

## Three-phase Brushless Motor PWM Controller with Digital Speed Control

### Description

HA13484/NT are PWM control IC for general use three-phase brushless DC motor and have following functions and features.

### Functions

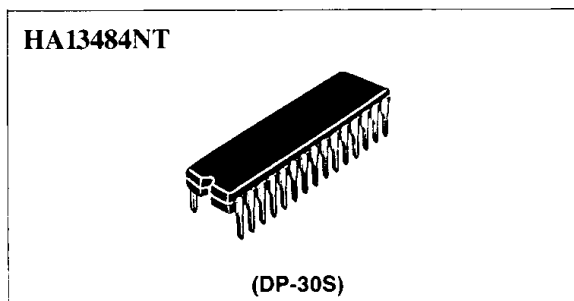
- Three-phase commutation circuit
- PWM control system
- Digital speed control system
- FG amp
- CLK oscillator
- Ready
- Direction
- Chip enable
- Current limiter
- Hall amps input dis-connection protect
- Low voltage inhibit

### Features

- Wide operating voltage range  
4.25 to 24.5 V
- Can handle various CLK frequency
- Can adjust limiting current by DC input

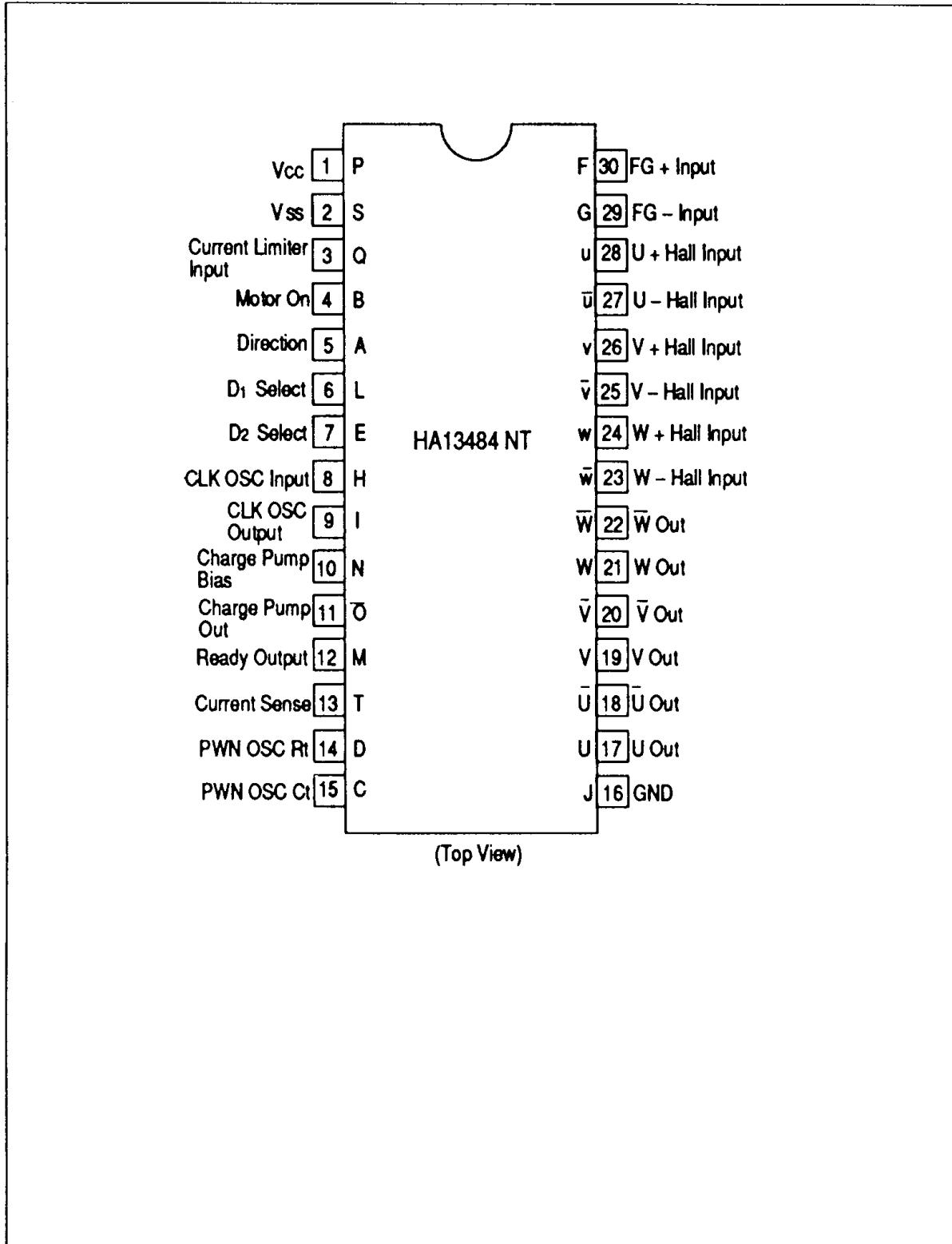
### Ordering Information

Type No.	Package
HA13484NT	400mil 30pin plastic shrink DIP (DP-30S)



# HA13484NT

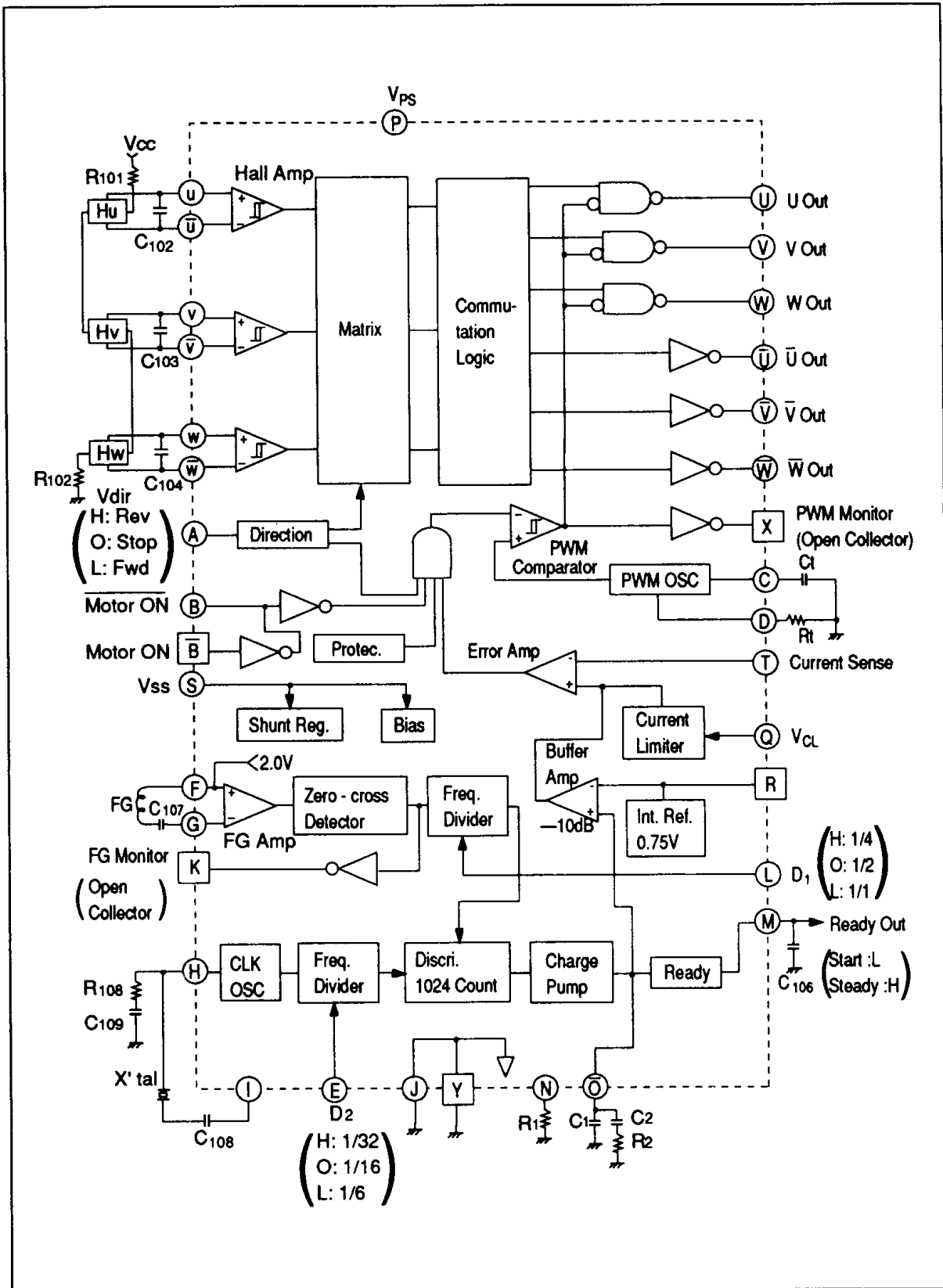
## Pin Arrangement



HA13484NT



Block Diagram



# HA13484NT

**Table 1 External Components**

Parts No.	Recommended value	Purpose	Note
R <sub>101</sub> , R <sub>102</sub>	—	Hall elements bias	1
R <sub>103</sub> , R <sub>203</sub> , R <sub>303</sub>	—	For speed up	
R <sub>104</sub> , R <sub>204</sub> , R <sub>304</sub>	—	For limiting sink current	2
R <sub>105</sub> , R <sub>205</sub> , R <sub>305</sub>	—	For limiting sink current	2
R <sub>106</sub>		For stability	
R <sub>107</sub>	—	Bias for regulator	3
R <sub>108</sub>	470 Ω	OSC stability	4
R <sub>1</sub> , R <sub>2</sub>	—	Integral constant	5
R <sub>t</sub>	6.8 kΩ	Time constant for PWM OSC	6
R <sub>NF</sub>	—	Current sense	7
C <sub>101</sub> , C <sub>102</sub> , C <sub>103</sub>	0.047 μF	For stability	
C <sub>104</sub>	≥0.1 μF	V <sub>cc</sub> by-passing	
C <sub>105</sub>		For stability	
C <sub>106</sub>	1.0 μF	Filter for ready	
C <sub>107</sub>	1.0 μF	FG coupling	8
C <sub>108</sub>	10 pF	AC coupling for OSC	
C <sub>109</sub>	4700 pF	OSC stability	4
C <sub>1</sub> , C <sub>2</sub>	—	Integral constant	5
C <sub>t</sub>	2200 pF	Time constant for PWM OSC	6
Q <sub>1</sub> , Q <sub>2</sub> , Q <sub>3</sub>	—	Source output transistor	
Q <sub>4</sub> , Q <sub>5</sub> , Q <sub>6</sub>	—	Sink output transistor	
D <sub>1</sub> , D <sub>2</sub> , D <sub>3</sub> , D <sub>4</sub> , D <sub>5</sub> , D <sub>6</sub>	—	Clamp diode	
X <sub>tal</sub>	—	Reference resonator	9

- Notes: 1. Set  $R_{101}$ ,  $R_{102}$  in order to get hall element output more than 100 mV<sub>PP</sub>.  
 2.  $R_{X04}$  and  $R_{X05}$  should be designed as

$$R_{X04}(k\Omega) \geq \frac{V_{CC}(V) - V_{BE}(V)}{20}, \quad R_{X05}(k\Omega) \geq \frac{V_{CC}(V)}{20}$$

Where  $V_{BE}$  is the base-emitter voltage of  $Q_1$  to  $Q_3$ .

3.  $R_{107}$  should satisfy the following equation.

$$\frac{V_{CC \text{ max}}(V) - 6.3}{0.06} \leq R_{107}(\Omega) \leq \frac{V_{CC \text{ min}}(V) - 6.3}{0.03}$$

**Table 3 Absolute Maximum Ratings ( $T_a = 25^\circ\text{C}$ )**

Item	Symbol	Rating	Unit	Note
Supply voltage	$V_{PS}$	34.5	V	1
Input voltage	$V_{in}$	0 to $V_{SS}$	V	2
Output current	$I_{out}$	30	mA	
$V_{SS}$ input current	$I_{SS}$	60	mA	
Power dissipation	$P_T$	650	mW	
Operating temperature range	$T_{opr}$	-20 to +70	$^\circ\text{C}$	
Storage temperature range	$T_{stg}$	-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. Recommended operating voltage range as follows.  
 $V_{PS} = 4.25$  to  $34.5$  V  
 $V_{SS} = 4.25$  to  $V_{reg}$   
 2. Apply to pin A, B,  $\bar{B}$ , E, L and T.

**Table 4 Electrical Characteristics ( $T_a = 25^\circ\text{C}$ ,  $V_{PS} = 24$  V,  $V_{SS} = 5.0$  V)**

Item	Symbol	Min	Typ	Max	Unit	Test conditions	Applica- tion terminal	Note	
Supply current	$I_{PS}$	—	2.5	4.0	mA	$V_{PS} = 34.5$ V	P		
	$I_{SS}$	—	20	30	mA	$V_{SS} = 6.0$ V	S		
Shunt reg.	Reg. voltage	$V_{reg}$	6.0	6.5	7.0	V	$I_{SS} = 30$ to $60$ mA	S	1
	Operating teigstance	$R_d$	—	—	15	$\Omega$	$I_{SS} = 30$ to $60$ mA		

# HA13484NT

## Electrical Characteristics (Ta = 25 °C, Vps = 24 V, Vss = 5.0 V) (cont)

Motor ON & Motor ON	Input low voltage	V <sub>IL1</sub>	—	—	0.8	V		B, $\bar{B}$
	Input high voltage	V <sub>IH1</sub>	2.0	—	—	V		
	Input current	I <sub>I1</sub>	—	—	±10	μA	V <sub>in</sub> = 0 V to V <sub>ss</sub>	B
		I <sub>IL1</sub>	—	60	200	μA	V <sub>in</sub> = 0 V	$\bar{B}$
I <sub>IH1</sub>		—	—	±10	μA	V <sub>in</sub> = V <sub>ss</sub>		
Direction D <sub>1</sub> & D <sub>2</sub>	Input low voltage	V <sub>IL2</sub>	—	—	1.0	V		A, E, L
	Input middle voltage	V <sub>IM2</sub>	1.75	—	2.75	V		
	Input high voltage	V <sub>IH2</sub>	3.5	—	—	V		
	Input current	I <sub>I2</sub>	—	—	±10	μA	V <sub>in</sub> = 0 V to V <sub>ss</sub>	
Hall amp	Input common mode voltage range	V <sub>H</sub>	2.1	—	V <sub>ps</sub> -1.9	V		u, $\bar{u}$ , v, $\bar{v}$ , w, $\bar{w}$
	Hysteresis	H <sub>YSH</sub>	—	20	—	mV		2
	Input current	I <sub>H</sub>	—	—	±15	μA	V <sub>H</sub> = 12 V	
Output	Leak current	I <sub>CER</sub>	—	—	100	μA	V <sub>CE</sub> = 34.5 V	U, $\bar{U}$ , V, $\bar{V}$ , W, $\bar{W}$
	Saturation voltage	V <sub>sat</sub>	—	—	0.4	V	I <sub>out</sub> = 20 mA	
	Transition time	t <sub>PHL</sub>	—	0.25	—	μs	R <sub>L</sub> = 1.2 kΩ turn-on	U, V, W
t <sub>PLH</sub>		—	0.3	—	μs	turn-off		
PWM OSC	R <sub>t</sub> bias voltage	V <sub>Rt</sub>	—	1.25	—	V	R <sub>t</sub> = 6.8 kΩ	D
	Operating frequency range	f <sub>p</sub>	5	—	100	kHz		C
	Amplitude	A	—	2.0	—	V <sub>PP</sub>		
Error amp	input current	I <sub>er</sub>	—	—	±5	μA	V <sub>i</sub> = 0 to 1.0 V	T
Buffer amp	Int. ref. voltage	V <sub>ref1</sub>	—	0.75	—	V		R
	Voltage gain	G <sub>cl</sub>	—	-10	—	dB	Pin 0 to T	T



**Electrical Characteristics (Ta = 25 °C, VPS = 24 V, VSS = 5.0 V) (cont)**

Current limiter	Input current	ICL		±5	μA	VCL = 0 to VSS	Q		
	Offset voltage	VOS	-10	-25	-40	mV	VCL = 0 to 1.0 V		
Charge Pump	R1 bias voltage	VR1	—	1.25	—	V	R1 = 15 kΩ	N	
	Charge current	ICHA	—	$\frac{VR1}{4R1}$	—	A	R1 = 15 kΩ	O	
	Discharge current	IDIS	—	$-\frac{VR1}{4R1}$	—	A	R1 = 15 kΩ		
	Leak current	Ioff	—	—	±50	nA			
FG amp	Input bias voltage	VFG	—	1.95	—	V		F	
	Input resistance	RFG	—	800	—	Ω		F, G	
	Input voltage range	VinFG	8	—	50	mVPP			
	Noise margin	nd	—	—	2	mVPP	Differential noise		
nc		—	—	1.0	VPP	Common mode noise			
CLK OSC	Maximum frequency	fc	—	—	8.0	MHz	I		
Discri	Count number	N	—	1024	—	—	—		
Ready	Input threshold voltage	VIL3	—	Vref1	—	V	O	3	
		VIH3	—	$Vref1 + 3VCL$	—	V			
	Output current	Ir+	—	300	—	μA	Vout = 2 V	Source	M
		Ir-	—	-300	—	μA		Sink	
	Output low voltage	VOL3	—	—	0.4	V			
	Output high voltage	VOH3	4.5	5.0	5.5	V			
PWM & FG monitor	Leak current	ICER4	—	—	±10	μA	Vout = 34.5 V	K, X	
	Output low voltage	VOL4	—	—	0.4	V	Iout = 1.0 mA		
Protect	LVI threshold	Vsd	—	3.75	—	V	S		

- Notes: 1. See Figure 1. And  $R_d$  can be calculated as:  
 $R_d(\Omega) = 33.3 \Delta V_{reg}(V)$   
 2. See Timing chart.  
 3. See Figure 2.

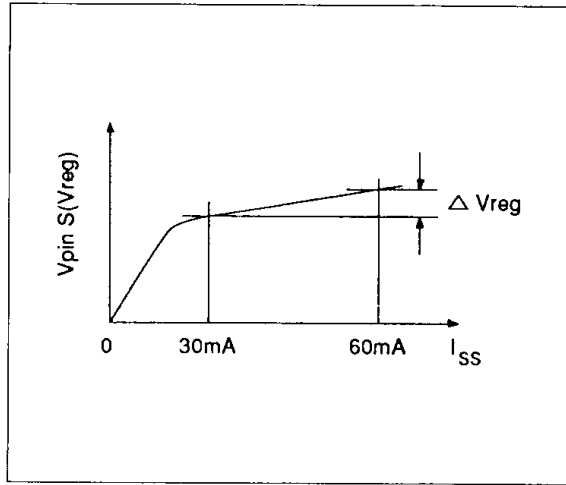


Figure 1.

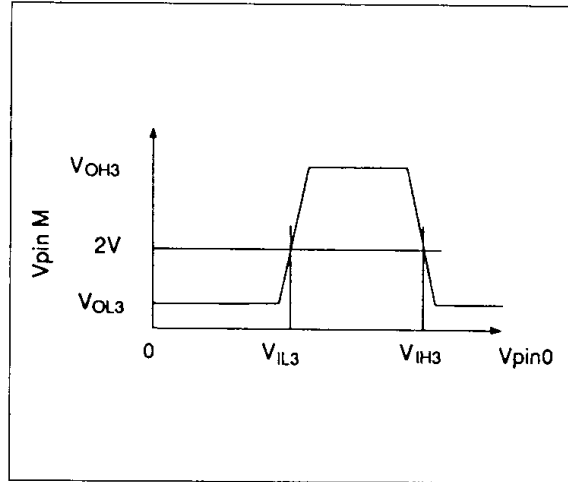


Figure 2.

4. Not necessary if the CLK frequency is less than 4MHz.  
 5. The integral constant can be designed as

$$\omega_0 \leq \frac{2\pi f_{FG} D_1}{20} \quad (\text{rad/s})$$

$$\frac{R_2}{R_1} = \frac{4}{9.55} \cdot \frac{\omega_0 R_{NF} N_0 J}{V_{R1} G_{ctl} K_T}$$

$$R_1 \leq 30(k\Omega)$$

$$C_1 = \frac{1}{\sqrt{10} \omega_0 R_2} \quad (F)$$

$$C_2 = 10C_1 \quad (F)$$

Where

$\omega_0$ =Servo loop's time constant

$f_{FG}$ =FG frequency (Hz)

$D_1$ =Frequency divider ratio

$R_{NF}$ =Current sense resistor ( $\Omega$ )

$N_0$ =Rotation number (rpm)

$V_{R1}$ =Charge pump reference voltage, 1.25 V

$G_{ctl}$ =Control gain, 0.316

$J$ =Inertia moment ( $\text{kg}\cdot\text{cm}\cdot\text{s}^2$ )

$K_T$ =Torque constant ( $\text{kg}\cdot\text{cm}/\text{A}$ )

6. The PWM frequency  $f_p$  can be calculated as

$$f_p = \frac{V_{rt}}{8C_t R_t} \quad (\text{Hz})$$

Where  $V_{rt}$  is the  $R_t$  reference voltage, 1.25 (V).

7. The limiting current  $I_{max}$  will be

$$I_{max} = \frac{V_{CL}(V)}{R_{NF}(\Omega)} \quad (A)$$

8.  $C_{107}$  can be designed using the following equation as an guide line.

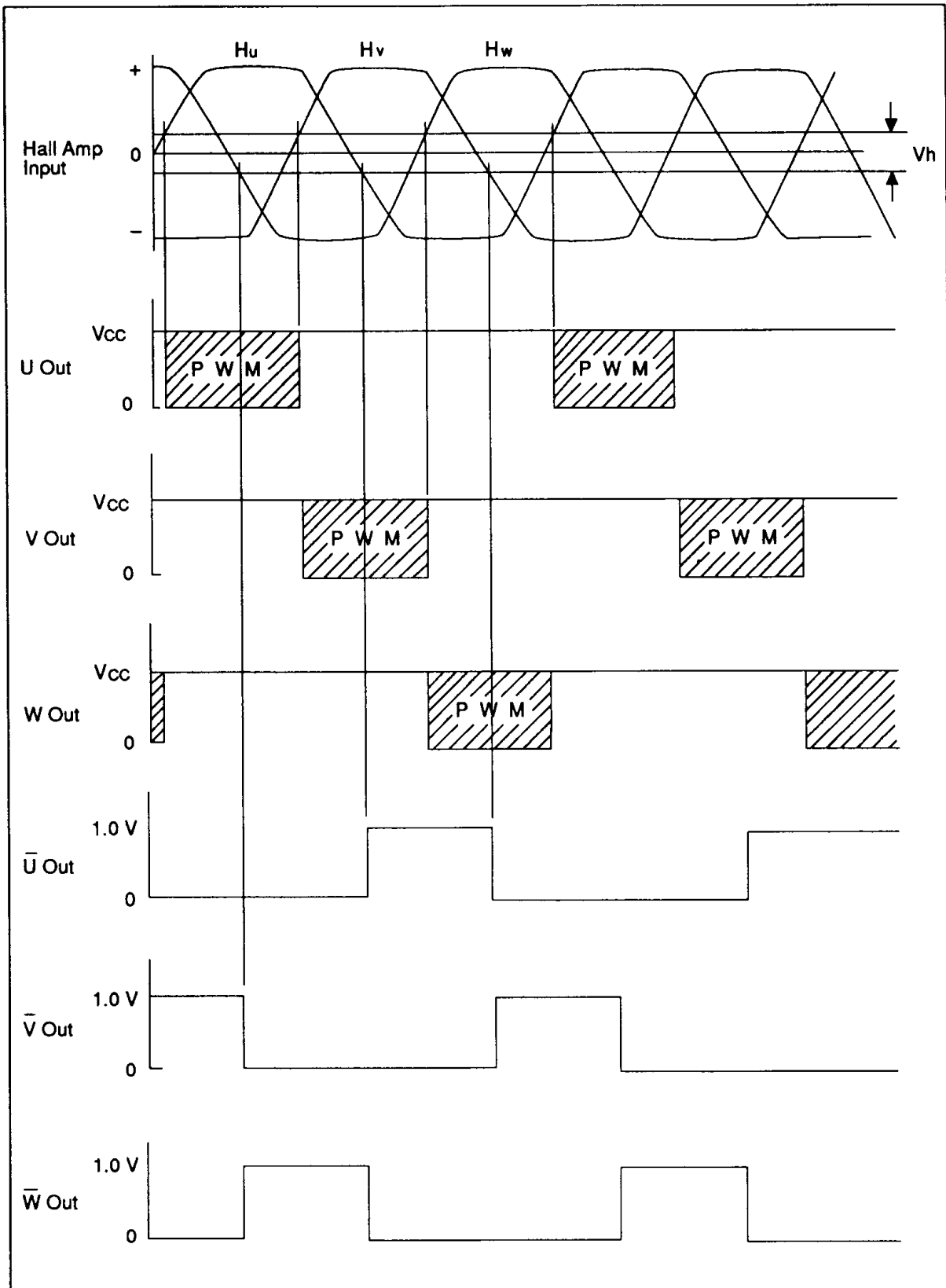
$$C_{107} \geq \frac{1}{2500 f_{FG}} \quad (F)$$

9. The relationship between FG frequency and  $X'tal$  frequency is as follows.

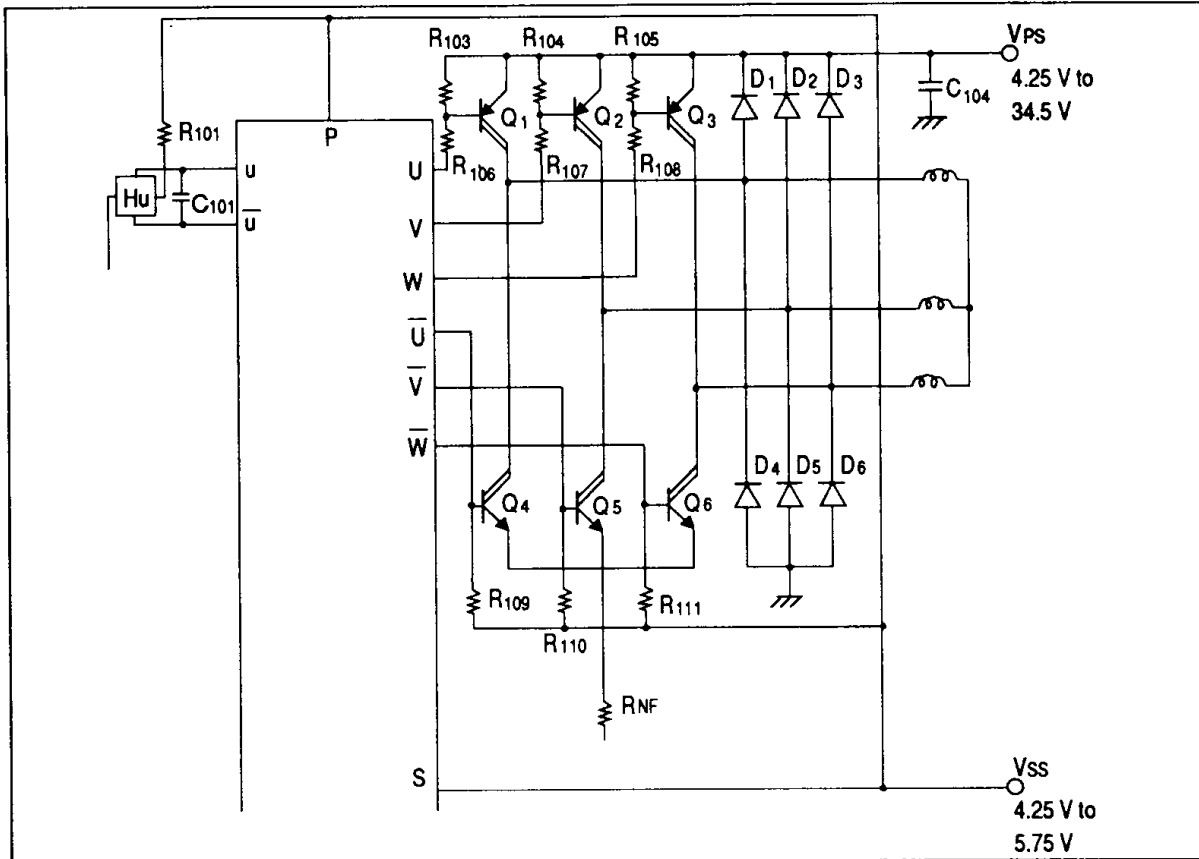
$$X'tal = \frac{8188 D_1 f_{FG}}{D_2} \quad (\text{Hz})$$

Where  $D_1$  and  $D_2$  are frequency divider ratio.

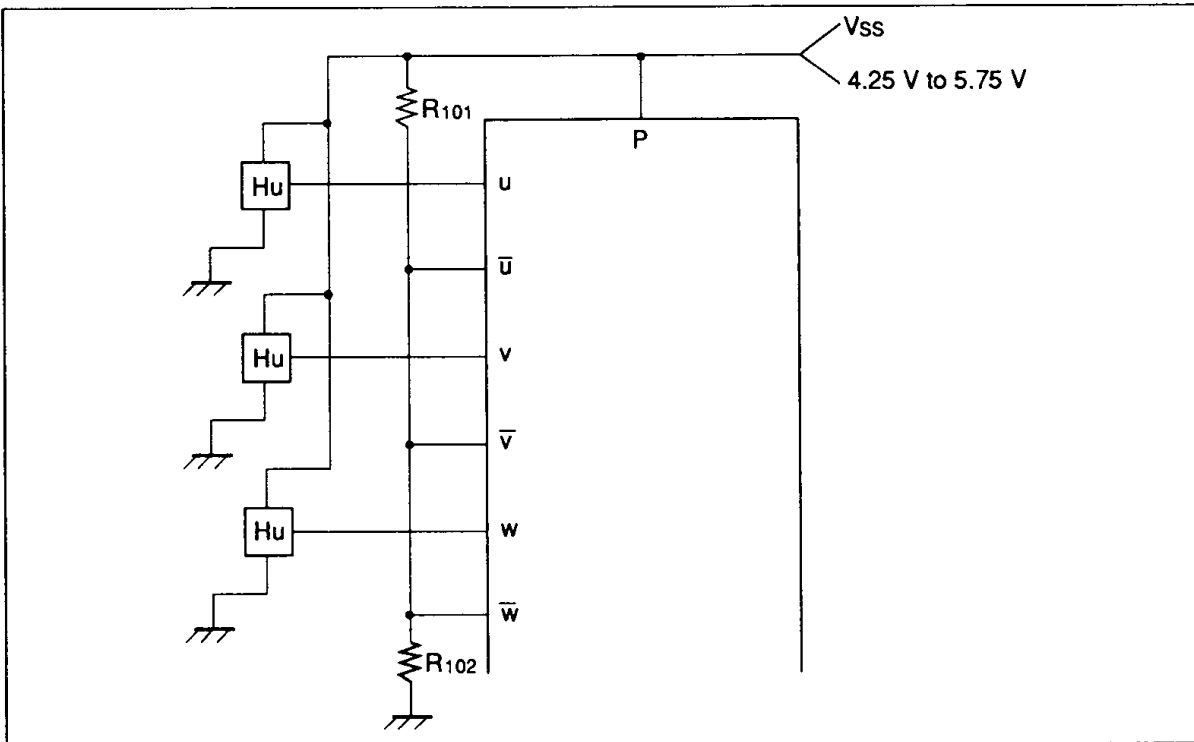
Timing Chart







Dual Supply



For Hall IC

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