

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

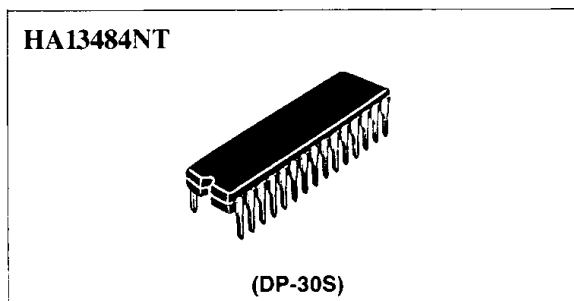
- Three-phase commutation circuit
- PWM control system
- Digital speed control system
- FG amp
- CLK oscillator
- Ready
- Direction
- Chip enable
- Current limiter
- Hall amps input dis-connection protect
- Low voltage inhibit

Features

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

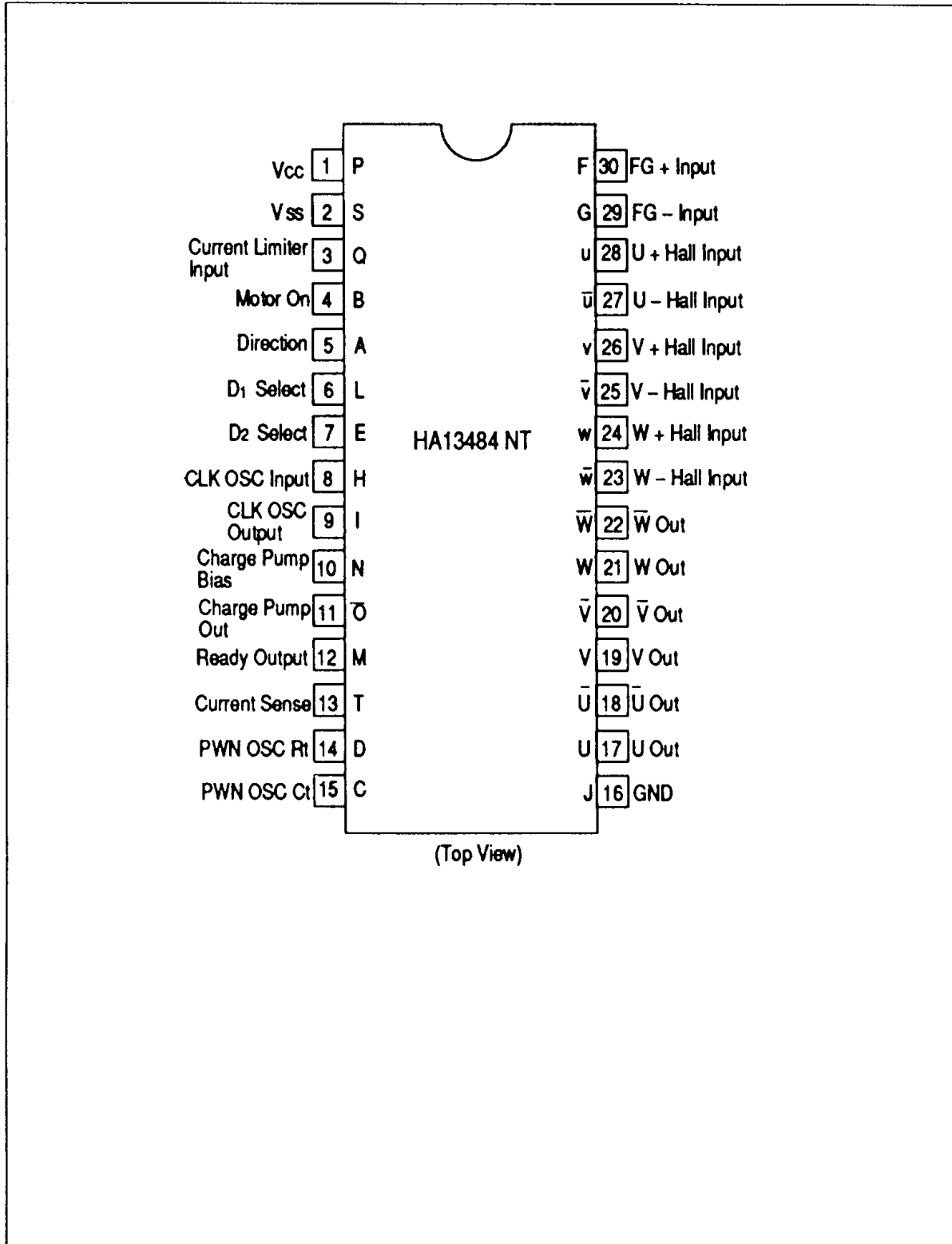
Ordering Information

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



HA13484NT

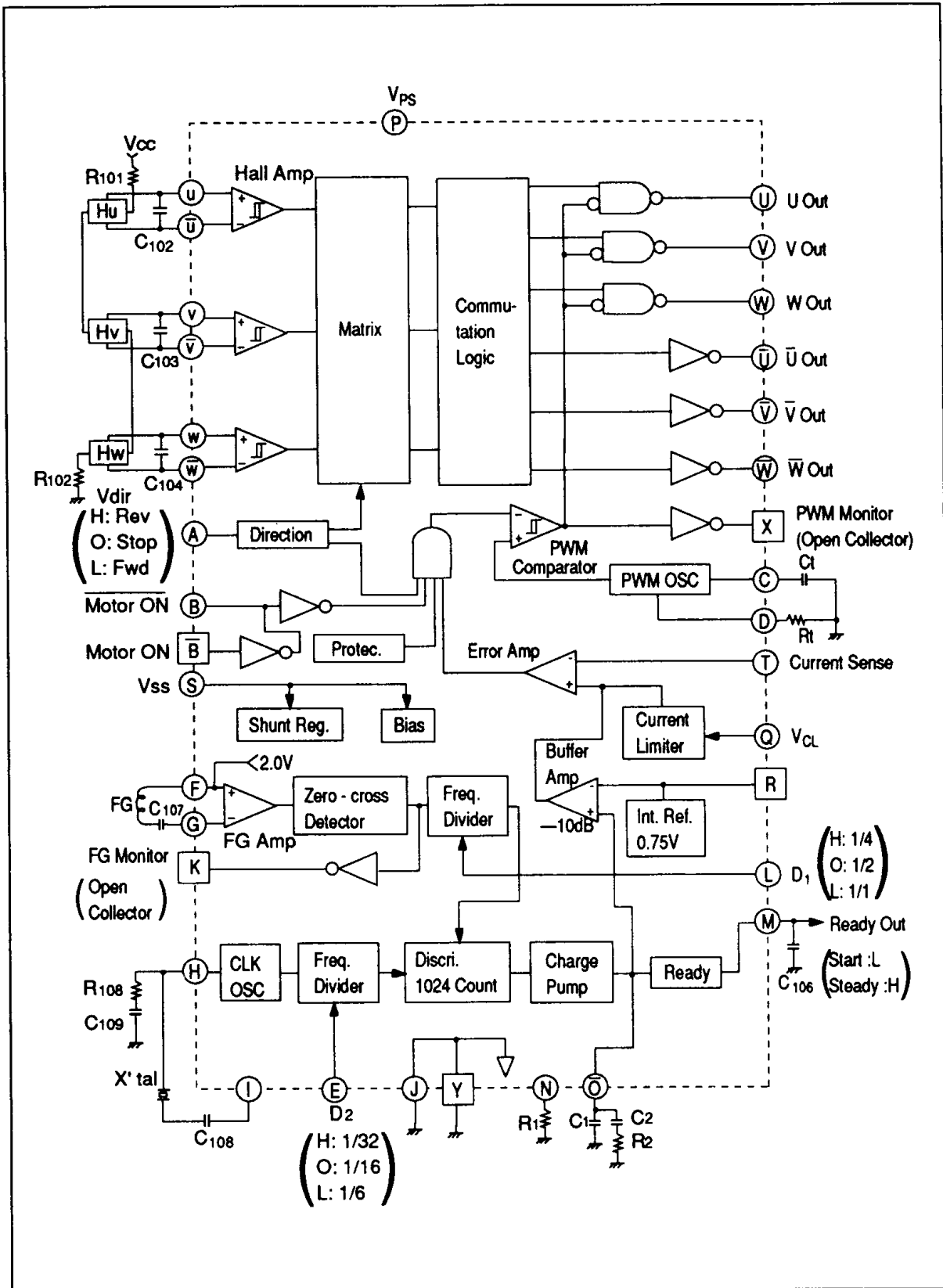
Pin Arrangement



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Block Diagram



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Table 1 External Components

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

- Notes: 1. Set R_{101} , R_{102} in order to get hall element output more than 100 mV_{PP}.
 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 legistance	R_d	—	—	15	Ω	$I_{SS} = 30$ to 60 mA		

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

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

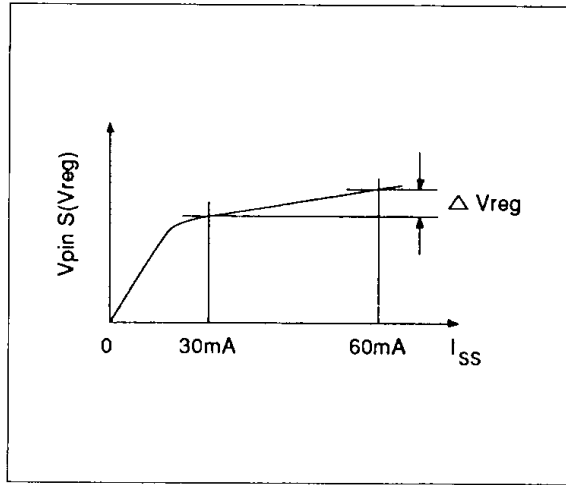


Figure 1.

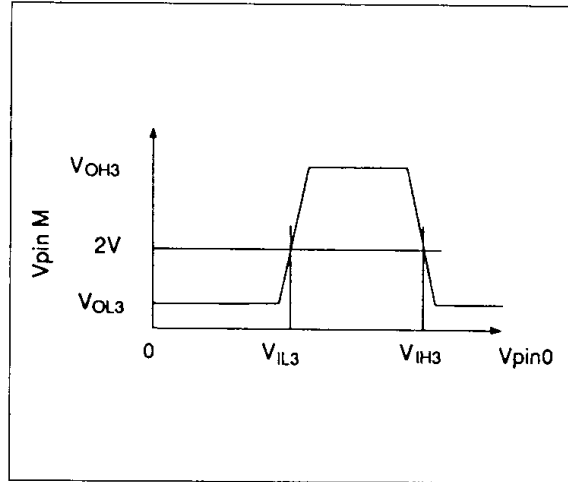


Figure 2.

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

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

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

$$R_1 \leq 30(\text{k}\Omega)$$

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

$$C_2 = 10C_1 \quad (\text{F})$$

Where

ω_0 =Servo loop's time constant

f_{FG} =FG frequency (Hz)

D_1 =Frequency divider ratio

R_{NF} =Current sense resistor (Ω)

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

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

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

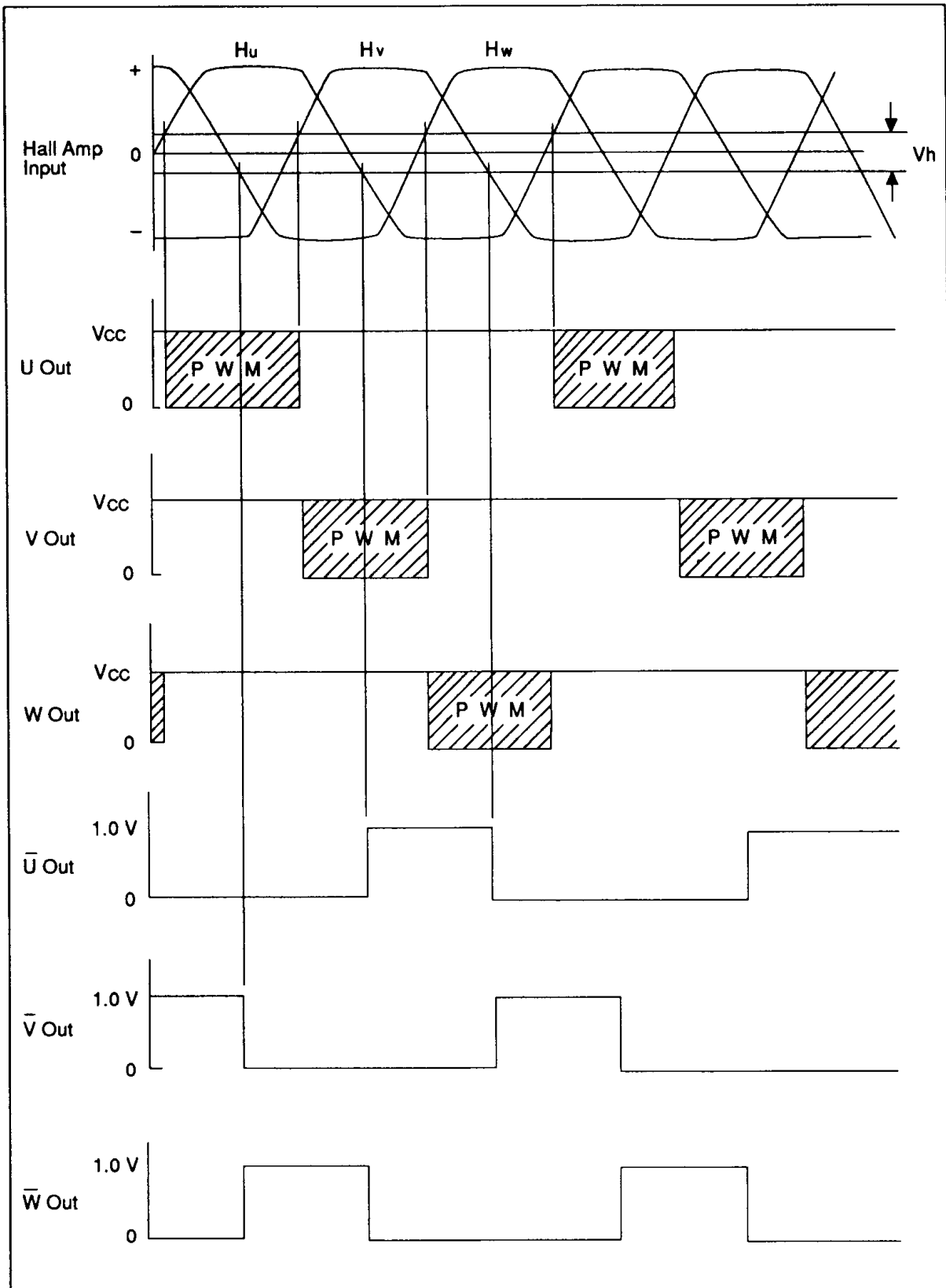
$$C_{107} \geq \frac{1}{2500 f_{FG}} \quad (\text{F})$$

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

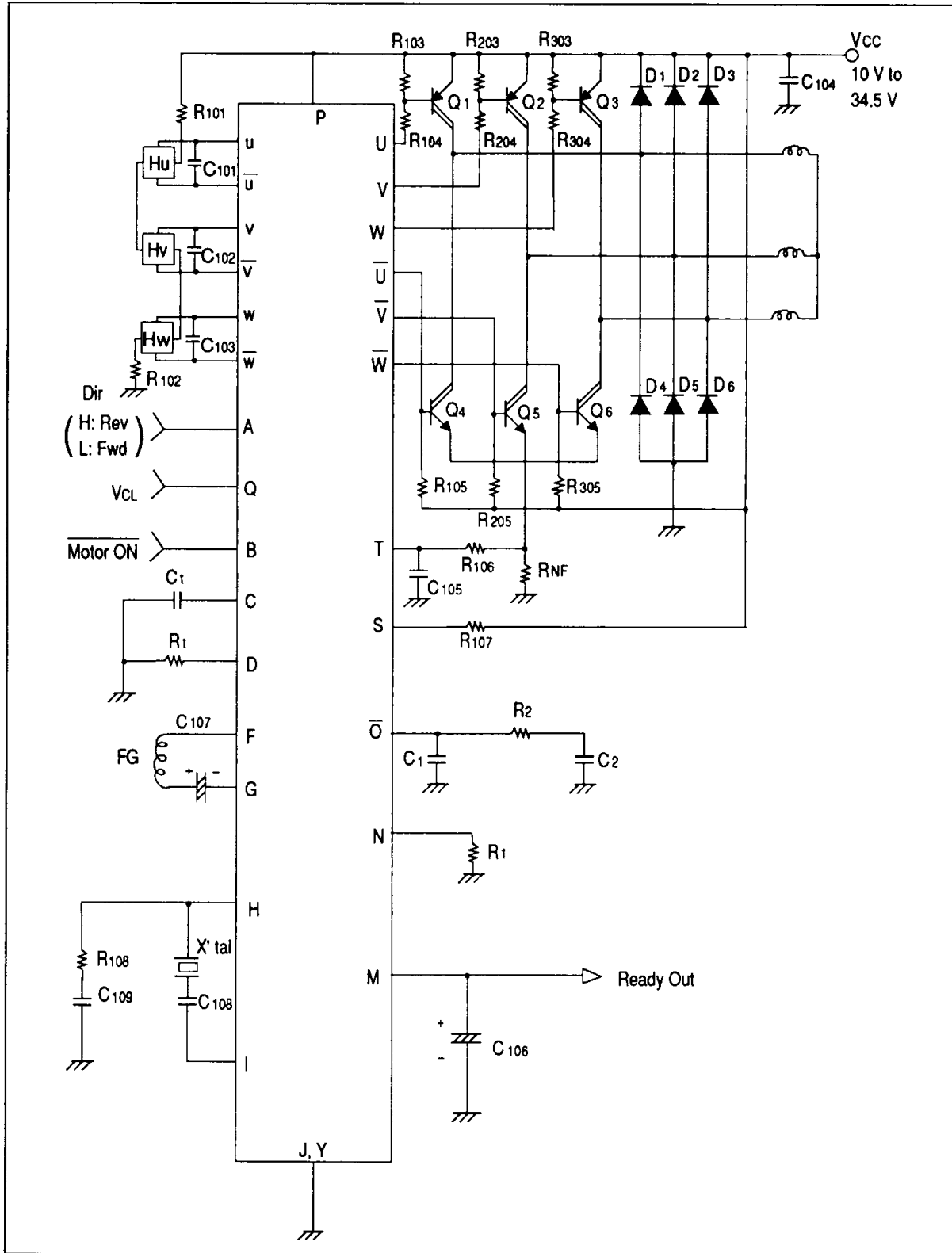
$$X'tal = \frac{8188 D_1 f_{FG}}{D_2} \quad (\text{Hz})$$

Where D_1 and D_2 are frequency divider ratio.

Timing Chart

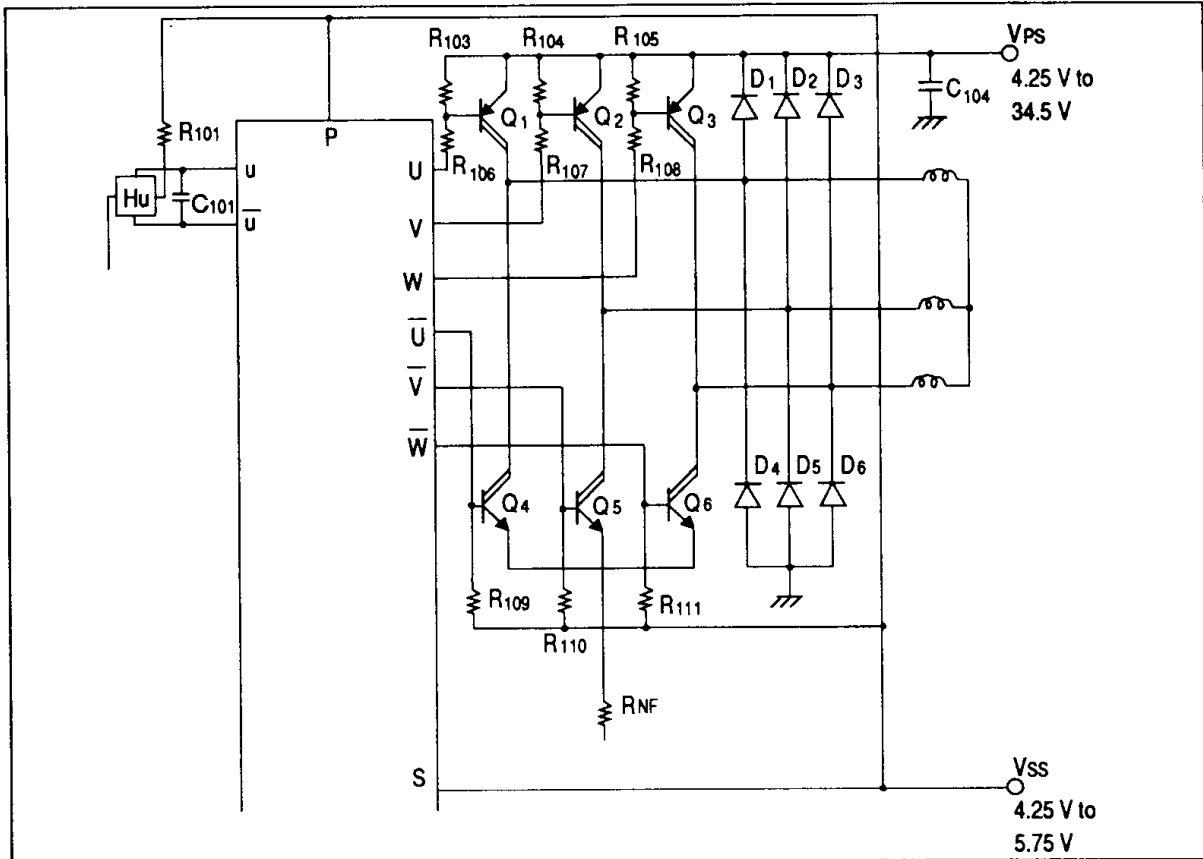


Application

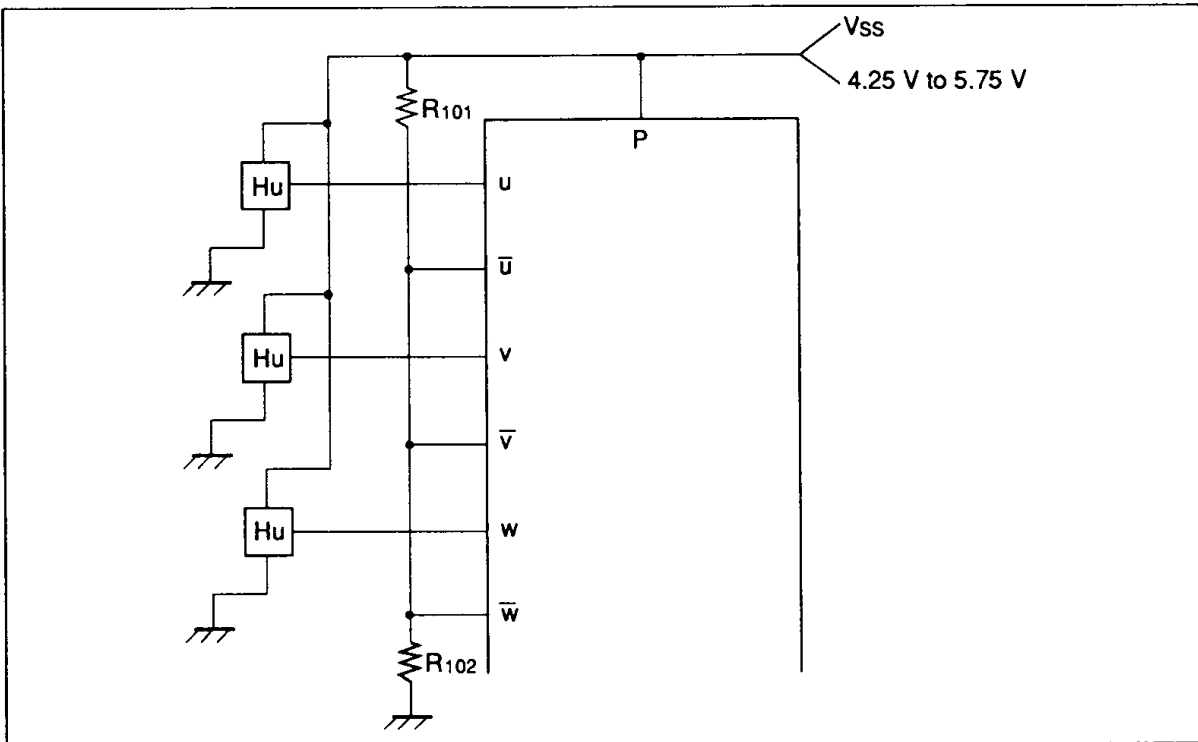


Single Supply





Dual Supply



For Hall IC