AN-1002

How to Check SOA of MOSFET

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MOSFET is used in various power supply applications. To provide a right Safe Operating Area (SOA) of MOSFET for designer is an important. SOA is define the maximum value of V_{DS}, I_D and time envelope of operation which guarantees safe operation when the MOSFET work in forward bias.

SOA (Safe Operating Area)

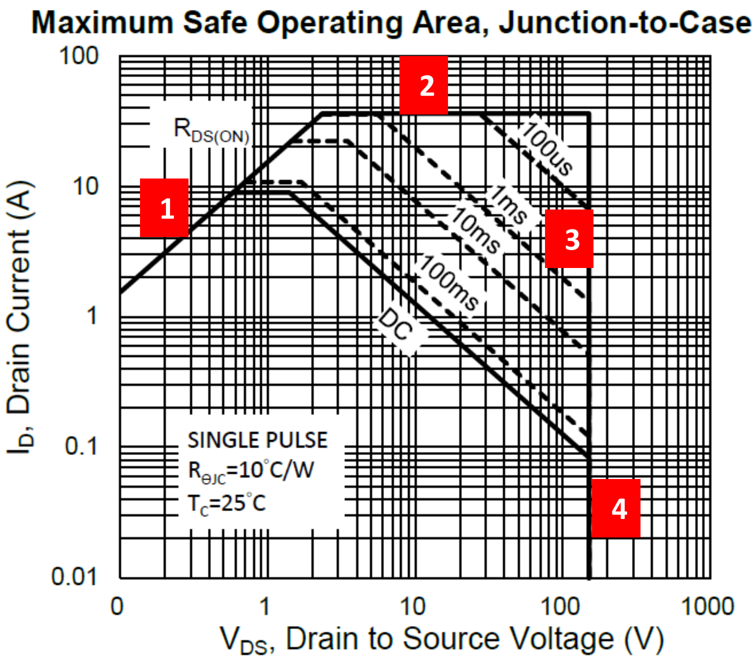

Fig 1. SOA of TSM650N15CS

The red number indicated as following

1 : Maximum $R_{DS(ON)}$ limit ; V_{DS} / I_D

2 : The line is limit by Pulsed Drain Current (I_{DM}) of MOSFET

3 : Pulsed power dissipation ; $P_{DM} = V_{DS} \times I_D = (T_J(max) - T_C (25°C)) / (R_{\theta JC} \times Z_{\theta JC})$

4 : The line is limit by drain to source breakdown voltage. (The TSM650N15CS's breakdown voltage is 150V)

How to check SOA limitations

◆ **$R_{DS(ON)}$**

$R_{DS(ON)} = V_{DS} / I_D$ TSM650N15CS => $R_{DS(ON)}$ = 65mohm@10V_{GS} (Refer to Datasheet)

The corner voltage is :

$\mathbf{V_{DS} = R_{DS(ON)} \times I_D}$ = 65mohm x 36A = 2.34V (Please refer to Fig 2)

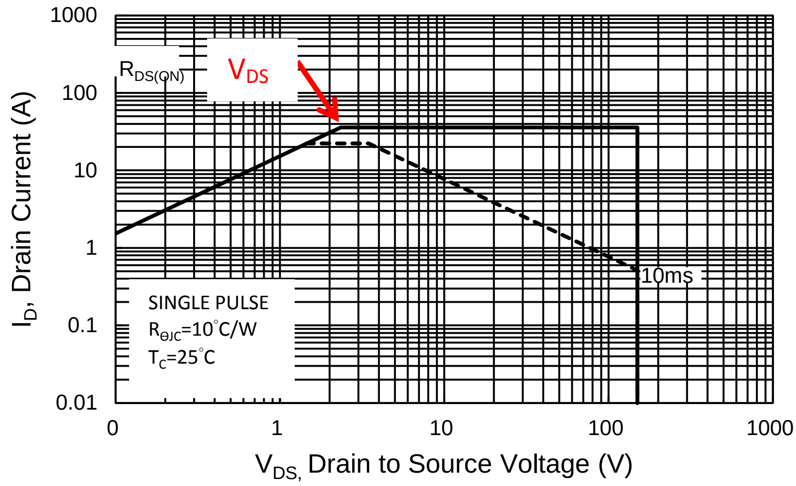

Fig 2. SOA of TSM650N15CS

◆ Pulsed Drain Current (I_{DM})

$$\mathbf{I_{DM} = I_D \times 4}$$

$$\mathbf{I_D = \sqrt{\,(T_J\,(max) - T_C\,(25°C)\,) / (\,R_{\theta JC} \times R_{DS(ON)} \times K\,)}}$$

TSM650N15CS => $R_{DS(ON)}$: 65mohm@10V_{GS} (Refer to Datasheet)

$R_{\theta JC}$: 10°C/W

K : 2.4@150°C (Refer to Fig 3)

K meant the $R_{DS(ON)}$ value changed under various Temperature. So, We will choice the K at 150°C junction temperature.

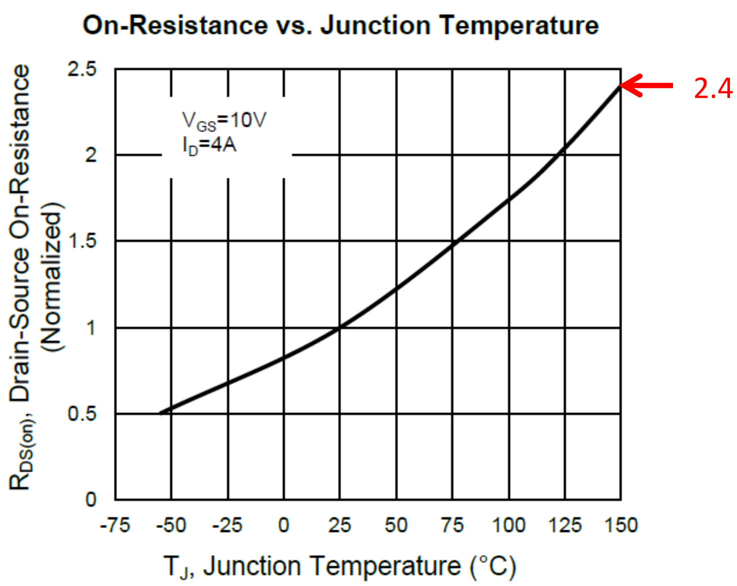

Fig 3. $R_{DS(ON)}$ vs. T_J

The I_{DM} is :

$I_D = \sqrt{(T_J(max) - T_C(25°C)) / (R_{θJC} \times R_{DS(ON)} \times K)}$ = (150°C - 25°C) / (10°C/W x 65mohm x 2.4) = 9 Amp

$I_{DM} = I_D \times 4$ = 9 Amp x 4 = 36 Amp (Refer to Fig 4)

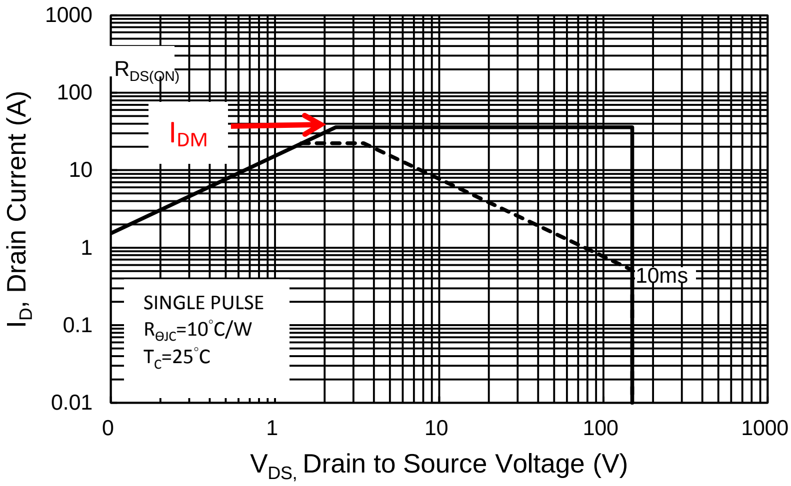

Fig 4. SOA of TSM650N15CS

◆ P_{DM} (Pulsed Power Dissipation)

$P_{DM} = V_{DS} \times I_D = (T_J(max) - T_C(25°C)) / (R_{θJC} \times Z_{θJC})$

TSM650N15CS => $R_{θJC}$: 10°C/W

$Z_{θJC}$: 0.16@ t =10mS (Refer to Fig 5)

V_{DS} : Breakdown Voltage of MOSFET

As usually, The power limit in timing period (Duty = t1/t2) , we have to check the thermal transient impedance.(Refer to Fig 3).

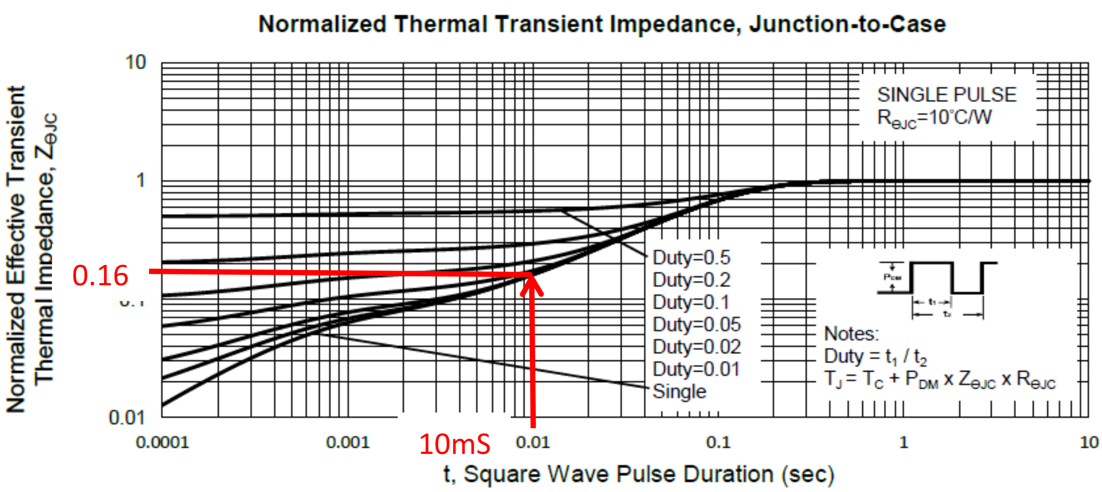

Fig 5. $Z_{θJC}$ of TSM650N15CS

For pulse width of 10mS, we get normalized figure of 0.16 from single pulse curve in the plot. Then we know the power dissipation for 10mS pulse as

The P_{DM} is :

P_{DM} = (T_J (max) – T_C (25°C) / ($R_{\theta JC}$ x $Z_{\theta JC}$) = (150°C - 25°C) / (10°C/W x 0.16) = 78.125 Watts (the black dot line)

P_{DM} = V_{DS} x I_D => I_D = P_{DM} / $V_{DS(Breakdown)}$ = 78.125W / 150V = 0.52Amp (Refer to Fig 6)

From above formula, We can know the current start point of 10mS is 0.52Amp. The purpose is according to those parameters and calculation. We can check the curve is okay or not at various timing conditions.

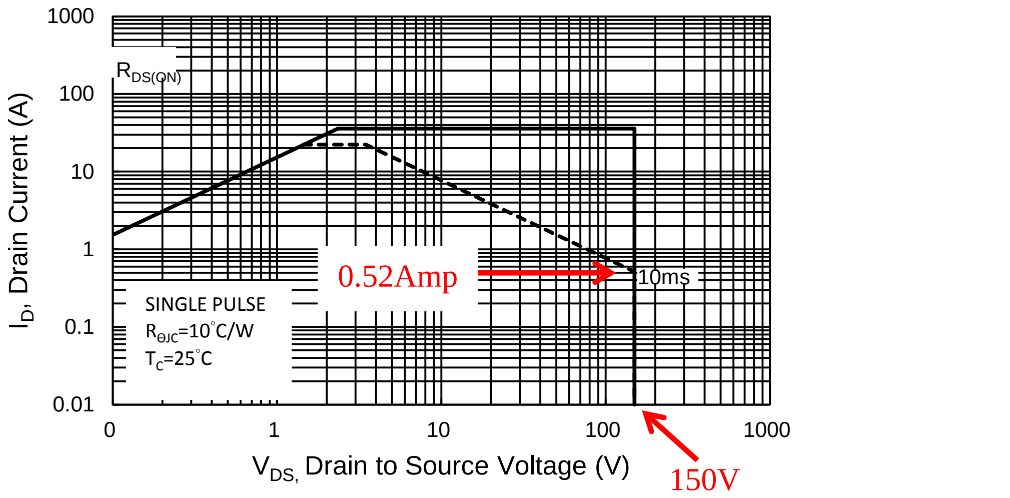

Fig 6. SOA of TSM650N15CS

◆ V_{DS} (Breakdown Voltage)

We can see the X axis of SOA curve. The voltage line is limit by the maximum Drain to Source breakdown voltage of MOSFET. (Refer to Fig 7) The TSM650N15's V_{DS} is 150V.

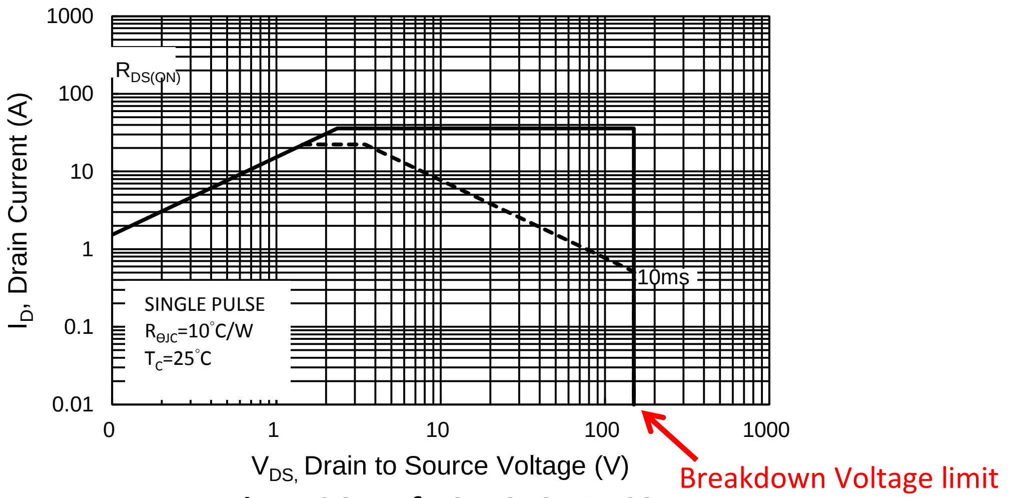

Fig 7. SOA of TSM650N15CS

◆ Conclusions

SOA is very important curve for designer to design different applications. The various limit-lines in the SOA curve respect different parameters. The datasheet typically provides the SOA curve in T_C =25°C/ T_J =150°C conditions and various single pulse lengths. Please follow up the SOA curve lines limit when to use power MOSFET in different applications.

References

1. TSM650N15CS ---------------------- 150V Power MOSFET Datasheet

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