Understanding Mosfet Threshold voltage and its characteristics

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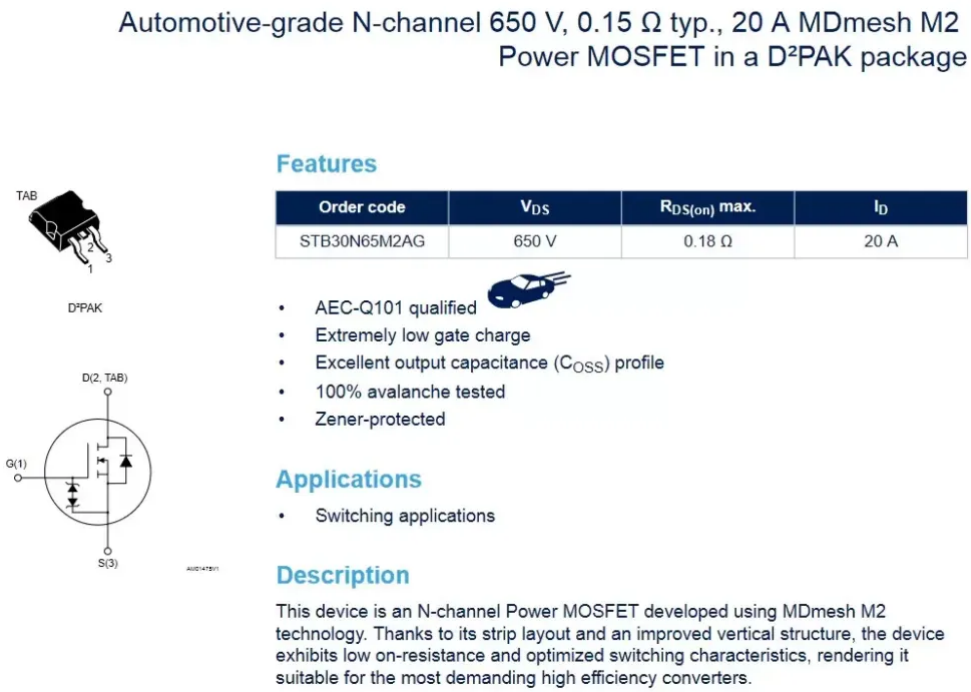
If you are an electronics enthusiast or an hobbyist than there might have been a chance that you have to use a Mosfet in your circuit and than a question arises that which and how should I select a Mosfet. There are two main important parameter that you should consider for selection and they are Mosfet Rds on and threshold voltage.

In this Article we look in detail what is Mosfet Threshold Voltage with its important characteristics and how it impacts the design. So if you are designing a high power circuit around say greater than 100W than precise Mosfet selection is needed.



Automotive-grade N-channel 650 V, 0.15 Ω typ., 20 A MDmesh M2
Power MOSFET in a D²PAK package

TAB
1 2 3
D²PAK

D(2, TAB)
G(1)
S(3)

Features

Order code	V_{DS}	$R_{DS(on)}$ max.	I_D
STB30N65M2AG	650 V	0.18 Ω	20 A

- AEC-Q101 qualified
- Extremely low gate charge
- Excellent output capacitance (C_{OSS}) profile
- 100% avalanche tested
- Zener-protected

Applications

- Switching applications

Description

This device is an N-channel Power MOSFET developed using MDmesh M2 technology. Thanks to its strip layout and an improved vertical structure, the device exhibits low on-resistance and optimized switching characteristics, rendering it suitable for the most demanding high efficiency converters.

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Mosfet Selection based on Voltage
Factors affecting Threshold Voltage of Mosfet
- Temperature
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What is Mosfet Threshold Voltage ?

This breakdown voltage is given in the suppliers datasheet and is rated in Volts and for our understanding we will use as an example of high voltage Mosfet
switch STB30N65M2AG datasheet.

Mosfet threshold voltage is nothing but the breakdown or the blocking voltage of the FET or CMOS such that if operated beyond this limit than FET or CMOS could be destroyed.

So for STB30N65M2AG (which is a high current high voltage FET) the threshold voltage is 650 V and is represented by VDS where V stands for threshold voltage, D stands for drain and S stands for Source that is drain to source blocking voltage.

The details can be founded in the datasheet in the above link provided. So if this FET operated beyond 650 V than there is a greater chance that it could lead to the breakdown and eventually failure mode.

Consider the above circuit in the first cycle the inductor is charged by turning on the switch, in the next cycle the inductor is discharged by turning of the switch, here comes the important part when the switch is turned off all the energy of the inductor is dumped into the switch,

Since the switch is closed the energy will not pass and will convert into voltage higher and higher depending on energy. so for choosing the MOSFET at this location maximum peak voltage should be known.

Now you can say peak voltage in my circuit comes around 600V, so I can choose FET of 650V that should be fine voltage wise but the answer is no if your peak voltage is 600V than also 650V FET will not work why?

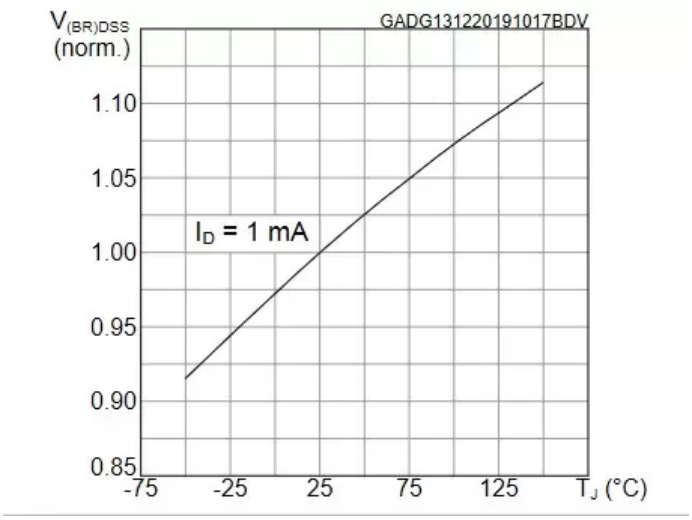
Mosfet Selection based on Voltage

The answer before deciding the FET voltage rating you should know the maximum peak and the most important parameter is operating temperature at that peak.

Usually the ratings mentioned in the datasheet is for 25degC, and if your circuit operating temperature goes down upto -40degC than you need take FET which has 650V at the -40degC such operating condition called as worst case operation.

for the example FET at -40degC gives voltage around 598V which is too low than the 650V.

How 598V ?



Check out this Mosfet threshold voltage characteristics at -40deg (x axis) points to around 0.92 factor (y axis), now multiply this factor with rated voltage which is at 25degC i.e. 650V*0.92 = 598V.

Usually with drain current MOSFET voltage doesn't change very high but almost remain same. The same theory is applicable to both wither p channel or N channel Mosfet.

If you see from the graph that at 25degC factor is 1 which means 650V*1 = 650V at 25degC. so next time for your worst case design choose the maximum voltage rating of your FET this way.

Factors affecting Threshold Voltage of Mosfet

if you look into the datasheet carefully than you will come to know that there some factors that could impact the drain to source breakdown voltage which is nothing but a threshold.

Temperature

As the temperature decreases the blocking voltage capability of the FET or CMOS or NMOS also decreases and increase in the temperature will increase the voltage capability.

Gate Voltage

With increase in the gate voltage increases the Threshold voltage and decreasing the gate voltage will decrease the VDS. check in the datasheet for detailed relation between these parameters.

do check how to design the high side Mosfet gate driver

Drain current

Ultimately it all leads to the power rating of the MOSFET based on the drain to source current and off resistance (which ultimately comes from gate threshold voltage) if the power rating is increased beyond the rated than even at 400V our FET could be destroyed easily.

So hope you liked this article where we learned one aspect of MOSFET selection based on its blocking or drain to source or threshold voltage