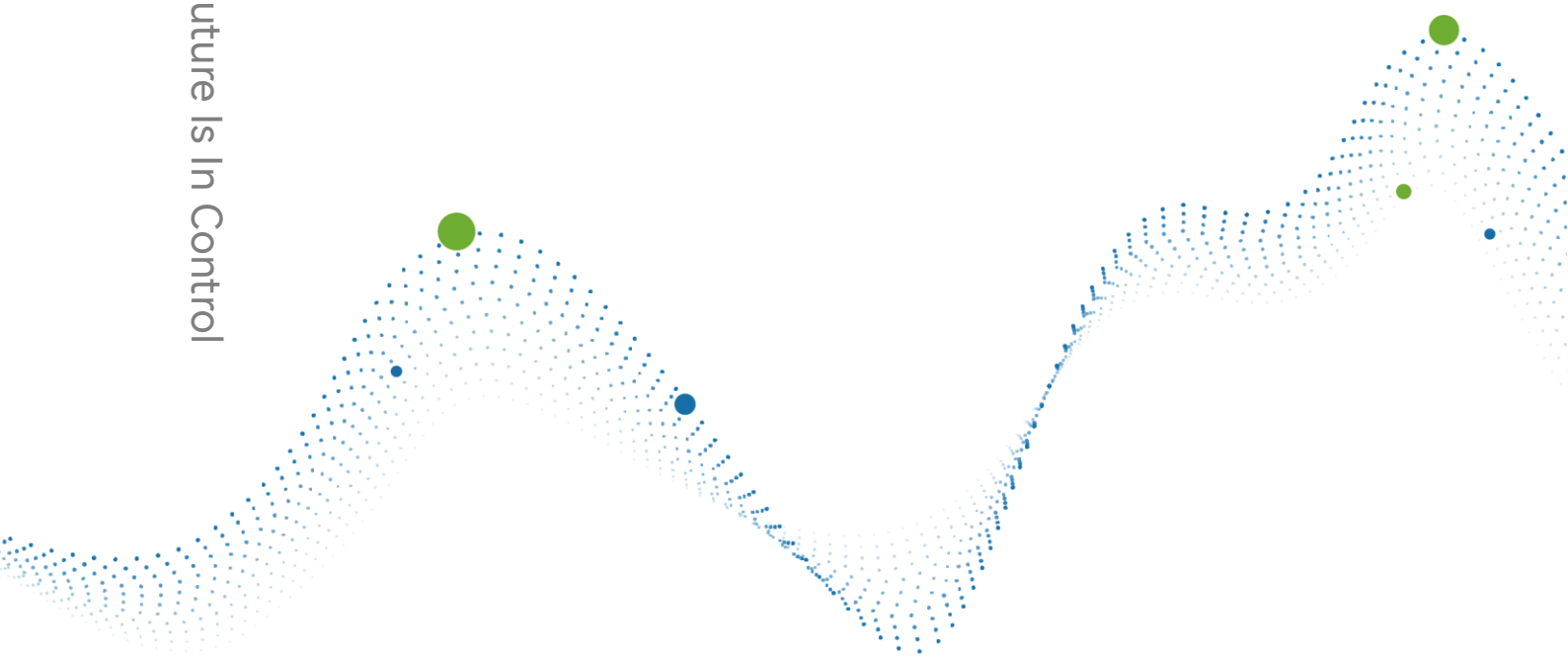
Fortior Tech

DATASHEET

FA1611

Single-phase Fully Integrated BLDC Motor Controller

Future Is In Control



Version: V3.1

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Contents

1 System Introduction

1.1 Overview

FA1611 is a fully integrated IC with built-in MOS and Hall-based sensor for single-phase BLDC motor driver applications.[1] It supports soft-switching square-wave control mode, and features with low noise. Motor control parameters, such as soft-switching slope, lead angle, etc., can be flexibly configured via GUI to achieve required efficiency and reduce noise, in order to meet different application requirements. Moreover, the chip supports 4-segment speed control curve, protection restart configurations and FG/RD output to fulfill different input and output requirements.

The above are the general descriptions on the product family. The features vary by models. For details, see section 1.7 Pin Definitions and 3 Ordering Information.

For concise description and easy differentiation, if it is specified that a feature is applied to a specific model, the feature is exclusive to this model. Otherwise, the feature is a common feature of the product family.

FA1611 product family: FA1611S (SOP8), FA1611N (DFN10), FA1611NA (DFN10)

Note

[1] FA1611NA supports external Hall input

1.2 Applications

Cooling fans, water-cooling fans, refrigerator fans, etc.

1.3 Features

- VCC range: 3.3V ~ 16V
- FA1611S drive current: 450mA@85℃
- FA1611N drive current: 550mA@85℃
- FA1611NA drive current: 550mA@85℃
- High level of integration with built-in MOS and Hall-based sensor
- Highly sensitive Hall-based sensor
- Single-phase and soft-switching square-wave control
- FG and RD output
- SPEED and I²C modes for motor speed regulation
- Built-in EFUSE
- Configurable 4-segment output curve
- Forward and reverse direction control
- Soft-on feature protects the motor from abrupt startup and reduces current shock and noise
- Support protection features, including CLP, OCP, TSD, MLP, etc.

1.4 Package

Figure 1-1 FA1611S

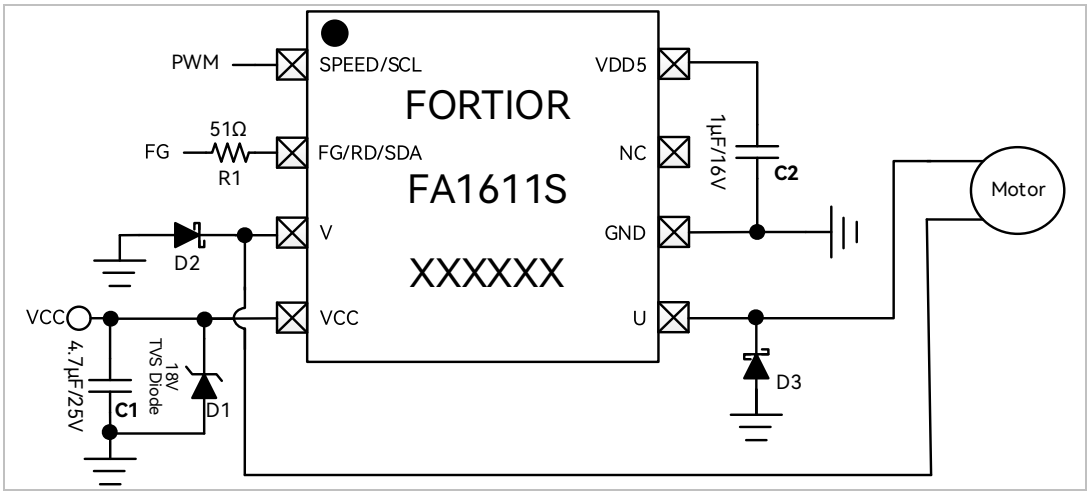
Figure 1-2 FA1611N

Figure 1-3FA1611NA

1.5 Typical Application Diagram

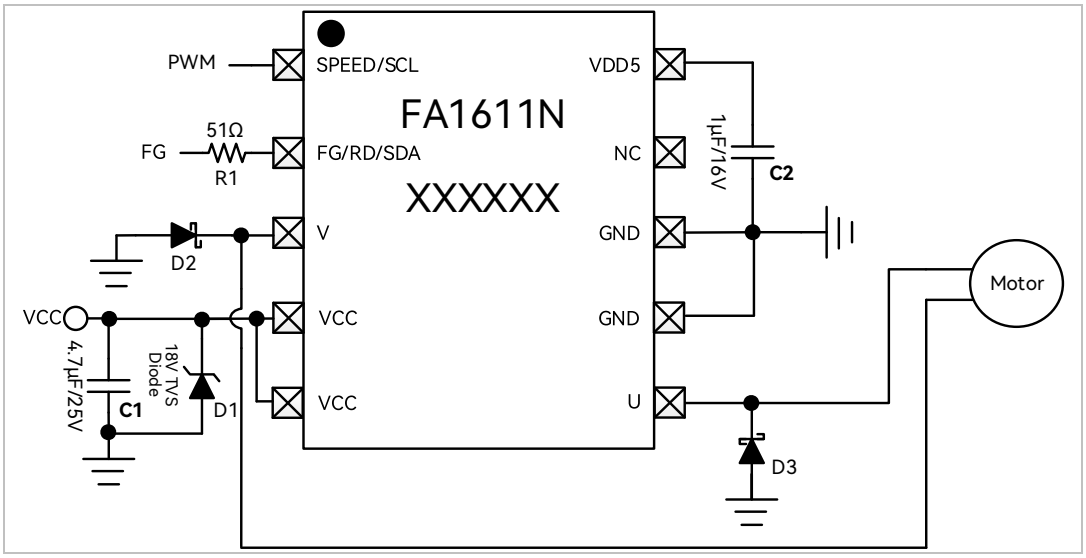
1.5.1 FA1611S

Figure 1-4 Typical Application Diagram of FA1611S



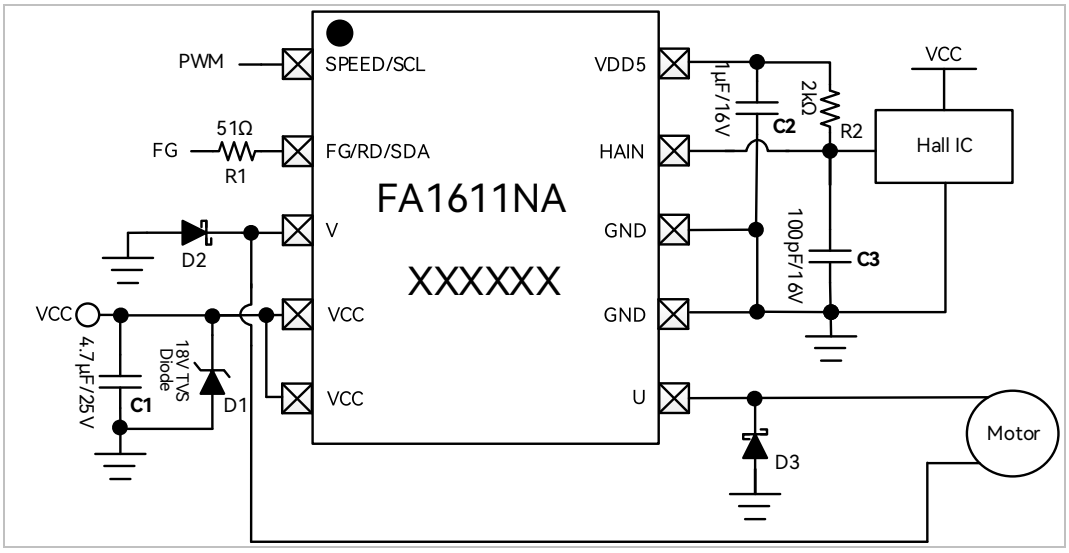
1.5.2 FA1611N

Figure 1-5 Typical Application Diagram of FA1611N



1.5.3 FA1611NA

Figure 1-6 Typical Application Diagram of FA1611NA



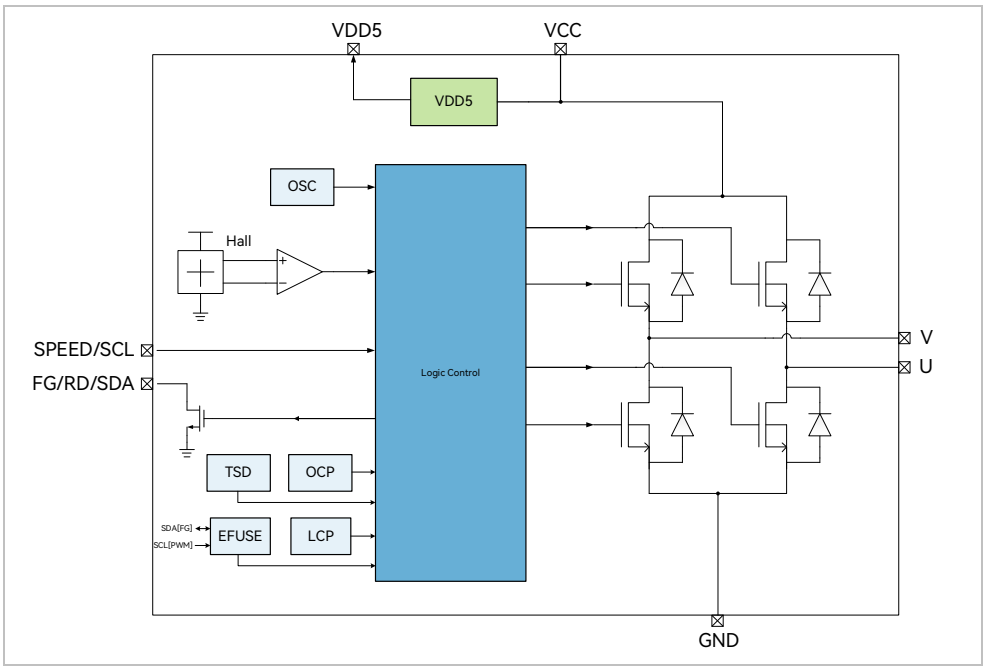
Note

Place C1 and C2 close to IC pins on PCB board.

1.6 Functional Block Diagram

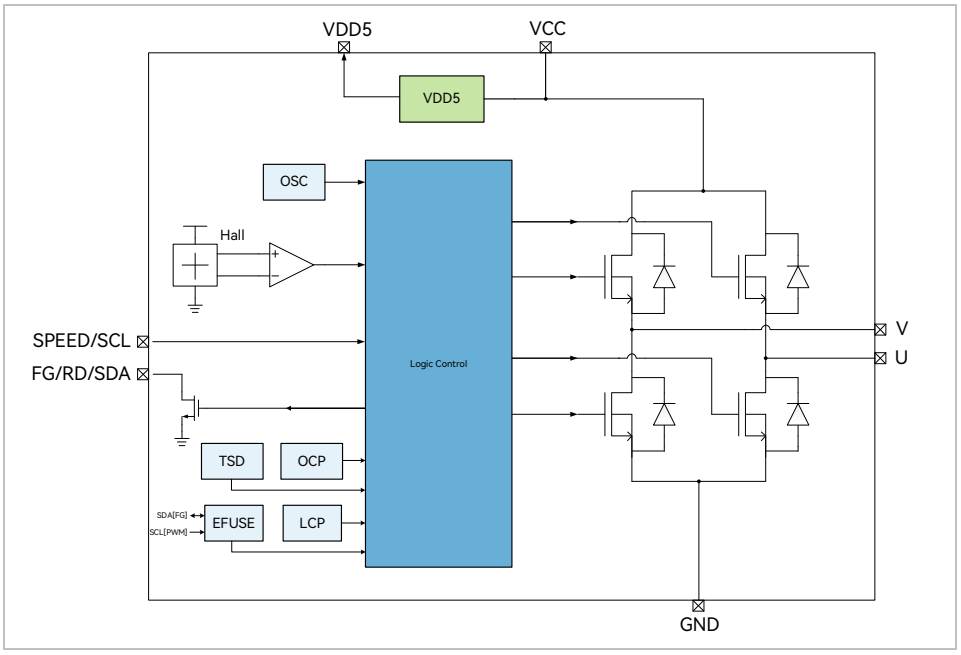
1.6.1 FA1611S

Figure 1-7 Functional Block Diagram of FA1611S



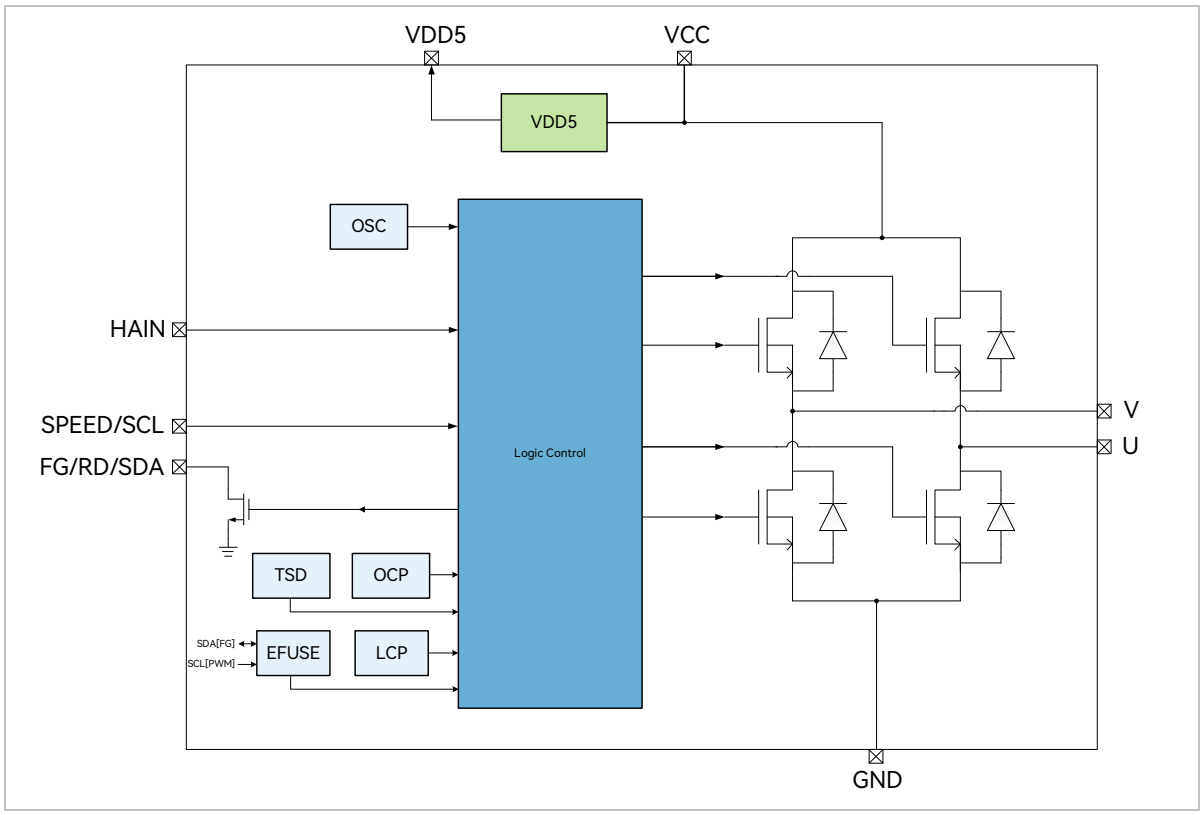
1.6.2 FA1611N

Figure 1-8 Functional Block Diagram of FA1611N



1.6.3 FA1611NA

Figure 1-9 Functional Block Diagram of FA1611NA



1.7 Pin Definitions

The IO types are defined as follows:

- DI = Digital Input
- DO = Digital Output
- DB = Digital Bidirectional
- P = Power Supply

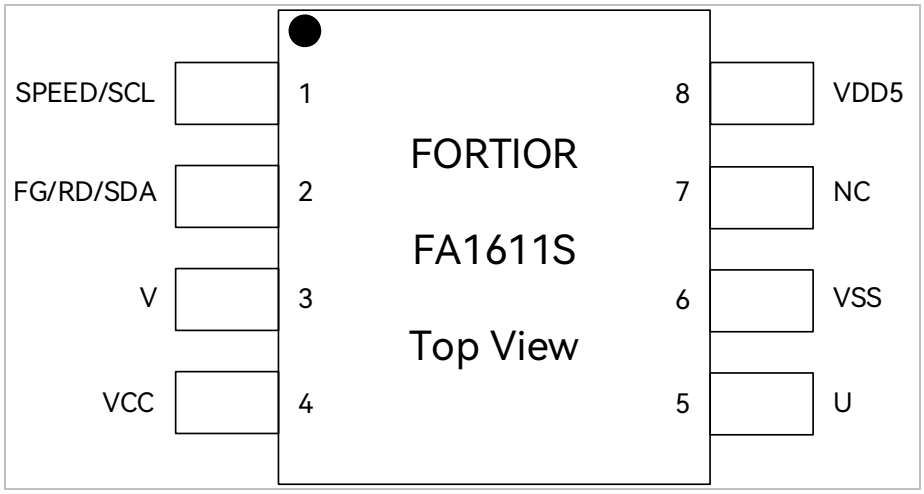
1.7.1 FA1611S SOP8 Pins

Table 1-1 FA1611S SOP8 Pin Descriptions

Pin	FA1611S SOP8	IO Type	Function Descriptions
SPEED/ SCL	1	DI/ DB	Speed control input; PWM speed regulation; Frequency ranges: 0.1 ~ 100kHz I²C SCL
FG/RD/ SDA	2	DO/ DB	Speed indication output; Collector open-drain output I²C SDA, configured as collector open-drain output
V	3	DO	V-phase output
VCC	4	P	Power supply. The input voltage range is 3.3V ~ 16V, with a capacitor of 4.7μF or above connected to ground
U	5	DO	U-phase output
VSS	6	P	Ground
NC	7	-	Not connected
VDD5	8	P	Internal LDO output connected in parallel with a 1μF ~ 4.7μF capacitor connected to ground

1.7.2 FA1611S SOP8

Figure 1-10 FA1611S SOP8 Pinout Diagram



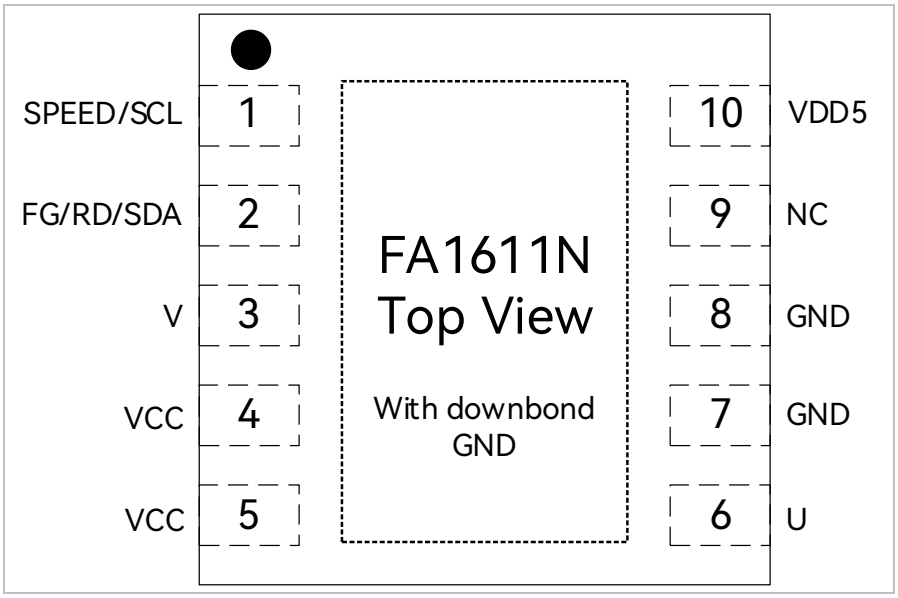
1.7.3 FA1611N DFN10 Pins

Table 1-2 FA1611N DFN10 Pinout Descriptions

Pin	FA1611N DFN10	IO Type	Function Descriptions
SPEED/ SCL	1	DI/ DB	Speed control input; PWM speed regulation; Frequency ranges: 0.1 ~ 100kHz I²C SCL
FG/RD/ SDA	2	DO/ DB	Speed indication output; Collector open-drain output I²C SDA, configured as collector open-drain output
V	3	DO	V-phase output
VCC	4	P	Power supply. The input voltage range is 3.3V ~ 16V, with a capacitor of 4.7μF or above connected to ground
VCC	5	P	Power supply. The input voltage range is 3.3V ~ 16V, with a capacitor of 4.7μF or above connected to ground
U	6	DO	U-phase output
GND	7	P	Ground
GND	8	P	Ground
NC	9	-	Not connected
VDD5	10	P	Internal LDO output connected in parallel with a 1μF ~ 4.7μF capacitor connected to ground
Bottom Pad	-	P	Ground

1.7.4 FA1611N DFN10 Pinout Diagram

Figure 1-11 FA1611N DFN10 Pinout Diagram



1.7.5 FA1611NA DFN10 Pins

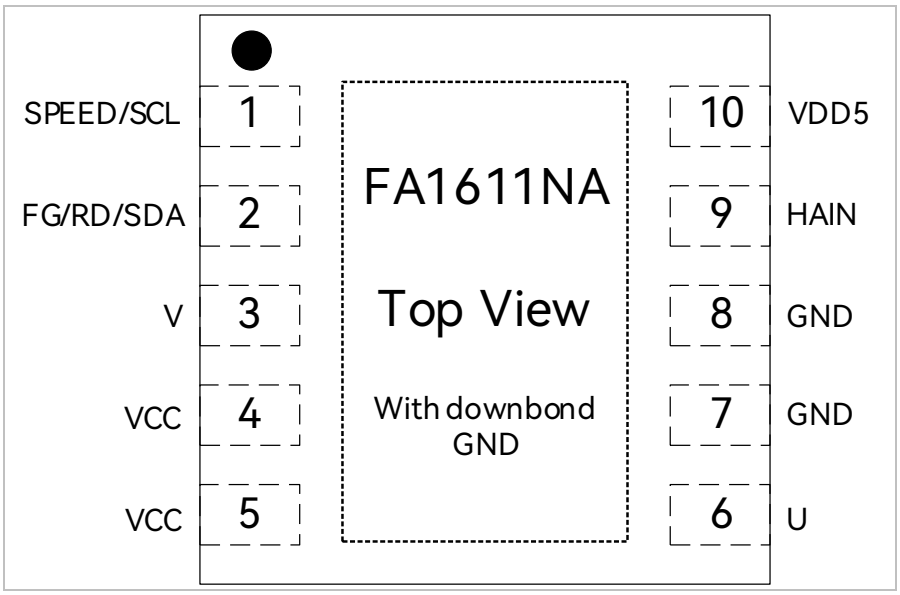
Table 1-3 FA1611NA DFN10 Pinout Descriptions

Pin	FA1611NA DFN10	IO Type	Function Descriptions
SPEED/	1	DI/	Speed control input; PWM speed regulation; Frequency ranges: 0.1 ~ 100kHz
SCL		DB	I²C SCL
FG/RD/ SDA	2	DO/ DB	Speed indication output; Collector open-drain output I²C SDA, configured as collector open-drain output
V	3	DO	V-phase output
VCC	4	P	Power supply. The input voltage range is 3.3V ~ 16V, with a capacitor of 4.7μF or above connected to ground
VCC	5	P	Power supply. The input voltage range is 3.3V ~ 16V, with a capacitor of 4.7μF or above connected to ground
U	6	DO	U-phase output
GND	7	P	Ground
GND	8	P	Ground
HAIN	9	DI	Hall IC signal input

Pin	FA1611NA DFN10	IO Type	Function Descriptions
VDD5	10	P	Internal LDO output connected in parallel with a 1μF ~ 4.7μF capacitor connected to ground
Bottom Pad	-	P	Ground

1.7.6 FA1611NA DFN10 Pinout Diagram

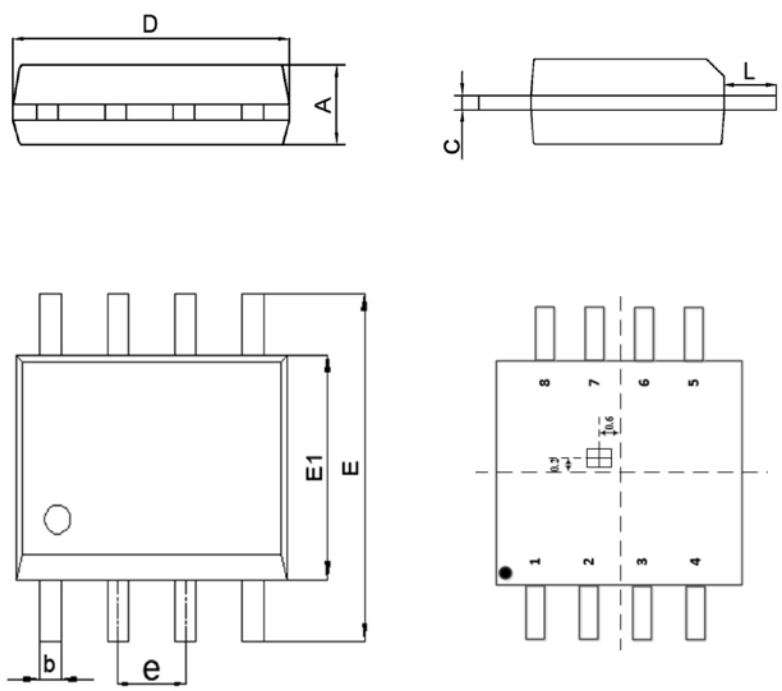
Figure 1-12 FA1611NA DFN10 Pinout Diagram



2 Package Information

2.1 FA1611S SOP8_3.9X4.9

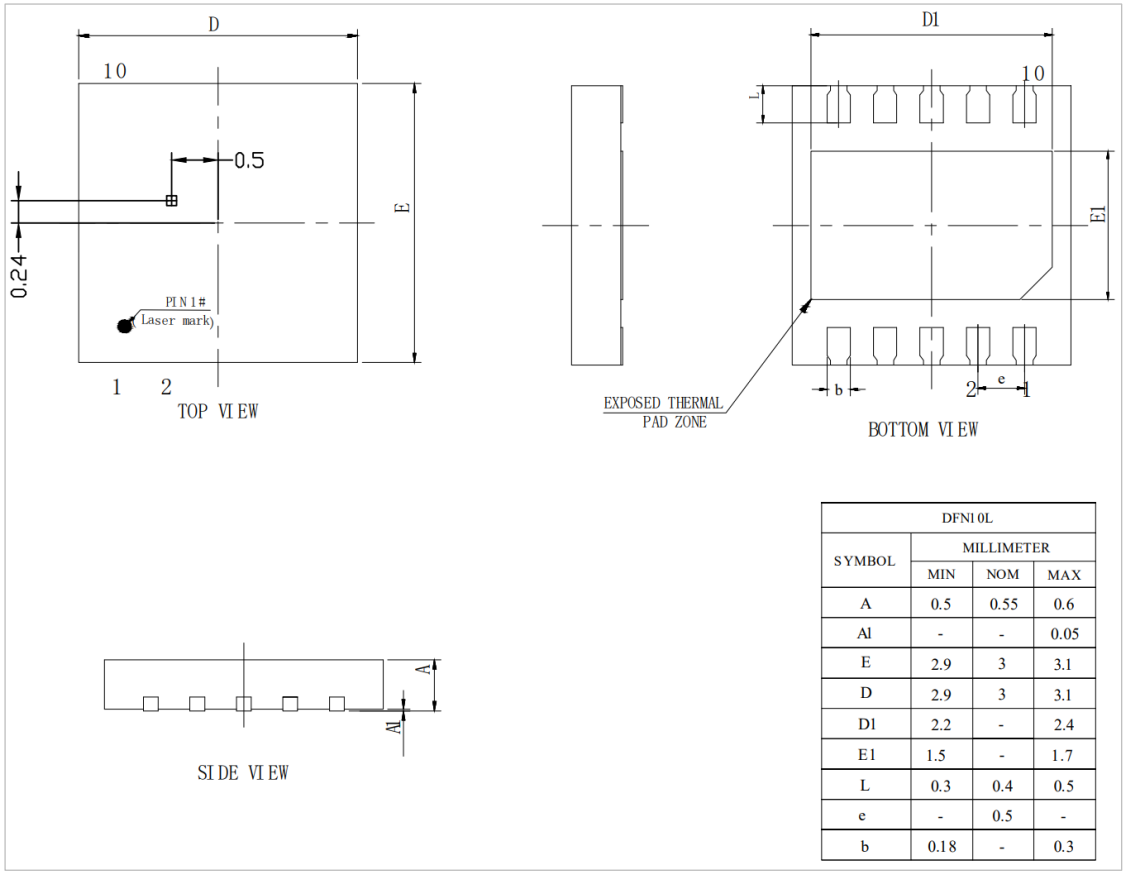
Figure 2-1 FA1611S SOP8_3.9X4.9 Package Drawings and Dimensions



SYMBOL	MILLIMETER		
	MIN	NOM	MAX
A	1.30	1.40	1.50
b	0.33	0.40	0.47
c	0.20	-	0.25
D	4.70	4.90	5.10
E	5.90	6.00	6.10
E1	3.80	3.90	4.00
e	1.27 (BSC)		
L	0.90	1.00	1.10

2.2 FA1611N DFN10_3X3

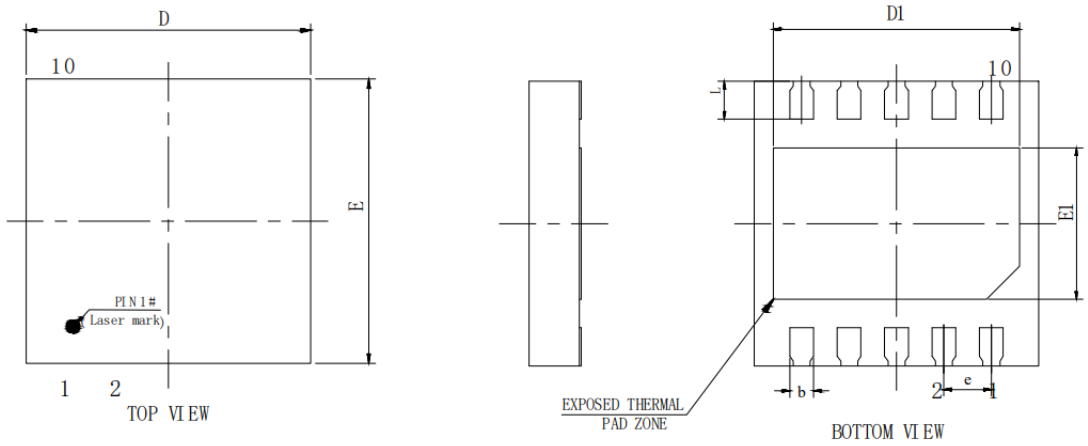
Figure 2-2 FA1611N DFN10_3X3 Package Drawings and Dimensions



DFN10L			
SYMBOL	MILLIMETER		
	MIN	NOM	MAX
A	0.5	0.55	0.6
A1	-	-	0.05
E	2.9	3	3.1
D	2.9	3	3.1
D1	2.2	-	2.4
E1	1.5	-	1.7
L	0.3	0.4	0.5
e	-	0.5	-
b	0.18	-	0.3

2.3 FA1611NA DFN10_3X3

Figure 2-3 FA1611NA DFN10_3X3 Package Drawings and Dimensions



DFN10L			
SYMBOL	MILLIMETER		
	MIN	NOM	MAX
A	0.5	0.55	0.6
A1	-	-	0.05
E	2.9	3	3.1
D	2.9	3	3.1
D1	2.2	-	2.4
E1	1.5	-	1.7
L	0.3	0.4	0.5
e	-	0.5	-
b	0.18	-	0.3

3 Ordering Information

Table 3-1 Model Selections

Model	Power Supply (V)	Rdson (High Side + Low Side) (Ω)	Average Drive Current (A)	Built-in Hall	Control Features			Protection Features					Operating Junction Temperature T_J (°C)	Lead-free	Package
					Drive Type	Speed Regulation		Over-current Protection/Current	Under-voltage Lockout	Over-voltage lockout (OVLO)	Motor Lock Protection	Over-temperature Protection			
						I²C	PWM								
FA1611S	3.3 ~ 16	1	450mA	√	Soft-switching square-wave control	√	√	√	-	-	√	√	-40 ~ 150	√	SOP8 3.9X4.9mm
FA1611N	3.3 ~ 16	1	550mA	√	Soft-switching square-wave control	√	√	√	-	-	√	√	-40 ~ 150	√	DFN10 3X3mm

Model	Power Supply (V)	Rdson (High Side + Low Side) (Ω)	Average Drive Current (A)	Built-in Hall	Control Features			Protection Features					Operating Junction Temperature T_J (°C)	Lead-free	Package
					Drive Type	Speed Regulation		Over-current Protection/Current	Under-voltage Lockout	Over-voltage lockout (OVLO)	Motor Lock Protection	Over-temperature Protection			
						I^2C	PWM								
FA1611NA	3.3 ~ 16	1	550mA	-	Soft-switching square-wave control	√	√	√	-	-	√	√	-40 ~ 150	√	DFN10 3X3mm

4 Electrical Characteristics

4.1 Absolute Maximum Ratings

4.1.1 FA1611S

Table 4-1 Absolute Maximum Ratings of FA1611S

(T_A = 25℃ and VCC = 12V unless otherwise specified)

Parameter	Test Conditions	Min.	Typ.	Max.	Unit
Operating Junction Temperature T_J		-40	-	150	℃
Storage Temperature T_{STG}		-55	-	150	℃
Operating Ambient Temperature T_A		-40	-	85	℃
VCC to VSS Voltage		-0.3	-	20	V
VDD5 to VSS Voltage		-0.3	5	6.5	V
U, V, FG/RD/SDA to VSS Voltage		-0.3	-	VCC + 0.3	V
SPEED/SCL, NC to VSS Voltage		-0.3	-	VDD + 0.3	V

4.1.2 FA1611N

Table 4-2 Absolute Maximum Ratings of FA1611N

(T_A = 25℃ and VCC = 12V unless otherwise specified)

Parameter	Test Conditions	Min.	Typ.	Max.	Unit
Operating Junction Temperature T_J		-40	-	150	℃
Storage Temperature T_{STG}		-55	-	150	℃
Operating Ambient Temperature T_A		-40	-	85	℃
VCC to VSS Voltage		-0.3	-	20	V
VDD5 to VSS Voltage		-0.3	5	6.5	V
U, V, FG/RD/SDA to VSS Voltage		-0.3	-	VCC + 0.3	V
SPEED/SCL, NC to VSS Voltage		-0.3	-	VDD + 0.3	V

4.1.3 FA1611NA

Table 4-3 Absolute Maximum Ratings of FA1611NA

(T_A = 25℃ and VCC = 12V unless otherwise specified)

Parameter	Test Conditions	Min.	Typ.	Max.	Unit
Operating Junction Temperature T_J		-40	-	150	℃
Storage Temperature T_{STG}		-55	-	150	℃
Operating Ambient Temperature T_A		-40	-	85	℃
VCC to VSS Voltage		-0.3	-	20	V
VDD5 to VSS Voltage		-0.3	5	6.5	V
U, V, FG/RD/SDA to VSS Voltage		-0.3	-	VCC + 0.3	V
SPEED/SCL, HAIN to VSS Voltage		-0.3	-	VDD + 0.3	V

Notes:

Stress values greater than "Absolute Maximum Ratings" listed in Table 4-1 ~ Table 4-3 may cause irremediable damages to the device. These are stress ratings only, and it is NOT recommended to use your device in conditions that go beyond these stress ratings. Exposure to "Absolute Maximum Ratings" for extended periods may affect device reliability.

4.2 Global Electrical Characteristics

4.2.1 FA1611S

Table 4-4 Global Electrical Characteristics of FA1611S

(T_A = 25℃ and VCC = 12V unless otherwise specified)

Parameter	Test Conditions	Min.	Typ.	Max.	Unit
VCC Operating Voltage		3.3	-	16	V
VDD5 Operating Voltage	I = 0mA ~ 10mA	4.8	5	5.2	V
VCC Operating Current $I_{VCC-work}$	T_A = 85℃	-	-	450	mA
Idling Current I_{VCC}		-	2.5	-	mA
Rdson（H+L）		-	1	-	Ω
Output Signal Wave		22	24	26	kHz
Positive Magnetic Threshold		-	1.5	3	mT
Negative Magnetic Threshold		-3	-1.5	-	mT

4.2.2 FA1611N

Table 4-5 Global Electrical Characteristics of FA1611N

(T_A = 25℃ and VCC = 12V unless otherwise specified)

Parameter	Test Conditions	Min.	Typ.	Max.	Unit
VCC Operating Voltage		3.3	-	16	V
VDD5 Operating Voltage	I = 0mA ~ 10mA	4.8	5	5.2	V
VCC Operating Current $I_{VCC-work}$	T_A = 85℃	-	-	450	mA
Idling Current I_{VCC}		-	2.5	-	mA
Rdson（H+L）		-	1	-	Ω
Output Signal Wave		22	24	26	kHz
Positive Magnetic Threshold		-	1.5	3	mT
Negative Magnetic Threshold		-3	-1.5	-	mT

4.2.3 FA1611NA

Table 4-6 Global Electrical Characteristics of FA1611NA

(T_A = 25℃ and VCC = 12V unless otherwise specified)

Parameter	Test Conditions	Min.	Typ.	Max.	Unit
VCC Operating Voltage		3.3	-	16	V
VDD5 Operating Voltage	I = 0mA ~ 10mA	4.8	5	5.2	V
VCC Operating Current $I_{VCC-work}$	T_A = 85℃	-	-	450	mA
Idling Current I_{VCC}		-	2.5	-	mA
Rdson（H+L）		-	1	-	Ω
Output Signal Wave		22	24	26	kHz

4.3 Protection Electrical Characteristics

Table 4-7 Protection Electrical Characteristics

(T_A = 25℃ and VCC = 12V unless otherwise specified)

Parameter	Test Conditions	Min.	Typ.	Max.	Unit
Motor Lock Detection Time during Startup T_{ON_START}		-	0.75	-	s
Motor Lock Detection Time during Normal Operation T_{ON_RUN}		-	0.3	-	s
Restart Time after Motor Lock Detection T_{OFF}		-	4	-	s
CLP Current I_{Lcp}		-	1.2	-	A

Parameter	Test Conditions	Min.	Typ.	Max.	Unit
OCP Current I_{OCP}		-	1.6	-	A
TSD Threshold Temperature		-	165	-	℃
TSD Recovery Temperature		-	140	-	℃

4.4 IO Electrical Characteristics (SPEED/FG)

Table 4-8 IO Electrical Characteristics (SPEED/FG)

(T_A = 25℃ and VCC = 12V unless otherwise specified)

Parameter	Test Conditions	Min.	Typ.	Max.	Unit
High-level Input Voltage V_{IH}	VCC ≥ 5.5V	2.8	-	5.5	V
High-level Input Voltage V_{IH}	VCC < 5.5V	2.8	-	VCC	V
Low-level Input Voltage V_{IL}		-0.3	-	1	V
SPEED Pull-up Resistor[1]		-	33	-	kΩ
SPEED Pull-down Resistor[1]		-	33	-	kΩ

Note

[1] SPEED pull-up resistor or pull-down resistor is selected according to internal configurations.

4.5 SPEED Frequency

Table 4-9 SPEED Frequency

(T_A = 25℃ and VCC = 12V unless otherwise specified)

Parameter	Test Conditions	Min.	Typ.	Max.	Unit
SPEED Input Frequency		0.1	-	100	kHz

4.6 Package Thermal Resistance

Table 4-10 SOP8 Package Thermal Resistance

Parameter	Test Conditions	Value	Unit
Junction-to-ambient Thermal Resistance θ_{JA}[1]	JEDEC standard, 1S0P PCB	150	℃/W

Table 4-11 DFN10 Package Thermal Resistance

Parameter	Test Conditions	Value	Unit
Junction-to-ambient Thermal Resistance θ_{JA}[1]	JEDEC standard, 2S2P PCB	119	℃/W

Note

[1] The actual measurements may vary depending on the conditions.

5 Function Descriptions

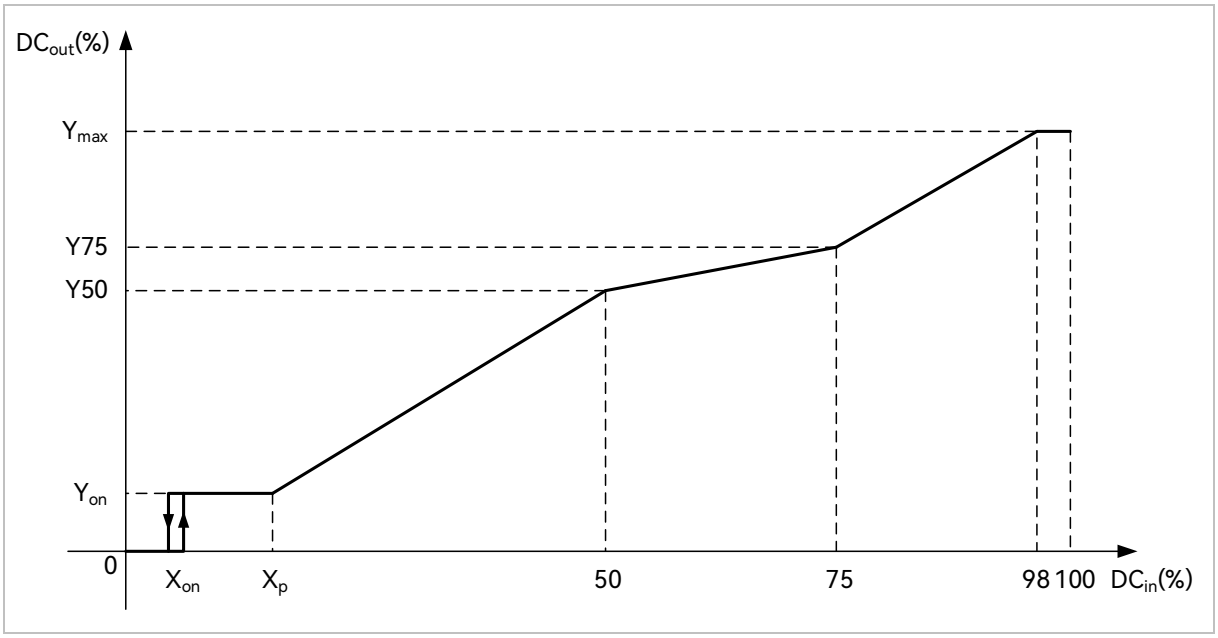
5.1 Speed Control

5.1.1 Speed Control Modes

The chip supports two types of speed control input interface: SPEED and I²C, and only one of them can be chosen at a time. If SPEED is selected, voltage value input to the SPEED pin controls the speed, and if I²C is selected, SPEED pin serves as the clock line (SCL) and FG/RD/SDA pin as the data line (SDA).

5.1.2 Speed Control Curve

Figure 5-1 Speed Control Curve

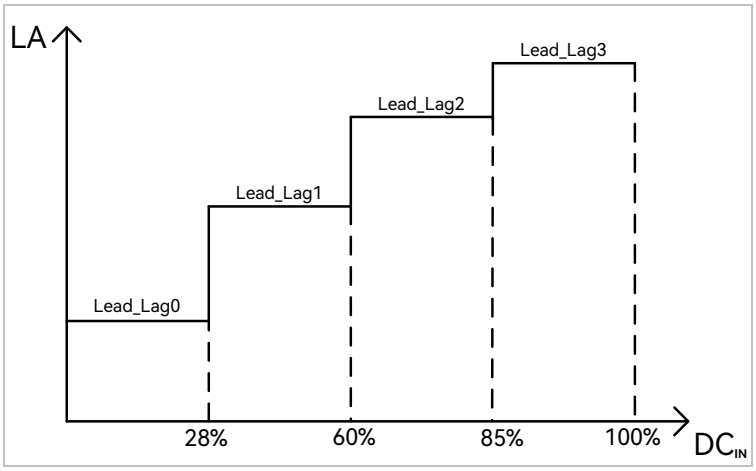


The chip outputs four-segment speed control curves, where Xon ranges from 0 to 50%, Xp from 0 to 50%, Yon from 0 to 50%, Y50 from 25 to 75%, Y75 from 50 to 100% and Ymax from 75 to 100%, and the slope of each curve must be positive. Set Xon as 0.78%. The chip shall stop when input low-level PWM, otherwise it shall stop while input PWM duty cycle is below Xon - 0.9%.

5.2 Lead Angle Settings

The lead angle is controlled by Lead_Lag0/1/2/3 and ranges from -11° to 40°. The output lead angle is determined by SPEED input.

Figure 5-2 Lead Angle Settings



5.3 Startup and Output Control

The startup duty cycle can be set as 0~50% or 30~70%, and startup acceleration as 90%/s, 65%/s, 45%/s or 25%/s.

Speed detection and fault indication (FG/RD/SDA) pin is an open-drain output. Frequency multiplication of the FG signals can be set as 1, 1/2, 1/3 or to follow Hall output. RD signals can be output as STABLE, ~STABLE or ~RUN signal.

Configure Hall Inv to control motor forward and reverse rotation, enable presents forward rotation, disable presents reverse rotation.

Figure 5-3 FA1611 Output Waveform during Startup (Startup Duty Cycle at 30~70% and Acceleration at 90%/s)

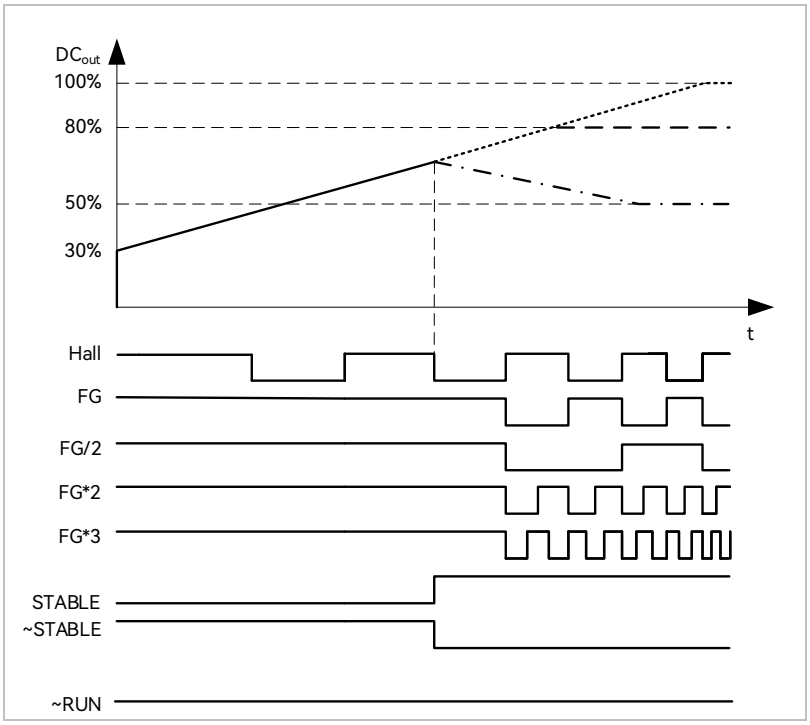
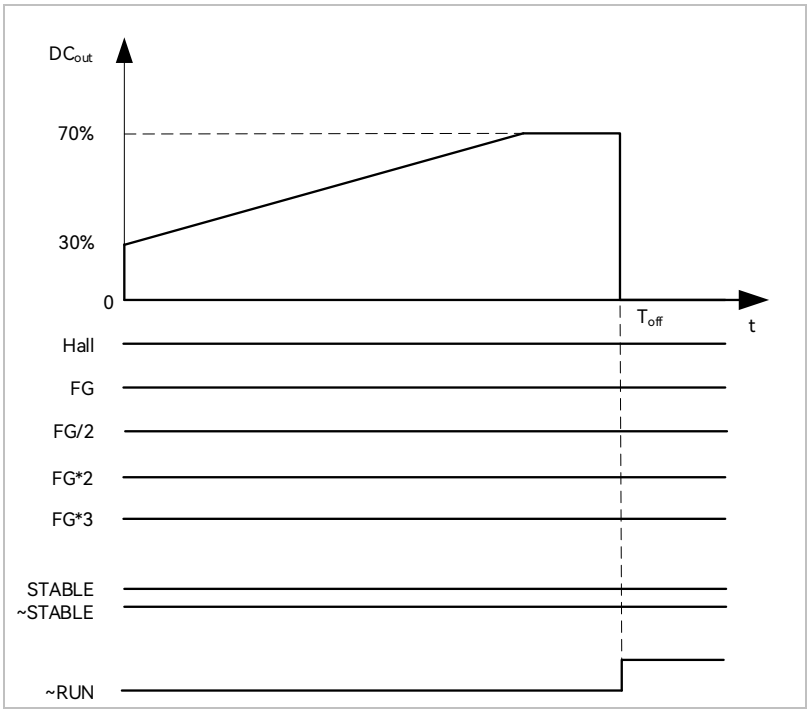


Figure 5-4 FA1611 Output Waveform of Motor Lock Detection during Startup (Startup Duty Cycle at 30~70% and Acceleration at 90%/s)



5.4 SPEED

Speed control (SPEED) pin is used to input duty cycle for speed regulation depending on the settings. In addition, SPEED pin serves as the clock line (SCL) for I^2C communication.

5.5 Overcurrent Protection

When the sampling current exceeds the overcurrent protection threshold, the chip shuts down and waits for 4s to decide whether to restart (depending on software settings).

5.6 Current Limiting Protection

The chip turns off the high-side output when it detects the current limiting protection signal, and releases the high-side output until the protection signal is recovered to normal.

5.7 Motor Lock Protection

Motor lock protection circuitry monitors operating state of the motor. Motor lock detection time during startup is 0.75s, and motor lock detection time during normal operation is 0.3s. When the conditions (Hall-based duration) for motor lock are satisfied, the chip shuts down and waits for 4s to decide whether to restart (depending on software settings).

5.8 Over-temperature Protection

When the chip junction temperature is greater than 165℃, the chip automatically turns off the output until the chip junction temperature drops below 140℃ and then resumes the output.

6 Maximum Power Dissipation and Ambient Temperature

The relationship between the maximum power dissipation and ambient temperature of FA1611 is shown below.

Figure 6-1 Maximum Power Dissipation and Ambient Temperature of FA1611S

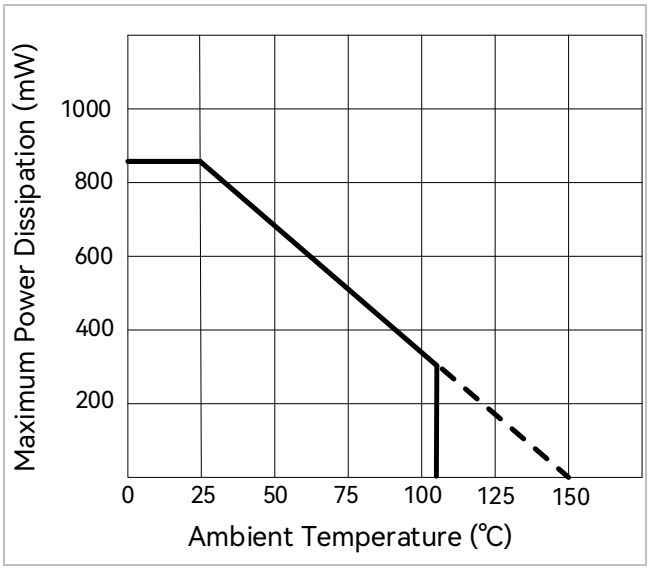
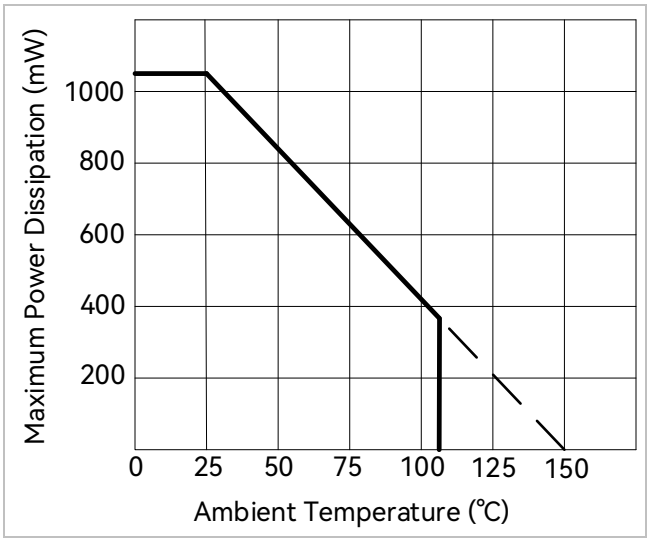


Figure 6-2 Maximum Power Dissipation and Ambient Temperature of FA1611N



7 Revision History

Rev.	Description	Date	Prepared By
V1.2	First release, translated from Chinese version 1.2	2023/09/07	Freya Fu
V1.3	1. Added test condition “VCC ≥ 5.5V” to the parameter “High-level Input Voltage V_{IH}” in Table 4-4 IO Electrical Characteristics (DIR/SPEED/FG), modified the minimum value "0.7*VDD5" as 2.8V and added the maximum value 5.5V; 2. Added the parameter “High-level Input Voltage V_{IH}” (test condition VCC < 5.5V) in Table 4-4 IO Electrical Characteristics (DIR/SPEED/FG); Modified the maximum value “0.2*VDD5” of Low-level Input Voltage V_{IL} in Table 4-4 IO Electrical Characteristics (DIR/SPEED/FG) as “1V” and added the minimum value 0.3V.	2024/02/22	Freya Fu
V1.4	Added descriptions “If Xon is set to 0.78%, the chip stops output only when the input PWM signal remains at a low level, otherwise, the PWM duty cycle must be less than Xon - 0.9%.” in 5.1.2 Speed Control Curve.	2025/01/07	Freya Fu
V2.0	1. Added descriptions on FA1611N; 2. Added FA1611S and FA1611N product pictures in section 1.2 Applications; 3. Updated Figure 1-3 Typical Application Diagram of FA1611S and added Note; 4. Updated Figure 1-5 Functional Block Diagram of FA1611; 5. Updated descriptions on V/U pins in section 1.6.1 FA1611S SOP8 Pins; 6. Updated 1.6.2 FA1611S SOP8 Pinout Diagram; 7. Added “Average Drive Current (A)” in section 3 Order Information; 8. Added section 4.5 SPEED Frequency; 9. Added description “Configure Hall_Inv to control motor forward and reverse rotation. When it is enabled, the motor rotates in forward direction, while it is disabled, the motor rotates in reverse direction.” in section 5.3 Startup and Output Control; 10. Added section 5.8 Over-temperature Protection; 11. Adopted document standard V8.0.	2025/02/25	Freya Fu

Rev.	Description	Date	Prepared By
V2.1	1. Updated Figure 2-2 FA1611N DFN10_3X3 Package Drawings and Dimensions; 2. Modified the maximum value “VDD5 + 0.3” of SPEED/SCL, FG/RD/SDA, NC to VSS Voltage in section 4.1 Absolute Maximum Ratings as “VCC + 0.3”; 3. Modified “Acceleration at 95%/s” in the title of Figure 5-3 FA1611 Output Waveform during Startup and Figure 5-4 FA1611 Output Waveform of Motor Lock Detection during Startup as “Acceleration at 90%/s”; 4. Modified some descriptions.	2025/03/06	Eric Deng
V3.0	1. Added FA1611NA; 2. Added “ The above are the general descriptions on the product family. The features vary by models. For details, see section 1.7 Pin Definitions and 3 Ordering Information” and “ For concise description and easy differentiation, if it is specified that a feature is applied to a specific model, the feature is exclusive to this model. Otherwise, the feature is a common feature of the product family” to 1.1 Overview; 3. Modified the “U, V to VSS Voltage” and the Max. of “U, V to VSS Voltage” as “U, V, FG/RD/SDA to VSS Voltage” and “VCC + 0.3” in 4.1.1 FA1611S and 4.1.2 FA1611N; Modified the “SPEED/SCL, FG/RD/SDA, NC to VSS Voltage” and the Max. of “SPEED/SCL, FG/RD/SDA, NC to VSS Voltage” as “SPEED/SCL, NC to VSS Voltage” and “VDD + 0.3” in 4.1.1 FA16 11S and 4.1.2 FA1611N.	2025/03/26	Freya Fu
V3.1	Added chapter 6 Maximum Power Dissipation and Ambient Temperature	2025/06/04	Freya Fu

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