FEELING TECHNOLOGY

FD1251Kf

All-in-One Variable Speed BLDC Motor Driver IC

Features

Halogen Free

- Built-in high sensitivity Hall-effect sensor
- H-bridge MOS driver
- Output dynamic hard-switching to reduce vibration and acoustic noise
- Rotor lock shutdown & auto-restart function
- DC bias variable speed control
- Tachometer signal(FG) output
- Thermal shutdown protection(TSD)
- Available in TS826 package
- For 12V BLDC motor / FAN systems

General Description

FD1251Kf 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 DC bias 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 FD1251Kf 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.

Block Diagram

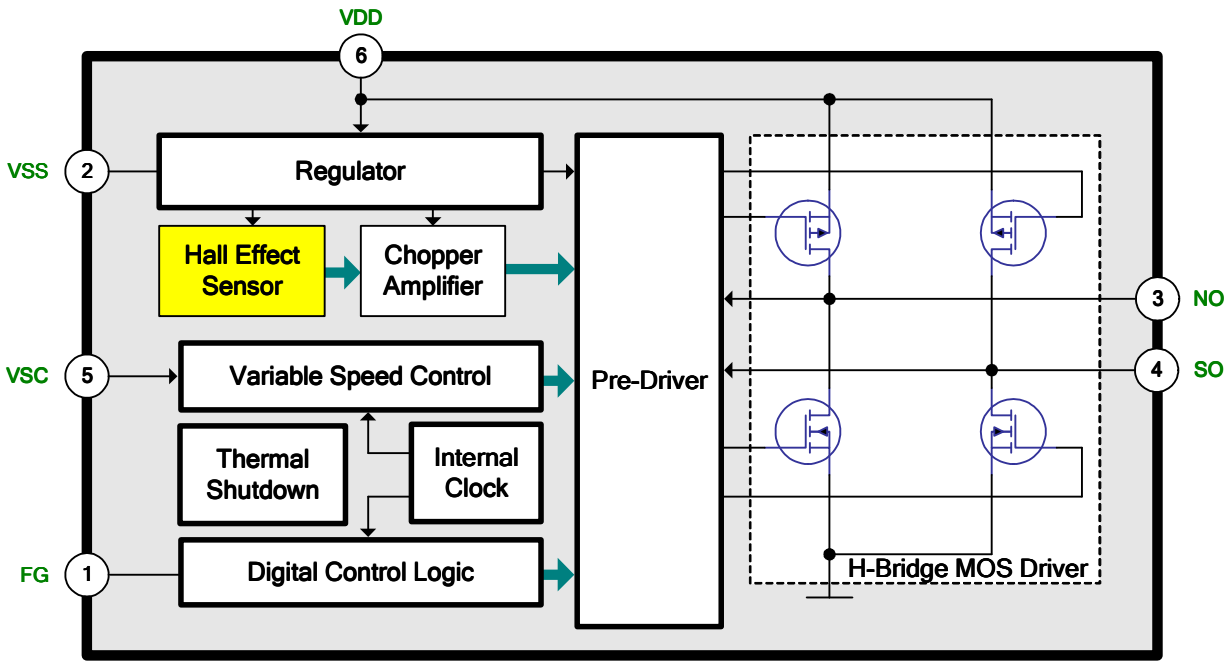
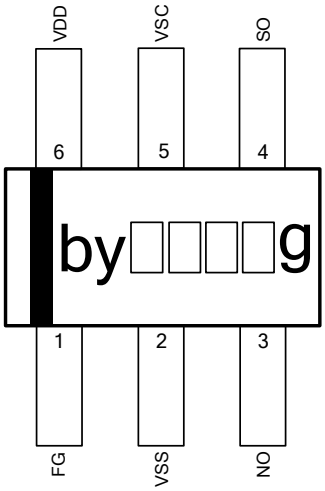


Figure 1

Pin Assignment



FD1251Kf

Figure 2

Pin Descriptions

Name	I/O	FD1251Kf	Description
FG	O	1	Tachometer Signal Output
VSS	G	2	IC Ground
NO	O	3	Driver Output 1
SO	O	4	Driver Output 2
VSC	I	5	DC Bias Variable Speed Control
VDD	P	6	IC Power Supply

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

Functional Descriptions

Refer to the block diagram (Figure 1), FD1251Kf 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 FD1251Kf 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.).

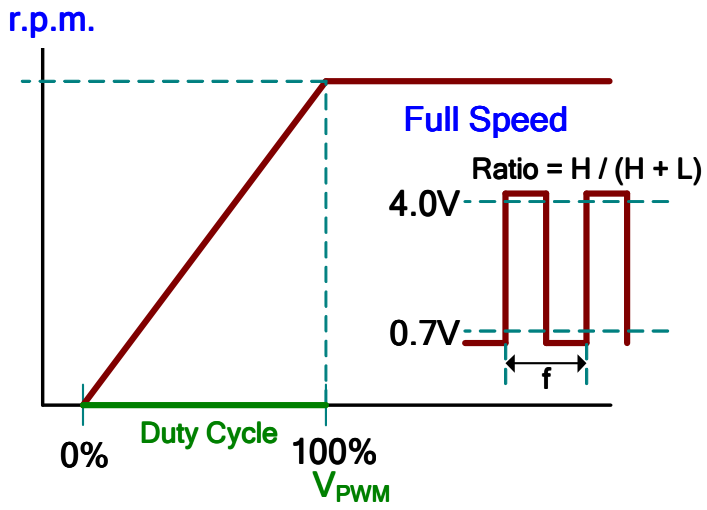


Figure 3

Note:

(1) The lower-limit for the PWM pulse frequency is 200Hz, and the recommended frequency range is in the range of 25~30kHz 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%.

➢ ***DC Level Mode***

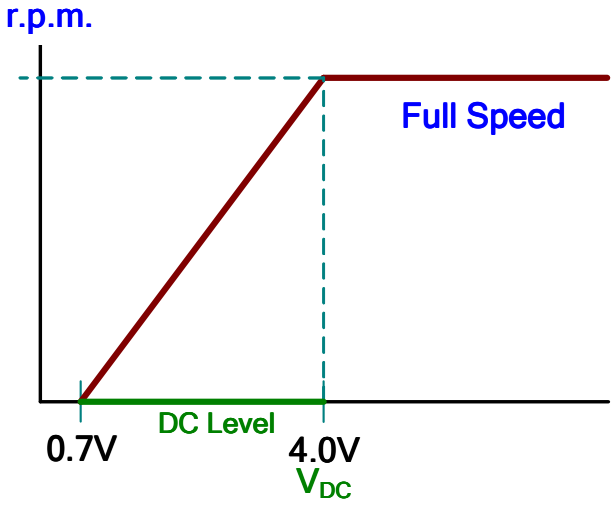


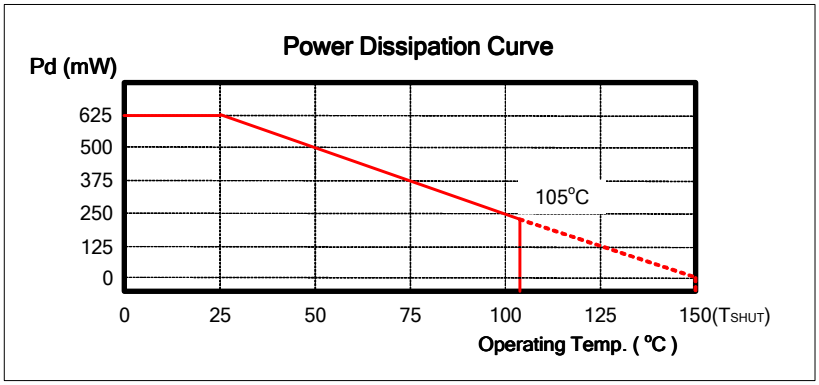
Figure 4

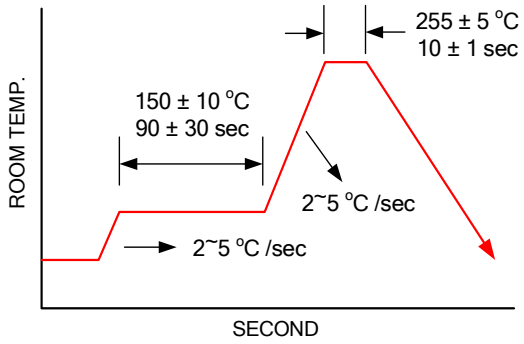
Applying a DC voltage to the VSC pin and the FD1251Kf will generate PWM pulses internally with duty cycle ratio in output “ON” state according to the diagram below(Figure 4), which can be utilized by the user to control the speed of the motor. The rotation speed will be higher if the voltage applied to the VSC pin is higher.

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	-	18.0	V
DC Supply Current (No Loading)	$I_{DD(AVG.)}$	-	-	-	8.0	mA
Maximum Output Current	$I_{O(MAX.)}$	-	-	-	500	mA
Tachometer Signal Sink Current	$I_{FG(ON)}$	-	-	-	25	mA
Tachometer Signal Off Voltage	$V_{FG(OFF)}$	-	-0.3	-	18.0	V
VSC Input Voltage	$V_{(VSC)}$	-	-0.3	-	V_{DD}	V
Junction Temperature	T_j	-	-	-	170	℃
Maximum Power Dissipation	$P_{D(TS826)}$	-	-	-	625	mW
Thermal Resistance (※1)	θ_{ja}	TS826	-	0.200	-	℃/mW
Thermal Resistance (※1)	θ_{jc}	TS826	-	0.056	-	℃/mW
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 ℃)*





IR-reflow Soldering Condition

Figure 5

Recommended Operating Conditions

Parameter	Symbol	Conditions	Values			Unit
			Min.	Typ.	Max.	
Supply Voltage	V_{DD}	-	4.0	-	15.0	V
Operating Temperature Range	$T_{OP.}$	-	-20	-	105	℃

DC Electrical Characteristics V_{DD}=12.0V, $T_{OP.}$=25℃ (unless otherwise specified)

Parameter	Symbol	Conditions	Values			Unit
			Min.	Typ.	Max.	
DC Supply Current	$I_{DD(AVG.)}$	No Loading	-	5.0	-	mA
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} = 3.0V	-	10.0	-	Ω
		V_{DD} = 12.0V	-	5.0	-	
DC Bias Threshold Voltage	$V_{VSCTH(L)}$	-	-	0.7	-	V
	$V_{VSCTH(H)}$	-	-	4.0	-	
Internal PWM Frequency	f_{PWM}	-	-	40	-	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}	-	2.8	4.0	5.2	s
Locked Rotor Off/On Ratio	T_{OFF}/T_{ON}	-	10	-	-	-
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	30	45	G
Release Point	B_{RP}		-45	-30	-5	G
Hysteresis	B_{HYS}		10	-	90	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

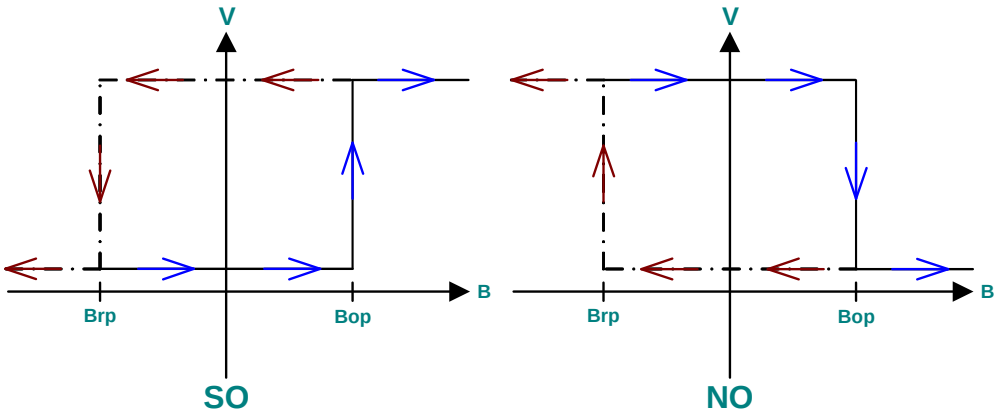


Figure 6

Performance Graphs

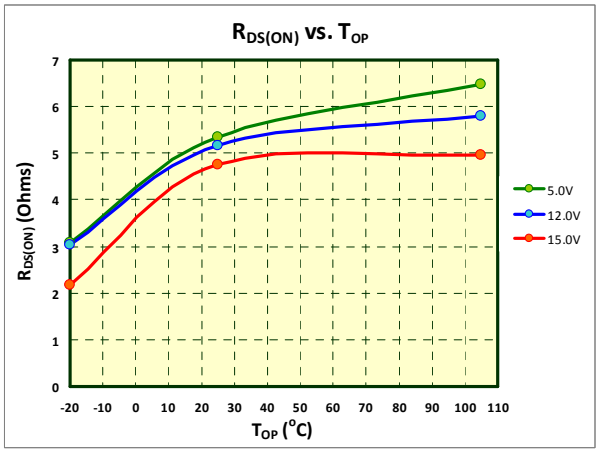


Figure 7

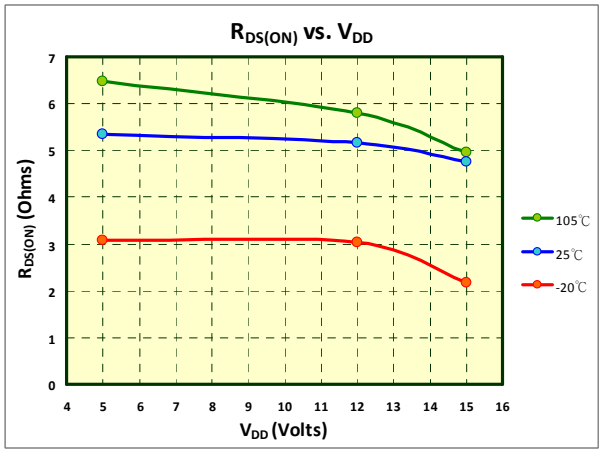


Figure 8

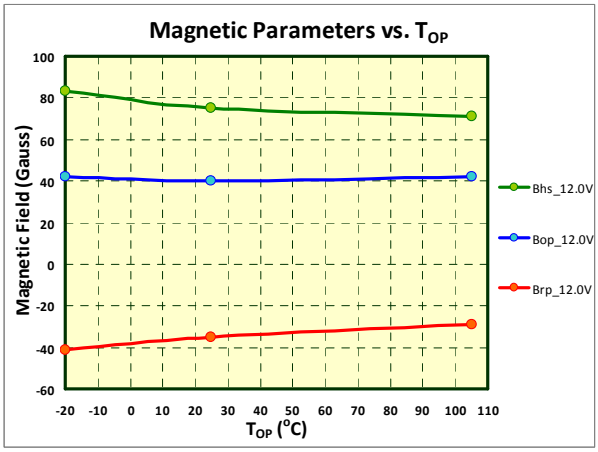


Figure 9

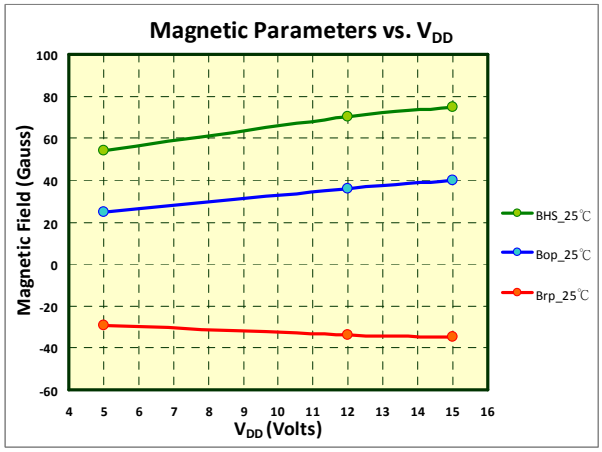


Figure 10

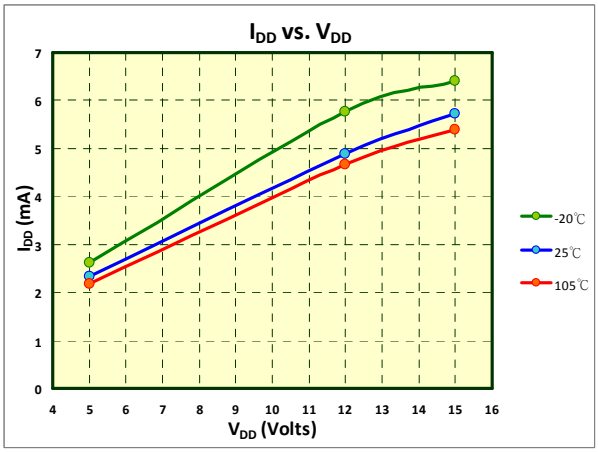


Figure 11

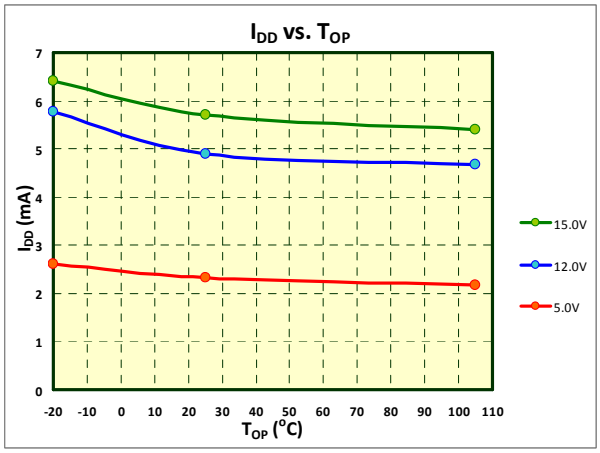


Figure 12

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.

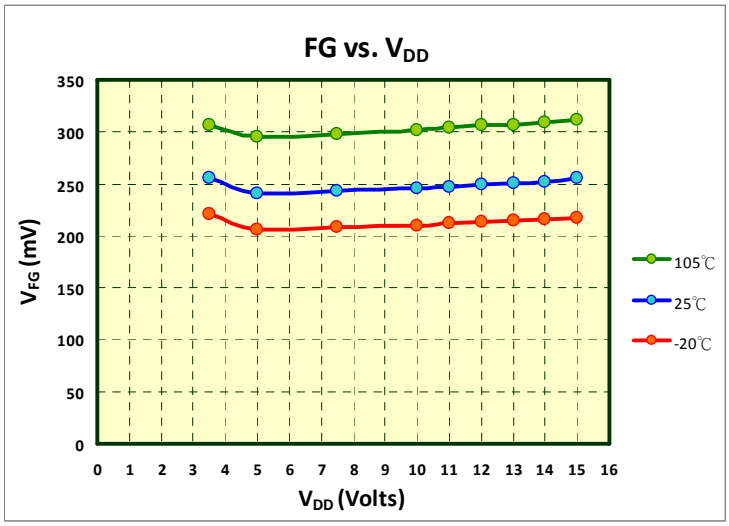


Figure 13

Power Loss Calculation

The main power loss of FD1251Kf 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.

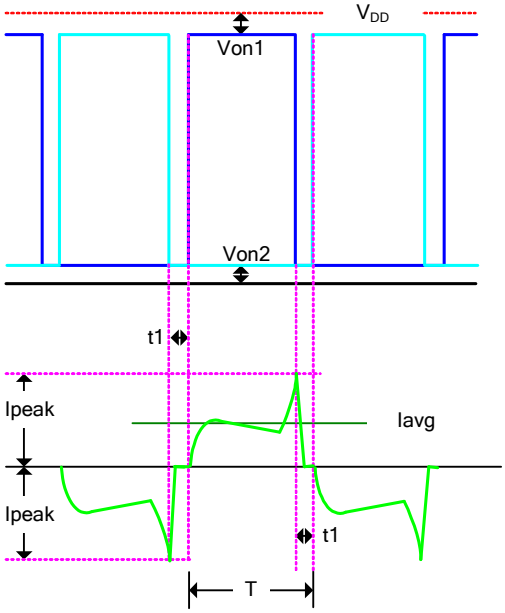


Figure 14

Total Power Loss Calculation Formula:

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

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

Application Circuits Reference

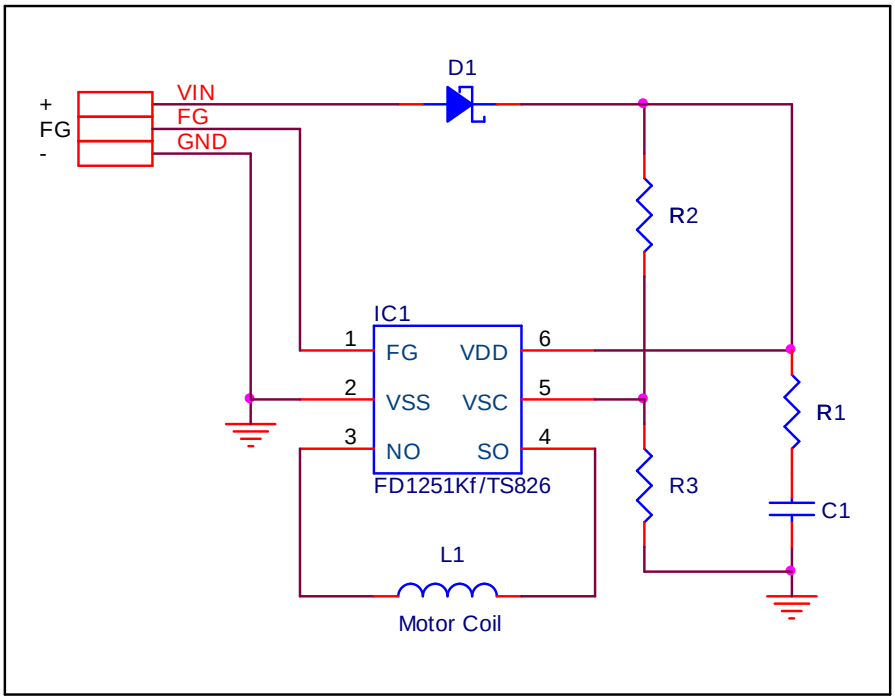


Figure 15 FD1251Kf 3-Wire DC Bias Variable Speed BLDC Motor Application Circuits

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-R3 is the speed of BLDC motor limitation resistance divider.***

FD1251Kf Output Waveforms Description(DC Bias Mode Operation)

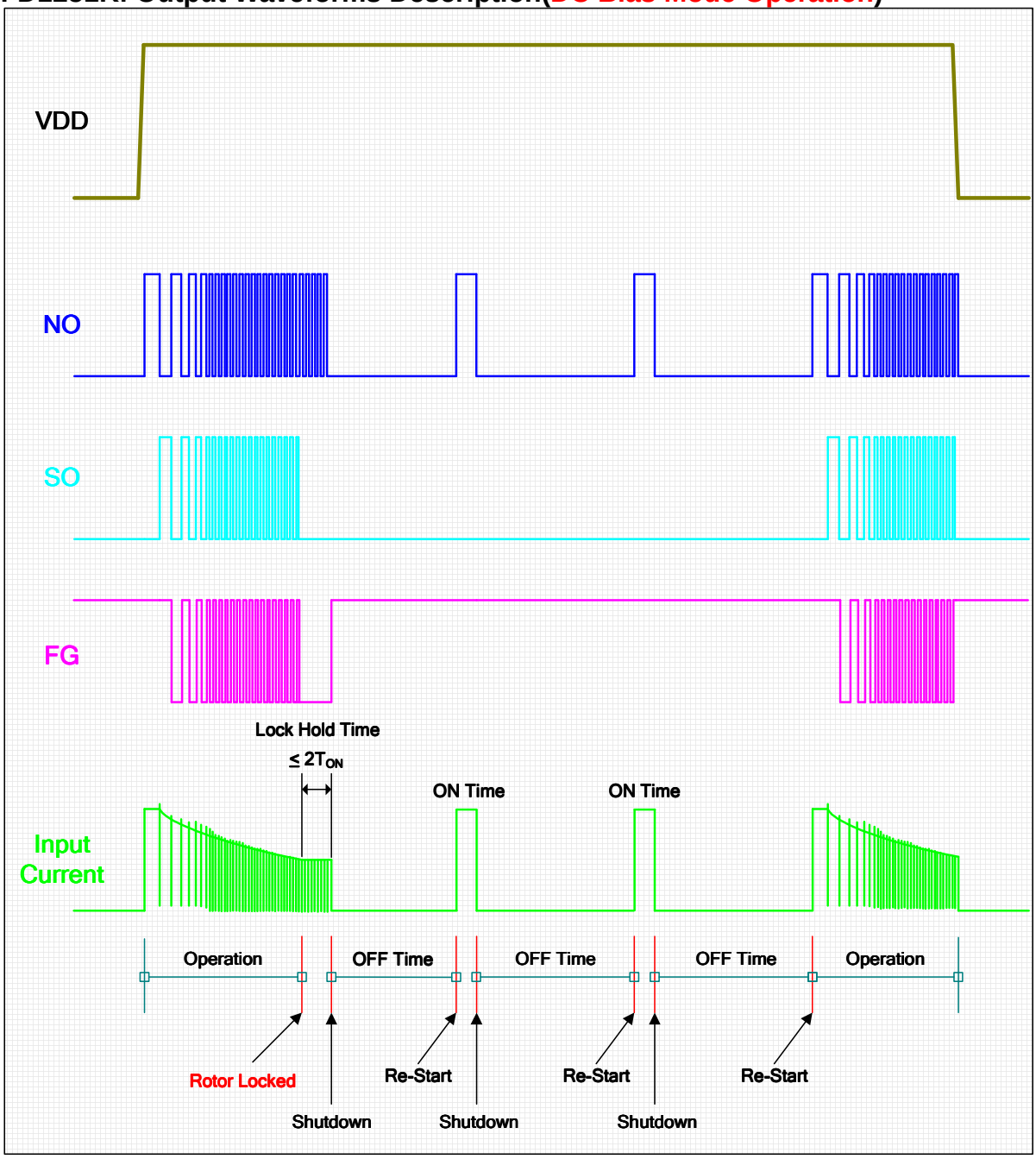
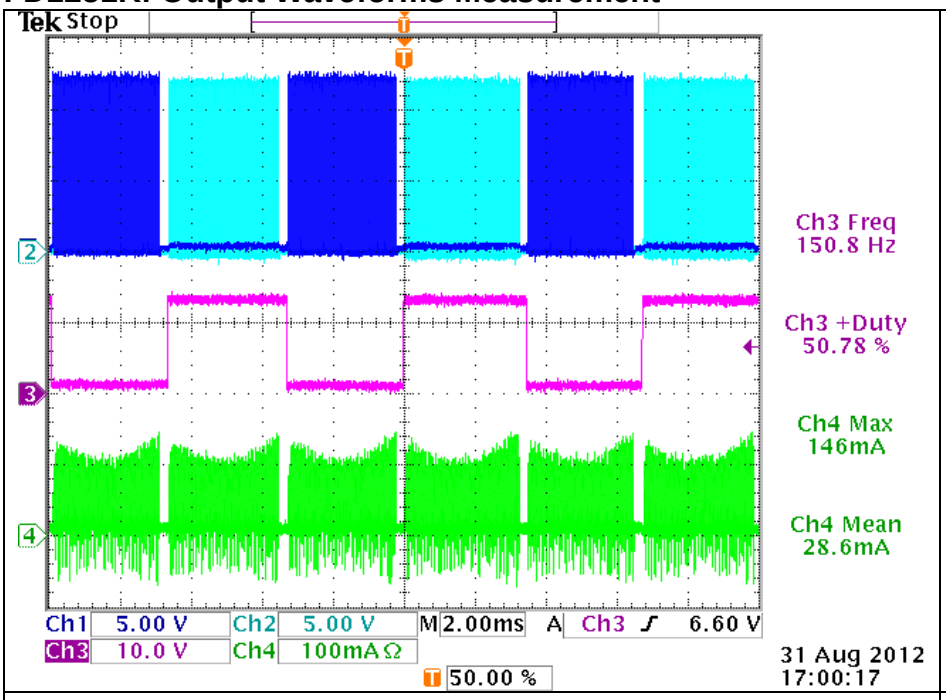


Figure 16

FD1251Kf Output Waveforms Measurement



FD1251Kf +12.0V Normal Operation

Ch1: NO Output
Ch2: SO Output
Ch3: FG Output
Ch4: Input Current

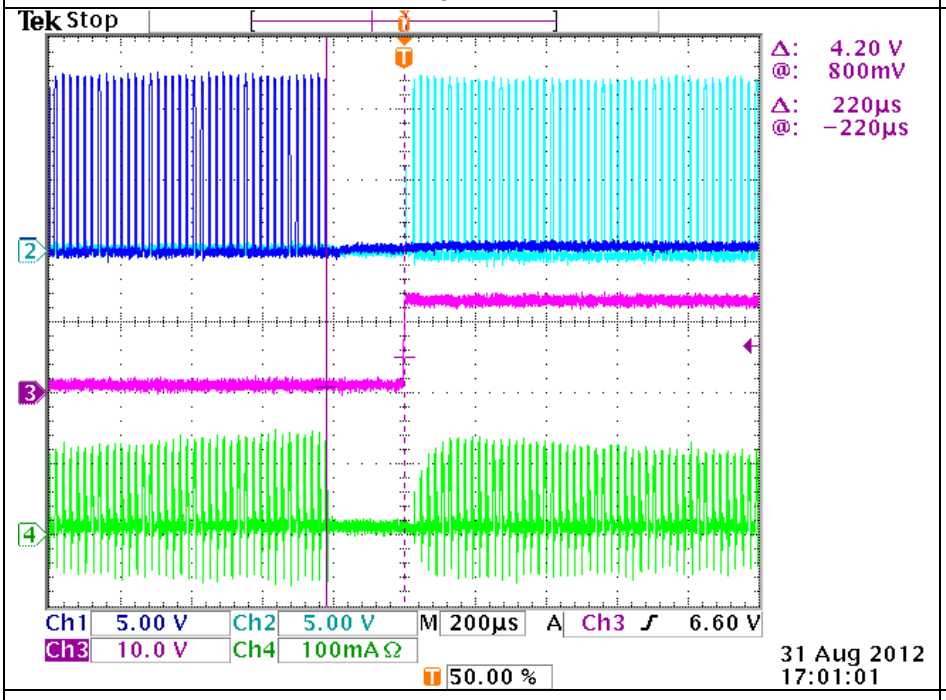
Motor Speed
(~ 4,524 rpm)

Input Average Current
(~ 28.6 mA)

Input Peak Current
(~ 146 mA)

FG Signal Duty Ratio
(~ 1.032)

Figure 17



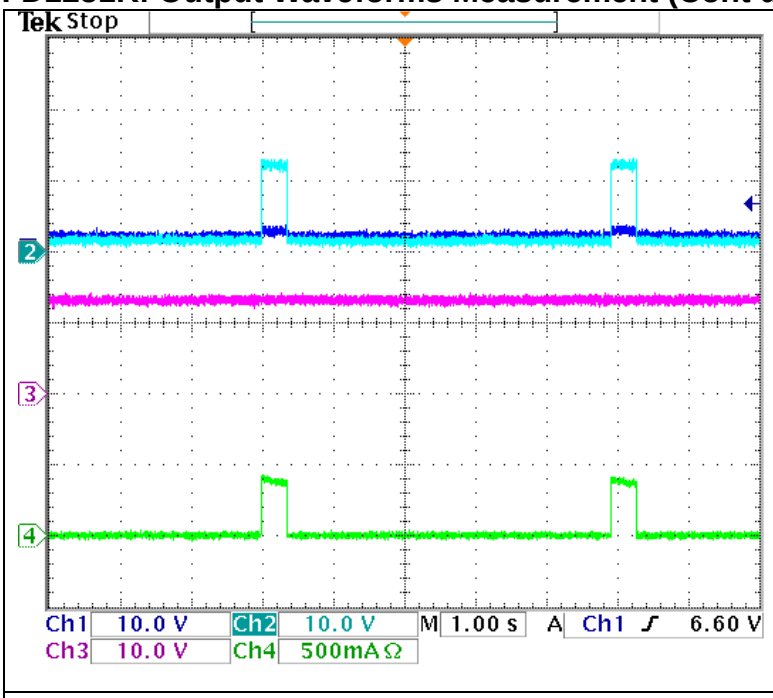
FD1251Kf +12.0V Soft-Switching

Ch1: NO Output
Ch2: SO Output
Ch3: FG Output
Ch4: Input Current

Switching time
(~ 220 µs)

Figure 18

FD1251Kf Output Waveforms Measurement (Cont'd)



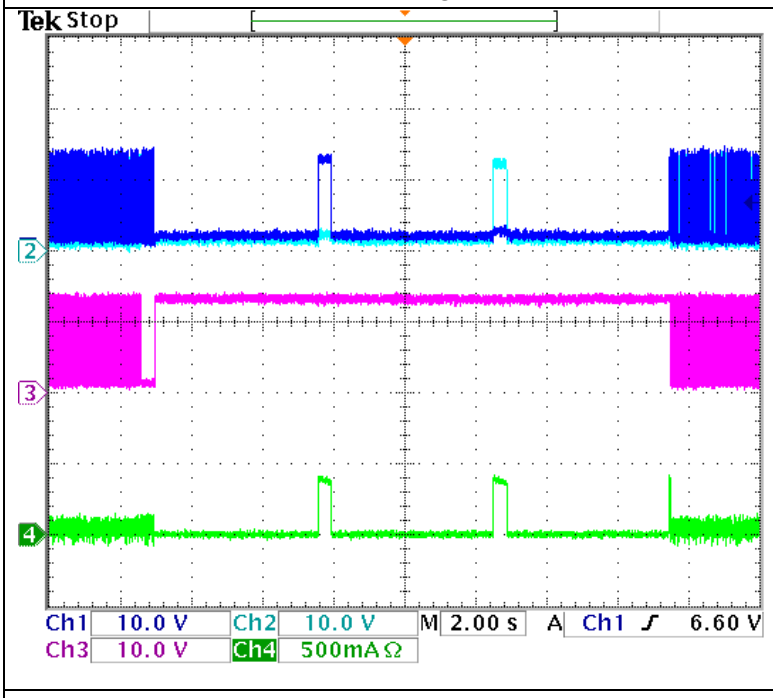
FD1251Kf +12.0V
Motor Locked

Ch1: NO Output
Ch2: SO Output
Ch3: FG Output
Ch4: Input Current

On time
(~ 0.367 s)

Off time
(~ 4.560 s)

Figure 19



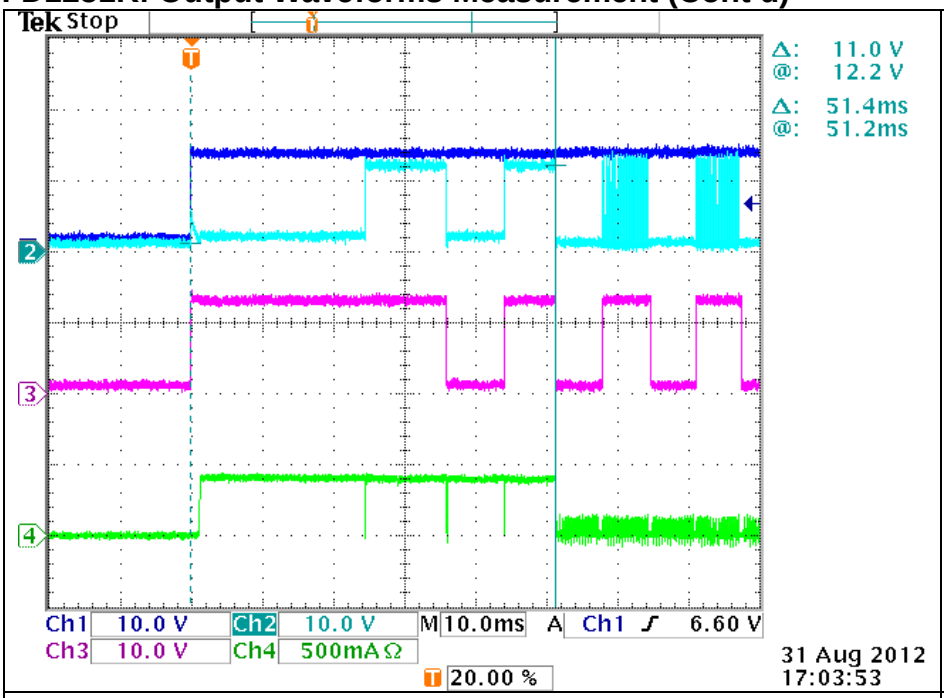
FD1251Kf +12.0V
Motor Locked
Auto Re-Start
(Operation → Hold → Operation)

Ch1: NO Output
Ch2: SO Output
Ch3: FG Output
Ch4: Input Current

Input Hold Current
(~ 420 mA)

Figure 20

FD1251Kf Output Waveforms Measurement (Cont'd)

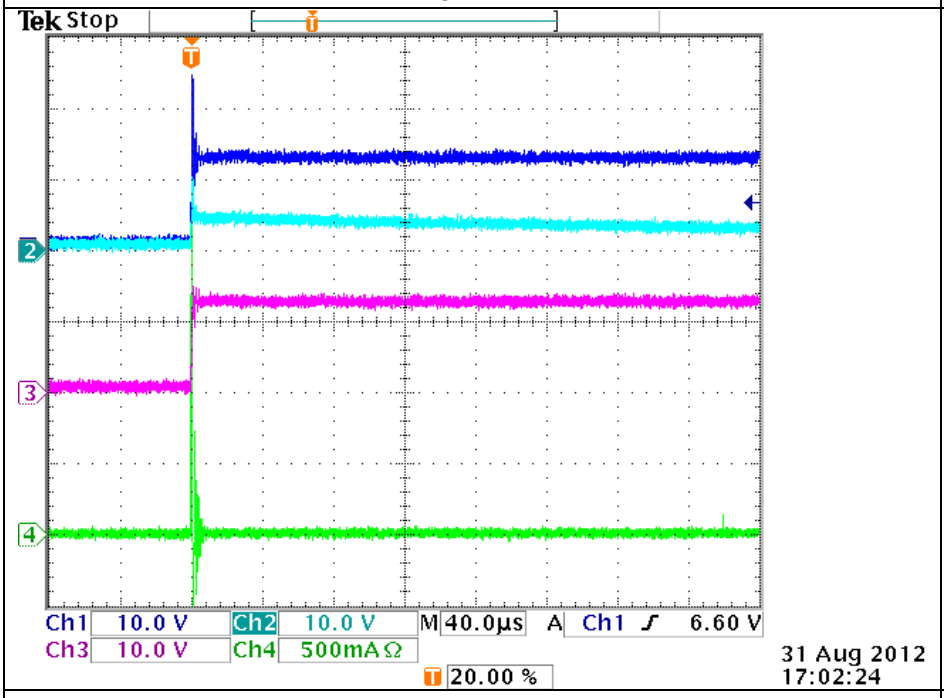


FD1251Kf +12.0V Power-On

Ch1: Input Voltage
Ch2: SO Output
Ch3: FG Output
Ch4: Input Current

Power rotation phase time (~ 51.4 ms)

Figure 21



FD1251Kf +13.2V Power-On (Hot-Plug)

Ch1: Input Voltage
Ch2: SO Output
Ch3: FG Output
Ch4: Input Current

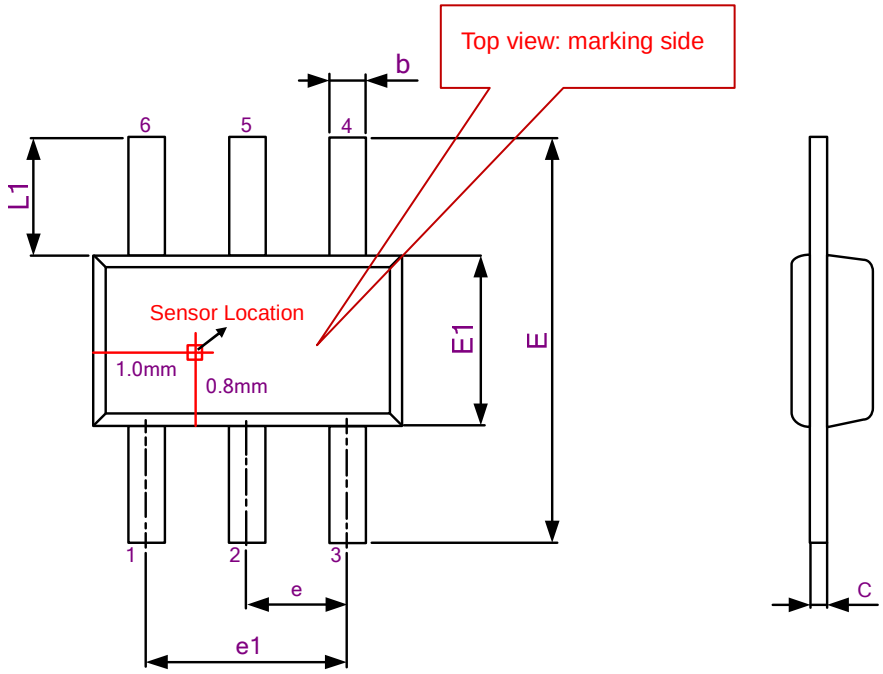
External Parts:
R = 1.0Ω
C = 0.1µF

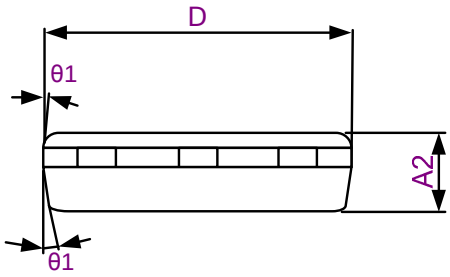
Poor R-C value condition would occur the over-shoot peak voltage and input current bouncing without the damping effect.

Figure 22

Package Dimension (Unit: mm)

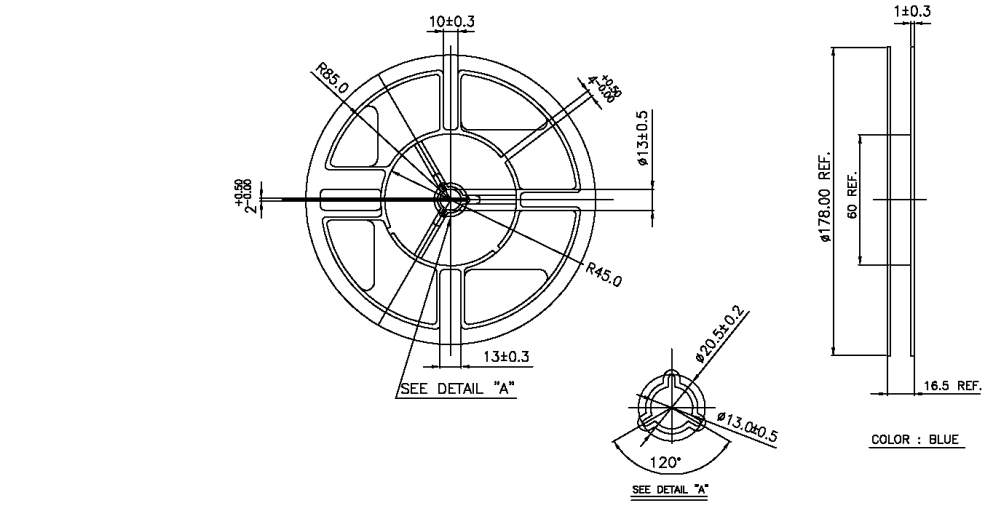
TS826 (Halogen Free)

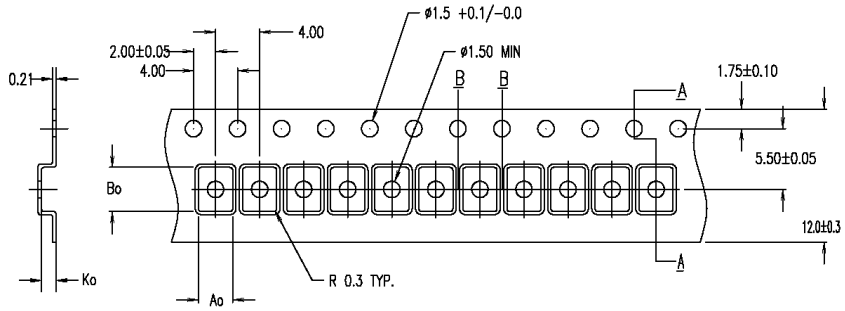


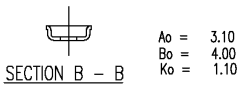


Symbols	Dimension In Millimeters		
	Min.	Nom.	Max.
A2	0.700	0.750	0.775
b	0.350	-	0.500
c	0.100	-	0.200
D	2.800	2.900	3.000
E	3.600	3.800	4.000
E1	1.500	1.600	1.700
e	0.950 BSC.		
e1	1.900 BSC.		
L1	1.100 REF.		
θ1	4°	10°	12°

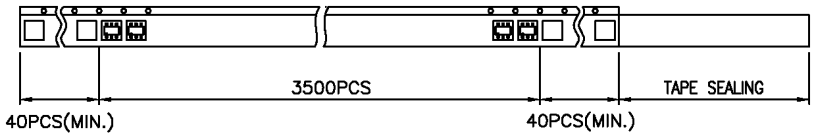
TS826 Reel & Tape

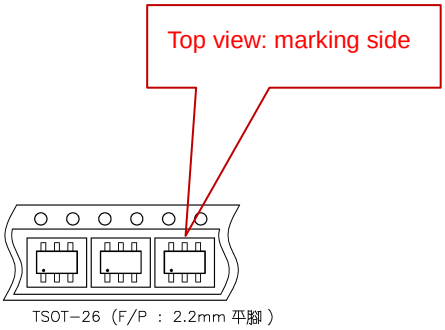






Ao = 3.10
Bo = 4.00
Ko = 1.10





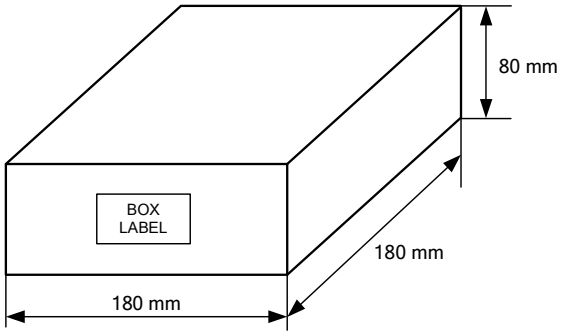
TSOT−26 (F/P : 2.2mm 平腳)

包裝方式： 3500 EA/PER REEL

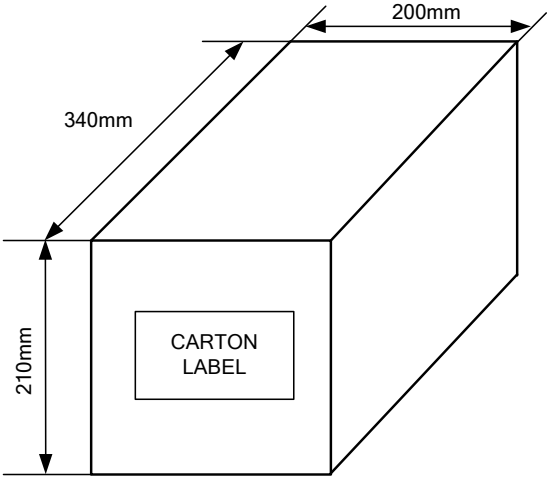
USER DIRECTION OF FEED

1. 10 sprocket hole pitch cumulative tolerance ± 0.2mm
2. Camber not to exceed 1mm in 100mm.
3. Material: Anti−Static Black Advantek Polystyrene.
4. Ao and Bo measured on a plane 0.3mm above the bottom of the pocket.
5. Ko measured from a plane on the inside bottom of the pocket to the top surface of the carrier.
6. Pocket position relative to sprocket hole measured as true position of pocket, not pocket hole.

TS826 Inside Box & Carton Dimension



INSIDE BOX

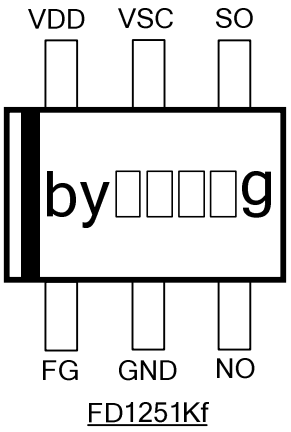


CARTON

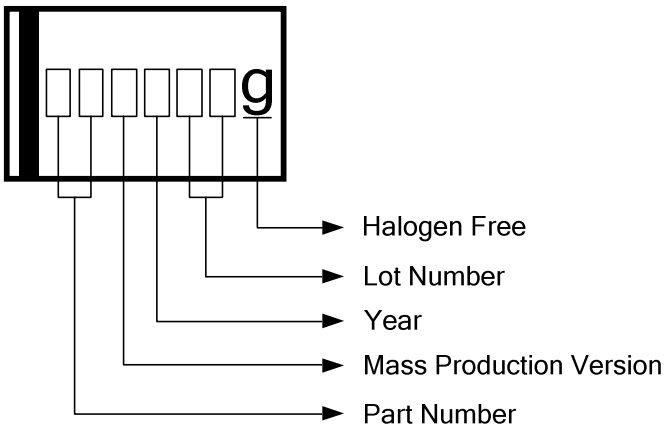
TS826 Packing Quantity Specification

	Quantity
3,500 ea /1 Reel	3,500 ea / Reel
3 Reels /1 Inside Box	10,500 ea / Inside Box
4 Inside Boxes /1 Carton	42,000 ea / Carton

IC Pin Connection



Marking Distinguish



Order Information

Part Number	Operating Temperature	Package	Description		MOQ	MSL
FD1251Kf-G1	-20℃ to +105℃	TS826	±45G (B)	Tachometer O/P	-	3
FD1251KfR-G1					3,500EA / REEL	