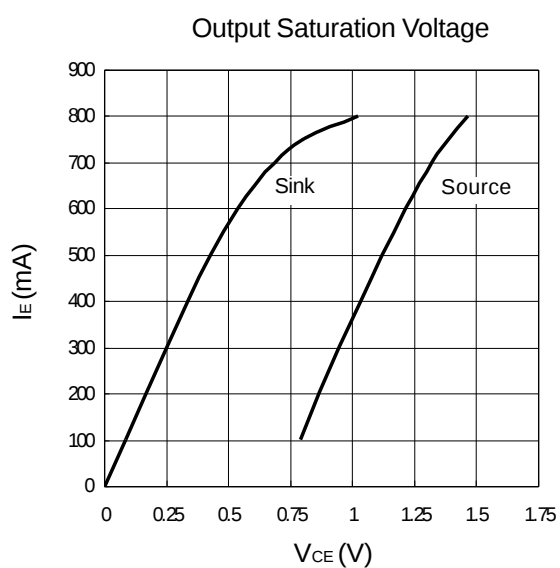
## Typical Application Circuit



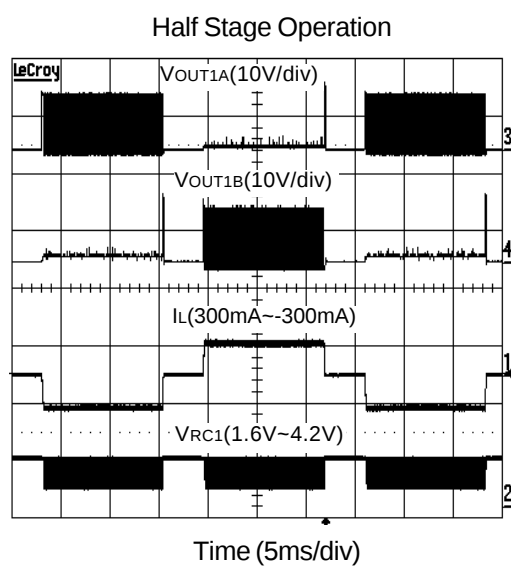
## Typical Characteristics



## Typical Characteristics



## Typical Characteristics



## Application Information

### PWM Current Control

The APX6219 dual bridge is designed to drive both windings of a bipolar stepper motor. Output current is sensed and controlled independently in each bridge by an external sense resistor ( $R_s$ ), internal comparator, and monostable multivibrator. When the bridge is turned on, current increases in the motor winding and it is sensed by the external sense resistor until the sense voltage ( $V_{COMPIN}$ ) reaches the level set at the comparator's input:

$$I_{TRIP} = V_{REF}/10 R_s$$

The comparator then triggers the monostable which turns off the source driver of the bridge. The actual load current peak will be slightly higher than the trip point (especially for low-inductance loads) because of the internal logic and switching delays. This delay ( $T_D$ ) is typically 2 $\mu$ s. After turn-off, the motor current decays, going through the ground-clamp diode and sink transistor (source off). The source driver's off time is determined by the external RC timing components, where  $T_{OFF} = R_T C_T$  within the range of 30k $\Omega$  to 100k $\Omega$  and 470pF to 1000pF. When VRC drop to certain voltage, the source driver will be re-enabled automatically (bridge on), the winding current is again limited at the desired level.

Loads with high  $V_{BB}$ , low  $L$ , high-frequency and low current will may result in high turn-on current peaks. This peak (appearing across  $R_s$ ) will attempt to trip the comparator, resulting in erroneous current control or high-frequency oscillations. An external  $R_C C_C$  time delay should be used to form low pass filter to reduce noise to avoid the comparator's fault operation. The locations of  $R_C$ ,  $C_C$ ,  $R_C$  components should be as close to the APX6219 as possible.

### Logic Control Of Output Current

Two logic level inputs (I0 and I1) allow digital selection of the motor winding current at 100%, 67%, 33%, or 0% of the maximum level per the table. The 0% output current condition turns off all drivers in the bridge and can be used as an OUTPUT Disable/Enable function.

During half-step operations, the I0 and I1 allow the  $\mu$ P to control the motor at a constant torque between all positions in an eight-step sequence. This is accomplished by digitally selecting 67% drive current when two phases are on. When all drivers are turn off will make rapid current decay when phases be changed. This helps to ensure proper motor operation at high step rates.

The logic control inputs can also be used to select a reduced current level (and reduced power dissipation) for 'hold' conditions and/or increased current (and available torque) for start-up conditions.

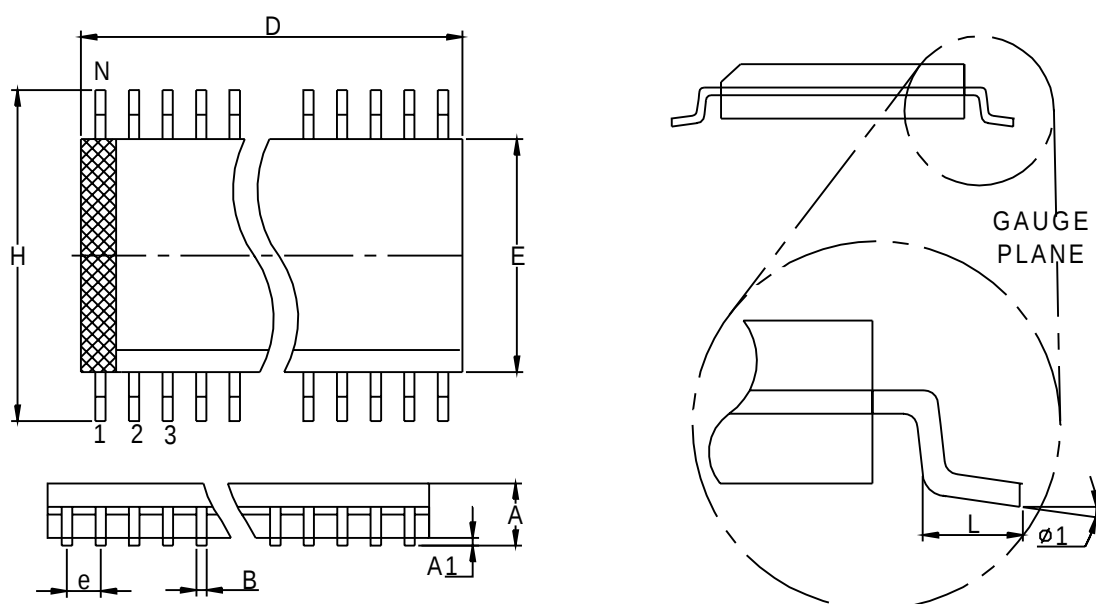
### General

The PHASE input to each bridge determines the direction motor winding current flows. An internally generated deadtime (approximately 2 $\mu$ s) prevents shoot through that can occur when switching the PHASE input. Thermal protection circuitry turns off all drivers when the junction temperature reaches +150°C. It is only intended to protect the device from failures due to excessive junction temperature and should not imply that output short circuits are permitted. The output drivers are re-enabled when the junction temperature cools to +130°C.

The APX6219 output drivers are optimized for low output saturation, less than 2V (source plus sink) at loading 500mA. Under normal operating conditions, this allows continuous operation of both bridges simultaneously at 750mA (such as Typical Application).

## Package Information

SO – 300mil ( Reference JEDEC Registration MS-013)

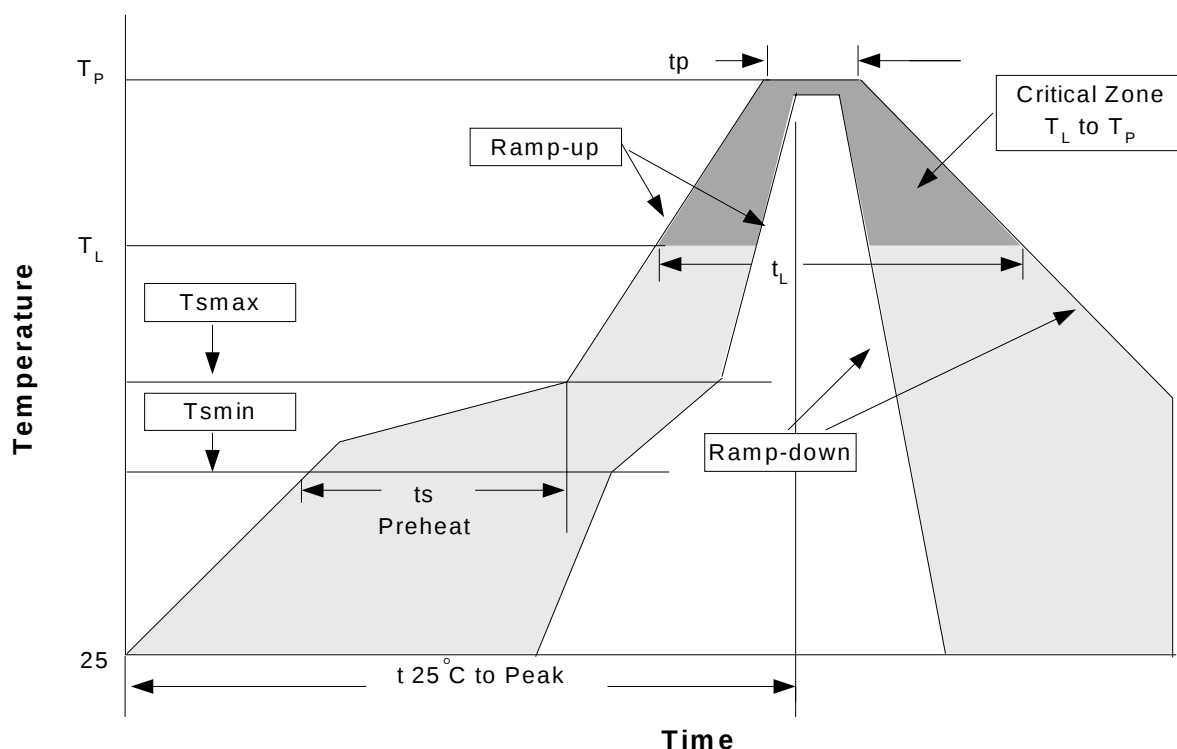


| Dim | Millimeters    |       | Variations- D |       |       | Dim | Inches         |        | Variations- D |       |       |
|-----|----------------|-------|---------------|-------|-------|-----|----------------|--------|---------------|-------|-------|
|     | Min.           | Max.  | Variations    | Min.  | Max.  |     | Min.           | Max.   | Variations    | Min.  | Max.  |
| A   | 2.35           | 2.65  | SO-16         | 10.10 | 10.50 | A   | 0.093          | 0.1043 | SO-16         | 0.398 | 0.413 |
| A1  | 0.10           | 0.30  | SO-18         | 11.35 | 11.76 | A1  | 0.004          | 0.0120 | SO-18         | 0.447 | 0.463 |
| B   | 0.33           | 0.51  | SO-20         | 12.60 | 13    | B   | 0.013          | 0.020  | SO-20         | 0.496 | 0.512 |
| D   | See variations |       | SO-24         | 15.20 | 15.60 | D   | See variations |        | SO-24         | 0.599 | 0.614 |
| E   | 7.40           | 7.60  | SO-28         | 17.70 | 18.11 | E   | 0.2914         | 0.2992 | SO-28         | 0.697 | 0.713 |
| e   | 1.27BSC        |       | SO-14         | 8.80  | 9.20  | e   | 0.050BSC       |        | SO-14         | 0.347 | 0.362 |
| H   | 10             | 10.65 |               |       |       | H   | 0.394          | 0.419  |               |       |       |
| L   | 0.40           | 1.27  |               |       |       | L   | 0.016          | 0.050  |               |       |       |
| N   | See variations |       |               |       |       | N   | See variations |        |               |       |       |
| Ø 1 | 0°             | 8°    |               |       |       | Ø 1 | 0°             | 8°     |               |       |       |

## Physical Specifications

|                    |                                                                      |
|--------------------|----------------------------------------------------------------------|
| Terminal Material  | Solder-Plated Copper (Solder Material : 90/10 or 63/37 SnPb), 100%Sn |
| Lead Solderability | Meets EIA Specification RSI86-91, ANSI/J-STD-002 Category 3.         |

## Reflow Condition (IR/Convection or VPR Reflow)



## Classification Reflow Profiles

| Profile Feature                                                                                                                                                                                        | Sn-Pb Eutectic Assembly          | Pb-Free Assembly                 |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------|----------------------------------|
| Average ramp-up rate ( $T_L$ to $T_P$ )                                                                                                                                                                | 3°C/second max.                  | 3°C/second max.                  |
| Preheat <ul style="list-style-type: none"> <li>- Temperature Min (<math>T_{smin}</math>)</li> <li>- Temperature Max (<math>T_{smax}</math>)</li> <li>- Time (min to max) (<math>t_s</math>)</li> </ul> | 100°C<br>150°C<br>60-120 seconds | 150°C<br>200°C<br>60-180 seconds |
| Time maintained above: <ul style="list-style-type: none"> <li>- Temperature (<math>T_L</math>)</li> <li>- Time (<math>t_L</math>)</li> </ul>                                                           | 183°C<br>60-150 seconds          | 217°C<br>60-150 seconds          |
| Peak/Classification Temperature ( $T_p$ )                                                                                                                                                              | See table 1                      | See table 2                      |
| Time within 5°C of actual Peak Temperature ( $t_p$ )                                                                                                                                                   | 10-30 seconds                    | 20-40 seconds                    |
| Ramp-down Rate                                                                                                                                                                                         | 6°C/second max.                  | 6°C/second max.                  |
| Time 25°C to Peak Temperature                                                                                                                                                                          | 6 minutes max.                   | 8 minutes max.                   |

Notes: All temperatures refer to topside of the package .Measured on the body surface.

## Classificatin Reflow Profiles(Cont.)

Table 1. SnPb Entectic Process – Package Peak Reflow Temperatures

| Package Thickness | Volume mm <sup>3</sup><br><350 | Volume mm <sup>3</sup><br>≥350 |
|-------------------|--------------------------------|--------------------------------|
| <2.5 mm           | 240 +0/-5°C                    | 225 +0/-5°C                    |
| ≥2.5 mm           | 225 +0/-5°C                    | 225 +0/-5°C                    |

Table 2. Pb-free Process – Package Classification Reflow Temperatures

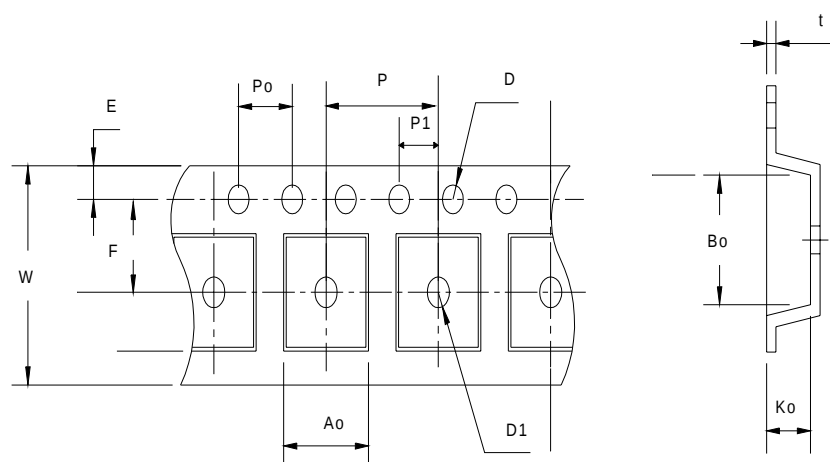
| Package Thickness | Volume mm <sup>3</sup><br><350 | Volume mm <sup>3</sup><br>350-2000 | Volume mm <sup>3</sup><br>>2000 |
|-------------------|--------------------------------|------------------------------------|---------------------------------|
| <1.6 mm           | 260 +0°C*                      | 260 +0°C*                          | 260 +0°C*                       |
| 1.6 mm – 2.5 mm   | 260 +0°C*                      | 250 +0°C*                          | 245 +0°C*                       |
| ≥2.5 mm           | 250 +0°C*                      | 245 +0°C*                          | 245 +0°C*                       |

\*Tolerance: The device manufacturer/supplier **shall** assure process compatibility up to and including the stated classification temperature (this means Peak reflow temperature +0°C. For example 260°C+0°C) at the rated MSL level.

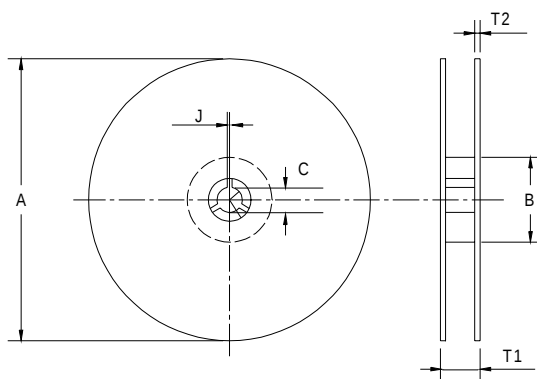
## Reliability test program

| Test item     | Method              | Description                    |
|---------------|---------------------|--------------------------------|
| SOLDERABILITY | MIL-STD-883D-2003   | 245°C , 5 SEC                  |
| HOLT          | MIL-STD-883D-1005.7 | 1000 Hrs Bias @ 125 °C         |
| PCT           | JESD-22-B, A102     | 168 Hrs, 100 % RH , 121°C      |
| TST           | MIL-STD-883D-1011.9 | -65°C ~ 150°C, 200 Cycles      |
| ESD           | MIL-STD-883D-3015.7 | VHBM > 2KV, VMM > 200V         |
| Latch-Up      | JESD 78             | 10ms , I <sub>tr</sub> > 100mA |

## Carrier Tape



## Carrier Tape(Cont.)



| Application | A          | B          | C            | J         | T1         | T2         | W          | P         | E          |
|-------------|------------|------------|--------------|-----------|------------|------------|------------|-----------|------------|
| SOP- 24     | 330±1      | 62 ±1.5    | 12.75 ± 0.15 | 2 ± 0.6   | 24.4 ± 0.2 | 2 ± 0.2    | 24 ± 0.3   | 12 ± 0.1  | .75± 0.1   |
|             | F          | D          | D1           | Po        | P1         | Ao         | Bo         | Ko        | t          |
|             | 11.5 ± 0.1 | 1.55 ± 0.1 | 1.5 ± 0.25   | 4.0 ± 0.1 | 2.0 ± 0.1  | 10.9 ± 0.1 | 15.9 ± 0.1 | 3.1 ± 0.1 | .35 ± 0.05 |

(mm)

## Cover Tape Dimensions

| Application | Carrier Width | Cover Tape Width | Devices Per Reel |
|-------------|---------------|------------------|------------------|
| SOP- 24     | 24            | 21.3             | 1000             |

## Customer Service

### Anpec Electronics Corp.

Head Office :

5F, No. 2 Li-Hsin Road, SBIP,

Hsin-Chu, Taiwan, R.O.C.

Tel : 886-3-5642000

Fax : 886-3-5642050

Taipei Branch :

7F, No. 137, Lane 235, Pac Chiao Rd.,

Hsin Tien City, Taipei Hsien, Taiwan, R. O. C.

Tel : 886-2-89191368

Fax : 886-2-89191369