HA13544F

Combo (Spindle & VCM) Driver

The HA13544F is combination of Spindle and VCM Driver designed for HDD and have following functions and features.

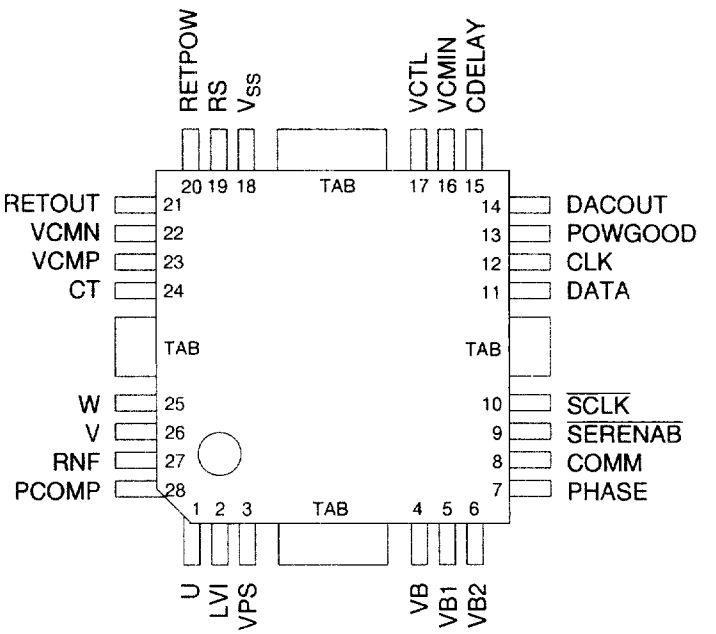
Functions

- 1.0 A max/3-phase spindle motor driver
- 400 mA max VCM driver
- 100 mA max retract driver
- 11 bit serial interface
- 9 bit DAC for VCM control
- Commutation logic for sensor-less motor
- Center tap pull-up driver for half wave driver
- Soft switching matrix
- Booster
- Power monitor
- OTSD

Features

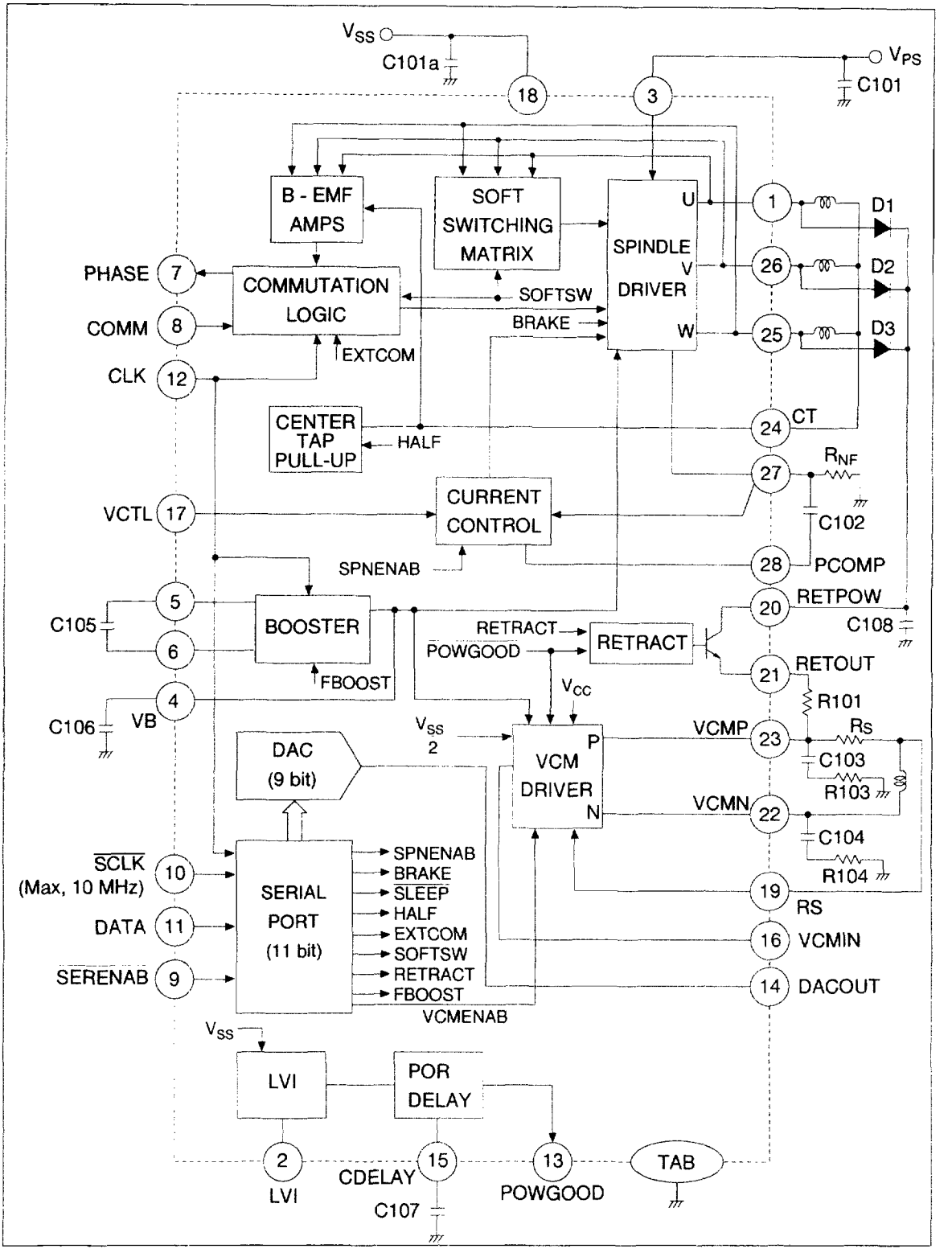
- Low output saturation voltage
  - Spindle driver 1.0 V typ (@0.8 A)
  - 0.2 V typ (@0.1 A)
  - VCM driver 1.0 V typ (@400 mA)
- Soft switching drive
- Minimum surface mount package body size 7 × 7 mm

Pin Arrangement



(Top view)

Block Diagram



Serial Port

1. Construction

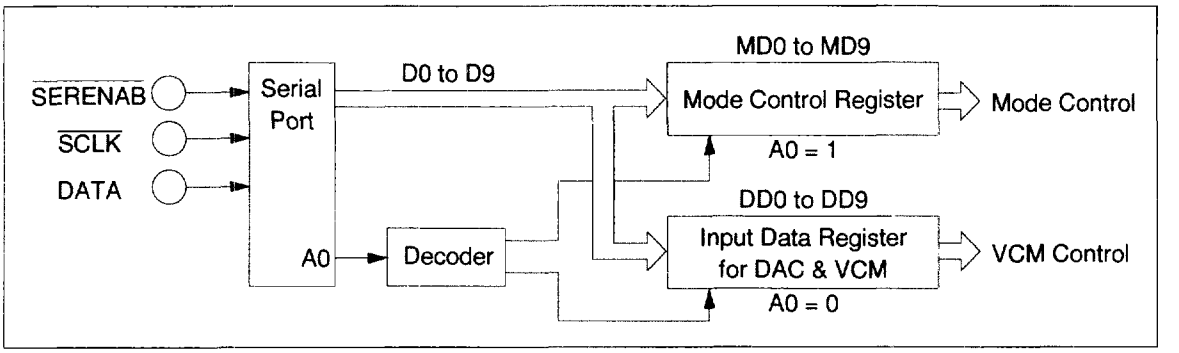


Figure 1 Serial Port

2. Data construction

2.1. Input Data Construction

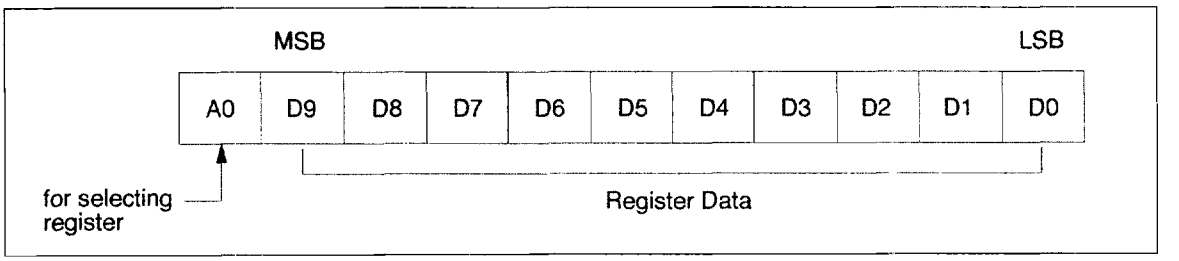


Figure 2 Input Data (1)

The serial port is required the 11 bit data (D0 to D9 and A0). Address bit A0 is used to select the register as follows. When the data length is less than 11 bits, the internal register will not be up dated. And when the data length is more than 11 bits, this register will take late 11 bits and ignore the faster bit.

A0	Resister
0	Input data register of DAC & VCMGAIN
1	Mode control register

2.2. Mode Control Register (A0 = 1)

Bit	Symbol	1	0	Note
MD0	SPNENAB	Spindle enable	Spindle disable	1
MD1	BRAKE	Brake enable	Brake disable	1
MD2	$\overline{\text{SLEEP}}$	Active	Sleep	2
MD3	HALF	Half wave drive	Full wave drive	
MD4	EXTCOM	External commutation	Internal commutation	3
MD5	SOFTSW	Soft switching	Switching	
MD6	VCMENAB	VCM enable	VCM disable	
MD7	RETRACT	Retracting	Not retracting	5
MD8	STANBY	Stanby	Active	2
MD9	FBOOST	For low frequency input	For high frequency input	4

Notes: 1. The spindle motor is independently winding to the value of the MD1, during the MD0 is true.(See Table 1)

2. The bit MD2 and MD8 select a sleep mode, stanby mode and active mode.(See Table 2)

3. The bit MD4 select a commutation mode at driving by B-EMF sensing. (See Commutation timing)

4. The bit MD9 determine the operating frequency of Booster Circuit. According to the frequency of Input CLK at pin 12, the value of MD9 should be chosen as shown Table 3.

5. The bit MD7 set up a retract driver.(See Table 4)

Table 1

MD0	MD1	Function
0	0	Spindle OFF
0	1	Brake ON
1	0	Spindle ON
1	1	Spindle ON

Table 2

MD2	MD8	Function
0	0	Sleep
0	1	Sleep
1	0	Active
1	1	Stanby

Table 3

f_{CLK}(Pin12)	MD9
7.1 MHz to 10 MHz	0
4.0 MHz to 7.0 MHz	1

Table 4

MD6	MD7	Function
0	1	Retracting
1	1	Not Retracting
×	0	Not Retracting

2.3. Input Data Register (A0 = 0)

$\frac{\text{Bit}}{\text{DD0 to DD9}}$: These input data are used to control the output current at VCM driver as shown follows.

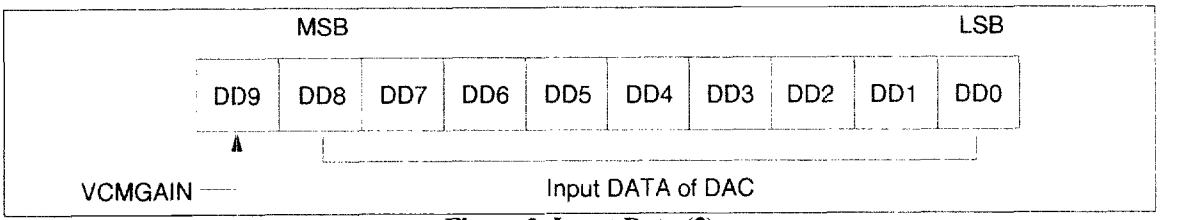


Figure 3 Input Data (2)

The data bit DD9 determine the transfer gain G_{VCM} which is specified as the relationship between the input data at the input data register and the output current at VCM amplifier. (See the right table)

Note : Short of VCMIN(pin16) and DACOUT(pin14).

DD9	DATA	I_O [mA]
1	1FF	$+199.2/R_S$
1	100	0.000
1	000	$-200.0/R_S$
0	1FF	$+49.8/R_S$
0	100	0.000
0	000	$-50.0/R_S$

Data Input Timing

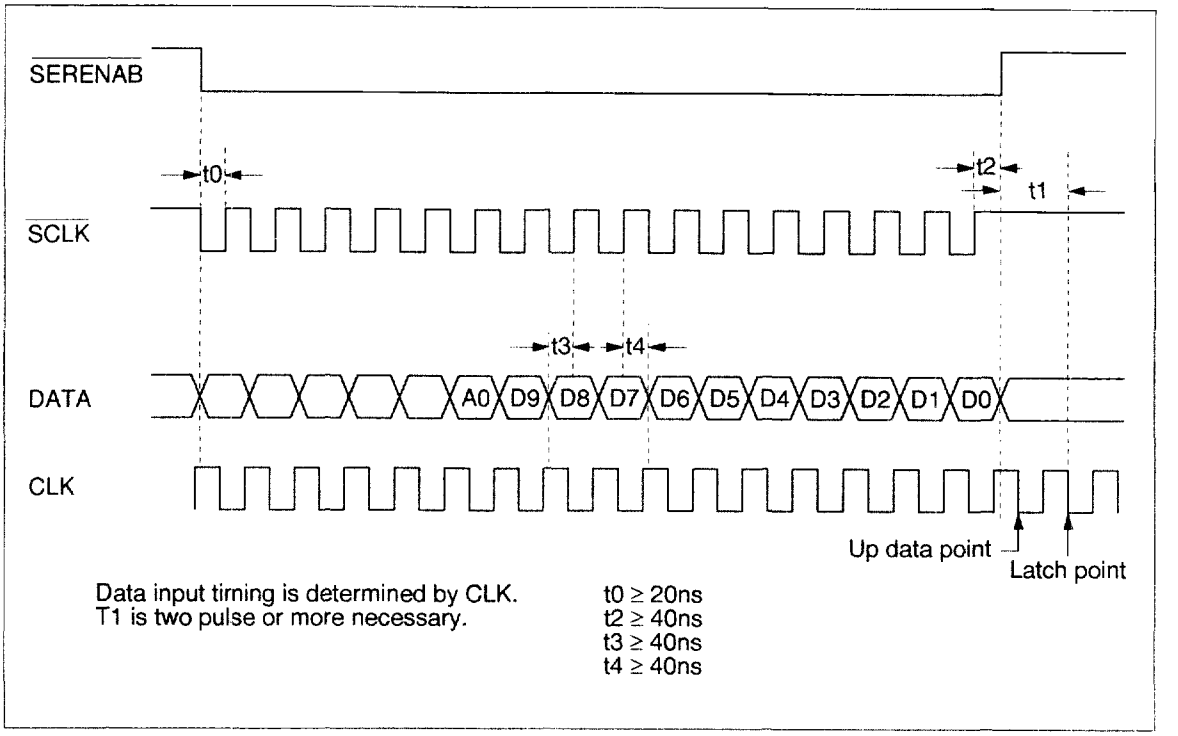


Figure 4 Input Timing on Serial Port

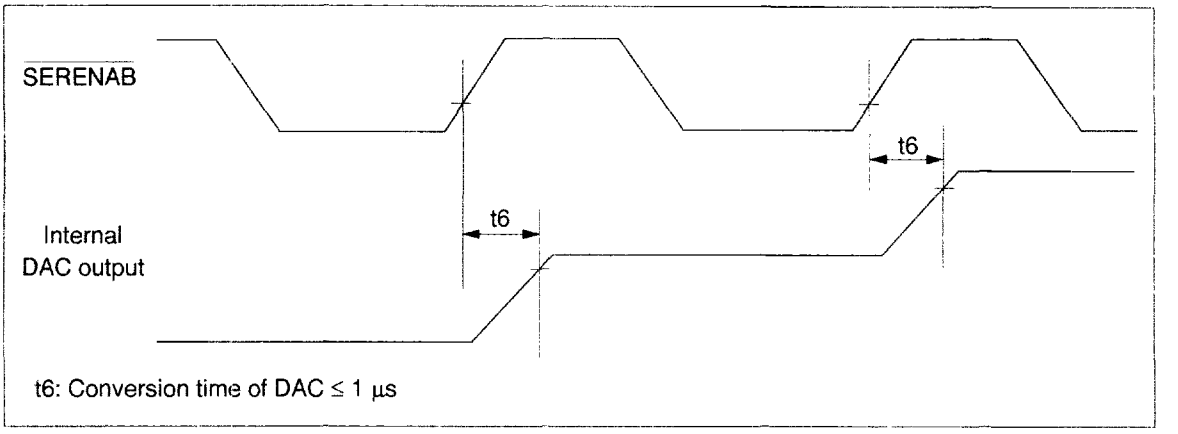
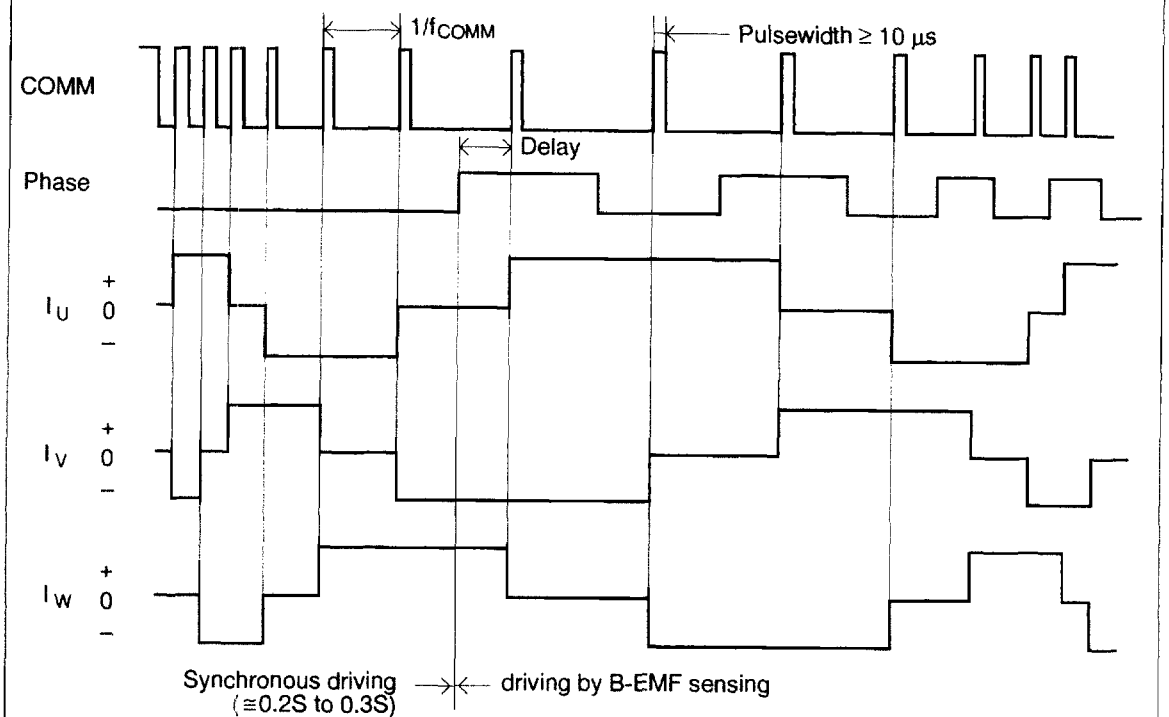


Figure 5 Conversion Timing on DAC

Commutation Timing (for starting up)

• Commutation for starting up



Note : The frequency of COMM signal f_{COMM} can be designed as follows.

$$f_{COMM} = 2.5\sqrt{\frac{P \cdot K_T \cdot I_O}{J}}$$ (for begin of synchronous driving) [Hz] (1)

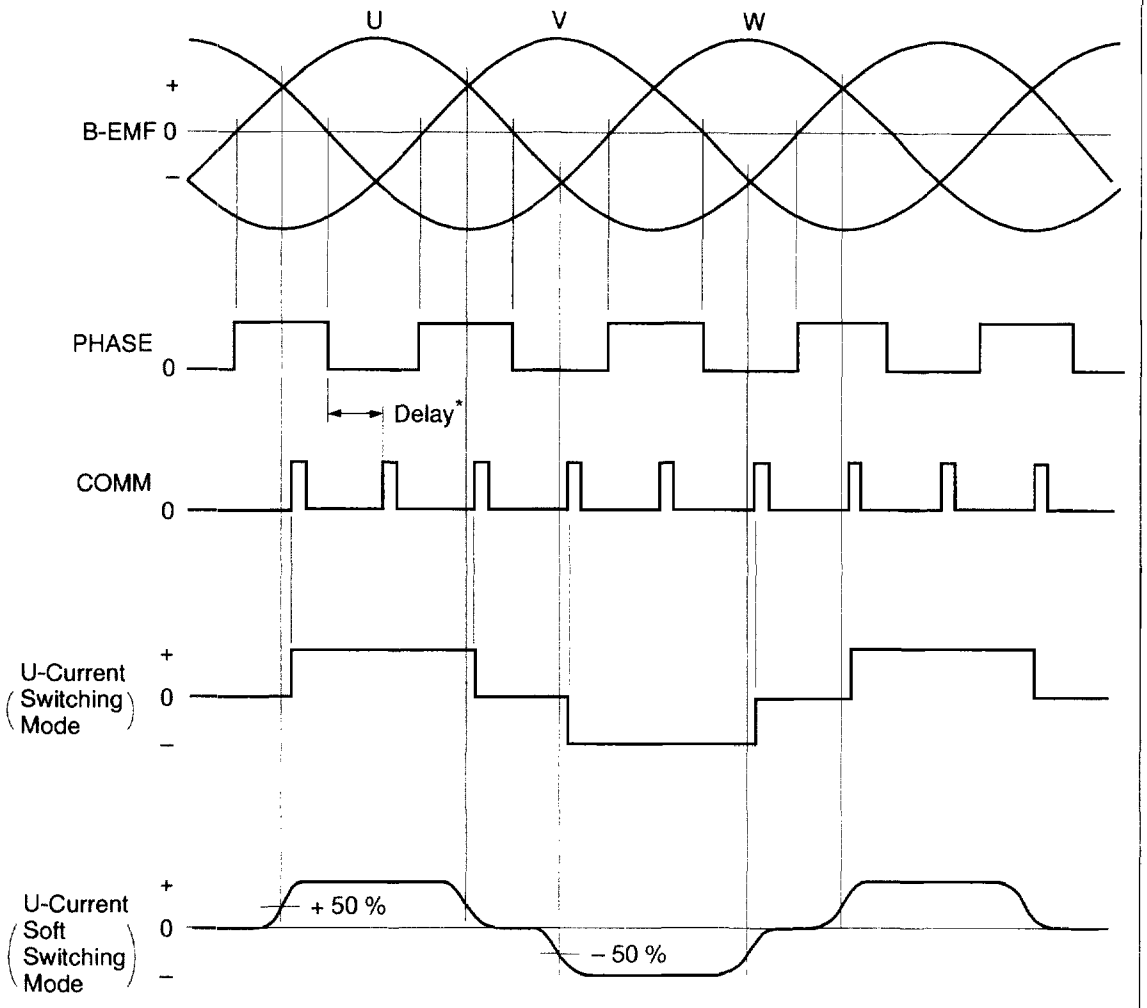
$$f_{COMM} = 0.5\sqrt{\frac{P \cdot K_T \cdot I_O}{J}}$$ (for end of synchronous driving) [Hz] (2)

Where,

P: Pole number of spindle motor
K_T: Torque constant (kg • cm/A)
I_O: Start up current (A)
J: Moment of inertia (kg • cm • S^2)

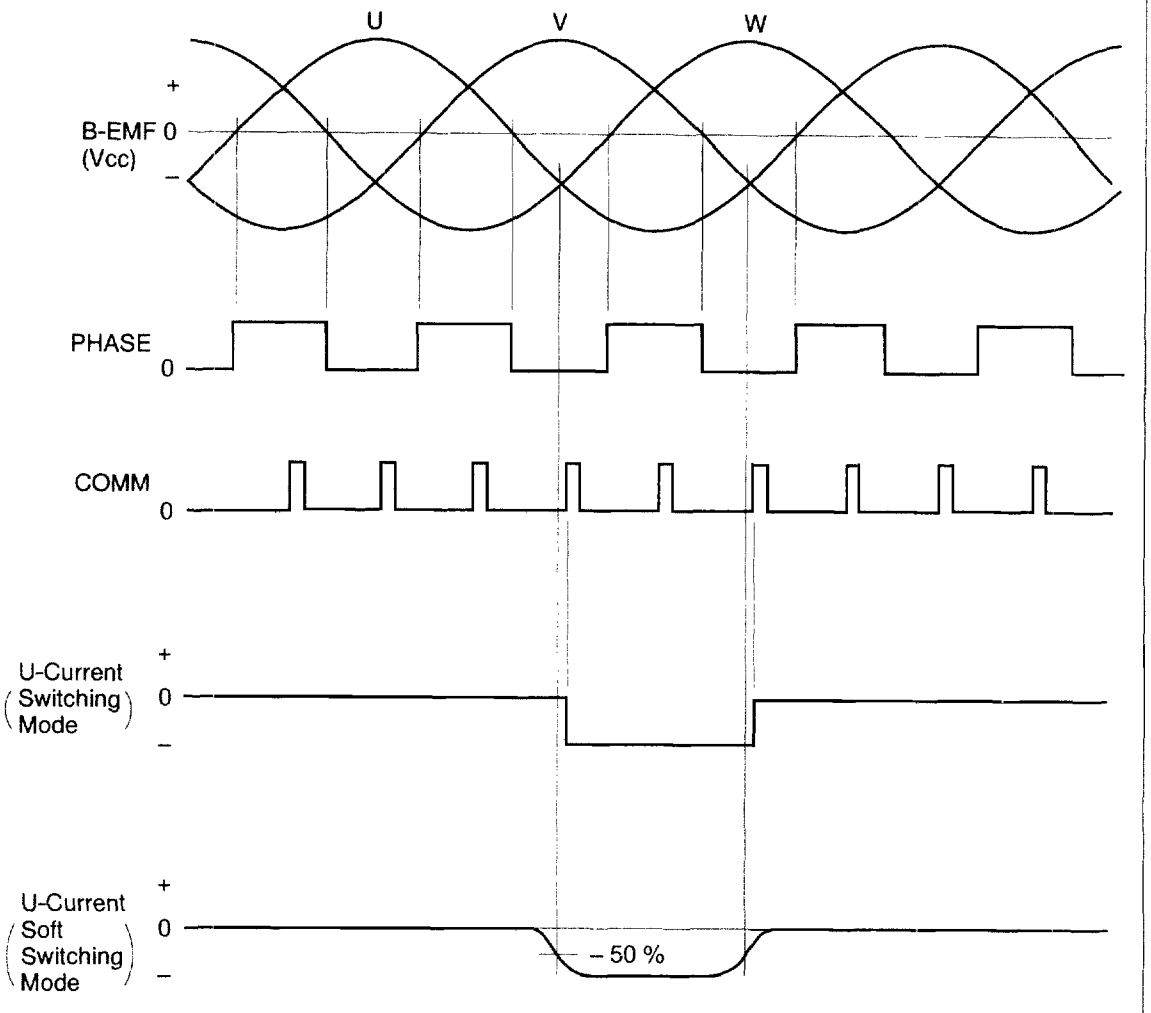
Commutation Timing

• External Commutation Mode (Full Wave Drive) (for B-EMF sensing drive)

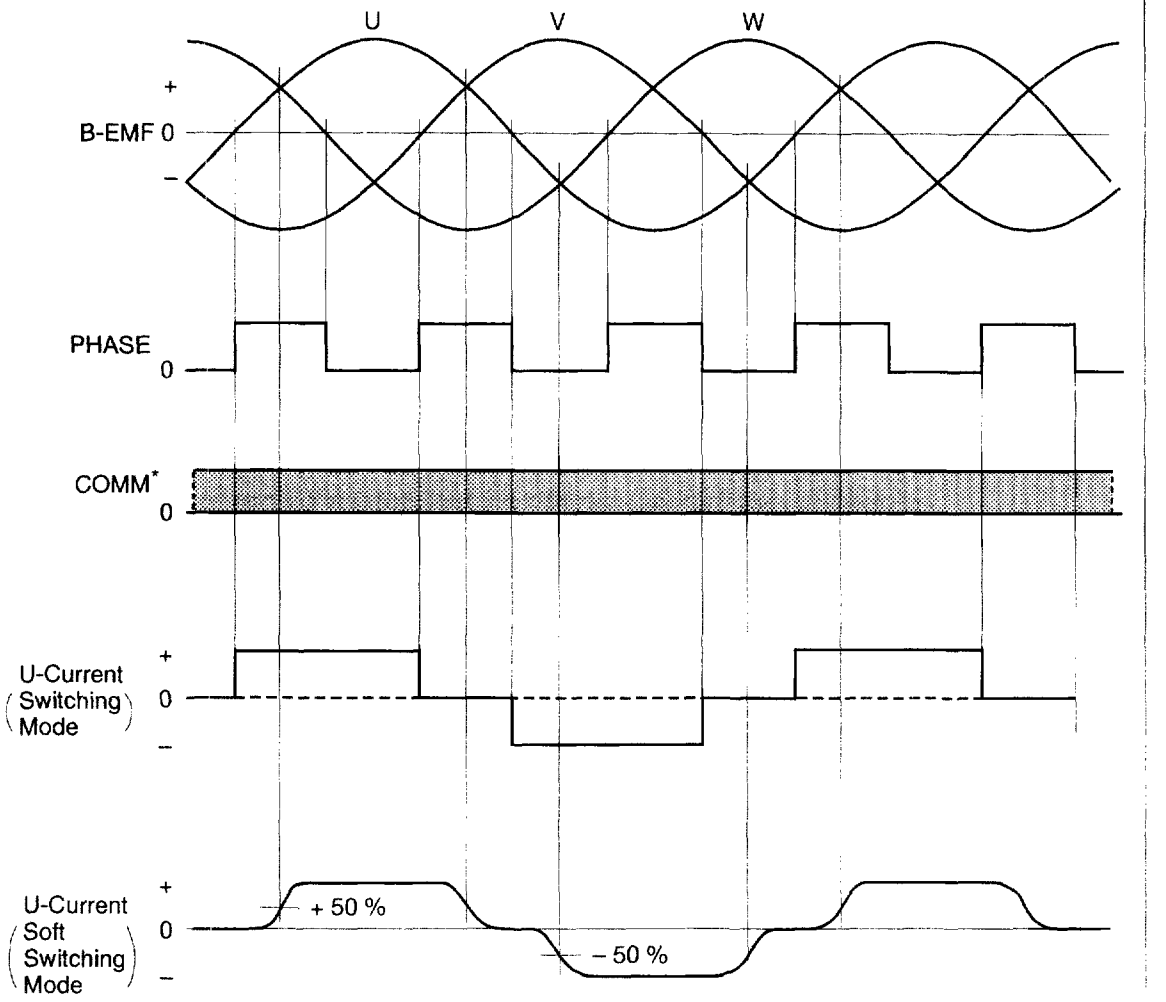


Note : Provided by MPU

• External Commutation Mode (Half Wave Mode)

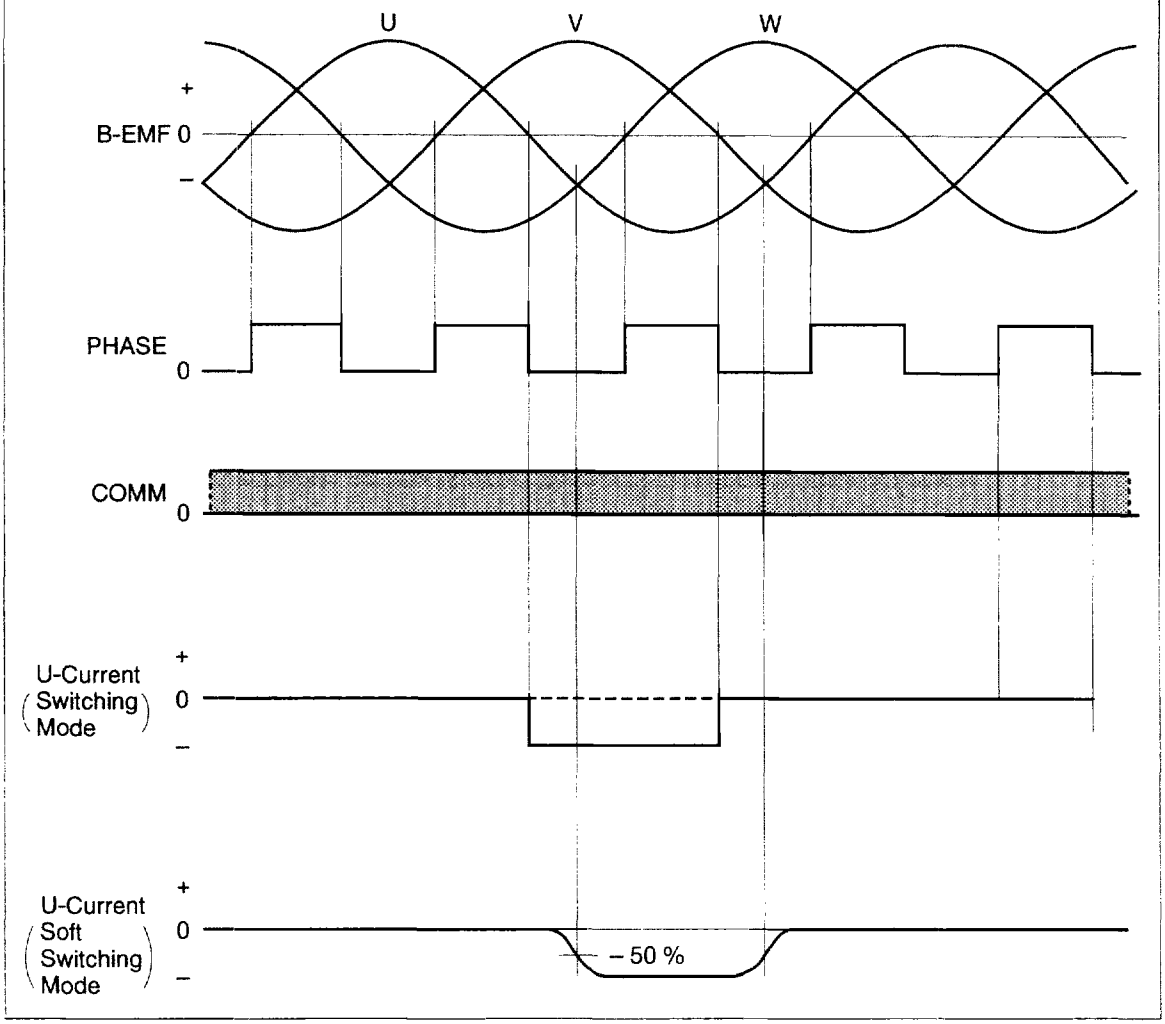


• Internal Commutation Mode (Full Wave Mode)

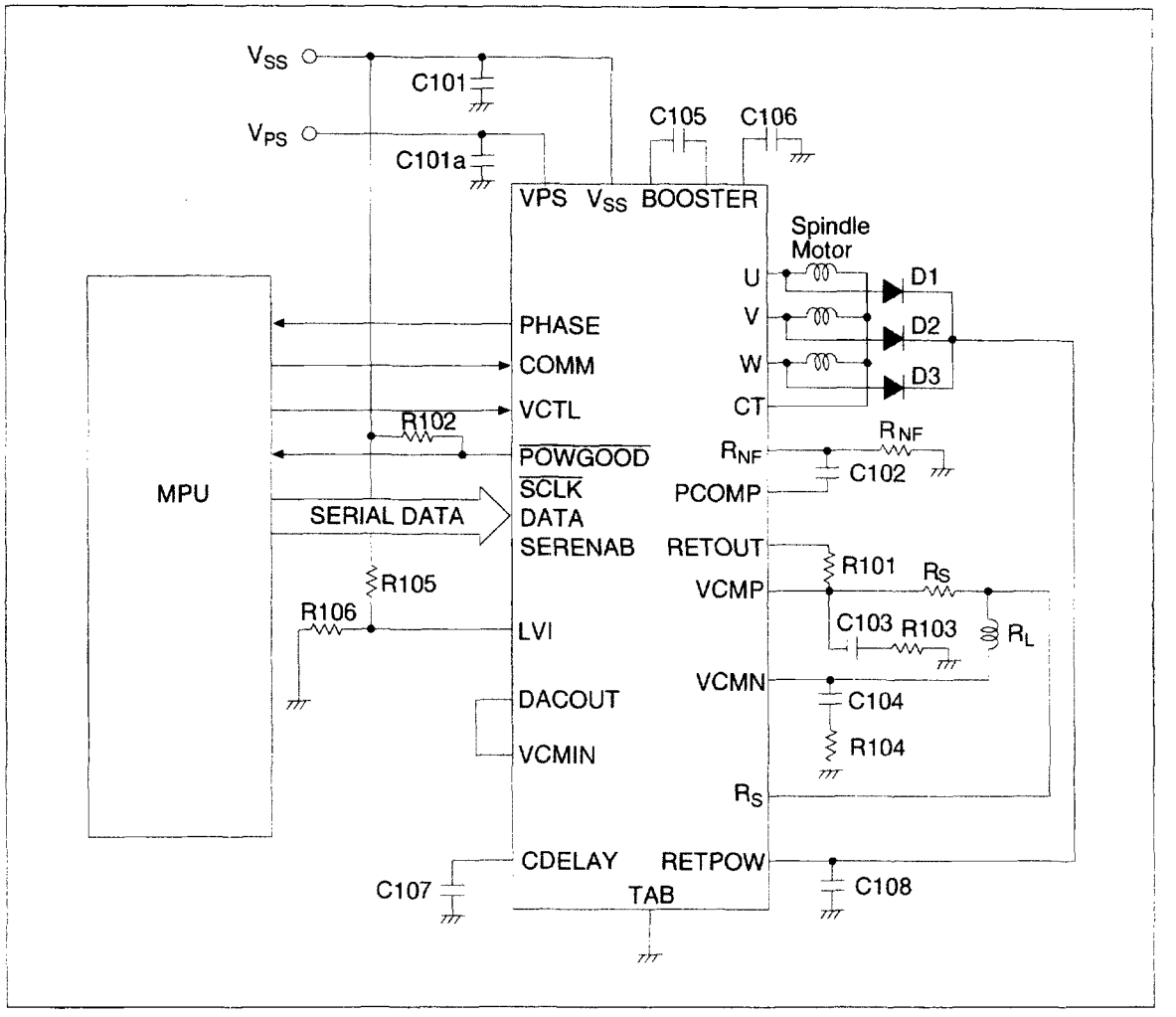


Note: When the internal commutation mode is selected, the commutation of the motor is automatically selected at the B-EMF sensing drive. But don't open the COMM terminal.

• Internal Commutation Mode (Half Wave Mode)



Application



External Component

Parts No.	Recommended Value	Purpose	Notes
R_{101}	—	Set retract current	1
R_{102}	51 kΩ	Pull up	
R_{103}, R_{104}	2.2 Ω	For stability	
R_{105}, R_{106}	—	Set LVI operation voltage	2
R_{nf}	≥ 0.2 Ω	Spindle current sense	3
R_S	0.47 Ω	VCM current sense	
C_{101}	0.1 µF	Power supply bypass	
C_{101a}	0.1 µF	Power supply bypass	
C_{102}	0.1 µF	Phase compensation for spindle driver	
C_{103}, C_{104}	0.1 µF	For stability	
C_{105}	0.22 µF	For booster	
C_{106}	2.2 µF	For booster	
C_{107}	—	P_{OR} delay	4
C_{108}	—	Retpower filter	
D1, D2, D3	—	For retract	

Notes: 1. The retract current is determined as follows.

$$Iret = \frac{Vretpow - Vsatret}{R_{101} + R_L + R_S} \quad (3)$$

Where,
R_L : VCM coil Resister.
Vsatret : Retout saturation voltage (See electrical characteristics)

2. The LVI operation voltage V_{LVI} and LVI return voltage V_{ON} can be designed as follows.(See Figure 6)

$$V_{LVI} = Vsd\left(1 + \frac{R_{105}}{R_{106}}\right) \text{ (for } V_{CC1}) \quad (4)$$

Set up to $V_{LVI} \geq 3.7$ V

Vsd : (See electrical characteristics)

$$Von = (Vsd + Vhys)\left(1 + \frac{R_{105}}{R_{106}}\right) \quad (5)$$

Vhys : (See electrical characteristics)

3. The motor starting up current Io is determined as follows.

$$Io = \frac{Vref1}{Rnf} \quad (A) \quad (6)$$

Where,
Vref1: reference voltage for current limiter
(See electrical characteristics)

4. The power on reset delay time is determined as follows.
$t_{POR} = 10^5 \cdot C_{107}$ (See electrical characteristics) (7)
(See Figure 6)

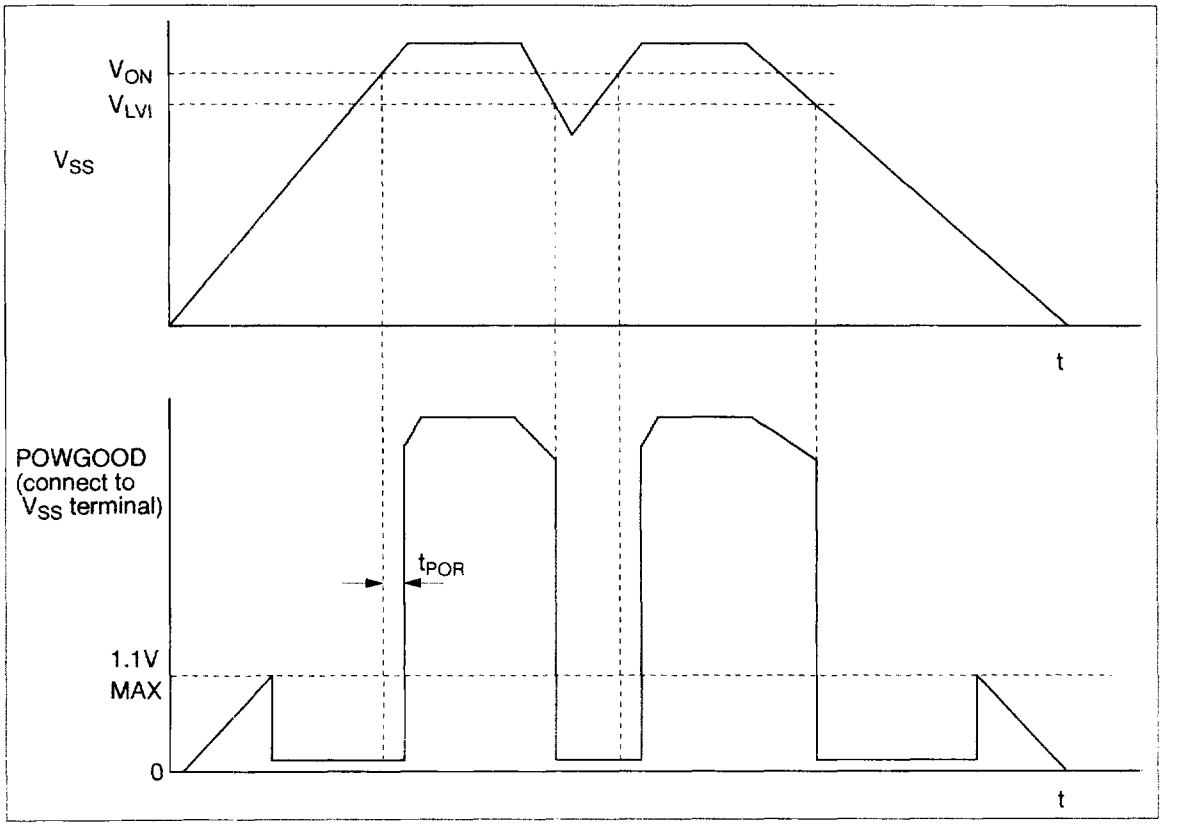


Figure 6 Timing for POWGOOD

Absolute Maximum Ratings (Ta = 25°C)

Item	Symbol	Value	Units	Notes
Power supply voltage	V_{SS}	7.0	V	1
	V_{PS}	7.0	V	1
Spindle current	Ispn	1.0	A	2
VCM current	Ivcm	400	mA	2
Retract current	Iret	100	mA	2
Input voltage	Vin	0 to V_{CC}	V	
Power dissipation				
Ta = 65°C	Pt1	1.0	W	3
Tc = 100°C	Pt2	2.0	W	3
Junction temperature	Tj	150	°C	4
Storage temperature range	Tstg	–55 to +125	°C	

Notes:
1. Operating voltage range is 4.25 V to 5.75 V. (Exclude of POWGOOD)
   POWGOOD operating voltage range is V_{SS} = 1.0 V to 5.75 V.
2. ASO of each output transistor is shown below (See figure 7, 8). Operating locus must be with in the ASO.
3. Thermal resistance is shown below.
   $\theta j - c \leq 25°C/W$
   $\theta j - a \leq 80°C/W$
4. Operating junction temperature range is 0 to +125°C.
5. It is notice that the ESD (Electro Static Damage) level of this IC is almost 25% lower than the other motor driver's IC.

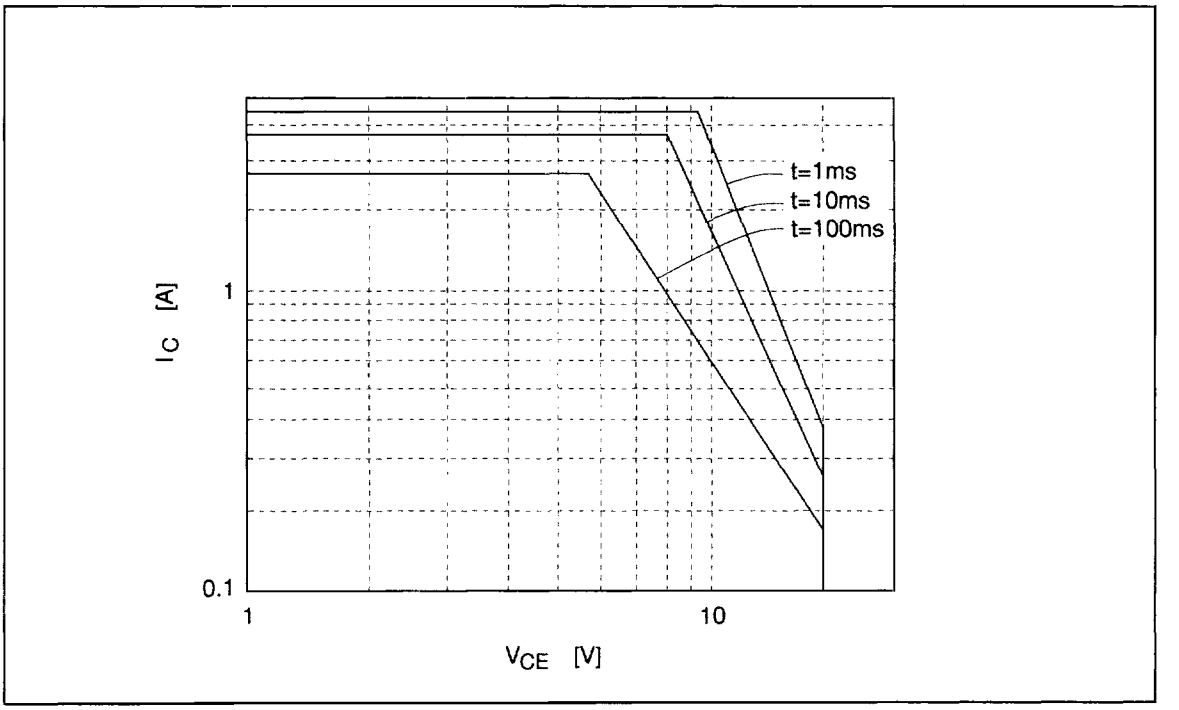


Figure 7 ASO of output stage (Spindle)

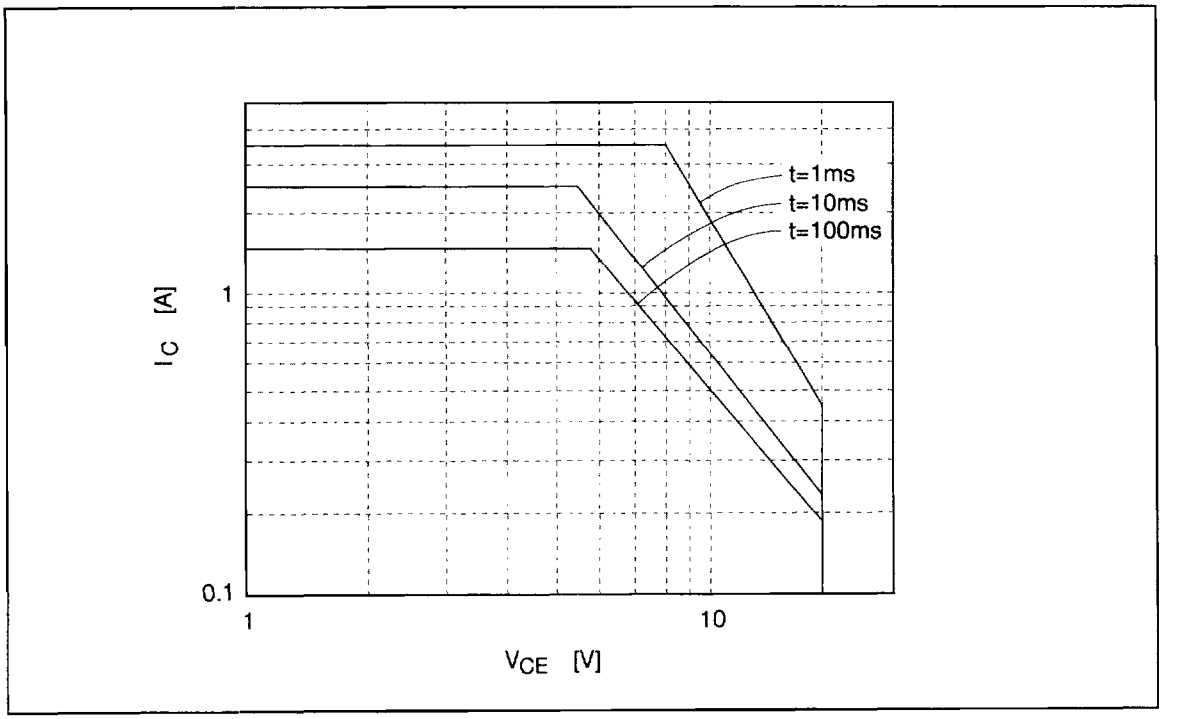


Figure 8 ASO of output stage (VCM)

Electrical Characteristics (Ta = 25°C, V_{CC} = 5 V)

Item		Symbol	Min	Typ	Max	Units	Test Conditions	Applicable Terminal	Note
Supply current		I_{CC0}	—	—	2.0	mA	Sleep mode	3, 18	1
		I_{CC1}	—	—	5.0	mA	Stanby mode		
		I_{CC2}	—	15	20	mA	Active mode		
Logic input	Input low current	I_{IL}	—	0	±10	μA	Vil = 0 V	8, 9, 10, 11, 12	
	Input high current	I_{IH}	—	—	±10	μA	Vih = 5 V		
	Input low voltage	V_{IL}	—	—	1.5	V			
	Input high voltage	V_{IH}	3.5	—	—	V			
	Clock frequency	f_{CLK}	—	—	10	MHz			
Logic output	Output high voltage	V_{OH}	4.4	—	—	V	I_{OH} = 1 mA	7	
	Output low voltage	V_{OL}	—	—	0.4	V	I_{OL} = 1 mA		
Spindle driver	Total saturation voltage	Vspnsat1	—	1.0	1.4	V	Ispn = 0.8 A	1, 25, 26	
		Vspnsat2	—	0.2	0.3	V	Ispn = 100 mA		
	Output leak current	Icer1	—	—	5	mA	$V_O = V_{CC}$ + 3 V		
	Current limiter reference voltage	Vref1	306	340	374	mV	R_{NF} = 1.0 Ω	17	
	Current control input current	Iin	—	—	±10	μA			
	Current control reference voltage	Vref2	0.63	0.70	0.77	μA			
	Current control gain	Gctl	−8.3	−6.3	−4.3	dB			
B-EMF amps	Input sensitivity	Vmin	—	50	—	mVp-p		1, 25, 26	2
VCM driver	Input resistance	Rin(H)	42	60	78	kΩ		16	
	Output quiescent voltage	Vq	2.5	2.63	2.75	V		22, 23	
	Output leak current	Icer2	—	—	±5	mA			
	Total output saturation voltage	Vsatvcm1	—	1.0	1.35	V	Ivcm = 400 mA		
		Vsatvcm2	—	0.8	1.0	V	Ivcm = 200 mA		
	Gain Bandwidth	B(H)	—	40	—	kHz	DD9 = 1 R_S = 1.0 Ω, R_L = 14 Ω		2
		B(L)	—	95	—	kHz	DD9 = 0		

Electrical Characteristics (Ta = 25°C, V_{CC} = 5 V) (cont)

Item		Symbol	Min	Typ	Max	Units	Test Conditions	Applicable Terminal	Note
DAC	Resolution	Ires	—	1/512	—	—		14	
	Output resistance	Rout	—	—	50	Ω	Iout(DAC)=200μA		
DAC & VCM	Full scale of output current	I_{FS1}	360	400	440	mA	DD9=1 R_S=1.0Ω, R_L=14Ω	14, 16, 22, 23	3
		I_{FS2}	90	100	110	mA	DD9=0		
	Offset	Ioff1	—	—	±15	LSB	DD9=1 R_S=1.0Ω, R_L=14Ω		
		Ioff2	—	—	±15	LSB	DD9=0		
	Linearity	I_{LIN}	—	—	±1	LSB			
Retract driver	Retpow input voltage	Vretpow	1.4	—	—	V	Iret = 20 mA R_S=1.0Ω, R_L=14Ω	20	
	Retout saturation voltage	Vsatret	—	1.0	1.2	V	Iret = 100 mA	21	
LVI	Operating voltage	Vsd	1.27	1.34	1.41	V		2	
	Hysteresis	Vhys	—	0.15	—	V		2	2
POR	Power on reset delay time	POR	5	10	20	ms	C_{107} = 0.1 μF	13	
	Output leak current	Icer3	—	—	±10	μA	Vpin13 = 7.0 V		
	Opendrain	Vol1	—	—	0.4	V	I_{OL} = 1 mA		
	Output low voltage	Vol2	—	—	0.2	V	V_{SS} = 1.1 V R_{102} = 51 kΩ		
OTSD	Operating temperature	Tsd	125	150	—	°C			2
	Hysteresis	Thys	—	25	—	°C			

Note: 1. Specified some of supply current on pin 18 and pin 3.
2. Design guide only.
3. Connected to pin16 and pin14.