

# HA13481S

Three Phase Motor Driver with Speed Discriminator

## Description

The HA13481S is hall sensorless three-phase brushless DC motor driver for HDD and, have following functions and features.

## Functions

- Back-EMF detector
- Start up circuit
- Running commutation
- Output amp. (Driving capability; 2.0 A/phase)
- Zerocross detector
- Programmable frequency divider
- OSC
- Speed discriminator
- Charge pump
- Control amp.
- Current limiter
- Start up monitor
- Ready signal
- Chip enable
- Motor on/off control
- Internal protector (OTSD, LVI)

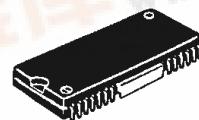
## Features

- Hall sensorless
- Low saturation voltage; 2.0 V max.  
(@ $I_O = 1.0$  A)
- Applicable for both 4 MHz and 5 MHz clock
- Small surface mount package ( $\theta_j - c \leq 7^\circ\text{C}/W$ )

## Ordering Information

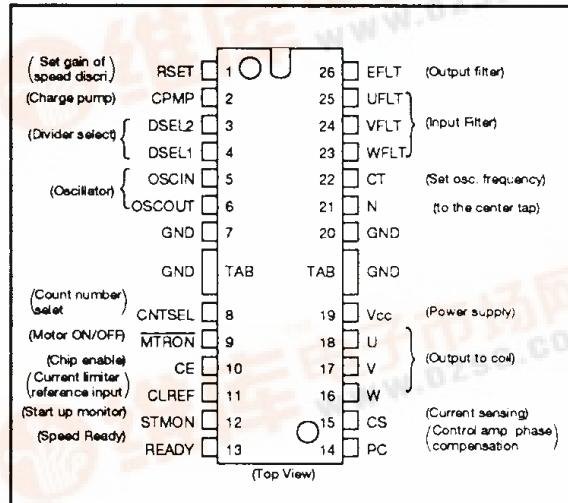
Type No.	Package
HA13481S	MP-26DT

HA13481S

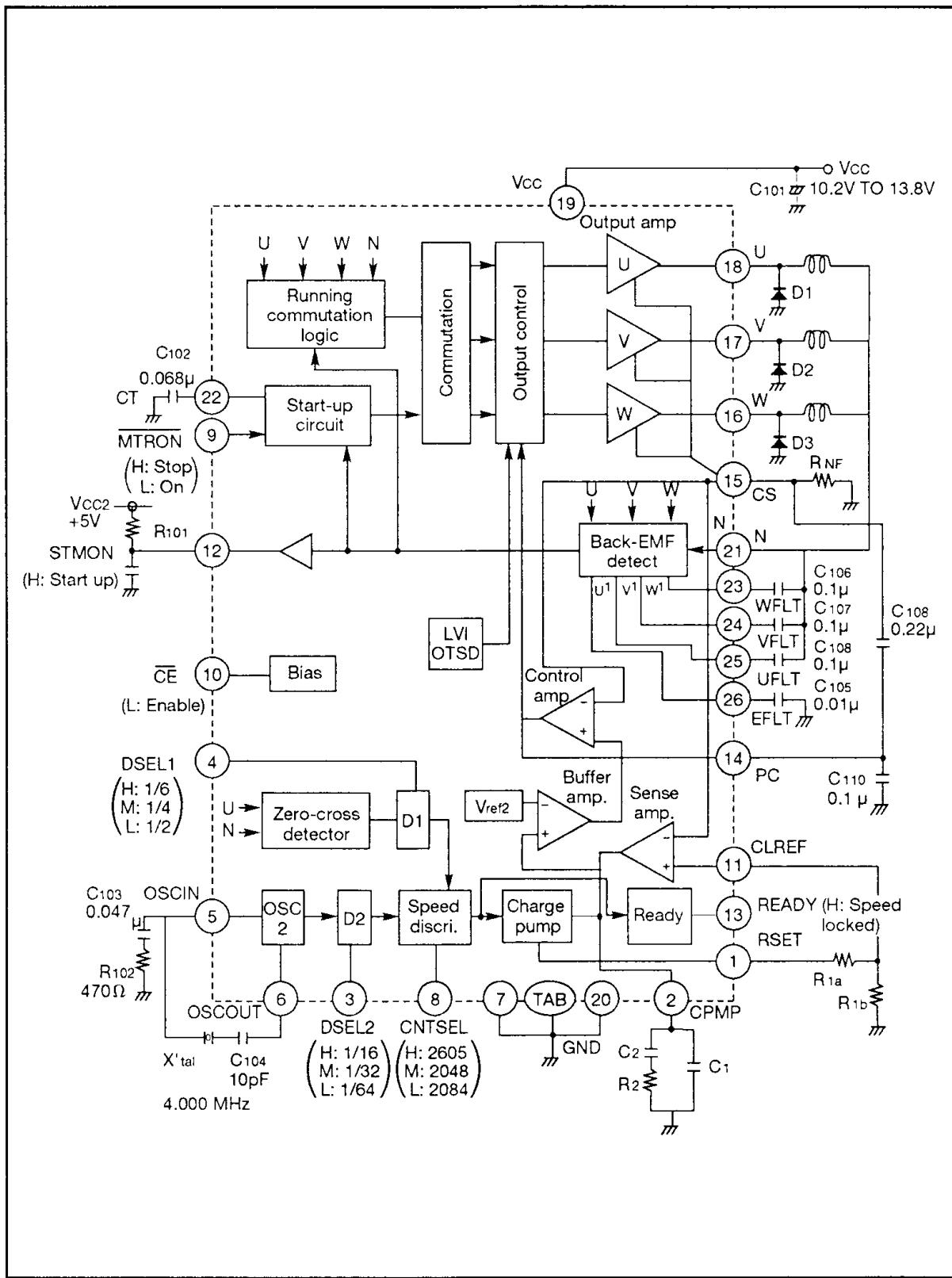


(MP-26DT)

## Pin Arrangement



## Block Diagram



## External Components

Parts No.	Recommended Value	Purpose	Notes
R <sub>101</sub>	47 kΩ ≤ R <sub>101</sub> ≤ 1 MΩ	Pull up	1
R <sub>102</sub>	470 kΩ	Oscillation stability	2
R <sub>1a</sub>	3.9 kΩ	V/I converter	
R <sub>1b</sub>	1.3 kΩ	V/I converter	3
R <sub>2</sub>	560 kΩ	Integral constant	
C <sub>101</sub>	10 µF and 0.1 µF	Power supply by-passing	
C <sub>102</sub>	0.068 µF	Oscillation	1
C <sub>103</sub>	0.047 µF	Oscillation stability	2
C <sub>104</sub>	10 µF ± 1%	AC-coupling	
C <sub>105</sub>	0.01 µF	Output filter	4
C <sub>106</sub> , C <sub>107</sub> , C <sub>108</sub>	0.1 µF	Input filter	5
C <sub>109</sub>	0.22 µF	Control amp phase compensation	
C <sub>110</sub>	0.1 µF		
C <sub>111</sub>	—	Time constant	1
C <sub>1</sub>	0.022 µF	Integral constants	3
C <sub>2</sub>	0.22 µF		
D <sub>1</sub> , D <sub>2</sub> , D <sub>3</sub>	—	Output clamp	6
Xtal	—	Oscillation	7
R <sub>NF</sub>	—	Current sensing	8

Notes: 1. By adding the C<sub>111</sub> on pin 12, the excitation frequency of the motor transit from high frequency to low frequency. By this operation, the back motion of the motor at starting condition can be minimized. The oscillation frequency f<sub>osc1</sub>, the C<sub>102</sub> and the time constant C<sub>111</sub> • R<sub>101</sub> are determined by following equations.

$$2 \times 10^{-3} \times \frac{N_o \cdot P}{V_E} < f_{osc1} < 0.25 \sqrt{\frac{I_o \cdot K_T \cdot P}{J}} \text{ [Hz]} \dots \dots \dots (1)$$

$$C_{102} = \frac{1}{f_{osc1} \cdot (V_{th1} - V_{th2})} \cdot \frac{I_{ts} \cdot I_{tf}}{I_{ts} + I_{tf}} = 0.52 / f_{osc1} \text{ [µF]} \dots \dots \dots (2)$$

$$C_{111} \cdot R_{101} > \frac{1}{I_n [V_{CC2} / (V_{CC2} - 2.5)] \cdot f_{osc1}} \text{ [S]} \dots \dots \dots (3)$$

Where,

N<sub>o</sub> : Standard rotation speed (rpm)

P : Number of pole

V<sub>I</sub> : Back EMF at running (V<sub>p-p</sub>)

I<sub>o</sub> : Starting up current (A)

K<sub>T</sub> : Torque constant (kg • cm/A)

J : Moment of inertia (kg • cm • S<sup>2</sup>)

2. Unnecessary below 4 MHz oscillation frequency.

3. The integral constant can be designed as

$$\omega_o \leq \frac{2\pi}{10 \cdot m} \times \frac{N_o}{60} \times \frac{P}{2} \dots \dots \dots (4)$$

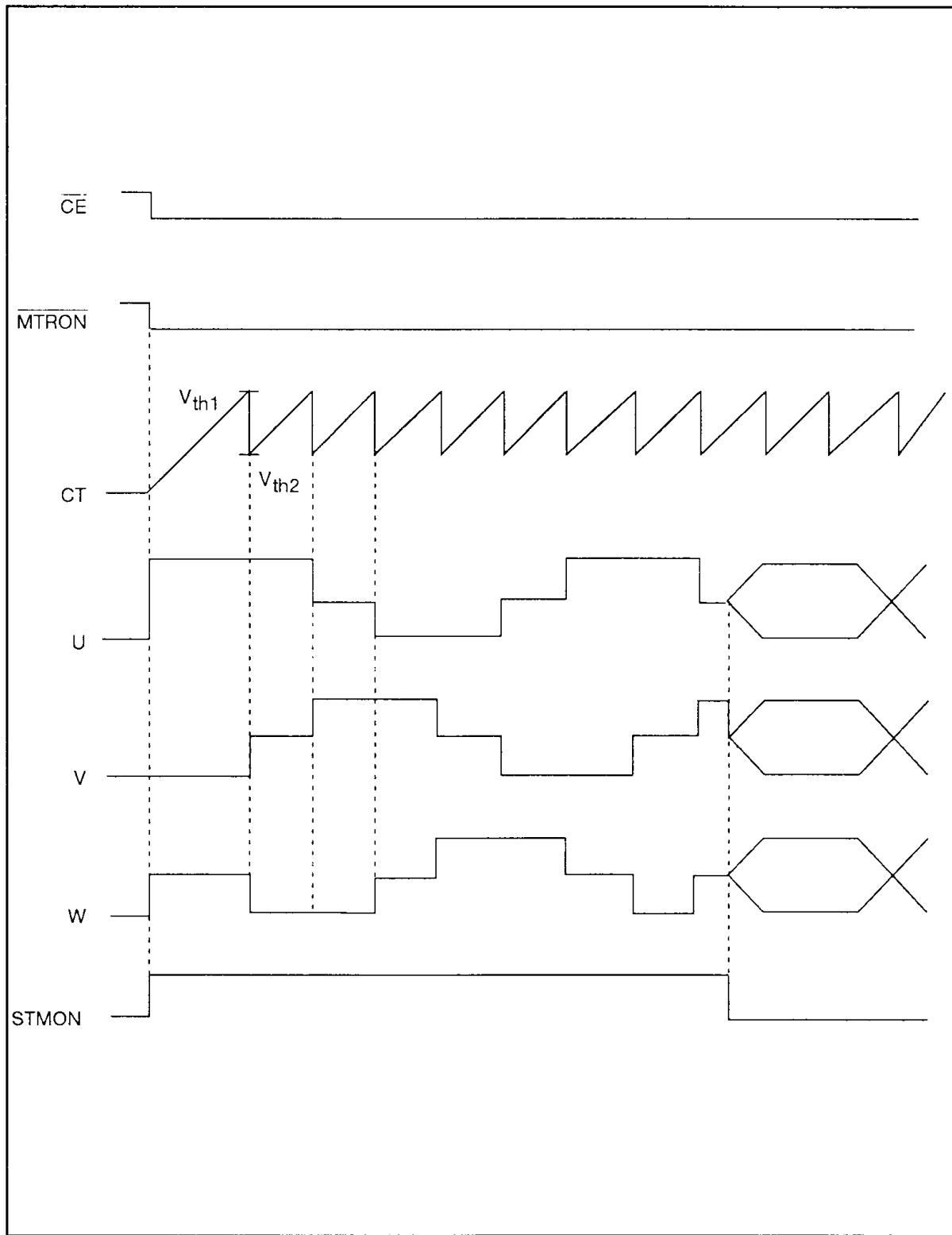
$$\frac{R_2}{R_{1a} + R_{1b}} = \frac{4}{9.55} \times \frac{R_{NF} \cdot J \cdot \omega_o \cdot N_o}{V_{ref2} \cdot K_T \cdot G_{CTL}} \dots \dots \dots (5)$$

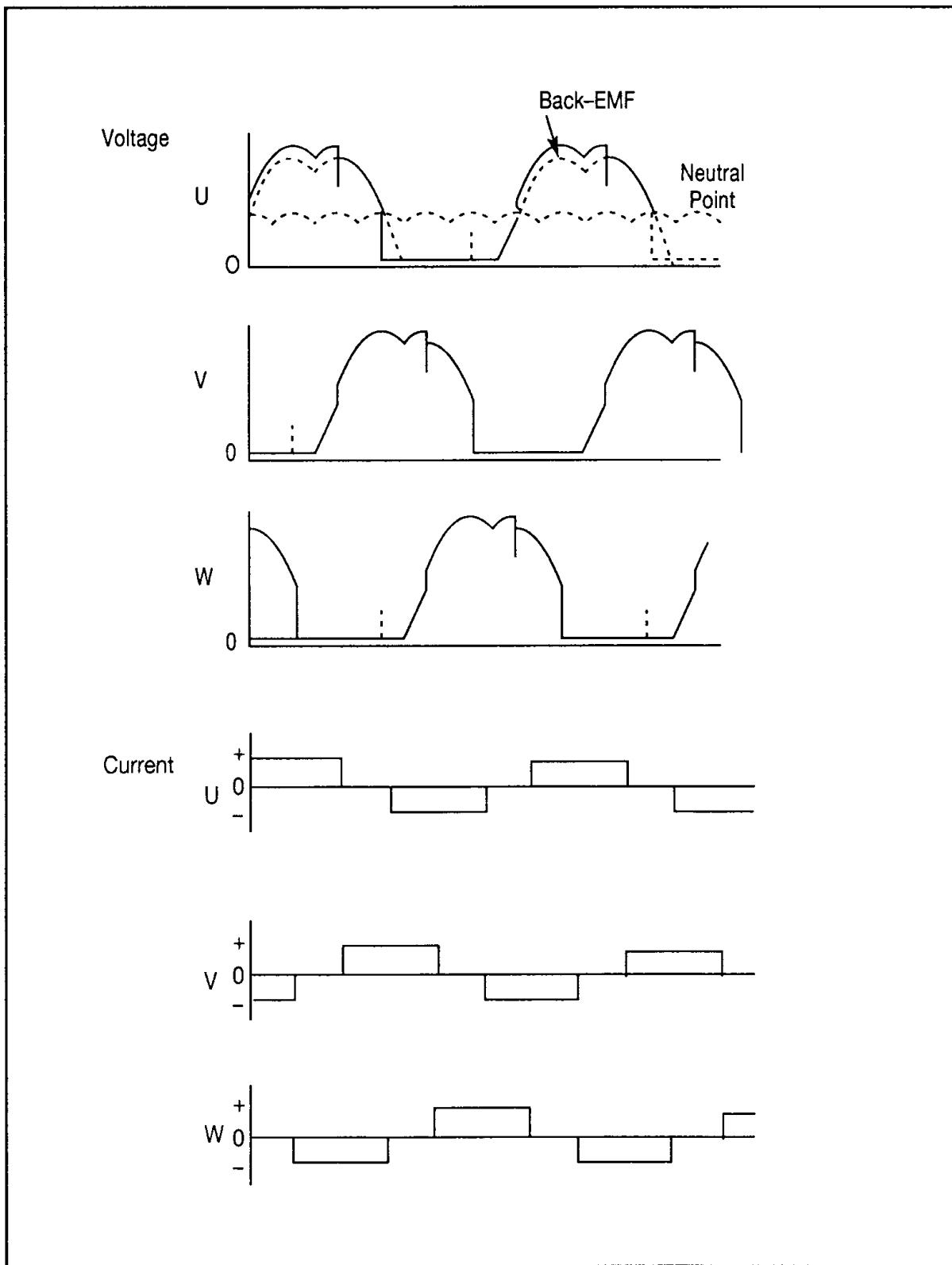
$$R_{1a} + R_{1b} \leq 25 \text{ kΩ} \dots \dots \dots (6)$$

$$C_1 = 1 / (\sqrt{10 \cdot \omega_o} \cdot R_2) \text{ [F]} \dots \dots \dots (7)$$

$$C_2 = 10 \cdot C_1 \text{ [F]} \dots \dots \dots (8)$$



**Timing Chart****Start-up**

**Running**

**Absolute Maximum Ratings ( $T_a = 25^\circ\text{C}$ )**

Item	Symbol	Rating	Unit	Notes
Power supply voltage	$V_{CC}$	+15	V	1
Input voltage	$V_{IN}$	$V_{CC}$	V	2
Output current	$I_O$	+2	A	3
Power dissipation	$P_T$	5	W	4
Junction temperature	$T_j$	+150	$^\circ\text{C}$	5
Storage temperature	$T_{stg}$	-55 to +125	$^\circ\text{C}$	

The absolute maximum ratings are limiting values, to be applied individually, beyond which the device may be permanently damaged. Functional operation under any of these conditions is not guaranteed. Exposing a circuit to its absolute maximum rating for extended periods of time may affect the device's reliability.

- Notes:
1. Operating voltage range is 10.2 V to 13.8 V.
  2. Applied to CE, MTRON, CNTSEL, DSEL 1 and DSEL2 inputs.
  3. ASO. of upper and lower power transistors are shown below.  
Operating locus must be within the ASO.

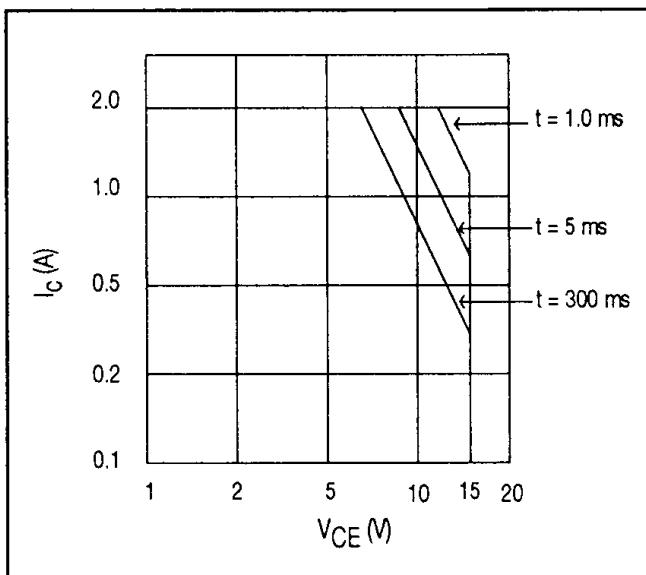


Figure 3 ASO. of Output Stages

4. Value at  $T_C = 115^\circ\text{C}$   
Thermal resistance is shown below.  
 $\theta_j - c \leq 7^\circ\text{C/W}$ ,  $\theta_j - a \leq 15^\circ\text{C/W}$  (Using Fe board),  $\theta_j - a \leq 62^\circ\text{C/W}$  (Using glass epoxide board)
5. Operating junction temperature is  $T_{jop} = 0^\circ\text{C}$  to  $+125^\circ\text{C}$

# HA13481S

## Electrical Characteristics (Ta = 25°C, V<sub>CC</sub> = 12 V)

Block	Item	Symbol	Min	Typ	Max	Unit	Test conditions	Applicable Terminal	Notes
Total	Quiescent current	I <sub>CC1</sub>	—	25	38	mA	Pin 10 = 0.0 V	19	
		I <sub>CC2</sub>	—	—	4.0		Pin 10 = 5.0 V		
CE	Input low voltage	V <sub>IL1</sub>	—	—	0.8	V	Enable	10	
	Input high voltage	V <sub>IH1</sub>	2.0	—	—		Disable		
	Input low current	I <sub>IL1</sub>	—	—	±100	µA	Pin 10 = 0.0 V		
	Input high current	I <sub>IH1</sub>	—	—	±100		Pin 10 = 5.5 V		
Motor on	Input low voltage	V <sub>IL2</sub>	—	—	0.8	V	Motor on	9	
	Input high voltage	V <sub>IH2</sub>	2.0	—	—		Motor off		
	Input low current	I <sub>IL2</sub>	—	—	±100	µA	Pin 9 = 0.0 V		
	Input high current	I <sub>IH2</sub>	—	—	±100		Pin 9 = 5.5 V		
Output amp.	Leak current	I <sub>CER1</sub>	—	—	2.0	mA	V <sub>CE</sub> = 15 V	16,17,18	
	Saturation voltage	V <sub>sat1</sub>	—	—	1.2	V	I <sub>O</sub> = 0.3 A	1	
		V <sub>sat2</sub>	—	—	2.0		I <sub>O</sub> = 1.0 A		
		V <sub>sat3</sub>	—	—	3.0		I <sub>O</sub> = 1.5 A		
	Current limiter	Ref. voltage	V <sub>OCL</sub>	V <sub>CLREF</sub> -25	V <sub>CLREF</sub> ±0	V <sub>CLREF</sub> +25	mV	V <sub>CLREF</sub> = 250 mV, R <sub>NF</sub> = 1.0 Ω	14,15 2
	Input current	I <sub>ICL</sub>	—	—	±5	µA			
B-EMF detector	Min. input sensitivity	V <sub>min1</sub>	70	100	130	mV <sub>P-P</sub>	Pin 21 = 4.2 V	21,23,24, 25,26	
Start-up circuit	OSC	Threshold voltage	V <sub>th1</sub>	3.3	3.5	3.7	V		22 3
		Threshold voltage	V <sub>th2</sub>	0.3	0.5	0.7			
		Sink current	I <sub>ts</sub>	40	55	80	µA	Pin 22 = 2.0 V Pin 12 = 5.0 V	
		Source current	I <sub>tf</sub>	0.9	1.6	2.8			
Start-up monitor	Leak current	I <sub>CER2</sub>	—	—	±100	µA	V <sub>CE</sub> = 15 V	12	4
	Low voltage	V <sub>OL2</sub>	—	—	0.4	V	I <sub>O</sub> = 1.0 mA		
Running communication	Min. input sensitivity	V <sub>min2</sub>	20	—	—	mV <sub>P-P</sub>	Pin 21 = 2.8 V	16,17, 18,21	6
Control amp.	Gain	G <sub>ctl</sub>	-8	-6	-4	dB		2,15	
	Internal reference	V <sub>ref1</sub>	0.9	1.0	1.1	V			
Oscillator	Frequency error	f <sub>err</sub>	—	—	±0.1	%	X'tal	5,6	7
	Operating frequency	f <sub>osc2</sub>	—	—	8	MHz			
Zero-cross detector	Min. input sensitivity	V <sub>min3</sub>	500	—	—	mV <sub>P-P</sub>	Pin 21 = 4.2V	18,21	
Divider select 1	Input low voltage	V <sub>IL3</sub>	—	—	1.0	V	DIV. rate = 1/2	4	
	Input middle voltage	V <sub>IM3</sub>	2.0	—	3.1		DIV. rate = 1/4		
	Input high voltage	V <sub>IH3</sub>	3.9	—	—		DIV. rate = 1/6		
	Input low current	I <sub>IL3</sub>	-150	-105	-75	µA	Pin 4 = 0.0 V	4	
	Input high current	I <sub>IH3</sub>	95	135	190		Pin 4 = 5.5 V		

Electrical Characteristics ( $T_a = 25^\circ\text{C}$ ,  $V_{CC} = 12 \text{ V}$ )

Block	Item	Symbol	Min	Typ	Max	Unit	Test conditions	Applicable Terminal Note
Divider select 2	Input low voltage	$V_{IL4}$	—	—	1.0	V	DIV. rate = 1/643	7
	Input middle voltage	$V_{IM4}$	2.0	—	3.1	V	DIV. rate = 1/32	
	Input high voltage	$V_{IH4}$	3.9	—	—	V	DIV. rate = 1/16	
	Input low current	$I_{IL4}$	-150	-105	-75	$\mu\text{A}$	Pin 3 = 0.0 V	3
	Input high current	$I_{IH4}$	95	135	190	$\mu\text{A}$	Pin 3 = 5.5 V	
Count number select	Input low voltage	$V_{IL5}$	—	—	1.0	V	Discr. count number	8
	Input middle voltage	$V_{IM5}$	2.0	—	3.1	V	2084	
	Input high voltage	$V_{IH5}$	3.9	—	—	V	2084	7
	Input low current	$I_{IL5}$	-150	-105	-75	$\mu\text{A}$	2605	
	Input high current	$I_{IH5}$	95	135	190	$\mu\text{A}$	Pin 8 = 5.5 V	
Charge pump	R1 set-up voltage	$V_{ref2}$	0.95	1.05	1.15	V	$R_{1a} + R_{1b}$ = 5.0 $\text{k}\Omega$	1
	Charge current	$I_{CH}$	44	52	61	$\mu\text{A}$	Pin 2 = 1.0 V	
	Discharge current	$I_{DIS}$	44	52	61	$\mu\text{A}$	Pin 2 = 1.0 V	2
	Leak current	$I_{CER4}$	—	—	$\pm 50$	nA	Pin 2 = 1.0 V	
Ready	Current ratio	$I_{rat}$	0.9	1.0	1.1	—	$I_{rat} = I_{CH}/I_{DIS}$	11
	Output high voltage	$V_{OH1}$	3.8	4.2	4.6	V	$I_0 = 1.0 \text{ mA}$	
LVI	Output low voltage	$V_{OL1}$	—	—	0.4	V	$I_0 = 1.0 \text{ mA}$	5
	Recovery voltage	$V_{LVI}$	—	—	8.0	V	—	
OSTSD	Operating temperature	$T_{TSD}$	125	150	—	$^\circ\text{C}$	—	6
	Hysteresis temperature	$T_{hys}$	—	25	—	—	—	

- Notes:
- Sum of upper and lower saturation voltage.
  - Symbol " $V_{CLREF}$ " denotes the applied voltage at pin 11, and " $V_{OCL}$ " is measured from TAB (GND) to pin 15.
  - See timing chart.
  - This terminal is open collector output.
  - See figure 4.
  - Design guide only
  - The maximum frequency, selecting the combination  $DSELZ = H$  and  $CNTSEL = H$ , must be less than 4 MHz.

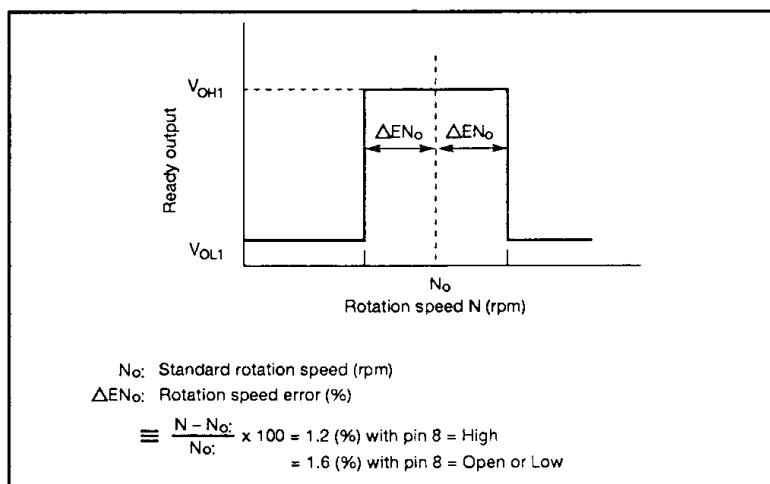
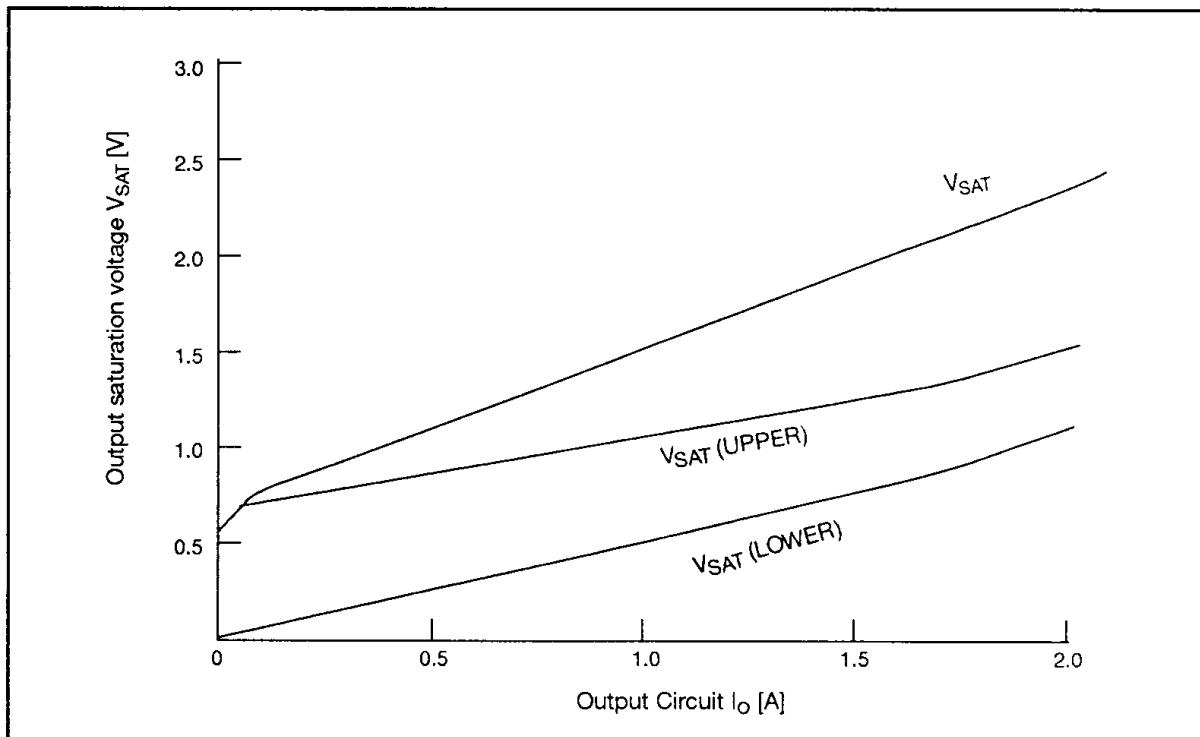
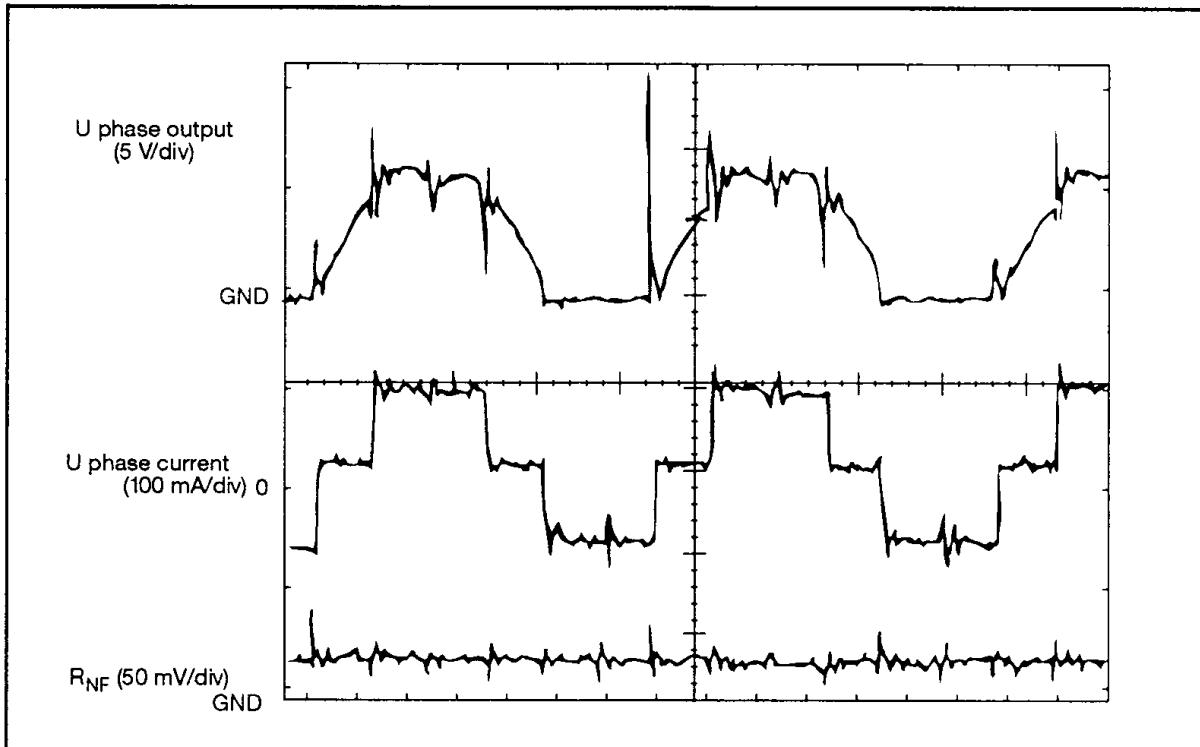


Figure 4 Operation of Ready Circuit

**References****Figure 5**  $V_{SAT}$  vs  $I_O$ **Figure 6** Waveform on Actual Application (3.5" 8 poles motor)