

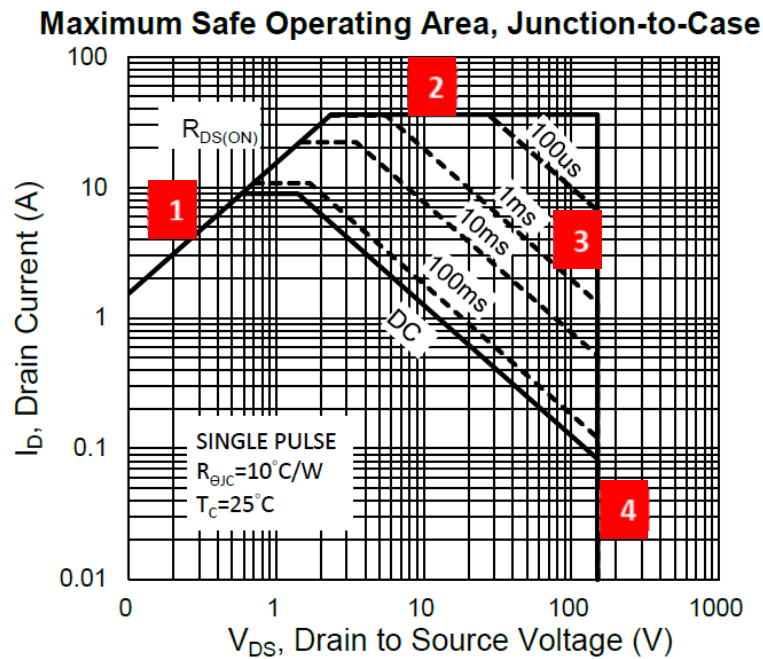
## **AN-1002**

### How to Check SOA of MOSFET

## How to check SOA of MOSFET

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 )

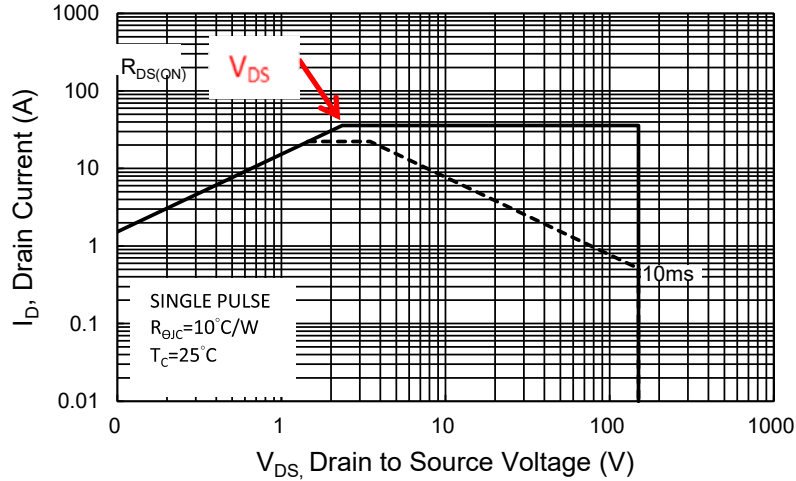


**Fig 1. SOA of TSM650N15CS**

**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

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



**Fig 2. SOA of TSM650N15CS**

◆ Pulsed Drain Current (  $I_{DM}$  )

$I_{DM} = I_D \times 4$

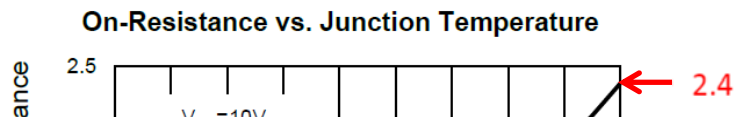
$I_D = \frac{V ( T_J (\text{max}) - T_C ( 25^\circ\text{C} ) )}{ ( R_{\theta JC} \times R_{DS(ON)} \times K )}$

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

$R_{\theta JC}$  : 10°C/W

K : 2.4@150°C ( Refer to Fig 3 )

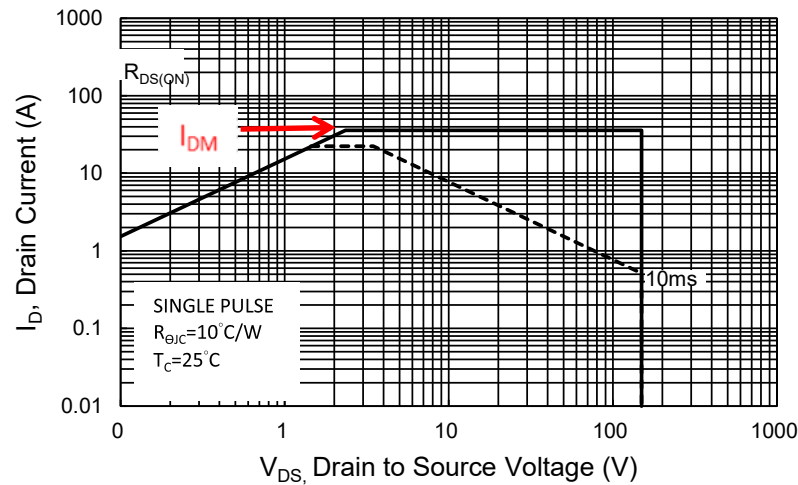
K meant the  $R_{DS(ON)}$  value changed under various Temperature. So, We will choice the K at 150°C junction temperature.



The  $I_{DM}$  is :

$$I_D = \sqrt{(T_J(\text{max}) - T_C(25^\circ\text{C})) / (R_{\theta JC} \times R_{DS(ON)} \times K)} = (150^\circ\text{C} - 25^\circ\text{C}) / (10^\circ\text{C/W} \times 65\text{mohm} \times 2.4) = 9 \text{ Amp}$$

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



**Fig 4. SOA of TSM650N15CS**

◆  **$P_{DM}$  ( Pulsed Power Dissipation )**

$$P_{DM} = V_{DS} \times I_D = (T_J(\text{max}) - T_C(25^\circ\text{C})) / (R_{\theta JC} \times Z_{\theta JC})$$

TSM650N15CS =>  $R_{\theta JC} : 10^\circ\text{C/W}$

$Z_{\theta JC} : 0.16 @ t = 10\text{ms}$  ( Refer to Fig 5 )

$V_{DS} : \text{Breakdown Voltage of MOSFET}$

As usually, The power limit in timing period ( Duty =  $t_1/t_2$  ), we have to check the thermal transient impedance.( Refer to Fig 3 ).

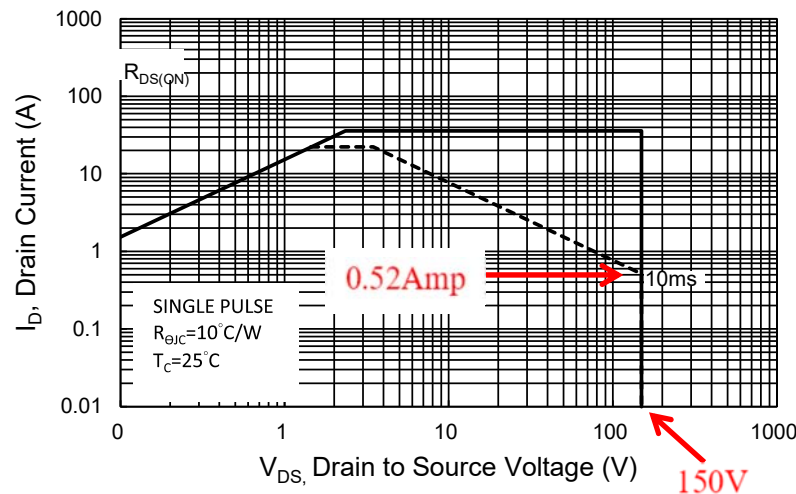
For pulse width of 10mS, we get normalized figure of 0.16 from single pulse curve in the plot. Then we know the power dissipation for 10mS pulse as

The  $P_{DM}$  is :

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

$$P_{DM} = V_{DS} \times I_D \Rightarrow I_D = P_{DM} / V_{DS(\text{Breakdown})} = 78.125\text{W} / 150\text{V} = 0.52\text{Amp ( Refer to Fig 6 )}$$

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.

## ◆ 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  $T_C = 25^\circ\text{C}$  /  $T_J = 150^\circ\text{C}$  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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