

**SANYO**

No. 3295

**LB1693****3-Phase Brushless Motor Driver****Overview**

The LB1693 is a driver IC for 3-phase brushless motors. It is ideally suited for office automation equipment and DC fan motors.

**Features**

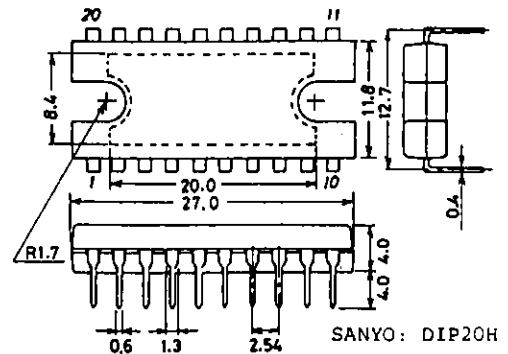
- 3-phase brushless motor driver
- 45V withstand voltage and 2.5A output current
- PWM switch regulator control section
- Current limiter
- Overvoltage and overcurrent protection circuit
- Thermal shutdown circuit
- Hall amp with hysteresis characteristic

**Absolute Maximum Ratings at Ta = 25°C**

			unit
Maximum Supply Voltage	V <sub>CC</sub> max	45	V
	V <sub>M</sub> max	45	V
Maximum Output Current	I <sub>O</sub>	2.5	A
Allowable Power Dissipation	P <sub>d</sub> max	3	W
			2W
Operating Temperature	T <sub>opr</sub>	-20 to +80	°C
Storage Temperature	T <sub>stg</sub>	-55 to +150	°C

**Allowable Operating Conditions at Ta = 25°C**

			unit
Supply Voltage	V <sub>CC</sub>	9 to 36	V
	V <sub>M</sub>	V <sub>H</sub> to 41	V
Voltage Regulator Output Current	I <sub>VH</sub>	0 to 20	mA
V <sub>H</sub> Supply Voltage	V <sub>H</sub>	4.5 to 5.5	V
Comparator Output Current	I <sub>osc</sub>	0 to 30	mA

**Package Dimensions 3037A**  
(unit: mm)

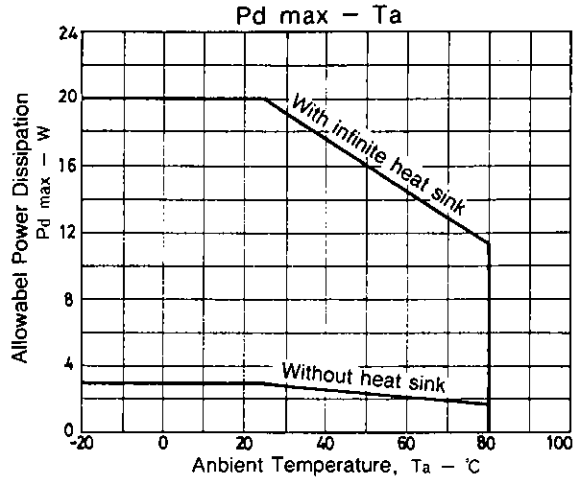
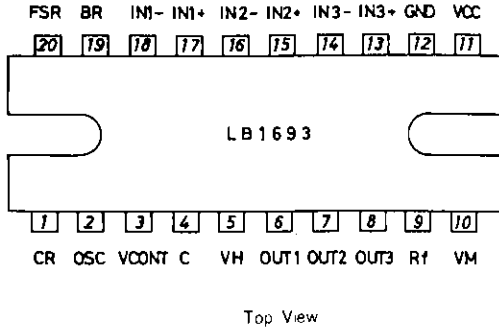
**SANYO Electric Co., Ltd. Semiconductor Business Headquarters**  
TOKYO OFFICE Tokyo Bldg., 1-10, 1 Chome, Ueno, Taito-ku, TOKYO, 110 JAPAN

# LB1693

**Electrical Characteristics at Ta = 25°C, V<sub>CC</sub> = V<sub>M</sub> = 24V**

			min	typ	max	unit
Supply Current	I <sub>CC1</sub>	Stop mode		5	8	mA
	I <sub>CC2</sub>	Hall current = 5mA		15	21	mA
Output Saturation Voltage	V <sub>O sat1</sub>	I <sub>O</sub> = 1A, V <sub>O(SINK)</sub> + V <sub>O(SOURCE)</sub>		2.1	3.0	V
	V <sub>O sat2</sub>	I <sub>O</sub> = 2A, V <sub>O(SINK)</sub> + V <sub>O(SOURCE)</sub>		3.0	4.2	V
Output Leakage Current	I <sub>O leak</sub>				100	μA
Voltage Regulator Output Voltage	V <sub>H</sub>	I <sub>VH</sub> = 10mA	6.5	7.0	7.5	V
Voltage Regulator Load Fluctuation	ΔV <sub>H1</sub>	V <sub>CC</sub> = 9.5 to 36V		70	200	mV
Voltage Regulator Load Fluctuation	ΔV <sub>H2</sub>	I <sub>VH</sub> = 0 to 20mA				
Voltage Regulator Temperature Coefficient [Hall Amp]				-2		mV/°C
Input Bias Current	I <sub>HB</sub>			1	4	μA
Common-Mode Input Voltage Range			1.5		V <sub>H</sub> - 1.8	V
Hysteresis Width	ΔV <sub>IN</sub>		28	38	46	mV
Low to High Input Voltage	V <sub>SLH</sub>		8	20	32	mV
High to Low Input Voltage	V <sub>SHL</sub>		-32	-20	-8	mV
<b>Oscillator</b>						
'H'-Level Output Voltage				3.45		V
'L'-Level Output Voltage				1.0		V
Oscillation Frequency	f	R = 36kΩ, C = 4700pF		10		kHz
Amplitude			2.1	2.45	2.8	Vp-p
Temperature Coefficient	Δf			0.1		%/°C
<b>Comparator</b>						
Output Voltage	V <sub>OSC</sub>	I <sub>OSC</sub> = 30mA		1.1	1.5	V
Rising Time	t <sub>r</sub>			0.5		μs
Falling time	t <sub>f</sub>			0.5		μs
<b>Forward/Stop/Reverse</b>						
Forward	V <sub>FSR1</sub>			0	0.8	V
Stop	V <sub>FSR2</sub>		2.1	2.5	2.9	V
Reverse	V <sub>FSR3</sub>		4.2	5.0		V
Brake Operation Off	V <sub>BR1</sub>				0.8	V
Brake Operation On	V <sub>BR2</sub>		2.0			V
<b>Current Limiter</b>						
Limiter 1	V <sub>RF1</sub>		0.42	0.5	0.6	V
Limiter 2	V <sub>RF2</sub>		0.34	0.4	0.48	V
Overvoltage Protection Voltage	V <sub>OVSD</sub>		38	42	44.5	V
Hysteresis Width	ΔV <sub>OVSD</sub>		0.8	1.3	1.8	V
Thermal Shutdown Temperature	TSD	Design goals	150	180		°C
Hysteresis Width	ΔTSD			25		°C
Low-Voltage Protection Voltage	V <sub>LVSD</sub>		3.6	4.0	4.4	V
Hysteresis Width	ΔV <sub>LVSD</sub>		0.04	0.11	0.18	V
Upper Diode Voltage	V <sub>F</sub>	I <sub>O</sub> = 1A	0.8	2.8	4.7	V

Pin Assignment



Pin Description

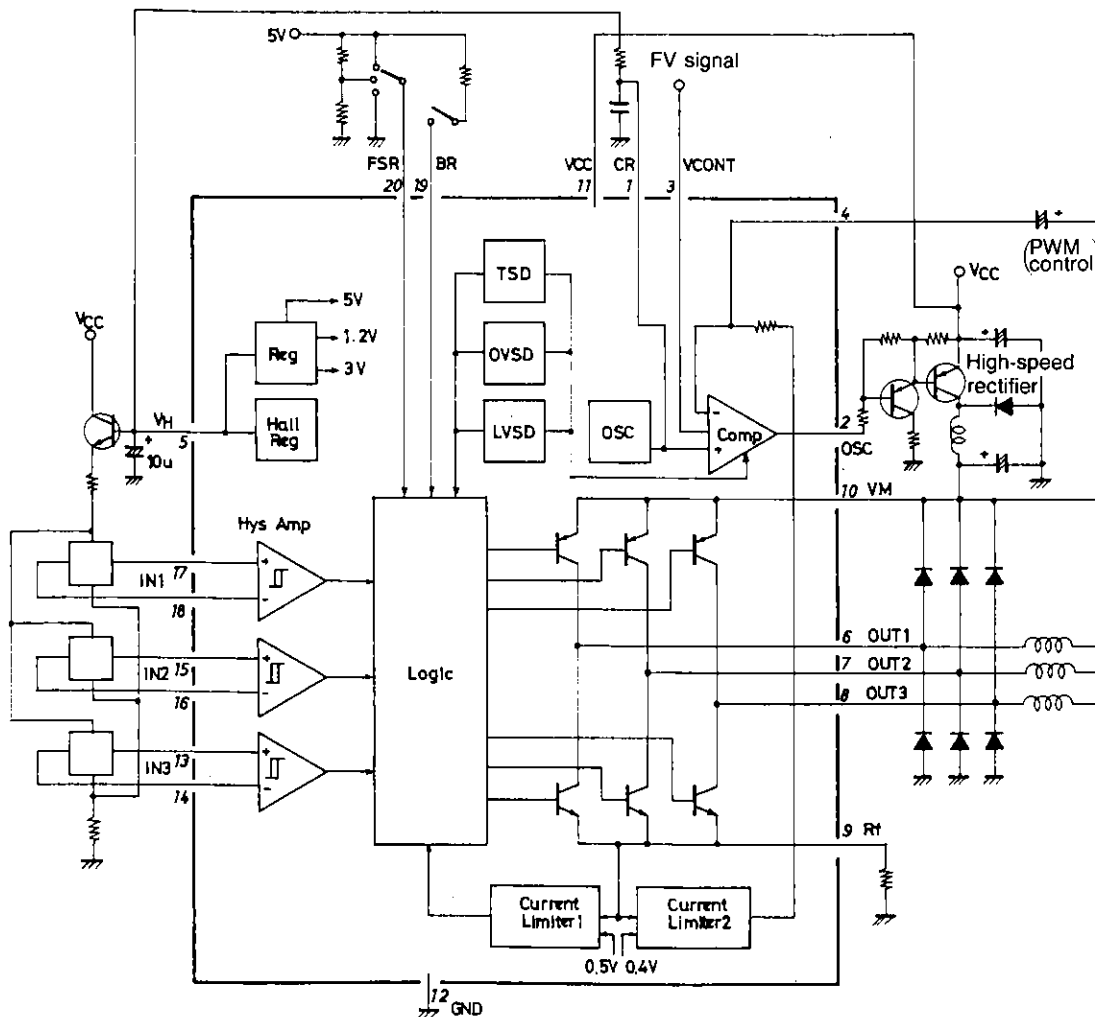
Pin Name	Pin No.	Description
IN <sup>+</sup> , IN <sup>-</sup>	17, 18 15, 16 13, 14	OUT1 : Hall element input pins for Phase 1 High logic is the state when IN1 <sup>+</sup> > IN1 <sup>-</sup> . OUT2 : Hall element input pins for Phase 2 High logic is the state when IN1 <sup>+</sup> > IN1 <sup>-</sup> . OUT3 : Hall element input pins for Phase 3 High logic is the state when IN1 <sup>+</sup> > IN1 <sup>-</sup> .
OUT1 OUT2 OUT3	6 7 8	Output pin for Phase 1 Output pin for Phase 2 Output pin for Phase 3
V <sub>CC</sub>	11	Power supply pin for applying voltage to each section other than output section
V <sub>M</sub>	10	Power supply for output section
R <sub>F</sub>	9	Output current detect pin; R <sub>F</sub> is inserted between this pin and ground to detect the output current as a voltage.
GND B <sub>R</sub>	12 19	Ground for other than but output The minimum potential of output transistor is at the R <sub>f</sub> pin. Brake pin The brake is switched on/off by setting this pin high (2 V or more)/low (0.8 V or less).
FSR	20	Forward/stop/reverse control pin The motor is driven forward, stopped, or driven in reverse according to the voltage at this pin. Forward : 0 to 0.8 V Stop : 2.1 to 2.9 V Reverse : 4.2 to 5.0 V
V <sub>H</sub>	5	Power pin for Hall elements When using the internal (stabilized) power supply: V <sub>H</sub> =7 V typ. When using an external (stabilized) power supply: V <sub>H</sub> =5 V typ.
CR	1	Sets the oscillation frequency for the switching regulator.
OSC	2	Outputs duty-controlled pulses; open collector output.
V <sub>CONT</sub>	3	Speed control pin; varies the switching regulator output voltage.
C	4	Suppresses ripples in the motor current during operation of current limiter 2.

Truth Table

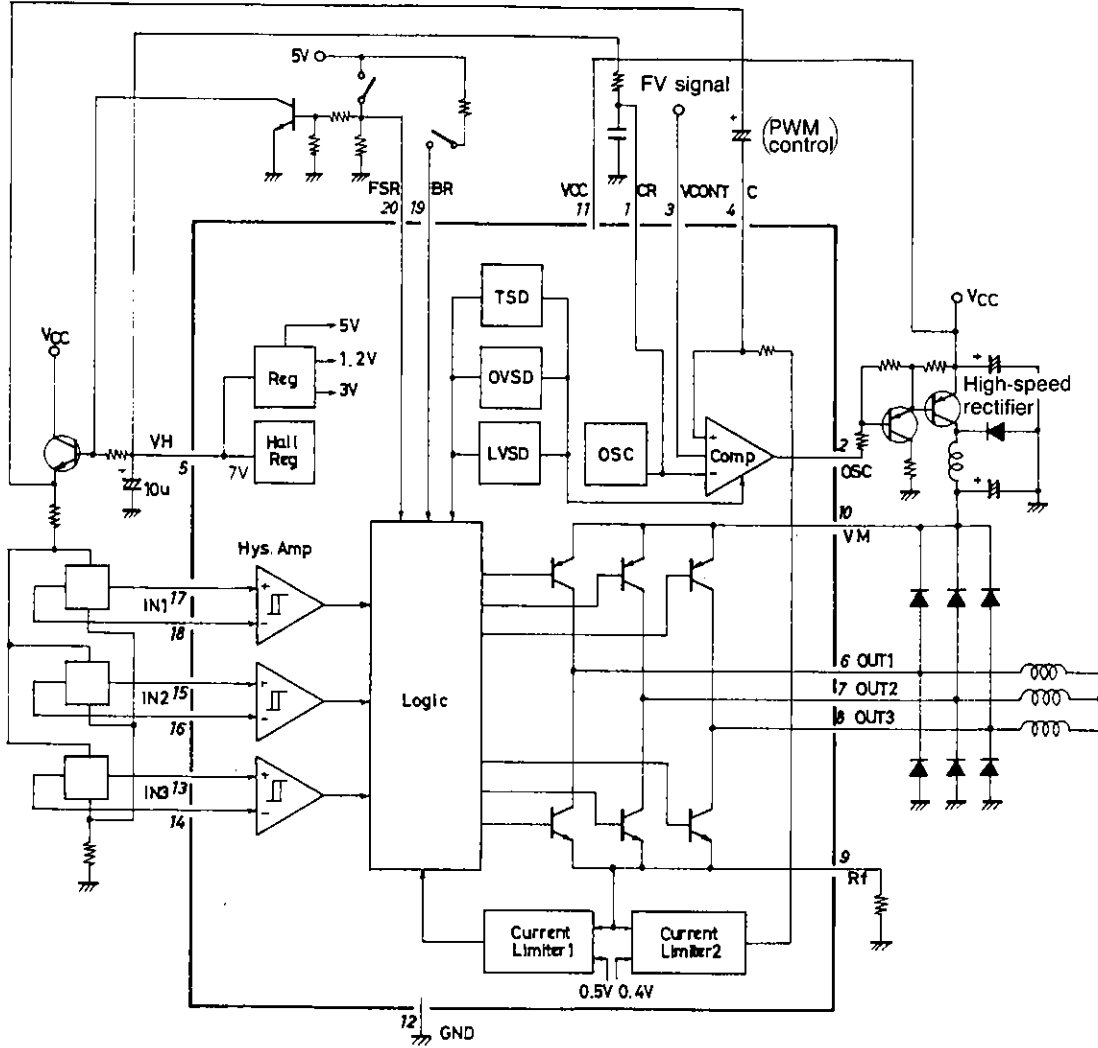
Item	Source Sink	Input			Forward/Reverse Control
		IN1	IN2	IN3	
1	OUT3 → OUT2	H	H	L	L
	OUT2 → OUT3				H
2	OUT3 → OUT1	H	L	L	L
	OUT1 → OUT3				H
3	OUT2 → OUT3	L	L	H	L
	OUT3 → OUT2				H
4	OUT1 → OUT2	L	H	L	L
	OUT2 → OUT1				H
5	OUT2 → OUT1	H	L	H	L
	OUT1 → OUT2				H
6	OUT1 → OUT3	L	H	H	L
	OUT3 → OUT1				H

Block Diagram and Peripheral Circuit Diagram

PWM control (1)

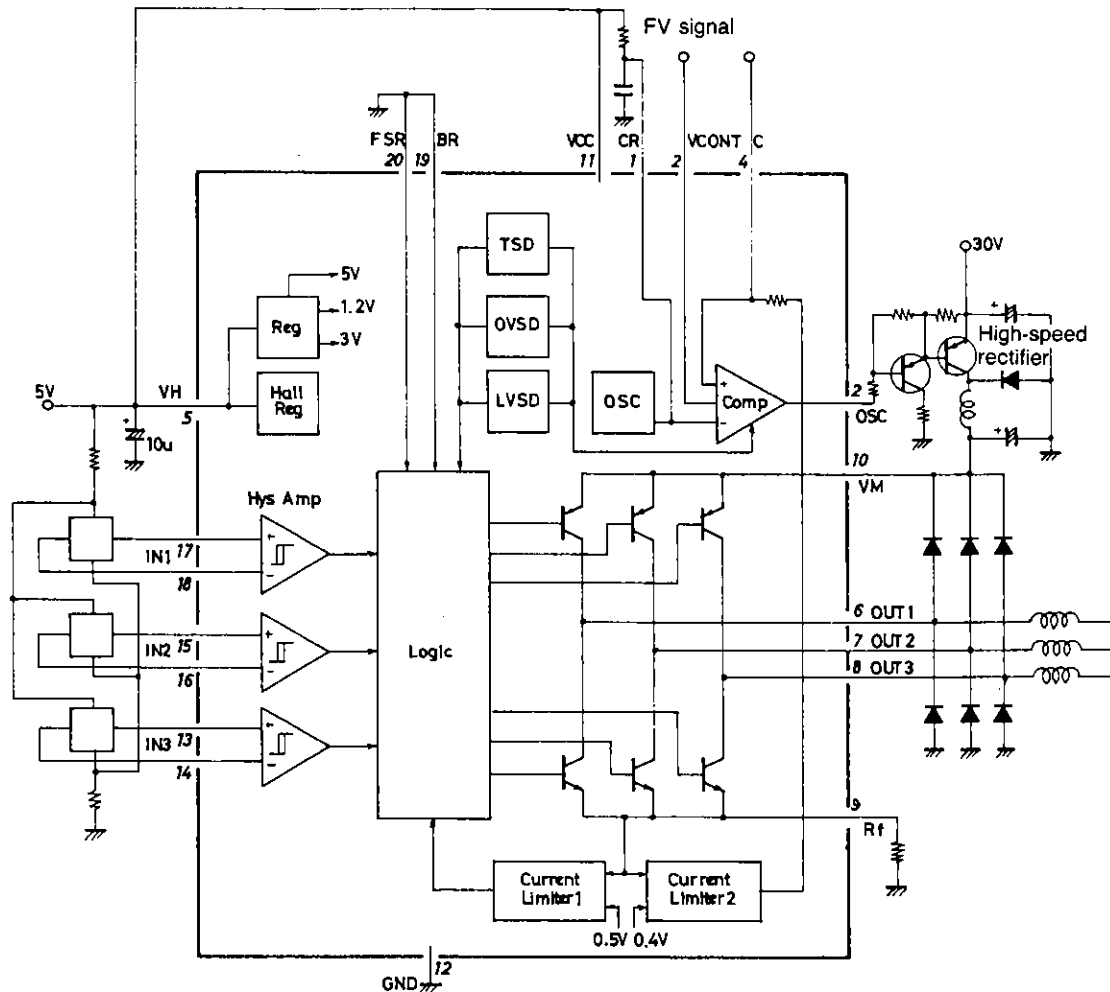


PWM control (2)

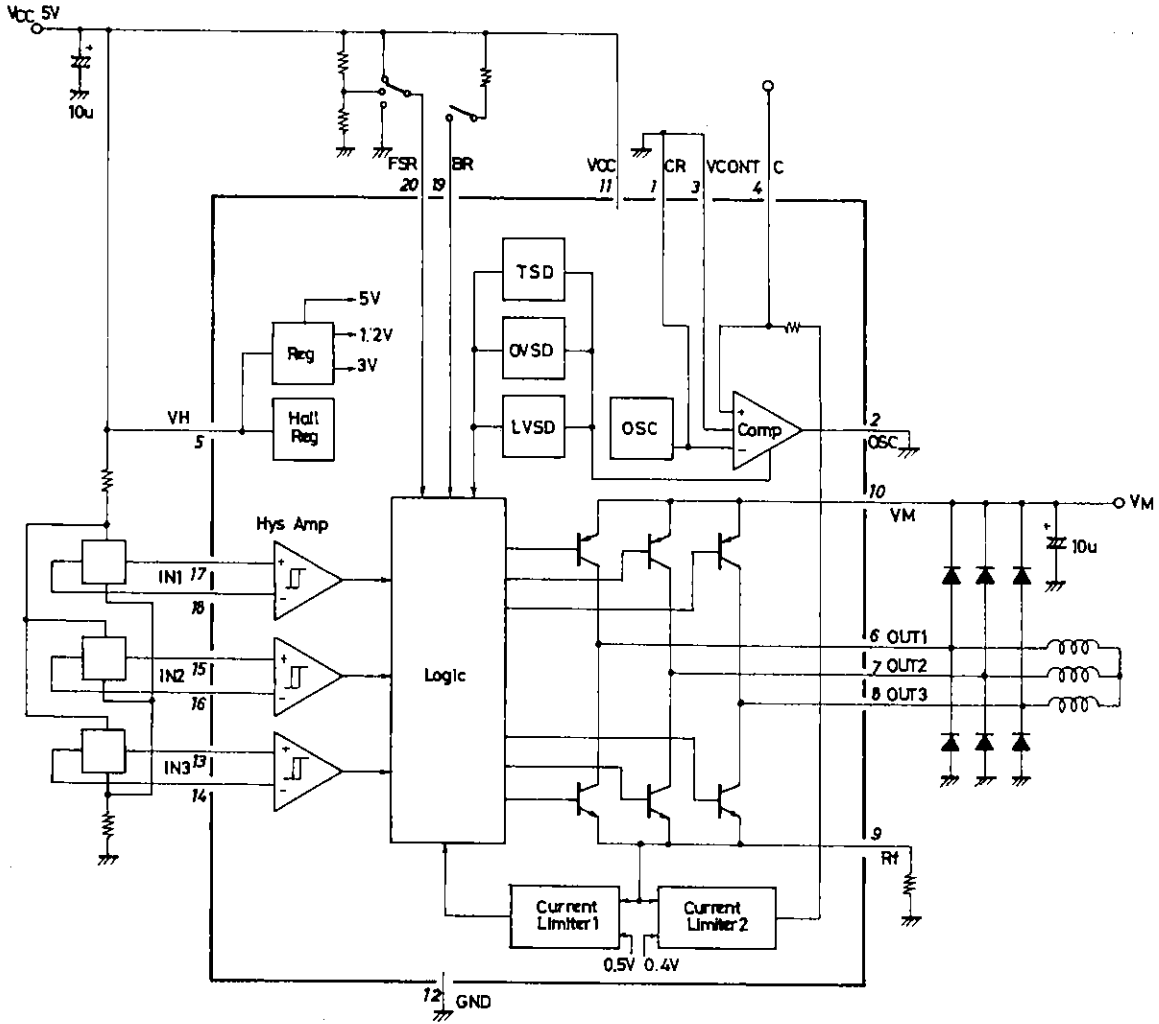


LB1693

$V_{CC}=V_H=5\text{ V}$   
 PWM control



$V_{CC}=5V$   
 $V_M$  ) No speed control



1. Switching regulator oscillation circuit (PWM generation circuit)

1-1. Oscillation circuit (40 to 50kHz max.)

Figure 1 shows the oscillation circuit that generates the triangular waves. The oscillation frequency for this circuit is determined by the following equation (with  $V_H=7V$  typ.)

$$f = \frac{1}{t_0 + t_1} \text{ (Hz)}$$

$$t_0 \approx 0.56CR \text{ (charging)}$$

$$t_1 \approx 1.34CR_N \text{ (discharging)}$$

( $R_N$  is the internal resistance of  $1.4k\Omega$  approx.)

In actual applications,  $R \gg R_N$  is used to suppress the influence of variation in the IC's internal resistance.

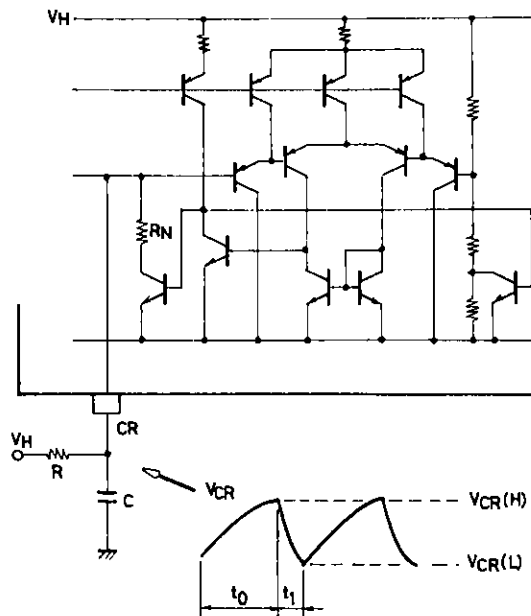


Figure 1 Oscillation Circuit

1-2. Comparator circuit

Figure 2 shows the comparator circuit for comparing the triangular wave output, the speed control signal, etc.

Input terminals

- CR Inputs the triangular wave output.
- V<sub>CONT</sub> Inputs the speed control signal.
- C Goes high when current limiter 2 is operating.  
(When V<sub>C(H)</sub> > V<sub>CR(H)</sub>, the OSC output is off.)

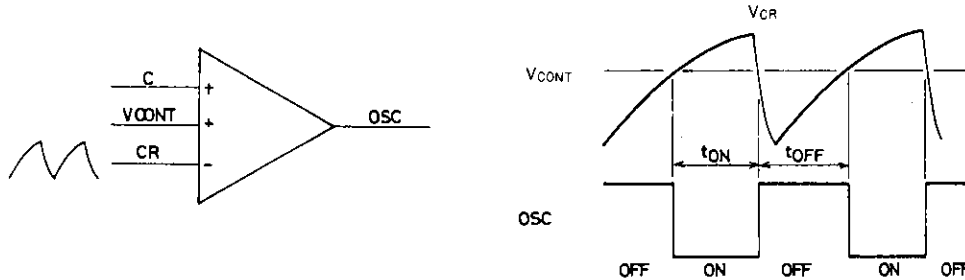


Figure 2 Comparator Circuit

2. Position detection circuit (Hall element input circuit)

The position detection circuit is a differential amp with hysteresis (38mV typ.). For the operating DC level, use within the common-mode phase input voltage range (1.5 to V<sub>H</sub> - 1.8 V). Also it is recommended that the input level is at least three times (150 to 200mVp-p) the hysteresis.

3. V<sub>H</sub> power supply circuit

The V<sub>H</sub> power supply pins can be used from the internal power supply or an external power supply. When using the internal power supply, the internal logic operates with V<sub>H</sub>=7 V typical (V<sub>CC</sub>=24 V). When using an external power supply, set V<sub>CC</sub>=V<sub>H</sub>=5 V and operate the internal logic at 5 V.

4. Current limiter circuits

4-1. Current limiter 1

The current is limited by moving the sink side transistor from saturated to undaturated, so ASO can be a problem.

$$I = \frac{V_{BE1}}{R_F} \quad (A)$$

Therefore, design so that as much as possible current limiter 1 is not triggered.

Also, take particular care not to exceed the maximum output current (2.5A) when current limiter 1 is triggered.

4-2. Current limiter 2

This circuit limits the current by lowering the PWM output duty, thus lowering the V<sub>M</sub> voltage.

When current limiter 2 is triggered, the output current is no greater than 2A.

$$I = \frac{V_{BE2}}{R_F}$$

When not controlling the PWM, add a current limiter to the V<sub>M</sub> power supply. (A current setting no greater than 60% to 70% of the current value of current limiter 1 and a short delay time are recommended.)

5. Protection circuits

5-1. Overvoltage protection circuit

If the voltage at the V<sub>CC</sub> pin rises above the regulated voltage (38 V), PWM output is inhibited and the sink side output driver is switched off.

5-2. Low-voltage protection circuit

If the voltage at the V<sub>CC</sub> pin falls below the regulated voltage, just as in 5-1, PWM output is inhibited and the sink side output driver is switched off.

This circuit is to prevent malfunctioning.

5-3. Thermal shutdown circuit

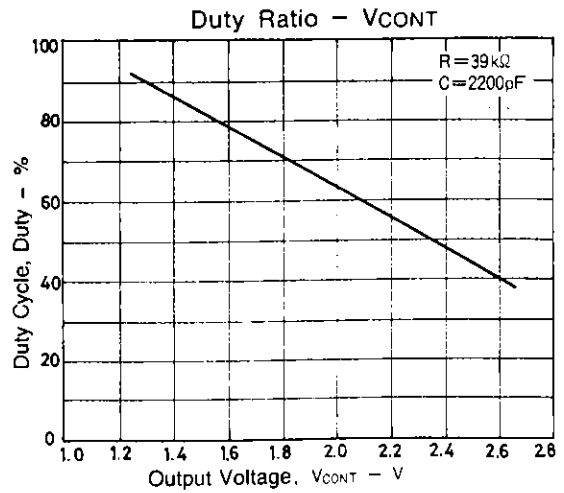
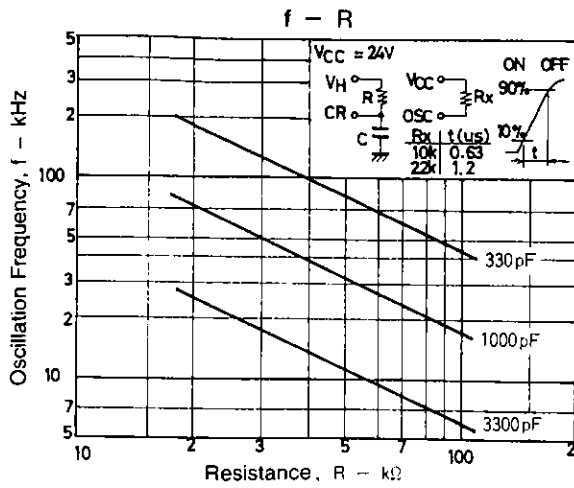
If the junction temperature rises above the regulated temperature, just as in 5-1, PWM output is inhibited and the sink side output driver is switched off.

6. Minimum voltage at V<sub>M</sub> power

Use a voltage greater than the V<sub>H</sub> voltage for the V<sub>M</sub> power supply voltage

$$V_M \geq V_H$$





- No products described or contained herein are intended for use in surgical implants, life-support systems, aerospace equipment, nuclear power control systems, vehicles, disaster/crime-prevention equipment and the like, the failure of which may directly or indirectly cause injury, death or property loss.
- Anyone purchasing any products described or contained herein for an above-mentioned use shall:
  - ① Accept full responsibility and indemnify and defend SANYO ELECTRIC CO., LTD., its affiliates, subsidiaries and distributors and all their officers and employees, jointly and severally, against any and all claims and litigation and all damages, cost and expenses associated with such use:
  - ② Not impose any responsibility for any fault or negligence which may be cited in any such claim or litigation on SANYO ELECTRIC CO., LTD., its affiliates, subsidiaries and distributors or any of their officers and employees jointly or severally.
- Information (including circuit diagrams and circuit parameters) herein is for example only; it is not guaranteed for volume production. SANYO believes information herein is accurate and reliable, but no guarantees are made or implied regarding its use or any infringements of intellectual property rights or other rights of third parties.