SONY

CXA3537EN/TN

Fan Motor Driver

Description

The CXA3537EN/TN is a single-phase full wave drive type motor driver IC designed for the fan motors of laptop computers.

Power saving drive is achieved with a newly developed Drive Duty Control (DDC) system.

This DDC system also makes it possible to easily change the motor rotational speed without changing the motor components.

Features

- Supports single-phase full wave drive type fan motors
- High efficiency driving with the DDC system
- Four kinds of drive duty can be selected by changing the IC taps
- Low output stage saturation voltage
- Current slope control when cutting off the drive current
- Wide operating voltage range
- FG output
- Thermal protection circuit
- Small package

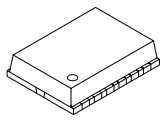
Applications

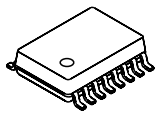
Laptop PC fan motors

Structure

Bipolar silicon monolithic IC

12 pin VSON (Plastic) 16 pin TSSOP (Plastic)





Absolute Maximum Ratings (Ta = 25°C)

• Supply voltage	Vcc	14	V
• Motor drive voltage*1	Vs	14	V
• Output current	I_O	300	mA
• FG output current	I_O (FG)	4	mA
• Allowable power dissipation	P_D	260	mW
• Operating temperature	Topr	–20 to +85	°C
• Storage temperature	Tstg	–65 to +150	°C

*1 CXA3537TN only. The VS pin voltage should not exceed the V_{CC} pin voltage.

Recommended Operating Conditions (Ta = 25°C)

• Supply voltage	Vcc	3.0 to 13.2 (5.0V Typ.)	V
• Motor drive voltage*1	Vs	0 to Vcc	V
• Hole voltage in-phase input range	V_{IH}	0.5 to Vcc – 1.3	V
• Hole input minimum signal voltage		10 to	mVp-p
• CEXT capacitor capacitance	Cext	0.01 to 0.022	µF
• CHLD capacitor capacitance	Chld	0.01 to 0.047	µF
• REXT resistance value	Rext	8 to 100	kΩ

*1 CXA3537TN only.

E00207C24-PS

Block Diagram

CXA3537EN

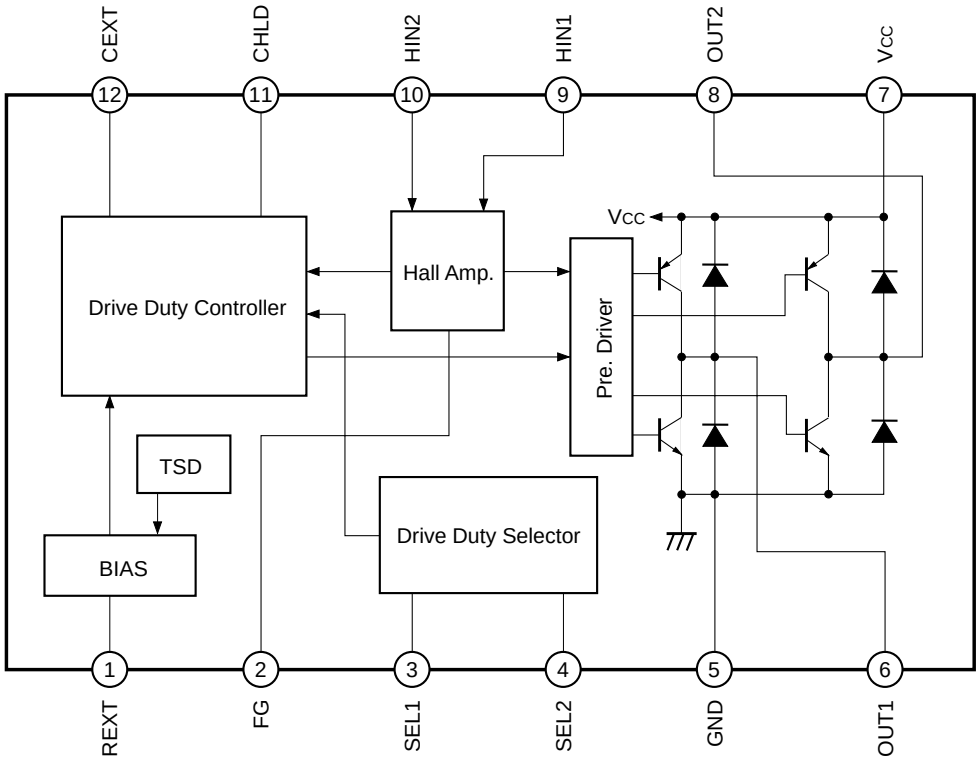


Fig. 1

CXA3537TN

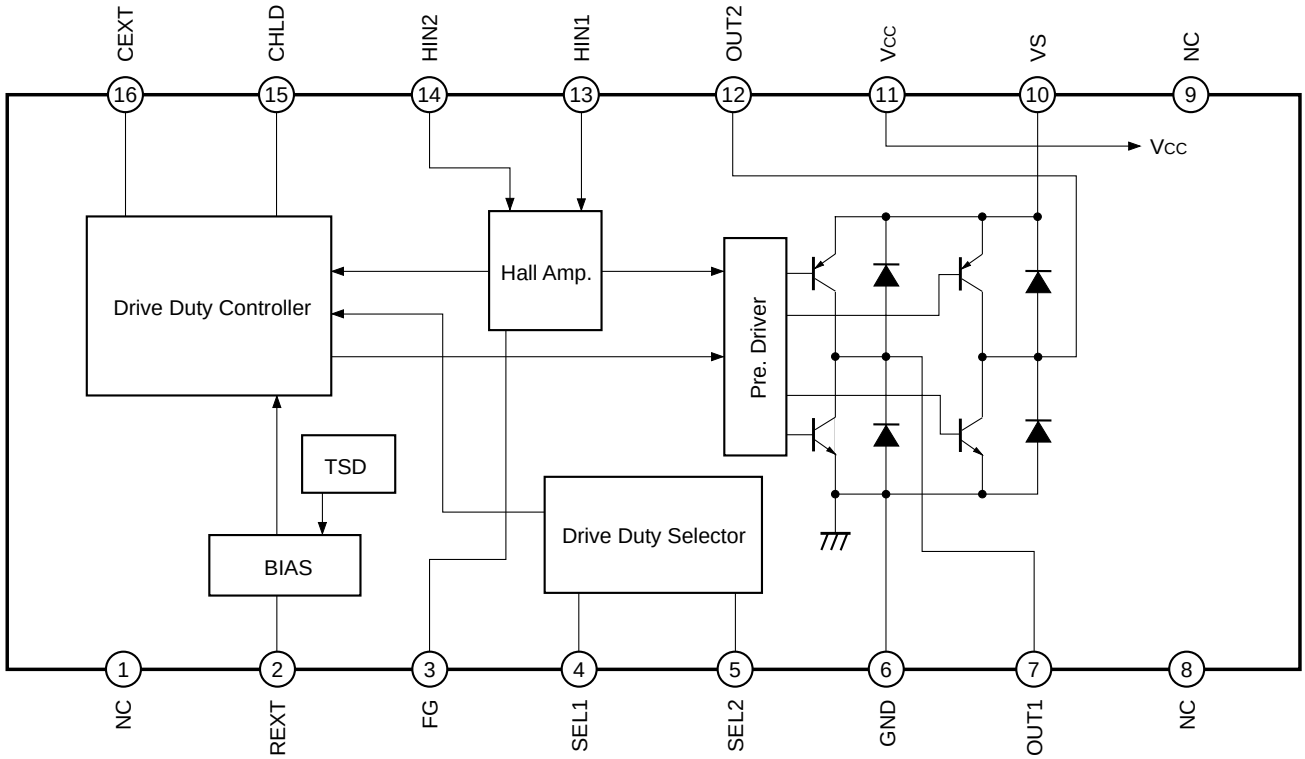


Fig. 2

Electrical Characteristics (Ta = 25°C, V_{CC} = 5V, Vs = 5V*1)

Item	Symbol	Min.	Typ.	Max.	Unit	Conditions and remarks
Supply current	I_{CC}		1.6	2.1	mA	*2
Output voltage H	V_{OH}	V_{CC} – 0.4	V_{CC} – 0.2		V	I_O = 120mA
Output voltage L	V_{OL}		0.2	0.4	V	I_O = –120mA
Hole input dead voltage			2	5	mV	Zero peak value
Initial no-drive time	T1	25	32	39	%	*3
Drive time (1)	T2 (1)	21	28	36	%	SEL1 = L, SEL2 = L*3
Drive time (2)	T2 (2)	31	38	46	%	SEL1 = H, SEL2 = L*3
Drive time (3)	T2 (3)	41	48	56	%	SEL1 = L, SEL2 = H*3
Drive time (4)	T2 (4)	51	58	66	%	SEL1 = H, SEL2 = H*3
Forced drive speed	F3	60	65	75	%	*4
FG voltage L			0.2	0.4	V	I_O (FG) = –2mA
FG leak current				30	µA	Apply 5V during FG off
Thermal protection	TSD	140	170		°C	Design target value (reference value)

*1 The VS pin is only on the CXA3537TN. VS and V_{CC} are connected internally for the CXA3537EN.

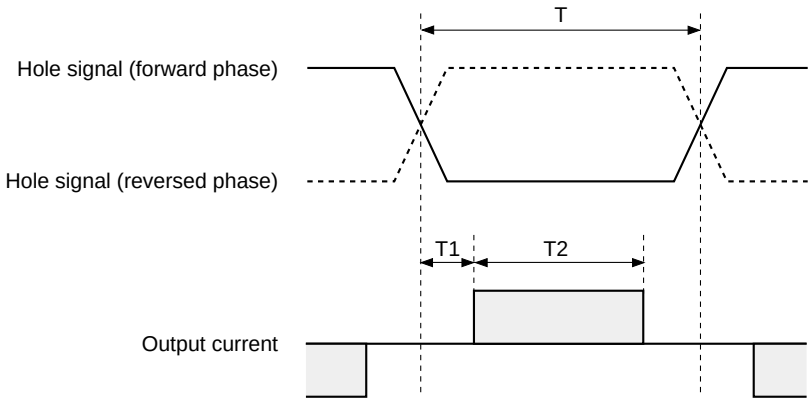
*2 Circuit current not including the output stage. The CEXT pin is connected to GND.

*3 Time ratio with the half period of 1ms when R1 (REXT) = 15kΩ and C1 (CEXT) = C2 (CHLD) = 0.01µF, during 40mVp-p 500Hz rectangular wave signal input. R1, C1 and C2 are the same values even for the F3 measurement (*4).

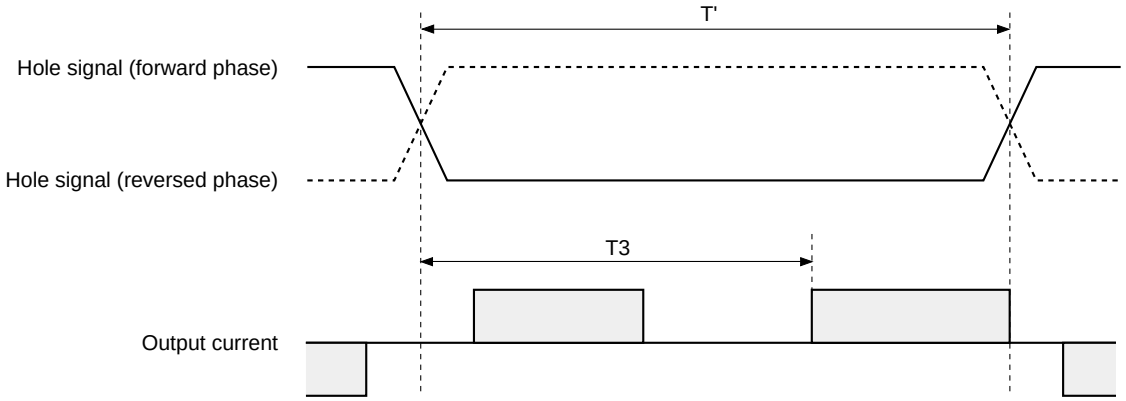
*4 Speed ratio with the setting rated half period of 1 ms during 40mVp-p 1.75ms half period rectangular wave signal input.

Operating Waveforms

(1) Operating waveform at the rated speed



(2) Operating waveform at low speed



T: Specified rated rotational speed time (This is used as 100 [%].)
T': Hole polarity inversion time at low speed
T1: Initial drive wait time [%]
T2: Drive duty [%]
T3: Forced drive mode transition time
F3: Forced drive mode transition speed = T/T3 × 100 [%]

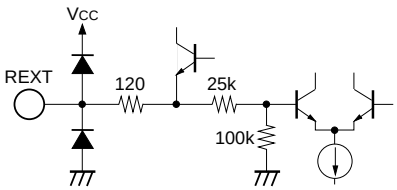
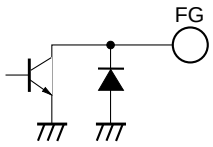
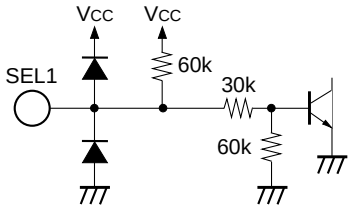
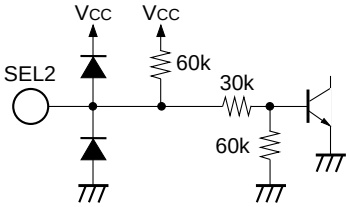
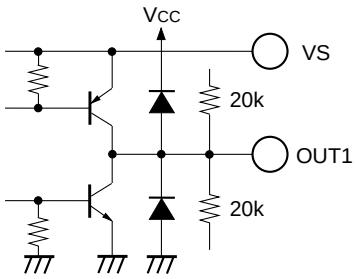
Fig. 3

Truth Table

Mode	HIN1	HIN2	OUT1	OUT2	FG
When rotating (during drive)	L	H	H	L	off
	H	L	L	H	L
When rotating (during no-drive)	L	H	off	off	off
	H	L	off	off	L
During thermal protection	*1	*1	off	off	off

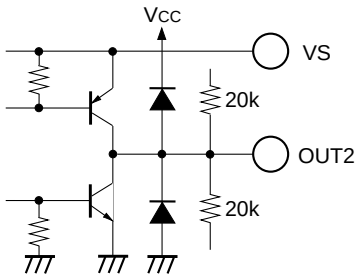
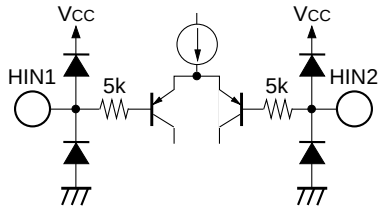
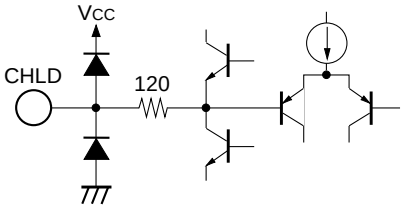
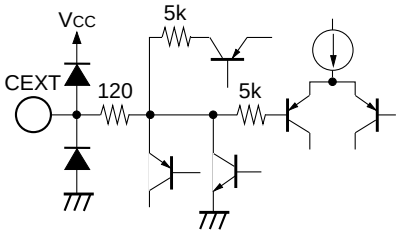
*1 Does not depend on the hole output conditions.

Pin Description (Ta = 25°C, Vcc = 5V)

Pin No.	Symbol	Pin voltage (typ.)	Equivalent circuit	Description
1, 8, 9	NC	***		No connected. These pins are only on the CXA3537TN.
2 (1)	REXT	1.56V		Sets the charging current to the capacitor connected to the CEXT pin. Connect to GND via a resistor. Set the resistor value according to the motor rated rotational speed.
3 (2)	FG	***		FG signal output. This pin forms an open collector.
4 (3)	SEL1	2.1V		Input for selecting the drive duty. The duty is selected by switching this pin between open or connected to GND. This pin has a built-in pull-up resistor.
5 (4)	SEL2	2.1V		Input for selecting the drive duty. The duty is selected by switching this pin between open or connected to GND. This pin has a built-in pull-up resistor.
6 (5)	GND	0V		GND.
7 (6)	OUT1	***		Output. (For the CXA3537EN, the VS pin in the figure to the left is connected internally to the Vcc pin.)

The numbers in the Pin No. column indicate the CXA3537TN pin numbers. The numbers in parentheses are the CXA3537EN pin numbers.

"***" in the Pin voltage column indicates undetermined values.

Pin No.	Symbol	Pin voltage (typ.)	Equivalent circuit	Description
10	VS	≤ Vcc	(See Pins 7 and 12.)	IC output stage drive block power supply. This pin is only on the CXA3537TN.
11 (7)	Vcc	5V		Power supply.
12 (8)	OUT2	***		Output. (For the CXA3537EN, the VS pin in the figure to the left is connected internally to the Vcc pin.)
13 (9)	HIN1	***		Hole element signal input.
14 (10)	HIN2	***		Hole element signal input.
15 (11)	CHLD	1.7V		Holds the motor rotational speed signal. Connect to GND via a capacitor.
16 (12)	CEXT	1.4V		Controls the motor drive time. Connect to GND via a capacitor.

The numbers in the Pin No. column indicate the CXA3537TN pin numbers. The numbers in parentheses are the CXA3537EN pin numbers.

"***" in the Pin voltage column indicates undetermined values.

Description of Operation

(1) Drive operating mode

The CXA3537EN/TN performs DDC mode operation near the rated rotational speed area set by the external constant, and operates in forced drive mode which forcibly applies the drive current during startup or when rotating at low speed.
The IC automatically switches between these two modes.

(2) DDC mode (Drive Duty Control mode)

The Drive Duty Control (DDC) system achieves high driving efficiency by applying the drive current centering on rotational angles which have a high drive torque generation efficiency relative to the drive current, and cutting the drive current at rotational angles which have a low drive torque generation efficiency.

Fig. 4 shows the full wave drive operating waveforms for a general single-phase motor.

(a) shows the hole element output signal.
One cycle of this waveform represents an electrical angle of 360°, and the electrical angle is determined as shown in Fig. 4.
(b) is the drive current applied to the motor coil.
This waveform assumes that an even current flows each time the hole polarity changes.
(Here, the effects of counter electromotive force on the coil are omitted to simplify the description.)
(c) represents the drive torque generated by the drive current.
The drive torque generally forms a curve with peak values around the electrical angles of 90° and 270°, and bottom values around 0° and 180°.

In other words, this shows that even when the same amount of current is applied, there are rotational angle ranges where large drive torque can be obtained, and rotational angle ranges where only small drive torque can be obtained.

Fig. 5 shows the DDC system operating waveforms.

(a) is the hole element output signal.
(b) is the drive current. The drive current is applied centering on rotational angles which have a high drive torque generation efficiency, and cut at angles of rotation which have a low drive torque generation efficiency.
(c) is the drive torque generated by the drive current.

The power saving performance of the DDC system is examined below.
The drive torque generated by a constant drive current is assumed to form a sine wave relative to the rotational angle.
If the drive duty is 50%, the input power is also 50% compared to the general single-phase full wave drive system.
However, the average drive torque relative to the rotational angle is approximately 70% of that for the general single-phase full wave drive system.

$$\int_{45°}^{135°} \sin\theta \, d\theta \;/\; \int_{0°}^{180°} \sin\theta \, d\theta \approx 0.7$$

In other words, even though the power consumption drops by 50%, the average drive torque only drops by approximately 30%. This difference creates the power saving performance of the DDC system.

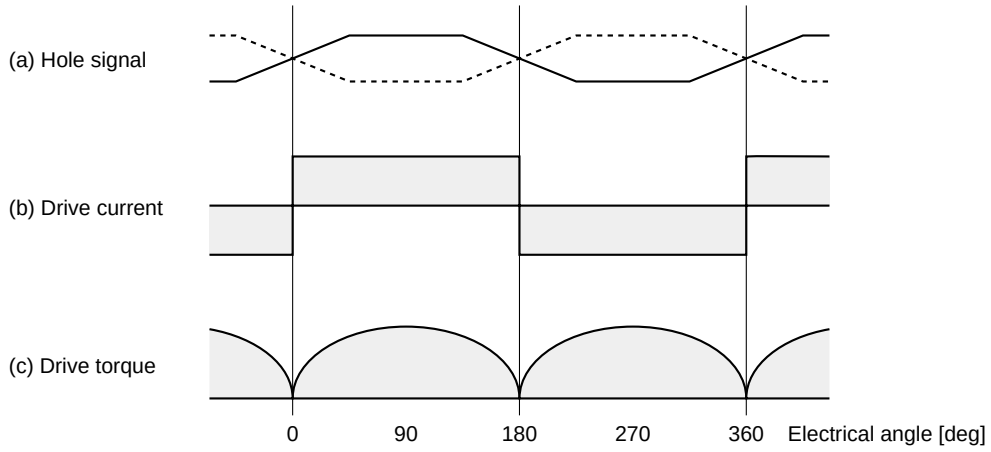


Fig. 4. Operating Waveforms of a General Single-phase Full Wave Drive Type Driver

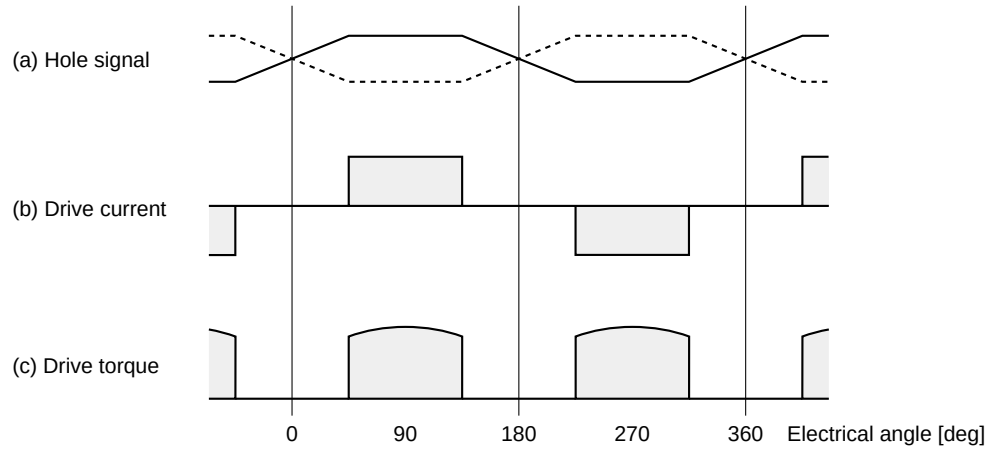


Fig. 5. Operating Waveforms of a DDC System Single-phase Full Wave Drive Type Driver

(3) Forced drive mode

This drive mode is used when starting up the motor or in the low speed transient status.

The operating waveforms during startup are the same as Fig. 4.

Notes on Specifications

(1) Determining the external constants

1. Procedure for determining the external constants
   The procedure for determining the CXA3537EN/TN peripheral constant values and the drive duty selector pins SEL1 and SEL2 connection conditions is as follows.
   1) Determine CHLD from the table below based on the number of motor poles and the target rated rotational speed.
   2) Determine CEXT and REXT from Fig. 6.
   3) Drive the motor and determine the SEL1 and SEL2 connection conditions.

   See the Application Circuit for the connection and wiring methods of each constant.

2. Selecting CHLD
   Obtain the CHLD value from the following table based on the number of motor poles and the target rated rotational speed.

   Recommended CHLD pin external capacitor value by number of fan motor poles according to the rated rotational speed

Recommended CHLD value	4-pole motor	6-pole motor	8-pole motor
0.01µF	7500 [rpm] or more	5000 [rpm] or more	3750 [rpm] or more
0.022µF	3400 [rpm] or more	2250 [rpm] or more	1700 [rpm] or more
0.033µF	2250 [rpm] or more	1500 [rpm] or more	1100 [rpm] or more
0.047µF	1600 [rpm] or more	1000 [rpm] or more	800 [rpm] or more

   The capacitance value of the CHLD pin external capacitor is determined according to the number of poles and rated rotational speed of the fan motor. The table above gives the recommended values. Select a CHLD capacitance value that is the recommended value or one level larger than the recommended value.

3. Selecting CEXT and REXT
   Determine CEXT and REXT from Fig. 6 based on the number of motor poles and the target rated rotational speed.
   When the number of motor poles is 6 or 8 poles, convert the rotational speed to 1.5 times or 2 times the actual motor rotational speed, respectively.

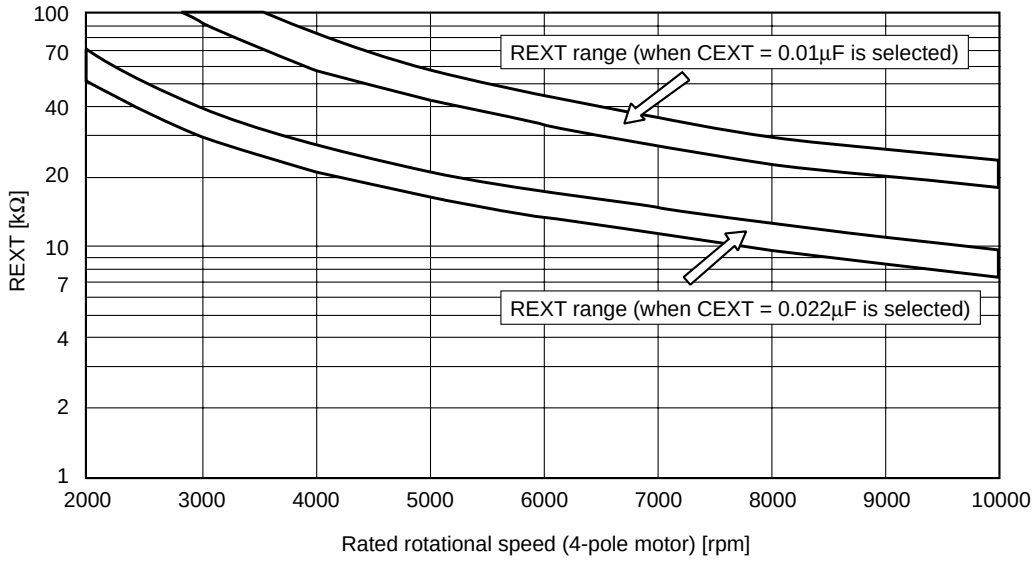


Fig. 6. REXT Pin External Resistance Value According to the Motor Rated Rotational Speed

4. SEL1 and SEL2 connection conditions
   Finally, obtain the tap conditions for selecting the drive duty based on actual operation.
   Set the three external constants, then connect and drive the motor.
   Switch the two taps (SEL1 and SEL2 pins) between open and connected to GND to select the tap conditions that most closely achieve the target rated rotational speed.

(2) External control of the SEL1 and SEL2 pins (taps)

The SEL1 and SEL2 pins have built-in pull-up resistors that are connected to the V_{CC} pin.
When controlling SEL1 and SEL2 from external equipment, care should be taken for the pin current that flows from the CXA3537EN/TN SEL1 and SEL2 pins to the external equipment.
Both the SEL1 and SEL2 pins are low at a voltage of 0.4V or less.

(3) DDC system motor rotational speed

For drive circuits with the same output stage loss characteristics, the average drive torque obtained by the DDC system is less than the torque obtained by the general full interval drive system, so the motor rotational speed also drops. The degree to which the speed drops depends on the motor characteristics. For compact fan motors this drop in rotational speed is from several percent up to approximately 10%.
However, the CXA3537EN/TN has a low output saturation voltage, so the output stage loss is also small, which works to suppress the drop in motor rotational speed due to the DDC system.

(4) Hole element signal level conditions

The input voltage signal from the hole element must be differential with a voltage amplitude of 10mVp-p or more.
In addition, the signal must also be within the hole voltage in-phase input range. If the hole input voltage signal is outside the hole voltage in-phase input range, take measures such as connecting a resistor in series to the hole element power supply line or GND line to bring the hole signal within the range.

(5) Power supply pin capacitor

Adding a capacitor near the IC power supply pin is recommended.
When a capacitor cannot be added near the power supply pin, particular care should be taken for the following points.

- There should not be surges which exceed the IC ratings.
- Anti-noise performance should be sufficient.
- There should be sufficient electrical characteristics margin on the side supplying power to the fan motor.

(6) Using the VS pin (CXA3537TN only)

When using the VS pin electrically separated from the V_{CC} pin, take care that the VS pin voltage does not exceed the V_{CC} pin voltage.

(7) Current slope control when cutting off the output current

The CXA3537EN/TN has a function for gradually turning off the drive current when cutting off the drive current.
When the load is a resistor, the transition time when cutting off the drive current is fixed at 6µs (typ.). This is in order to reduce the ringing noise produced around the load when cutting off the drive current. However, this slope is not gradual enough to sufficiently suppress the surge current generated when cutting off the drive current to the load.
Surge countermeasures should be taken as necessary.

(8) FG output

The FG output forms an open collector. If the voltage applied to the FG pin is within the IC rated voltage, it can exceed the Vcc pin voltage. The FG output outputs a frequency pulse that is proportional to the motor rotational speed as shown in the Truth Table.

(9) Thermal shutdown

The CXA3537EN/TN has a built-in thermal shutdown circuit. When the IC chip temperature exceeds 170°C (typ.), the output drive current is turned off. Then, the IC functions recover automatically when the IC chip temperature falls to 140°C (typ.).

(10) Thermal loss reduction ratio

The IC allowable power dissipation changes according to the IC ambient temperature.

The IC power dissipation also changes according to the load conditions, supply voltage conditions and other factors, so check to make sure the allowable power dissipation ratio is satisfied in the actual operating condition.

Allowable power consumption vs. Ambient temperature

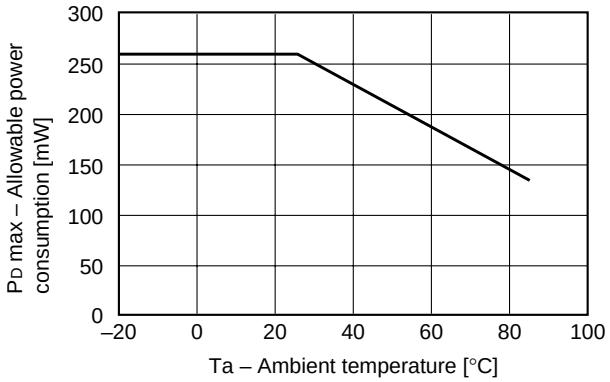
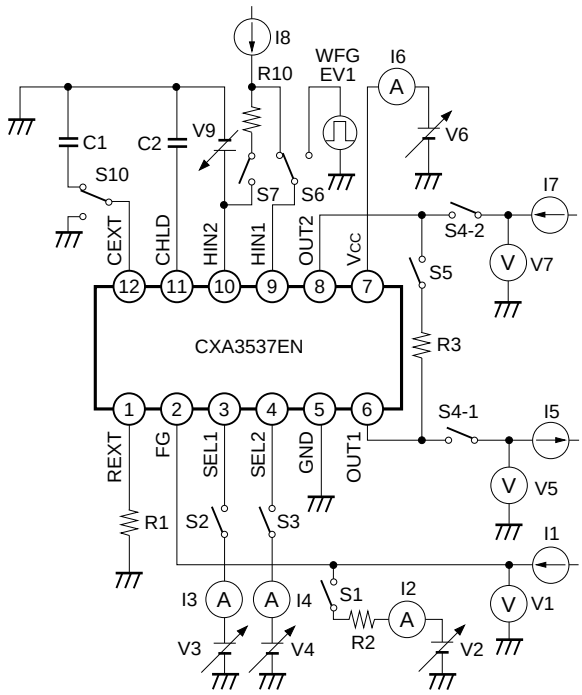


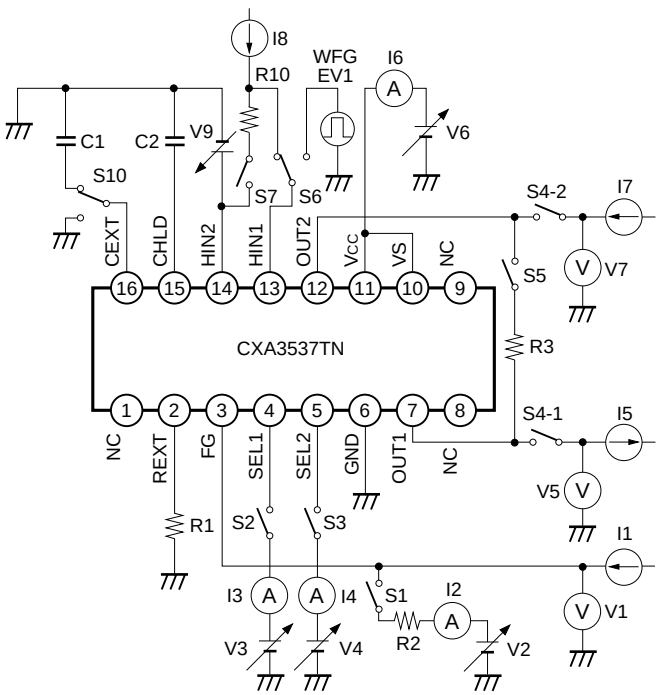
Fig. 7. Thermal Loss Reduction Ratio

Measurement Circuit

CXA3537EN

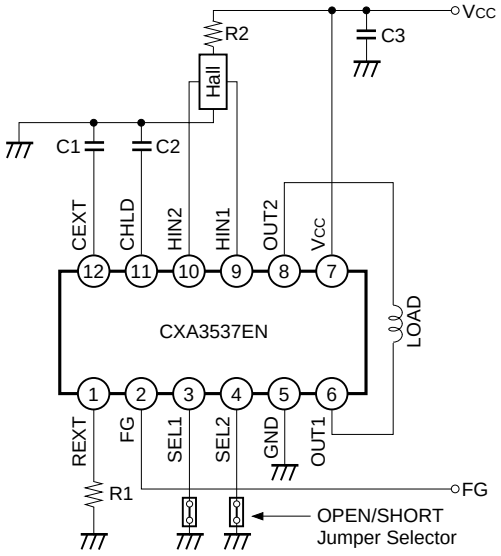


CXA3537TN



Application Circuit

CXA3537EN



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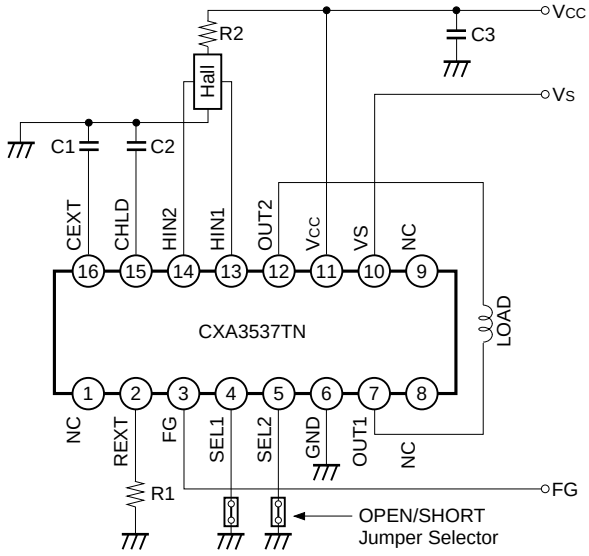
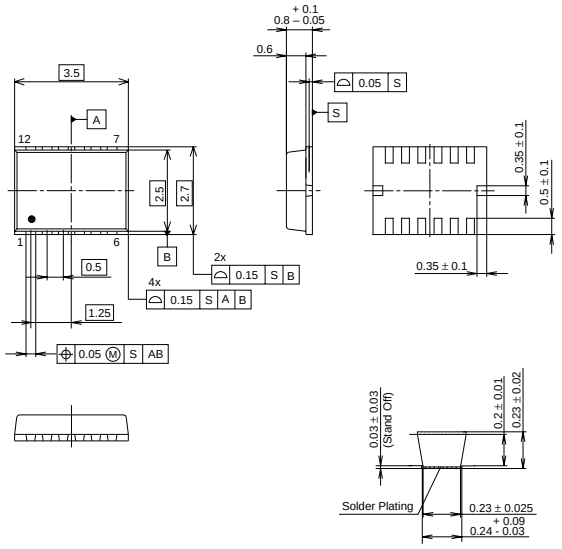


Application circuits shown are typical examples illustrating the operation of the devices. Sony cannot assume responsibility for any problems arising out of the use of these circuits or for any infringement of third party patent and other right due to same.

Package Outline Unit: mm

CXA3537EN

12PIN VSON(PLASTIC)



TERMINAL SECTION

NOTE: 1) The dimensions of the terminal section apply to the ranges of 0.1mm and 0.25mm from the end of a terminal.

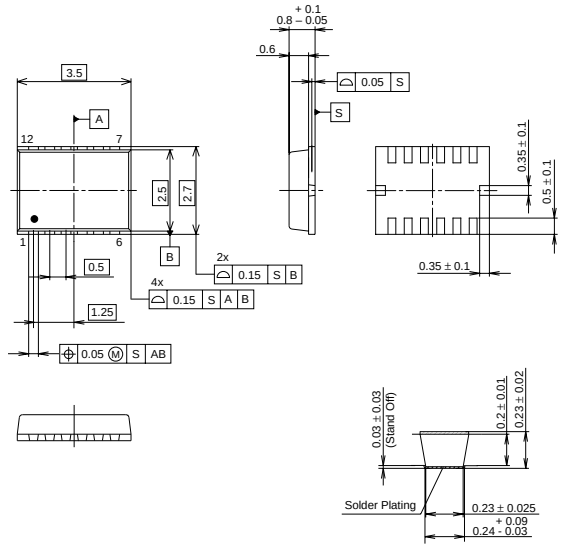
PACKAGE STRUCTURE

PACKAGE MATERIAL	EPOXY RESIN
TERMINAL TREATMENT	SOLDER PLATING
TERMINAL MATERIAL	COPPER ALLOY
PACKAGE MASS	0.02g

SONY CODE	VSON-12P-01
EIAJ CODE	————
JEDEC CODE	————

Kokubu & SCT Ass'y

12PIN VSON(PLASTIC)



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NOTE: 1) The dimensions of the terminal section apply to the ranges of 0.1mm and 0.25mm from the end of a terminal.

PACKAGE STRUCTURE

PACKAGE MATERIAL	EPOXY RESIN
TERMINAL TREATMENT	SOLDER PLATING
TERMINAL MATERIAL	COPPER ALLOY
PACKAGE MASS	0.02g

SONY CODE	VSON-12P-01
EIAJ CODE	————
JEDEC CODE	————

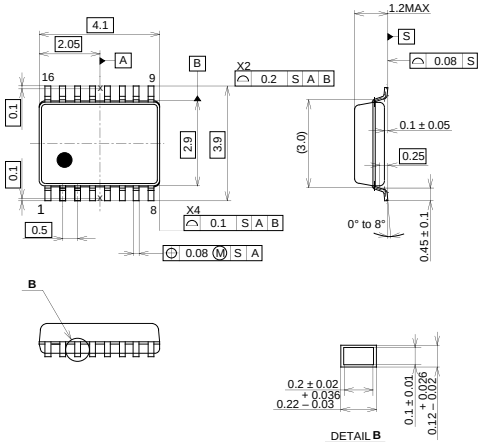
LEAD PLATING SPECIFICATIONS

ITEM	SPEC.
LEAD MATERIAL	COPPER ALLOY
SOLDER COMPOSITION	Sn-Bi Bi:1-4wt%
PLATING THICKNESS	5-18μm

Package Outline Unit: mm

CXA3537TN

16PIN TSSOP(PLASTIC)



SONY CODE	TSSOP-16P-L01
EIAJ CODE	————————
JEDEC CODE	————————

PACKAGE STRUCTURE

PACKAGE MATERIAL	EPOXY RESIN
LEAD TREATMENT	SOLDER PLATING
LEAD MATERIAL	COPPER ALLOY
PACKAGE MASS	0.03g