HA13501S — Preliminary

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)

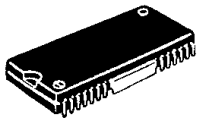
Features

- 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 ($\theta_j - c \leq 7°C/W$)

Ordering Information

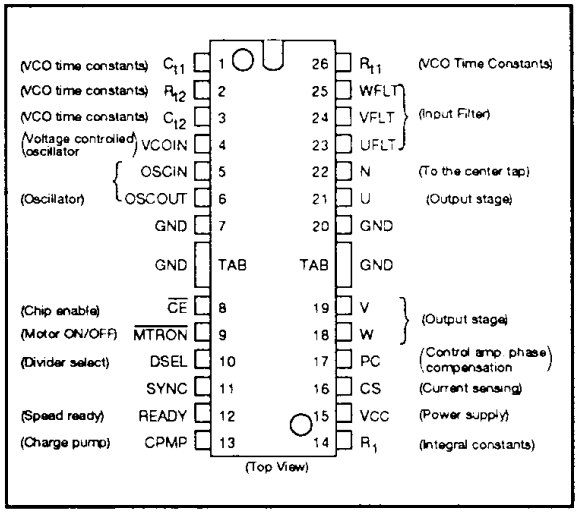
Type No.	Package
HA13501S	MP-26DT

HA13501S

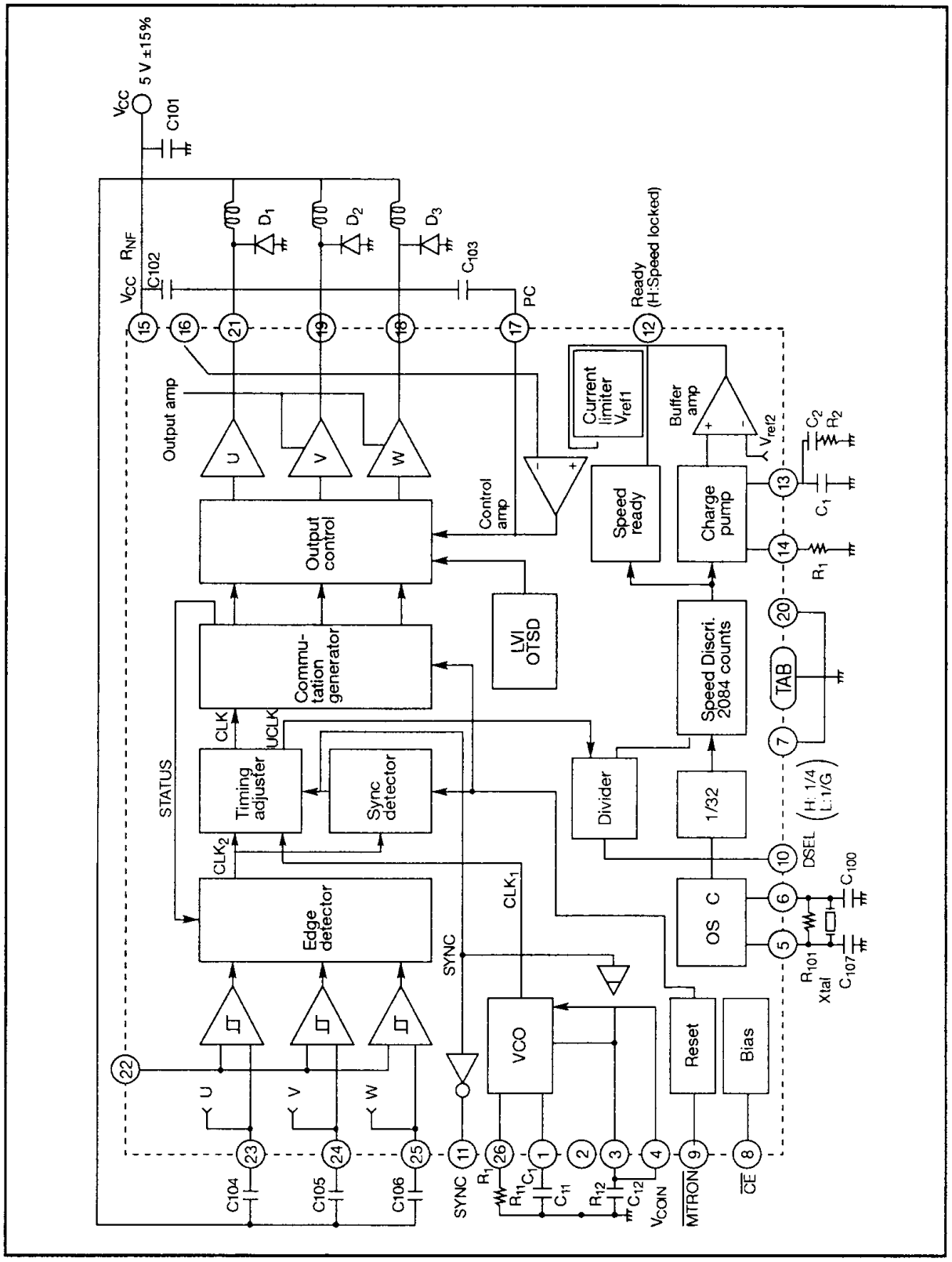


(MP-26DT)

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}, C_{105}, C_{106}	0.01 μF	Output filter	
C_{107}, C_{108}	10 μF	Oscillation	
C_{t1}	—	VCO time constants	1
C_{t2}	—	–VCO time constants	2
C_1	—	Integral constants	4
C_2	—		
D_1, D_2, D_3	—	Output clamp	5
X'tal	—	Oscillation	6

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

(i) $V_{Pin}4 = 0$ V

$$f_{VCO} = \frac{0.75}{C_{t1} \bullet R_{t1}} \quad (= f_{VCO1}) \quad \text{.....(1)}$$

(ii) $0 \text{ V} < V_{Pin}4 \leq 2$ V

$$f_{VCO} = (0.75 - 0.34 \bullet V_{PIN}4) / C_{t1} \bullet R_{t2} \quad \text{.....(2)}$$

(iii) $V_{Pin}4 > 2$ V

$$f_{VCO} = \frac{0.075}{C_{t1} \bullet R_{t1}} \quad (= f_{VCO2}) \quad \text{.....(3)}$$

(c.f. figure 3 in references)

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

$$f_{VCO1} = 0.05 \sqrt{\frac{P \bullet K_T \bullet I_O}{J}} \quad \text{.....(4)}$$

Where,
J : Morment of inertia (kg • cm • s^2)
P : number of poles in the motor
K_T : Torque constant (kg • cm/A)
I_{omax}: Output maximum current (A)

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

$$C_{t2} \bullet R_{t2} \cong 0.5\, T_S \quad \text{.....(5)}$$

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:

$$I_{omax} = V_{ref1} / R_{NF} \quad \text{.....(6)}$$

where,
V_{ref1}: Current limiter reference voltage

4. The integral constant can be designed as follows:

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

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

$R_1 \leq 25\ k\Omega$ .....(9)

$C_1 = 1 / (\sqrt{10} \bullet \omega_o \bullet R_2)$ [F] .....(10)

$C_2 = 10 \bullet C_1$ [F] .....(11)

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

5. Some motors require these components.

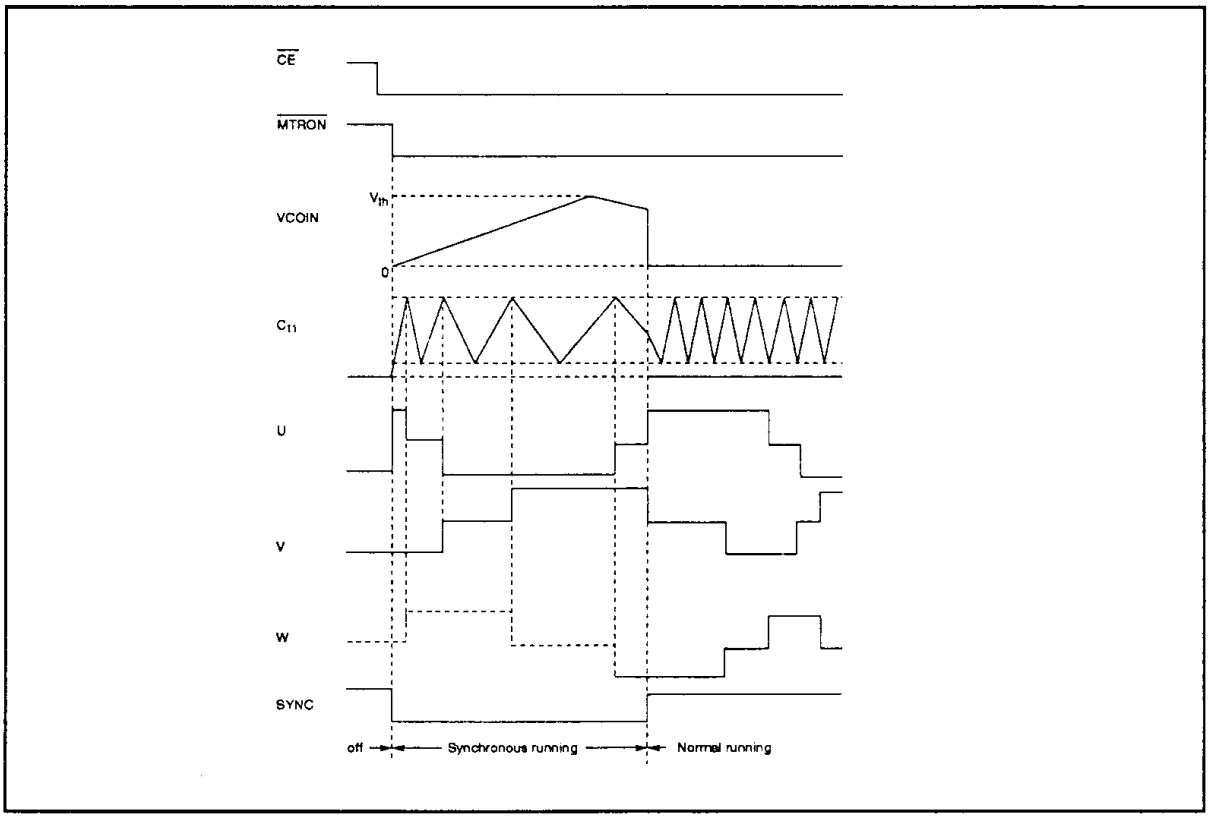
6. The OSC frequency f_{OSC} is determined by the following equation:

$f_{OSC} = 555.6\ N_o \bullet P \bullet D$ .....(12)

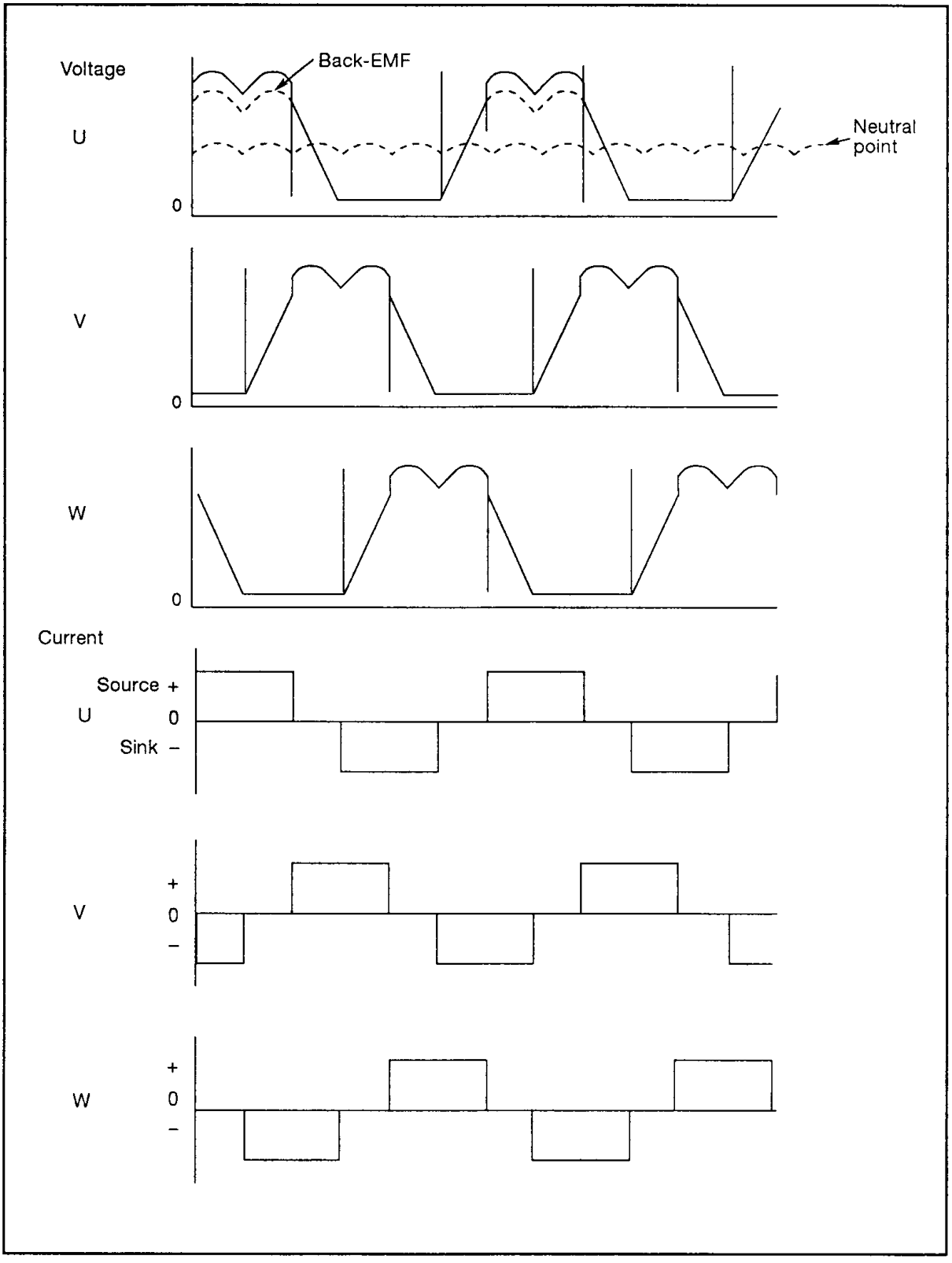
where,
N_o : Standard rotation speed (rpm)
D : Dividing ratio on divider
D = 1/6 @ Pin 10 = Low)
D = 1/4 @ Pin 10 = High)
In order to minimize the error of rotation speed, select the dividing ratio m as follows:
at 8 pole motor → D = 1/4
at 12 pole motor → D = 1/6

Timing Chart

Start-up



Running


Voltage
Back-EMF
U
Neutral point
0
V
0
W
0
Current
Source +
U
0
Sink –
V
+
0
–
W
+
0
–

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 $\overline{CE}$, 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.
$\theta_{j-c} \leq 7°C/W$, $\theta_{j-a1} \leq 15°C/W$ (using Fe board), $\theta_{j-a2} \leq 62°C/W$ (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		
$\overline{CE}$	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	
	Saturation voltage	V_{sat1}	—	—	0.8	V	I_O = 0.1 A		1
		V_{sat2}	—	—	1.5		I_O = 0.8 A		
	Curren 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	—	I/V		1	3
VCO input control	Sink current	I_{ts}	—	10	—	μA	R_{t2} = 130 kΩ	3	
	Source current	I_{tf}	—	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, V_{CC} = 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	R_1 = 8.2 kΩ	14	
	Charge current	I_{CH}	125	150	175	μA	R_1 = 8.2 kΩ Pin 13 = 1.0 V	13	
	Discharge current	I_{DIS}	−125	−150	−175				
	Leak current	I_{CER4}	—	—	±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

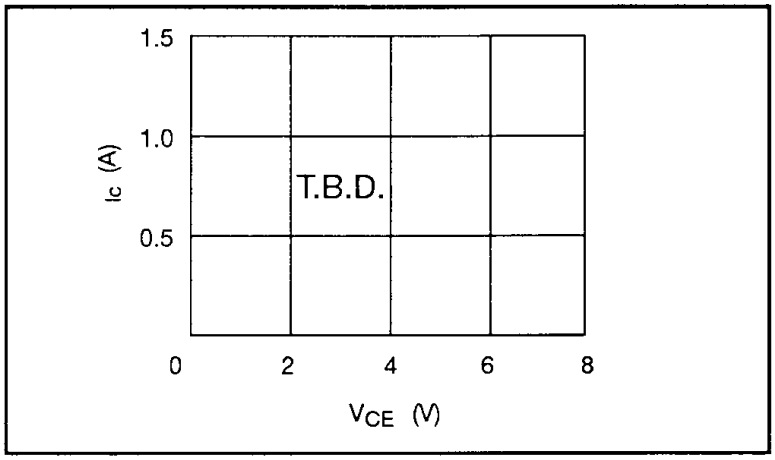


Figure 1 ASO Output Stages

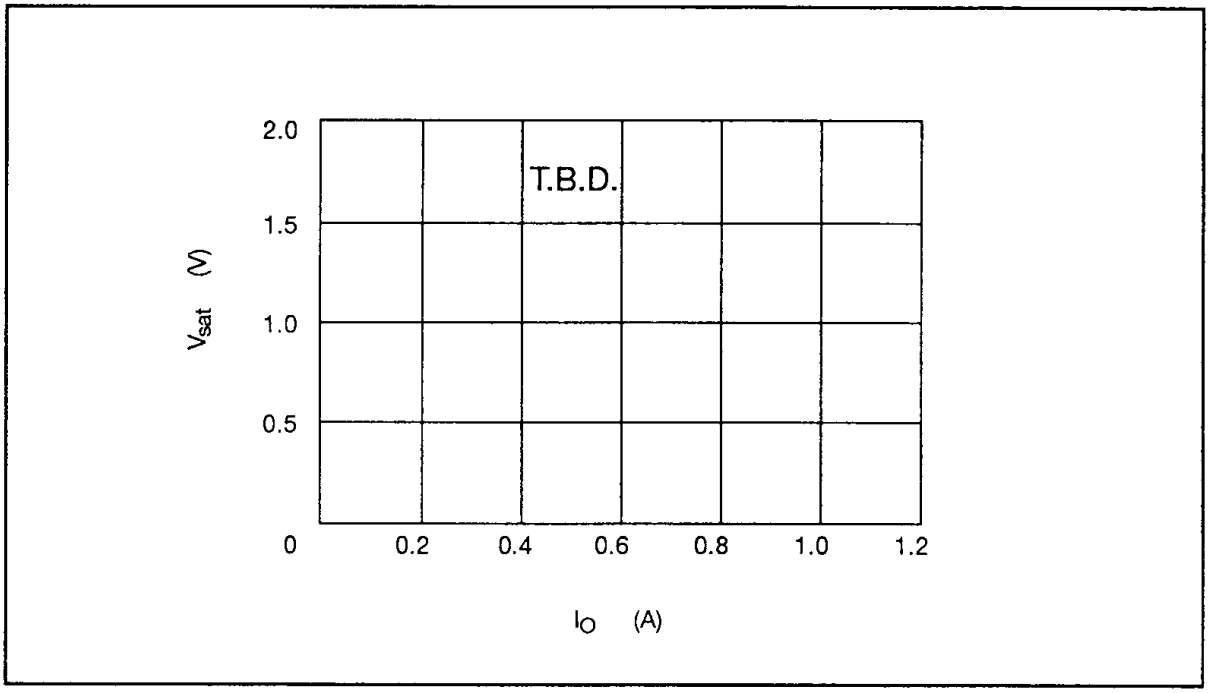


Figure 2 Saturation Voltage of Output Stages

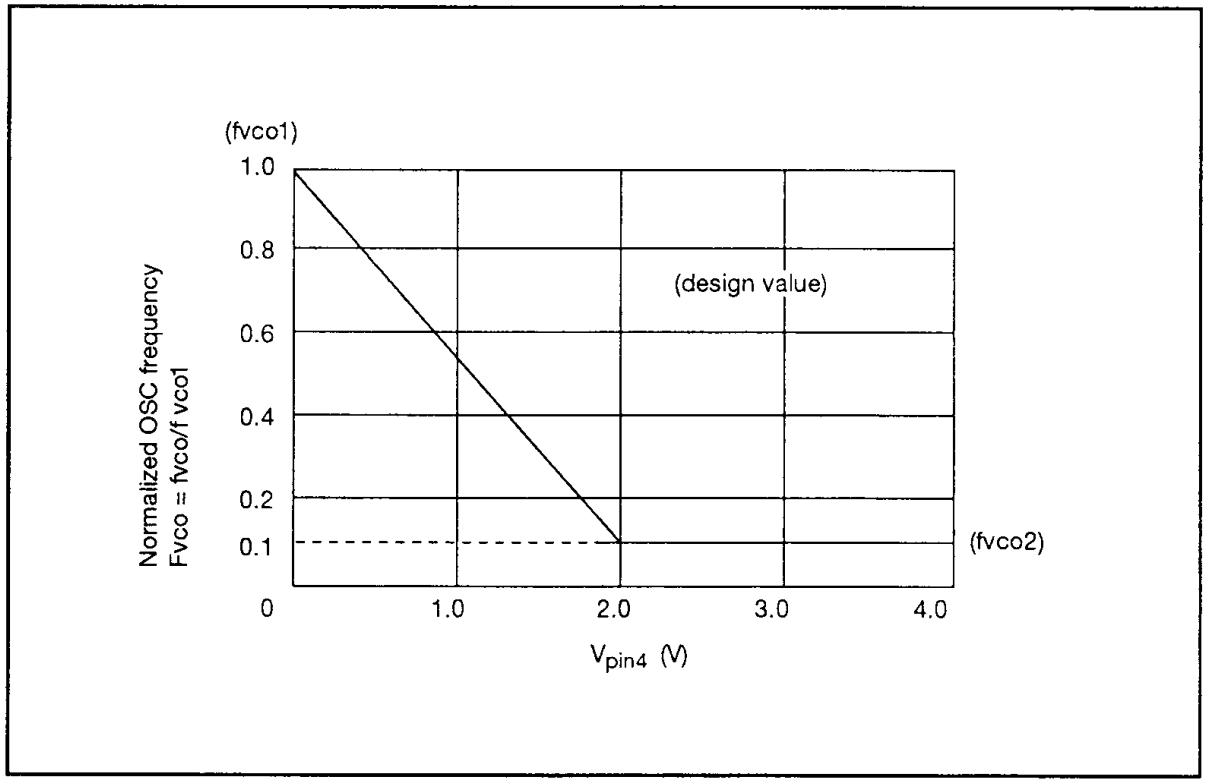


Figure 3 VCO Characteristics