

Three Phase Motor Driver with Speed Discriminator

Description

The HA13501S is hall sensorless three-phase brushless DC motor driver for HDD and, has the following functions and features.

Functions

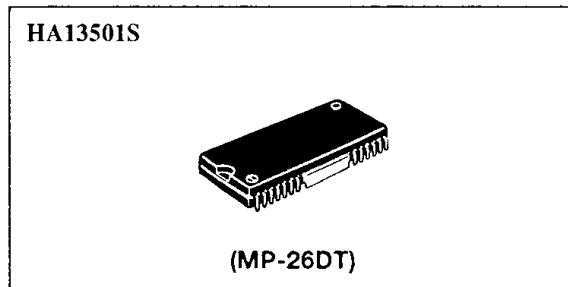
- 3-phase motor drive circuit (1.2 A/phase)
- Start up circuit
- Digital servo system
- Digital ready circuit
- Chip enable
- Motor on/off
- Internal protector (OTSD, LVI)

Features

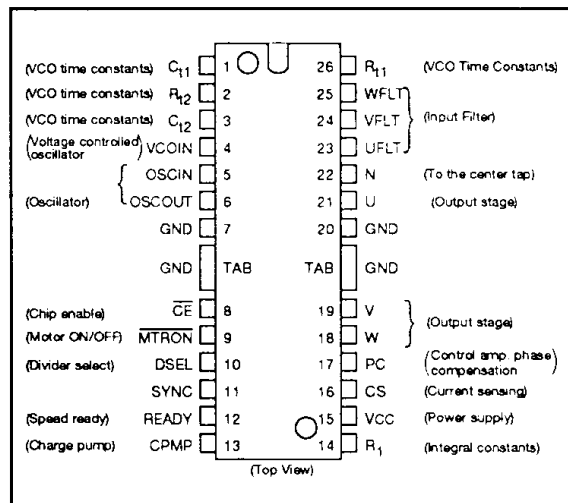
- Hall sensorless motor driving system
- Low saturation voltage; 1.5 V max. (@ $I_O = 0.8$ A)
- Applicable for 4.0 MHz clock
- Small surface mount package ($\theta_j - c \leq 7^\circ\text{C/W}$)

Ordering Information

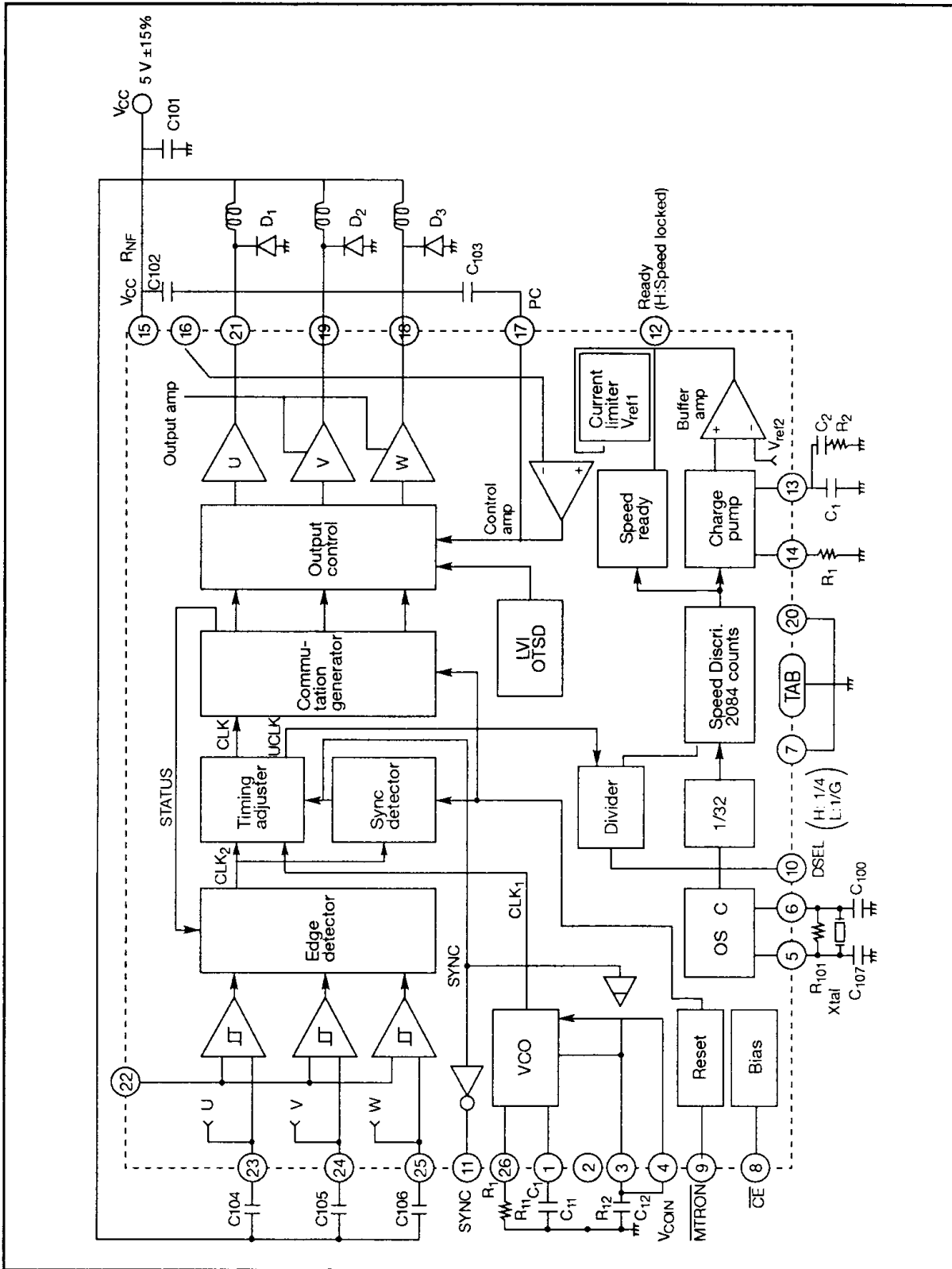
Type No.	Package
HA13501S	MP-26DT



Pin Arrangement



Block Diagram



External Components

Parts No.	Recommended Value	Purpose	Notes
R ₁₀₁	1 MΩ	Oscillation	
R _{t1}	10 kΩ ≤ ≥ 100 kΩ	VCO time constants	1
R _{t2}	100 kΩ ≤ ≥ 1 kΩ	VCOIN time constants	2
R _{NF}	—	Current sensing	3
R ₁	8.2 kΩ ≤ ≥ 47 kΩ	Integral constants	4
R ₂	—		
C ₁₀₁	10 μF and 0.1 μF	Power supply by-passing	
C ₁₀₂	0.1 μF	Control amp phase compensation	
C ₁₀₃	0.01 μF		
C _{104, C105, C106}	0.01 μF	Output filter	
C _{107, C108}	10 μF	Oscillation	
C _{t1}	—	VCO time constants	1
C _{t2}	—	-VCO time constants	2
C ₁	—	Integral constants	4
C ₂	—		
D _{1, D2, D3}	—	Output clamp	5
X'tal	—	Oscillation	6

Notes: 1. The relationship of time constant C_{t1} • R_{t1} and the VCO frequency f_{VCO} is shown as follows:

(i) V_{Pin4} = 0 V

$$f_{VCO} = \frac{0.75}{C_{t1} \cdot R_{t1}} \quad (= f_{VCO1}) \dots\dots\dots(1)$$

(ii) 0 V < V_{Pin4} ≤ 2 V

$$f_{VCO} = (0.75 - 0.34 \cdot V_{PIN4}) / C_{t1} \cdot R_{t2} \dots\dots\dots(2)$$

(iii) V_{Pin4} > 2 V

$$f_{VCO} = \frac{0.075}{C_{t1} \cdot R_{t1}} \quad (= f_{VCO2}) \dots\dots\dots(3)$$

(c.f. figure 3 in references)

The maximum frequency f_{VCO1} should be satisfied with the following equation:

$$f_{VCO1} = 0.05 \sqrt{\frac{P \cdot K_T \cdot I_O}{J}} \dots\dots\dots(4)$$

Where,

- J : Morment of inertia (kg • cm • s²)
- P : number of poles in the motor
- K_T : Torque constant (kg • cm/A)
- I_{omax}: Output maximum current (A)

2. The time constant C_{t2} • R_{t2} which determine the frequency transition time of the VCO, should be satisfied with the following equation:

$$C_{t2} \cdot R_{t2} \cong 0.5 T_S \dots\dots\dots(5)$$

where T_S is the motor starting up time
(c.f. figure 2 in references)

3. Output maximum current I_{omax} is determined by the following equation:

$$I_{omax} = V_{ref1} / R_{NF} \dots\dots\dots(6)$$

where,

V_{ref1}: Current limiter reference voltage



4. The integral constant can be designed as follows:

$$\omega_o \leq \frac{2\pi D}{10} \times \frac{N_o}{60} \times \frac{P}{2} \dots\dots\dots(7)$$

$$\frac{R_2}{R_1} = \frac{1}{9.55} \times \frac{R_{NF} \cdot J \cdot \omega_o \cdot N_o}{V_{R1} \cdot K_T \cdot G_{CTL}} \dots\dots\dots(8)$$

$$R_1 \leq 25 \text{ k}\Omega \dots\dots\dots(9)$$

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

$$C_2 = 10 \cdot C_1 \text{ [F]} \dots\dots\dots(11)$$

where,

G_{CTL} : gain from pin 13 to pin 16 (see electrical characteristics)

5. Some motors require these components.

6. The OSC frequency f_{OSC} is determined by the following equation:

$$f_{OSC} = 555.6 N_o \cdot P \cdot D \dots\dots\dots(12)$$

where,

N_o : Standard rotation speed (rpm)

D : Dividing ratio on divider

$D = 1/6$ @ Pin 10 = Low)

$D = 1/4$ @ Pin 10 = High)

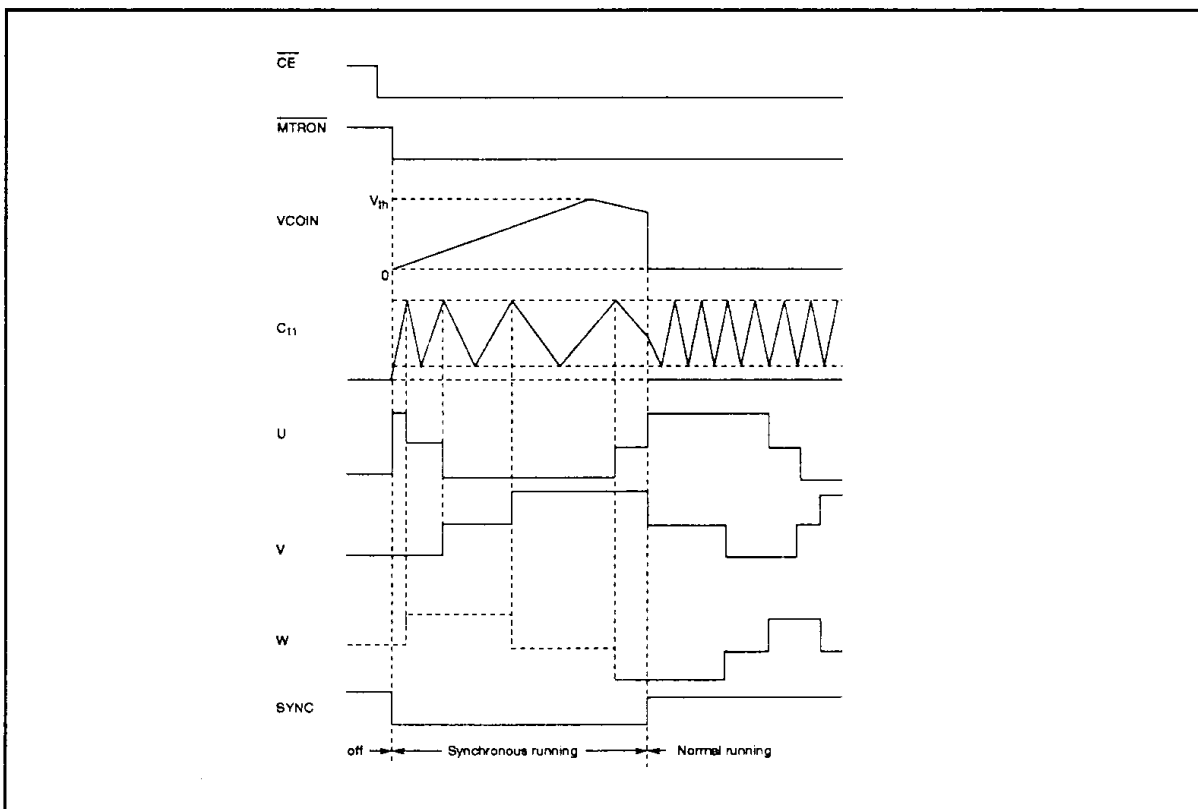
In order to minimize the error of rotation speed, select the dividing ratio m as follows:

at 8 pole motor $\rightarrow D = 1/4$

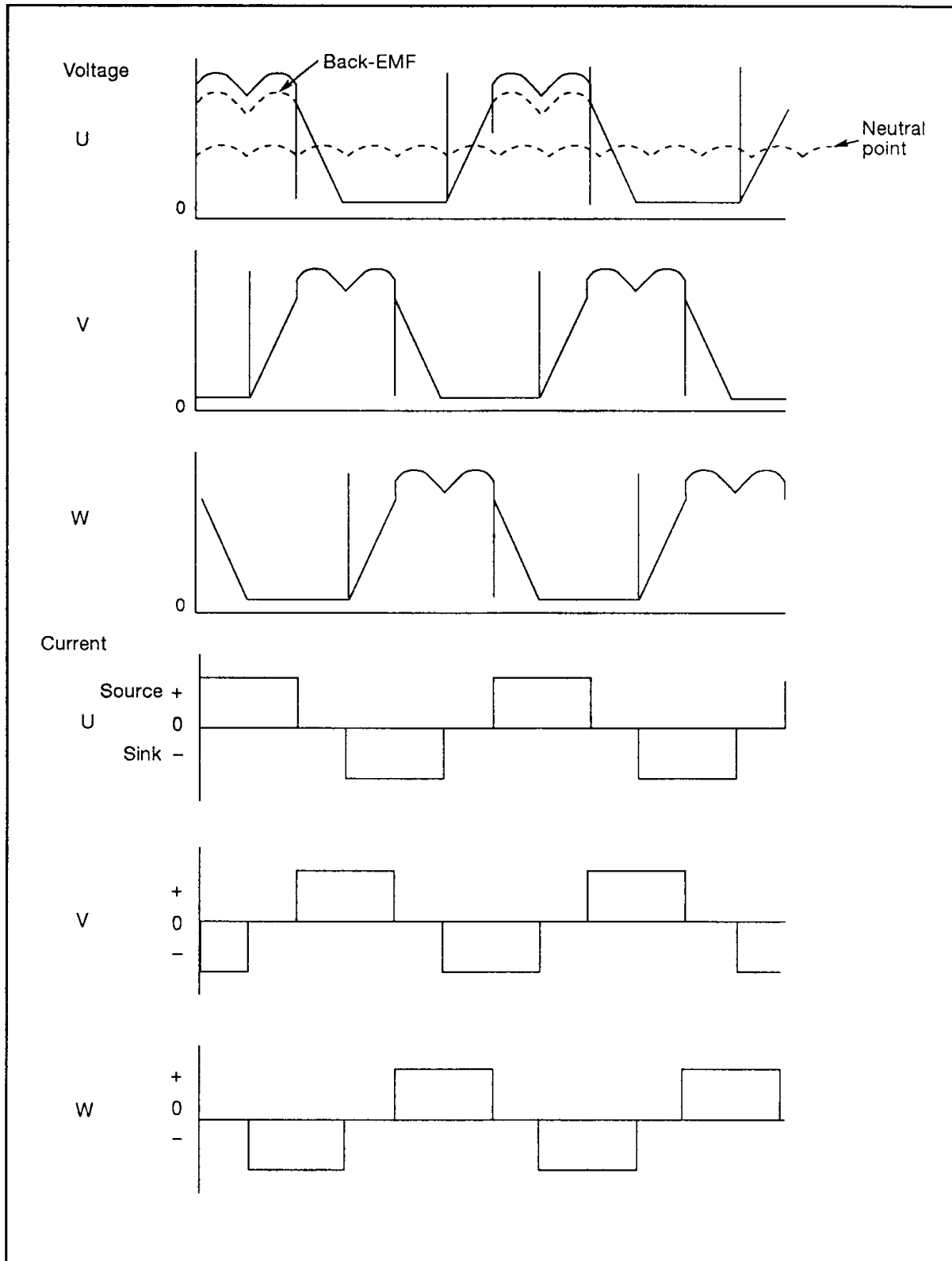
at 12 pole motor $\rightarrow D = 1/6$

Timing Chart

Start-up



Running



HA13501S

Absolute Maximum Ratings (Ta = 25°C)

Item	Symbol	Rating	Unit	Notes
Power supply voltage	V _{CC}	7.0	V	1
Input voltage	V _{IN}	V _{CC}	V	2
Output current	I _O	1.2	A	3
Power dissipation	P _T	2.0	W	4
Junction temperature	T _J	+150	°C	5
Storage temperature	T _{stg}	-55 to +125	°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 4.25 V to 5.75 V.
 2. Applied to CE, MTRON, DSEL 1 and VCOIN inputs.
 3. Operating locus must be within the ASO.
 ASO of upper and lower power transistors are shown figure 1 in references.
 4. Value at T_C = 136°C
 Thermal resistance is shown below.
 $\theta_{j-c} \leq 7^\circ\text{C/W}$, $\theta_{j-a1} \leq 15^\circ\text{C/W}$ (using Fe board), $\theta_{j-a2} \leq 62^\circ\text{C/W}$ (using glass epoxy board)
 5. Operating junction temperature is T_{jop} = 0°C to +125°C.

Electrical Characteristics (Ta = 25°C, V_{CC} = 5.0 V)

Block	Item	Symbol	Min	Typ	Max	Unit	Test conditions	Applicable Terminal	Notes
Total	Quiescent current	I _{CC1}	—	10	15	mA	Pin 8 = 0 V	15	
		I _{CC2}	—	—	2.0		Pin 8 = 5.0 V		
CE	Input low voltage	V _{IL}	—	—	1.5	V		8,9,10	
MTRON	Input high voltage	V _{IH1}	3.5	—	—				
DSEL	Input low current	I _{IL}	—	—	±10	μA	Pin 8, 10 = 0 V		
	Input high current	I _{IH}	—	—	±10		Pin 8, 10 = 5.0 V		
Output amp.	Leak current	I _{CER1}	—	—	1.0	mA	V _{CE} = 7 V	18,19,21	1
	Saturation voltage	V _{sat1}	—	—	0.8	V	I _O = 0.1 A		
		V _{sat2}	—	—	1.5		I _O = 0.8 A		
	Current ref. voltage limiter	V _{ref1}	225	250	275	mV	R _{NF} = 1.0 Ω	16	2
VCO	Input current	I _{in}	—	—	200	nA	Pin 4 = 0 V	4	
	OSC frequency	f _{VCO1}	90	110	130	Hz	Pin 4 R _{T1} = 0 V = 68 kΩ	1	
	OSC frequency	f _{VCO2}	9	11	13	Hz	Pin 4 C _{T1} = 2.5 V = 0.1 μF	1	
	V/F conversion gain	G _{VF}	—	-0.45	—	V/V		1	3
VCO input control	Sink current	I _{ts}	—	10	—	μA	R _{T2} = 130 kΩ	3	
	Source current	I _{tt}	—	1	—		Pin 3 = 2.0 V		
	Set up voltage	V _{RT2}	1.1	1.3	1.5	V	R _{T2} = 130 kΩ	2	
	Threshold voltage	V _{th}	2.2	2.5	2.8	V		3	4
Zero x comparator	Min. input sensitivity	V _{min2}	60	—	—	mV _{P-P}	Pin 22 = 1.5 V	21,19,18	
Control amp	Gain	G _{ctl}	—	0	—	dB		13,16	
	Internal reference	V _{ref2}	1.15	1.25	1.35	V			
Oscillator frequency error		f _{err}	—	—	±0.1	%	X'tal	5,6	
Speed discri	Operating frequency	f _{osc}	—	—	8	MHz		5,6	5
	Count number	N	—	2084	—	—			



Electrical Characteristics (Ta = 25°C, VCC = 12 V) (Cont'd.)

Block	Item	Symbol	Min	Typ	Max	Unit	Test conditions	Applicable Terminal	Note
Charge pump	R1 set-up voltage	V	1.15	1.25	1.35	V	R1 = 8.2 kΩ	14	
	Charge current	I _{CH}	125	150	175	μA	R1 = 8.2 kΩ Pin 13 = 1.0 V	13	
	Discharge current	I _{DIS}	-125	-150	-175				
	Leak current	I _{CE R4}	—	—	±50	nA			
	Current ratio	I _{rat}	0.9	1.0	1.1	—	I _{rat} = I _{CH} /I _{DIS}		
Sync running monitor	Output high voltage	V _{OH1}	V _{CC} - 0.4	—	—	V	I _O = -1.0 mA	11	
	Output low voltage	V _{OL1}	—	—	0.4		I _O = 1.0 mA		
Ready	Output high voltage	V _{OH2}	V _{CC} - 0.4	—	—	V	I _O = -1.0 mA	12	6
	Output low voltage	V _{OL2}	—	—	4.0		I _O = 1.0 mA		
LVI	Recovery voltage	V _{LVI}	—	—	8.0	V			
OSTSD	Operating temperature	T _{TSD}	125	150	—	°C			5
	Hysteresis temperature	T _{hys}	—	25	—				

- Notes:
1. Sum of upper and lower saturation voltage.
 2. The reference voltage V_{ref2} is measured from pin 15 to pin 16.
 3. See figure 3 in references.
 4. See timing chart.
 5. Design guide only
 6. Ready output becomes high while the rotation speed error is smaller than 1%.

References

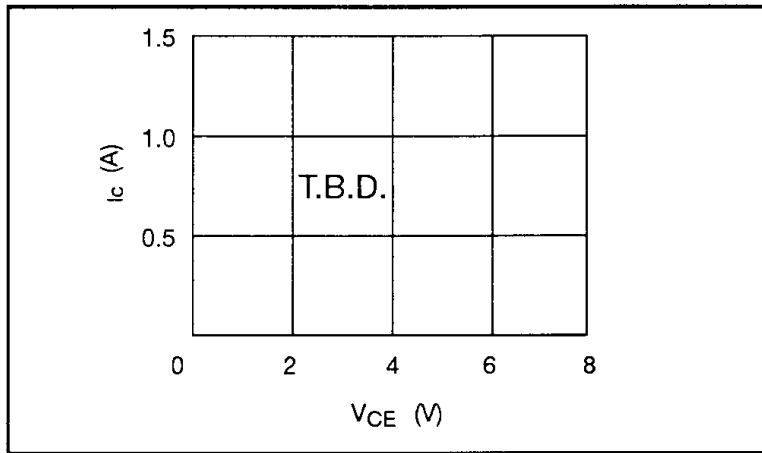


Figure 1 ASO Output Stages

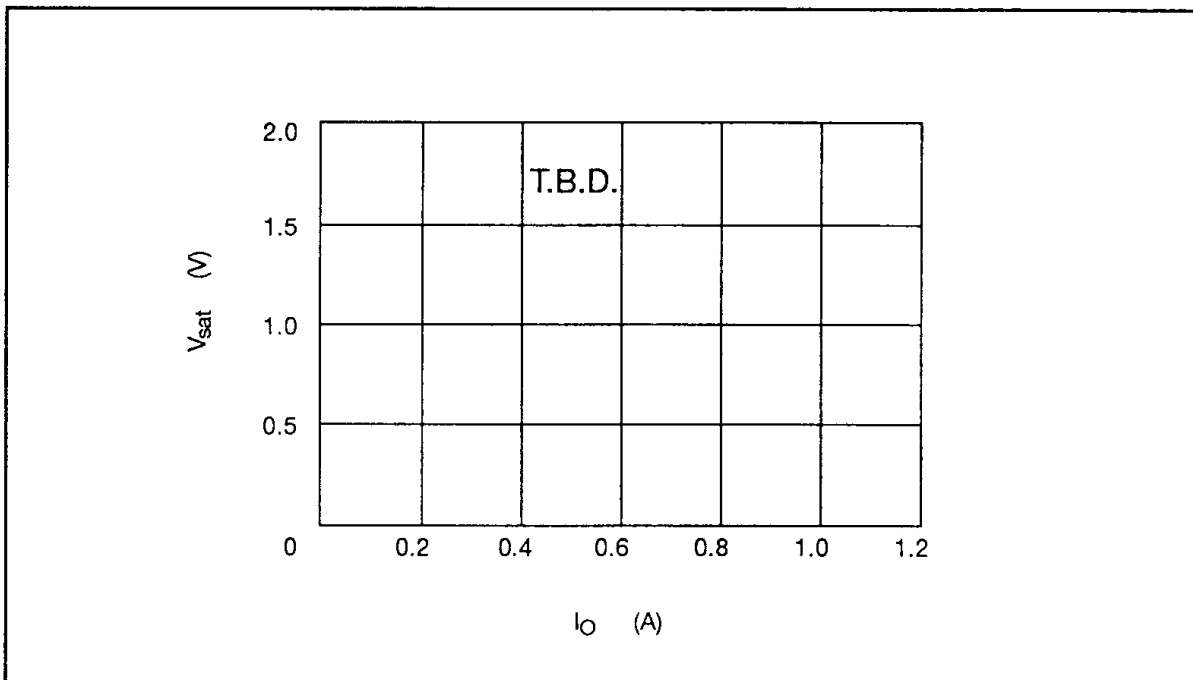


Figure 2 Saturation Voltage of Output Stages

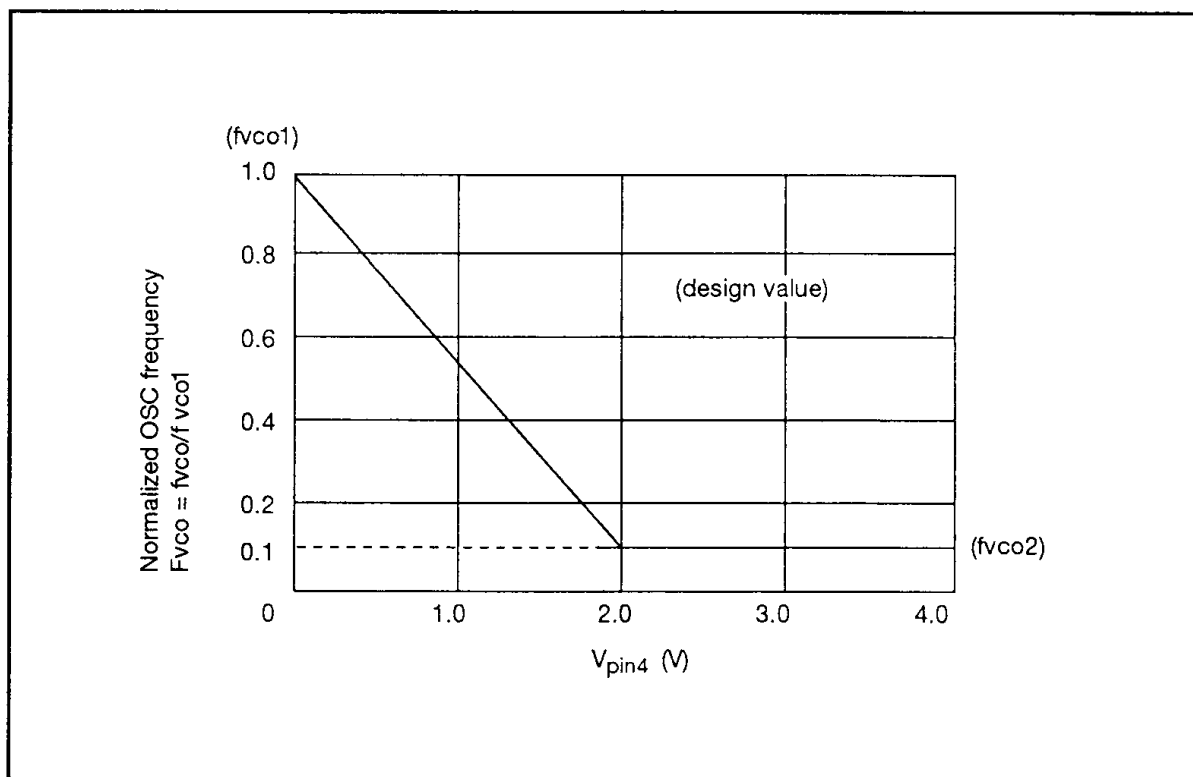


Figure 3 VCO Characteristics

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