Single-Phase Full-Wave Motor Driver for Fan Motor

Features

- Single Phase Full Wave Fan Driver
- Built-in Variable Speed Curve Function. It can compensate motors whose Speed curve is not linear
- Current Limit Circuit
- Built-in LOCK Protection and Auto Restart Function
- Built-in Adjustable Lead Angle Function
- Built-in Adjustable PWM Soft Switching Function
- Low Standby Current
- FG(Rotation Speed Detection)Output
- Built-in Thermal Protection Circuit
- Lead Free and Green Device Available (RoHS Compliant)

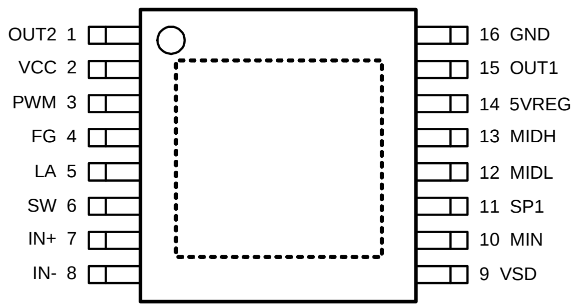
General Description

The APX9203 is a single-phase full-wave motor driver for DC fan motors. It's suitable for variable speed curve applications, and then It is suitable for cooler DC fan that needs silent drivers. When PWM is at low level in a short time, the supply current is less than 30uA. In normal operation, the supply current is less than 8mA. The APX9203 is available in TSSOP-16P package.

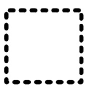
Applications

- Motor Drivers For Silent Fan Motors

Pin Configuration



TSSOP-16P
(Top View)


=Thermal Pad (connected to the GND plane for better heat dissipation)

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.

Ordering and Marking Information

APX9203 □□-□□□ Assembly Material Handling Code Temperature Range Package Code	Package Code R: TSSOP - 16P Operating Ambient Temperature Range I : -40 to 110 °C Handling Code TR : Tape & Reel Assembly Material G: Halogen and Lead Free Device
APX9203 R : APX9203 XXXXX	XXXXX - Date Code

Note: ANPEC lead-free products contain molding compounds/die attach materials and 100% matte tin plate termination finish; which are fully compliant with RoHS. 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. ANPEC defines “Green” to mean lead-free (RoHS compliant) and halogen free (Br or Cl does not exceed 900ppm by weight inhomogeneous material and total of Br and Cl does not exceed 1500ppm by weight).

Absolute Maximum Ratings (Note 1)

Symbol	Parameter	Ratings	Unit
V_{CC}	VCC Pin Supply Voltage (VCC to GND)	-0.3 to 20	V
I_{OUT}	V_{OUT1}, V_{OUT2} Pin Maximum Output Peak Current	1.2	A
V_{OUT1},V_{OUT2}	V_{OUT1},V_{OUT2} Pins Output Voltage (OUT1 to GND, OUT2 to GND)	-0.3 to 20	V
V_{PWM}	PWM Pin Input Voltage (PWM to GND)	-0.3 to 20	V
V_{LA}	LA Pin Input Voltage (LA to GND)	-0.3 to 7	V
V_{VSD}	VSD Pin Input Voltage (VSD to GND)	-0.3 to 7	V
V_{MIN}	MIN Pin Input Voltage (MIN to GND)	-0.3 to 7	V
V_{SW}	SW PIN Input Voltage (SW to GND)	-0.3 to 7	V
V_{SP1}	SP1 Pin Input Voltage (SP1 to GND)	-0.3 to 7	V
V_{MIDH}	MIDH Pin input Voltage (MIDH to GND)	-0.3 to 7	V
V_{MIDL}	MIDL Pin input Voltage (MIDL to GND)	-0.3 to 7	V
V_{FG}	FG Pin Output Voltage (FG to GND)	-0.3 to 20	V
I_{FG}	FG Pin Maximum Output Sink Current	10	mA
I_{5VREG}	5VREG Pin Maximum Output Current	20	mA
T_J	Maximum Junction Temperature	-40 to 150	°C
T_{STG}	Storage Temperature	-55 to 150	°C
T_{SDR}	Maximum Lead Soldering Temperature, 10 Seconds	260	°C

Note 1: Absolute Maximum Ratings are those values beyond which the life of a device may be impaired. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

Thermal Characteristics

Symbol	Parameter	Typical Value	Unit
θ_{JA}	Thermal Resistance-Junction to Ambient (Note 2) TSSOP-16P	83	$^{o}C/W$
P_D	Power Dissipation, $T_A=25^{o}C$ TSSOP-16P	1.5	W

Note 2 : Mounted on a board (60x38x1.6t mm, Glass epoxy). The Thermal Pad on the bottom of TSSOP-16P package should soldered directly to the PCB's Thermal Pad area that with several thermal vias connect to ground plan, and the PCB is a 2-layer 10mm square area with 2oz cooper thickness.

Recommended Operation Conditions (Note 3)

Symbol	Parameter	Range	Unit
V_{CC}	VCC Pin Supply Voltage	3 to 15	V
V_{LA}	LA Pin Input Voltage	0 to V_{5VREG}-0.2	V
V_{VSD}	VSD Pin Input Voltage	0 to V_{5VREG}-0.2	V
V_{MIN}	MIN Pin Input Voltage	0 to V_{5VREG}	V
V_{SW}	SW Pin Input Voltage	0 to V_{5VREG}-0.2	V
V_{SP1}	SP1 Pin Input Voltage Range	0 to V_{5VREG}	V
V_{MIDH}	MIDH Pin input Voltage (MIDH to GND)	0 to V_{5VREG}	V
V_{MIDL}	MIDL Pin input Voltage (MIDL to GND)	0 to V_{5VREG}	V
V_{ICM}	Common-Mode Hall Input Voltage Range	0.2 to V_{5VREG}-1.5	V
T_A	Ambient Temperature	-40 to 90	^{o}C

Note 3: Refer to the typical application circuit

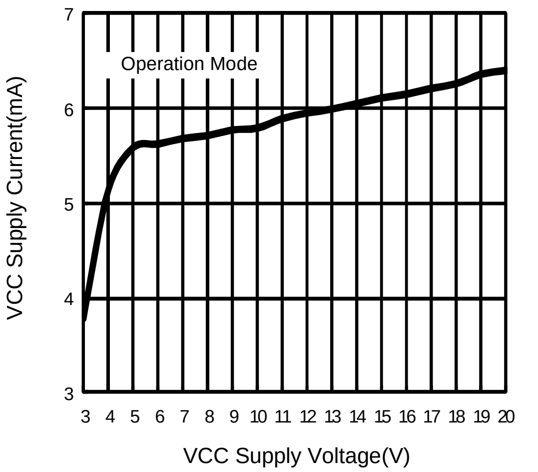
Electrical Characteristics (V_{CC} = 12V, T_A = 25°C, unless otherwise specified)

Symbol	Parameter	Test Conditions	APX9203 Min	APX9203 Typ	APX9203 Max	Unit
SUPPLY CURRENT						
V_{5VREG}	5VREG Pin Output Voltage	I_{5VREG} = 10mA	4.8	5	5.2	V
I_{CC1}	Rotation Mode		-	6	8	mA
I_{CC2}	Standby Mode	PWM= GND	-	15	30	uA
OUTPUT DRIVERS						
V_{OL}	Low-side Output Saturation Voltage	I_{OUT}=300mA	-	0.1	0.2	V
V_{OH}	High-side Output Saturation Voltage	I_{OUT}=300mA	-	0.12	0.25	V
V_{FG}	FG Pin Low Voltage	I_{FG}=5mA	-	0.1	0.2	V
I_{FGL}	FG Pin Off Leakage Current	V_{FG}=12V	-	-	1	μA
HALL SENSITIVITY						
VHYS	Input Hysteresis Voltage (Note 4)		-	±8	±15	mV
LOCK PROTECTION						
T_{ON}	Lock Protection Detection On Time	IN+ =5V,IN- =0V	0.35	0.5	0.65	Sec
T_{OFF}	Lock Protection Detection Off Time	IN+ =5V,IN- =0V	3.5	5	6.5	Sec
PWM CONTROL						
V_{PWML}	PWM Input Low Level Voltage		-0.3	-	0.8	V
V_{PWMH}	PWM Input High Level Voltage		2	-	V_{CC}	V
I_{PWML}	PWM Low Input current	V_{PWM}=0V	-	-10	-20	uA
F_{PWM}	PWM Input Frequency		200	-	50K	Hz
T_{QS}	Quick Start Enable Time		-	60	-	ms
LEADING ANGLE						
T_{LA1}	Lead Angle Correction	V_{LA}=0V= V_{5VREG}	-	0	-	°
T_{LA2}		V_{LA}=0.25* V_{5VREG}	8.2	9.6	10.8	
T_{LA3}		V_{LA}=0.5* V_{5VREG}	20.6	22	-	
CURRENT PROTECTION						
I_{LIM}	Current Limit Level		-	1.1	-	A
THERMAL PROTECTION						
	Over-Thermal Protection Temperature		-	165	-	℃
	Over-Thermal Protection Hysteresis		-	30	-	℃

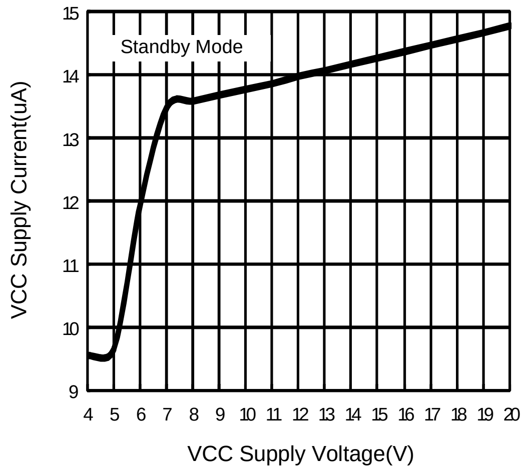
Note4: Refer page 23 HB Pin & Hall Input. Recommend the hall input level to be 60mVp-p or above in any condition.

Typical Operating Characteristics

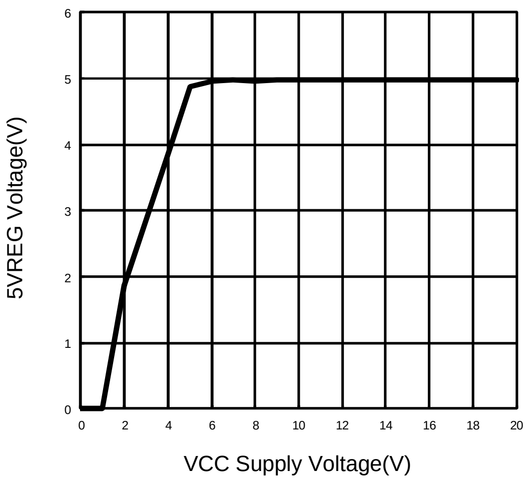
VCC Supply Current vs. VCC Supply Voltage



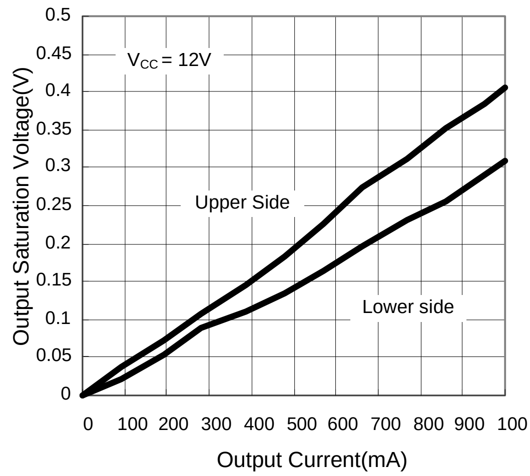
VCC Supply Current vs. VCC Supply Voltage



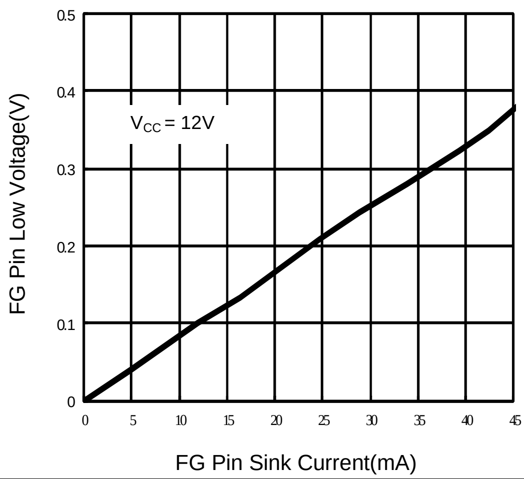
5VREG vs. VCC Supply Voltage



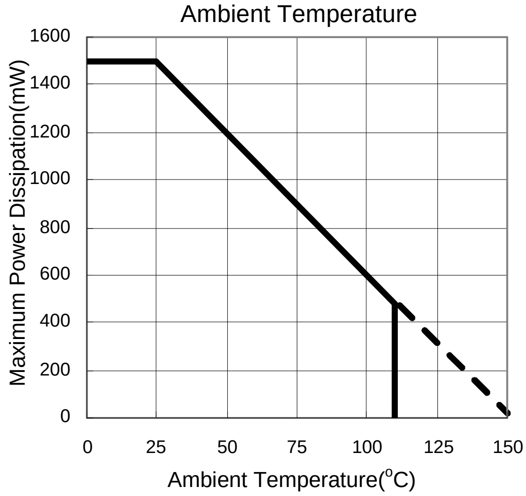
Output Saturation Voltage vs. Output Current



FG Pin Low Voltage vs. Sink Current



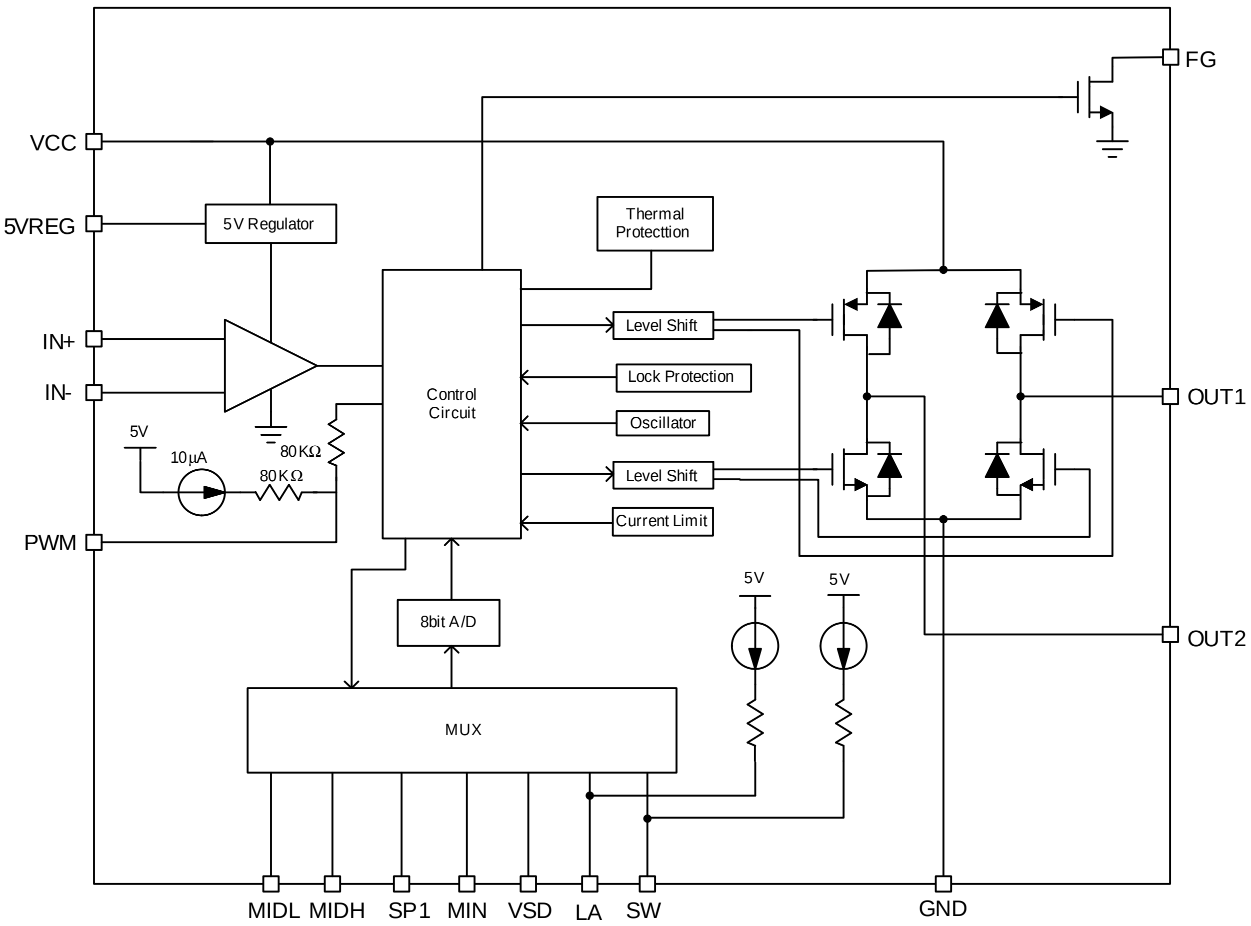
Maximum Power Dissipation vs.
Ambient Temperature



Pin Description

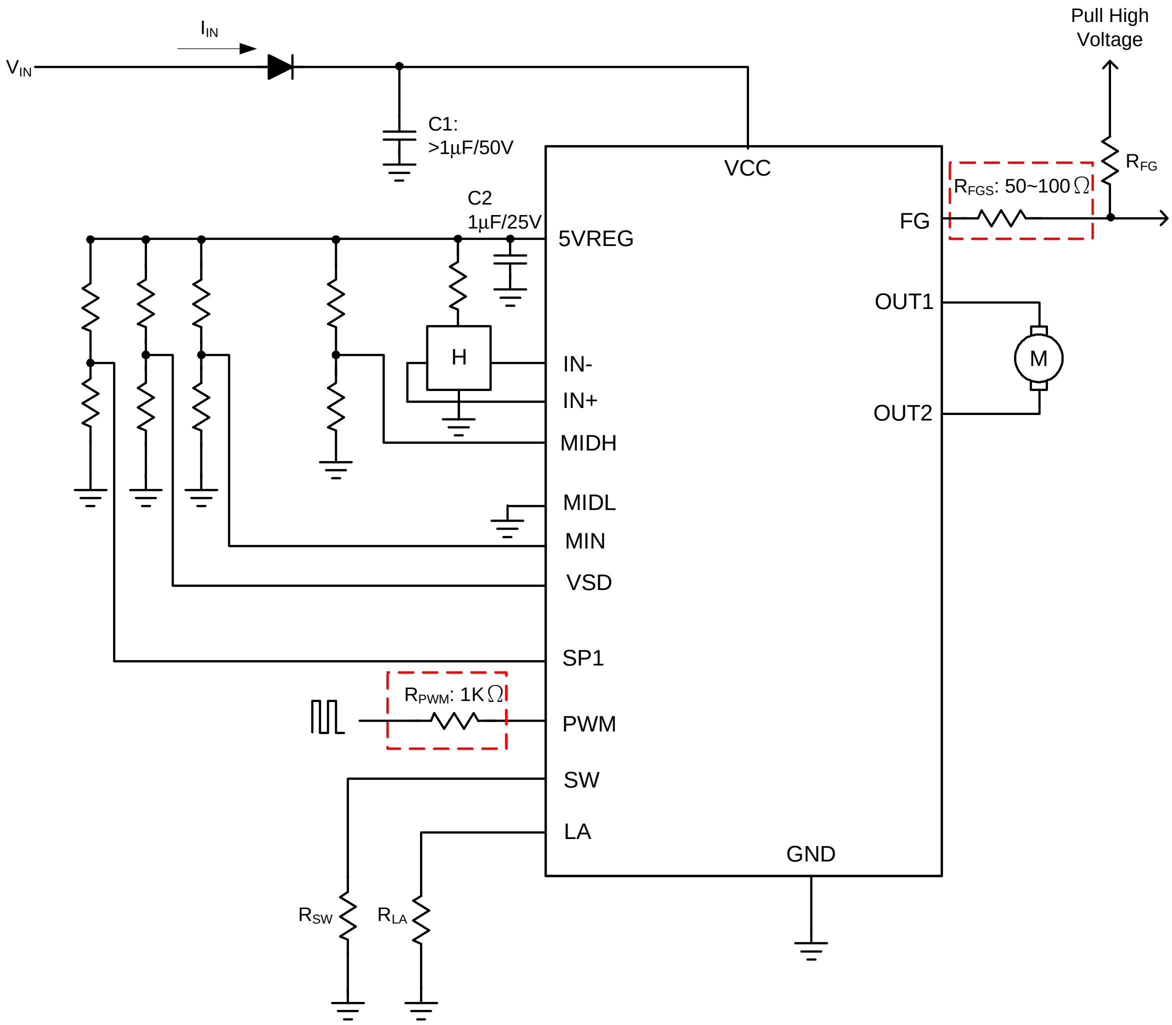
PIN NAME	PIN No.	FUNCTION
	TSSOP-16P	
OUT2	1	H-bridge Output Connection.
VCC	2	Supply Voltage Input Pin.
PWM	3	PWM Signal Input Terminal.
FG	4	Rotation Speed Output. This is an open-drain output.
LA	5	Lead Angle Setting.
SW	6	Soft Switching Term Setting.
IN+	7	Hall Input +. Connect to hall element positive output.
IN-	8	Hall Input -. Connect to hall element negative output.
VSD	9	Output Duty Shutdown Setting.
MIN	10	Minimum Output Duty Setting.
SP1	11	Input Duty Setting For Turning Point (DI_{SP1}).
MIDL	12	Output Duty Setting (DO_{MIDL}) For Turning Point (D_{IMIDL}).
MIDH	13	Output Duty Setting (DO_{MIDH}) For Turning Point (DI_{MIDH}).
5VREG	14	5V Regulator Output.
OUT1	15	H-bridge Output Connection.
GND	16	Power GND.

Block Diagram



Typical Application Circuit

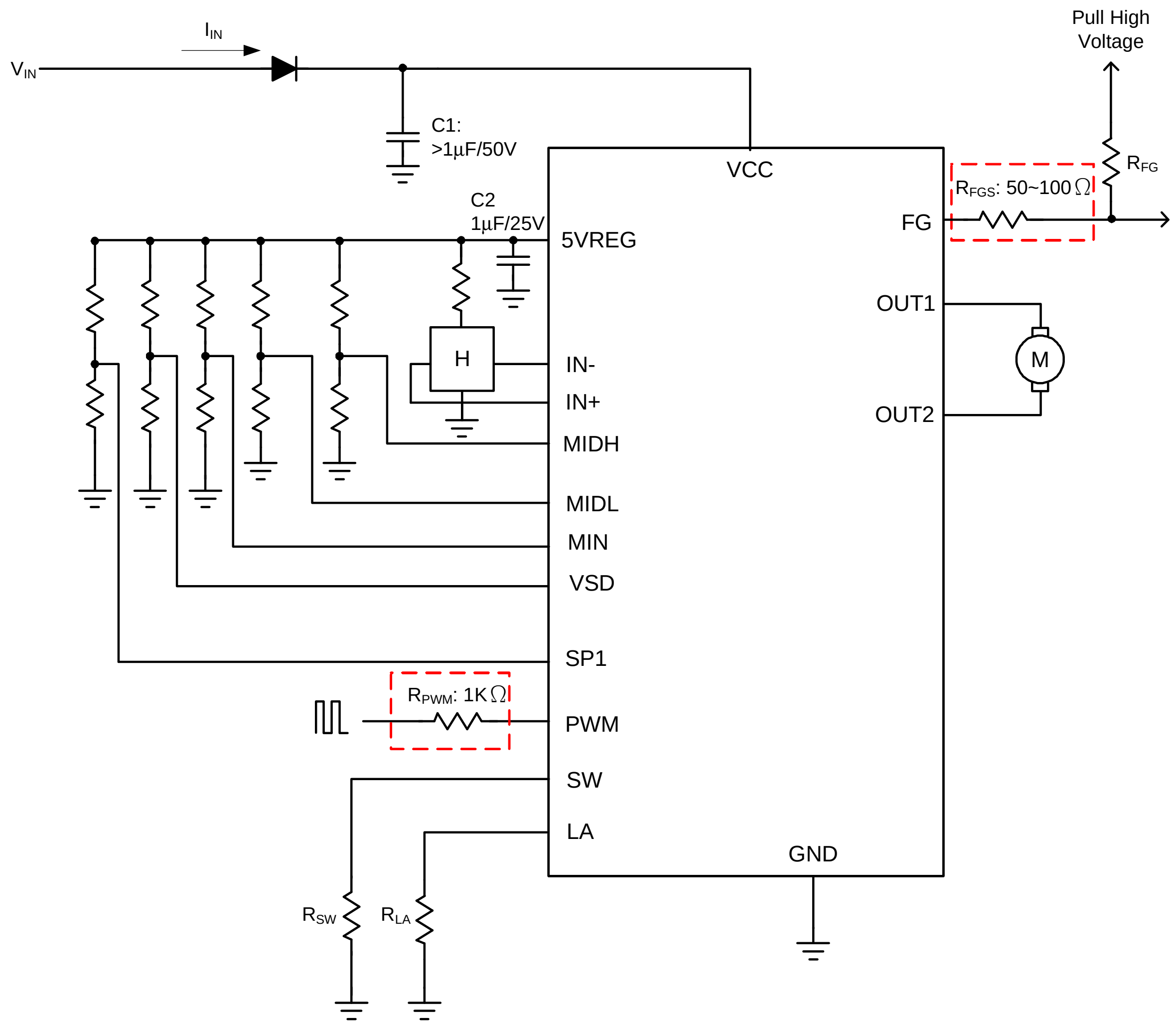
TypeA: single turning point application for speed curve



Note: R_{PWM} and R_{FGS} are optional to protect internal circuit for abnormal voltage stress.

Typical Application Circuit (Cont.)

Type B: twin turning points application for speed curve



Note: R_{PWM} and R_{FGS} are optional to protect internal circuit for abnormal voltage stress.

Function Description

MIN and MIDH Output Duty Control for Type A (SP1, VSD and MIDL are not used)

The APX9203 has five input pins MIN MIDL MIDH SP1 VSD to control speed curve of fan motor when the APX9203 works in rotation mode. The input of MIN pin sets the minimum output duty (DO_{MIN}) at the beginning, and MIDL sets the output duty (DO_{MIDL}) for turning point (DI_{MIDL}). MIDH sets the output duty (DO_{MIDH}) for turning point(DI_{MIDH}).SP1 sets the turning point (DI_{SP1}) for that Output duty maintains MIN output duty setting from PWM=0% until DI_{SP1}.VSD sets the output shutdown function. Output duty is shut down when PWM input duty smaller than the VSD Shutdown Duty (DI_{VSD}) Setting. In this case, we only use MIN and MIDH to control the output speed curve. First, the input of MIN pin sets the minimum output duty at the PWM 0% duty, and then the speed curve keeps linear slope to DI_{MIDH}. Then the speed curve changes to another slope till PWM full duty.

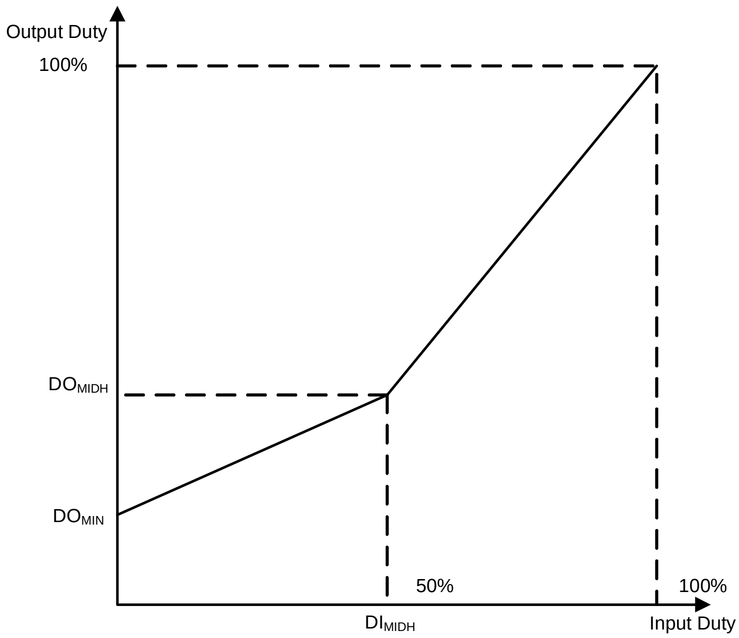


Figure1: MIN and MIDH Output Duty Control for Type A

ALL Duty Setting are approximated by below formulas:

$$DO_{MIN}\,(\%) = 100\% \times \frac{V_{MIN}}{V_{5VREG}} \,,\quad DO_{MIDH}\,(\%) = 100\% \times \frac{V_{MIDH}}{V_{5VREG}}$$

Note1: SP1 Pin and MIDL Pin connect to GND. VSD Pin connects to 5VREG.

Note2: DI_{MIDH} is fixed at 50%.

Note3: DO_{MIN} can't be larger than DO_{MIDH}.

Function Description (Cont.)

MIN, MIDH, and SP1 Output Duty Control for Type A (VSD and MIDL are not used)

In this case, we use MIN, MIDH and SP1 to control the output speed curve. The input of MIN pin sets the minimum output duty (DO_{MIN}) at the PWM 0% duty, and besides the speed keeps constant to DI_{SP1}. Then the speed curve keeps linear slope until DI_{MIDH}. Finally, the speed curve changes to another slope till PWM full duty.

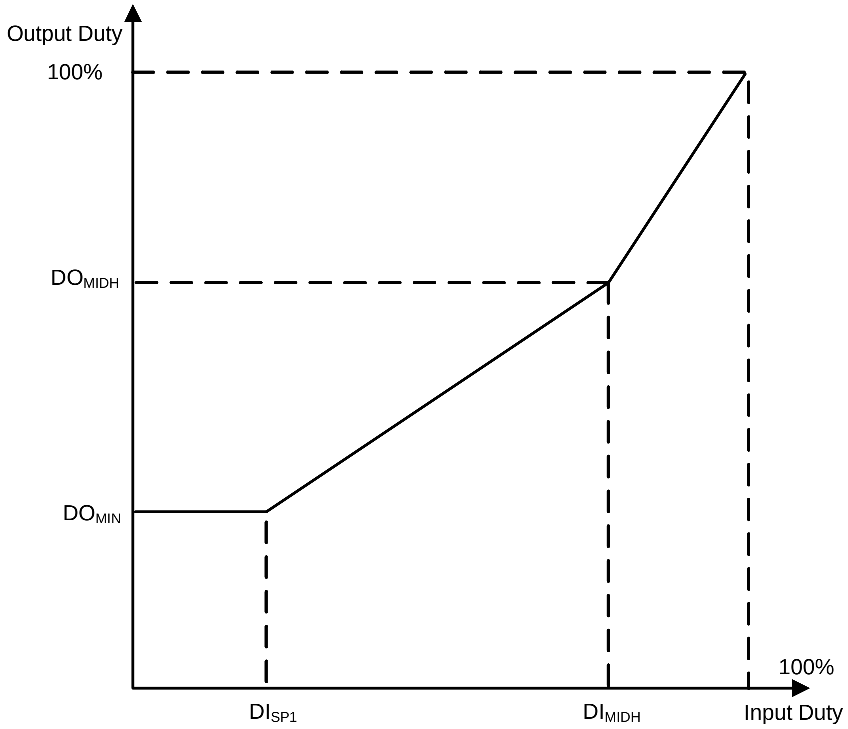


Figure 2: MIN, MIDH, and SP1 Output Duty Control for Type A

ALL Duty Setting are approximated by below formulas:

$$DO_{MIN}(\%) = 100\% \times \frac{V_{MIN}}{V_{5VREG}}. \quad DO_{MIDH}(\%) = 100\% \times \frac{V_{MIDH}}{V_{5VREG}}. \quad DI_{SP1}(\%) = 100\% \times \frac{V_{SP1}}{V_{5VREG}}.$$

Note1: In this case, DI_{MIDH} is not fixed, and the formula is presented below.

$$DI_{MIDH} = (100\% - DI_{SP1})/2 + DI_{SP1}$$

Note2: MIDL Pin connects to GND. VSD Pin must pull high to 5VREG

Note3: DO_{MIN} can't be larger than DO_{MIDH}.

Function Description (Cont.)

MIN, MIDH, and VSD Output Duty Control for Type A (SP1 and MIDL are not used)

In this case, we use MIN, MIDH and VSD to control the output speed curve. The application is just like previous **MIN and MIDH Output Duty Control for Type A** in addition to VSD shutdown function. The output duty is shut down when PWM input duty lower than $DI_{VSD.}$

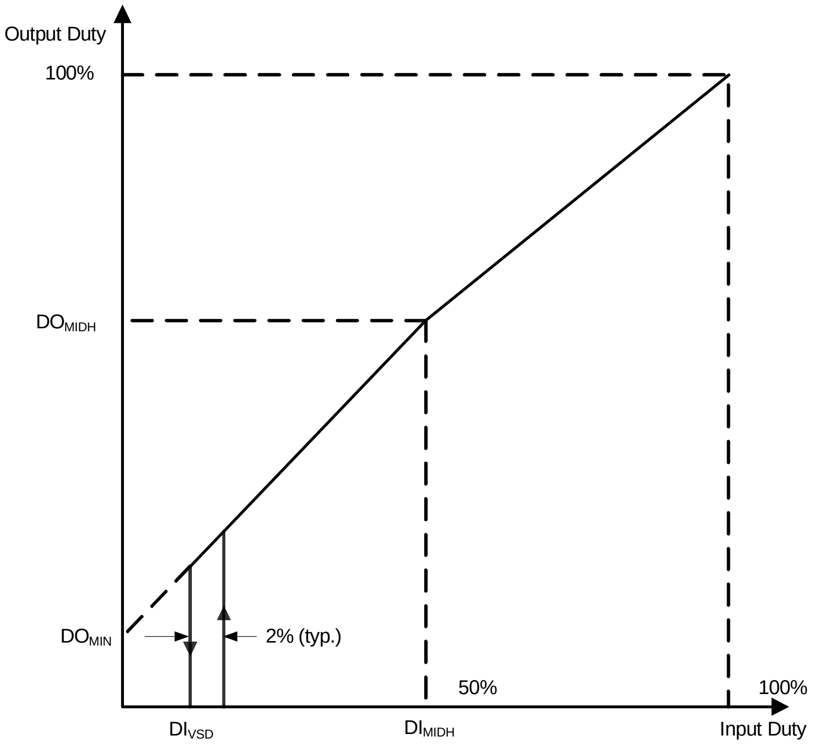


Figure 3: MIN, MIDH, and VSD Output Duty Control for Type A

ALL Duty Setting are approximated by below formulas:

$$DO_{MIN}(\%) = 100\% \times \frac{V_{MIN}}{V_{5VREG}} \text{ . } DO_{MIDH}(\%) = 100\% \times \frac{V_{MIDH}}{V_{5VREG}} \text{ . } DI_{VSD}(\%) = 100\% \times \frac{V_{VSD}}{V_{5VREG}} \text{ .}$$

Note1: SP1 and MIDL Pin connect to GND

Note2: DI_{MIDH} is fixed at 50%.

Note3: DI_{VSD} has about 2% duty hysteresis.

Note4: DO_{MIN} can't be larger than $DO_{MIDH.}$

Function Description (Cont.)

SP1, MIDH, and VSD Output Duty Control for Type A (MIN and MIDL are not used)

In this case, we use SP1, MIDH and VSD to control the output speed curve. If VSD Shutdown function is disable, whatever the input duty is given, the output is be shut down(DO_{MIN} =0%) until DI_{SP1}.Therefore the point of this application is that minimum output duty is be set to zero. In addition, DI_{MIDH} is not fixed and VSD Shutdown Function is added.

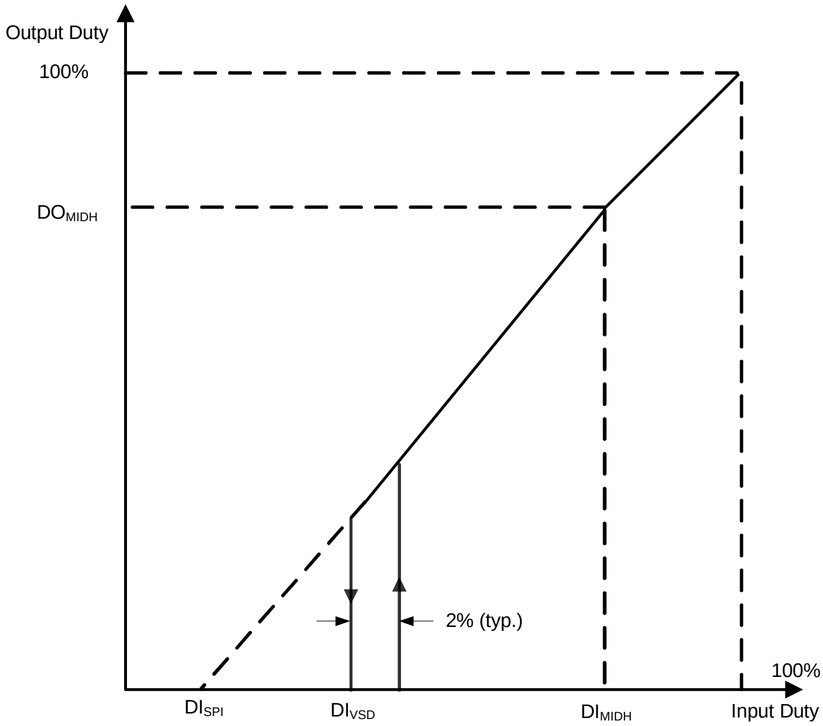


Figure 4: SP1, MIDH, and VSD Output Duty Control for Type A

ALL Duty Setting are approximated by below formulas:

$DI_{SP1}(\%) = 100\% \times \frac{V_{SP1}}{V_{5VREG}}$. $DO_{MIDH}(\%) = 100\% \times \frac{V_{MIDH}}{V_{5VREG}}$. $DI_{VSD}(\%) = 100\% \times \frac{V_{VSD}}{V_{5VREG}}$.

Note1: In this case, DI_{MIDH} is not fixed, and the formula is presented below.

$DI_{MIDH} = (100\% - DI_{SP1})/2 + DI_{SP1}$

Note2: MIN and MIDL Pin connect to GND.

Note3: DI_{VSD} has about 2% duty hysteresis.

Note4: DO_{MIN} can't be larger than DO_{MIDH}.

Function Description (Cont.)

MIN, MIDL, and MIDH Output Duty Control for Type B (SP1 and VSD are not used)

In this case, we only use MIN, MIDL, and MIDH to control the output speed curve. First, the input of MIN pin sets the minimum output duty at the PWM 0% duty, and then the speed curve keeps linear slope to DI_{MIDL}, and then the speed curve changes to second slope until DI_{MIDH}. Then the speed curve changes to third slope till PWM full duty.

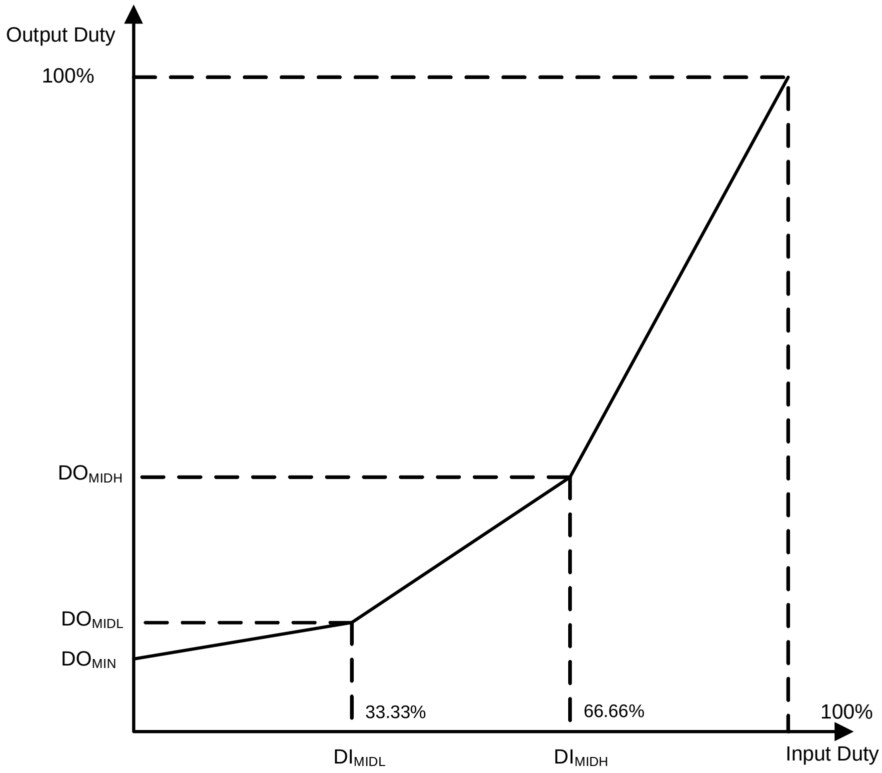


Figure 5: MIN, MIDL, and MIDH Output Duty Control for Type B

ALL Duty Setting are approximated by below formulas:

$$DO_{MIN}(\%) = 100\% \times \frac{V_{MIN}}{V_{5VREG}} \; . \quad DO_{MIDL}(\%) = 100\% \times \frac{V_{MIDL}}{V_{5VREG}} . \quad DO_{MIDH}(\%) = 100\% \times \frac{V_{MIDH}}{V_{5VREG}} .$$

Note1: SP1 Pin connects to GND.VSD Pin connects to 5VREG.

Note2: DI_{MIDL} is fixed at 33.33%, and DI_{MIDH} is fixed at 66.66%.

Note3: DO_{MIN} can't be larger than DO_{MIDL}, and DO_{MIDL} can't be larger than DO_{MIDH}.

Function Description (Cont.)

MIN, MIDL, MIDH, and SP1 Output Duty Control for Type B (VSD is not used)

In this case, we use MIN, MIDL, MIDH and SP1 to control the output speed curve. The input of MIN pin sets the minimum output duty (DO_{MIN}) at the PWM 0% duty, and besides the speed keeps constant to DI_{SP1}. Then the speed curve keeps first slope until DI_{MIDL}, and then the speed curve changes to second slope until DI_{MIDH}. Finally, the speed curve changes to third slope till PWM full duty.

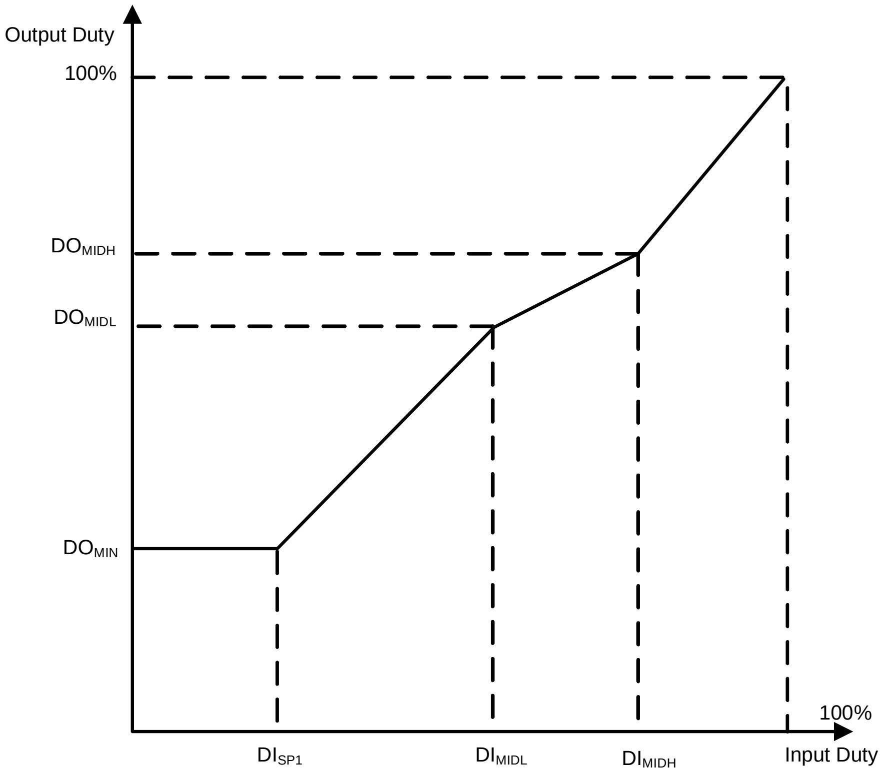


Figure 6: MIN, MIDL, MIDH, and SP1 Output Duty Control for Type B

ALL Duty Setting are approximated by below formulas:

$$DO_{MIN}(\%) = 100\% \times \frac{V_{MIN}}{V_{5VREG}} \ .\ DO_{MIDL}(\%) = 100\% \times \frac{V_{MIDL}}{V_{5VREG}} \ .\ DO_{MIDH}(\%) = 100\% \times \frac{V_{MIDH}}{V_{5VREG}} \ .\ DI_{SP1}(\%) = 100\% \times \frac{V_{SP1}}{V_{5VREG}}\ .$$

Note1: In this case, DIMIDL and DIMIDH are not fixed, and the formulas are presented below.

$$DI_{MIDL} = (100\% - DI_{SP1})/3 + DI_{SP1} \quad DI_{MIDH} = (100\% - DI_{SP1}) \times 2/3 + DI_{SP1}$$

Attention! DI_{SP1} can't be larger than 25%.

Note2: VSD Pin must pull high to 5VREG.

Note3: DO_{MIN} can't be larger than DO_{MIDL}, and DO_{MIDL} can't be larger than DO_{MIDH}.

Function Description (Cont.)

MIN,MIDL,MIDH and VSD Output Duty Control for Type B(SP1 is not used)

In this case, we use MIN, MIDL, MIDH and VSD to control the output speed curve. The application is just like previous **MIN, MIDL, and MIDH Output Duty Control for Type B** in addition to VSD shutdown function. The output duty is shut down when PWM input duty lower than DI_{VSD}.

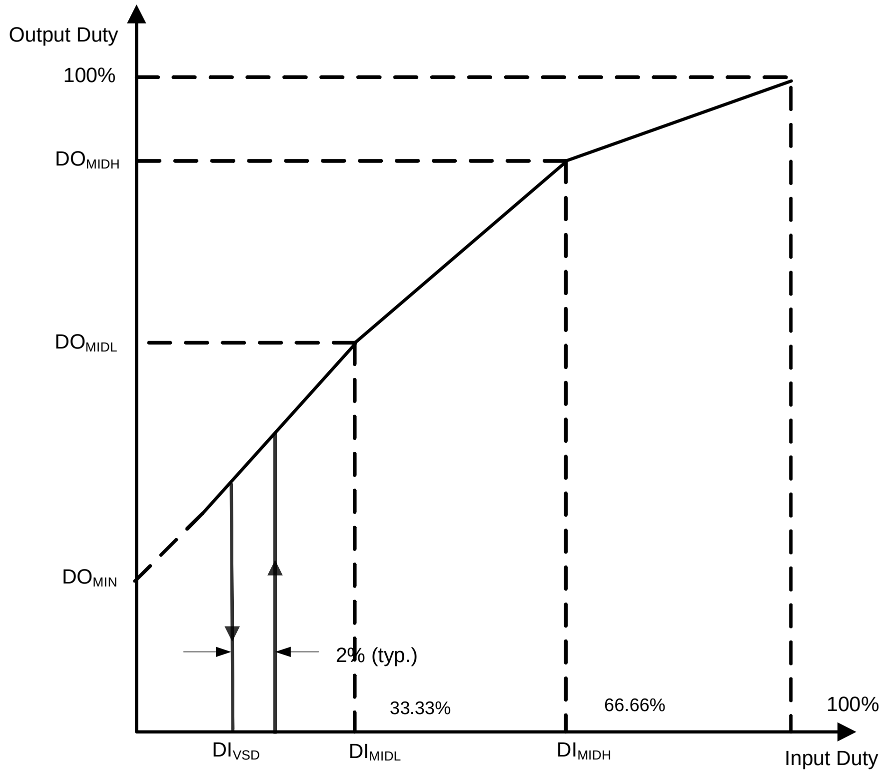


Figure 7: MIN, MIDL, MIDH, and VSD Output Duty Control for Type B

ALL Duty Setting are approximated by below formulas:

$DO_{MIN}(\%) = 100\% \times \frac{V_{MIN}}{V_{5VREG}}$. $DO_{MIDL}(\%) = 100\% \times \frac{V_{MIDL}}{V_{5VREG}}$. $DO_{MIDH}(\%) = 100\% \times \frac{V_{MIDH}}{V_{5VREG}}$. $DI_{VSD}(\%) = 100\% \times \frac{V_{VSD}}{V_{5VREG}}$.

Note1: SP1 Pin connects to GND.

Note2: DI_{MIDL} is fixed at 33.33%, and DI_{MIDH} is fixed at 66.66%.

Note3: DI_{VSD} has about 2% duty hysteresis.

Note 4: DO_{MIN} can't be larger than DO_{MIDL}, and DO_{MIDL} can't be larger than DO_{MIDH}.

Function Description (Cont.)

SP1, MIDL, MIDH, and VSD Output Duty Control for Type B (MIN is not used)

In this case, we use SP1, MIDL, MIDH and VSD to control the output speed curve. If VSD Shutdown function is disable, whatever the input duty is given, the output is be shut down(DO_{MIN} =0%) until DI_{SP1}.Therefore the point of this application is that minimum output duty is be set to zero. In addition, DI_{MIDL} and DI_{MIDH} are not fixed and VSD Shutdown Function is added.

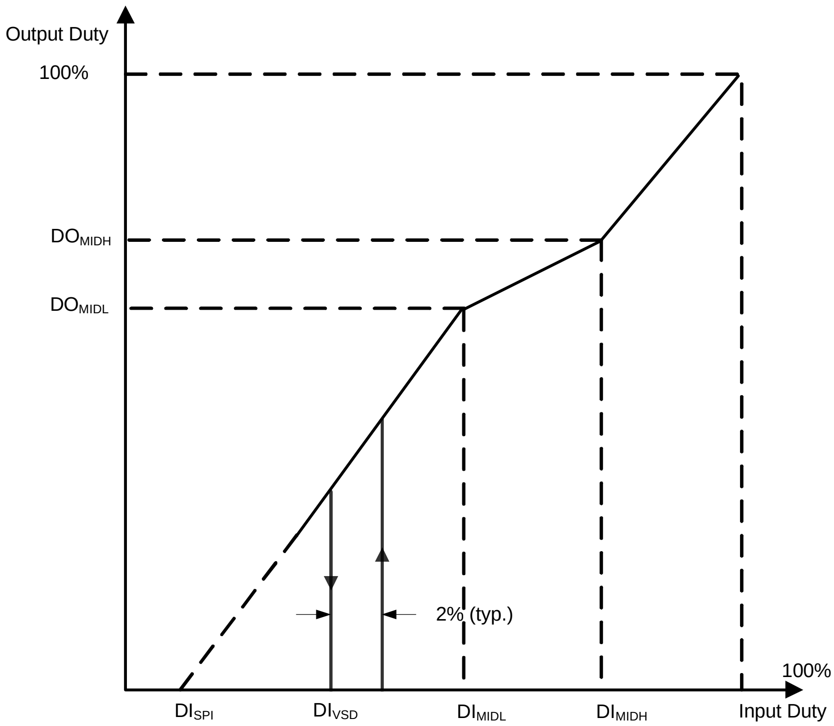


Figure 8: SP1, MIDL, MIDH, and VSD Output Duty Control for Type B

ALL Duty Setting are approximated by below formulas:

$DI_{SP1}(\%) = 100\% \times \frac{V_{SP1}}{V_{5VREG}}$. $DO_{MIDL}(\%) = 100\% \times \frac{V_{MIDL}}{V_{5VREG}}$. $DO_{MIDH}(\%) = 100\% \times \frac{V_{MIDH}}{V_{5VREG}}$. $DI_{VSD}(\%) = 100\% \times \frac{V_{VSD}}{V_{5VREG}}$.

Note1: In this case, DI_{MIDL} and DI_{MIDH} are not fixed, and the formulas are presented below.

$DI_{MIDL} = (100\% - DI_{SP1})/3 + DI_{SP1}$ $\quad DI_{MIDH} = (100\% - DI_{SP1}) \times 2/3 + DI_{SP1}$

Attention! DI_{SP1} can't be larger than 25%.

Note2: MIN pin connects to GND.

Note3: DI_{VSD} has about 2% duty hysteresis.

Note4: DO_{MIN} can't be larger than DO_{MIDL}, and DO_{MIDL} can't be larger than DO_{MIDH}.

Function Description (Cont.)

Lock Protection and Auto Restart

The APX9203 provides the lockup protection and automatic restart functions for preventing the coil burn-out in the fan is locked. This IC has an internal counter to determine the shutdown time (T_{OFF}) and restart time (T_{ON}). During shutdown time, the output drivers keep turning off for 5 seconds and then enter the restart time. During the restart time, one output is high and the other is low, which makes a torque for fan rotation. The restart time has 0.5 second. If the locked condition is not removed, the shutdown restart process will be recurred until the locked condition is released (see Figure 9 Lockup/Auto Restart Waveform).

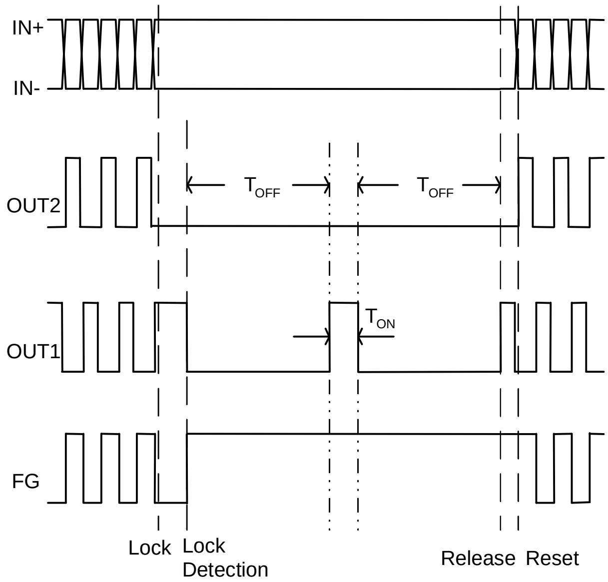


Figure 9: Lockup /Auto Restart Waveform

Quick Start and Standby Mode

This IC would enter standby mode when the time of PWM low level over T_{QS}. It will shut down amplifier, FG and, 5VREG (FG is shut down first after quick start time). Thus, the supply current is around 15uA. In standby mode, the lock protection function doesn't work. Therefore, starting fan is unobstructed when releasing standby mode.

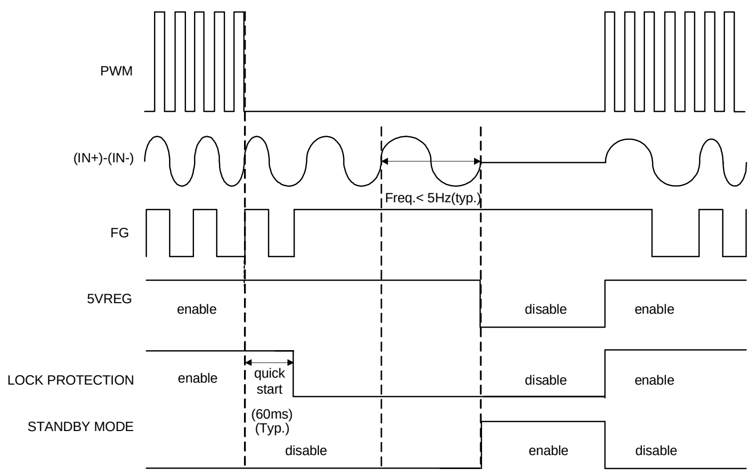


Figure 10: Quick Start Waveform

Function Description (Cont.)

Soft Switching

Soft switching is performed by changing the output PWM duty gradually when conducting phase switches.

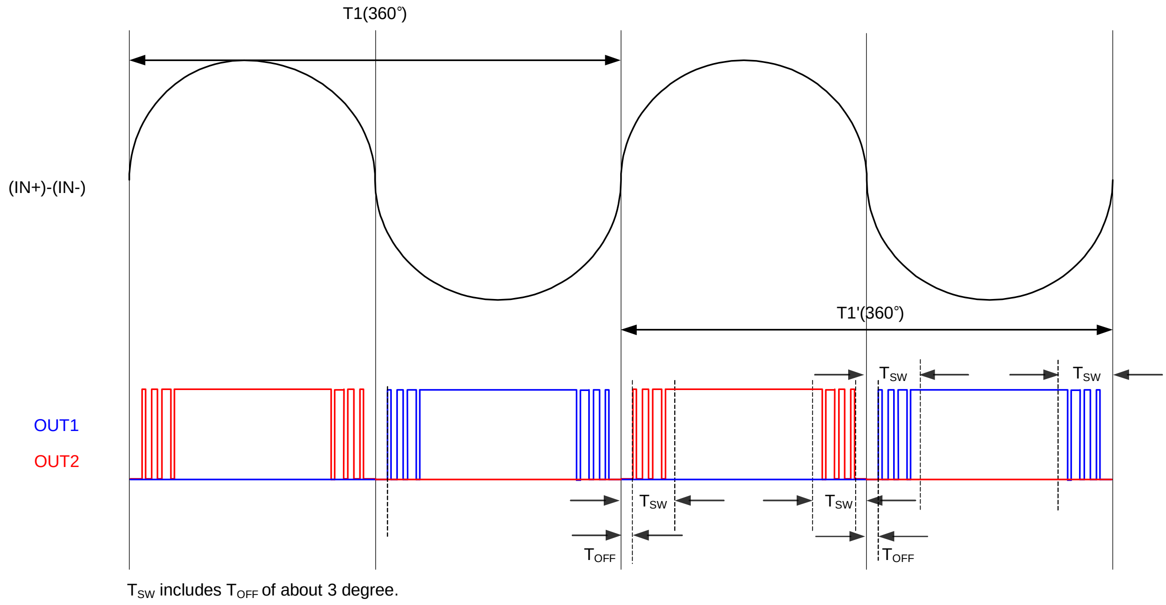


Figure11: Soft Switching Waveform

Time of soft switching (T_{SW}) is determined by the time of prior hall signal (360°) and voltage of SW pin. In soft switching after conducting phase switch, the output PWM duty changes gradually from 0% to 100% of the output PWM duty determined by SW voltage by 63 steps in maximum. In soft switching before conducting phase switch, the output PWM duty changes gradually from 100% to 0% of the output PWM duty determined by SW voltage by 63 steps in maximum.

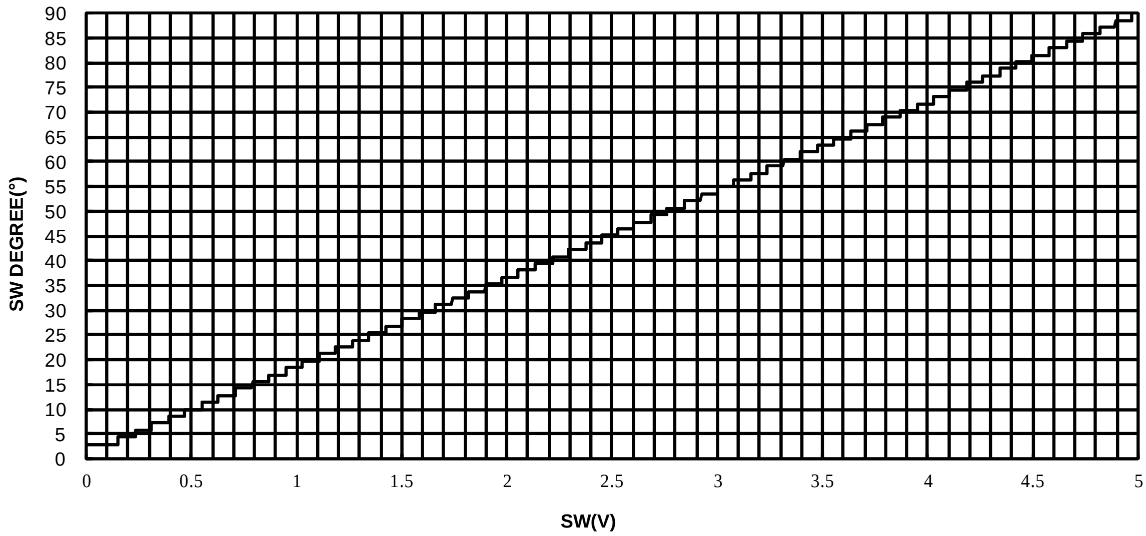


Figure12: SW degree VS. SW Voltage

Function Description (Cont.)

We could use the equation and table below to find out the R_{sw} needed.

$R_{sw} = \frac{V_{SW}}{20uA}(\Omega)$. The V_{sw} is the midpoint to avoid the edge vibration, and the value of internal current source is 20uA.

Step	V_{SW}(V)	Term(°)	Step	V_{SW}(V)	Term(°)	Step	V_{SW}(V)	Term(°)	Step	V_{SW}(V)	Term(°)
1	0	3	17	1.38	25.4	33	2.64	47.9	49	3.91	70.3
2	0.19	4.4	18	1.46	26.8	34	2.72	49.3	50	3.99	71.7
3	0.27	5.8	19	1.54	28.2	35	2.8	50.7	51	4.07	73.2
4	0.35	7.2	20	1.62	29.6	36	2.88	52.1	52	4.14	74.6
5	0.43	8.6	21	1.7	31	37	2.96	53.5	53	4.22	76
6	0.51	10	22	1.78	32.4	38	3.04	54.9	54	4.3	77.4
7	0.59	11.4	23	1.86	33.9	39	3.12	56.3	55	4.38	78.8
8	0.67	12.8	24	1.94	35.3	40	3.2	57.7	56	4.46	80.2
9	0.75	14.2	25	2.02	36.7	41	3.28	59.1	57	4.54	81.6
10	0.83	15.6	26	2.09	38.1	42	3.35	60.5	58	4.62	83
11	0.91	17	27	2.17	39.5	43	3.43	61.9	59	4.70	84.4
12	0.99	18.4	28	2.25	40.9	44	3.51	63.3	60	4.78	85.8
13	1.07	19.8	29	2.33	42.3	45	3.59	64.7	61	4.85	87.2
14	1.15	21.2	30	2.41	43.7	46	3.67	66.1	62	4.93	88.6
15	1.23	22.6	31	2.49	45.1	47	3.75	67.5	63	5	90
16	1.30	24	32	2.57	46.5	48	3.83	68.9			

Function Description (Cont.)

Lead Angle

The lead angle can be adjusted between 0° and 22° in 17 separate steps according to the input voltage level on the LA input, which works with 0 to 4.8 V. If Lead Angle function is not used, leave it floating.

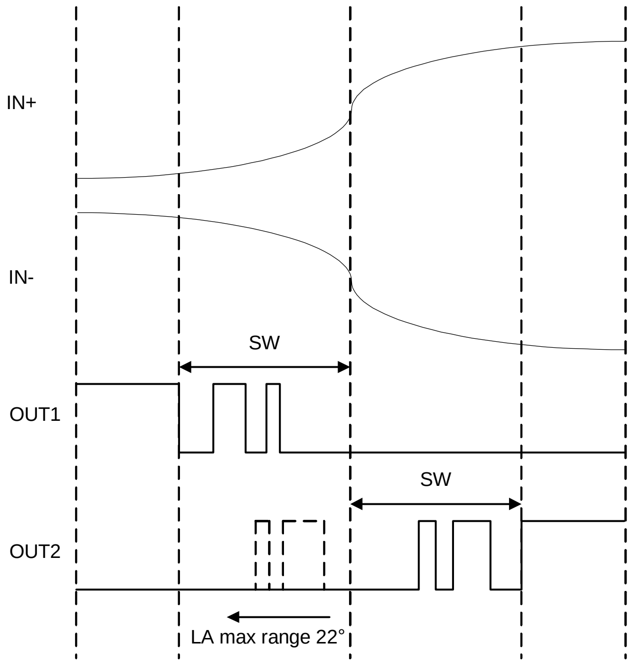


Figure 13: Lead Angle Waveform

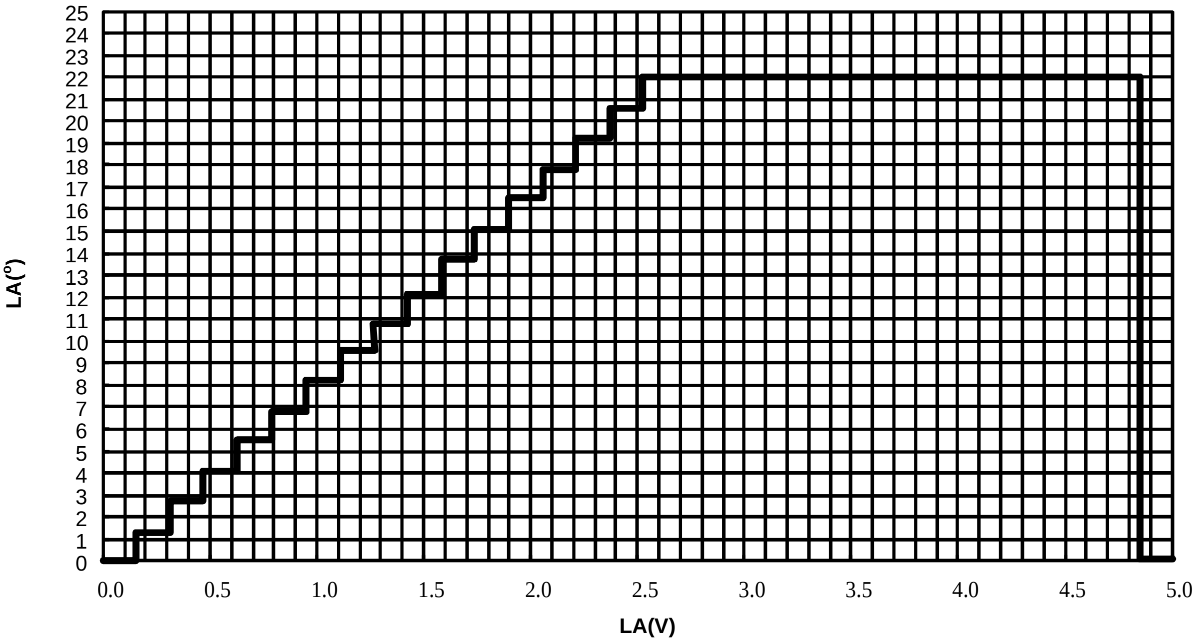


Figure 14: LA Degree VS. LA Voltage

Function Description (Cont.)

We could use the equation and table below to find out the R_{LA} needed.

$R_{LA} = \frac{V_{LA}}{20uA}(\Omega)$. The V_{LA} is the midpoint to avoid the edge vibration, and the value of internal current source is 20uA.

Step	V_{LA}(V)	Term(°)	Step	V_{LA}(V)	Term(°)	Step	V_{LA}(V)	Term(°)	Step	V_{LA}(V)	Term(°)
1	0	0	6	0.87	6.8	11	1.66	13.7	16	2.45	20.6
2	0.23	1.3	7	1.03	8.2	12	1.82	15.1	17	2.61	22
3	0.39	2.7	8	1.19	9.6	13	1.98	16.5			
4	0.55	4.1	9	1.34	10.8	14	2.13	17.8			
5	0.71	5.5	10	1.5	12.1	15	2.29	19.2			

Function Description (Cont.)

HB Pin & Hall Iinput

HB output 1.3V voltage reference is for hall element bias. Being short lines is for noise immunity. Hall input amplifier has 15mV hysteresis. Therefore, we recommend the hall input level to be 60mVp-p or above in any condition.

FG Output

The FG pin is an open-drain output, connecting a pull up resistor to a high level voltage for the speed detection function. During the Lock Mode, the FG will always high (switch off) (See Truth Table). Open the terminal when it is not used.

Current Limit

The APX9203 includes an internal current sense circuits for current limit. When the total current of output over the current limit level (1.1A) , the high side driver will be turned off to stop supplying current to the motor until I_{OUT}<1.1A or re-power on.

Thermal Protection

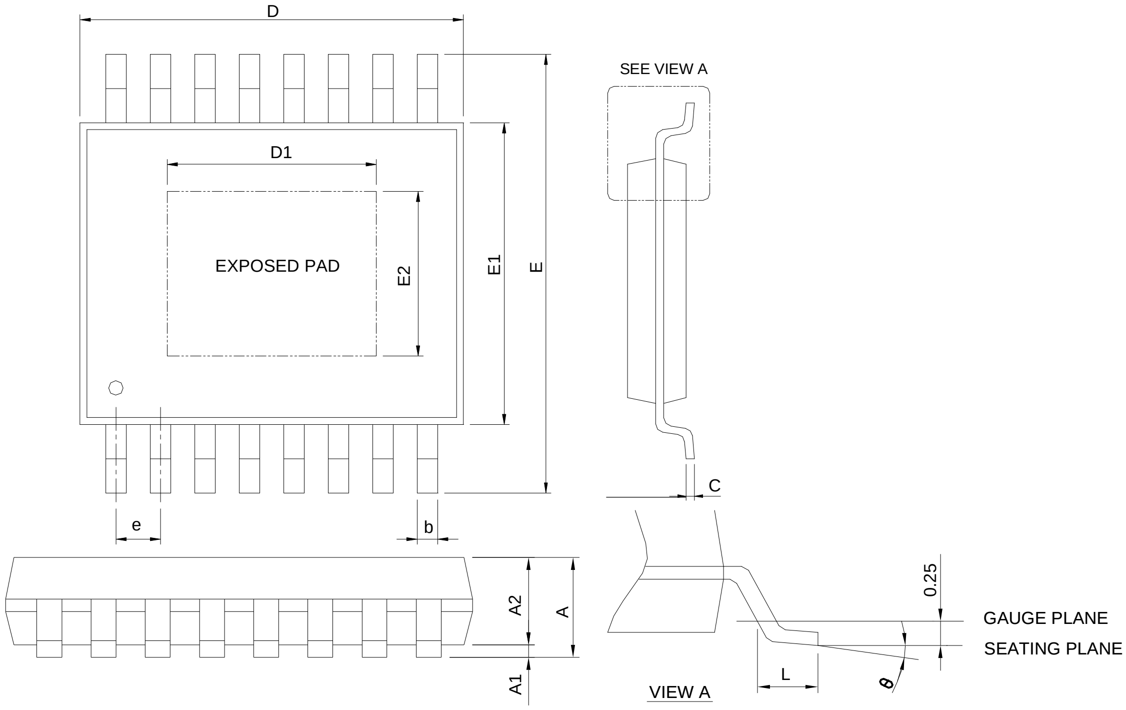
The APX9203 has thermal protection. When internal junction temperature reaches 165°C, the output devices will be switched off. When the IC's junction temperature cools by 30°C, the thermal sensor will turn the output devices on again, resulting in a pulsed output during continuous thermal protection.

Truth Table

INPUT		OUTPUT			
IN-	IN+	OUT1	OUT2	FG	Mode
H	L	H	L	L	Rotation(Drive) (PWM ON)
L	H	L	H	OFF	
H	L	OFF	L	L	Rotation(Regeneration) (PWM OFF)
L	H	L	OFF	OFF	
H	L	L	L	OFF	Lock Mode
L	H	L	L	OFF	

Package Information

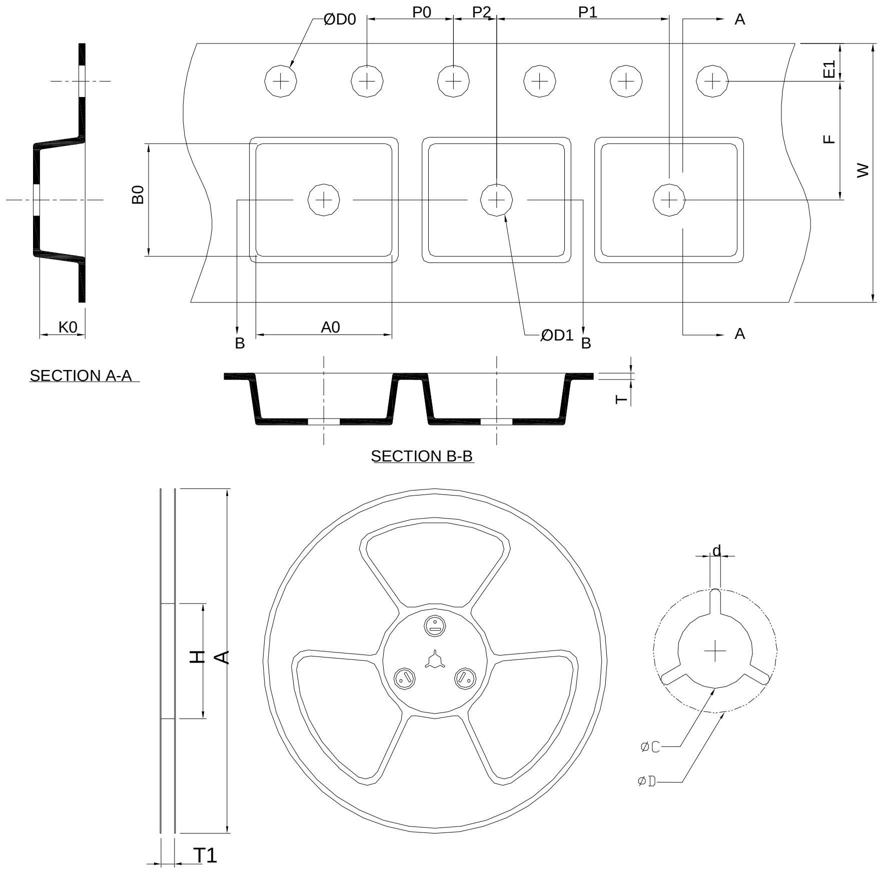
TSSOP-16P



SYMBOL	TSSOP-16P			
	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
D1	2.00	3.50	0.079	0.138
E	6.20	6.60	0.244	0.260
E1	4.30	4.50	0.169	0.177
E2	2.50	3.50	0.098	0.138
e	0.65 BSC		0.026 BSC	
L	0.45	0.75	0.018	0.030
θ	0^o	8^o	0^o	8^o

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-16P	330.0±2.00	50 MIN.	12.4+2.00 -0.00	13.0+0.50 -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 -0.00	1.5 MIN.	0.6+0.00 -0.40	6.80±0.20	5.40±0.20	1.60±0.20

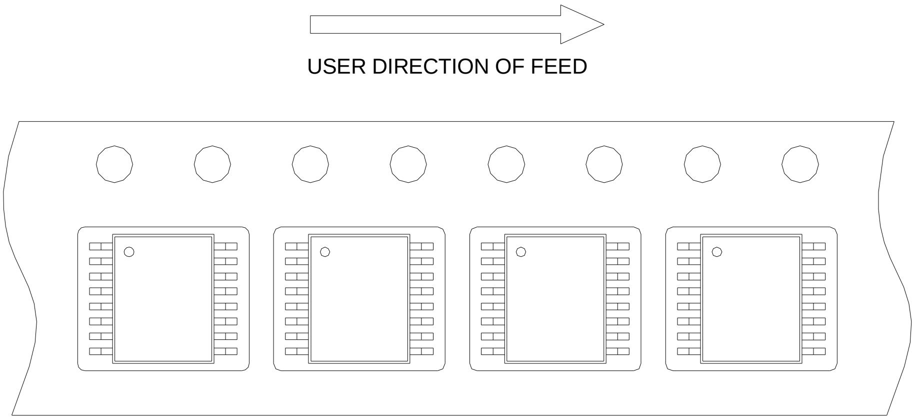
(mm)

Devices Per Unit

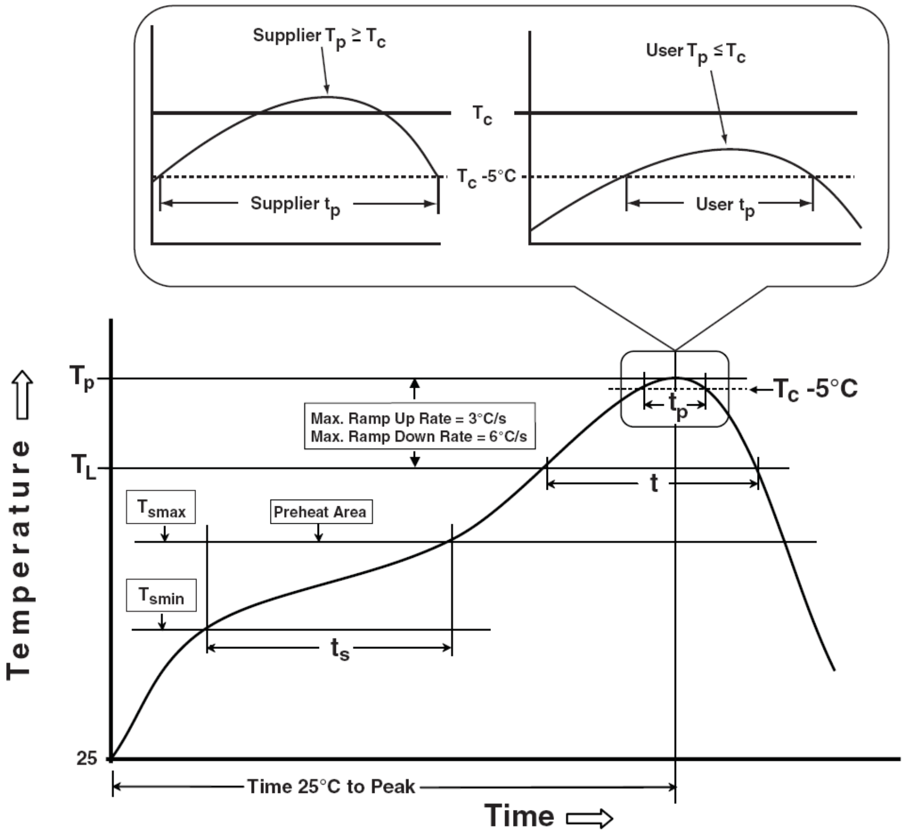
Package Type	Unit	Quantity
TSSOP- 16P	Tape & Reel	2500

Taping Direction Information

TSSOP-16P



Classification Profile



Classification Reflow Profiles

Profile Feature	Sn-Pb Eutectic Assembly	Pb-Free Assembly
Preheat & Soak Temperature min (T_{smin}) Temperature max (T_{smax}) Time (T_{smin} to T_{smax}) (t_s)	100 °C 150 °C 60-120 seconds	150 °C 200 °C 60-120 seconds
Average ramp-up rate (T_{smax} to T_P)	3 °C/second max.	3°C/second max.
Liquidous temperature (T_L) Time at liquidous (t_L)	183 °C 60-150 seconds	217 °C 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.

Classification Reflow Profiles (Cont.)

Table 1. SnPb Eutectic Process – Classification Temperatures (Tc)

Package Thickness	**Volume mm^3 <350**	**Volume mm^3 ^{3}350**
<2.5 mm	235 °C	220 °C
≥2.5 mm	220 °C	220 °C

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

Package Thickness	**Volume mm^3 <350**	**Volume mm^3 350-2000**	**Volume mm^3 >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 @ Tj=125°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, 1_{tr}≧100mA

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