

**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.

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

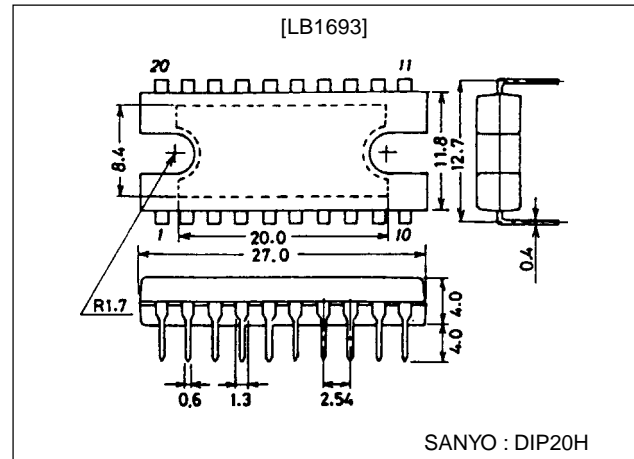
Parameter	Symbol	Conditions	Ratings	Unit
Maximum supply voltage	V_{CC} max		45	V
	V_M max		45	V
Maximum Output current	I_O		2.5	A
Allowable power dissipation	P_d max	Independent IC	3	W
		With infinite heat sink	20	W
Operating temperature	T_{opr}		-20 to +80	°C
Storage temperature	T_{stg}		-55 to +150	°C

Allowable Operating Conditions at Ta = 25°C

Parameter	Symbol	Conditions	Ratings	Unit
Supply voltage	V_{CC}		9 to 36	V
	V_M		V_H to 41	V
Voltage regulator output current	I_{VH}		0 to 20	mA
V_H supply voltage	V_H		4.5 to 5.5	V
Comparator output current	I_{OSC}		0 to 30	mA

Package Dimensions

unit:mm

3037A-DIP20H

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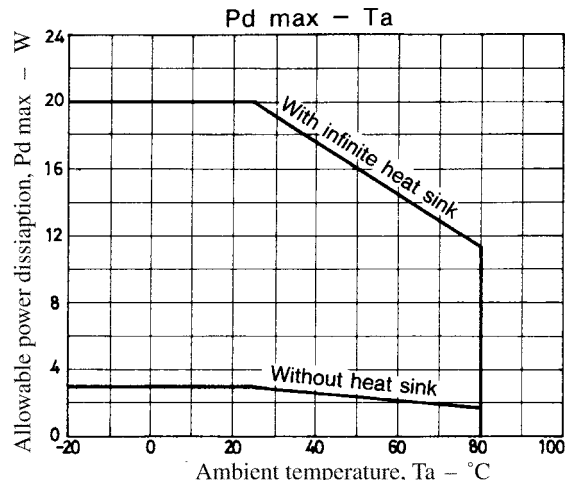
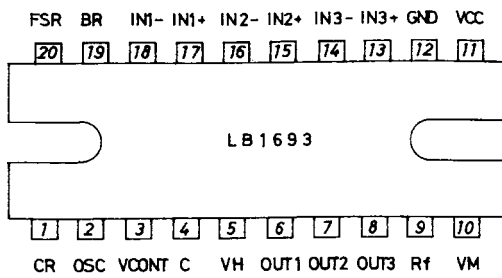
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Electrical Characteristics at $T_a = 25^\circ\text{C}$, $V_{CC}=V_M=24\text{V}$

Parameter	Symbol	Conditions	Ratings			Unit
			min	typ	max	
Supply current	I_{CC1}	Stop mode		5	8	mA
	I_{CC2}	Hall current=5mA		15	21	mA
Output saturation voltage	$V_{O\ sat1}$	$I_O=1\text{A}$, $V_{O(sink)}+V_{O(source)}$		2.1	3.0	V
	$V_{O\ sat2}$	$I_O=2\text{A}$, $V_{O(sink)}+V_{O(source)}$		3.0	4.2	V
Output leakage current	$I_O\ leak$				100	μA
Voltage regulator output voltage	V_H	$I_{VH}=10\text{mA}$	6.5	7.0	7.5	V
Voltage regulator load fluctuation	ΔV_{H1}	$V_{CC}=9.5\text{ to }36\text{V}$		70	200	mV
Voltage regulator load fluctuation	ΔV_{H2}	$I_{VH}=0\text{ to }20\text{mA}$		140	250	mV
Voltage Regulator temperature coefficient				-2		$\text{mV}/^\circ\text{C}$
[Hall amp]						
Input bias current	I_{HB}			1	4	μA
Common-mode input voltage range			1.5		$V_H-1.8$	V
Hysteresis width	ΔV_{IN}		28	38	46	mV
Low to high input voltage	V_{SLH}		8	20	32	mV
High to low input voltage	V_{SHL}		-32	-20	-8	mV
Oscillator						
High-level output voltage				3.45		V
Low-level output voltage				1.0		V
Oscillation frequency	f	$R=36\text{k}\Omega$, $C=4700\text{pF}$		10		kHz
Amplitude			2.1	2.45	2.8	Vp-p
Temperature coefficient	Δf			0.1		$\%/^\circ\text{C}$
Comparator						
Output voltage	V_{OSC}	$I_{OSC}=30\text{mA}$		1.1	1.5	V
Rising time	t_r			0.5		μs
Falling time	t_f			0.5		μs
Forward/Stop/Reverse						
Forward	V_{FSR1}			0	0.8	V
Stop	V_{FSR2}		2.1	2.5	2.9	V
Reverse	V_{FSR3}		4.2	5.0		V
Brake operation off	V_{BR1}				0.8	V
Brake operation on	V_{BR2}		2.0			V
Current limiter						
Limiter1	V_{Rf1}		0.42	0.5	0.6	V
Limiter2	V_{Rf2}		0.34	0.4	0.48	V
Overvoltage protection voltage	V_{OVSD}		38	42	44.5	V
Hysteresis width	ΔV_{OVSD}		0.8	1.3	1.8	V
Thermal shutdown temperature	TSD	Design target	150	180		$^\circ\text{C}$
Hysteresis width	ΔTSD			25		$^\circ\text{C}$
Low-voltage protection voltage	V_{LVSD}		3.6	4.0	4.4	V
Hysteresis width	ΔV_{LVSD}		0.04	0.11	0.18	V
Upper diode voltage	V_F	$I_O=1\text{A}$	0.8	2.8	4.7	V

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Pin Assignment



Pin Description

Pin Name	Pin No.	Description
IN1 ⁺ , IN1 ⁻	17, 18	OUT1: Hall element input pins for Phase 1. High logic is the state when IN1 ⁺ > IN1 ⁻ .
IN2 ⁺ , IN2 ⁻	15, 16	OUT2: Hall element input pins for Phase 2. High logic is the state when IN1 ⁺ > IN1 ⁻ .
IN3 ⁺ , IN3 ⁻	13, 14	OUT3: Hall element input pins for Phase 3. High logic is the state when IN1 ⁺ > IN1 ⁻ .
OUT1	6	Output pin for Phase 1.
OUT2	7	Output pin for Phase 2.
OUT3	8	Output pin for Phase 3.
V _{CC}	11	Power supply pin for applying voltage to each section other than output section.
V _M	10	Power supply for output section.
R _f	9	Output current detect pin; R _f is inserted between this pin and ground to detect the output current as a voltage.
GND	12	Ground for other output The minimum potential of output transistor is at the R _f pin.
B _R	19	Brake pin The brake is switched on/off by setting this pin high (2V or more)/low (0.8V 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 0.8V Stop : 2.1 to 2.9V Reverse : 4.2 to 5.0V
V _H	5	Power pin for Hall elements When using the internal (stabilized) power supply : V _H =7V typ. When using the external (stabilized) power supply : V _H =5V typ.
CR	1	Sets the oscillation frequency for the switching regulator/
OSC	2	Outputs duty-controlled pulsed ; open collector output.
V _{CONT}	3	Speed control pin ; varies the switching regulator output voltage.
C	4	Suppresses ripples in the motor current during operation of current limiter 2.

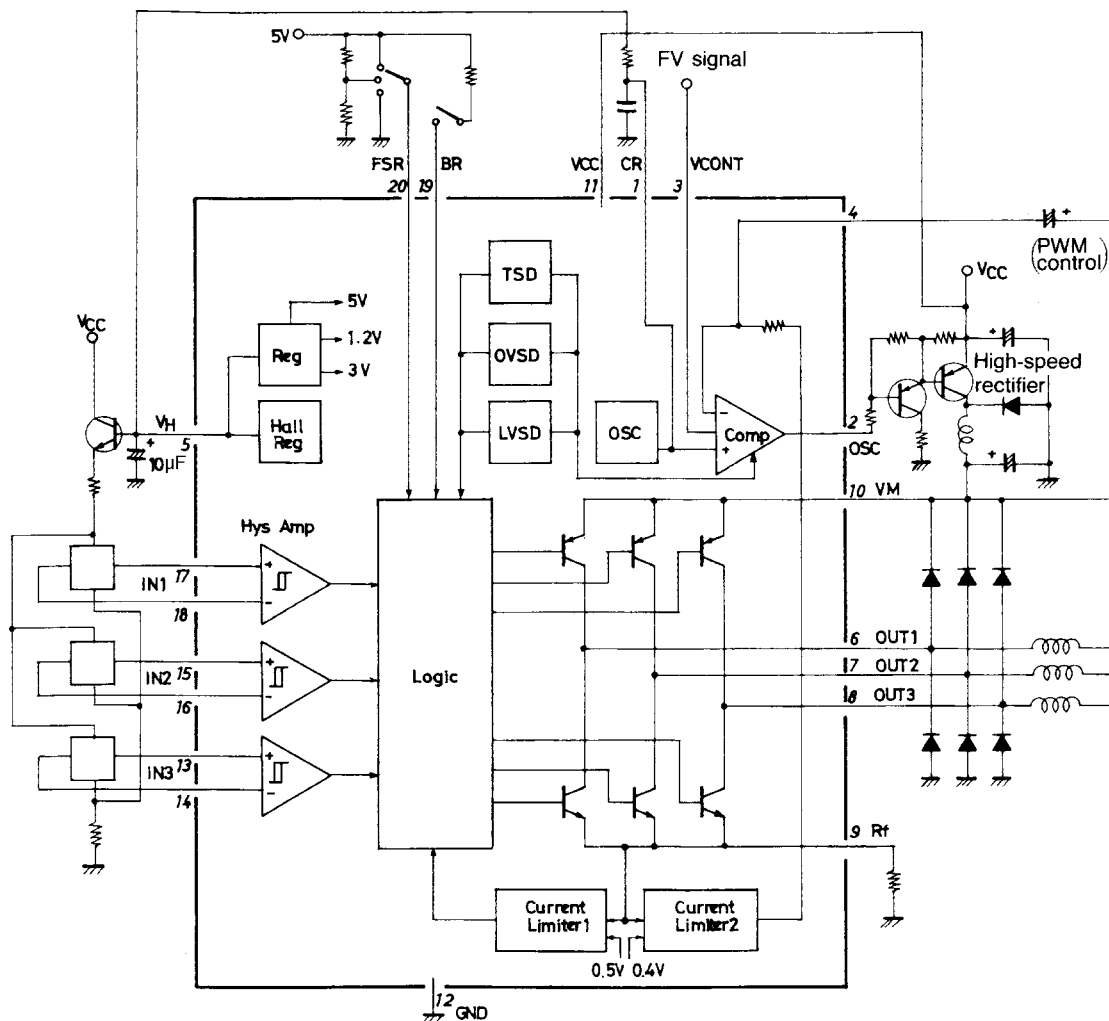
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Truth Table

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

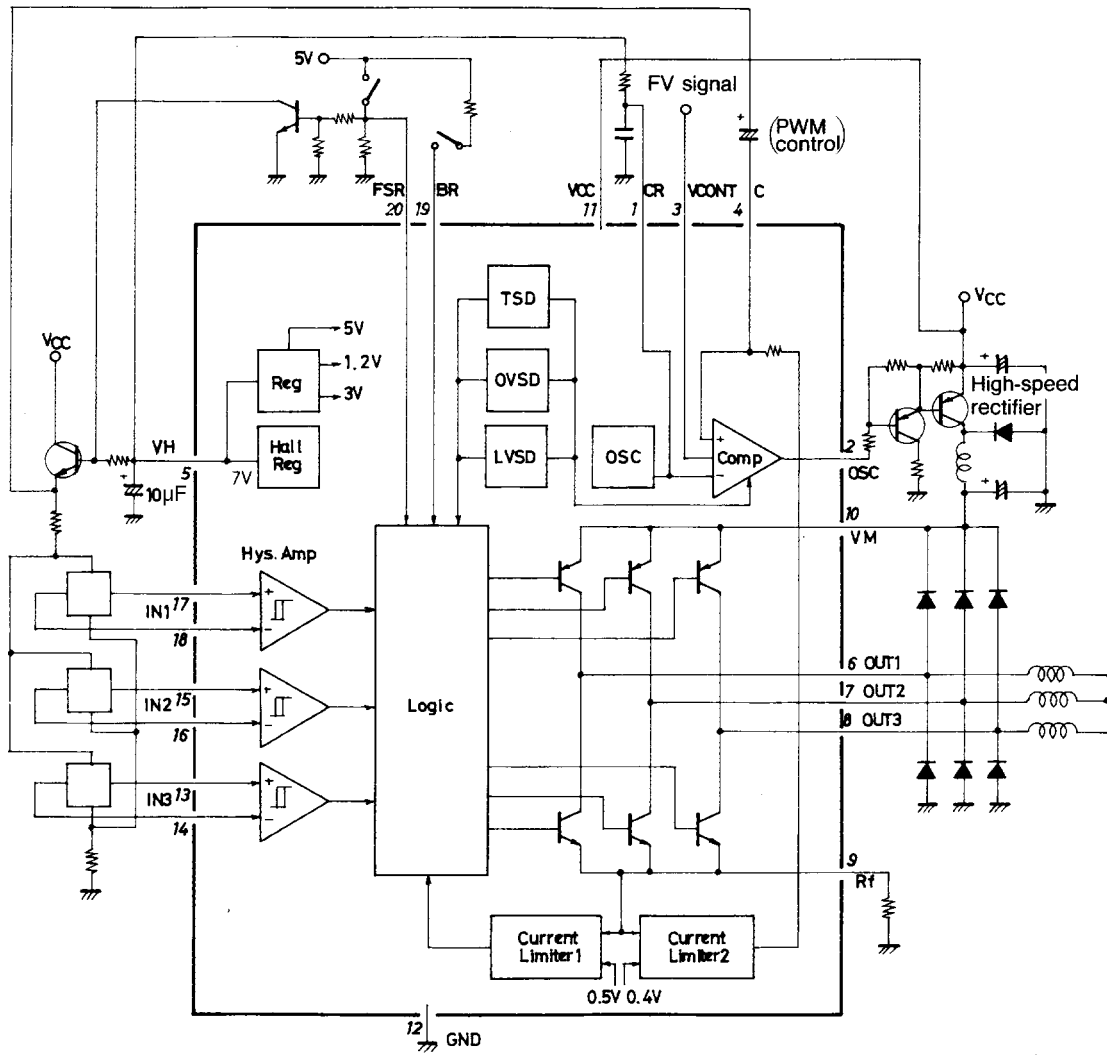
Block Diagram and Peripheral Circuit Diagram

PWM control (1)



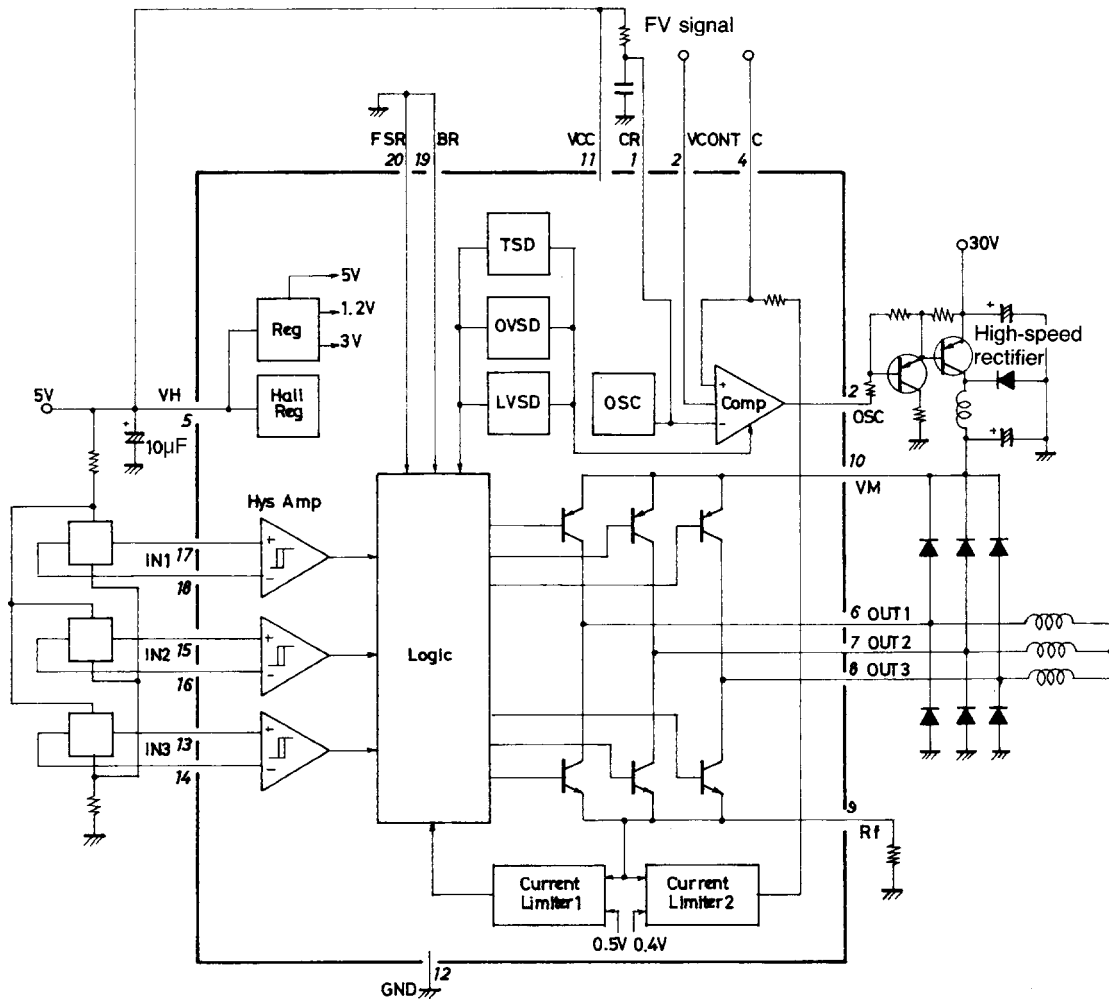
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PWM control (2)



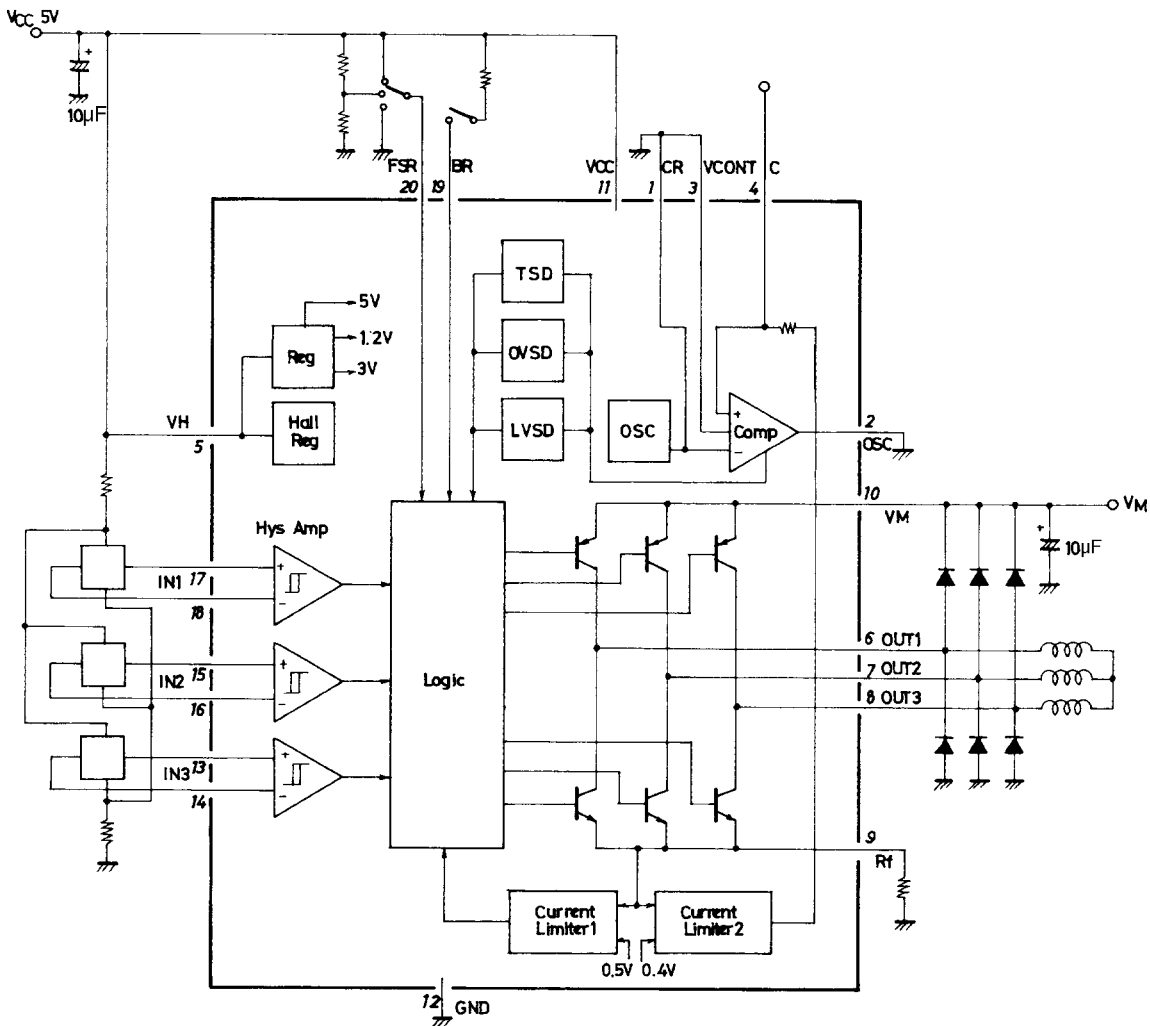
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$V_{CC}=V_H=5V$ PWM control



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$V_{CC}=5V$, V_M are 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.)

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

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

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

(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.

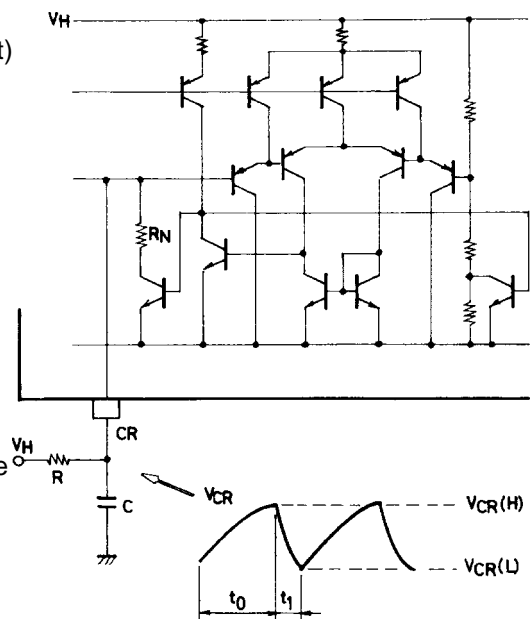


Figure 1 Oscillation Circuit

1-2. Comparator circuit

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

input terminals

CR Input the triangular wave output.

V_{CONT} Input the speed control signal.

C Goes high when current limiter 2 is operating.
(When V_{C(H)} > V_{CR(H)}, the OSC output is off.)

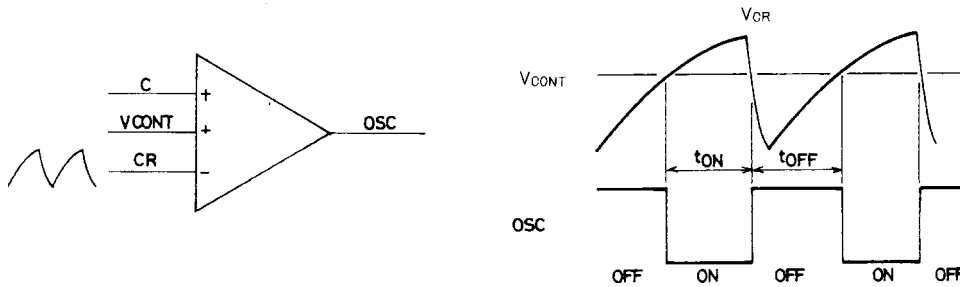


Figure 2 Comparator Circuit

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_H-1.8V). Also it is recommended that the input level is at least three times (150 to 200mVp-p) the hysteresis.

3. V_H power supply circuit

The V_H power supply pins can be used to from the internal power supply or an external power supply. When using the internal power supply, the internal logic operates with V_H=7V typical (V_{CC}=24V). When using an external power supply, set V_{CC}=V_H=5V and operate the internal logic at 5V.

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.

$$I = \frac{V_{Rf1}}{R_f} \quad (A)$$

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

$$I = \frac{V_{Rf2}}{R_f}$$

When not controlling the PWM, add a current limiter to the V_M 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_{CC} pin rises above the regulated voltage (38V), 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_{CC} pin falls below the regulated voltage, just as in 5-1, PWM output is inhibited and the sink side output driver is switched off.

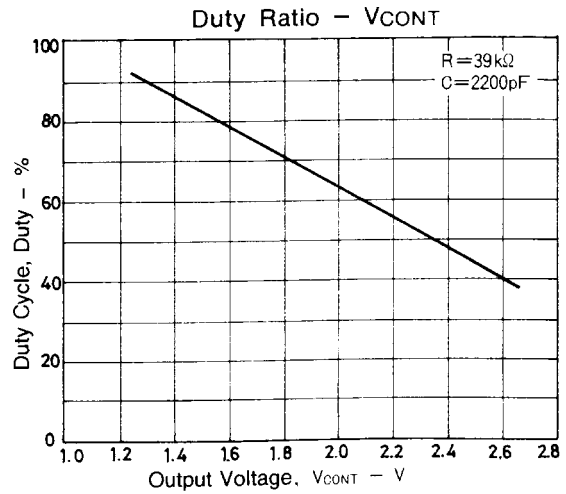
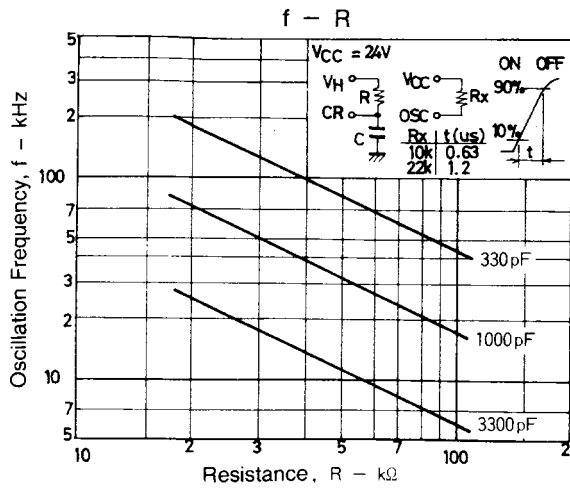
5-3. Thermal shutdown circuit

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

6. Minimum voltage at V_M power

Use a voltage greater than the V_H voltage for the V_M power supply voltage

$$V_M \geq V_H$$



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