

1

丹羽 雅彦/宮崎 仁/ 魚田 隆/中野 正次/
山田 博之/松村 南/戸川 治朗



■

● (1)

가

● (2)

Ni-Cr

가

●

(3)

●

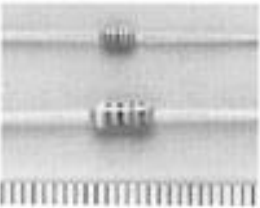
(4)

(耐)

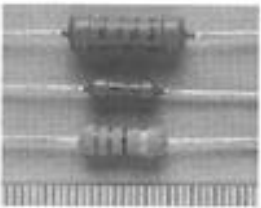
가



1. (가)



2.



3.



4.

(Metal glaze:
)

가

- (5) 가

 $M \Omega$

가 가

UL, CSA

(7).

ON/OFF

- $$\bullet \quad m\Omega \quad (8) \quad . \quad m\Omega$$

-

- 가 (6)

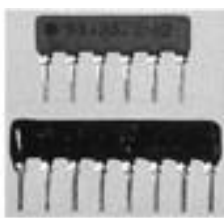
(線材)

가

- (megohm)
MΩ

- 가 (9)

가 (正)



5.

6.



7.



8.

[KOA()]



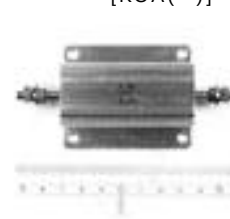
9.

10.

()]

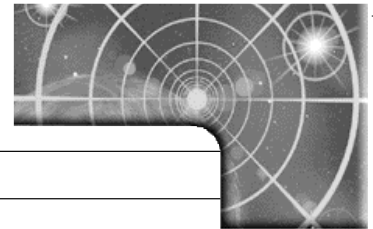


11.

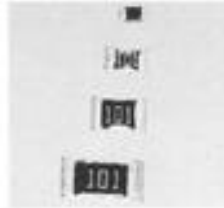


12.

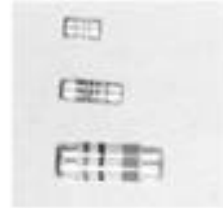
()]



13.



14.



15.



16.

[()] [()] [()]

- (10)

- (12)

(Metal-Clad),

(photo etching)

가

가

- (11)

- (13)

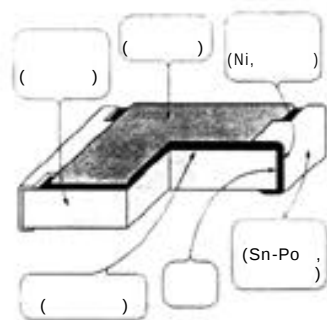
(丹羽 雅彦)

가

가

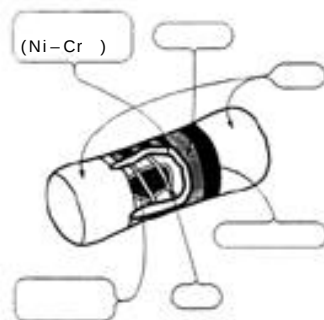
- (14)

(1).

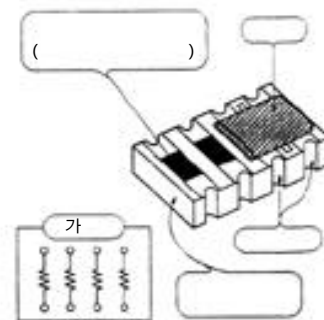


1.

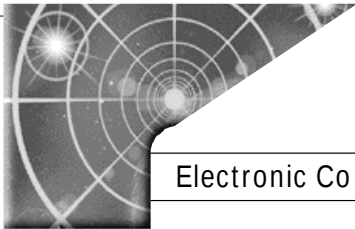
()



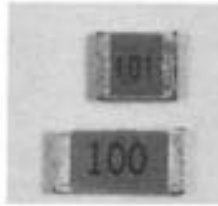
2.



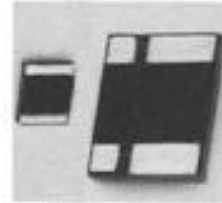
3.



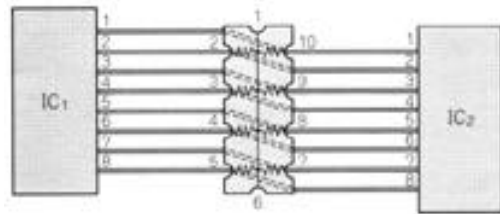
17. [()]



18. [KOA()]



19. [()]



4.

가

가

, 4 , 1005 2 , 4

(17)

8

가 4 가
IC ,

6.4×3.

(flow/reflow soldering)

2mm. 4.0×2.0mm

3.2×1.6mm

가

■

(16, 3)

2 4

1

가

가

(70 80%

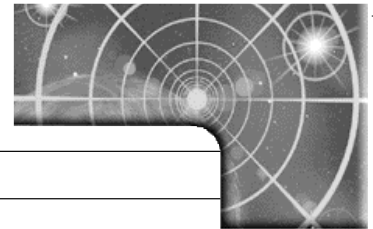
가

가)

가

가

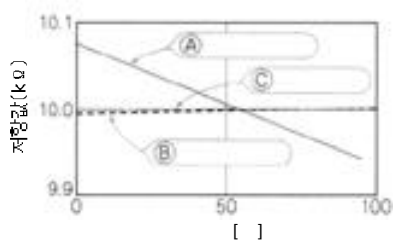
2012 1608 2 ,



- (18)
가 , 가 4
2 , 2
- (19)
가 4 . (丹羽 雅彦)

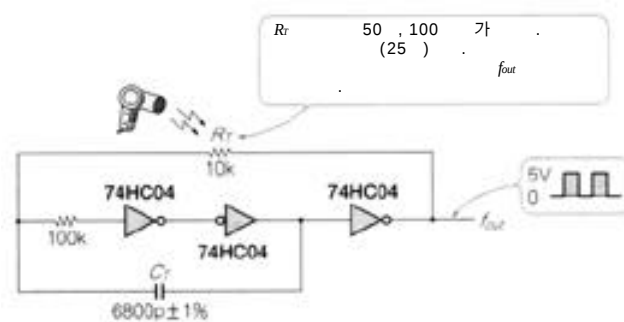


가 , 가 .
()
-200 -800ppm/
±5%(J)
±10%(K)
가 가 , 가
가 -300ppm/ 가
0 100 30000ppm, 3%
Ni-Cr
가



	0	50	100
(10kΩ, ±5%)	10.076 kΩ	10.002 kΩ	9.943 kΩ
(10kΩ, ±0.5%, ±100ppm/°C)	9.994 kΩ	9.998 kΩ	10.001 kΩ
(10kΩ, ±0.05%, ±15ppm/°C)	9.999 kΩ	10.000 kΩ	10.000 kΩ

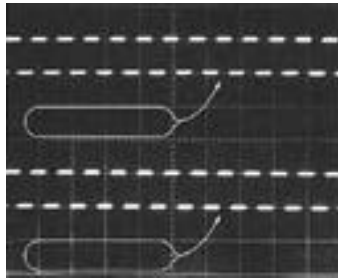
5.



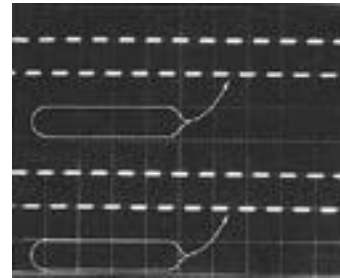
$$f_{out} = \frac{1}{0.45 C_r R_r} \text{ [Hz]}$$

가
Rr 가 , fout 가 Rr

6.



20.
(@ $T_a = 50$, $50 \mu\text{s}/\text{div}$)



21.
(@ $T_a = 100$, $50 \mu\text{s}/\text{div}$)

가 $\pm 100\text{ppm}/$
 $\pm 5\text{ppm}/$ 가
 $\pm 5\%(J)$, $\pm 2\%(G)$
 $\pm 1\%(F)$, $\pm 0.5\%(D)$, $\pm 0.25\%(C)$, $\pm 0.1\%(B)$,
 $\pm 0.05\%(A)$

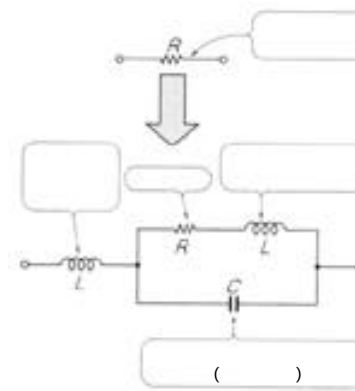
• ($\pm 5\%$),
 ($\pm 0.05\%$, $\pm 15\text{ppm}/$)
 ($\pm 0.05\%$, $\pm 15\text{ppm}/$)

10k Ω . 5

CR . 6
 100 $T_a = 50$

20, 21
 가
 ()
 () 가

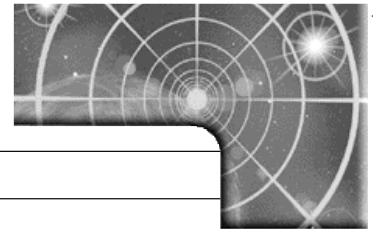
• !
 가 , 가
 가
 op / /
 가



7.

± 10 $\pm 25\%$

1 $\mu\text{V}/\text{V}$,
 0.1 $\mu\text{V}/\text{V}$.
 가
 가
 (7).



가 .

(宮崎 仁)

(derating)

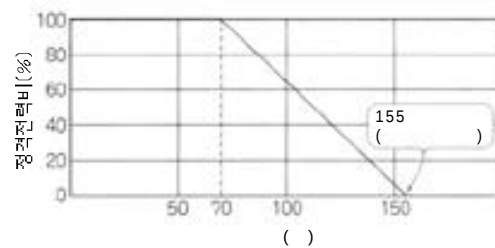
R P 가 V
 I
 $P=I \times V=I^2 \times R=V^2/R$
 P
 ()

2 100Ω
 $1/2W$, 200Ω $1/4W$, 400Ω
 $1/8W$
 $1/4W$ $1/8W$
 $(\pm 15V)$

가 가
 (宮崎 仁)

가

가 가
 () 가 (8).



2
 $5V$ 가
 $5V$
 100Ω $52/$
 $100=0.25W$, 200Ω $0.125W$, 400Ω $0.$
 $0.0625W$ 가 25 ,

70
 50% , 155 0% 가 112.5

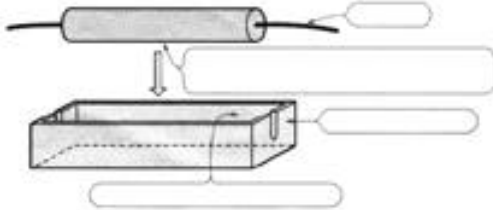
8.

•

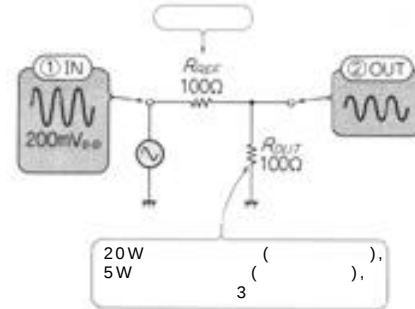
가 가 (9).

TV

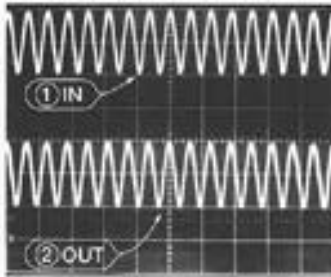
1 20W 가 (1).



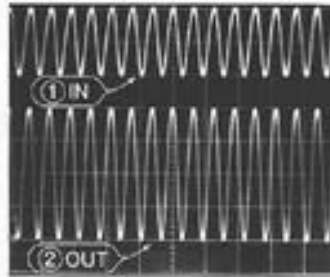
9.



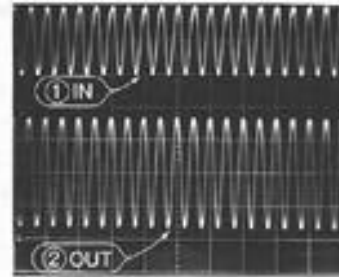
10.



22. 100Ω, 20W
-6dB
(@f=160kHz, 10μs/div :200mV/div,
:100mV/div)



23. 100Ω, 20W
-6dB
(@f=16MHz, 0.1μs/div :200mV/
div, :100mV/div)



24. 100Ω, 20W
-6dB
(@f=20MHz 0.1μs/div :200mV/
div, :100mV/div)

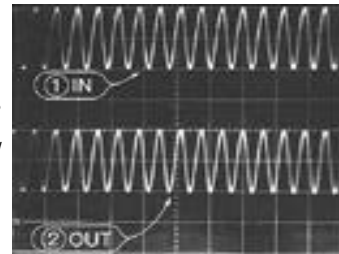
1. [()]

		[Ω]		[mm]				[g]
				L	W	H	ℓ	
MS-2	2	0.1~430	470~10k	18±1	6.4±1	6.4±1	35±3	2.2
MS-3	3	0.1~680	750~20k	22±1	8.0±1	8.0±1	35±3	3.9
MS-5	5	0.1~680	750~30k	22±1	9.5±1	9.0±1	35±3	5.3
MS-7	7	0.1~1.3k	1.5k~30k	35±1	9.5±1	9.0±1	35±3	7.8
MS-10	10	0.1~2.4k	2.7k~30k	48±1.5	9.5±1	9.0±1	35±3	10.9
MS-15	15	0.1~2.4k	2.7k~30k	48±1.5	12.5±1.2	12.5±1.2	35±3	18.5
MS-20	20	0.2~3.6k	3.9k~30k	63.5±1.5	12.5±1.2	12.5±1.2	35±3	22.5

25.

-6dB

(@f=32MHz 0.05μs/
div :200mV/div,
:100mV/div)



가

가 . L

C

10

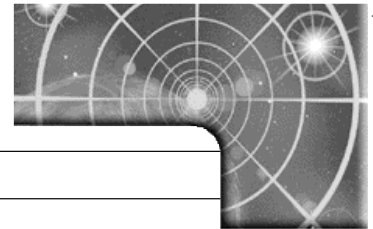
-6dB

()

()

2

-6dB ,

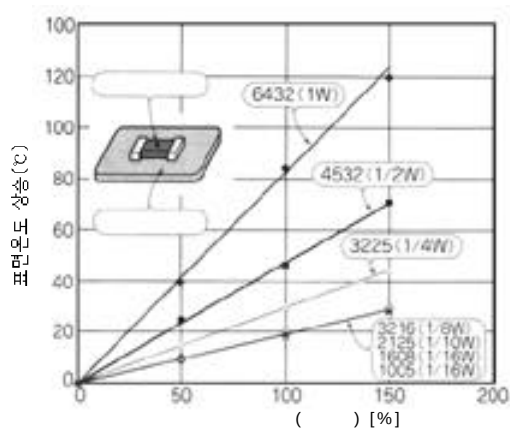


22 20W, 100Ω 가
160kHz -6dB
16MHz
가 (23).
5W, 100Ω
20MHz(24) 25) 32MHz(
64MHz
가 (宮崎 仁)

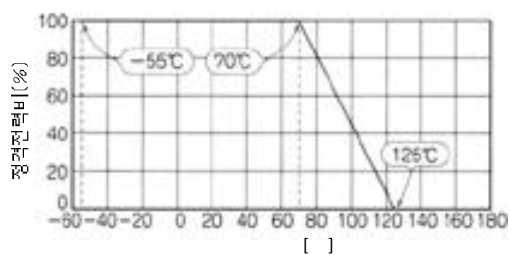


•

가
11 (1W)
(
)
(glass epoxy)
가



11.

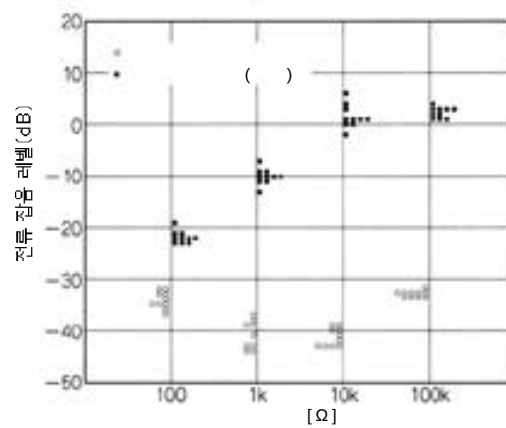


12.

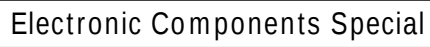
• (TCR)

(TCR: Temperature of Coefficient Resistance)

± 200ppm/ 가
± 25ppm/ 가

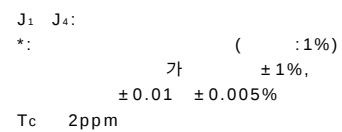
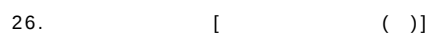


13.

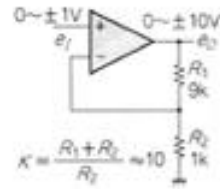
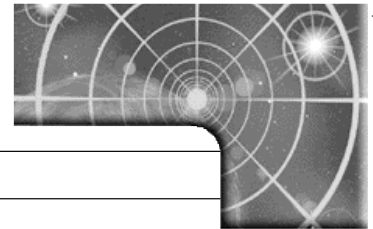


1

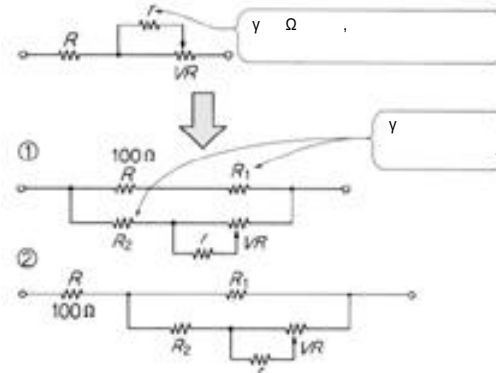
-



14.



15.



16.

가 , 100ppm
가 가
가
() 200 500ppm
가 1%
Tc Tc 2 5ppm
%
가 가
가

35μm , 0.5mm , 50mm
50mΩ 100Ω 0.05%

(Tc)

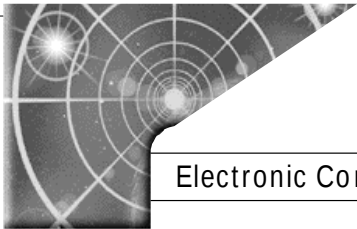
14
1Ω , 1Ω 1%(10mΩ)
R 10ppm

가 4

•
-
Tc가 ratio 가
(15)
, Tc
10
Tc 1ppm 가
가

가 가
가 가
가 16
가

가 100kΩ
1GΩ , 0.01%
10¹¹Ω 1ppm
(
가
(魚田 隆)



4

• 4 가

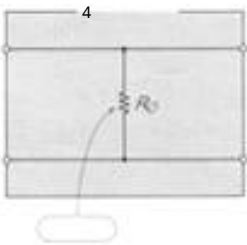
(27). 2
가
(17).

• 가

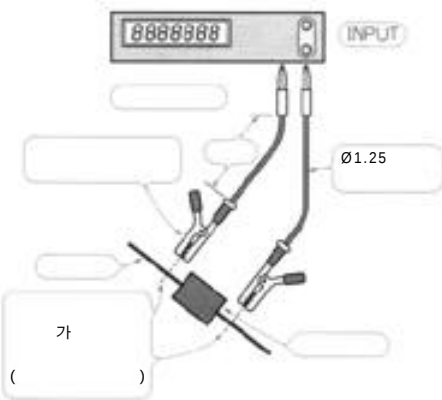
가 가 , 가
가 가 가
가 가
가 1mm , 35 μ m 10mm
5m Ω
m Ω



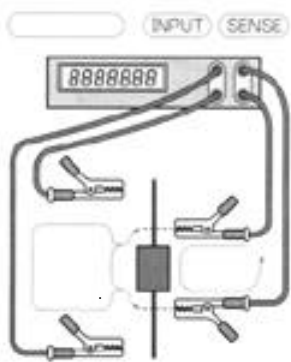
27. 4 () [18(a)].



17. 4

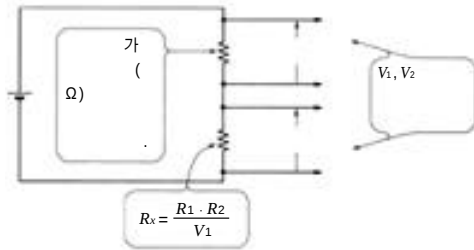
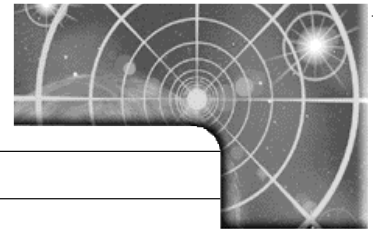


(a) 2



(b) 4

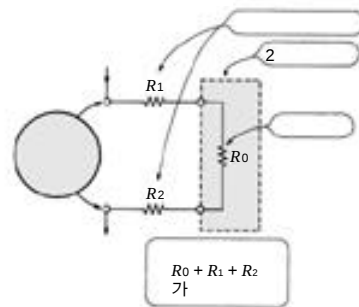
18.



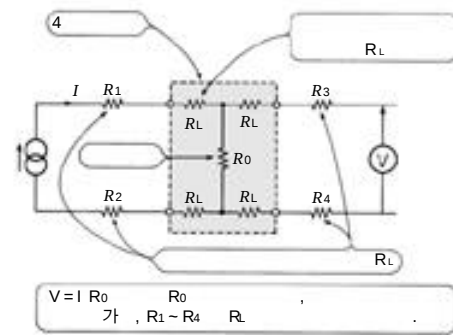
19.

2. 4

	[mΩ]	[%]	[mΩ]	[%]
PCWR05000D	50,000	± 0.5	49.9723	- 0.055
PCWR02000D	20,000	± 0.5	20.0112	+ 0.056
RBHHR0010F	1,0000	± 1	1.0026	+ 0.26



(a) 2



(b) 4

• 4

0.5%

18(b)

4
4

• 4

LCR

• 10mΩ

, 10mΩ
가

(

가

1mA

10mΩ

4

10μV

가

0

μV가

가

4

19

R1

•

(4)

20

1A

1mΩ

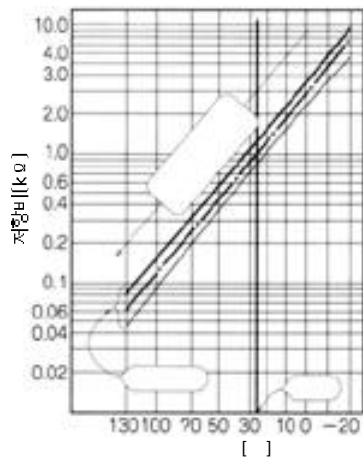
1mV

2

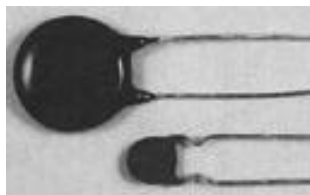
(中野 正次)

- (thermistor)
가 , 가 NTC가
PTC 가 NTC가
(28).
NTC
21 石塚
130V DC
SW가 OFF
가 C
SW가 ON 가
100A
가 23

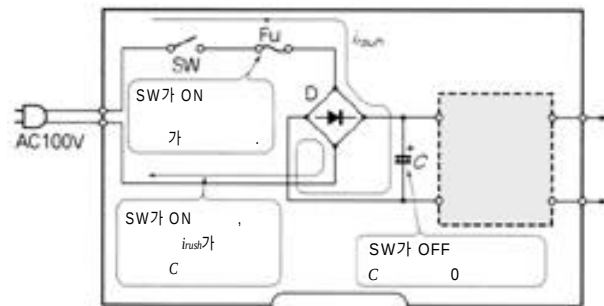
- NTC
22
AC100V
TH
SW가 OFF
TH
C
가



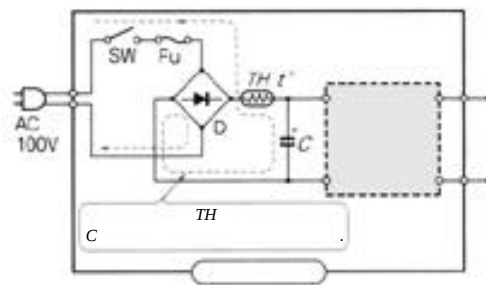
21.



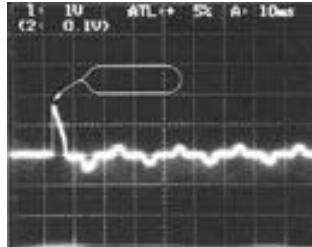
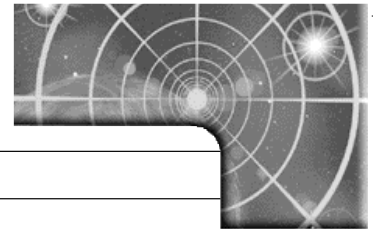
28. [石塚 ()]



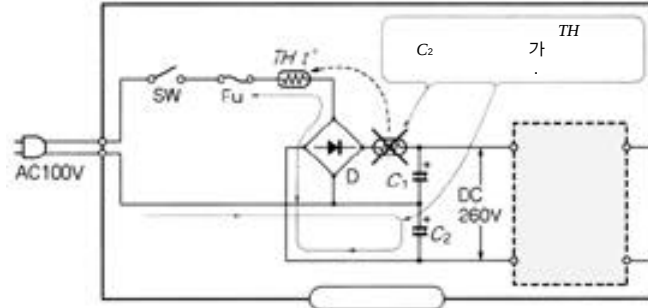
22. NTC



23.



29.



24.

가

가

3.

	[Ω]		[A]		R _L [Ω]	[]	[]
	@25	@55	@25	@55			
3D22	3	3.5	2.9	0.233	220	-30 ~ +130	
4D22	4	3.0	2.5	0.310	230		
6D22	6	2.5	2.1	0.465	260		
4D18	4	2.6	2.1	0.310	170		
8D18	8	1.9	1.6	0.620	220		
8D13	8	1.6	1.3	0.620	160		
16D13	16	1.2	1.0	1.240	220		
5D11	5	2.0	1.6	0.388	130		
8D11	8	1.6	1.3	0.620	160	-30 ~ +200	
10D9	10	1.3	1.0	0.775	130		
16D9	16	1.0	0.8	1.240	160		
4W25	4	7.8	7.1	0.102	450		
6W22	6	6.1	5.6	0.153	450		

가

AC

AC100V

140V

V_{max}

A

가

I_p

25A

가

I_p

R

$$R = V_p / I_p = 155.5 / 25 = 6.22 [\Omega]$$

3 石塚 () 8D13

8Ω

(29)

17A

가

(戸川 治朗)

가

100/200V

±10%

100V

110V가

V_{max} 155.5V가



표 4. 저항기 사양 일람

종류	항목	정격전력(W)	허용차	저항값 범위	E표준수	사용주요온도범위	저항온도계수	최고사용전압	최고부하 전압	최고단속부하량 최고사용전압 × 2.5	내전압
탄소피막 저항기									최고사용전압×2		
금속 피막저항기								최고사용전압×2	최고사용전압×2		
금속산화물 피막 저항기 (산화금속 피막저항기)								최고사용전압×2	최고사용전압×2	최고사용전압 × (2~3)	
시멘트 저항기								최고사용전압×2	최고사용전압×2		
시멘트 저항기 (원선타입)								최고사용전압×2	최고사용전압×2		
시멘트 저항기 (금속판 타입)											
퓨즈 저항기										정격전압 × (2.5~3)	
각형칩 저항기									최고사용전압×2		
박막 칩 저항(각형)									최고사용전압×2		
원통형 칩 저항기 (탄소피막)									최고사용전압×2		
종류	항목	정격(W)	허용차	저항값 범위	저항온도계수	종류	항목	정격(W)	허용차	저항값 범위	저항온도계수
저항 네트워크						범람 저항기					
하이 메그음 저항기				정도		칩 저항 네트워크					
밀리옴 저항기				정도		트리머블 칩 저항기					
라니어 정온도 계수 저항기					정도	칩 퓨즈 저항기					
금속박 저항기						저저항칩 저항기					정도
원선저항기											정도
메탈 클레드 저항기											정도