1. Introduction

Whilst there are international standards associated with electrical parameter naming and definitions, it is a fact that datasheets are not required to be created to a fixed international standard. This means datasheets must be read and interpreted carefully to ensure that parameter descriptions and values are correctly understood. Datasheet creators often wish to present the highest numbers possible for parameter values by measuring parameters under “favourable conditions”. This is done irrespective of whether such conditions are relevant to an application in which a device may be used.

It is also possible that the same symbol or closely similar symbol for a parameter is used in manufacturers’ datasheets, but the description of the parameter by each manufacturer may differ. This is important to bear in mind when reading any datasheet to ensure that a right understanding is gained.

The IFRM parameter is considered in this datasheet explanation note.

2. I_{FRM} defined as “repetitive peak forward current”

In a WeEn datasheet, the $\mathbf{I_{FRM}}$ parameter is defined and shown in the line after the $\mathbf{I_{F(AV)}}$ rating (See Table 1).

Table 1. Example from a WeEn diode datasheet

Symbol	Parameter description	Conditions	Value	Unit
$\mathbf{I_{F(AV)}}$	Average forward current	δ = 0.5; square wave pulse; $T_{mb} \leq 131$ °C	20	A
$\mathbf{I_{FRM}}$	Repetitive peak forward current	δ = 0.5; t_p = 25µs; square wave pulse; $T_{mb} \leq 131$ °C	40	A
$\mathbf{I_{FSM}}$	Non-repetitive peak forward current	t_p = 10ms; $T_{(init)}$ = 25 °C; sine wave pulse	220	A
		t_p = 10µs; $T_{(init)}$ = 25 °C; sine wave pulse	1440	A

In **Table 1,** a “20A average forward current” in a diode with δ = 0.5; square wave pulse, means a repetitive peak forward current of 40A can be conducting for 50% of the time provided $T_{mb} \leq 131$ °C.

This applies to a high frequency circuit where each pulse is relatively short and so in the datasheet, the $\mathbf{I_{FRM}}$ parameter shows a peak forward current of 40A with condition δ = 0.5 and a duration limitation of t_p = 25µs with $T_{mb} \leq 131$ °C (See Fig. 1).

The limiting of the pulse duration to 25µs corresponds to a lower limit of 20kHz for the frequency of operation. Since most power supply circuits operate at higher frequencies, this is not an issue. Effectively, the WeEn $\mathbf{I_{FRM}}$ parameter is an *additional clarification* of the $\mathbf{I_{F(AV)}}$ rating in the continuous current conduction condition.

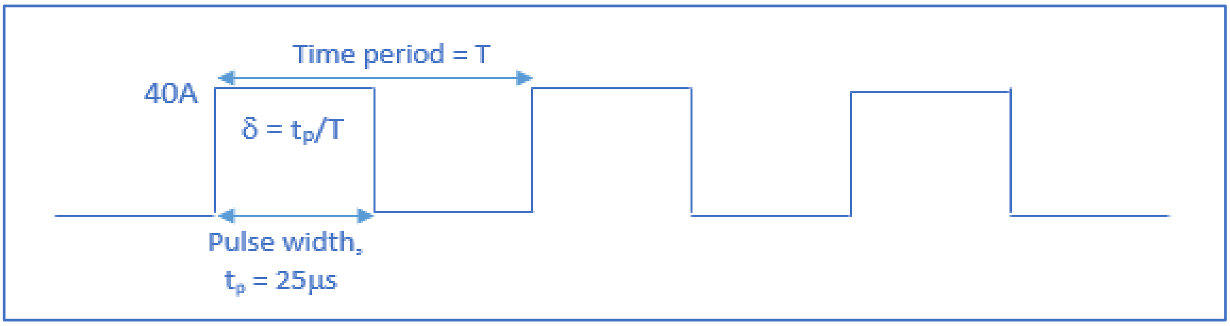

Fig.1 Peak current of 40A with δ = 0.5 and frequency = 1/T Hz

3. I_{FRM} defined as “repetitive peak forward surge current”

Table 2 shows an example of the $\mathbf{I_{FRM}}$ parameter of another manufacturer *defined in a different way* as “repetitive peak forward surge current”. This means that this version of the $\mathbf{I_{FRM}}$ parameter is *not* related to the $\mathbf{I_{F(AV)}}$ parameter but to the $\mathbf{I_{FSM}}$ rating which shares the same condition of “t_p = 10ms; half sine wave” (See Table 2).

Table 2. Example from another manufacturer’s diode datasheet

Symbol	Parameter description	Conditions	Value	Unit
I_{FRM}	Repetitive peak forward surge current	$T_c \leq 25$ °C; t_p = 10ms; half sine pulse	86	A
		$T_c \leq 110$ °C; t_p = 10ms; half sine pulse	56	A
I_{FSM}	Non-repetitive forward surge current	$T_c \leq 25$ °C; t_p = 10ms; half sine pulse	130	A
		$T_c \leq 110$ °C; t_p = 10ms; half sine pulse	104	A

The $\mathbf{I_{FSM}}$ (non-repetitive forward surge current) half-sine wave condition is for a single half-sine wave while the condition for this $\mathbf{I_{FRM}}$ parameter must be assumed to be for a continuous series of half-sine waves repeating every 20ms (for 50Hz).

It is questionable that testing with such a continuous series of half-sine waves at 50Hz would be of interest to the power circuit designer wishing to use high frequency diodes. However, the non-repetitive, single pulse of the $\mathbf{I_{FSM}}$ rating is relevant because it can relate to the inrush current pulse that a diode sees when a Switch Mode Power Supply (SMPS) starts-up. It is difficult to understand how a repetitive (continuous) series of half-sine waves at very low frequency (50Hz) could relate to any application condition that a diode would experience in high frequency switching power supplies (>20 kHz)

A series of indefinitely repeating 10ms half-sine waves effectively relates to “continuous current capability” rather than “surge” despite the naming of the parameter “repetitive peak forward *surge* current”.

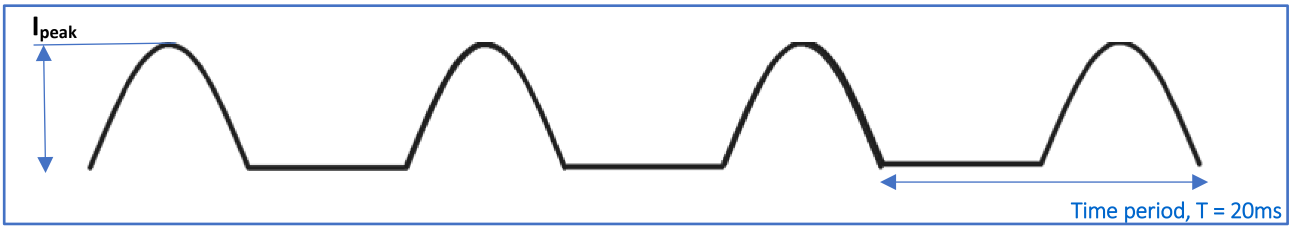

Fig. 2 Continuous current of 10ms half-sine waves

4. “Continuous current capability of power diodes” -RMS equivalent

By translating whatever conditions are used by a manufacturer to the “RMS equivalent”, it is possible to have a meaningful and fair comparison of the capability between various devices.

Any ratings related to continuous conduction, whether in the form of $\mathbf{I_{F(AV)}}$ using square values, $\mathbf{I_{FRM}}$ using half-sine waves or even $\mathbf{I_F}$ for DC current, enable a calculation of the average continuous power generated in the component. This shows how high $T_{junction}$ would rise and what max T_{mb} (or T_c) is allowed when conducting that level of RMS power. The calculation of the average continuous power for any waveform can be done using the “Vo” and “Rs” in the forward current characteristics in the datasheet.

For “continuous current capability” of diodes, the condition at T_c =25 °C is not meaningful because “continuous conduction” implies that power is being dissipated from the diode to the ambient in steady-state and consequently T_c at 25 °C is not possible.

It is important then to consider the higher temperature condition $T_c \leq 110$ °C. In Table 2, the value of 56A is presented as the $\mathbf{I_{FRM}}$ value referring to the *peak* of the half-sine wave. In such a case, mathematically, a half-sine wave repeating at 50Hz has an RMS value of $\mathbf{I_{peak}/2}$ and so for this condition 56A is equivalent to $\mathbf{I_{F(RMS)}}$ of 28A.

Using the WeEn definition, the continuous current capability given by $\mathbf{I_{F(AV)}}$ = 20A at 50% duty cycle for T_{mb} (this is the same as T_c) for this square pulse waveform is $\frac{\sqrt{Ipeak^2}}{2}$. This gives 28.2A.

This equivalent RMS current of 28.2A at $T_{mb} \leq 131$ °C ($T_c \leq 131$ °C) is a superior figure to the equivalent RMS current of 28A @ $T_c \leq 110$ °C. In this comparison, the WeEN device can handle a higher continuous

RMS current while allowing a higher Tc than another manufacturer even though a simple comparison of parameter values might indicate otherwise (e.g. $\mathbf{I_{FRM}}$ = 40A compared to 56A). The same conclusion will be true if we do the calculations for any other waveform combinations.

5. Conclusion

Datasheet creators often wish to present the highest numbers possible for parameter values by measuring parameters under “favourable conditions”. This is done irrespective of whether such conditions are relevant to an application in which a device may be used. Careful reading of the datasheet parameter symbols, definitions and conditions is required to reach a correct understanding of a power device’s $\mathbf{I_{FRM}}$ capability. Simply looking at values in a column will lead a designer and purchaser to wrong conclusions. This note explains how to translate continuous current datasheet conditions to an RMS equivalent current for meaningful and fair comparison.

Revision history

Rev	Date	Description
v.1	20190828	initial version

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