All-in-One Variable Speed BLDC Motor Driver IC

Halogen Free

General Description

FD0267Af is a single-phase full-wave BLDC motor driver IC with embedded Hall-effect sensor and rotation speed(FG) output. It integrates a H-bridge MOS driver, a high and precisely sensitive Hall-effect sensor and a digital control logic with an internal clock for rotor locked driver shutdown and auto re-start, tachometer(FG) output logic, and the BLDC motor's speed control function in the TS826 package, it makes the BLDC motors' PCBs(printed circuit boards) design easy and fabrication of the ultra-small BLDC motors and FANs as simple as possible.

For safety, Lock-shutdown function would turn the IC's internal drivers off avoiding over-heat when the rotor is locked, and the IC will try to re-start the rotor's torque after the time of these drivers' shutdown.

The IC contains the PWM direct input variable speed control and the tachometer signal(FG) output function, the external succeeding system could control the BLDC motor speed and readout the BLDC motor's speed(FG) from the signal pin of FD0267Af IC.

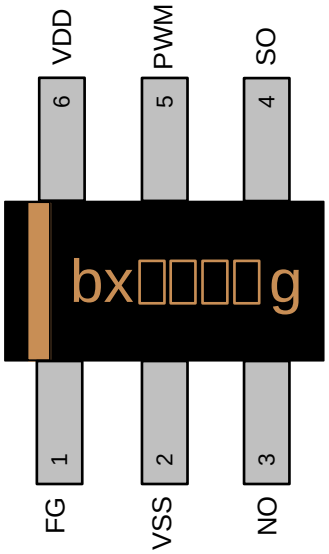
Thermal-shutdown protection(TSD) ensures the internal drivers of the IC are operating under a safe operating temperature range, and all the protection mechanisms mentioned above combine to provide a complete protecting scenario for the BLDC motor systems, avoid any possible damages and guarantee a correct and safe operation.

Features

- Built-in high sensitivity Hall-effect sensor
- H-bridge MOS driver
- Output soft-switching to reduce vibration and acoustic noise
- Rotor lock shutdown & auto-restart function
- PWM variable speed control
- Tachometer signal(FG) output
- Thermal shutdown protection(TSD)
- Available in TS826 package
- For 5V BLDC motor / FAN systems

Pin Descriptions

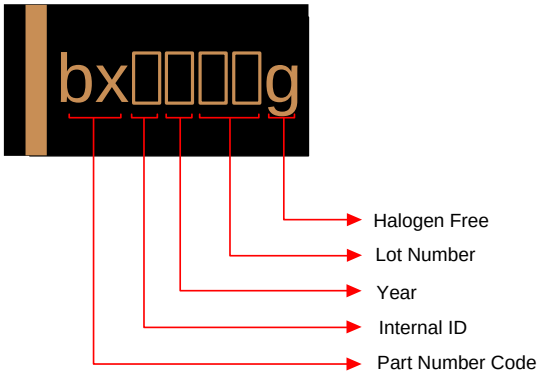
FD0267Af



Name	I/O	NO.	Description
FG	O	1	Tachometer Signal Output
VSS	G	2	IC Ground
NO	O	3	Driver Output 1
SO	O	4	Driver Output 2
PWM	I	5	PWM Variable Speed Control
VDD	P	6	IC Power Supply

Legend: I=input, O=output, I/O=input/output, P=power supply, G=ground

Marking Information



Halogen Free: Halogen free product indicator

Lot Number: Wafer lot number's last two digits

For Example: XX686 → 86

Year: Production year's last digit

Internal ID: Internal Identification Code

Part Number Code: Part number identification code for this product.

Block Diagram

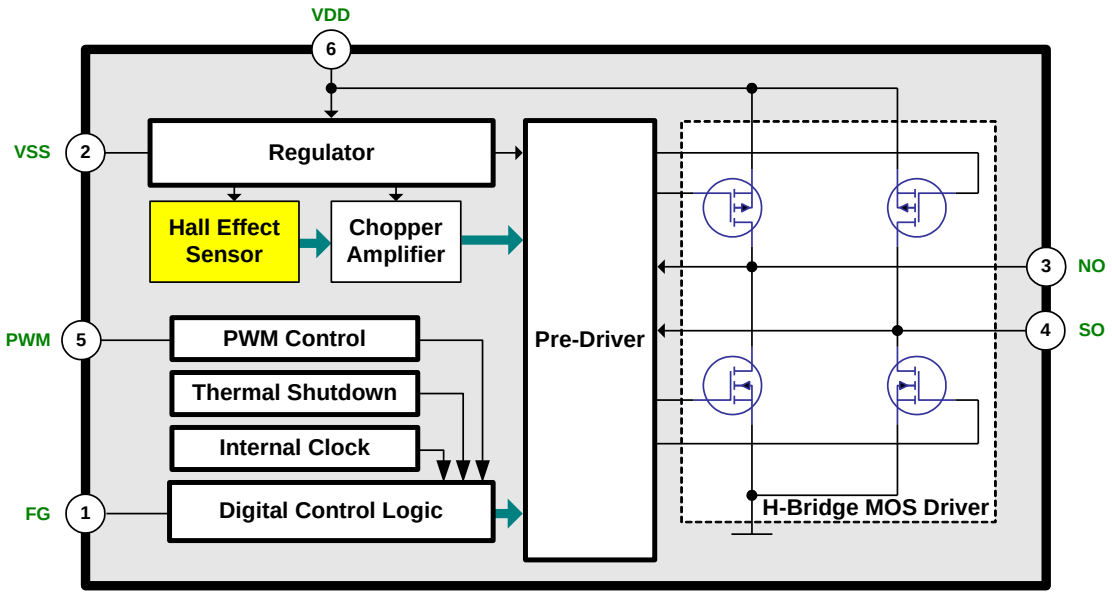


Figure 1

Functional Descriptions

Refer to the block diagram (Figure 1), FD0267Af is composed of the following building blocks:

- **Regulator**

The regulator provides a precise, low temperature coefficient bias reference for internal analog/digital blocks.

- **Hall-Effect Sensor with Chopper Amplifier**

To achieve a higher magnetic sensitivity the chopper amplifier structure is adopted in this design. Use of this structure dynamically removes both the offset and flicker noise at the same time.

- **Digital Control Logic with Internal Clock**
  - Timer part – generates an interval of time when rotor locked event is occurred.
  - Signal part – generates the tachometer signal(FG) output.
- **H-Bridge MOS Driver with Pre-Driver**

The driver provides a BLDC motor / FAN coil driving capability.

- **Variable Speed Control**
  - ***PWM Mode***

    When the external PWM signal connects to the PWM pin of FD0267Af IC, it will pass the duty cycle ratio and frequency of the signal to the coil driver and make the BLDC motor speed changing as well.

    Figure 3 is a reference example about the relationship between the PWM signal duty cycle and the BLDC motor's speed(R.P.M.).

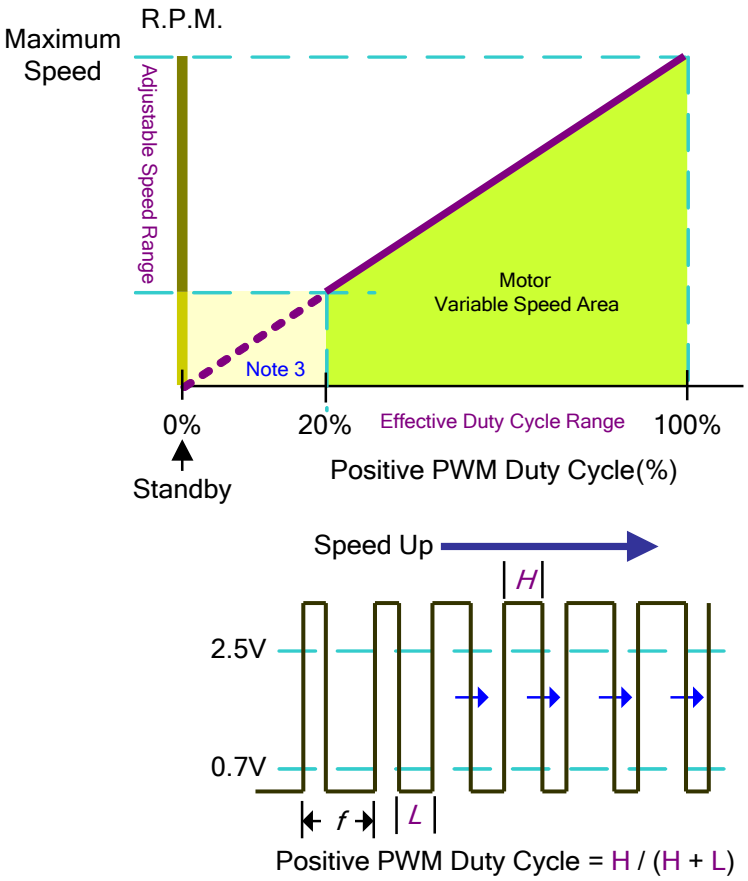


Figure 3

Note:

(1) The lower-limit for the PWM pulse frequency is 200Hz, and the recommended frequency range is in the range of 25k~30kHz where the PWM input pulses will not generate acoustic noise.

(2). The PWM pin contains an internal pull-up resistor, the BLDC motor becomes full speed operation when this pin is left un-connected(floating).

(3). Under 20% IC still has an on torque to re-start the BLDC motor until IC enters standby mode when the duty cycle is 0%.

Order Information

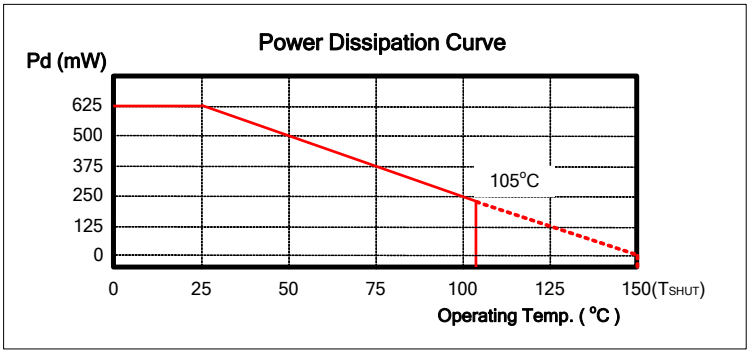
Part Number	Operating Temperature	Package	Description		MOQ	MSL
FD0267AfR-G1	-20℃ to +105℃	TS826	±40G (B)	Tachometer O/P	3,500 EA / REEL	3

Absolute Maximum Ratings

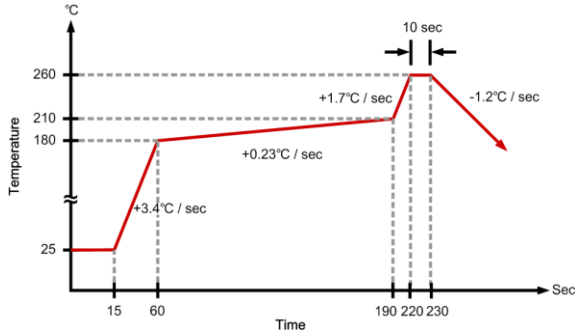
Parameter		Symbol	Conditions	Values			Unit
				Min.	Typ.	Max.	
Operating Temperature		$T_{OP.}$	-	-20	-	105	℃
Storage Temperature		$T_{ST.}$	-	-40	-	150	℃
DC Supply Voltage		$V_{DD(MAX.)}$	-	-0.3	-	7.0	V
DC Supply Current	No Loading	$I_{DD(AVG.)}$	-	-	-	5.0	mA
	Standby	$I_{DD(STBY.)}$	-	-	-	100	μA
Maximum Output Current		$I_{O(MAX.)}$	-	-	-	800	mA
Tachometer Signal Sink Current		$I_{FG(ON)}$	-	-	-	25	mA
Tachometer Signal Off Voltage		$V_{FG(OFF)}$	-	-0.3	-	7.0	V
PWM Input Voltage		$V_{(PWM)}$	-	-0.3	-	V_{DD}+0.3	V
Junction Temperature		T_j	-	-	-	170	℃
Maximum Power Dissipation		$P_{D(TS826)}$	-	-	-	625	mW
Thermal Resistance (※1)		θ_{ja}	TS826	-	200	-	℃/W
Thermal Resistance (※1)		θ_{jc}	TS826	-	56	-	℃/W
Magnetic Flux Density		B	-	-	-	Unlimited	Gauss
IR-Reflow Lead Temperature		T_P	10sec	-	-	260	℃

Note1: *device mounted with copper area of approximately 35mm^{2,} 1oz, no air flow. (room temperature: 25 ℃)*

Power Derating Curve



IR Re-flow Soldering Curve



Recommended Operating Conditions

Parameter	Symbol	Conditions	Values			Unit
			Min.	Typ.	Max.	
Supply Voltage	V_{DD}	-	1.7	-	5.5	V
Operating Temperature Range	$T_{OP.}$	-	-20	-	105	℃

DC Electrical Characteristics V_{DD}=5.0V, $T_{OP.}$=25℃ (unless otherwise specified)

Parameter	Symbol	Conditions	Values			Unit
			Min.	Typ.	Max.	
DC Supply Current	$I_{DD(AVG.)}$	No Loading	-	4.0	-	mA
	$I_{DD(STBY.)}$	$V_{(PWM)}$ = 0	-	50	-	μA
FG Saturation Voltage	$V_{FG(ON)}$	$I_{FG(ON)}$ = 5mA	-	-	0.4	V
FG Off Leakage Current	$I_{FG(OFF)}$	$V_{FG(OFF)}$ = 5.0V	-	-	10	μA
On Resistance (R_{PMOS}+R_{NMOS})	$R_{DS(ON)}$	V_{DD} = 1.7V	-	2.0	-	Ω
		V_{DD} = 5.0V	-	1.0	-	
PWM Threshold Voltage	$V_{PWMTH(L)}$	-	0	-	0.7	V
	$V_{PWMTH(H)}$	-	2.5	-	V_{DD}	
PWM Sync. Frequency	f_{PWM}	-	0.2	-	60	KHz
Thermal Shutdown Threshold	$T_{(SHDN.)}$	T_j Temperature	150	-	-	℃
Thermal Shutdown Hysteresis	$T_{(TSHY.)}$	T_j Temperature	-	30	-	℃
Locked Rotor On Period	t_{ON}	-	0.28	0.4	0.52	s
Locked Rotor Off Period	t_{OFF}	-	2.1	3.0	3.9	s
Locked Rotor Off/On Ratio	t_{OFF}/t_{ON}	-	7	-	-	-
Power-On 1’st Hold Period	t_{HOLD1}	Rotor Lock to Power-on	-	2xt_{ON}	-	s
Locked Rotor 1’st Hold Period	t_{HOLD2}	Rotation to Rotor Lock	t_{ON}	-	2xt_{ON}	s

Magnetic Characteristics

Parameter	Symbol	Conditions	Values			Unit
			Min.	Typ.	Max.	
Operate Point	B_{OP}	$T_{OP.}$ = 25℃	5	25	40	G
Release Point	B_{RP}		-40	-25	-5	G
Hysteresis	B_{HYS}		10	-	80	G

Driver Output vs. Magnetic Pole

Parameter	Test Conditions	NO	SO
North Pole	B > B_{OP}	Low	High
South Pole	B < B_{RP}	High	Low

Note: *The magnetic pole is applied facing the branded side of the package*

Hysteresis Characteristics

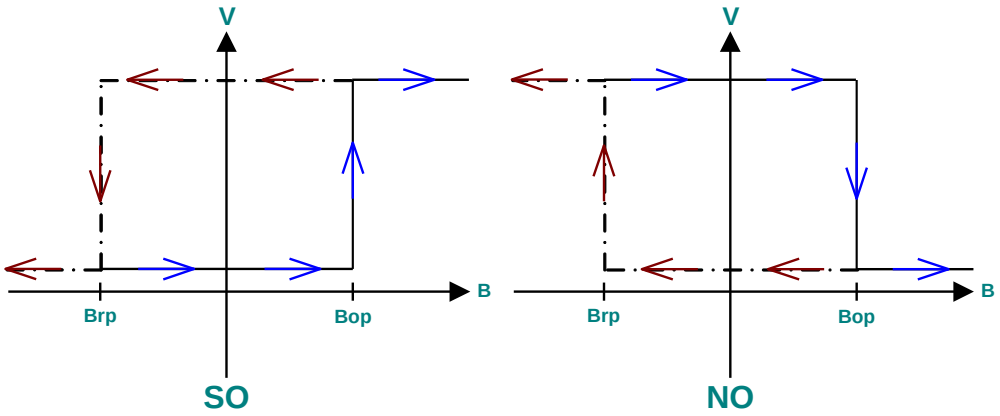


Figure 5

Performance Graphs

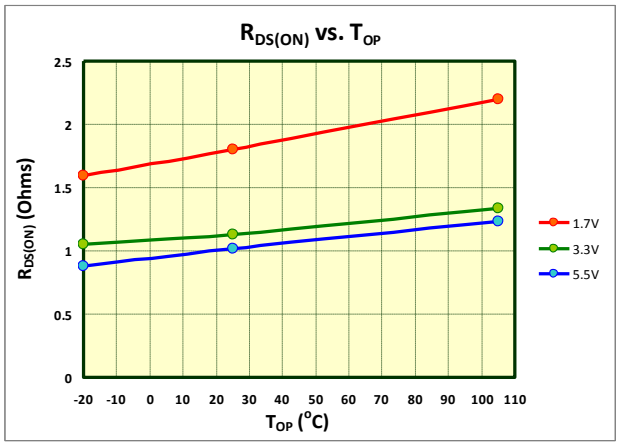


Figure 6

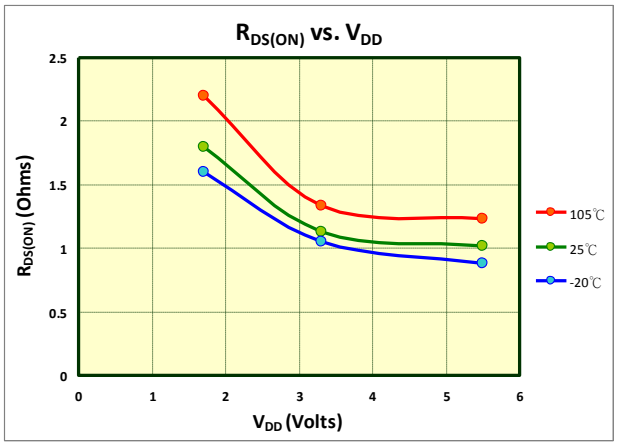


Figure 7

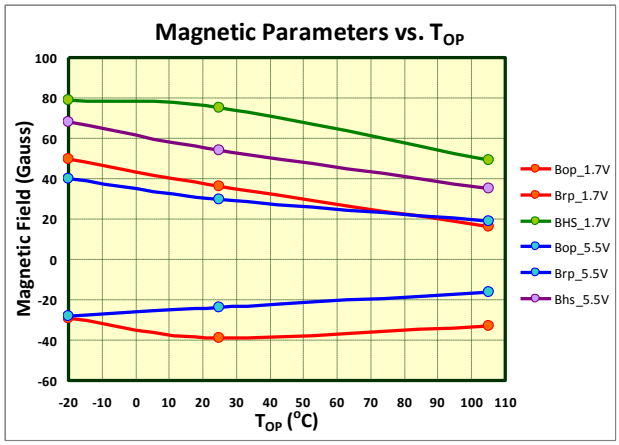


Figure 8

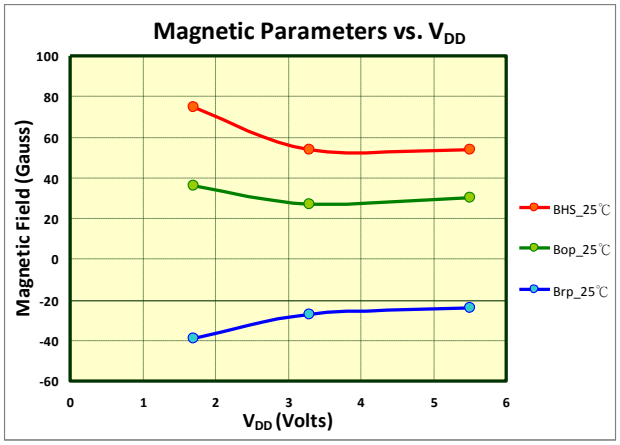


Figure 9

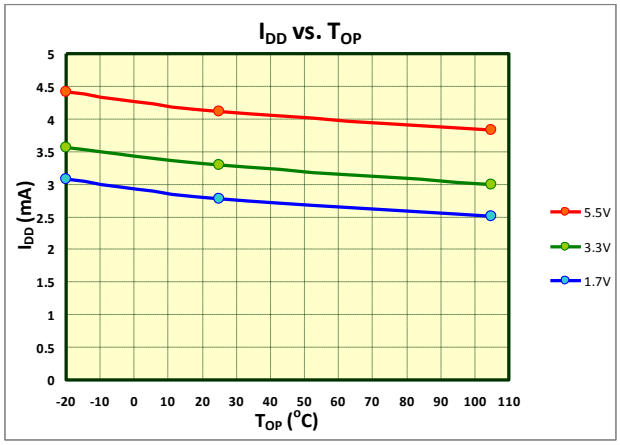


Figure 10

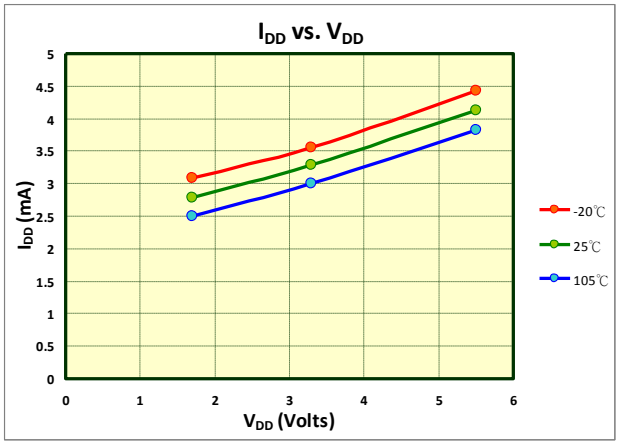


Figure 11

Tachometer Signal(FG) Description

The output on voltage of FG signal is relative to the ambient temperature and supply voltage of the IC. Figure 12 is a curve of this relationship at the condition of a 5mA sink current. If the signal level isn't correct, the tachometer signal(FG) will be incorrectly detected by the succeeding system.

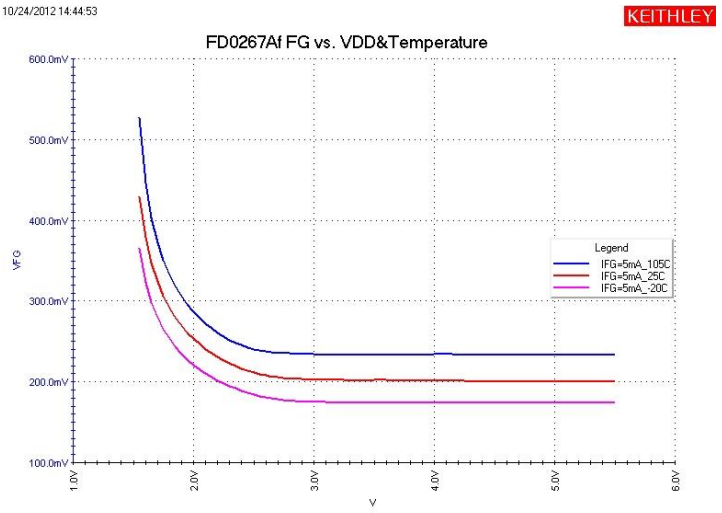


Figure 12

Power Loss Calculation

The main power loss of FD0267Af is composed of four parts, the first is from the IC internal supply current (I_{DD}) with the IC operation voltage (V_{DD}), the second is the ON loss from the IC high-side and low-side on voltage with coil on current, the third is the soft-switching loss and the fourth is the signal turn on loss.

The following are the approximate formulas which express the relationships. If the PCB thermal resistance condition and power loss calculation are known, the chip junction temperature can be estimated as well.

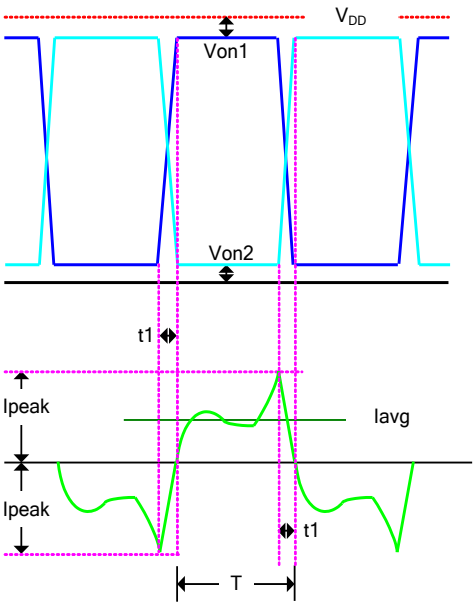


Figure 13

Total Power Loss Calculation Formula:

$$Pc = V_{DD} \times I_{DD} + (Von1 + Von2) \times Iavg \times \frac{(T - t1)}{T} + \frac{1}{2} \times V_{DD} \times Ipeak \times \frac{t1}{T} + \frac{1}{2} \times V_{on(FG)} \times I_{sink(FG)}$$

$$Tj = Pc \times \theta ja + Ta \le k \times TSD \quad k = 0.8 \sim 0.9$$

Application Circuits Reference

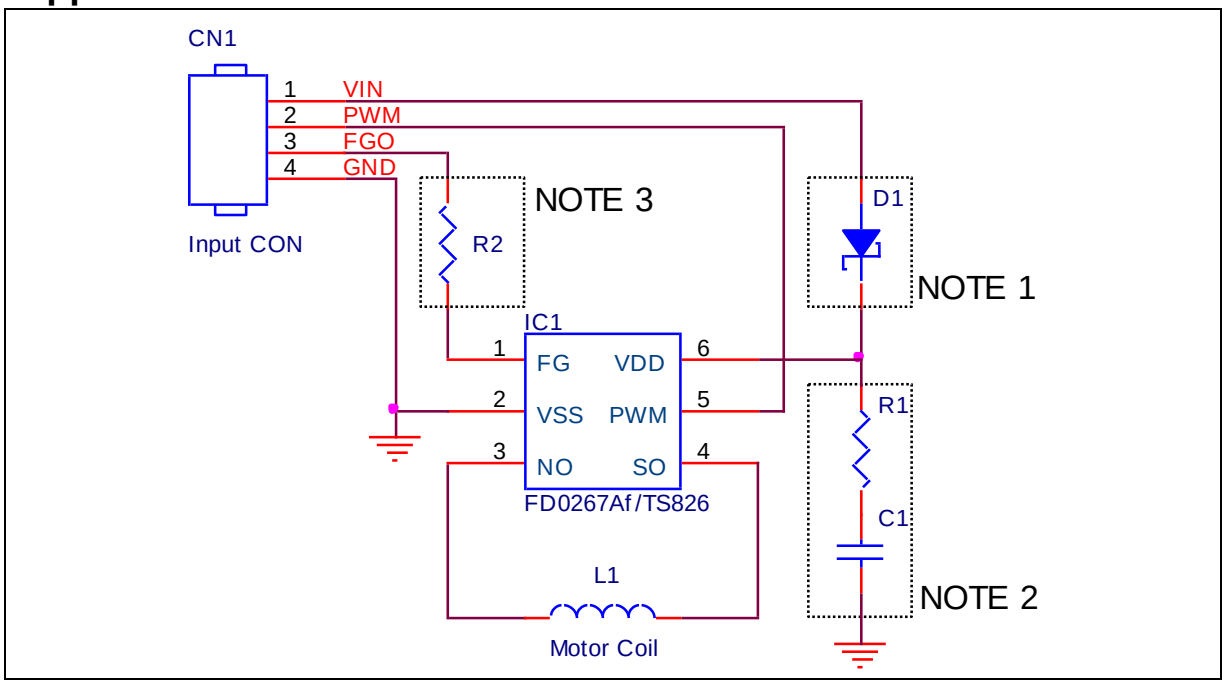


Figure 14 FD0267Af 4-Wire PWM Variable Speed BLDC Motor Application Circuits

NOTE:

1. D1 is a low cut-in Schottky barrier diode for start-up and reverse protection operation.
2. R1 and C1 are for power supply filtering function, and must be placed as close to IC1 as possible.
3. R2 is a current limit resistance when FG-VSS is reversed by connection.

The IC laying aside mode declaration is as follows:

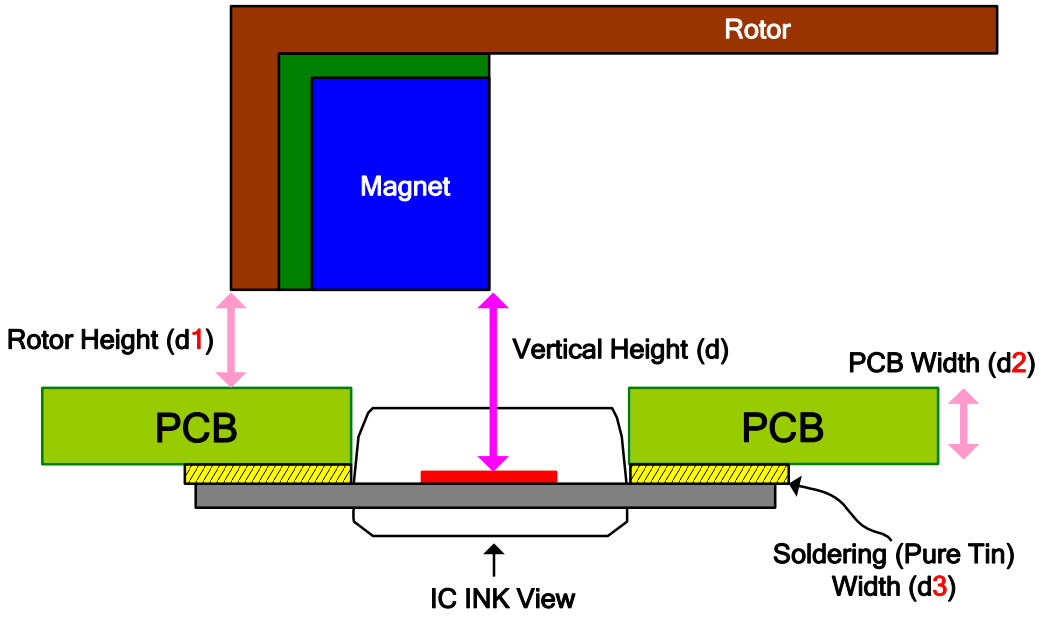


Figure 15

FD0267Af Output Waveforms Description

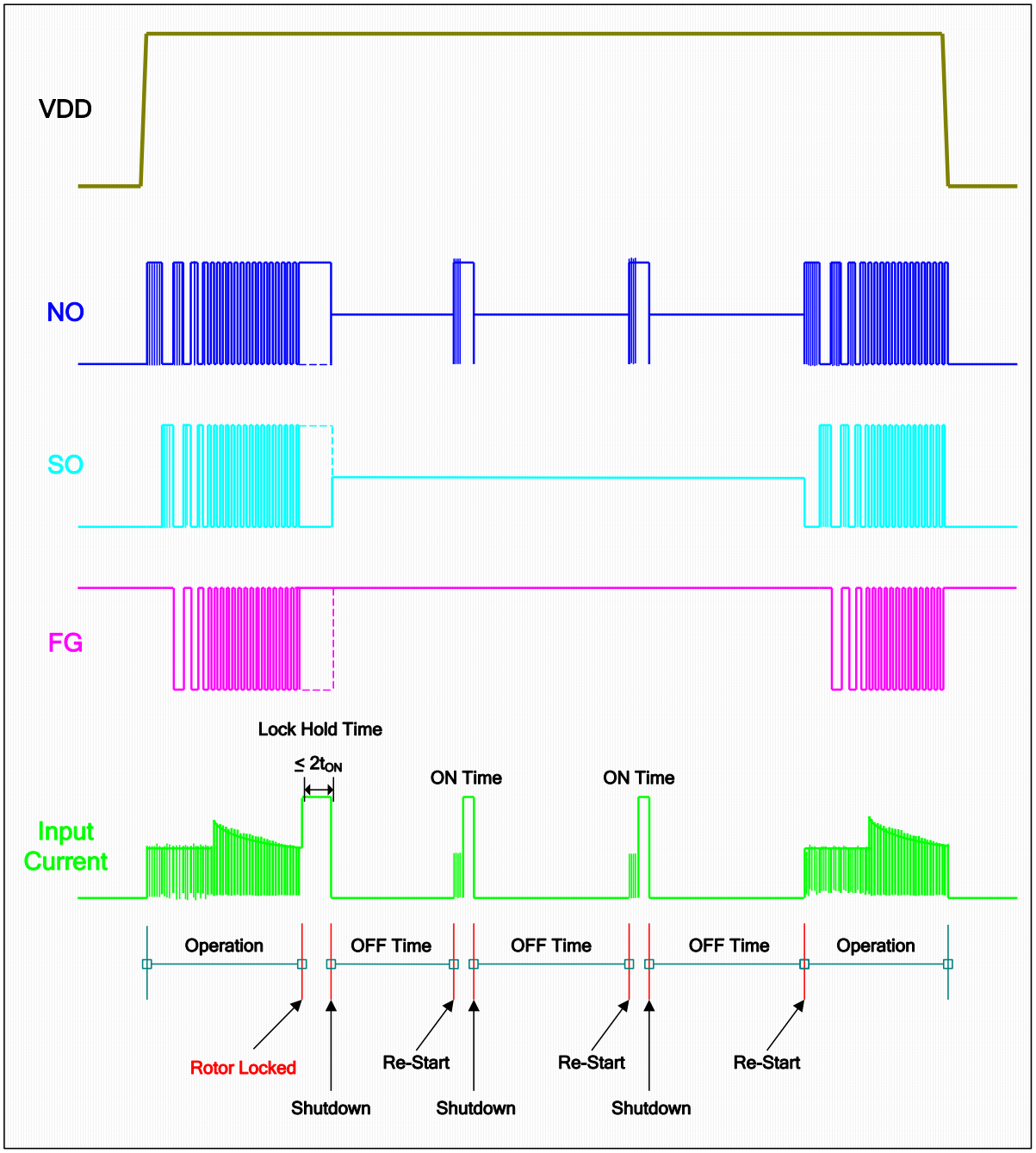
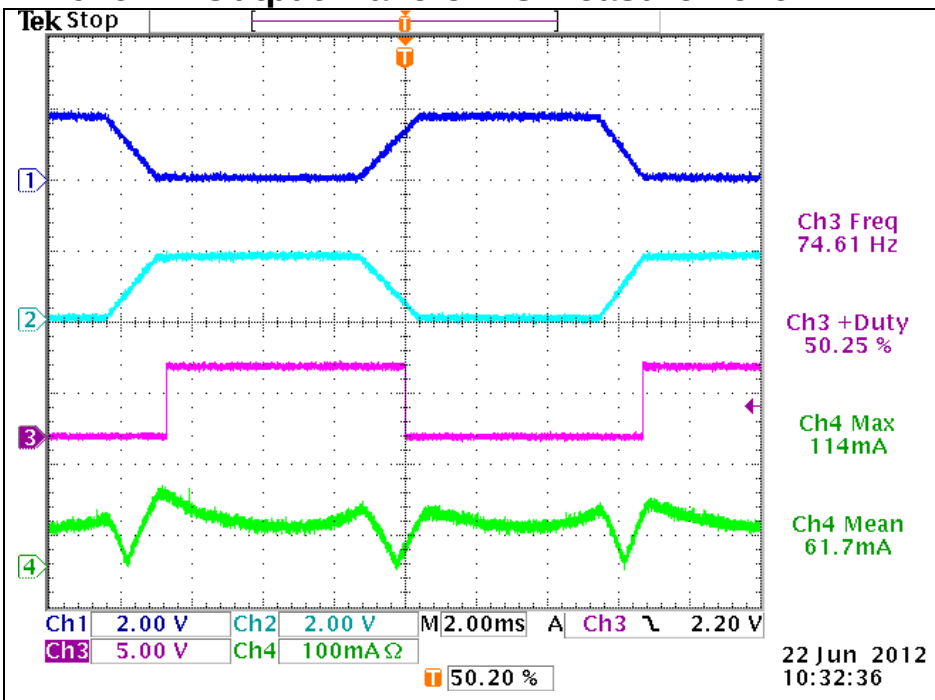


Figure 16

FD0267Af Output Waveforms Measurement



FD0267Af
+1.8V
Normal Operation

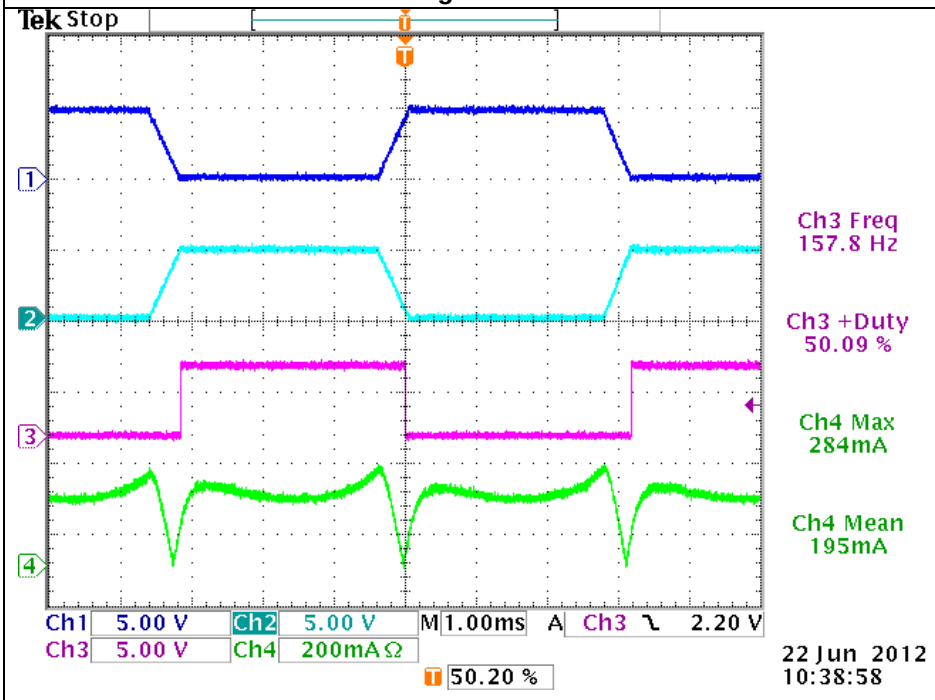
CH1: NO Output
CH2: SO Output
CH3: FG Output
CH4: Input Current

Motor Speed
(~ 2,238 rpm)

Duty Cycle Ratio
(~ 1.01)

Average Current
(~ 61.7 mA)

Figure 17



FD0267Af
+5.0V
Normal Operation

CH1: NO Output
CH2: SO Output
CH3: FG Output
CH4: Input Current

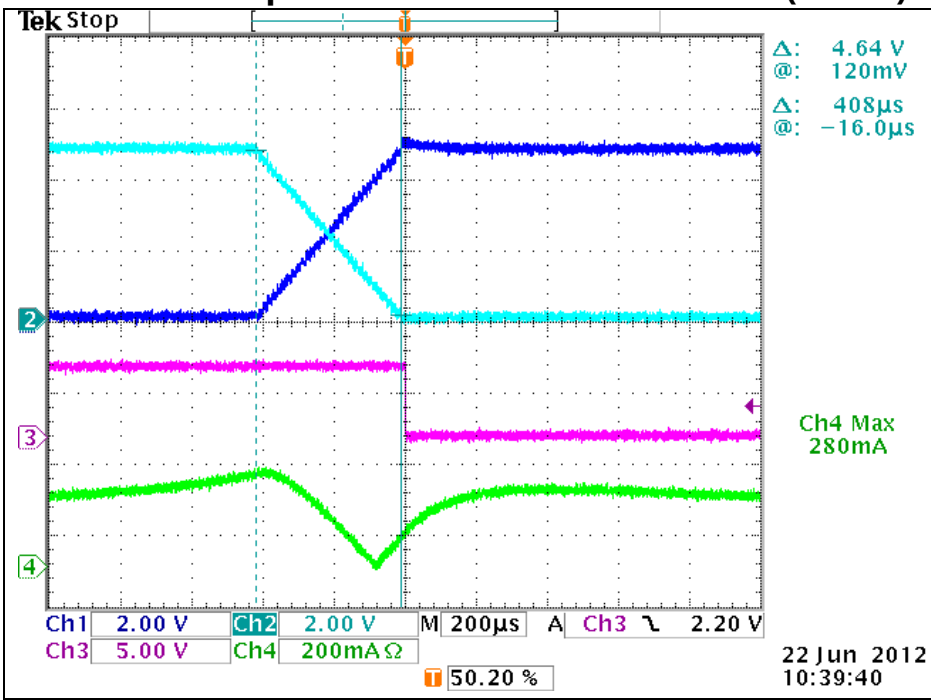
Motor Speed
(~ 4,734 rpm)

Duty Cycle Ratio
(~ 1.004)

Average Current
(~ 195 mA)

Figure 18

FD0267Af Output Waveforms Measurement(Cont'd)

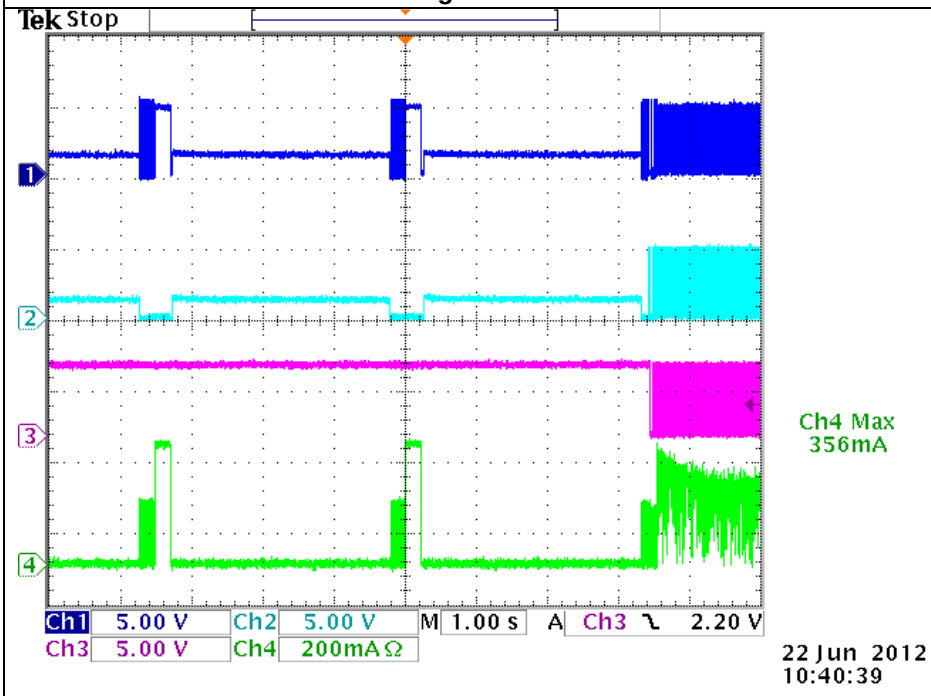


FD0267Af
+5.5V
Soft-Switching

CH1: NO Output
CH2: SO Output
CH3: FG Output
CH4: Input Current

Switch time
(~ 408 µs)

Figure 19



FD0267Af
+5.0V
Rotor Locked

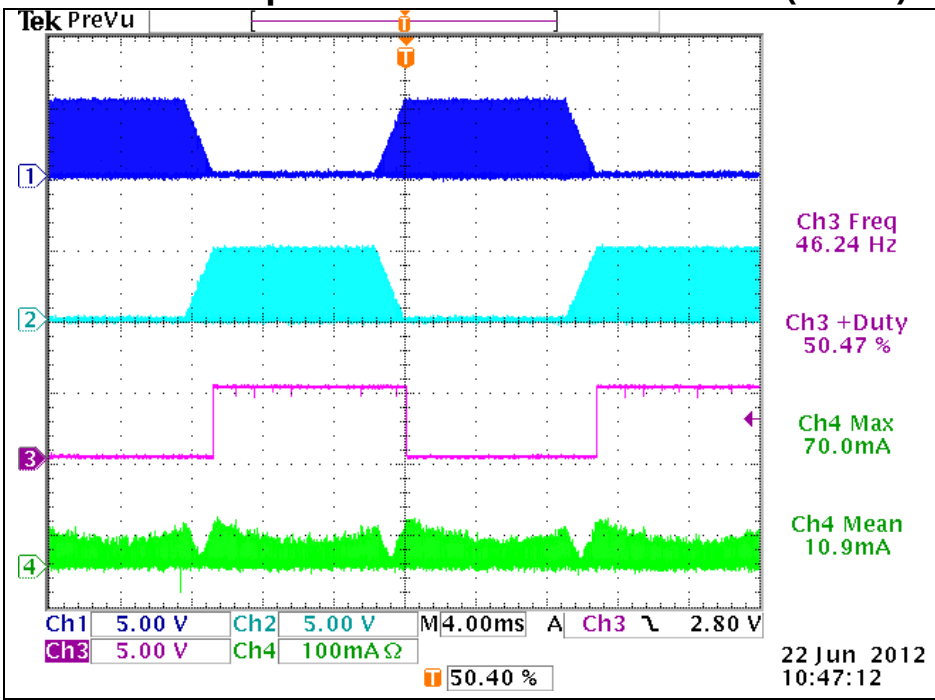
CH1: NO Output
CH2: SO Output
CH3: FG Output
CH4: Input Current

On time: (~ 0.44 s)

Off time: (~ 3.00 s)

Figure 20

FD0267Af Output Waveforms Measurement(Cont'd)



FD0267Af
+5.0V
Variable Speed
(~ 20% Duty)

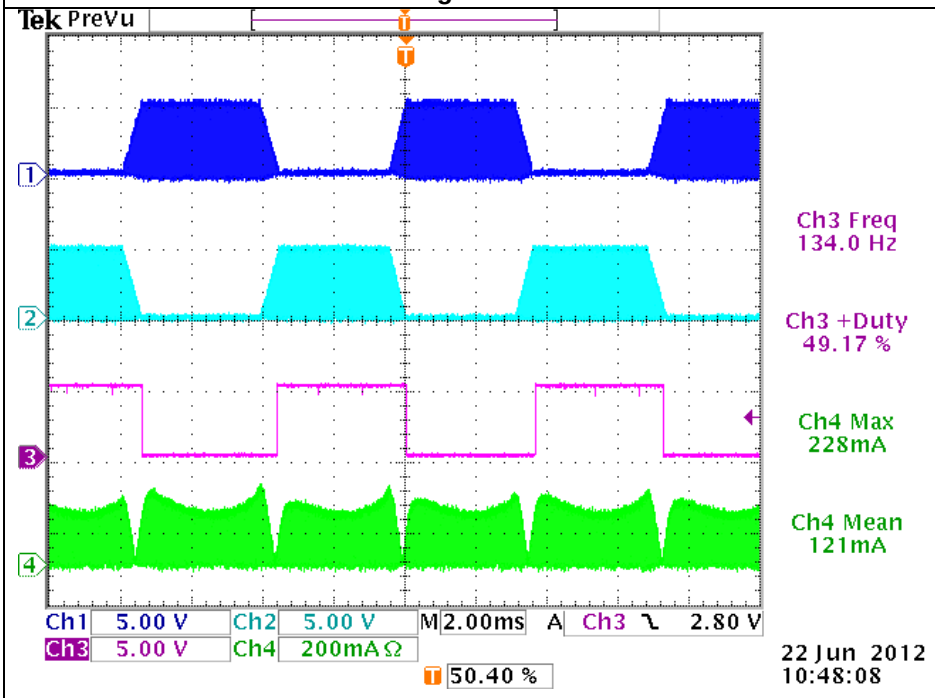
CH1: NO Output
CH2: SO Output
CH3: FG Output
CH4: Input Current

Motor Speed
(~ 1,387 rpm)

Average Input Current
(~ 10.9 mA)

Duty Cycle Ratio
(~ 1.019)

Figure 21



FD0267Af
+5.0V
Variable Speed
(~ 80% Duty)

CH1: NO Output
CH2: SO Output
CH3: FG Output
CH4: Input Current

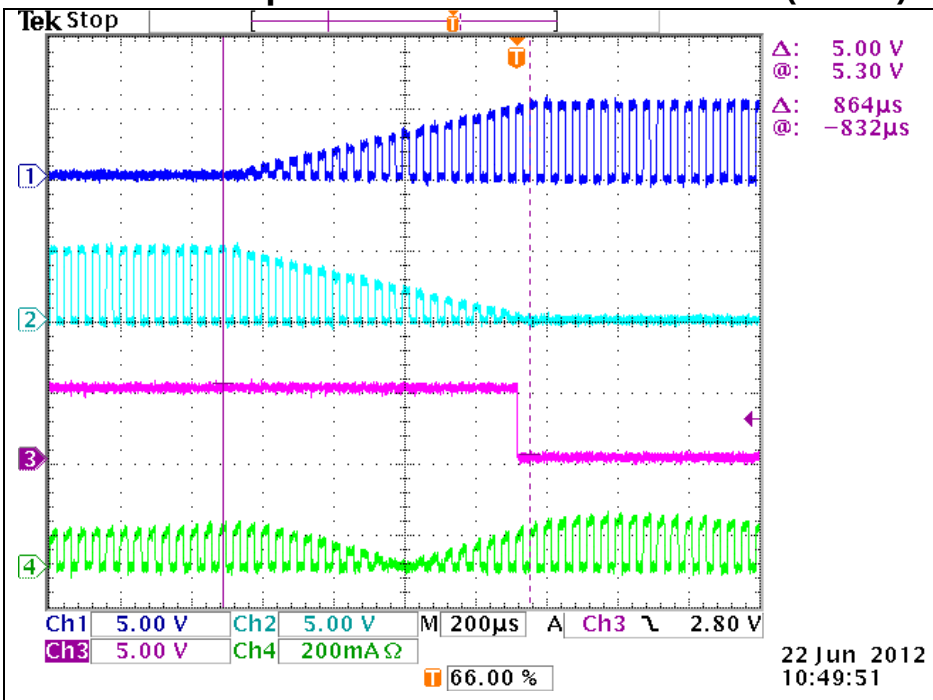
Motor Speed
(~ 4,020 rpm)

Average Input Current
(~ 121 mA)

Duty Cycle Ratio
(~ 1.033)

Figure 22

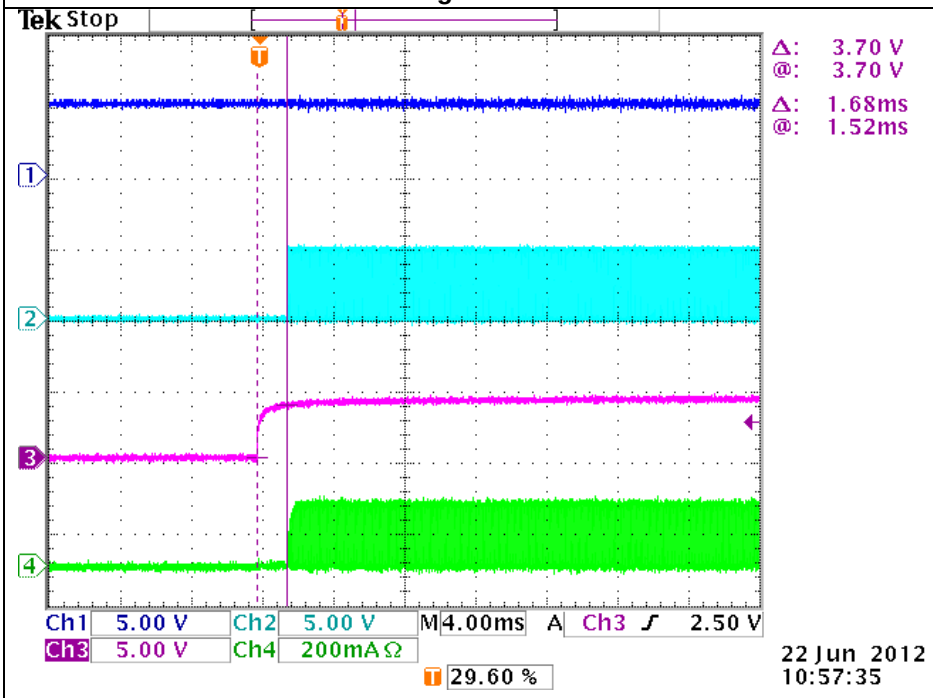
FD0267Af Output Waveforms Measurement(Cont'd)



FD0267Af
+5.0V
Variable Speed
(~ 50% Duty)
Soft-Switching

CH1: NO Output
CH2: SO Output
CH3: FG Output
CH4: Input Current

Figure 23



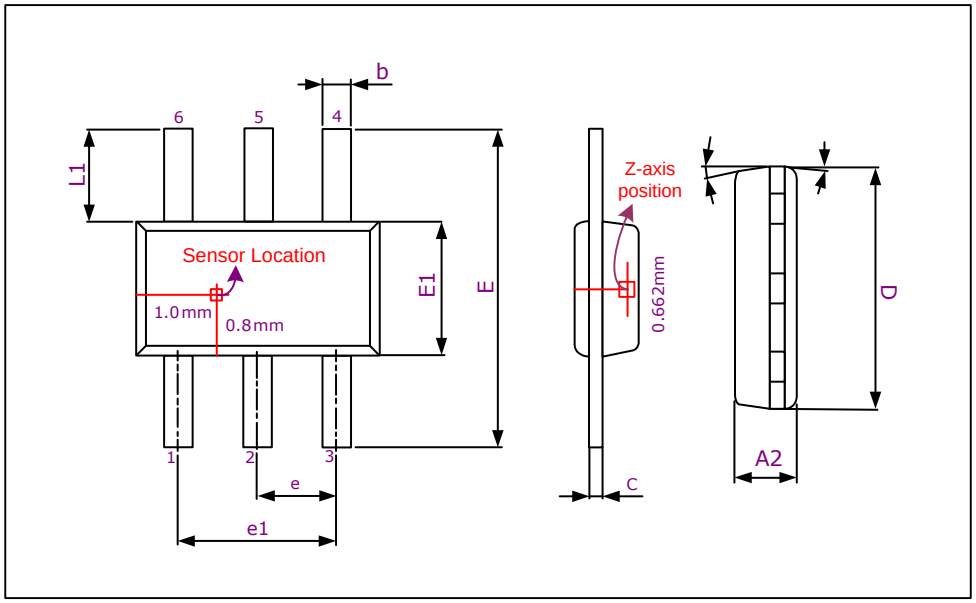
FD0267Af
+5.0V
Quick Start

CH1: Input Voltage
CH2: SO Output
CH3: PWM Input
CH4: Input Current

Figure 24

Package Dimension

TS826 (Halogen Free)



Unit: mm

Symbols	Dimension In Millimeters		
	Min.	Nom.	Max.
A2	0.700	0.750	0.775
b	0.350	-	0.500
c	0.100	-	0.200
D	2.800	2.900	3.000
E	3.600	3.800	4.000
E1	1.500	1.600	1.700
e	0.950 BSC.		
e1	1.900 BSC.		
L1	1.100 REF.		