

**LB1693**

## 3-Phase Brushless Motor Driver

### Overview

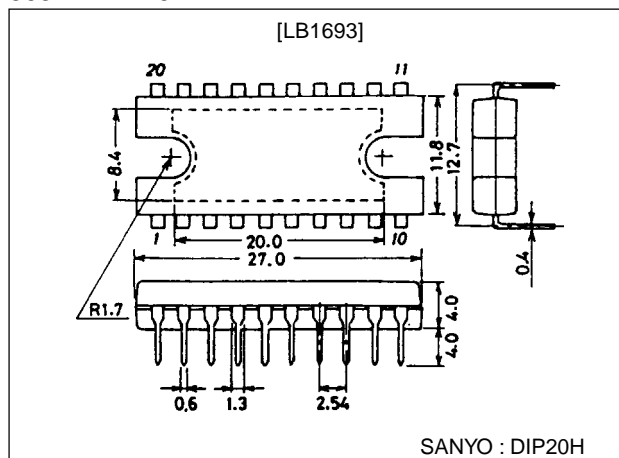
The LB1693 is a driver IC for 3-phase brushless motors. It is ideally suited for office automation equipment and DC fan motors.

### 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.

### Package Dimensions

unit:mm

**3037A-DIP20H**

### Specifications

#### Absolute Maximum Ratings at $T_a = 25^\circ\text{C}$

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

#### Allowable Operating Conditions at $T_a = 25^\circ\text{C}$

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

■ Any and all SANYO products described or contained herein do not have specifications that can handle applications that require extremely high levels of reliability, such as life-support systems, aircraft's control systems, or other applications whose failure can be reasonably expected to result in serious physical and/or material damage. Consult with your SANYO representative nearest you before using any SANYO products described or contained herein in such applications.

■ SANYO assumes no responsibility for equipment failures that result from using products at values that exceed, even momentarily, rated values (such as maximum ratings, operating condition ranges, or other parameters) listed in products specifications of any and all SANYO products described or contained herein.

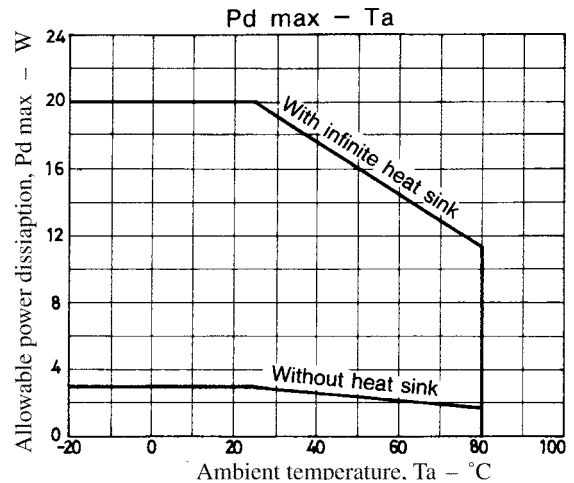
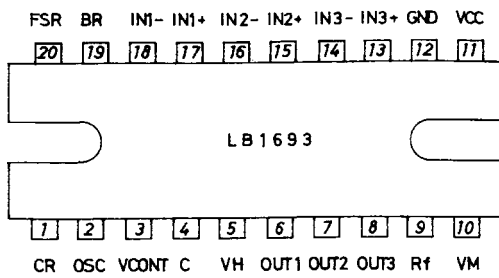
**SANYO Electric Co., Ltd. Semiconductor Business Headquarters**

TOKYO OFFICE Tokyo Bldg., 1-10, 1 Chome, Ueno, Taito-ku, TOKYO, 110-8534 JAPAN

83198HA (KT)/4250TA, TS(GTPS) No.3295-1/9

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

Parameter	Symbol	Conditions	Ratings			Unit
			min	typ	max	
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		140	250	mV
Voltage Regulator temperature coefficient				-2		mV/°C
[Hall amp]						
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
Oscillator						
High-level output voltage				3.45		V
Low-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 <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
Forward/Stop/Reverse						
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
Current limiter						
Limiter1	V <sub>Rf1</sub>		0.42	0.5	0.6	V
Limiter2	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 target	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

[illegible]

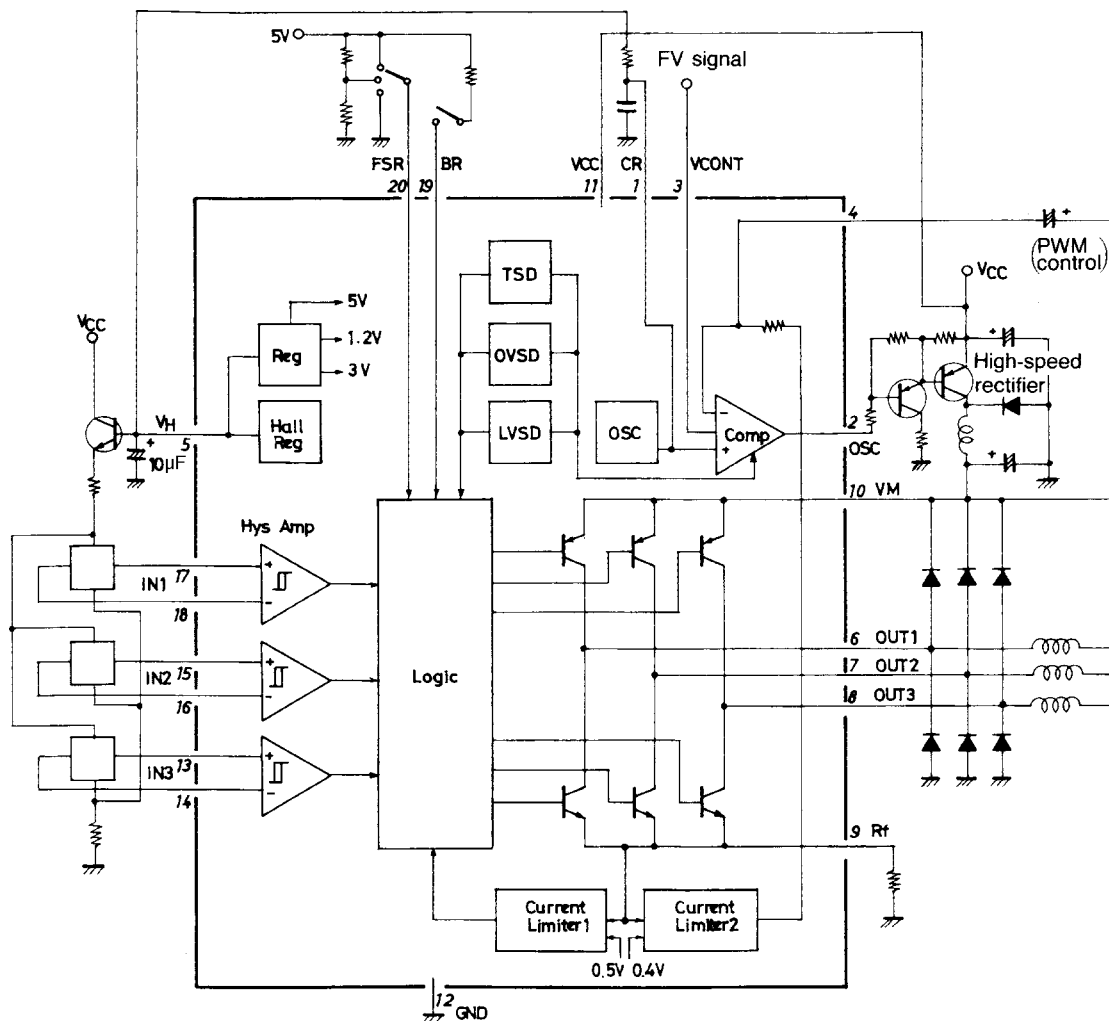
Pin Name	Pin No.	Description
IN1 <sup>+</sup> , IN1 <sup>-</sup>	17, 18	OUT1: Hall element input pins for Phase 1. High logic is the state when IN1 <sup>+</sup> > IN1 <sup>-</sup> .
IN2 <sup>+</sup> , IN2 <sup>-</sup>	15, 16	OUT2: Hall element input pins for Phase 2. High" logic is the state when IN1 <sup>+</sup> > IN1 <sup>-</sup> .
IN3 <sup>+</sup> , IN3 <sup>-</sup>	13, 14	OUT3: Hall element input pins for Phase 3. High logic is the state when IN1 <sup>+</sup> > IN1 <sup>-</sup> .
OUT1	6	Output pin for Phase 1.
OUT2	7	Output pin for Phase 2.
OUT3	8	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	12	Ground for other output The minimum potential of output transistor is at the R <sub>f</sub> pin.
B <sub>R</sub>	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 <sub>H</sub>	5	Power pin for Hall elements When using the internal (stabilized) power supply : V <sub>H</sub> =7V typ. When using the external (stabilized) power supply : V <sub>H</sub> =5V typ.
CR	1	Sets the oscillation frequency for the switching regulator/
OSC	2	Outputs duty-controlled pulsed ; open collector output.
V <sub>CONT</sub>	3	Speed control pin ; varies the swithcing regulator output vottage.
C	4	Suppresses ripples in the motor current during operation of current limiter 2.

Truth Table

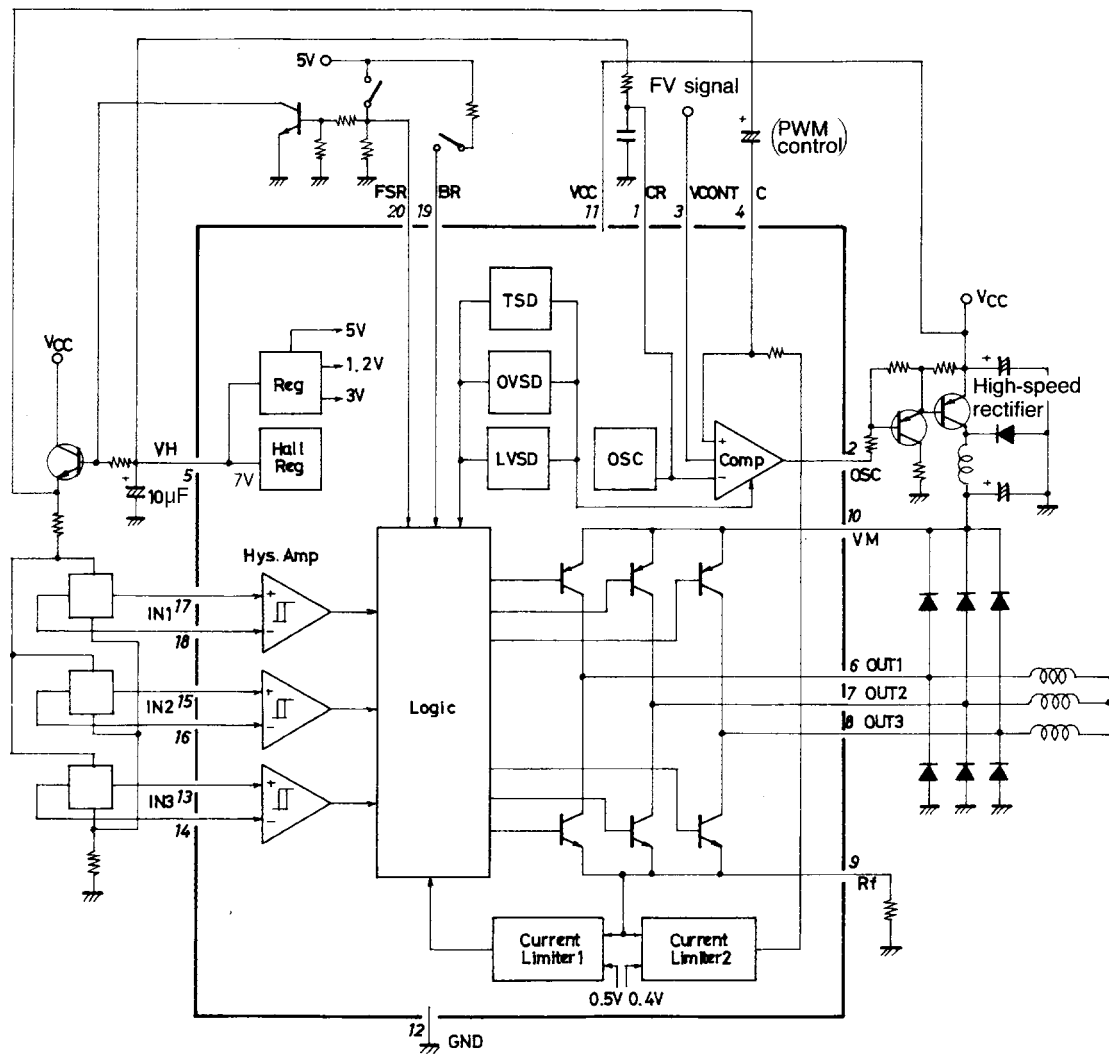
Item	Source Sink	Input			Forward/Reverse Control
		IN1	IN2	IN3	
1	OUT3 → OUT2	H	H	L	L
	OUT2 → OUT3				H
2	OUT3 → OUT1	H	L	L	L
	OUT1 → OUT3				H
3	OUT2 → OUT3	L	L	H	L
	OUT3 → OUT2				H
4	OUT1 → OUT2	L	H	L	L
	OUT2 → OUT1				H
5	OUT2 → OUT1	H	L	H	L
	OUT1 → OUT2				H
6	OUT1 → OUT3	L	H	H	L
	OUT3 → OUT1		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

# Block Diagram and Peripheral Circuit Diagram

PWM control (1)

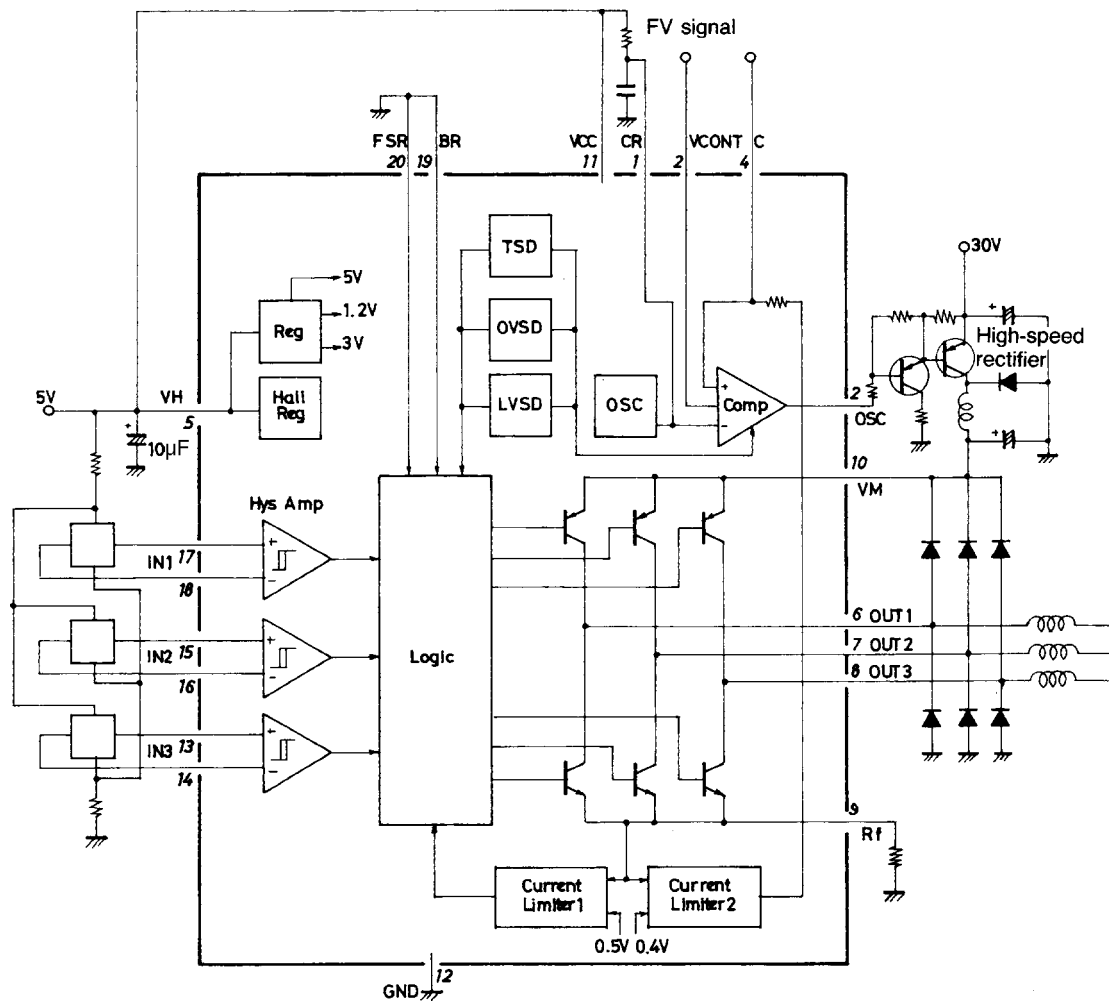


PWM control (2)

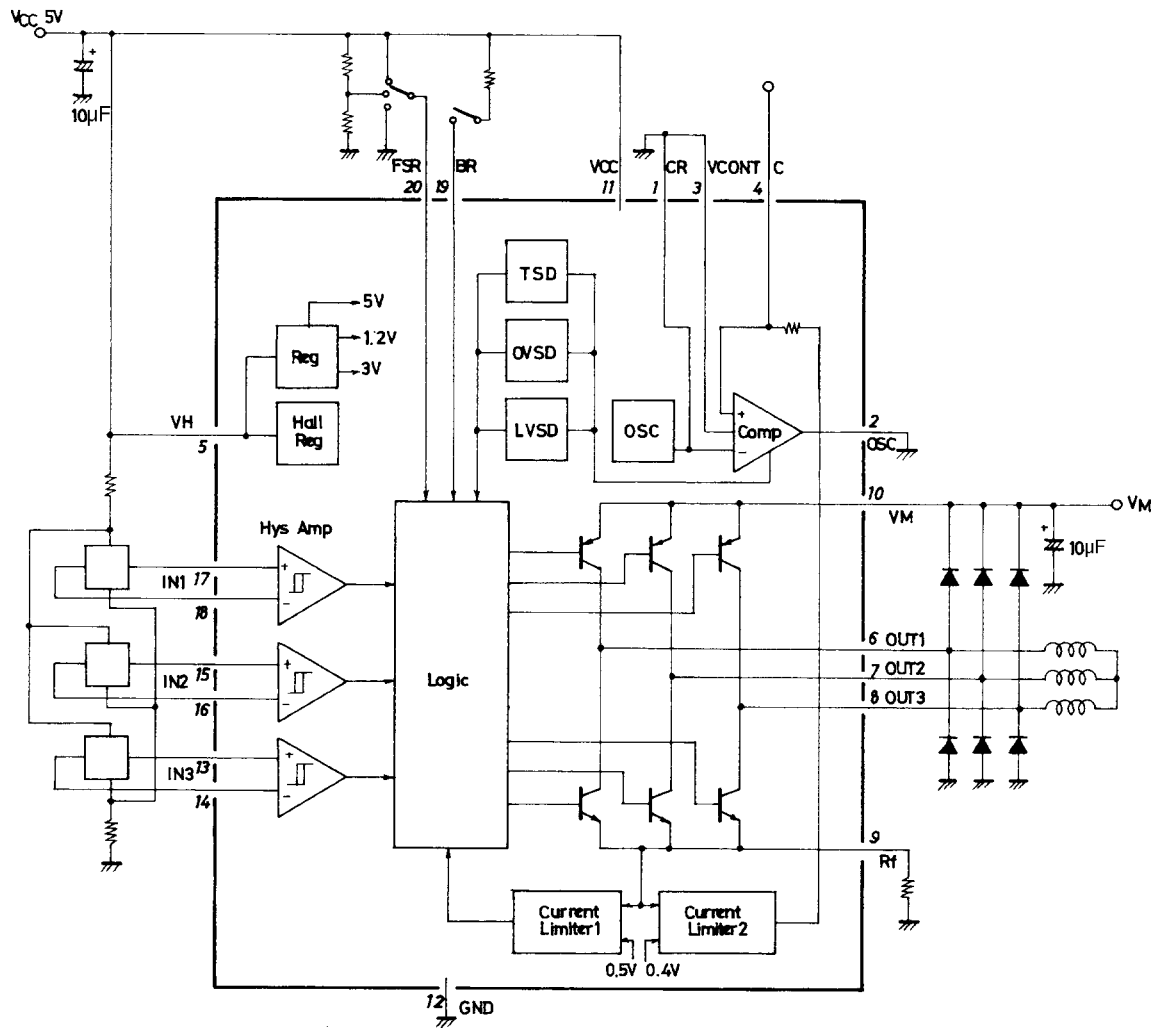


# LB1693

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



$V_{CC}=5V$ ,  $V_M$  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 1.4kΩ approx.)

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

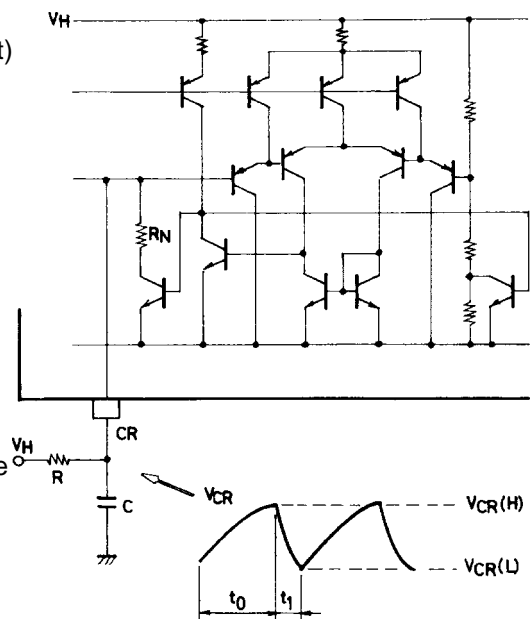


Figure 1 Oscillation Circuit

## 1-2. Comparator circuit

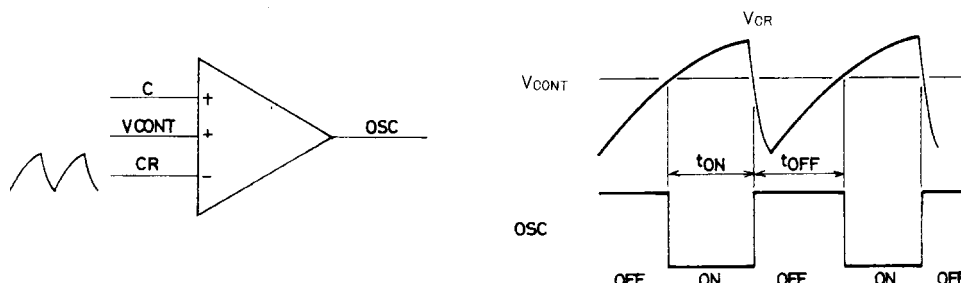
Figure 2 shows the comparator circuit for comparing the triangular wave output, the speed control signal, etc.

input terminals

CR Input the triangular wave output.

V<sub>CONT</sub> 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

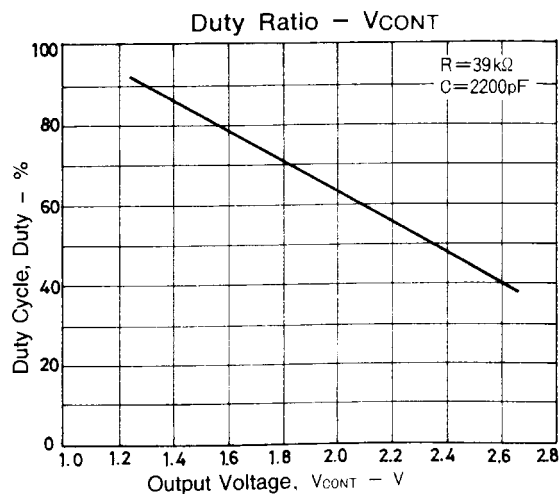
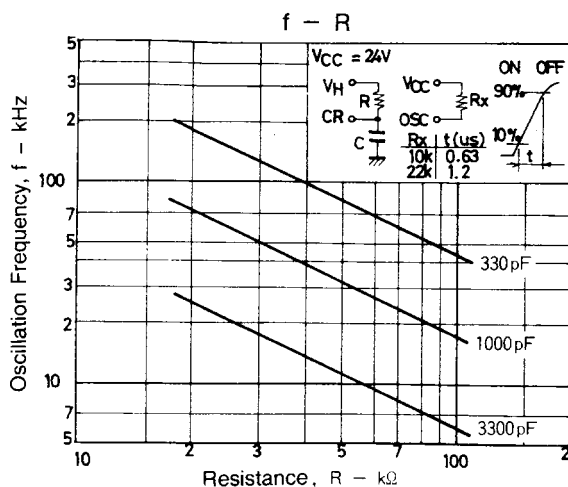
If the junction temperature rises above the regulated temperature, just as in 5-1, PMW output is inhibited and the sink output driver is switched off.



6. Minimum voltage at  $V_M$  power

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

$$V_M \geq V_H$$



- Specifications of any and all SANYO products described or contained herein stipulate the performance, characteristics, and functions of the described products in the independent state, and are not guarantees of the performance, characteristics, and functions of the described products as mounted in the customer's products or equipment. To verify symptoms and states that cannot be evaluated in an independent device, the customer should always evaluate and test devices mounted in the customer's products or equipment.
- SANYO Electric Co., Ltd. strives to supply high-quality high-reliability products. However, any and all semiconductor products fail with some probability. It is possible that these probabilistic failures could give rise to accidents or events that could endanger human lives, that could give rise to smoke or fire, or that could cause damage to other property. When designing equipment, adopt safety measures so that these kinds of accidents or events cannot occur. Such measures include but are not limited to protective circuits and error prevention circuits for safe design, redundant design, and structural design.
- In the event that any and all SANYO products described or contained herein fall under strategic products (including services) controlled under the Foreign Exchange and Foreign Trade Control Law of Japan, such products must not be exported without obtaining export license from the Ministry of International Trade and Industry in accordance with the above law.
- No part of this publication may be reproduced or transmitted in any form or by any means, electronic or mechanical, including photocopying and recording, or any information storage or retrieval system, or otherwise, without the prior written permission of SANYO Electric Co., Ltd.
- Any and all information described or contained herein are subject to change without notice due to product/technology improvement, etc. When designing equipment, refer to the "Delivery Specification" for the SANYO product that you intend to use.
- 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.

This catalog provides information as of August, 1998. Specifications and information herein are subject to change without notice.