Re: MOSFET body diodes

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- *From*: "Fritz Schlunder" <me@xxxxxxxxxxx>
- *Date*: Mon, 24 Oct 2005 17:46:53 −0700

"Terry Given" <my_name@xxxxxxxx> wrote in message
news:1130188291.913848@xxxxxxxxxx
> John Larkin wrote:
> > I have blown fets in h−bridges driving motors, at very low currents.
> > Seems the substrate diodes had a snap recovery characteristic that
> > blew the gates out somehow. These were older power fets, and I think
> > some newer parts are rated to survive this.
> >
> > John
> >
>
> Hi John,
>
> Win mentioned this in a post a few months back − seems the snap−off can
> be sub−ns, and the resultant enormous dI/dt drops enough V across stray
> L to over−voltage the gates.
>
> If we guess Lstray = 10nH and Vsplat = 30V, Idead = 30V*1ns/10nH = 3A.
> So with sub−ns snap−off, its probably fairly easy to do....
>
> Cheers
> Terry

This is an interesting theory, but I find it hard to believe. Any parasitic Lstrays in series with the drain or source would tend to cause the drain voltage to increase, and source voltage to decrease. The gate however is a relatively large capacitor, and it's voltage cannot change instantly. Any change in gate voltage must be supplied with current through the gate driver circuit. The really important thing however, is that the body diode snap off event would try to increase the gate source voltage (for an N−channel device). As the gate source voltage were to increase beyond the threshold voltage of the MOSFET, the device would begin to turn on, thus inherently limiting the peak dI/dt event, and consequently, the maximum gate−source voltage reached.

Far more likely in my mind is the high speed snap off will cause the drain−source voltage to increase sufficiently that it will cause drain−source avalanche. The drain−source capacitor is much smaller than the gate source capacitor, so the drain source voltage is free to change much more readily by stray L's than the gate source voltage. Note that the peak avalanche current could be as high as the peak reverse recovery current. Depending upon how good or bad the body diode is, and how fast the reverse recovery event is forced (presumably by the speed at which the opposing MOSFET in a half or full bridge turns on), the peak diode reverse current may conceivably be higher than the load current.

This has some interesting implications. This means peak MOSFET drain−source avalanche current during reverse recovery could be very high, and is quite unpredictable given the inadequate reverse recovery information provided by most MOSFET manufacturer's datasheets. Even the best datasheets leave me wanting, it seems reverse recovery characteristics are notoriously undercharacterized by both the MOSFET and diode industries.

If the MOSFET is sufficiently avalanche rugged, the MOSFET should survive totally unharmed. On the other hand, most MOSFETs (even avalanche rated MOSFETs) don't have unlimited peak avalanche capability. As International Rectifier's application note AN 1005 suggests:

http://www.irf.com/technical−info/appnotes/an−1005.pdf

It would seem MOSFET destruction during avalanche can occur either due to thermal failure, or too much peak current.

Avalanche ruggedness is a very nice feature in a MOSFET, even if your intended application isn't supposed to cause normal avalanche conditions. An RC snubber between drain and source can't necessarily always prevent avalanche under these conditions since such a circuit has it's own parasitic Lstray which would limit how fast the current can ramp up during snap off. Additionally, there are practical limits as to how close an RC snubber could be placed, some unclamped Lstray will still exist between MOSFET drain−source since some Lstray is built right into the MOSFET package.

Note that when a discrete MOSFET fails it almost always fails (unless the failure is so spectacular as to fuse or blow the package apart) with all three terminals shorted together with relatively modest resistance. This could lead some to erroneously attribute the MOSFET failure with gate oxide failure. Note that the gate oxide is very thin and naturally must cover the entire die in order to access all of the MOSFET cells. This means that if even one tiny localized part of the die should fail (explode for instance), the gate oxide will probably be locally damaged, thus producing the gate−drain−source shorts without ever having to subject the gate−source capacitance to excessively high voltage.

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* ***Follow−Ups***:
    * ***Re: MOSFET body diodes***
        * *From:* John Larkin
* ***References***:
    * ***MOSFET body diodes***
        * *From:* Mike Young
    * ***Re: MOSFET body diodes***
        * *From:* John Larkin
    * ***Re: MOSFET body diodes***
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