

Standard Metal Film Resistors



A homogeneous film of metal alloy is deposited on a high grade ceramic body. After a helical groove has been cut in the resistive layer, tinned connecting leads of electrolytic copper are welded to the end-caps.

The resistors are coated with a colored lacquer (light-blue for type SFR16S; light-green for type SFR25 and red-brown for type SFR25H) which provides electrical, mechanical and climatic protection. The encapsulation is resistant to all cleaning solvents, in accordance with "MIL-STD-202E, method 215", and "IEC 60068-2045".

FEATURES

- Low cost
- Low noise (max. 1.5 $\mu\text{V/V}$ for $R > 1 \text{ M}\Omega$)
- Small size (SFR16S-0204, SFR25/25H-0207)
- Lead (Pb)-free solder contacts
- Pure tin plating provides compatibility with lead (Pb)-free and lead containing soldering processes
- Compatible with "Restriction of the use of Hazardous Substances" (RoHS) directive 2002/95/EC (issue 2004)



APPLICATIONS

- General purpose resistors

TECHNICAL SPECIFICATIONS			
DESCRIPTION	VALUE		
	SFR16S	SFR25	SFR25H
Resistance Range	$\pm 5 \%$; 1 Ω to 3 $\text{M}\Omega$	$\pm 5 \%$; 0.22 Ω to 10 $\text{M}\Omega$	
	$\pm 1 \%$; 4.99 Ω to 3 $\text{M}\Omega$	$\pm 1 \%$; 1 Ω to 10 $\text{M}\Omega$	
	jumper (0 Ω)	jumper (0 Ω)	
Resistance Tolerance	$\pm 1 \%$, E24/E96 series; $\pm 5 \%$, E24 series		
Temperature Coefficient:			
$R < 4.7 \Omega$	$\leq \pm 250 \times 10^{-6}/\text{K}$	$\leq \pm 100 \times 10^{-6}/\text{K}$	$\leq \pm 100 \times 10^{-6}/\text{K}$
$4.7 \Omega \leq R \leq 100 \text{ k}\Omega$	$\leq \pm 100 \times 10^{-6}/\text{K}$	$\leq \pm 100 \times 10^{-6}/\text{K}$	$\leq \pm 100 \times 10^{-6}/\text{K}$
$100 \text{ k}\Omega < R \leq 1 \text{ M}\Omega$	$\leq \pm 250 \times 10^{-6}/\text{K}$	$\leq \pm 100 \times 10^{-6}/\text{K}$	$\leq \pm 100 \times 10^{-6}/\text{K}$
$R > 1 \text{ M}\Omega$	$\leq \pm 250 \times 10^{-6}/\text{K}$	$\leq \pm 250 \times 10^{-6}/\text{K}$	$\leq \pm 250 \times 10^{-6}/\text{K}$
Absolute Maximum Dissipation at $T_{\text{amb}} = 70^\circ\text{C}$	0.5 W	0.4 W	0.5 W
Thermal Resistance, R_{th}	170 K/W	200 K/W	150 K/W
Maximum Permissible Voltage	200 V	250 V	350 V
Noise:			
$R < 68 \text{ k}\Omega$	max. 0.1 $\mu\text{V/V}$	max. 0.1 $\mu\text{V/V}$	max. 0.1 $\mu\text{V/V}$
$68 \text{ k}\Omega \leq R \leq 100 \text{ k}\Omega$	max. 0.5 $\mu\text{V/V}$	max. 0.1 $\mu\text{V/V}$	max. 0.1 $\mu\text{V/V}$
$100 \text{ k}\Omega \leq R \leq 1 \text{ M}\Omega$	max. 1.5 $\mu\text{V/V}$	max. 0.1 $\mu\text{V/V}$	max. 0.1 $\mu\text{V/V}$
$R > 1 \text{ M}\Omega$	max. 1.5 $\mu\text{V/V}$	max. 1.5 $\mu\text{V/V}$	max. 1.5 $\mu\text{V/V}$
Basic Specifications	IEC 60115-1 and 60115-2		
Climatic Category (IEC 60068)	55/155/56		
Stability, ΔR max., After:			
Load:			
R range	$\pm (2 \% R + 0.05 \Omega)$	$\pm (2 \% R + 0.05 \Omega)$	$\pm (2 \% R + 0.05 \Omega)$
Climatic Tests:			
$R \leq 1 \text{ M}\Omega$	$\pm (1 \% R + 0.05 \Omega)$	$\pm (1 \% R + 0.05 \Omega)$	$\pm (1 \% R + 0.05 \Omega)$
$R > 1 \text{ M}\Omega$	$\pm (1 \% R + 0.05 \Omega)$	$\pm (1 \% R + 0.05 \Omega)$	$\pm (2 \% R + 0.1 \Omega)$
Soldering	$\pm (0.25 \% R + 0.05 \Omega)$	$\pm (0.25 \% R + 0.05 \Omega)$	$\pm (0.25 \% R + 0.05 \Omega)$
Short Time Overload	$\pm (0.25 \% R + 0.05 \Omega)$	$\pm (0.25 \% R + 0.05 \Omega)$	$\pm (1 \% R + 0.05 \Omega)$

Note:

- R value is measured with probe distance of $24 \pm 1 \text{ mm}$ using 4-terminal method

12NC INFORMATION

- The resistors have a 12-digit numeric code starting with 23.
- The subsequent 6 digits for 1 % or 7 digits for 5 % indicate the resistor type and packaging.
- The remaining digits indicate the resistance value:
 - The first 3 digits for 1 % or 2 digits for 5 % indicate the resistance value.
 - The last digit indicates the resistance decade.

Last Digit of 12NC for $\pm 5\%$ Tolerance

RESISTANCE DECADE	LAST DIGIT
0.10 to 0.91 Ω	7
1 to 9.1 Ω	8
10 to 91 Ω	9
100 to 910 Ω	1
1 to 9.1 k Ω	2
10 to 91 k Ω	3
100 to 910 k Ω	4
1 to 9.1 M Ω	5
≥ 10 M Ω	6

Last Digit of 12NC for $\pm 1\%$ Tolerance

RESISTANCE DECADE	LAST DIGIT
1 to 9.76 Ω	8
10 to 97.6 Ω	9
100 to 976 Ω	1
1 to 9.76 k Ω	2
10 to 97.6 k Ω	3
100 to 976 k Ω	4
1 to 9.76 M Ω	5
≥ 10 M Ω	6

12NC Example

The 12NC of a SFR25 resistor, value 5600 $\Omega \pm 5\%$, taped on a bandolier of 5000 units in ammopack is: 2322 181 43562.

12NC - resistor type and packaging

TYPE	TOL.	ORDERING CODE 23..			
		BANDOLIER IN AMMOPACK			BANDOLIER ON REEL
		RADIAL TAPED	STRAIGHT LEADS		STRAIGHT LEADS
		4000 units	1000 units	5000 units	5000 units
SFR16S	$\pm 5\%$	—	..22 187 73...	..22 187 53...	..06 187 23...
	$\pm 1\%$	—	—	..06 187 3...	..06 187 1....
	jumper ⁽¹⁾	—	—	..06 187 90013	..22 187 90346
SFR25	$\pm 5\%$	..06 184 03...	..22 181 53...	..22 181 43...	..22 181 63...
	$\pm 1\%$	—	—	..22 188 2...	..06 181 8....
	jumper ⁽²⁾	—	..22 181 90018	..22 181 90019	..06 181 90011
SFR25H	$\pm 5\%$	—	..22 186 16...	..22 186 76...	..06 186 63...
	$\pm 1\%$	—	—	..22 186 3....	..06 186 8....

Notes:

(1) The jumper has a maximum resistance $R_{max.} = 30$ m Ω at 3 A (SFR16S).

(2) The jumper has a maximum resistance $R_{max.} = 10$ m Ω at 5 A (SFR25).

PART NUMBER AND PRODUCT DESCRIPTION

PART NUMBER: SFR2500001001FA500

S	F	R	2	5	0	0	0	0	1	0	0	1	F	A	5	0	0
MODEL/SIZE	SPECIAL CHARACTER		TCR/MATERIAL		VALUE				TOLERANCE		PACKAGING ⁽³⁾		SPECIAL				
SFR16S0 SFR2500 SFR25H0	0 = Neutral Z = Value overflow (special)		0 = Standard Z = Jumper		3 digit value 1 digit multiplier MULTIPLIER 7 = *10 ⁻³ 2 = *10 ² 8 = *10 ⁻² 3 = *10 ³ 9 = *10 ⁻¹ 4 = *10 ⁴ 0 = *10 ⁰ 5 = *10 ⁵ 1 = *10 ¹ Z = 0000				F = ± 1 % J = ± 5 % Z = Jumper		N4 A5 A1 R5		The 2 digits are used for all special parts. 00 = Standard				
PRODUCT DESCRIPTION: SFR25 1 % A5 1K0																	
SFR25		1 %		A5		1K0											
MODEL/SIZE		TOLERANCE		PACKAGING ⁽³⁾		RESISTANCE VALUE											
SFR16S SFR25 SFR25H		± 1 % ± 5 %		N4 A5 A1 R5		47K = 47 kΩ 51R1 = 51.1 Ω											

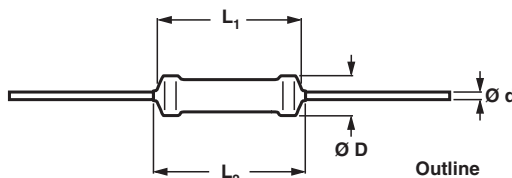
Notes:

(3) Please refer to table PACKAGING.

- The PART NUMBER is shown to facilitate the introduction of a unified part numbering system for ordering products.

PACKAGING

CODE	PIECES	DESCRIPTION	MODEL/SIZE
N4	4000	Bandolier in ammpack radial taped	SFR25
A5	5000	Bandolier in ammpack straight leads	SFR16S, SFR25, SFR25H
A1	1000	Bandolier in ammpack straight leads	SFR16S, SFR25, SFR25H
R5	5000	Bandolier on reel straight leads	SFR16S, SFR25, SFR25H

DIMENSIONS**DIMENSIONS** - resistor types and relevant physical dimensions in millimeters

TYPE	Ø D _{max.}	L ₁ max.	L ₂ max.	Ø d
SFR16S	1.9	3.5	4.1	0.45 ± 0.05
SFR25	2.5	6.5	7.5	0.58 ± 0.05
SFR25H	2.5	6.5	7.5	0.58 ± 0.05

MASS PER 100 UNITS

TYPE	MASS (g)
SFR16S	10.2
SFR25	20.5
SFR25H	20.5

OUTLINES

The length of the body (L₁) is measured by inserting the leads into holes of two identical gauge plates and moving these plates parallel to each other until the resistor body is clamped without deformation ("IEC publication 60294").

MARKING

The nominal resistance and tolerance are marked on the resistor using four or five coloured bands in accordance with IEC publication 60062 "Color codes for fixed resistors".

FUNCTIONAL PERFORMANCE**PRODUCT CHARACTERIZATION**

Standard values of nominal resistance are taken from the E96/E24 series for resistors with a tolerance of ± 1 % or ± 5 %. The values of the E96/E24 series are in accordance with "IEC publication 60063".

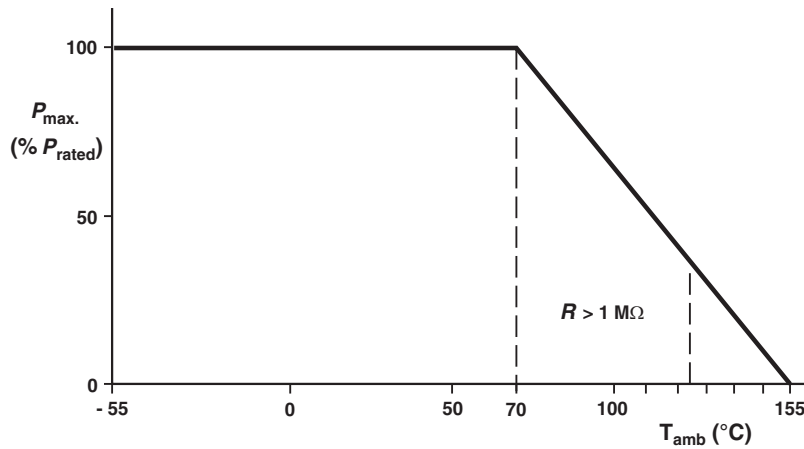
LIMITING VALUES

TYPE	LIMITING VOLTAGE ⁽¹⁾ (V)	LIMITING POWER (W)
SFR16S	200	0.5
SFR25	250	0.4
SFR25H	350	0.5

Note:

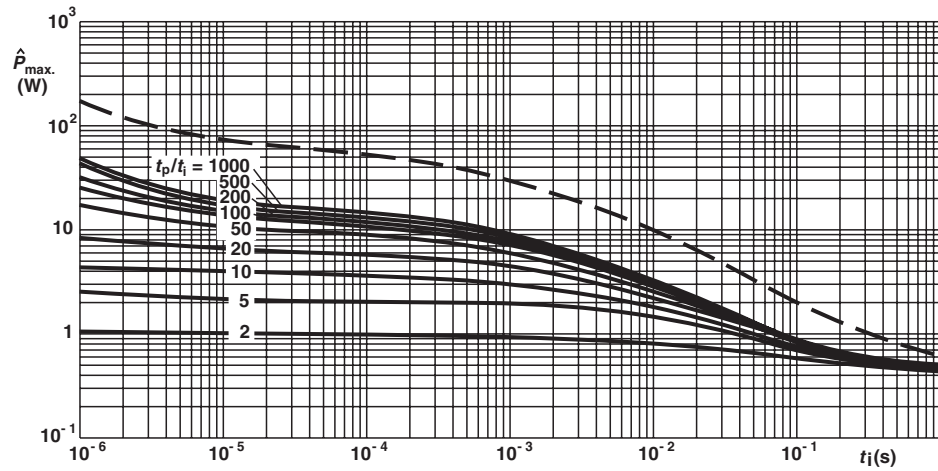
⁽¹⁾ The maximum voltage that may be continuously applied to the resistor element, see "IEC publication 60115-1".
The maximum permissible hot-spot temperature is 155 °C.

The power that the resistor can dissipate depends on the operating temperature

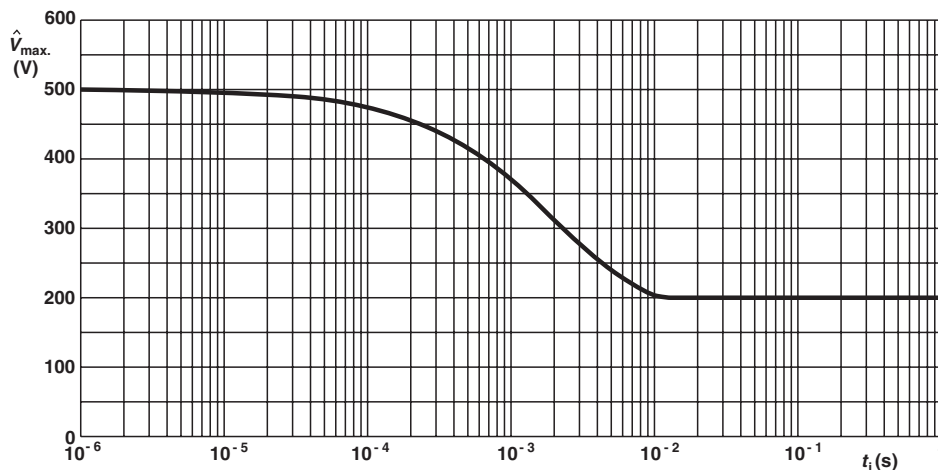


Maximum dissipation ($P_{max.}$) in percentage of rated power as a function of the ambient temperature (T_{amb}).

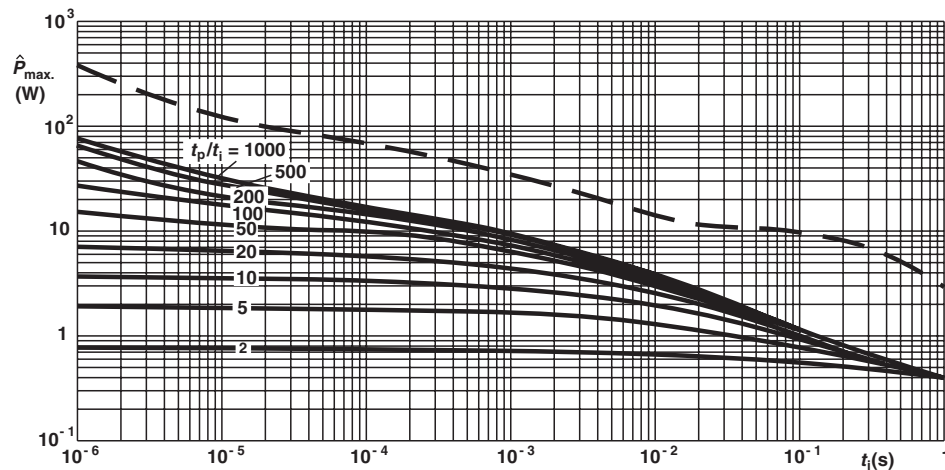
Derating



SFR16S Pulse on a regular basis; maximum permissible peak pulse power ($\hat{P}_{max.}$) as a function of pulse duration (t_i)

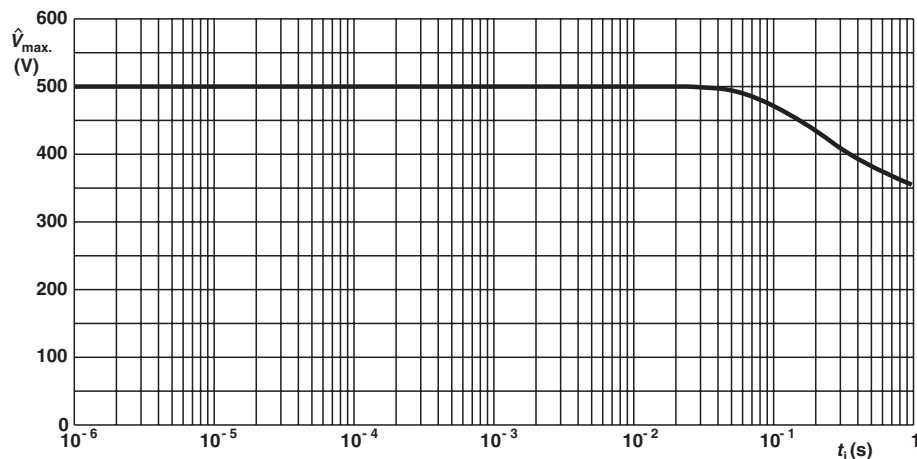


SFR16S Pulse on a regular basis; maximum permissible peak pulse voltage ($\hat{V}_{max.}$) as a function of pulse duration (t_i)

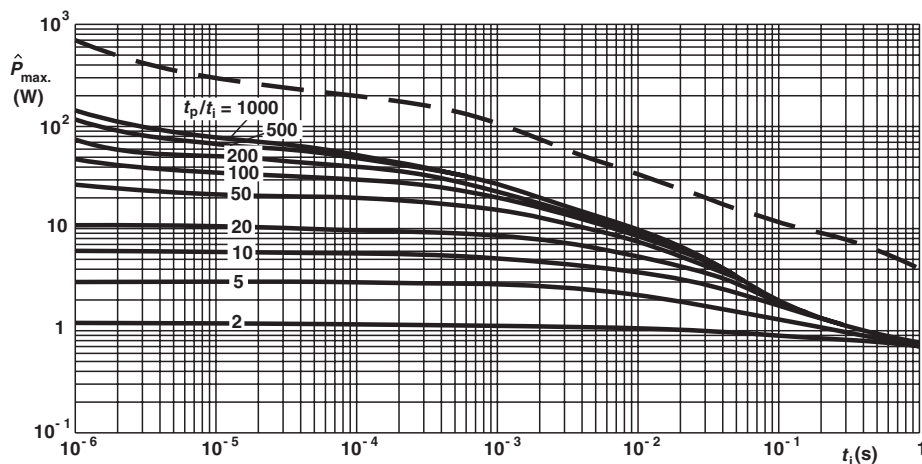


SFR25 Pulse on a regular basis; maximum permissible peak pulse power ($\hat{P}_{max.}$) as a function of pulse duration (t_i)

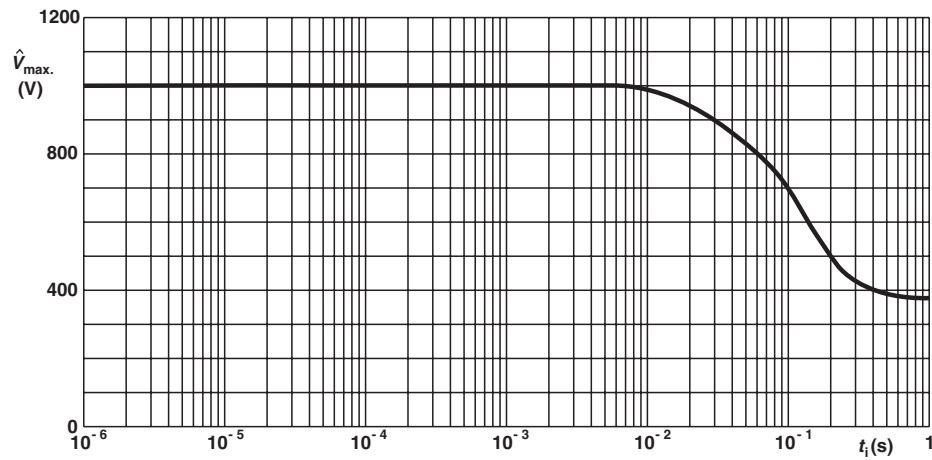
Pulse Loading Capabilities



SFR25 Pulse on a regular basis; maximum permissible peak pulse voltage ($\hat{V}_{max.}$) as a function of pulse duration (t_i)

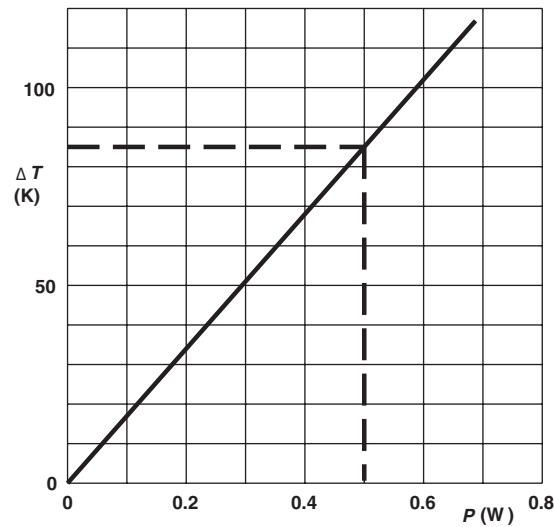


SFR25H Pulse on a regular basis; maximum permissible peak pulse power ($\hat{P}_{max.}$) as a function of pulse duration (t_i)

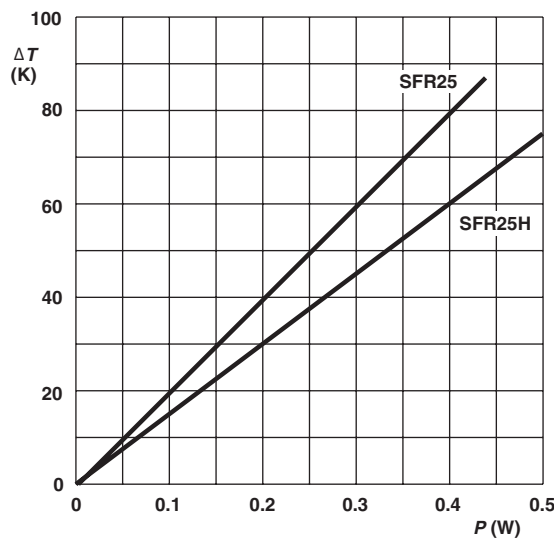


SFR25H Pulse on a regular basis; maximum permissible peak pulse voltage ($\hat{V}_{max}$) as a function of pulse duration (t_i)

Pulse Loading Capabilities



SFR16S Hot-spot temperature rise (ΔT) as a function of dissipated power



SFR25/SFR25H Hot-spot temperature rise (ΔT) as a function of dissipated power

Application Information

TESTS AND REQUIREMENTS

Essentially all tests are carried out in accordance with the schedule of "IEC publication 60115-1", category 55/155/56 (rated temperature range - 55 °C to + 155 °C; damp heat, long term, 56 days). The testing also covers the requirements specified by EIA and EIAJ.

The tests are carried out in accordance with IEC publication 60068-2, "Recommended basic climatic and mechanical robustness testing procedure for electronic components" and

under standard atmospheric conditions according to "IEC 60068-1", subclause 5.3.

In the Test Procedures and Requirements table the tests and requirements are listed with reference to the relevant clauses of "IEC publications 60115-1 and 60068-2"; a short description of the test procedure is also given. In some instances deviations from the IEC recommendations were necessary for our method of specifying.

TEST PROCEDURES AND REQUIREMENTS							
IEC 60115-1 CLAUSE	IEC 60068-2 TEST METHOD	TEST	PROCEDURE	RESISTANCE RANGE	REQUIREMENTS		
					SFR16S	SFR25	SFR25H
4.16	21 (U)	robustness of terminations:			number of failures < 10×10^{-6} number of failures < 10×10^{-6} no damage $\Delta R \text{ max.: } \pm (0.25 \% R + 0.05 \Omega)$		
4.16.2	21 (Ua1)	tensile all samples	$\varnothing$ 0.45 mm, load 5 N; 10 s $\varnothing$ 0.58 mm, load 10 N; 10 s				
4.16.3	21 (Ub)	bending half number of samples	$\varnothing$ 0.45 mm, load 2.5 N; 4 x 90° $\varnothing$ 0.58 mm, load 5 N; 4 x 90°				
4.16.4	21 (Uc)	torsion other half of samples	3 x 360° in opposite directions				
4.17	20 (Ta)	solderability	2 s; 235 °C; flux 600		good tinning; no damage		
4.18	20 (Tb)	resistance to soldering heat	3.5 seconds; 350 °C; solder bath method		$\Delta R \text{ max.: } \pm (0.25 \% R + 0.05 \Omega)$		
4.19	14 (Na)	rapid change of temperature	30 min at - 55 °C and 30 min at + 155 °C; 5 cycles		$\Delta R \text{ max.: } \pm (0.25 \% R + 0.05 \Omega)$		
4.20	29 (Eb)	bump	3 x 1500 bumps in 3 directions; 40 g		no damage $\Delta R \text{ max.: } \pm (0.25 \% R + 0.05 \Omega)$		
4.22	6 (Fc)	vibration	Frequency 10 Hz to 500 Hz; displacement 1.5 mm or acceleration 10 g; 3 directions; total 6 h (3 x 2 h)		no damage $\Delta R \text{ max.: } \pm (0.25 \% R + 0.05 \Omega)$		
4.23	2 (Ba) 30 (Db) 1 (Aa) 13 (M) 30 (Db)	climatic sequence:			$R_{\text{ins min.: } 1000 \text{ M}\Omega}$		
4.23.2		dry heat	16 h; 155 °C		$\Delta R \text{ max.: } \pm (1 \% R + 0.05 \Omega)$ $\Delta R \text{ max.: } \pm (1 \% R + 0.05 \Omega)$		
4.23.3		damp heat (accelerated) 1st cycle	24 h; 55 °C; 90 % to 100 % RH				
4.23.4		cold	2 h; - 55 °C				
4.23.5		low air pressure	2 h; 8.5 kPa; 15 °C to 35 °C				
4.23.6		damp heat (accelerated) remaining cycles	5 days; 55 °C; 95 % to 100 % RH	$R \leq 1 \text{ M}\Omega$ $R > 1 \text{ M}\Omega$			
4.24.2	3 (Ca)	damp heat (steady state)	56 days; 40 °C; 90 % to 95 % RH; dissipation 0.01 Pn		$R_{\text{ins min.: } 1000 \text{ M}\Omega}$ $\Delta R \text{ max.: } \pm (2 \% R + 0.05 \Omega)$		

TEST PROCEDURES AND REQUIREMENTS							
IEC 60115-1 CLAUSE	IEC 60068-2 TEST METHOD	TEST	PROCEDURE	RESISTANCE RANGE	REQUIREMENTS		
					SFR16S	SFR25	SFR25H
4.25.1		endurance	1000 h at 70 °C; P _n or V _{max} .		ΔR max.: $\pm (2 \% R + 0.05 \Omega)$		
4.8.4		temperature coefficient	between - 55 °C and + 155 °C (TCR x 10 ⁻⁶ /K)	$R < 4.7 \Omega$ $R \leq 100 \text{ k}\Omega$ $R \leq 1 \text{ M}\Omega$ $R > 1 \text{ M}\Omega$	$\leq \pm 250$ $\leq \pm 100$ $\leq \pm 250$ $\leq \pm 250$	$\leq \pm 100$ $\leq \pm 100$ $\leq \pm 100$ $\leq \pm 250$	$\leq \pm 100$ $\leq \pm 100$ $\leq \pm 100$ $\leq \pm 250$
4.7		voltage proof on insulation	$U_{\text{RMS}} = 400 \text{ V}$ (SFR16S) or $U_{\text{RMS}} = 600 \text{ V}$ (SFR25 and SFR25H); during 1 min; V-block method		no breakdown		
4.12		noise	"IEC publication 60195"	$R < 68 \text{ k}\Omega$ $R \leq 100 \text{ k}\Omega$ $R \leq 1 \text{ M}\Omega$ $R > 1 \text{ M}\Omega$	max. 0.1 $\mu\text{V/V}$ max. 0.5 $\mu\text{V/V}$ max. 1.5 $\mu\text{V/V}$ max. 1.5 $\mu\text{V/V}$	max. 0.1 $\mu\text{V/V}$ max. 0.1 $\mu\text{V/V}$ max. 0.1 $\mu\text{V/V}$ max. 1.5 $\mu\text{V/V}$	max. 0.1 $\mu\text{V/V}$ max. 0.1 $\mu\text{V/V}$ max. 0.1 $\mu\text{V/V}$ max. 1.5 $\mu\text{V/V}$
4.6.1.1		insulation resistance	U_{max} . DC = 500 V during 1 min; V-block method		R_{ins} min.: 1000 M Ω		
4.13		short time overload	Room temperature; P = 6.25 x P _n (SFR25) or 6.25 x 0.25 W (SFR16S); 5 s ON, 45 s OFF ($V \leq 2 \times V_{\text{max}}$); 10 cycles		ΔR max.: $\pm (0.25 \% R + 0.05 \Omega)$		ΔR max.: $\pm (1 \% R + 0.05 \Omega)$
		intermittent overload in accordance with "JIS-C5202 5.8"	16 x 0.16 W; 1 s ON and 25 s OFF; 10 000 $\pm$ 200 cycles; V _{max} = 600 V		ΔR max.: $\pm (0.75 \% R + 0.05 \Omega)$	-	-
see 2 nd amendment to "IEC 60115-1", Jan. '87		pulse load			see Pulse Loading Capabilities graphs		



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