MOSFET Rds(on) question

Asked 9 years, 8 months ago Active 9 years, 8 months ago Viewed 29k times

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I have a question related to the Rds(on) property of a MOSFET (IRF630N).

Once the MOSFET is turned on (Vgs > Vth) will Rds(on) vary with the increase of Vgs? Or it is not affected by the gate voltage once the MOSFET is on. Will it be affected only by the junction temperature? How is Rds(on) related to the Drain current?

2

mosfet

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edited May 21 '12 at 14:18

stevenvh

142k • 20 • 443 • 658

asked May 20 '12 at 20:52

Buzai Andras

727 • 4 • 10 • 19

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$R_{DS(ON)}$ is an important parameter, and many datasheets start with mentioning values for them.
For the FDC885N two values are mentioned in the *Features* section at the start of the datasheet:

> Max $R_{DS(ON)}$ = 27mΩ at V_{GS} = 10V, I_D = 6.1A

> Max $R_{DS(ON)}$ = 36mΩ at V_{GS} = 4.5V, I_D = 5.3A

From the same datasheet:

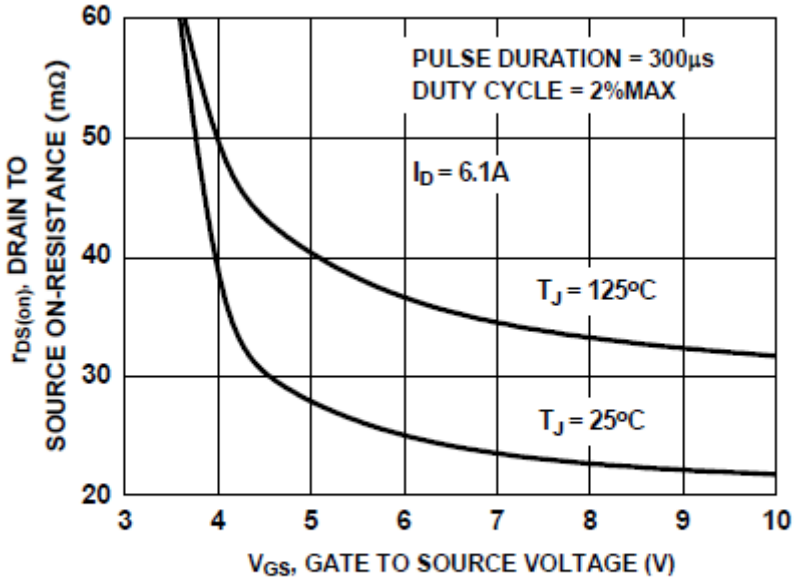

Figure 4. On-Resistance vs Gate to Source Voltage

So, yes, $R_{DS(ON)}$ varies with V_{GS}, and yes, it's higher at higher temperatures.

If your manufacturer can't give you the information and you really need it, move on to another manufacturer.

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edited May 21 '12 at 9:59

answered May 21 '12 at 5:15

stevenvh

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8 @"Read. The. Goddamn. Datasheet! For Pete's sake." Well for Pete's sake I have read the datasheet (for IRF630N) and I couldn't find the graph of Rds(on) vs Vgs (I may be blind). That, along with the hope of

receiving more clarifications, is why I asked the question. Also for a beginner a datasheet may be confusing. So please don't be rude. If you want to answer a question answer it. If no then don't. But please don't be rude. – Buzai Andras May 21 '12 at 9:44

1 @Buzai - Ok, sorry about that. I wouldn't like to invite all those to dinner who *never* had a look at a datasheet. The datasheet *should* give you the information. I have moved to a different manufacturer because of things like this. You're buying their product, you're entitled to a decent service. That's not just playing the bad boy, you may *need* that information. At least now you know that it varies. If you want to stick to the IRF630N, contact the manufacturer for details. – stevenvh May 21 '12 at 9:57

Thank you. I will take your advice and search for another product from a different manufacturer. – Buzai Andras May 21 '12 at 12:48

@stevenvh, corrected in time. By that I mean not a flag was given that day. Good answer. – Kortuk May 21 '12 at 13:56

@Kortuk - Yeah, don't worry, we'll be doing alright! :-) Thanks for keeping an eye on it. – stevenvh May 21 '12 at 14:17

5

There is no magic gate voltage threshold at which a FET suddenly switches from full off to full on. There is voltage at which a small change in gate voltage causes the most change in channel resistance, and sometimes this is termed the "threshold", but it is still a continuous function.

Look at the datasheet for a MOSFET intended for low gate voltage operation. These are sometimes called *logic level* FETs. They may have a reasonable on resistance at 3.3 V, but usually a bit better at 5 V, and sometimes they are specified for higher voltages too just so you know what the part can do should you be able to supply higher gate voltage.

For example, the IRLML2502 is guaranteed to not exceed 80 mΩ at 2.5 V on the gate, but is guaranteed to 45 mΩ at 4.5 V. That part is also specified to have a "gate threshold voltage" of 600 mV to 1.2 V, which is not really all that relevant of a spec. It is trying to tell you that the channel won't come on much as long as you hold the gate at 600 mV or less, but since they don't give you actual current or resistance numbers it's not much to design by.

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answered May 20 '12 at 21:04

Olin Lathrop
304k ● 36 ● 410 ● 879

fyi the gate threshold voltage is indeed spec'ed at a specific drain current, (0.25mA for the part you referenced). Ref the "Conditions" column in the electrical characteristics. – Art Brown May 20 '12 at 23:46

4

Rds(ON) improves (decreases) with higher gate voltage, even after the FET is ON (but if the gate voltage gets too high, the reliability of the part suffers).

Rds(ON) increases with junction temperature.

Rds(ON) is insensitive to drain current until you get near the active region of the FET (where it

Rds(ON) is insensitive to drain current until you get near the active region of the FET (where it comes out of saturation).

For the IRLML2502 referenced in Olin Lathrop's answer, there are plots of all three characteristics in the datasheet.

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edited May 21 '12 at 4:58

stevenvh
142k ● 20 ● 443 ● 658

answered May 20 '12 at 23:59
Art Brown
461 ● 3 ● 7

I have one more question (not sure if I should post another question for this). When using the MOSFET as a switch, for the on state is should be used in the triode mode (the BJT saturation mode analogous). Is this correct? – Buzai Andras May 21 '12 at 21:29

@BuzaiAndras: I'm not sure what you mean by triode mode. When using a MOSFET as a switch, you want to transition it rapidly through the region where the drain current is controlled by the gate-source voltage (as opposed to the drain current being either 0 (OFF, gate-source voltage < threshold) or set by external circuit elements (ON, Vgs >> threshold), in both directions. In practice, this means providing a slug of current to charge or discharge the gate capacitance. (The difference from a BJT is that you don't need to supply any "maintenance" current to hold a FET ON, once it's turned ON.) – Art Brown May 22 '12 at 0:23

I read in the lecture notes from the following link: ittc.ku.edu/~jstiles/312/handouts/... that the BJT saturation mode analogous in MOSFETS is the Triode mode. I am a little confused with the different names for the operation modes in MOSFETs vs BJTs. – Buzai Andras May 22 '12 at 6:54

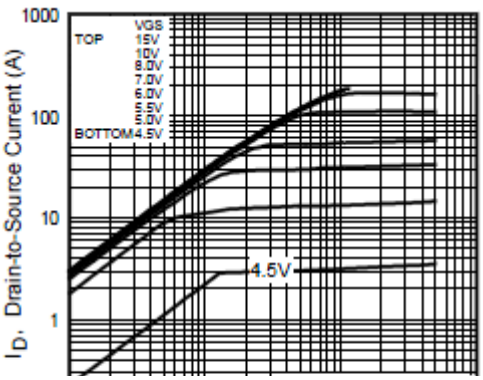
I find MOSFET mode terminology very unfortunate. (I think I learned "linear" instead of "triode".) – Art Brown May 22 '12 at 15:40

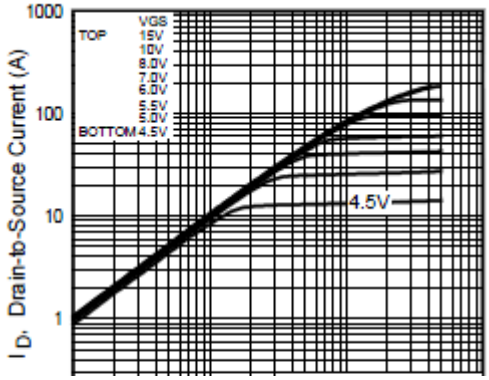
MOSFET Saturation = BJT Active, and MOSFET triode/linear = BJT Saturation from a circuit point of view. I like and tend to use the BJT jargon for both BJTs and FETs. One thing I think the ku notes could emphasize more is that in BJT Sat (FET triode) the Collector/Drain Current is determined by external circuit elements (to first order), e.g. for a supply Vs connected to the collector/drain by a resistor R, in sat/triode mode the coll/drain current is approximately Vs/R. – Art Brown May 22 '12 at 15:49

3

> Once the MOSFET is turned on (Vgs > Vth) will Rds(on) vary with the increase of Vgs? Or it is not affected by the gate voltage once the MOSFET is on.

There's not much Rdson variation. You can get a sense for how much this changes by looking at the VI curves on your particular MOSFET's datasheet. For example, take a look at the IRFP260N:





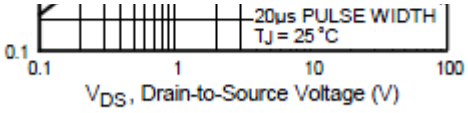


Fig 1. Typical Output Characteristics

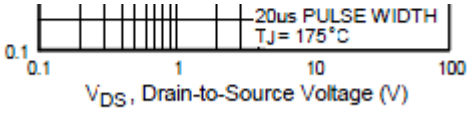


Fig 2. Typical Output Characteristics

These are the current vs. voltage characteristics for various gate voltages. The IRFP260N has guaranteed Rdson specs for 10Vgs; it's not a logic-level FET and expects 10V to fully turn on.

MOSFETs have two basic operational modes. If you want to operate them as a switch, then you want the current to be low enough so you're operating on the Rdson side of the curve: Vds = Rdson * Id. For a given gate-to-source voltage, there is a current limit above which Vds just shoots upwards because the MOSFET acts like a current sink. This is great for linear amplifiers but bad in power circuits and you usually won't want to operate here.

If you look at the datasheet curves, you'll note that the current limit changes quite a bit with Vgs. You'll also note that for the most part, the Rdson part of the curve does not change much with Vgs. At 25 C, Vgs above 5.5V has basically the same Rdson behavior, and at 175 C, Vgs of 4.5V or more has basically the same Rdson behavior.

> Will it be affected only by the junction temperature?

Variation vs. junction temperature is fairly predictable and will also be in the datasheet. You typically see a factor of 1.5 - 2.5 increase from 25 C to the maximum operating temperature (150-175 C) and need to plan accordingly.

answered May 21 '12 at 13:50

Jason S
13.8k ● 3 ● 40 ● 66