

# AN8245K, AN8245SCR

## Laser Disk Spindle Motor Controller

### Overview

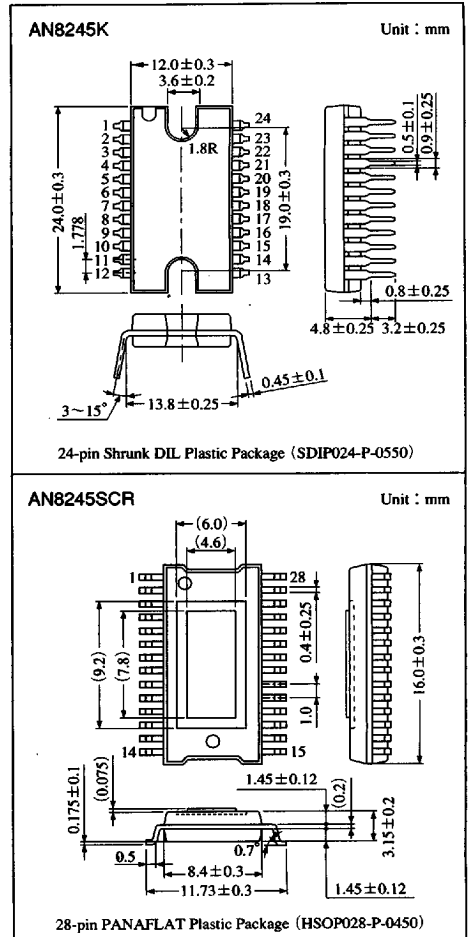
The AN8245K and AN8245SCR are speed control drive ICs of the brushless motors by means of the 3-phase full-wave current drive system. They are suitable for controlling/driving the laser disk spindle motors, LBP polygon mirror motors, and so on.

### Features

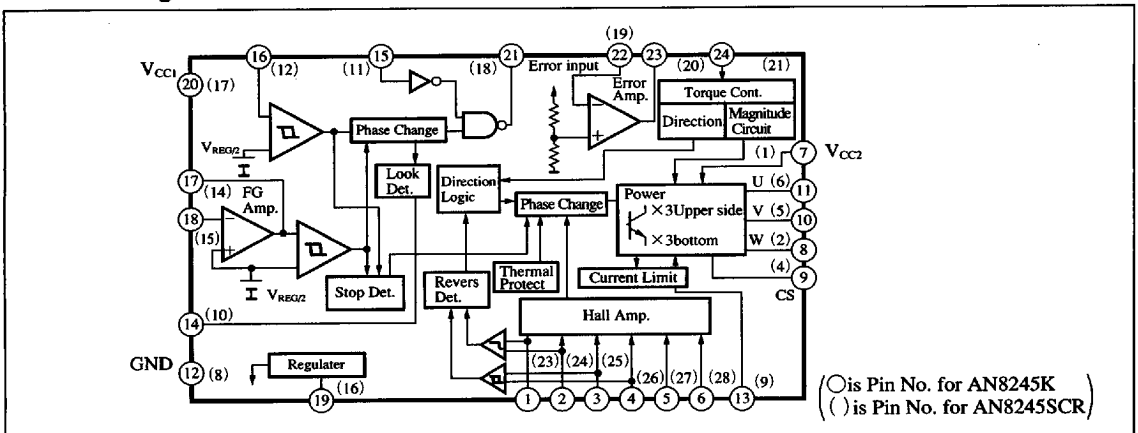
- Operating supply voltage range :  $V_{CC1} = 10.8$  to  $13.2V$   
 $V_{CC2} = 10.8$  to  $22V$
- 3-sensor 3-phase full-wave current drive ; power transistor built-in
- Maximum motor drive current :  $I_{Mmax.} = 1.5A$
- Digital PLL control
- Bidirectional torque control
- Provided with reverse detector and stop detector
- Synchronizing signal and stop signal output
- Built-in thermal protective and current limiter functions

### Applications

Control and drive of the Hall motors such as laser disk spindle motors, LBP polygon motors, and so on



### Block Diagram



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### ■ Absolute Maximum Ratings (Ta=25°C)

Parameter		Symbol	Rating	Unit
1st supply voltage		V <sub>CC1</sub>	15	V
2nd supply voltage		V <sub>CC2</sub>	24	V
1st supply current		I <sub>CC1</sub>	40	mA
Motor drive pin voltage	AN8245K	V <sub>8</sub> , V <sub>10</sub> , V <sub>11</sub>	24	V
	AN8245SCR	V <sub>2</sub> , V <sub>5</sub> , V <sub>6</sub>	24	V
Hall amp. input pin applied voltage	AN8245K	V <sub>1</sub> ~V <sub>6</sub>	0 to V <sub>CC1</sub>	V
	AN8245SCR	V <sub>23</sub> ~V <sub>28</sub>	0 to V <sub>CC1</sub>	V
Pin applied voltage	AN8245K	V <sub>14</sub> ~V <sub>21</sub>	0 to V <sub>CC1</sub>	V
	AN8245SCR	V <sub>10</sub> ~V <sub>18</sub>	0 to V <sub>CC1</sub>	V
Limiter control pin applied voltage	AN8245K	V <sub>13</sub>	to 5	V
	AN8245SCR	V <sub>9</sub>	to 5	V
Motor drive pin rush current	AN8245K	I <sub>8</sub> , I <sub>10</sub> , I <sub>11</sub>	-2 to +2 Note 1)	A
	AN8245SCR	I <sub>2</sub> , I <sub>5</sub> , I <sub>6</sub>		
Current detection pin rush current	AN8245K	I <sub>9</sub>	-2 to 0 Note 1)	A
	AN8245SCR	I <sub>4</sub>		
Regulator voltage output pin current	AN8245K	I <sub>19</sub>	-20 to +0.5	mA
	AN8245SCR	I <sub>16</sub>		
Power dissipation	AN8245K	P <sub>D</sub>	2500	mW
	AN8245SCR	P <sub>D</sub>	1400	mW
Operating ambient temperature		T <sub>opr</sub>	-20 to +75	°C
Storage temperature		T <sub>stg</sub>	-55 to +150	°C

Note 1) Single-shot pulse width : 50ms or less

### ■ Recommended Operating Range (Ta=25°C)

Parameter	Symbol	Range
Operating supply voltage range	V <sub>CC1</sub>	10.8V to 13.2V
	V <sub>CC2</sub>	10.8V to 22V

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### ■ Electrical Characteristics (Ta=25°C)

Parameter	Symbol	Condition	Range			Unit
			min	typ	max	
1st supply current	I <sub>CC</sub>	V <sub>CC1</sub> =12V, V <sub>IH</sub> =0V	10	15	20	mA
2nd supply current at standby	I <sub>QS</sub>	V <sub>CC1</sub> =12V, V <sub>IH</sub> =5V	—	0	0.1	mA
<b>Regulator Voltage Output Block</b>						
Output voltage	V <sub>OR</sub>	V <sub>CC1</sub> =12V, I <sub>OR</sub> =0mA	7.5	8	8.5	V
Output current	I <sub>OR</sub>	V <sub>CC1</sub> =12V	—	—	10	mA
Output impedance	Z <sub>OR</sub>	V <sub>CC1</sub> =12V	—	2	8.5	Ω
<b>FG Amp./Schmidt Block</b>						
Amp. offset voltage	V <sub>OSF</sub>	V <sub>CC1</sub> =12V	—	—	55	mV
Hysteresis width	V <sub>SF</sub>	V <sub>CC1</sub> =12V	80	110	140	mV
Stop detector voltage	V <sub>RF</sub>	V <sub>CC1</sub> =12V	—	—	170	mV
Amp. output voltage H	V <sub>OHF</sub>	V <sub>CC1</sub> =12V	10	—	—	V
Amp. output voltage L	V <sub>OLF</sub>	V <sub>CC1</sub> =12V	—	—	1	V
Output impedance	Z <sub>OF</sub>	V <sub>CC1</sub> =12V	—	60	100	Ω
<b>Phase Comparator Output L Block</b>						
V <sub>OR</sub> <sup>-</sup> (phase comparator output H)	V <sub>PHH</sub>	V <sub>CC1</sub> =12V	—	—	0.4	V
Phase comparator output L	V <sub>PHL</sub>	V <sub>CC1</sub> =12V	—	—	0.4	V

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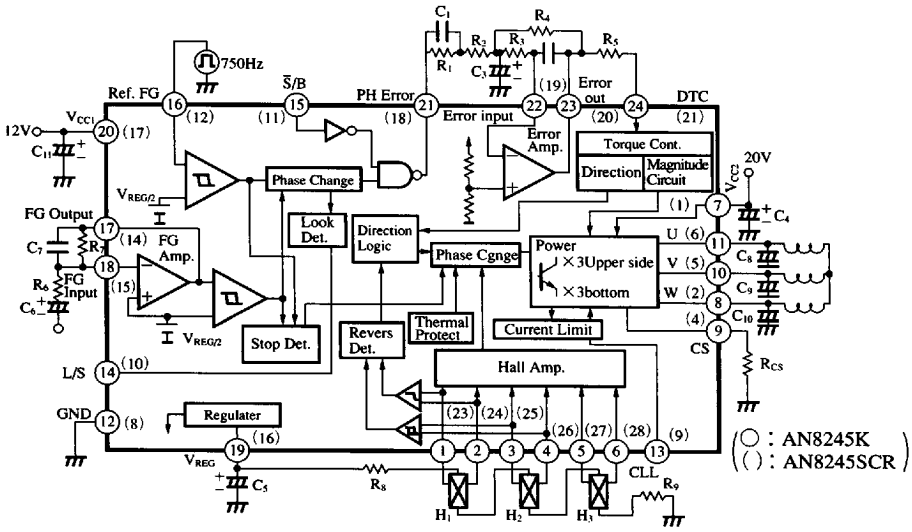
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**Electrical Characteristics (Cont.)** (Ta=25°C)

Parameter	Symbol	Condition	min	typ	max	Unit
<b>Phase Comparator Output L Block (Cont.)</b>						
Output sink current	$I_{PH}^+$	$V_{CC1} = 12V$	2.5	—	—	mA
Output source current	$I_{PH}^-$	$V_{CC1} = 12V$	300	350	—	$\mu A$
<b>Error Amp. Output Block</b>						
Output offset voltage	$V_{OSE}$	$V_{CC1} = 12V$	—	—	50	mV
Amp. output voltage H	$V_{OHE}$	$V_{CC1} = 12V$	10	—	—	V
Amp. output voltage L	$V_{OLE}$	$V_{CC1} = 12V$	—	—	1	V
Output impedance	$Z_{OE}$	$V_{CC1} = 12V$	—	60	100	$\Omega$
<b>Start/Brake</b>						
Input voltage L	$V_{ILS}$	$V_{CC1} = 12V$	—	—	0.8	V
Input voltage H	$V_{IHS}$	$V_{CC1} = 12V$	2.4	—	—	V
Input low current	$I_{IS}$	$V_{CC1} = 12V$	-5	-1	—	$\mu A$
<b>Phase Lock Signal Output</b>						
Output voltage H	$V_{OHL}$	$V_{CC1} = 12V$	4.5	5	—	V
Output voltage L	$V_{OLL}$	$V_{CC1} = 12V$	—	—	0.4	V
<b>Drive Block (Phase Lock Mode)</b>						
Forward torque command offset	$V_{OFD}$	$V_{CC1} = 12V$	-10	—	200	mV
Reverse torque command offset	$V_{ORD}$	$V_{CC1} = 12V$	-100	—	10	mV
Dead zone	$V_{DZ}$	$V_{CC1} = 12V$	30	—	250	mV
Output idle voltage	$V_{ID}$	$V_{CC1} = 12V$	—	0.8	10	mV
Forward again	$G_{DF}^+$	$V_{CC1} = 12V$	0.4	0.5	0.6	times
Reverse again	$G_{DF}^-$	$V_{CC1} = 12V$	-0.6	-0.5	-0.4	times
<b>Drive (Phase Lock Mode)</b>						
Start command voltage	$V_{STA}$	$V_{CC1} = 12V$	6	6.6	—	V
Stop command voltage	$V_{STO}$	$V_{CC1} = 12V$	—	0.8	1.5	V
Forward limiter voltage	$V_L^+$	$V_{CC1} = 12V$ Start command voltage $V_{DTC} = V_{STA}$	0.73	0.82	0.9	V
Reverse limited voltage	$V_L^-$	$V_{CC1} = 12V$ Start command voltage $V_{DTC} = V_{STO}$	0.73	0.82	0.9	V
<b>Hall Amp.</b>						
Hall input sensitivity	$V_{ISH}$	$V_{CC1} = 12V$	—	—	50	mV
Hall offset voltage	$V_{OSH}$	$V_{CC1} = 12V$	—	—	20	mV
Common mode input range	$V_{ICH}$	$V_{CC1} = 12V$	2	—	$V_{CC1} - 2$	V
Differential input range	$V_{IDH}$	$V_{CC1} = 12V$	—	—	400	mV
<b>Power Block</b>						
Saturation voltage on $V_{CC}$	$V_{SU}$	$V_{CC1} = 12V$	—	—	1.5	V
Saturation voltage on ground	$V_{SL}$	$V_{CC1} = 12V$	—	—	1	V
Off leak current	$I_{LO}$	$V_{CC1} = 12V$	—	0	—	mA
<b>FG Reference Single Processing</b>						
Hysteresis width	$V_{SR}$	$V_{CC1} = 12V$	0.5	0.65	0.8	V
Threshold voltage H	$V_{OHR}$	$V_{CC1} = 12V$	1.8	—	2.5	V
Threshold voltage L	$V_{OLR}$	$V_{CC1} = 12V$	1.2	1.5	1.8	V
<b>Thermal Protective Circuit</b>						
Thermal protection operating point	$T_P$	$V_{CC1} = 12V$	—	170	—	°C
Hysteresis width	$T_{HP}$	$V_{CC1} = 12V$	—	20	—	°C
Stop detector frequency	$f_s$	$V_{CC1} = 12V$	—	Fref/16	—	Hz

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■ Application Circuit



■ Pin Descriptions

(Pin Nos. in ○ for AN8245K, Pin Nos. in ( ) for AN8245SCR)

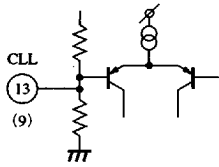
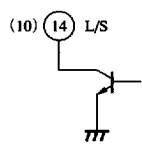
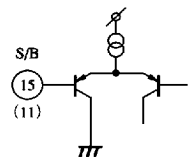
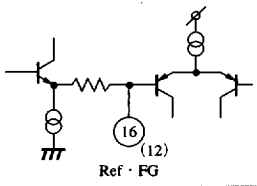

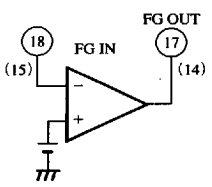


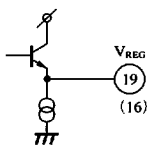
Pin No.		Pin name	Typical waveform	Description	Pin equivalent circuit
AN8245K	AN8245SCR				
7	1	2nd supply voltage (V <sub>CC2</sub> )	—	2nd power pin to supply the motor drive current	—
8	2	Motor drive output W	—	Motor drive output W pin	
	3	NC	—	Open pin	—
9	4	Current detection (CS)	—	Pin to detect the current required to drive the motor	
10	5	Motor drive output V (V)	—	Motor drive output V pin	
11	6	Motor drive output U (U)	—	Motor drive output U pin	

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■ Pin Descriptions (Cont.)

Pin No.		Pin name	Typical waveform	Description	Pin equivalent circuit
AN8245K	AN8245SCR				
	7	NC	—	Open pin	—
12	8	Ground (GND)	—	Ground pin	—
13	9	Limiter voltage control (CLL)	—	Pin to change the motor drive current limiting volt voltage	
14	10	Phase lock signal output (L/S)	—	Lock detection output pin by PLL control of the phase at motor rotation	
15	11	Start/brake signal input (S/B)	—	Start/brake signal input pin	
16	12	FG reference signal input (Ref FG)	—	FG reference signal input pin required for PLL control	
	13	NC	—	Open pin	—
17	14	FG amp. output (FG OUT)		Output pin of the FG amp.	
18	15	FG amp. inverting input (FG IN)		Inverting input pin of the FG amp.	
19	16	Regulator voltage output (V <sub>REG</sub> )		Regulator voltage output pin	

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### Pin Descriptions (Cont.)

Pin No.		Pin name	Typical waveform	Description	Pin equivalent circuit
AN8245K	AN8245SCR				
20	17	1st supply voltage (V <sub>CC1</sub> )	—	1st power pin to supply the voltage to the control circuit	—
21	18	Phase comparison output (PH Error)	—	Phase comparison output pin required for PLL control	
22	19	Error amp. inverting input (Error in)	—	Amp. circuit to amplify a phase/speed error signal and convert a torque signal	
23	20	Error amp. output (Error out)			
24	21	Torque control input (DTC)	—	Motor torque control input pin	
	22	NC	—	Open pin	—
1 } 6	23 } 28	Hall amp. 1+ to 3- inputs H <sub>1</sub> <sup>+</sup> } H <sub>3</sub> <sup>-</sup>	—	Hall element output input pin	

### Supplementary Explanation

The AN8245K and AN8245SCR have been developed as single-chip ICs for controlling and driving the laser spindle motors. They can be also available for controlling and driving the 3-phase brushless motors. Their functions and features are described below.

#### 1. Drive block

- 3-phase full-wave drive (1.5A)
- Current drive (current feedback available)
- Built-in motor current limiter (current limiter level variable)\*<sup>1</sup>
- Built-in thermal protective function
- Reverse rotation torque brake\*<sup>2</sup>
- Built-in reverse detector

#### 2. Control block

- PLL speed control method\*<sup>3</sup>
- Digital phase comparator
- Start/brake control pin
- Phase lock detection pin

\*<sup>1</sup> A motor current is detected by the resistor R<sub>CS</sub> between the Pin<sup>④</sup> (4) and GND. Since the potential of the Pin<sup>④</sup> (4) (CS pin) is controlled so that a value may not exceed a specified voltage (current limiter level) V<sub>L</sub>, the maximum motor current can be specified by V<sub>L</sub>/R<sub>CS</sub>. Because of the voltage of the Pin<sup>⑨</sup> (9) (CLL pin) = V<sub>L</sub>, V<sub>L</sub> can be made variable by connecting a resistor between GNDs via the Pin<sup>⑨</sup> (9).

\*<sup>2</sup> As the potentials of the torque command and DTC pin (Pin<sup>②④</sup> (21)) go below 1/2 · V<sub>reg</sub>, a torque is to be generated in the reverse rotating direction. As a result, the motor load with large inertia can be stopped and transient response can be improved.

To prevent the motor from rotating in the reverse direction, the following functions are provided :

- Motor current OFF function : When detecting a stop
- Forward full torque function : when detecting reverse rotation

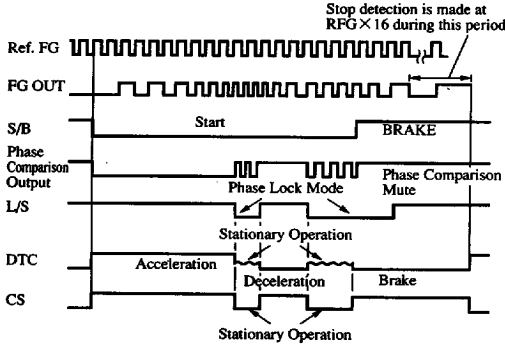
\*<sup>3</sup> The reference pulse to be input from the Pin<sup>⑩</sup> (12) (Ref.FG pin) and the pulse due to FG amp. waveform shaping are compared as to their digital phases to control the PLL speed. PLL of these ICs consists of a phase loop only in the from that dumping is obtained through the filters around the error amplifier.

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**Supplementary Description (Cont.)**

**Operational Chart of Pins**



• **Setting the External Parts (Refer to Product Specifications and Block Diagram)**

**1. Drive block**

- $C_8 \sim C_{10}$  : Connected between the phases of 3-phase coils or GNDs for absorbing the voltage spike of drive output by current drive (120 deg. conducted) or preventing oscillation of drive output. When oscillation tends to occur, it is recommended to insert a resistor of 10 to 500Ω in series with C (several μF as a capacity value).
- $R_8, R_9$  : Determine the Hall element current. It is recommended to set the Hall element output to about typ. 100 to 200mVpp.
- $R_{CS}$  : Determine the control system gain and the maximum motor current.
- $C_4, C_5, C_{11}$  : Used for decoupling the power supply and stabilized voltage output.

**2. Control block**

- $R_6, R_7, C_6, C_7$  : Set the filter for eliminating noise of a speed detecting FG signal and the FG amp. gain.

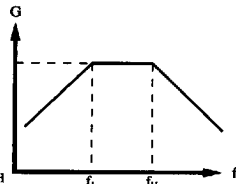
FG amp. gain  $G_{FG} = R_7/R_6$

Filter constant

$$f_L = \frac{1}{2\pi C_6 R_6} \text{ (Hz)}$$

$$f_H = \frac{1}{2\pi C_7 R_7} \text{ (Hz)}$$

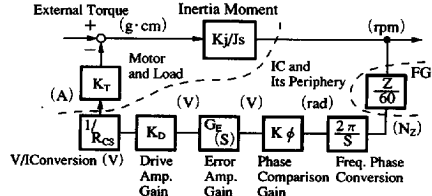
FC frequency  $f_{FG} = f_L < f_{FO} < f_H$



- $R_1 \sim R_4, C_1, C_2$  : Constitute the dumping filter for the control system and the ripple filter for phase comparison output.
- $R_5$  : Connects 10kΩ as the current control load of the transistor switch (operated at start and reverse motor drive detection) which is connected to the Pin②④ (21) in the IC.

**3. Design of the control system**

The following describes the important points when designing the speed control system with these ICs. The control system is shown in the following block diagram.



- $K_T$  : Motor torque constant (gcm/A)
- $J$  : Sum (gcm<sup>2</sup>) of inertia moment of the motor and load (disc, etc.)
- $S$  : Laplacian operator
- $K_j$  : Coefficient for changing a torque (gcm) into a motor speed (r.p.m.)  $9.36 \times 10^3$
- $Z$  : Number of FG teeth
- $K\phi$  : IC phase comparison gain  $8/2\pi$  (V/rad)
- $G_E(S)$  : Dumping of the error amp. block and the gain of the ripple filter
- $K_D$  : IC drive amp. gain 0.4 to 0.6
- $1/R_{CS}$  : V/I conversion gain by the IC and external resistor  $R_{CS}1/R_{CS}$  (A/V).

Make the following calculation, using the constants above.

$$A(S) = K_j/J_s$$

$$B(S) = \frac{Z}{60} \cdot \frac{2\pi}{S} K\phi \cdot G_E(S) \cdot K_D \cdot \frac{1}{R_{CS}} \cdot K_T$$

At this time, the motor speed change ΔN for disturbance torque ΔT is as follows.

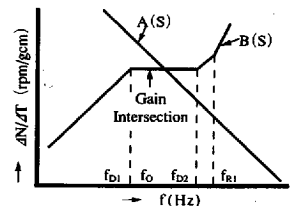
$$\frac{\Delta N}{\Delta T} = \frac{A(S)}{1 + A(S)B(S)} = \frac{1}{1/A(S) + B(S)}$$

When  $1/A(S) \gg B(S)$ ,  $\frac{\Delta N}{\Delta T} \approx A(S)$ , and when  $1/A(S) \ll B(S)$ ,  $\frac{\Delta N}{\Delta T} \approx 1/B(S)$ .

If shown in the figure, it will be almost as shown in the right one.

It is better for stable operation to satisfy the following conditions.

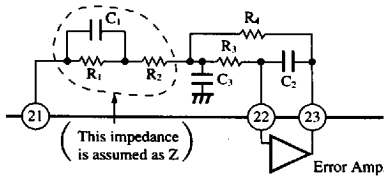
- $f_{D2} \geq 3 \cdot f_0$
- $f_{R1} \geq 5 \cdot f_0$
- $f_{D1} \leq f_0/3$
- $f_{FG}$  (FG frequency)  $\geq 20f_0$



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■ Supplementary Description (Cont.)

$f_{D1}$ ,  $f_{D2}$ , and  $f_{R1}$  are determined as follows.



The figure above shows an example of the external circuit around the error amplifier. This block constitutes the dumping filter for the control system and the ripple filter for phase comparison output.

$$G_E(S) = \frac{R_4}{Z} \cdot \frac{1}{1 + sC_2R_3R_4 \left( \frac{1}{Z} + \frac{1}{R_3} + \frac{1}{R_4} \right) + s^2C_2C_3R_3R_4}$$

$$Z = (R_1 + R_2) \frac{1 + sC_1(R_1/R_2)}{1 + sC_1R_1}$$

The transfer function  $G_E(S)$  of these filters are represented by the following expression, indicating the characteristics of the damping filter in Item 1 and of the ripple filter in Item 2.

Damping filter :  $f_{D1} = 1 / (2\pi C_1 R_1)$

$$f_{D2} = 1 / \{ 2\pi C_1 (R_1/R_2) \}$$

Ripple filter :

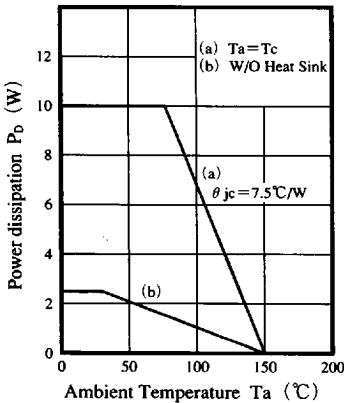
$$f_{R1} = 1 / 2\pi \sqrt{C_2 C_3 R_3 R_4}$$

$$\zeta = \left\{ C_2 C_3 C_4 \left( \frac{1}{Z} + \frac{1}{R_3} + \frac{1}{R_4} \right) \right\} / 2\sqrt{C_2 C_3 R_3 R_4}$$

■ Characteristics Curve

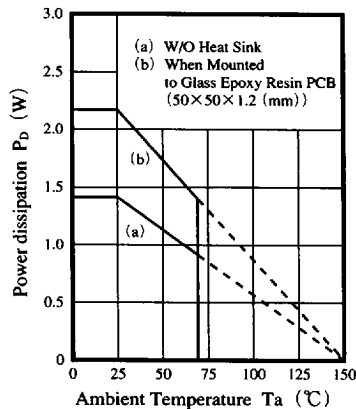
AN8245K

$P_D - T_a$



AN8245SCR

$P_D - T_a$



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