April 15th 2005

TB6571FG functional description

Ⅰ. Outline

The TB6571FG is a 3-phase full-wave brushless motor controller IC that employs a sine wave PWM drive mechanism with a speed control function.

Ⅱ. Power supply

1. Range of drive power supply voltage
   Supply voltage (Vcc) : 10 to28 V
   Maximum ratings : 30 V

2. How to power on and shut down?
   In powering on Vcc and shutting down, set the starting signal high to be placed in the stop state.

Ⅲ. Sine Wave PWM Drive

1. Drive mode
   1) Rotation state (f_H) > f : Square wave drive (120° energization).
   2) Rotation state (f_H) < f : Sine wave PWM drive (180° energization).

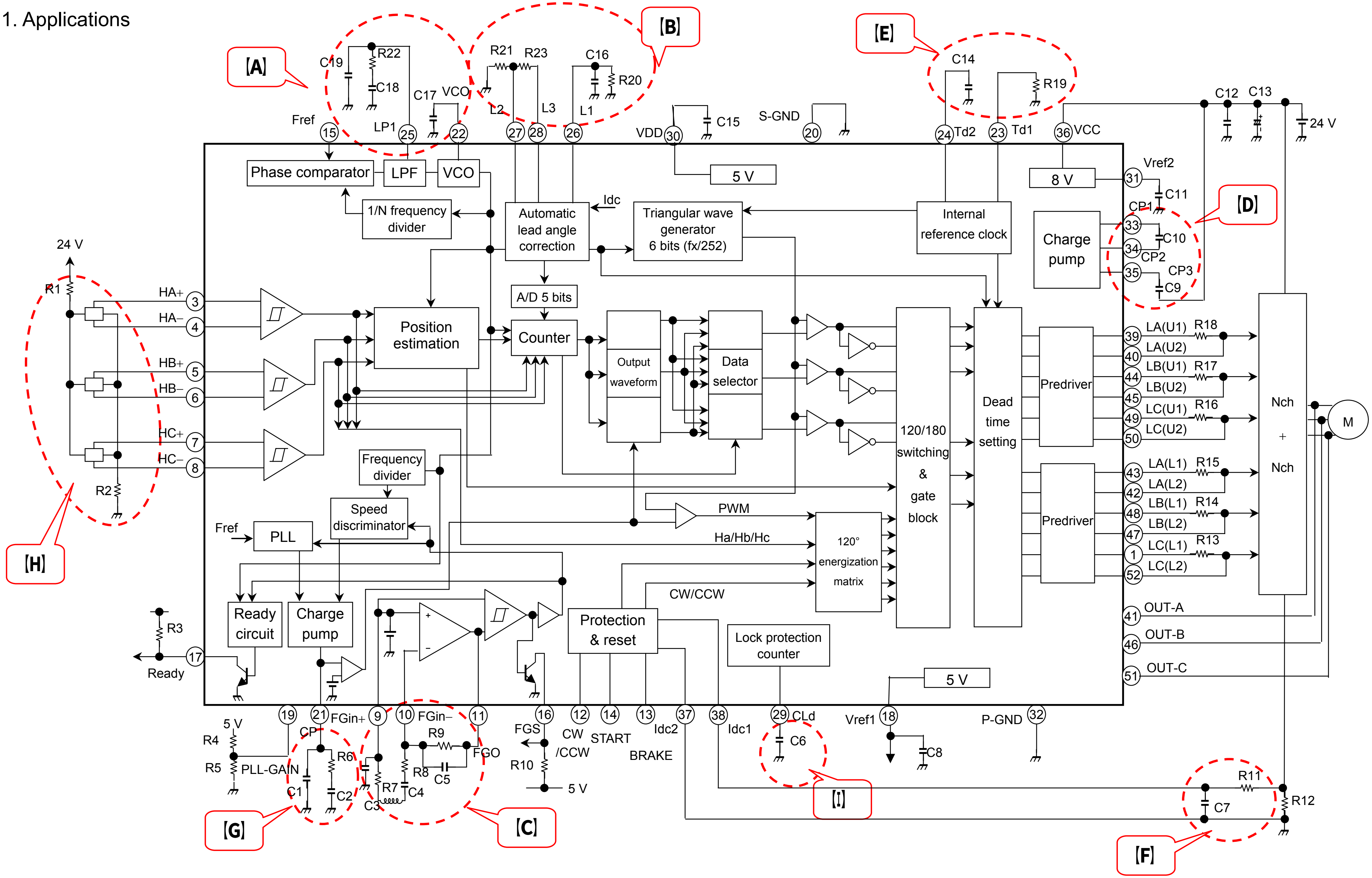
   f ･･･Frequency of the position detection signal (Hall device signals) for a single phase.
   f_H･･･Specified frequency ; $f_H = fx1 \div (2^{10} \times 32 \times 6)$
   fx1･･･System clock frequency ; $fx1 = 4 \times 1024 \times fref$

2. Sine wave PWM drive
   The TB6571FG compares the modulation waveforms with triangular waves to generate PWM signals. Please refer the technical data sheets in detail.

IV. Application Notes

The reference below will be helpful to determine the element constant number.

1. Applications



2. How to determine the element constant number?

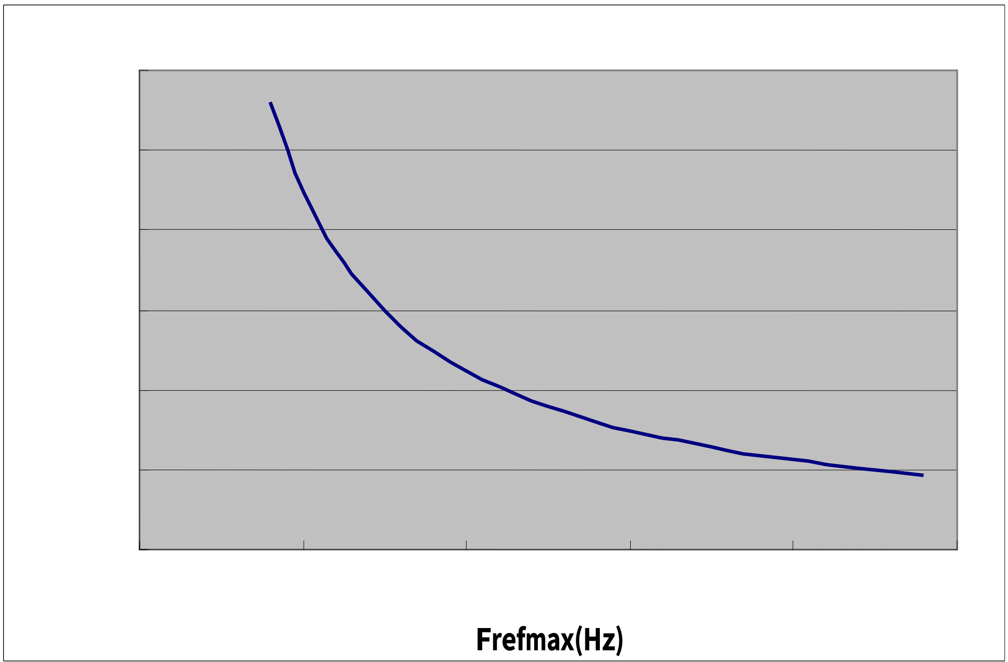
1) Elements which determine the range of Fref (C17, C18, C19, and R22) ・・・ Applications [A]

①Determine the maximum value of Fref (Frefmax).

②Then, C17 is obtained from the equation below.

C17 = 1.12 × 10^5 ÷ Frefmax (Unit: C17: [pF], Frefmax : [Hz])

The relation between Frefmax and C17 is shown below.



③Next, determine Kv.

Kv is obtained from the equation below.

Kv = 1.53 × 10^{-4} ÷ C17 (Unit : C17: [pF])

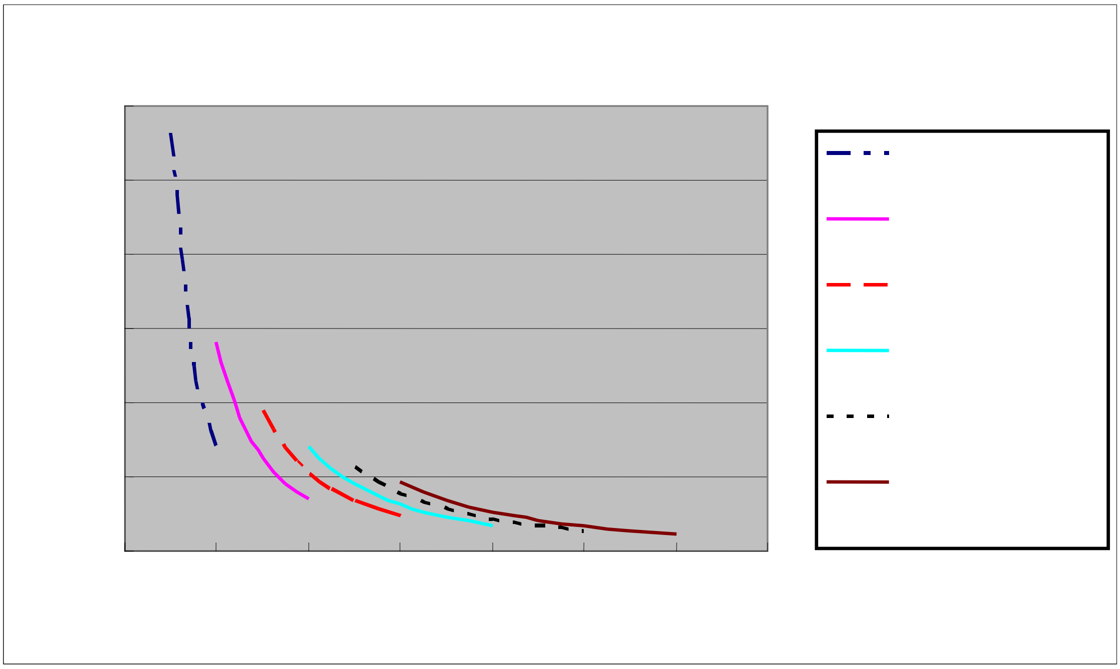
④Determine C19.

C19 is obtained by the values of Frefmin and Kv from the equation below. Frefmin means the minimum value of Fref.

C19 = 1.03 × 10^{10} × Kv ÷ $(Frefmin)^2$

(Unit : C19: [μF], Frefmin: [Hz])

The relation between Frefmin and C19 is shown below.



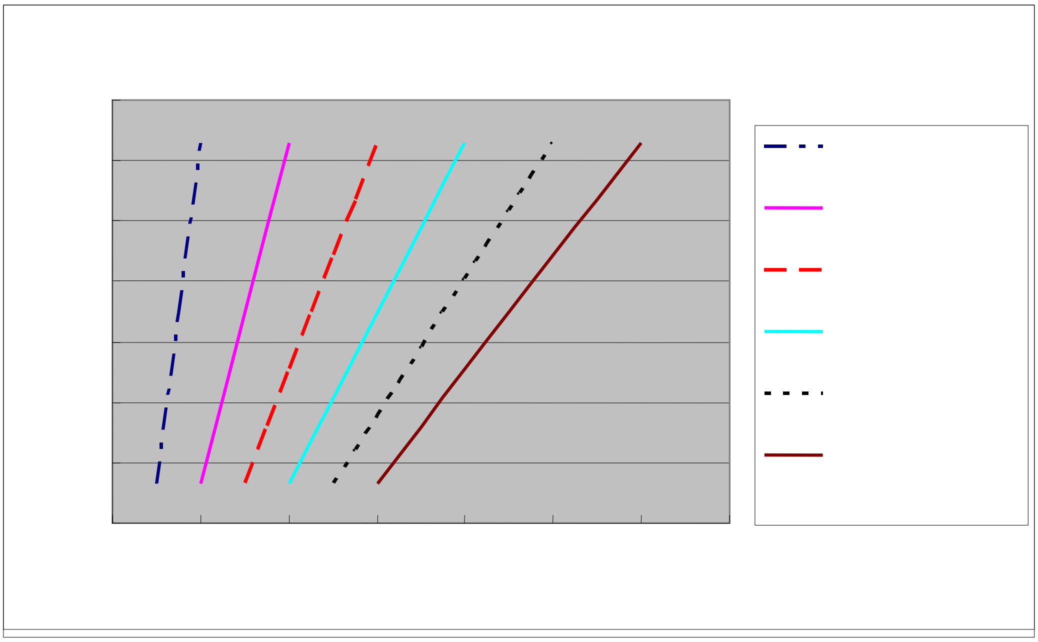
⑤Next, determine C18.

C18 is obtained by C19 from the equation below.

C18 = 5 × C19 (Unit : C18: [μF])

⑥Determine R22.

R22 is obtained by the values of Frefmin and Kv from the equation below.
$R22 = 6.176 \times 10^{-8} \times Frefmin \div Kv$
(Unit : R22: [kΩ], Frefmin: [Hz])
The relation between Frefmin and R22 is shown below.



⑦Recommendation value

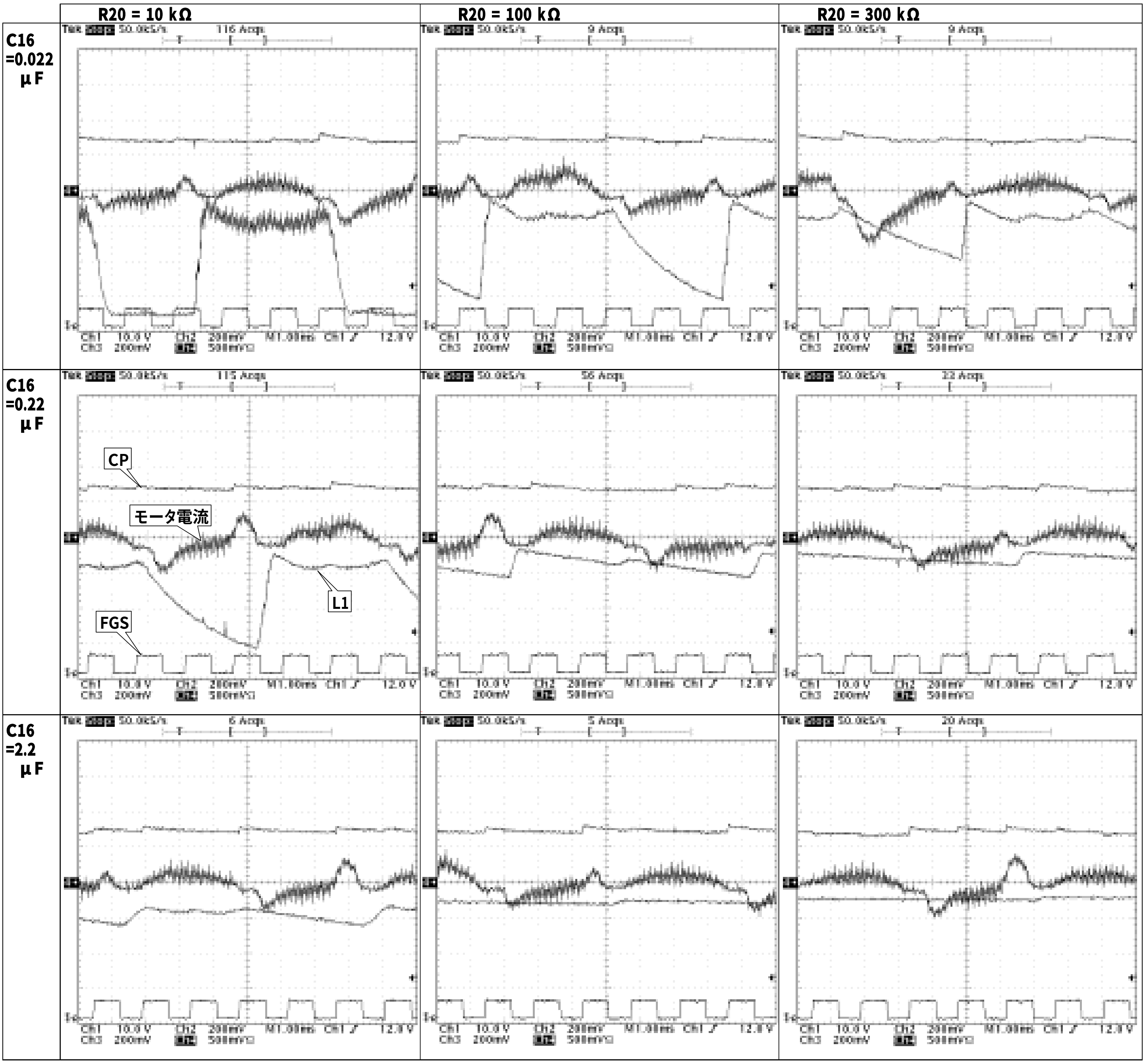
Recommendation values are shown in the table below.
Apply the value margin for each equation above because there are some differences between the calculated values and the theoretical values especially at the low range.
Regard the actual Fref range as approximate range because it is influenced by other elements. Actual Fref range means the range where FGS follows Fref.

Actual Fref range Frefmin ～ Frefmax	Calculated Fref range Frefmin ～ Frefmax	Recommendation value of element constant number			
		C17(pF)	C18(μF)	C19(μF)	R22(kΩ)
500 ～ 1200	300 ～ 1200	91	1.5	0.22	11
700 ～ 2000	500 ～ 2000	56	0.68	0.12	11

2) Elements of automatic lead angle correction （C16, R20, R21, R23）･･･Applications 【B】

①C16, R20

Waveforms of L1 and CP are recognized by combining C16 (0.022, 0.02, and 0.2µF) and R20 (10, 100, and 300kΩ). Refer the graphs below. Especially, the waveform of L1 is major different depending on the values of C16 and R20. The TB6571FG is operated stably when both C16 and R20 values are large (C16=2.2µF, R20=300kΩ).



Recommendation values are as follows;

C16 = Up to 2.2µF, R20= Up to 300kΩ.

②Lead angle is determined by R21 and R23.

Gain = (R21 + R23) / R21

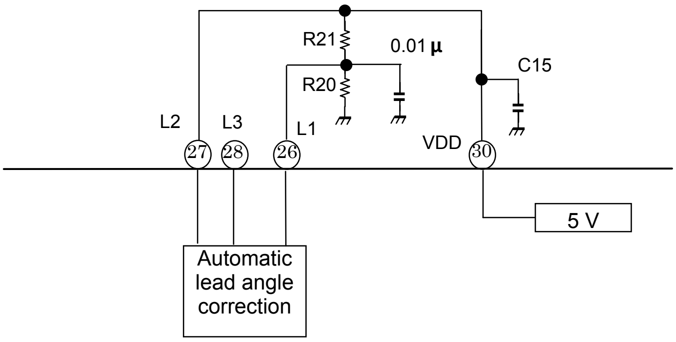
L1 is obtained by the values of Gain and VRF. Lead angle is proportional to L1 voltage. （L1 : 0〜2.5V ⇒Lead angle : 0〜29 °）。

③In case the hall device position is heaved by design with the lead angle in mind, the best values of R21 and R23 may be different from the recommended value. It depends on the user’s usage conditions.

3) How to connect wire in fixing automatic lead angle correction control.

① Connect L2 to VDD (5V). ②Open L3 ③Set the voltage of L1by resistor voltage divider.

Applications 【B】



4) Elements of FGin+, FGin-, and FGO (C3, C4, C5, R7, R8, and R9) ･･･Applications 【C】

①R8 ≦ 1 ÷ (2π × C4 × Frefmin)

R9 = R8 × GFG

C5 ≧ 1 ÷ (2π × R9 × Frefmax)

②In case C4=0.1μF, Frefmin=500Hz, Frefmax=2000Hz, and GFG= ×100 (GFG=FG Gain),

R8≦3.18kΩ. ⇒ R8=2～3kΩ and R9=200～300kΩ.

When R9 is 200kΩ, C5≧398pF. ⇒ C5=470～1000p

③C3=0.047～0.1μF, R7=0Ω.

④GFG (FG Gain) is FGO waveform. Input hysteresis of FG comparator needs to be set 0.2V on one side (0.4V per amplitude p-p).

5) Elements of C14 and R19 determining the elements of CP1, CP2, and CP3, which correspond to C9 and C10, and the internal standard clock (fx2). ･･･Applications 【D】 and 【E】

①C10 = 40000 ÷ fx2

C9 = 10 × C10

fx2 = 2 ÷ (C14 × R19), (fx2: Internal standard clock)

②In case C14=47pF and R19=5.6kΩ,

fx2=7598784Hz. ⇒ C10=0.0053μF and C9=0.053μF.

6) Element of Idc2 (C7 and R11) ･･･Applications 【F】

①R11 = 0.769 × 10^3 ÷ C7 ÷ fx2

②In case C7=1000pF and fx2=7598784Hz,

R11=101kΩ

7) Element of CP (C1, C2, and R6) ･･･Applications 【G】

As for C1, C2, and R6, there is a possibility the values are different depending on the usage motor.

8) Element of Hall bias (R1 and R2) ･･･Applications 【H】

As for R1 and R2, there is a possibility the values are different depending on the usage hall device.(Ex. Drive voltage etc.).

9) Set the time of lock protection circuit operation.･･･Applications 【I】

①Equation of the time of lock protection circuit operation.

$Tld = 53.3 \times 10^6 \times Cld$ ・・・・・(1)

Tld：Time of lock protection circuit operation（Unit : second）

Cld：External capacity of Cld terminal（Unit : F）

② Reference below shows how to introduce the equation.

fld：Oscillation frequency of Cld terminal（Unit : Hz）.

Lock protection frequency：$fld = 2.4 \times 10^{-6} \div Cld$ ・・・・・(2)

（Ex.・・・Cld＝0.1μF ⇒ $fld = 2.4 \times 10^{-6} \div (0.1 \times 10^{-6}) = 24Hz$）

Time of lock protection circuit opertion：Tld＝1÷fld×128 • • • • • (3)

（Ex. • • • fld＝24Hz ⇒ Tld＝1÷24×128＝5.33(s)）

From the equations (2) and (3), the equation (1) is introduced.

3. Recommendation value of external elements

Recommendation value examples of external elements are shown below. There are some devices where the values should be optimized depending on the usage motor and hall device.

	Connection terminal	Resistance (ohm)	Notes		Connection terminal	Capacitor (uF)	Notes
R1	Hall bias			C1	CP	0.01〜10	*2
R2	Hall bias			C2	CP	0.1〜10	*2
R3	Ready	10k		C3	FGin+	0.047〜0.1	*2
R4	PLL-GAIN	0	*1	C4	FGin−	0.1〜0.68	*2
R5	PLL-GAIN	open	*1	C5	FGo	470p〜1000p	*2
R6	CP	1k〜120k	*2	C6	cld	0.1	
R7	FGin+	0		C7	IDC1	1000p	*3
R8	FGin-	1k〜2.7k	*2	C8	Vref1	0.1	
R9	FGo	120k〜510k	*2	C9	CP3	0.1	
R10	FGS	10k		C10	CP2	0.022	
R11	IDC1	100k	*3	C11	Vref2	1	
R12	Sense R	0.05	*4	C12	Vcc	0.1	
R13	LC(L1)	470〜2k	*5	C13	Vcc	100〜220	
R14	LB(L1)	470〜2k	*5	C14	td2	51p	*6
R15	LA(L1)	470〜2k	*5	C15	VDD	1	
R16	LC(U1)	470〜2k	*5	C16	L1	0.1〜2.2	*8
R17	LB(U1)	470〜2k	*5	C17	VCO	43p〜120p	*9
R18	LA(U1)	470〜2k	*5	C18	LP1	0.1〜2.2	*9
R19	td1	5.6k〜10k	*6	C19	LP1	0.047〜0.33	*9
R20	L1	30k〜300k	*8	C20	HA	0.01	
R21	L2	10k	*7	C21	HB	0.01	
R22	LP1	10k〜20k	*9	C22	HC	0.01	
R23	L3	10k〜100k	*7				

*1 **When performing PLL control, voltage is impressed to a PLL-GAIN terminal.**

*2 **A constant value needs to be adjusted by the motor to be used.**

*3 **It is the filter on which the noise at the time of switching is dropped.**

*4 **A current limiter value changes with resistance.**

*5 **The switching speed of FET is controlled (noise reduction).**

*6 **PWM frequency and a dead time are set up.**

*7 **It is gain adjustment of lead angle. By the motor, adjustment is required.**

*8 **The peak hole time of lead angle is set up.**

*9 **By the input range of an external clock, adjustment of a constant is required.**