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.

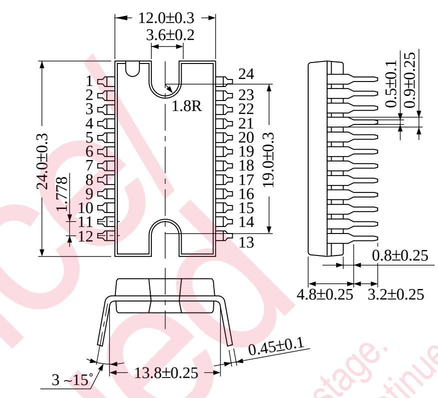
■ Features

- 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

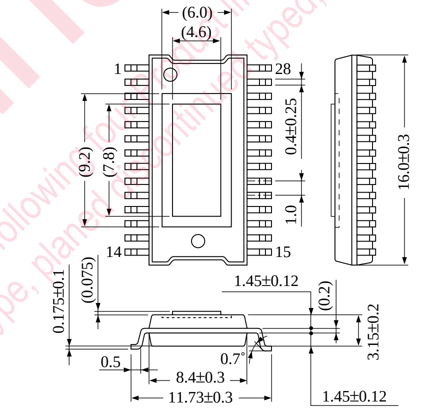
Control and drive of the Hall motors such as laser disk spindle motors, LBP polygon motors, and so on

AN8245K Unit : mm



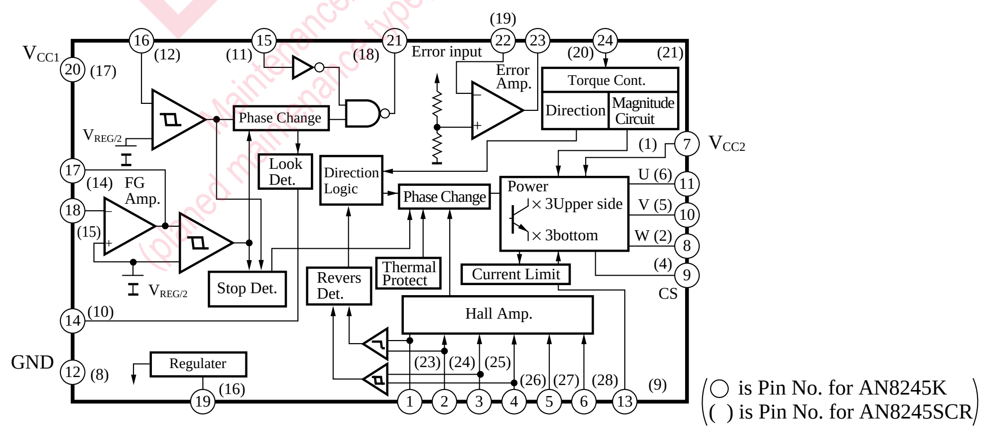
24-pin Shrunk DIL Plastic Package (SDIP024-P-0550)

AN8245SCR Unit : mm



28-pin PANAFLAT Plastic Package (HSOP028-P-0450)

■ Block Diagram



■ Absolute Maximum Ratings (Ta=25˚C)

Parameter		Symbol	Rating	Unit
1st supply voltage		V_{CC1}	15	V
2nd supply voltage		V_{CC2}	24	V
1st supply current		I_{CC1}	40	mA
Motor drive pin voltage	AN8245K	V_8, V_{10}, V_{11}	24	V
	AN8245SCR	V_2, V_5, V_6	24	V
Hall amp. input pin applied voltage	AN8245K	$V_1 \sim V_6$	0 to V_{CC1}	V
	AN8245SCR	$V_{23} \sim V_{28}$	0 to V_{CC1}	V
Pin applied voltage	AN8245K	$V_{14} \sim V_{21}$	0 to V_{CC1}	V
	AN8245SCR	$V_{10} \sim V_{18}$	0 to V_{CC1}	V
Limiter control pin applied voltage	AN8245K	V_{13}	to 5	V
	AN8245SCR	V_9	to 5	V
Motor drive pin rush current	AN8245K	I_8, I_{10}, I_{11}	–2 to + 2 Note 1)	A
	AN8245SCR	I_2, I_5, I_6		
Current detection pin rush current	AN8245K	I_9	–2 to 0 Note 1)	A
	AN8245SCR	I_4		
Regulator voltage output pin current	AN8245K	I_{19}	–20 to + 0.5	mA
	AN8245SCR	I_{16}		
Power dissipation	AN8245K	P_D	2500	mW
	AN8245SCR	P_D	1400	mW
Operating ambient temperature		T_{opr}	–20 to + 75	˚C
Storage temperature		T_{stg}	–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_{CC1}	10.8V to 13.2V
	V_{CC2}	10.8V to 22V

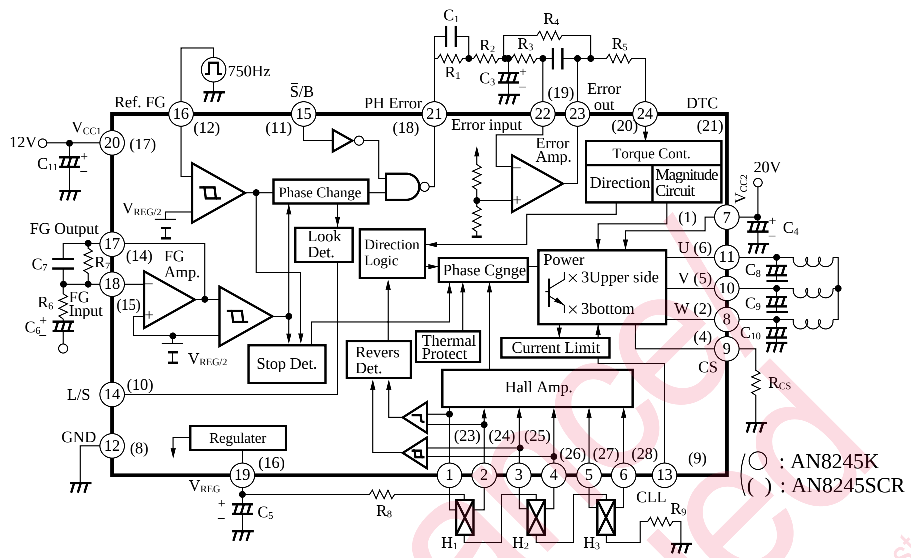
■ Electrical Characteristics (Ta=25˚C)

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

■ Electrical Characteristics (Cont.) (Ta=25˚C)

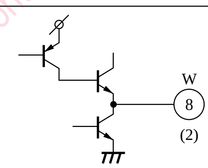
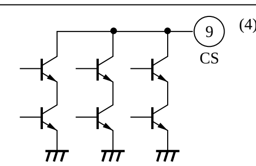
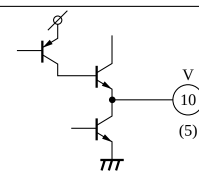
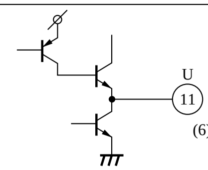
Parameter	Symbol	Condition	min	typ	max	Unit
Phase Comparator Output L Block (Cont.)						
Output sink current	I_{PH}^{+}	V_{CC1}=12V	2.5	—	—	mA
Output source current	I_{PH}^{-}	V_{CC1}=12V	300	350	—	µA
Error Amp. Output Block						
Output offset voltage	V_{OSE}	V_{CC1}=12V	—	—	50	mV
Amp. output voltage 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	Ω
Start/Brake						
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	—	µA
Phase Lock Signal Output						
Output voltage H	V_{OHL}	V_{CC1}=12V	4.5	5	—	V
Output voltage L	V_{OLL}	V_{CC1}=12V	—	—	0.4	V
Drive Block (Phase Lock Mode)						
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
Drive (Phase Lock Mode)						
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
Hall Amp.						
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
Power Block						
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
FG Reference Single Processing						
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
Thermal Protective Circuit						
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

■ Application Circuit

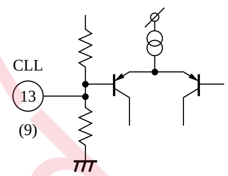
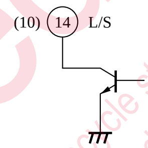
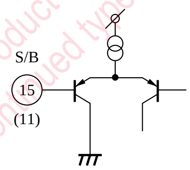
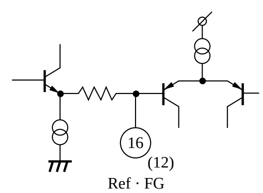
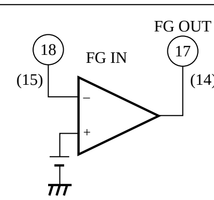
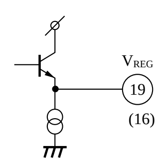


■ Pin Descriptions

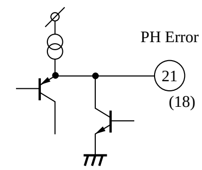
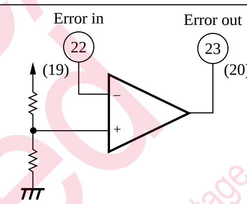
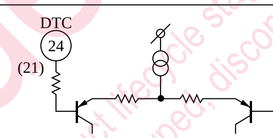
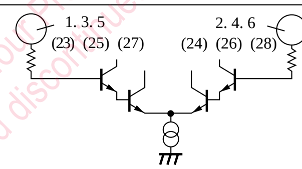
(Pin Nos. in ○ for AN8245K, Pin Nos. in ( ) for AN8245SCR)

Pin No.		Pin name	Typical waveform	Description	Pin equivalent circuit
AN8245K	AN8245SCR				
7	1	2nd supply voltage (V_{CC2})	—	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	

■ Pin Descriptions (Cont.)

Pin No. AN8245K	Pin No. AN8245SCR	Pin name	Typical waveform	Description	Pin equivalent circuit
	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 requied 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_{REG})	DC 8V	Regulator voltage output pin	

■ Pin Descriptions (Cont.)

Pin No. AN8245K	Pin No. AN8245SCR	Pin name	Typical waveform	Description	Pin equivalent circuit
20	17	1st supply voltage (V_{CC1})	—	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_1^+ ~ H_3^-	—	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 aiso available for controlling and driving the 3-phase brushless motors. Their functions and featuress are derscribed 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)*1
- Built-in thermal protective function
- Reverse rotation torque brake*2
- Built-in reverse detector

2. Control block
- PLL speed control method*3
- Digital phase comparator
- Start/brake control pin
- Phase lock detection pin

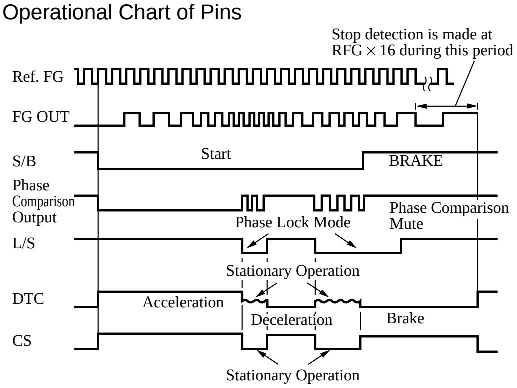
*1 A motor current is detected by the resistor R_{CS} between the Pin9 (4) and GND. Since the potential of the Pin9 (4) (CS pin) is controlled so that a value may not exceed a specified voltage (current limiter level) V_L, the maximum motor current can be specified by V_L/R_{CS}.
Because of the voltage of the Pin13 (9) (CLL pin) $=V_L$, V_L can be made variable by connecting a resistor between GNDs via the Pin13 (9).

*2 As the potentials of the torque command and DTC pin (Pin24 (21)) go below $1/2 \cdot V_{reg}$, 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

*3 The reference pulse to be input from the Pin16 (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.

■ Supplementary Description (Cont.)

Operational Chart of Pins



• Setting the External Parts (Refer to Product Specifi-cations 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 oscilla-tion 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 recommend 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.

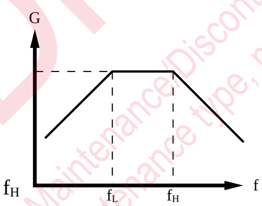
FG amp. gain $G_{FG} = R7/R6$

Filter constant

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

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

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

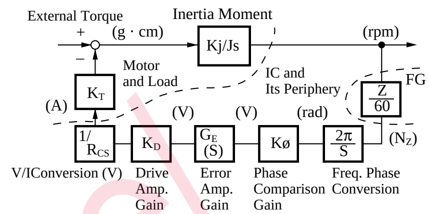


• $R_1 \sim R_4$, C_1, C_2 : Constitute the dumping filter for the control system and the ripple filter for phase comparison output.

• 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^2) of inertia moment of the motor and load (disc, etc.)

• S : Laplacian operator

• Kj : Coefficient for changing a torque (gcm) into a motor speed (r.p.m.) 9.36×10^3

• Z : Number of FG teeth

• Kø : IC phase comparison gain 8/2π (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.

$$A(S) = Kj/J_S$$

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

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 1A (S) ≫B (S), $\frac{\Delta N}{\Delta T}$ 6A (S), and when 1/A (S) ≪ B (S), $\frac{\Delta N}{\Delta T}$ 61/B (S).

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

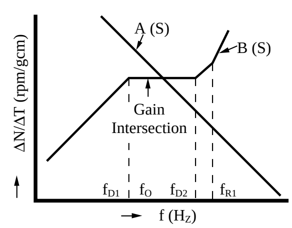
It is better for stable operation to satisfy the following conditions.

$f_{D2} \geq 3 \cdot f_O$

$f_{R1} \geq 5 \cdot f_O$

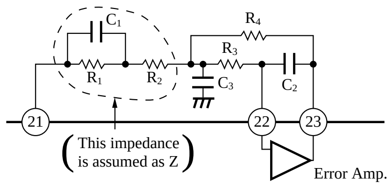
$f_{D1} \leq f_O/3$

f_{FG} (FG frequency) $\geq 20 f_O$



■ 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 : $f_{D1} = 1/(2\pi\, C_1R_1)$

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

Ripple filter :

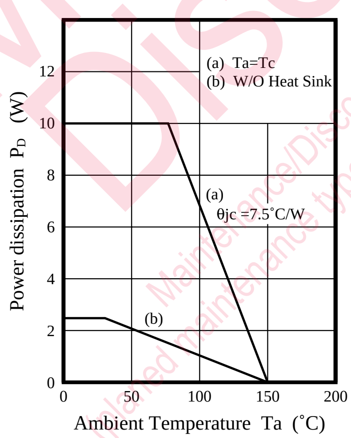
$$f_{R1} = 1/2\pi\sqrt{C_2C_3R_3R_4}$$

$$\zeta = \left\{C_2C_3C_4\left(\frac{1}{Z} + \frac{1}{R_3} + \frac{1}{R_4}\right)\right\}/2\sqrt{C_2C_3R_3R_4}$$

■ Charasteristics Curve

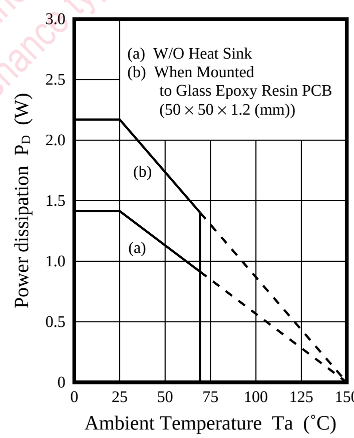
AN8245K

P_D — Ta



AN8245SCR

P_D — Ta



Request for your special attention and precautions in using the technical information and semiconductors described in this book

(1) If any of the products or technical information described in this book is to be exported or provided to non-residents, the laws and regulations of the exporting country, especially, those with regard to security export control, must be observed.

(2) The technical information described in this book is intended only to show the main characteristics and application circuit examples of the products, and no license is granted under any intellectual property right or other right owned by our company or any other company. Therefore, no responsibility is assumed by our company as to the infringement upon any such right owned by any other company which may arise as a result of the use of technical information described in this book.

(3) The products described in this book are intended to be used for standard applications or general electronic equipment (such as office equipment, communications equipment, measuring instruments and household appliances).
Consult our sales staff in advance for information on the following applications:

- Special applications (such as for airplanes, aerospace, automobiles, traffic control equipment, combustion equipment, life support systems and safety devices) in which exceptional quality and reliability are required, or if the failure or malfunction of the products may directly jeopardize life or harm the human body.
- Any applications other than the standard applications intended.

(4) The products and product specifications described in this book are subject to change without notice for modification and/or improvement. At the final stage of your design, purchasing, or use of the products, therefore, ask for the most up-to-date Product Standards in advance to make sure that the latest specifications satisfy your requirements.

(5) When designing your equipment, comply with the range of absolute maximum rating and the guaranteed operating conditions (operating power supply voltage and operating environment etc.). Especially, please be careful not to exceed the range of absolute maximum rating on the transient state, such as power-on, power-off and mode-switching. Otherwise, we will not be liable for any defect which may arise later in your equipment.
Even when the products are used within the guaranteed values, take into the consideration of incidence of break down and failure mode, possible to occur to semiconductor products. Measures on the systems such as redundant design, arresting the spread of fire or preventing glitch are recommended in order to prevent physical injury, fire, social damages, for example, by using the products.

(6) Comply with the instructions for use in order to prevent breakdown and characteristics change due to external factors (ESD, EOS, thermal stress and mechanical stress) at the time of handling, mounting or at customer's process. When using products for which damp-proof packing is required, satisfy the conditions, such as shelf life and the elapsed time since first opening the packages.

(7) This book may be not reprinted or reproduced whether wholly or partially, without the prior written permission of Matsushita Electric Industrial Co., Ltd.