THE DESIRABLE SHORT CIRCUIT PARAMETERS OF SEMICONDUCTOR FUSES

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INTRODUCTION Diodes and thyristors in the following called semiconductor devices SD have short-circuit withstand normally determined in manufacturers sheets* by two parameters: I_{TSM} - non repetitive peak on-state current and I^2t. This paper pointed out, that they do not give a complete determination of the requirements for the selection of semiconductor fuses (SF).

I^2t OR I_{TSM}? I^2t value is defined as follows:

$$I^2t = \int_0^{t_c} i^2 dt$$

where t_c - conductions current duration, i_T - on-state current. Generally that value is determined in data sheets for t_c = 10 ms. In some sheets its value is determined for t_c = 3 ms or 1,5 ms.

On the basis of simple calculation it is possible to demonstrate that manufacturer's I^2t value corresponds to the value calculated for the I_{TSM} declared in another place in data sheets. Well, it may be concluded that that does not give any supplementary information about the short-circuit withstand of examined SD. I^2t value is a simple transform of the already previously know value I_{TSM} only.

DECLARED I_{TSM} AND I_{FSM} Fig.1 shows a summary of manufacturers ratio values $I_{TSM}/I_{T(RMS)}$ versus $I_{T(RMS)}$, where

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* The comments given in this paper are based on data published by ten various European firms in 1974

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$I_{T(RMS)}$ is R.M.S. value of on-state current. From this figure it follows, that the permissible overload currents are very scattered. E.g. the ratios for the same manufacturer SD with nearly the same $I_{T\ RMS}$ (Fig.1, crosses 1A and 1B) differ about 1.5 times one from another. In other case (Fig.1, crosses 2A and 2B) SD, which $I_{T(RMS)}$ values differ abt 3.5 times, have approx. these same value of their non repetitive peak on-state current I_{TSM}. In the case of SD from different manufacturers or with an evidentially different way power losses leading but with the same $I_{T(RMS)}$ the differences are still greater e.g. crosses 3A and 3B and are up to abt 3.5.

<u>I^3t IS BETTER THAN I^2t</u> I_{TSM} and I^2t values given by manufacturer enable the various interpretations of those parameters under working conditions, depending on shape of the overload current curve in SD. Frequently encountered in service shapes are shown in Table I, column 1. In column 2 dependences for $\int_0^{t_c} i^2 dt$ calculations are given. In order to get more distinct further comparison results the I^2t value and I_M for one half-sine wave is treated as a basic one. Than, for this same I^2t but for different curve shapes calculations of I_M value carried out. Results are shown in column 3. Futhermore in column 4 for this same I_M the calculated values of $\int_0^{t_c} i^2 dt$ are given. The results are for this same time t_c.

For typical current shape there are very important values given in line2. E.g. for I^2t = const. the permissible current amplitude is 1.22 times greater than for one half sine-wave amplitude. It means, if $I_M = I_{TSM}$ for half sine-wave one might be overloaded the SD by 1.22 times greater current amplitude.

The short-circuit current time duration is an important factor determining the SD short overcurrent withstand. E.g. from Fig.2 for high data thyristor/it may be concluded that I^2t value decreased to abt 0.65 times if t_c changes from 10 ms to 1.5 ms.

The better determining parameter of SD short circuit current withstand instead of I^2t is I^3t. The next part of paper shows that not only for low data thyristors it is true [1].

The curve 1 in Fig.3 represents the permissible value of the I_{TSM} in the shape of a half-sine wave as determined by the manufacturer in the function of the time t_c. The curve 2 shows dependence calculated from the I^2t = const. condition. A great difference between the curves 1 and 2 is clearly visible. Curve 3 represents the calculated dependence as from I^3t = const. condition. In this case there is a much better conformity with the data given by the manufacturer. The numerous other calculations of the I_{TSM} following from the I^3t condition for $t_c \neq 10$ ms show a good conformity of results (+5%, -10%) with the data given by some manufacturers too. Therefore one may be pointed out, that the I^3t parameter gives the more precise coordinate possibility between SD and SF.

CONCLUSIONS The permissible overload currents of SD are very scattered, indeed. That's why the interchangeability between SD delivered by different manufacturers is impossible now.

The overload current parameters of SD in data sheets are defined for a determined curve shape and overload duration half sine-wave with a time t_c = 10 ms . The shape of the current fault curve in real systems, however, may differ considerably from the declared one. The differences in determining the I_{TSM} and I^2t in dependence upon the shape of the curve may be considerable. Relevant calculations are given in Table I.

The duration of the current fault is different from the declared value 10 ms in many cases. The I^3t = const.parameter gives a better representation of the influence of the fault current amplitude and duration for SD. Correction factors for the relevant calculations with consideration given to the shape of the current curve are compiled in Table I.

REFERENCES

1 Ky Hong, 'I^3t of fuses and semiconductors'. IEEE Transaction on Industrial Electronics and Control Instrumentation, Vol. ICEF 18, No.2, May 1971

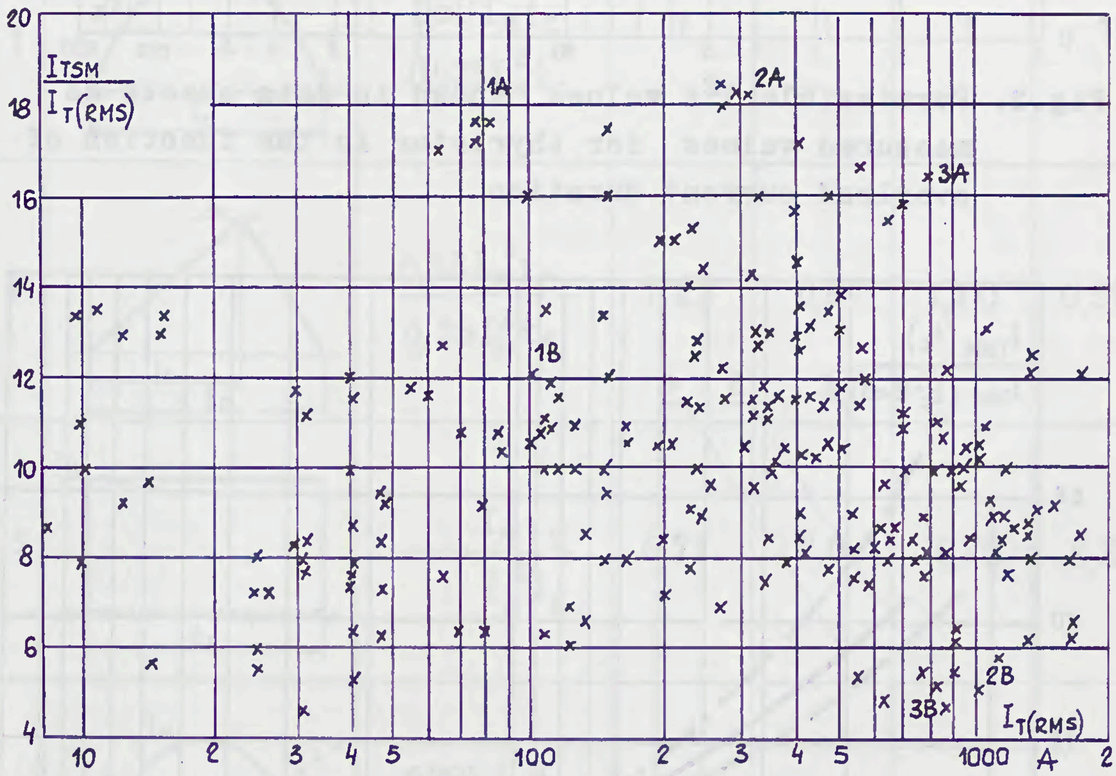


Fig.1. Diode and thyristors relative non-repetitive on-state current values in the function of on-state current absolute values as declared by manufacturers

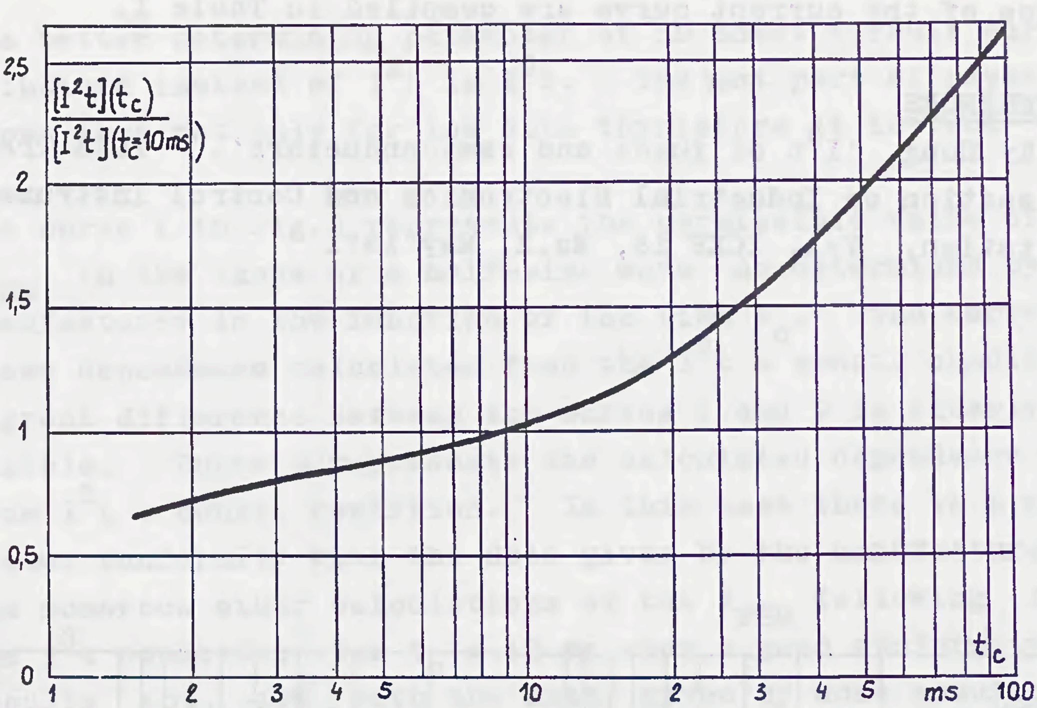


Fig.2. Permissible I^2t values shown in data sheets as measured values for thyristor in the function of overload current duration

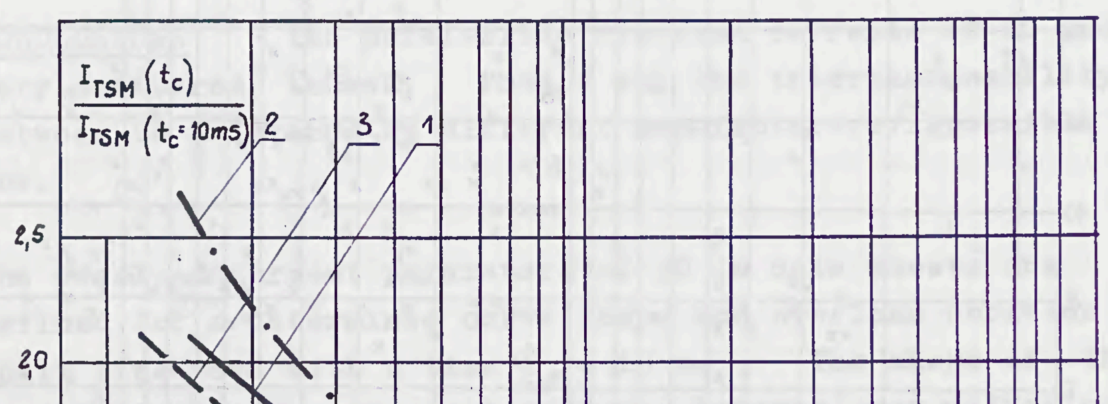
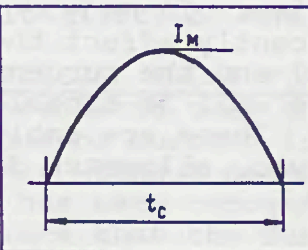
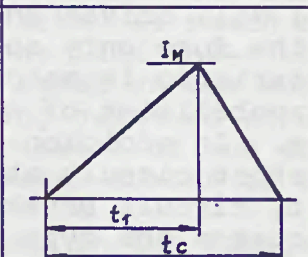
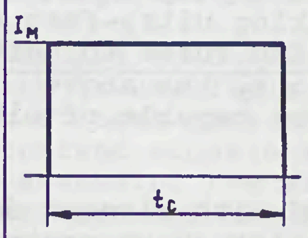
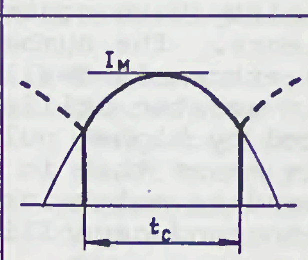
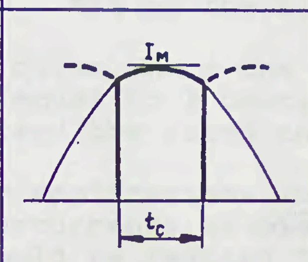


Fig.3. Comparison of non repetitive on-state current permissible values in the function of overload duration - 1 - value determined ny measurement; 2 - calculated from condition I^2t = const.; 3 - calculated from condition I^3t = const.

Table I Relations for determining I^2t and I^3t parameter values for various shapes of the current curve

	SHORT-CIRCUIT CURRENT CURVE SHAPS	RELATIONS $I^2t = f(I_M, t_c)$ $I^3t = f(I_M, t_c)$	RATIO OF I_M	RATIO OF $\int_0^{t_c} i^2 dt$	RATIO OF I_M	RATIO OF $\int_0^{t_c} i^2 dt$
		FOR	$I_M^2 t = const$	$I_M = const$	$I_M^3 t = const$	$I_M = const$
	1	2	3	4	5	6
1		$0{,}50 I_M^2 t_c$ / $0{,}425 I_M^3 t_c$	1	1	1	1
2		$0{,}33 I_M^2 t_c$ / $0{,}25 I_M^3 t_c$	1,22	0,67	1,20	0,59
3		$I_M^2 t_c$ / $I_M^3 t_c$	0,71	2,0	0,75	2,35
4		$0{,}704 I_M^2 t_c$ / $0{,}621 I_M^3 t_c$	0,84	1,45	0,88	1,46
5		$0{,}913 I_M^2 t_c$ / $0{,}875 I_M^3 t_c$	0,74	1,83	0,78	2,05