AN8235S

3.5-inch FDD Spindle Motor Controller

■ Overview

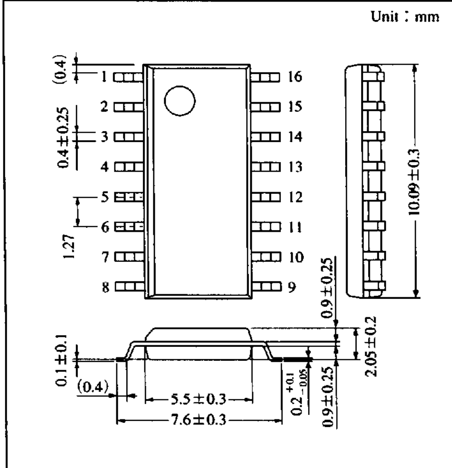
The AN8235S is an IC developed for controlling the 3.5-inch FDDs´ belt type spindle motors. Using the digital FG servo system, it can easilly realize adjustment-free low drift. It is also available as a DC motor speed control IC.

■ Features

- Operating supply voltage range : V_{CC}=4.4 to 6V
- Digital F/V conversion system
- Current feedback system
- Built-in speed changeover function
  - 1/1.2 : Correspond to 300/360 r.p.m.
  - 1/1.2 : Corresponds to 300/600 r.p.m.
- Built-in FG and EA amplifiers
- Built-in protective circuit (current limiter) function

■ Applications

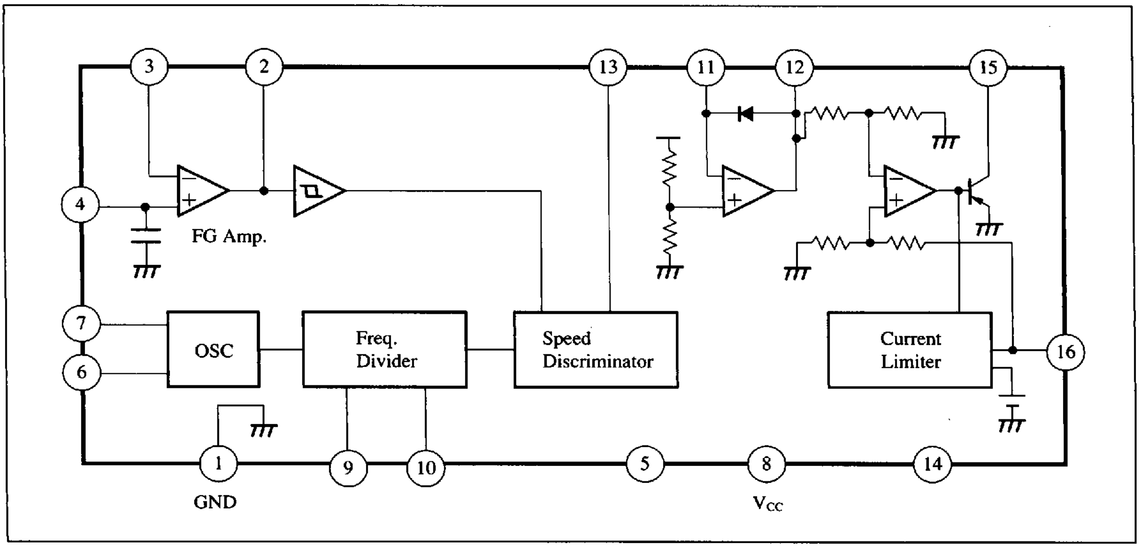
Control of the FDD spindle motors and DC motors



16-pin PANAFLAT Plastic Package (SOP016-P-0300)

ICs for Motor

■ Block Diagram



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■ Absolute Maximum Ratings (Ta=25℃)

Parameter	Symbol	Rating	Unit
Supply voltage	V_{CC}	7	V
Supply current	I_{CC}	20	mA
Power dissipation	P_D	380	mW
Operating ambient temperature	T_{opr}	−20 to +75	℃
Storage temperature	T_{stg}	−55 to +125	℃

■ Recommended Operating Range (Ta=25℃)

Parameter	Symbol	Range
Operating supply voltage range	V_{CC}	4.4V to 6V

■ Electrical Characteristics (Ta=25℃)

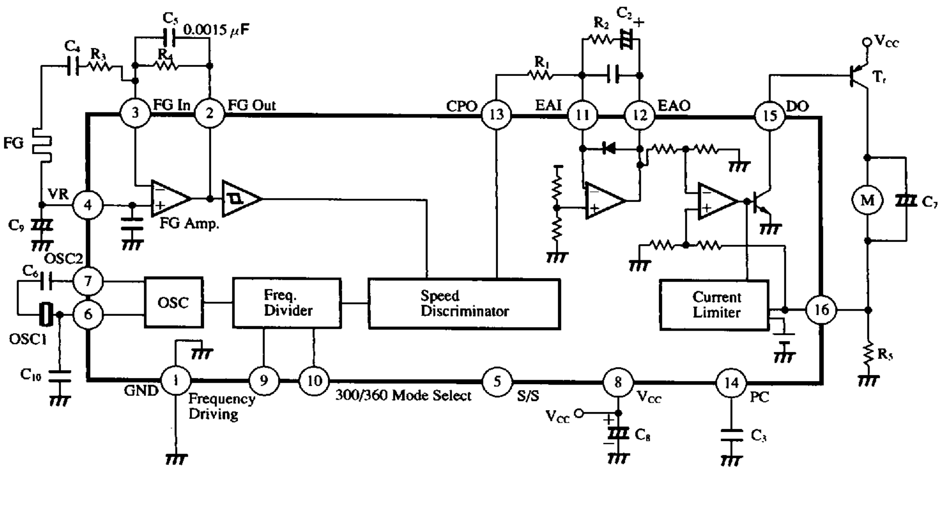
Parameter	Symbol	Condition	min	typ	max	Unit
Quiescent current at standby	I_{QS}	V_{CC}=5V, V_S=4.2V or OPEN	—	0.01	0.5	mA
Quiescent current at no load	I_{QN}	V_{CC}=5V, V_S=0V	6	11	18	mA
Reference Voltage Block						
Reference voltage	V_{OR}	V_{CC}=5V	2.15	2.4	2.65	V
Output sink current	I_{OR}^+	V_{CC}=5V	0.02	0.08	—	mA
Output source current	I_{OR}^-	V_{CC}=5V	—	−1.6	−0.8	mA
Output impedance	Z_{OR}	V_{CC}=5V, I_{OR}^-=0mA to −0.8mA	—	110	200	Ω
FG Amp./Schmidt Block						
Offset block	V_{OFS}	V_{CC}=5V	−20	—	20	mV
Output sink current	I_{OF}^+	V_{CC}=5V	1	3	—	mA
Output source current	I_{OF}^-	V_{CC}=5V	—	−3	−1	mA
Open loop gain	A_{FGG}	V_{CC}=5V	—	78	—	dB
Schmidt width	V_S	V_{CC}=5V	—	50	—	mV
Speed Discriminator Block						
Discriminator count 1	N_{CT}	V_{CC}=5V, V_{CT1}=0V, V_{CT2}=0V	—	1390	—	—
Speed discriminator error 1	$\Delta T1$	V_{CC}=5V CLK=100kHz V_{CT1}=0V, V_{CT2}=0V	6	10	14	μs
Speed discriminator error 2	$\Delta T2$		6	10	14	μs
Max. clock frequency	$f_{max.}$	V_{CC}=5V	1	2.2	—	MHz
1/1.2 select voltage	V_{CT1}	V_{CC}=5V	0.8	—	2	V
1/2 frequency-dividing select voltage	V_{CT2}	V_{CC}=5V	0.8	—	2	V
Speed discriminator output H	ΔV_{DH}	V_{CC}=5V	—	0.1	0.3	V
Speed discriminator output L	ΔV_{DL}	V_{CC}=5V	—	0.1	0.3	V
Output sink current	I_{DL}	V_{CC}=5V	1	3	—	mA
Output source current	I_{DH}	V_{CC}=5V	—	−3	−1	mA
Equivalent count 1	R_{C1}	V_{CC}=5V, 720rpm, V_{CT1}=LOW, V_{CT2}=LOW	—	1390	—	—
Equivalent count 2	R_{C2}	V_{CC}=5V, 600rpm, V_{CT1}=HIGH, V_{CT2}=LOW	—	1668	—	—
Equivalent count 3	R_{C3}	V_{CC}=5V, 360rpm, V_{CT1}=LOW, V_{CT2}=HIGH	—	2780	—	—
Equivalent count 4	R_{C4}	V_{CC}=5V, 300rpm, V_{CT1}=HIGH, V_{CT2}=HIGH	—	3336	—	—

Note) Equivalent count=CLK÷FG frequency (FG frequency when the motor is installed)

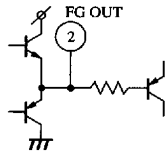
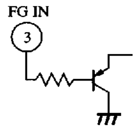
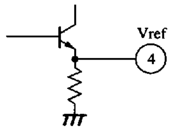
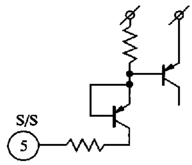
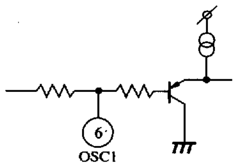
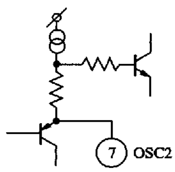
Electrical Characteristics (Cont.) (Ta=25℃)

Parameter	Symbol	Condition	min	typ	max	Unit
Error Amp. Block						
Integrating amp. error output 1	ΔV_{ERO1}	V_{CC}=5V Acceleration mode	0.3	0.7	1.1	V
Integrating amp. error output 2	ΔV_{ERO2}	V_{CC}=5V Acceleration mode	—	—	−0.3	V
Output sink current	I_{OE}^{+}	V_{CC}=5V	1	3	—	mA
Output source current	I_{OE}^{-}	V_{CC}=5V	—	−3	−1	mA
Open loop gain	A_{EAG}	V_{CC}=5V	—	73	—	dB
Input bias current	I_{EA}	V_{CC}=5V	—	20	—	nA
Gain bandwisth product	f_T	V_{CC}=5V	—	800	—	kHz
Predrive Output Block						
Drive output current	I_{OD}	V_{CC}=5V	16	33	—	mA
Limitter voltage	V_{LC}	V_{CC}=5V	0.225	0.25	0.275	V
Drive gain	G_D	V_{CC}=5V	0.54	0.67	0.8	time
Start/Stop Control Block						
Input voltage H (stop)	V_{OSH}	V_{CC}=5V	4.2	—	—	V
Input voltage L (start)	V_{OSL}	V_{CC}=5V	—	—	0.8	V
Input current H	I_{OSH}	V_{CC}=5V	−20	—	3	μA
Input current L	I_{OSL}	V_{CC}=5V	−500	−180	—	μA
Oscillation Circuit Block						
Ceramic oscillation frequency	f_S	V_{CC}=5V, Ceramic oscillator : 800kHz	—	800	—	kHz

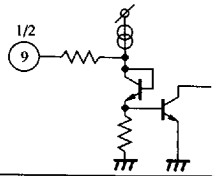
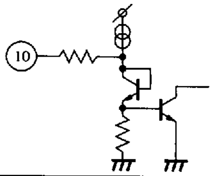
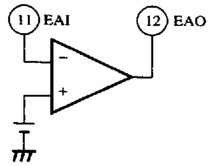
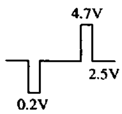
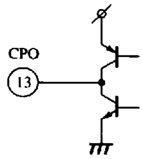
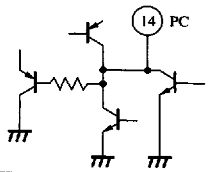
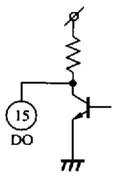
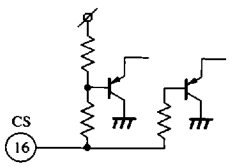
Application Circuit



■ Pin Descriptions

Pin No.	Pin name	Typical waveform	Description	I/O impedance	Pin equivalent circuit
1	Ground (GND)	DC 0V	Ground pin	—	——
2	FG amp. inverting output (FG IN)	—	Output pin of the FG amplifier	—	
3	FG amp. inverting input (FG IN)	—	Inverting input pin of the FG amplifier	—	
4	FG amp. non-inverting input (Vref)	DC 2.4V	Reference voltage source of the main circuit	—	
5	Start/Stop select (S/S)	—	Start/stop selector pin	—	
6	Oscillation circuit 1 (OSC 1)	—	Oscillation circuit input pin	—	
7	Oscillation circuit 2 (OSC 2)	—	Oscillation circuit output pin	—	
8	Power supply	—	Power pin	—	——

■ Pin Descriptions (Cont.)

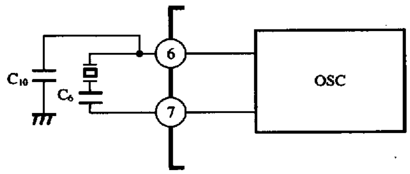
Pin No.	Pin name	Typical waveform	Description	I/O impedance	Pin equivalent circuit
9	1/2 frequency-dividing select (1/2)	—	300/600 r.p.m. selector pin	—	
10	1/1.2 speed select (1/1.2)	—	300/360 r.p.m. selector pin	—	
11	Error amp. inverting input (EAI)	—	Inverting input pin and amplifier output pin of the error amplifier	—	
12	Error amp. output (EAO)				
13	Speed error output (CPO)		Output pin of the speed discriminator circuit	—	
14	Phase compensation (PC)	—	Phase compensation pin for current feedback	—	
15	Predrive (DO)	—	Predrive pin of the external power PNP transistor	—	
16	Current detection (CS)	—	Current detection pin	—	

■ Supplementary Explanation

• Application

(1) Reference oscillator block

Set the motor speed according to the oscillation frequency of the oscillator block.

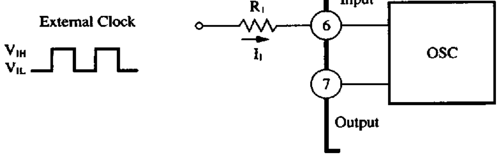


①Use a ceramic oscillator so that oscillations from 200kHz to 1MHz may be available.

②Some pF of capacitance is normally used for the capacitor C_6.
The oscillation frequency can finely adjusted according to a capacitance value.

③The capacitor C_{10} is a spurious measure for parasitic oscillation.

④When using the external clock
(input an external clock without oscillating the OSC block)
The external clock can be input from the input Pin⑥ of the OSC.



If an excessive input is applied, the OSC block may not function. In this case, connect the current limiting resistor R_I.
The input currents I_{IH} and I_{IL} flowing through the resistor R_I are expressed as follows.

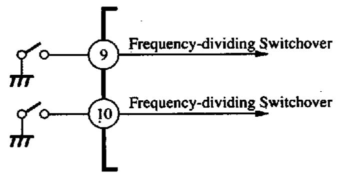
$$I_{IH}=\frac{V_{IH}-1.4}{R_I+R_{OSC}} \quad (\mu A)$$

$$I_{IL}=-\frac{1.4-V_{IL}}{R_I+R_{OSC}} \quad (\mu A)$$

(The V_{IH} and V_{IL} threshold levels inside the IC are calculated at 1.4V.)
However, R_{OSC} is an IC internal resistance and designed to be 2kΩ.
Design at about some 10μF as an IC drive capability.
A recommended R_I value is 10kΩ.
(conditions of V_{IH}=2.36V, V_{IL}=0.44V, I_I=80μA)

(2) Frequency-dividing selector block

Frequency-dividing can be switched over to "Low" or "High (Open)", using the Pins⑨ and ⑩.



Pin⑩	Pin⑨	Motor Speed (rpm)	Equivalent Counts
Low	Low	720	1390
Open (High)	Low	600	1668
Low	Open (High)	360	2780
Open (High)	Open (High)	300	3336

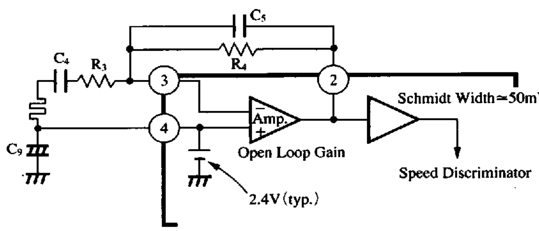
The motor speed N is obtained by the following expressin.

$$N \simeq 60 \cdot \frac{f_{OSC}}{N_C \cdot Z} \text{(rpm)}$$

f_{OSC} : Oscillation frequency (Hz)
N_C : Equivalent counts $N_C=\frac{f_{OSC}}{f_{FG}}$
Z : No. of the FG teeth
f_{FG} : FG frequency (Hz)

(3) FG amplifier and Schmidt circuit

The motor speed is detected and amplified, and then, a waveform is shaped by the Schmidt circuit.



①Use as an inverting amplifier as shown in the figure above.
The closed loop gain G is as follows.

$$G \simeq -\frac{R_4}{R_3}$$

Set the gain so that the output swing of the amplifier will be within a range of 1 to 3 V_{P-P}.
The voltage at the Pin④ has been set inside the IC to about 2.4V.

■ Supplementary Explanation (Cont.)

②Elimination of noise components

The high-pass filter is configured with C_4 and R_3, and the low-pass filter with C_5 and R_4. Noise components are eliminated by these filters. The cut-off frequencies f_{CH} and f_{CL} are as follows.

$$f_{CH} \simeq \frac{1}{2\pi \cdot C_4 \cdot R_3}$$

$$f_{CL} \simeq \frac{1}{2\pi \cdot C_5 \cdot R_4}$$

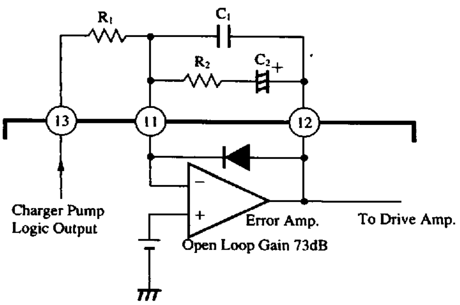
Suppose the FG frequency is f_{FG}, make setting so that the following condition will be satisfied.

$$f_{CH} < f_{FG} < f_{CL}$$

(4) Error Amplifier Block

The error amplifier smoothes and amplifiers a speed detection error.

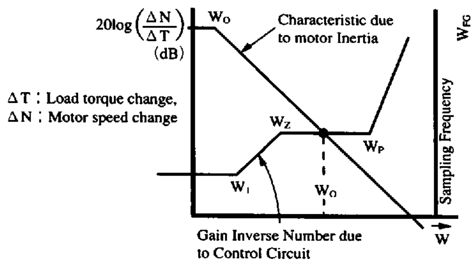
Main characteristics such as control system stability, transient characteristics, etc. are determined in this block.



①Obtaining the constants C and R

The body chart of the control system is shown below. Phase advance/delay compensation is combined by Miller integral in order to improve the characteristics in the low frequency range.

The frequencies at the respective pole and zero points are as follows



W_O : 1/ (motor's time constant)

W_1 : 1/ (Miller intergral time constant)

W_Z : $1/C_2R_2$

W_P : 1/ $(C1//C_2)$ R_2

②An important point to set the constants is to set the frequency W_0dB at the gain intersection so that the condition of $W_Z < W_O < W_P$ will be satisfied. This assures stability of the control system.

Normally, set as follows.

$K_1 = W_P/W_Z$ = approx.10 $K_P = W_{FG}/W_O > 20$

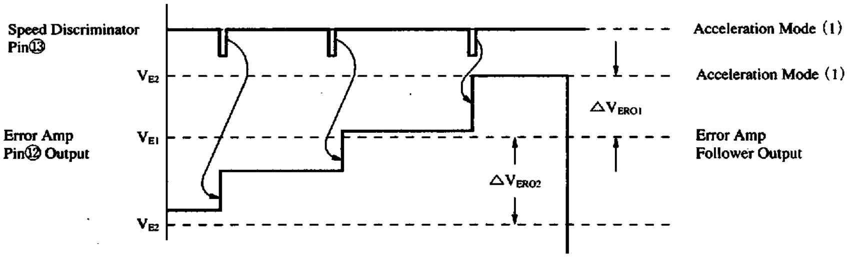
■ Supplementary Explanation (Cont.)

(5) Speed discriminator and error amplifier block

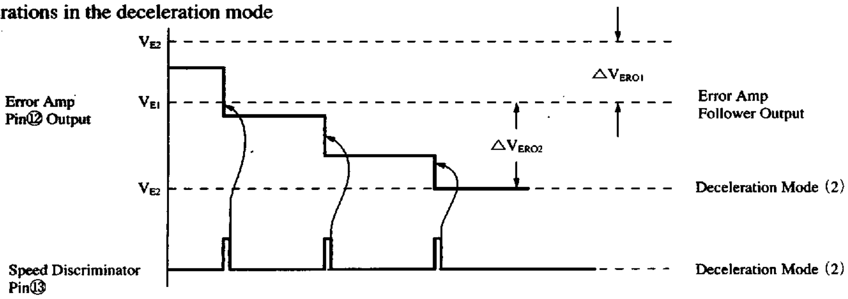
A waveform shaped FG signal and the reference frequency oscillated from the OSC block are compared by the speed discriminator, and a signal is output to the error amplifier.

An output change of the error amplifier changes motor drive current and keeps the motor speed constantly.

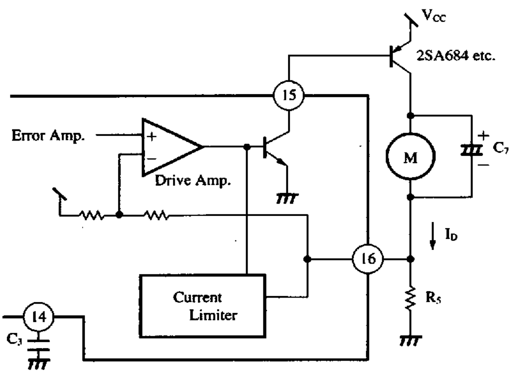
①Operations in the acceleration mode



②Operations in the deceleration mode



(6) Predrive block



■ Supplementary Explanation (Cont.)

Connect the motor drive power PNP transistor to the predrive output Pin⑮. Adjust the wattage of the power PNP transistor to the motor working condition.

The resistor R_5 is used to detect a current flowing to the motor and works as a current limiter. The reference voltage of the current limiter has been designed at 0.25V±10%.

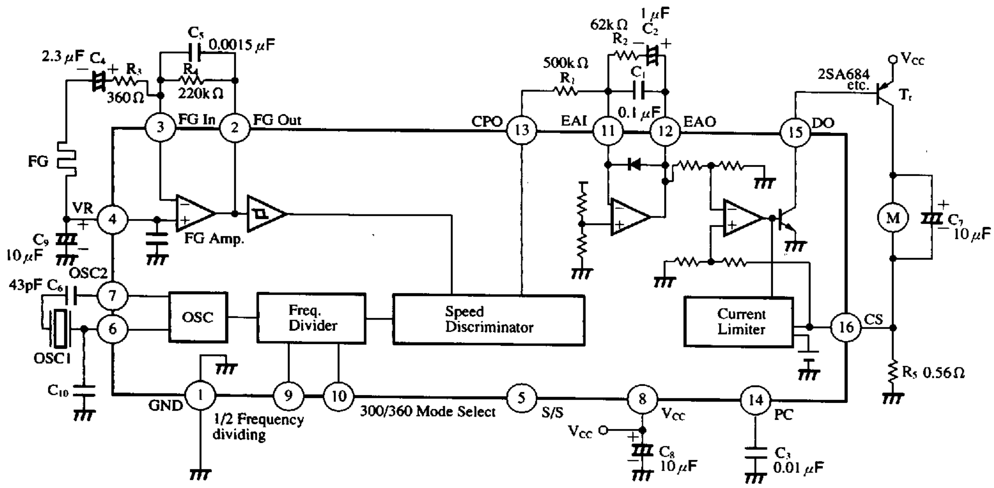
The capacitor C_3 is for phase compensation. When parasitic oscillation may occur depending on a type of motor, connect the capacitor C_7 to prevent parasitic oscillation.

(7) Start/stop

Motor rotation can be started/stopped with the Pin⑤.

The logic level starts at Low and stops at High. At the stop mode, current consumption can be reduced very much to as low as 500 μA or less.

(8) External parts



External Part No.		Recommended value	Function
R_1, R_2	C_1, C_2 Note 1)	—	Integration constant
R_3, R_4	C_4, C_5 Note 2)	—	FD amp. filter constant
	C_3 Note 3)	0.01 μF to 0.1 μF	Filter constant
R_5 Note 4)		0.56Ω	Current detection
	V_6, C_{10} Note 5)	—	OSC/AC conpling
	C_7 Note 6)	0.1 μF to 10 μF	For stablization
	C_8 Note 7)	0.1 μF to 10 μF	Power supply noise measure
	C_9 Note 8)	0.1 μF to 10 μF	For stabilization

Note 1) For C_1 and C_2, use the types which are less affected by a leak current. If you use those having a leak current, the motor speed will deviate.

(Example) When C_1=0.1 μF and C_2=1 μF and R_1=20Ω, a leak current of 125nA corresponds to 0.1% rotational deviation.

Note 2) When setting the closed loop gain of the FG amplifier to about 60dB, use the types less affected by a leak current for C_4, C_5.
In this case, note that the leak current will be the DC offset of an output voltage.

(Example) When R_1=100Ω and R_2=100kΩ, if the leak current of the capacitor is 1 μA, it will be a 100mV offset.

Note 3) It is for phase compensation of the current feedback loop and current limiter loop.

Note 4) It works as a current limiter when R_5 is not equal to 0.

Note 5) They are for fine adjustment of the oscillation frequency f_{OSC}.
Use those with low temperature dependency.

Note 6) When oscillation occurs depending on a type of motor, use this part for prevention of oscillation.

Note 7) Attach this part when operations become unstable due to noises coming from the power supply.

Note 8) Attach this part when the FD amplifier output becomes unstable due to noises.