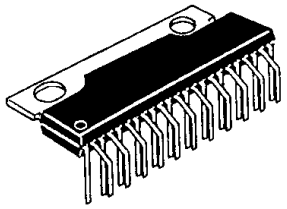
HA13406W

Three-Phase Brushless Motor Driver

Description

The HA13406W power IC is developed for driving three-phase brushless motors. It provides hall effect sensor amps, logic, output amps, control amp, and forward and back rotation circuit functions on one chip. The maximum driving current and voltage is as much as 3A at 12V per phase. Therefore, it finds its best use driving the spindle motor of a 5.25 inch hard disk drive.

HA13406W



(SP-23TA)

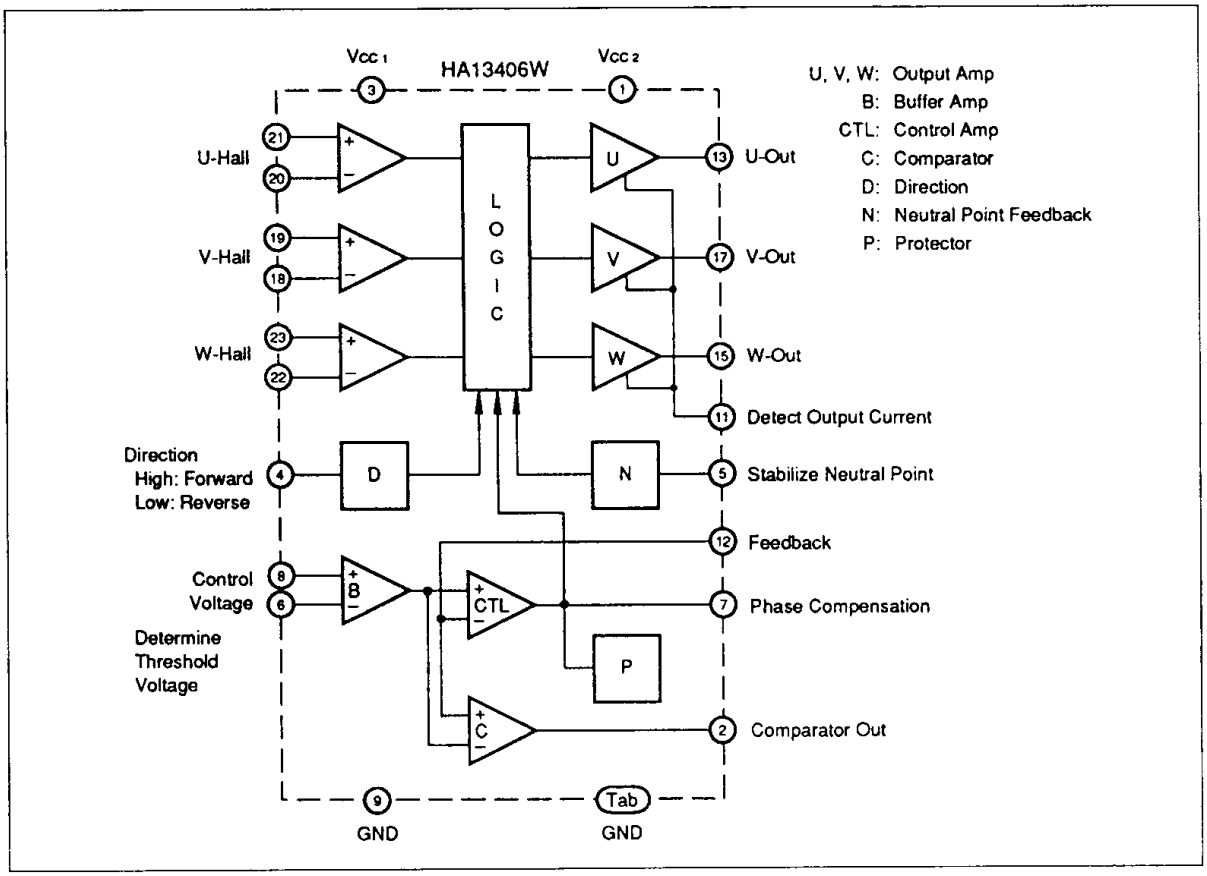
Features

- 3A output current capability
- Low output saturation voltage
- Hall effect amps with hysteresis
- Over temperature protection
- Low thermal resistance package

Ordering Information

Type No.	Package
HA13406W	SP-23TA

Block Diagram



Application

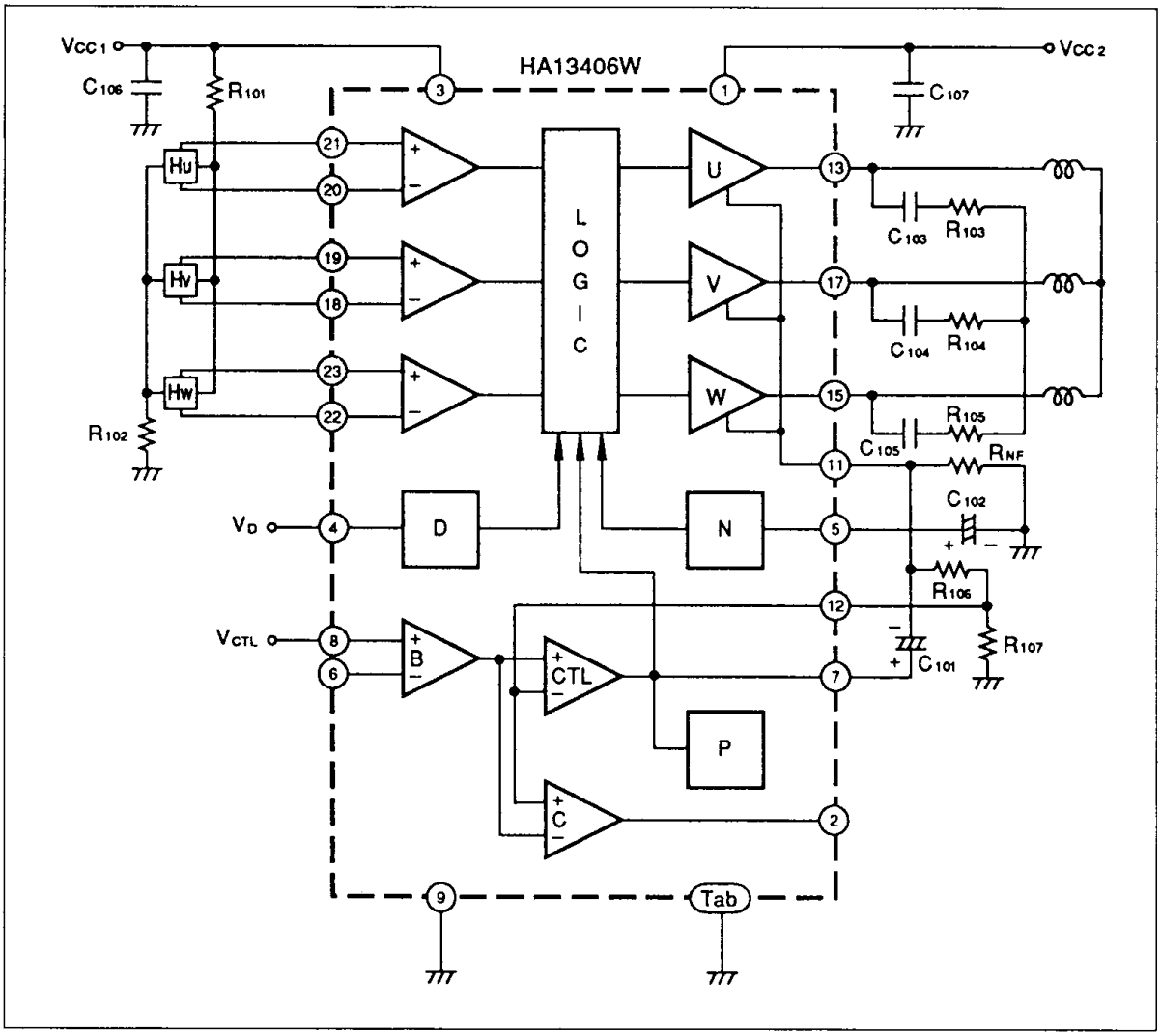


Figure 1 Linear Drive Circuit

Figure 1 and Table 1 show the HA13406W in a linear drive circuit.

The output stage is saturated at starting and is usually not saturated.

Therefore, the loss is comparatively large and a heat sink may be required.

The relationship between the current Io, which flows into the motor coil, and the control voltage V_{CTL} is:

$$Io = \frac{(R_{106}+R_{107})}{R_{107}} \cdot \frac{V_{CTL}-V_{Ref}}{R_{NF}} \quad \text{.....(1)}$$

where $V_{CTL} \geq V_{Ref}$

Here, V_{Ref} is the voltage at pin 6. It is set to Vcc1/2 internally.

Connecting the output of the servo IC to the terminal 8 constructs the servo driving system.

When $R_{106}=0$, and $R_{107}=\infty$ (voltage gain of the control amp is 0dB), equation (1) will be:

$$Io = \frac{V_{CTL}-V_{Ref}}{R_{NF}} \quad \text{.....(2)}$$

Table 1 Linear Drive External Components

Part No.	Recommended value	Purpose
R_{101}, R_{102}	(Note 1)	Hall effect element bias
R_{103}, R_{104}, R_{105}	10 Ω(1/4 W)	Stability
R_{106}, R_{107}	—	Determine the control amp gain
R_{NF}	0.22 Ω (2 W)	Detect output current
C_{101}	1 µF/16 WV	Control amp phase compensation
C_{102}	10 µF/16 WV	Stabilizes the neutral point
C_{103}, C_{104}, C_{105}	1 0µF/16 WV (Note 2)	Stability
C_{106}	0.1µF	Power supply by-passing
C_{107}	100 µF/16 WV	Power supply by-passing

Notes: 1. Set so that the input voltage of the hall effect amp (AC) will be more than 100mVpp.
2. If the system is adversely affected by the spike voltage at commutation, make it larger (max 22µF).

High-Efficiency Drive

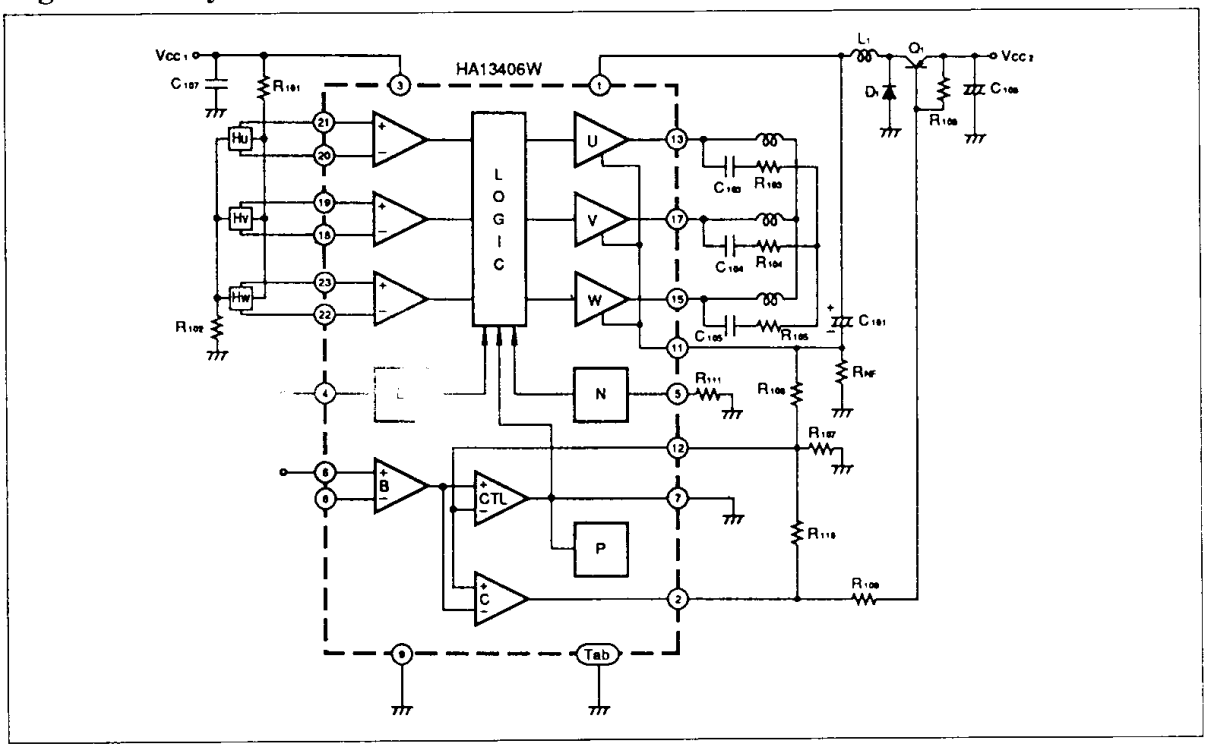


Figure 2 High-Efficiency Drive Circuit

Figure 2 and table 2 show the HA13406W in a high-efficiency drive circuit.
As the output stage is always saturated, the loss is less than in the linear drive application and the efficiency of the system may be increased.

The comparator C oscillates automatically and its on-off duty cycle is controlled by the control voltage V_{CTL} Consequently, the on-off duty cycle of the external switching transistor Q1 is also controlled by V_{CTL}. That is called PWM (pulse width modulation) control of power supply, which means that one pin voltage of IC's is controlled.

The voltage which appears at current detection resistor R_{NF} feeds back to the comparator C, so that the relationship between the current which flows into the motor coil, Io, and the control voltage V_{CTL} is also shown in the equation (1).

The automatic oscillating frequency fc is mostly determined by the external
constant on around the duty of 50%.

$$fc = \frac{R_{NF}\, R_{110}}{4L_1\, R_{106}} \quad \text{.....(3)}$$

fc should be set in the range between 20 and 100kHz.

Table 2 High-Efficiency Drive External Components

Part No.	Recommended value	Purpose
R_{101}, R_{102}	—	Hall effect element bias
R_{103}, R_{104}, R_{105}	10 Ω (1/4 W)	Stability (May be omitted if there is no oscillation)
R_{106}, R_{107}	—	Determine the control
R_{108}	2.2 kΩ (1/4 W)	Prevents errors caused by leak current
R_{109}	2.2 kΩ (1/4 W)	Limits comparator output current
R_{110}	—	Determines the comparator hysteresis
R_{111}	4.7 kΩ	Neutral point feedback circuit bias
R_{NF}	0.22 Ω (2 W)	Detect output current
C_{101}	100 µF/16 WV	Lowpass filter
C_{103}, C_{104}, C_{105}	0.1 µF	Stability (May be omitted if there is no oscillation)
C_{107}, C_{108}	0.1 µF	Power supply by-passing
L_1	1 mH	Lowpass filter
Q_1	—	Switches power supply
D_1	—	Flywheel diode

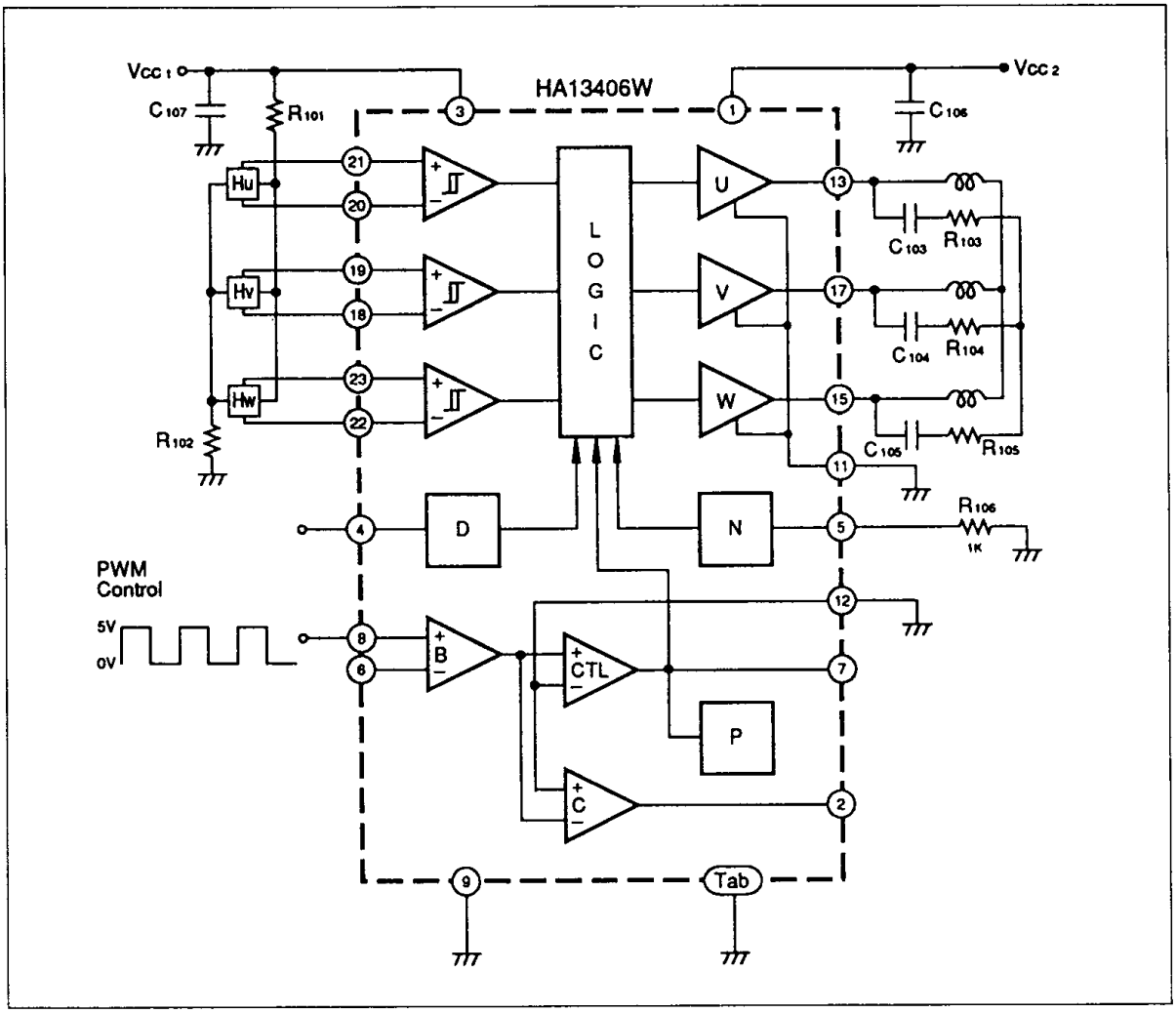


Figure 3 High-Frequency Drive Circuit

High-Frequency Drive

Figure 3 and table 3 show the HA13406W in a high-frequency drive circuit.

As the output stage is always saturated, the loss is less than in the linear drive application and the efficiency of the system may be increased.

In this application, output transistors are saturated or shut off. Output transistors switch on (saturate) at control input high, and switch off at the low state. That is, motor speed can be controlled by PWM.

The fundamental frequency should be in the range from 1kHz to 20kHz

Table 3 High-Frequency Drive External Components

Part No.	Recommended value	Purpose
R_{101}, R_{102}	—	Hall effect element bias
R_{103}, R_{104}, R_{105}	10 Ω (1/4 W)	Stability (May be omitted if there is no oscillation)
R_{106}	1 kΩ	Output stage bias
C_{103}, C_{104}, C_{105}	0.1 µF	Stability
C_{106}, C_{107}	0.1 µF	Power supply by-passing

Table 4 Absolute Maximum Ratings (Ta=25 °C)

Item		Symbol	Ratings	Unit
Control stage supply voltage (note 1)		V_{CC1}	7	V
Output stage supply voltage (note 1)		V_{CC2}	15	V
Output current		Io	3	A
Power dissipation		P_T	25	W
Thermal resistance	junction-case	θj–c	3.0	°C/W
	Junction-ambient	θj–a	40	
Hall effect amp input voltage		V_H	0 to V_{CC1}	V
Direction voltage		V_D	0 to V_{CC1}	V
Control voltage		V_{CTL}	0 to V_{CC1}	V
Junction temperature		Tj	150	°C
Operating junction temperature range		Tjop	–20 to +125	°C
Storage temperature range		Tstg	–55 to +125	°C

Note: 1. Recommended operating voltage

	Min	Typ	Max	Unit
V_{CC1}	4.5	5.0	5.5	V
V_{CC2}	10.2	12	13.8	V

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.

Table 5 Electrical Characteristics (T_a=25°C, V_{CC1}=5V, V_{CC2}=12V)

Item		Min	Typ	Max	Unit	Test Conditions		Test Terminal
Total	Quiescent current	—	10	15	mA	V_{CTL}=0V	V_{CC1}	3
		—	10	15	mA		V_{CC2}	1
		—	10	15	mA	V_{CTL}=V_{CC1}	V_{CC1}	3
		—	105	150	mA	R_L=Open	V_{CC2}	1
	Thermal shut-down temperature (Note 1)	—	150	—	°C	V_{CTL}=V_{CC1}, I_O=0.1 A		
Hall effect amp to logic	Input bias current	—	—	±50	μA			18-23
	Input common-mode voltage range	2.0	—	3.0	V			18-23
	Hysteresis width	15	—	30	mV	R_G=220 Ω		18-23
Output	Sustaining voltage	15	—	—	V	I_C=20 mA		13, 15, 17
	Leak current	—	—	10	mA	V_{CE}=15 V		13, 15, 17
	Saturating voltage	—	2.8	3.8	V	V_{CTL}=V_{CC1}, I_O=2.8 A		13, 15, 17
Buffer	Internal reference voltage	2.35	2.5	2.65	V			6
	Output resistance of reference	—	2.5	—	kΩ			6
	Threshold voltage	—	100	—	mV	I_O=20 mA		8
	Input current	—	0	±10	μA	V_{CTL}=5 V		8
		—	-3	±10	μA	V_{CTL}=1 V		8
	Voltage gain	—	0	—	dB	I_O=0.8 A, f=500 Hz		11
Control amp	Input offset voltage	—	100	—	mV	I_O=20 mA		12
	Voltage gain	—	0	—	dB	I_O=0.8 A, f=500 Hz		11

Electrical Characteristics (T_a=25°C, V_{CC1}=5V, V_{CC2}=12V) (cont)

Compara-tor	Leak current	—	—	1.0	mA	V_{CE}=15 V	2
	Saturation voltage	—	1.0	1.5	V	I_C=20 mA	2
Direction	Voltage range for forward mode	2.0	—	5	V		4
	Voltage range for reverse mode	0	—	0.7	V		4
	Input current	—	-1.2	—	mA	V_D=GND	4
		—	0	—	mA	V_D=5 V	4

Notes: 1. Case temperature
2. Sum of the upper and lower saturation voltage
3. Reference to pin 6

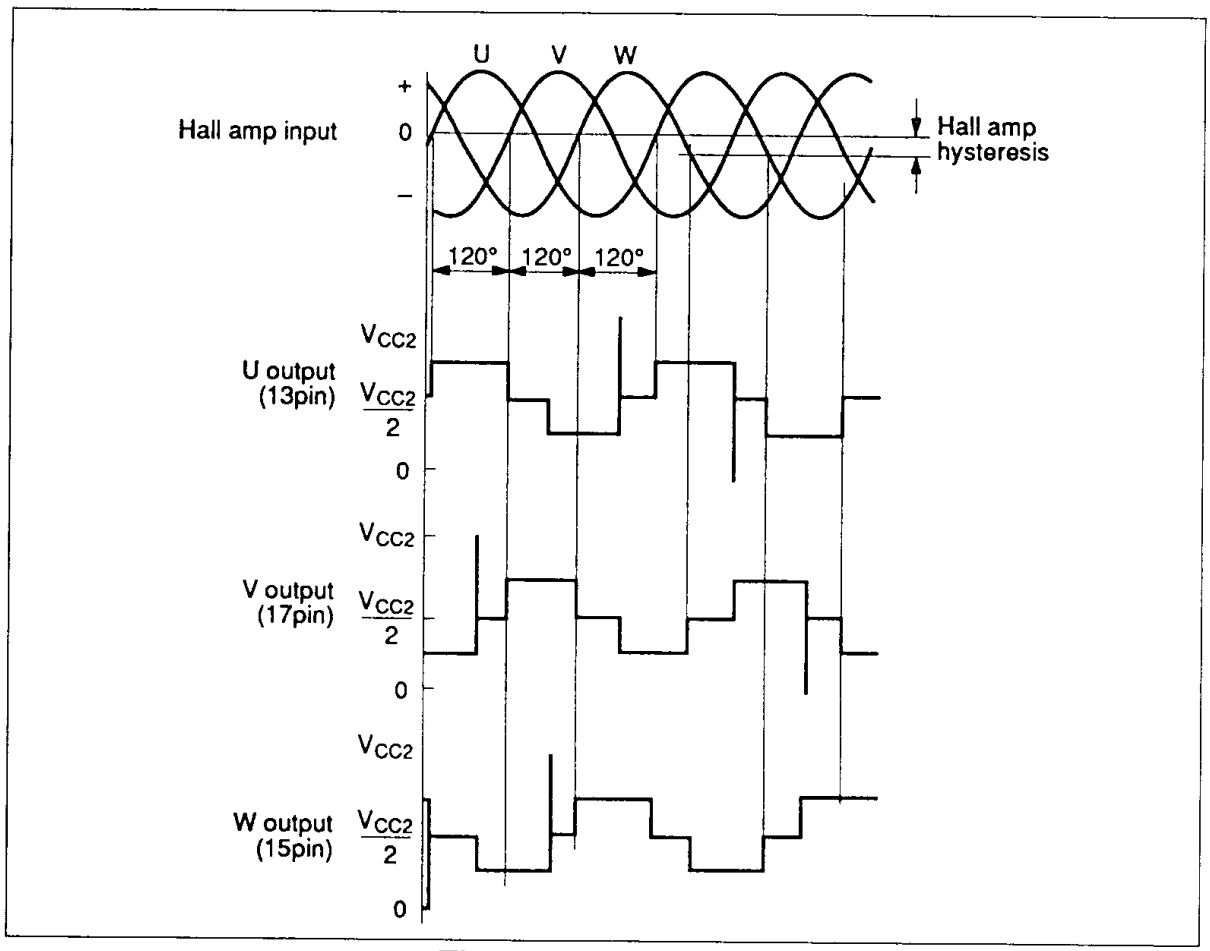


Figure 4 Timing Chart