Ordering number: EN 3295

Monolithic Digital IC

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
- Termal shutdown circuit
- Hall amp with hysteresis characteristic

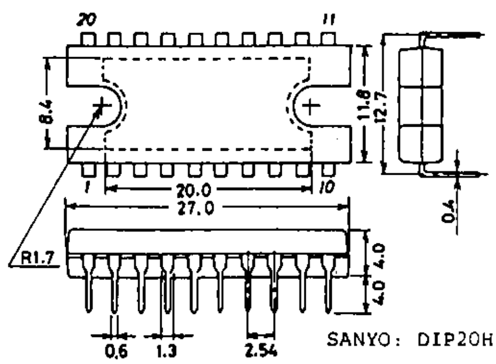
Absolute Maximum Ratings at Ta = 25°C

				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	Pd max	IC alone	3	W
				2W
Operating Temperature	Topr		−20 to +80	°C
Storage Temperature	Tstg		−55 to +150	°C

Allowable Operating Conditions at Ta = 25°C

			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 3037A
(unit: mm)



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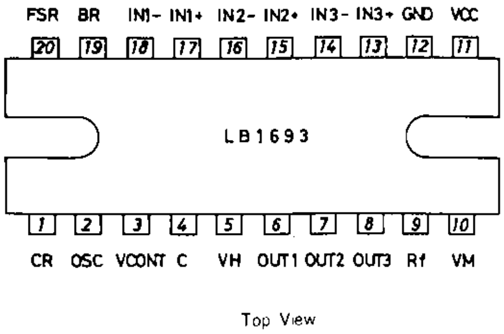
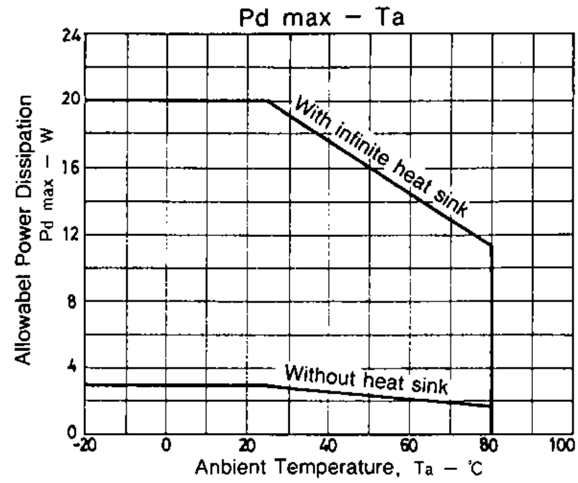
Electrical Characteristics at Ta = 25°C, $V_{CC} = V_M = 24V$

			min	typ	max	unit
Supply Current	$I_{CC}1$	Stop mode		5	8	mA
	$I_{CC}2$	Hall current=5mA		15	21	mA
Output Saturation Voltage	V_O sat1	I_O=1A, $V_{O(SINK)}+V_{O(SOURCE)}$		2.1	3.0	V
	V_O sat2	I_O=2A, $V_{O(SINK)}+V_{O(SOURCE)}$		3.0	4.2	V
Output Leakage Current	I_O leak				100	μA
Voltage Regulator Output Voltage	V_H	I_{VH} = 10mA	6.5	7.0	7.5	V
Voltage Regulator Load Fluctuation	ΔV_H1	V_{CC} = 9.5 to 36V		70	200	mV
Voltage Regulator Load Fluctuation	ΔV_H2	I_{VH} = 0 to 20mA				
Voltage Regulator Temperature Coefficient				-2		mV/°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						
'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
Comparator						
Output Voltage	V_{OSC}	I_{OSC}=30mA		1.1	1.5	V
Rising Time	tr			0.5		μs
Falling time	tf			0.5		μs
Forward/Stop/Reverse						
Forward	$V_{FSR}1$			0	0.8	V
Stop	$V_{FSR}2$		2.1	2.5	2.9	V
Reverse	$V_{FSR}3$		4.2	5.0		V
Brake Operation Off	$V_{BR}1$				0.8	V
Brake Operation On	$V_{BR}2$		2.0			V
Current Limiter						
Limiter 1	$V_{RF}1$		0.42	0.5	0.6	V
Limiter 2	$V_{RF}2$		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 goals	150	180		°C
Hysteresis Width	ΔTSD			25		°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=1A	0.8	2.8	4.7	V

Pin Assignment





Pin Description

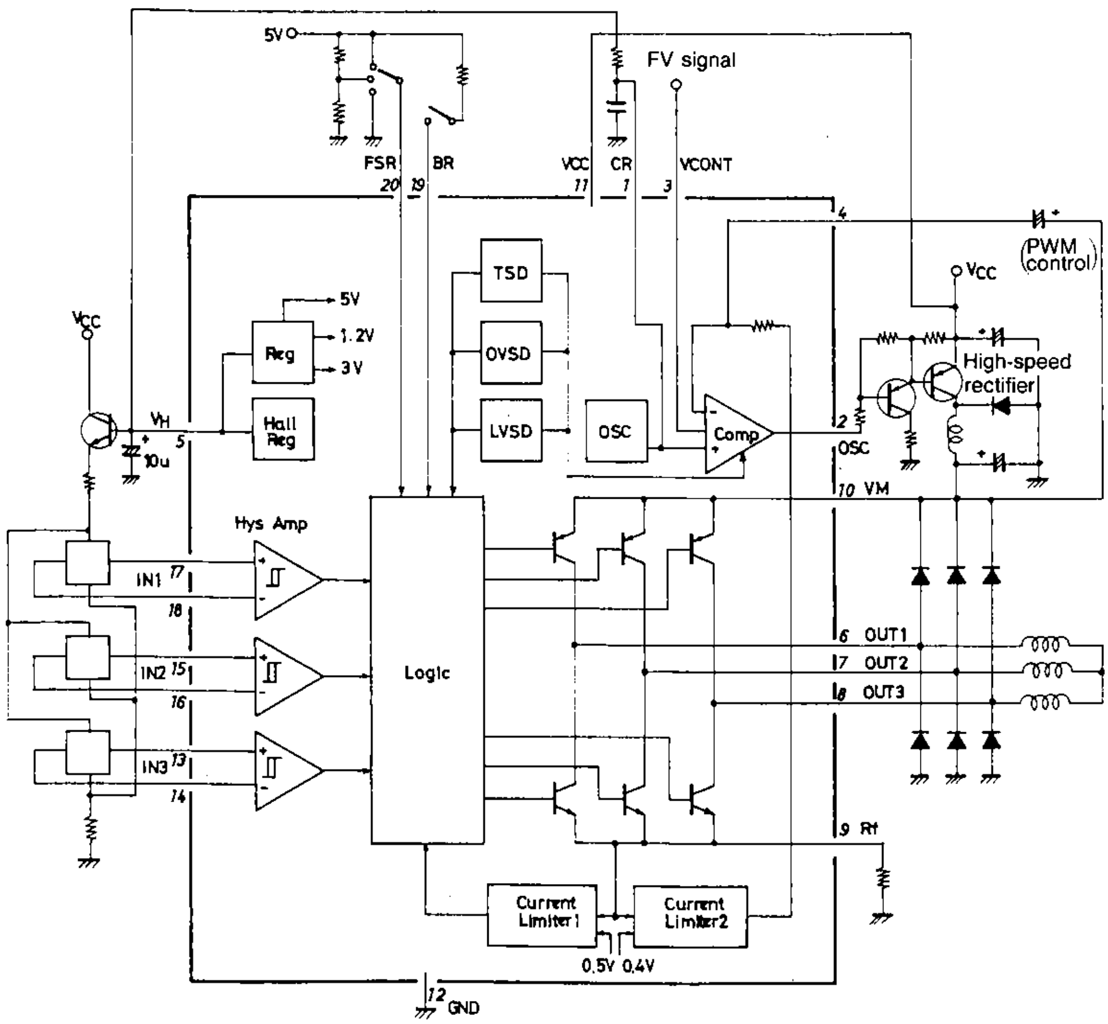
Pin Name	Pin No.	Description
IN^+, IN^-	17, 18 15, 16 13, 14	OUT1 : Hall element input pins for Phase 1 High logic is the state when $IN1^+ > IN1^-$. OUT2 : Hall element input pins for Phase 2 High logic is the state when $IN1^+ > IN1^-$. OUT3 : Hall element input pins for Phase 3 High logic is the state when $IN1^+ > IN1^-$.
OUT1 OUT2 OUT3	6 7 8	Output pin for Phase 1 Output pin for Phase 2 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 B_R	12 19	Ground for other than but output The minimum potential of output transistor is at the R_f 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_H	5	Power pin for Hall elements When using the internal (stabilized) power supply: V_H=7 V typ. When using an external (stabilized) power supply: V_H=5 V typ.
CR	1	Sets the oscillation frequency for the switching regulator.
OSC	2	Outputs duty-controlled pulses; 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.

Truth Table

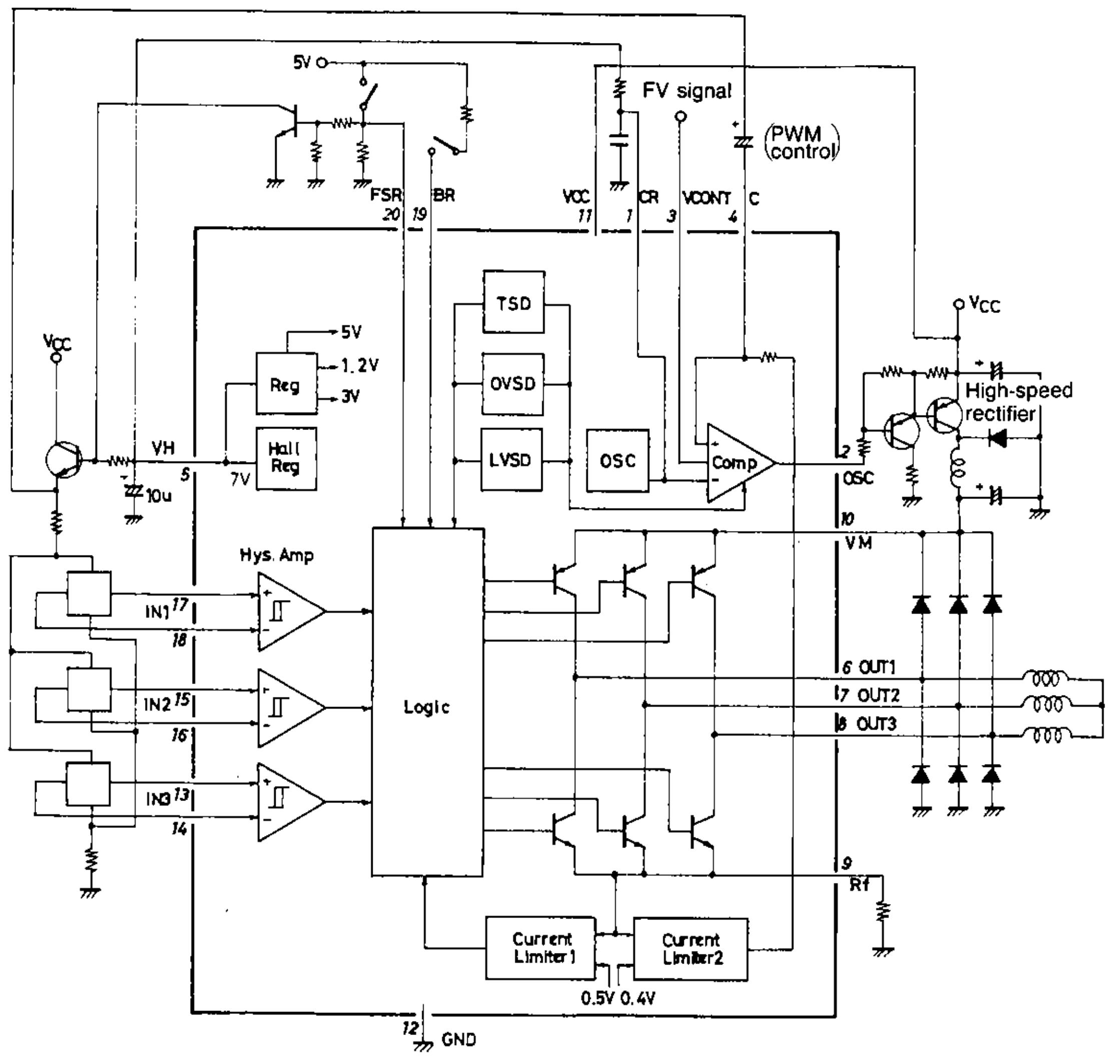
Item	Source Sink	Input			Forward/Reverse Control
		IN1	IN2	IN3	
1	OUT3 → OUT2	H	H	L	L
	OUT2 → OUT3				H
2	OUT3 → OUT1	H	L	L	L
	OUT1 → OUT3				H
3	OUT2 → OUT3	L	L	H	L
	OUT3 → OUT2				H
4	OUT1 → OUT2	L	H	L	L
	OUT2 → OUT1				H
5	OUT2 → OUT1	H	L	H	L
	OUT1 → OUT2				H
6	OUT1 → OUT3	L	H	H	L
	OUT3 → OUT1		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

Block Diagram and Peripheral Circuit Diagram

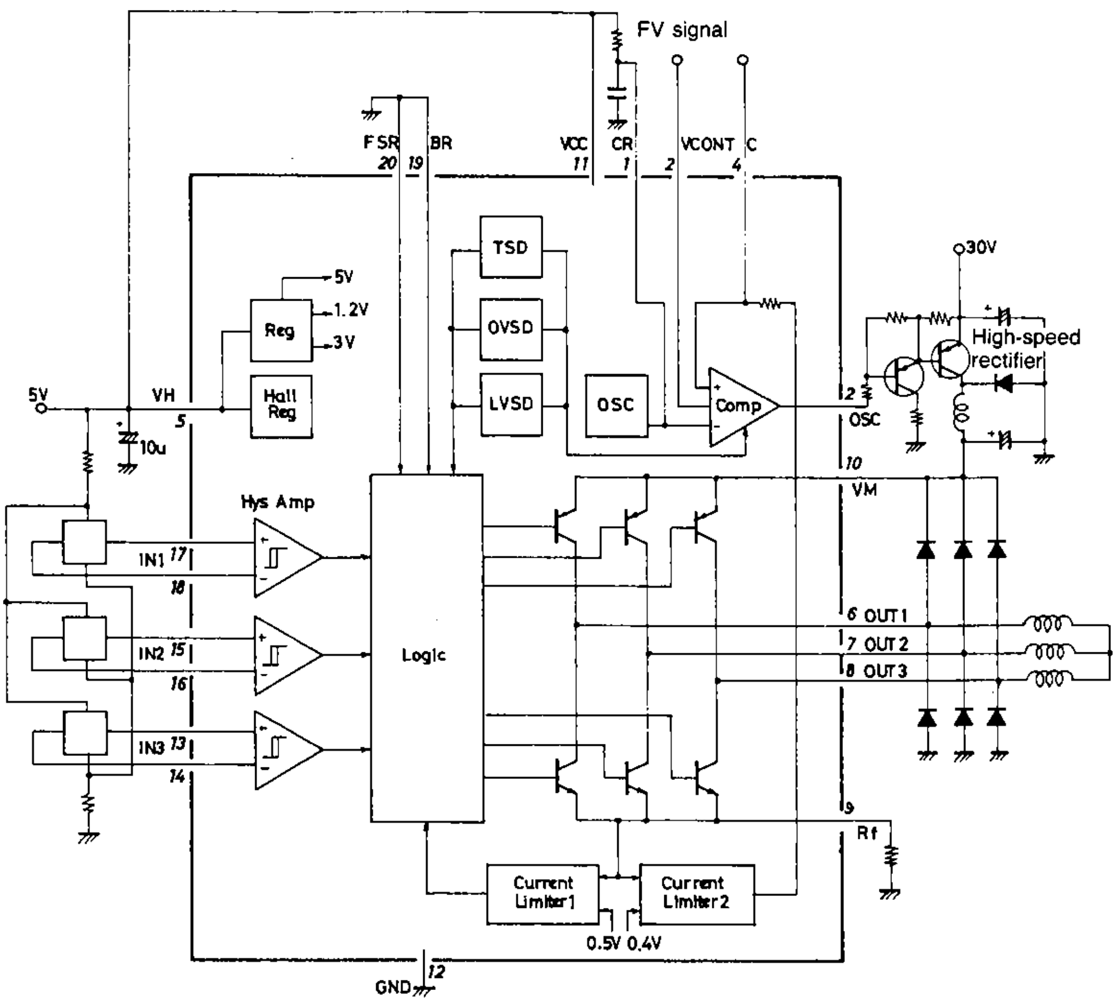
PWM control (1)



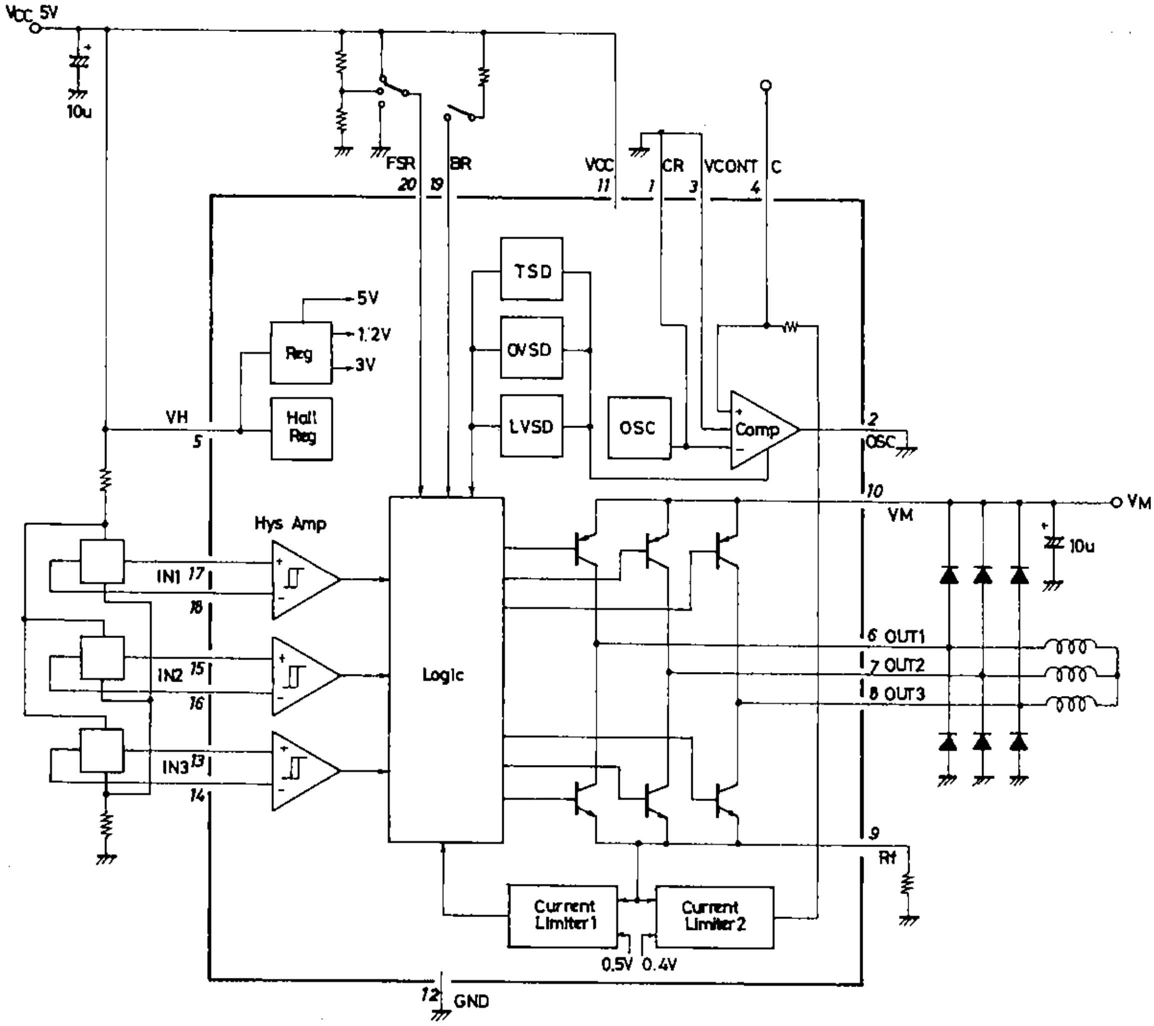
PWM control (2)



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



V_{CC}=5 V
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=7 V typ.)

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

$t_0 \simeq 0.56CR$ (charging)

$t_1 \simeq 1.34CR_N$ (discharging)

(R_N is the internal resistance of 1.4 kΩ approx.)

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

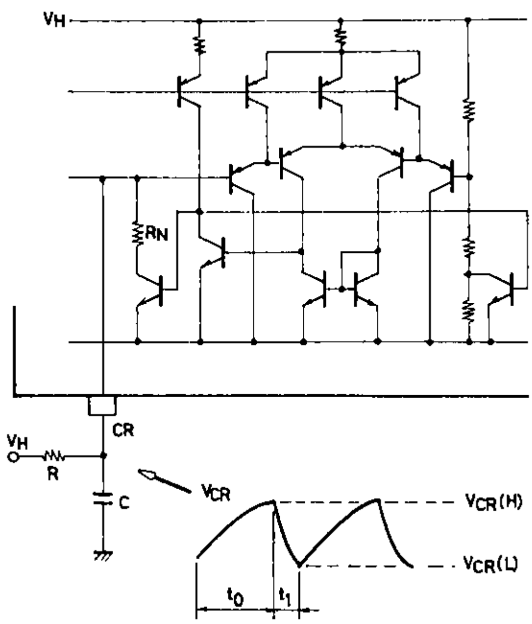


Figure 1 Oscillation Circuit

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_{CONT}	Inputs 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.)

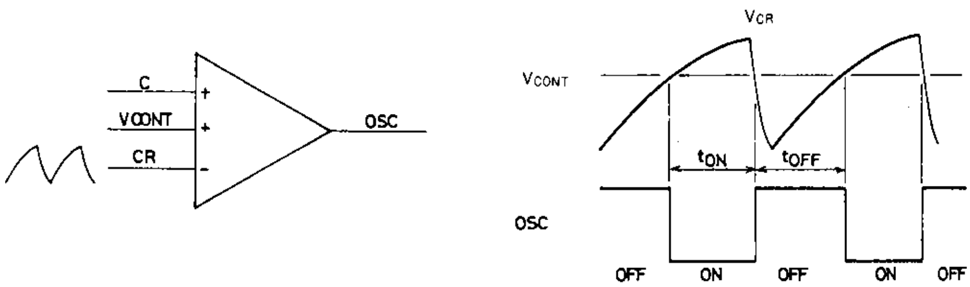


Figure 2 Comparator Circuit

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 $V_H - 1.8$ V). 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 from the internal power supply or an external power supply. When using the internal power supply, the internal logic operates with $V_H = 7$ V typical ($V_{CC} = 24$ V). When using an external power supply, set $V_{CC} = V_H = 5$ 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.

$$I = \frac{V_{RF}1}{R_F} \quad (A)$$

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.

$$I = \frac{V_{RF}2}{R_F}$$

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 (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_{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.

This circuit is to prevent malfunctioning.

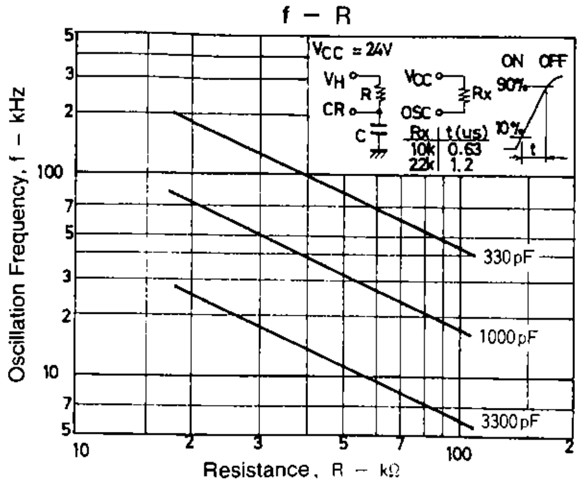
5-3. Thermal shutdown circuit

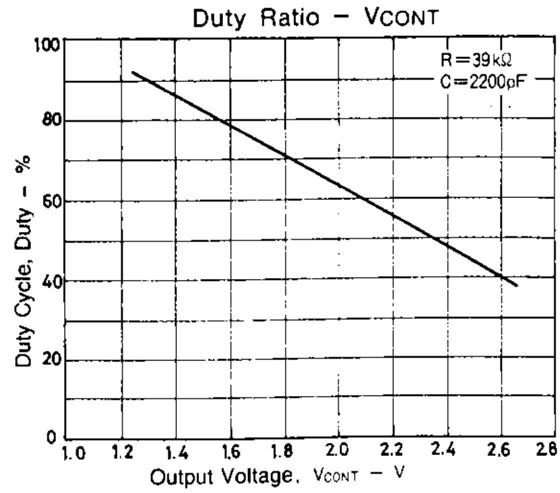
If the junction temperature rises above the regulated temperature, just as in 5-1, PWM output is inhibited and the sink side output driver is switched off.

6. Minimum voltage at V_M power

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

$$V_M \geqq V_H$$


f − R
VCC = 24V
VH
R
CR
C
VCC
Rx
OSC
ON OFF
90%
10%
Rx t(us)
10k 0.63
22k 1.2
330pF
1000pF
3300pF
Oscillation Frequency, f − kHz
Resistance, R − kΩ


Duty Ratio − VCONT
R=39kΩ
C=2200pF
Duty Cycle, Duty − %
Output Voltage, VCONT − V