Switching Measurement Standard and High Current Device Results

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The switching performance of a VJFET is tested according to JEDC standard JESD24. This document outlines the standard method for measuring all electrical and thermal characteristics of MOSFETs; however, is consistent for other FET devices. The standard circuit, as taken from the JEDEC standard document JESD24, used for evaluating the switching performance of a MOSFET device is shown in Figure 1 [1]. Figure 2 is an equivalent circuit redrawn to show a JFET as the device under test (D.U.T.).

Figure 1. Test Circuit taken from JEDEC document JESD24

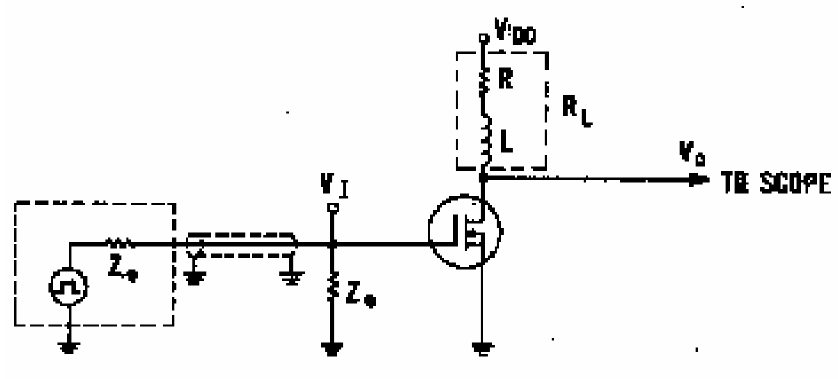
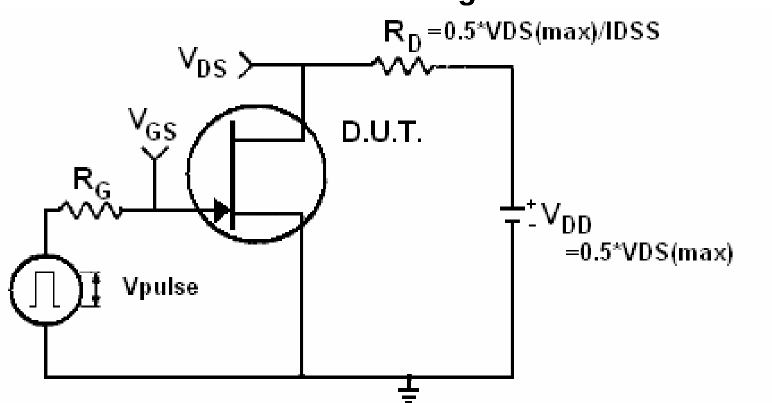
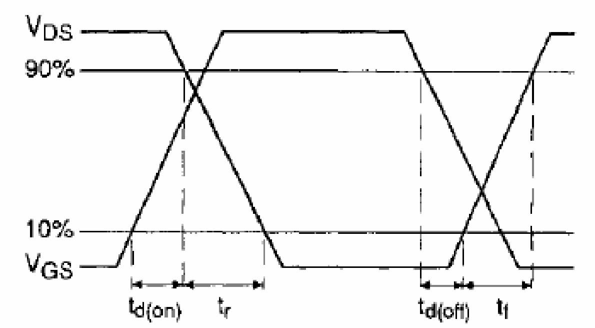


Figure 2. Test Circuit for Switching Time Measurements



The standard calls for setting the DC input voltage (**V_{DD}**) equal to half the rated blocking voltage (= 0.5***$V_{DS(max)}$**), while setting the load resistance (**R_D**) to allow for rated drain current (**I_{DSS}**) to flow through the device. During the testing procedure the gate voltage (**V_{GS}**), the drain voltage (**V_{DS}**), and drain current (**I_D**) are monitor as a control pulse (**V_{pulse}**) is applied to the gate. The resulting waveforms and standard method for measuring the switching speed of a FET device from these waveforms are illustrated in figure 3 below. In this figure, it is shown that the values for the rise time (**t_r**) and fall time (**t_f**) of a device are reference to the measured drain voltage. The values for the time delay during turn-on (**$td_{(on)}$**) and turn-off (**$td_{(off)}$**) transients are reference to the drain voltage and gate voltage. A breakdown of the critical points of measurement is listed below figure 3.

Figure 3. Standard Method for Switching Time Measurements



t_r: measured between VDS = 90% and VDS = 10% of the turn-on transient
t_f: measured between VDS = 10% and VDS = 90% of the turn-off transient
$td_{(on)}$: measured between VGS = 10% and VDS = 90% of the turn-on transient
$td_{(off)}$: measured between VGS = 90% and VDS = 10% of the turn-off transient

While the maximum blocking voltage is easily determined from the DC data, it is necessary to define what has been established as our definition of rated drain current **ID_{rated}** (or **I_{DSS}** as shown in the previous figures). To provide consistency in the testing data collect, **ID_{rated}** can be read from the DC I-V data by determining the value of drain current at VDS = 5V. The load resistance RD in the switching circuit is then adjust to match this value of **ID_{rated}** at half the rated blocking voltage.

Fabrication and Testing of a High Current Device Aimed at Motor Drive Applications

To promote the use of SiC devices in motor drive applications, a high current 600V device was fabricated by bonding multiple die in parallel until the desired current rating was achieved. For documentation purposes the fabricated device was tested for DC characteristics at room temperature and 175^{o}C, as well as tested for switching performance. The switching performance for this device after integration of each die is listed below.

Table 1. Switching Performance of the High Current Device

# of Parallel Die	VGS (V)	ID (A)	VDS (V)	t_r (ns)	t_f (ns)	$td_{(on)}$ (ns)	$Td_{(off)}$ (ns)	Von (V)
1	3/-30	36.4	300	42.0	20.0	12.8	9.6	5.0
2	3/-30	48.4	300	66.0	40.0	16.0	10.0	4.2
3	3/-30	88.2	300	96.0	40.0	10.4	12.8	3.0
4	3/-30	130.0	300	84.8	51.2	11.2	12.0	5.0

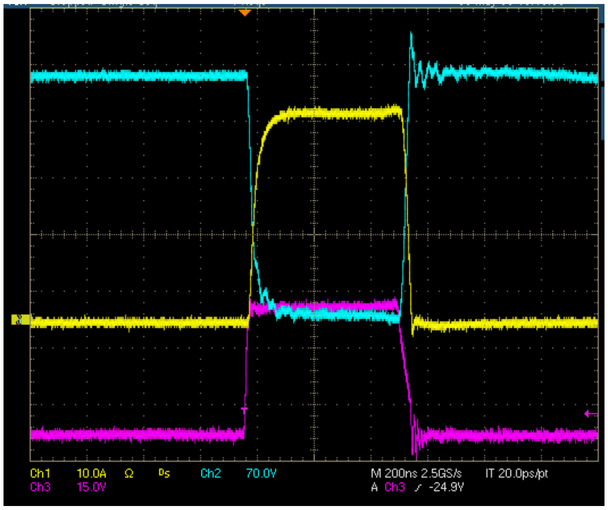


Figure 4. Switching Results for 1 Die

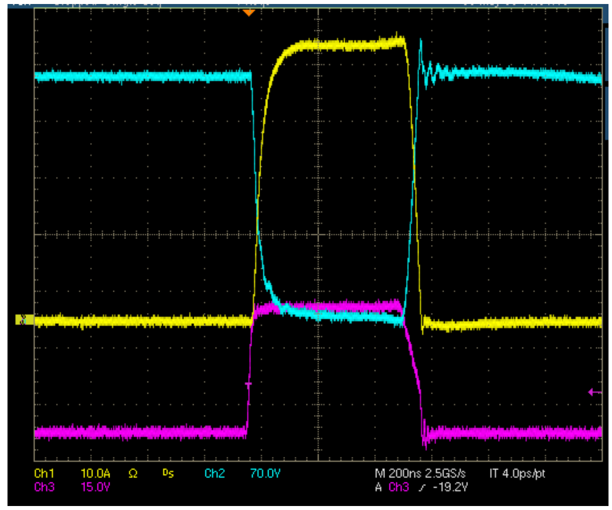


Figure 5. Switching Results for 2 Parallel Die

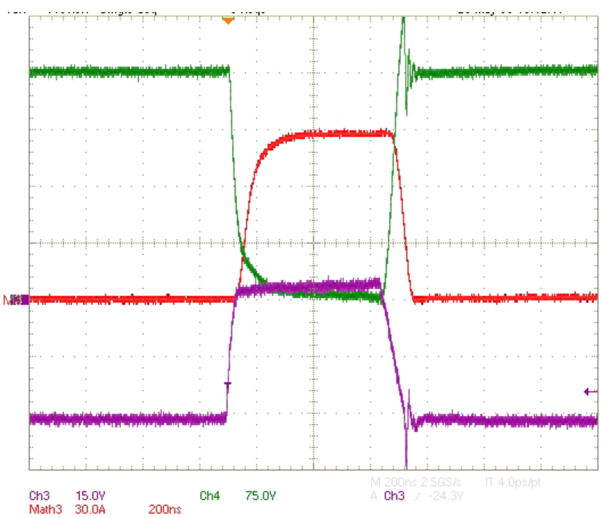


Figure 6. Switching Results for 3 Parallel Die

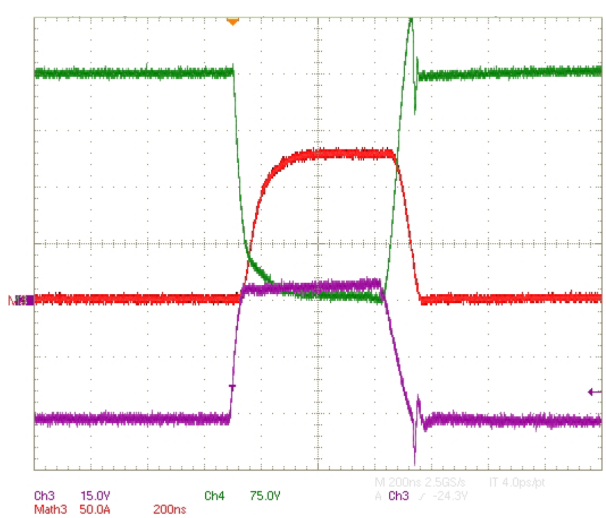


Figure 7. Switching Results for 4 Parallel Die

As shown in figure 7, it was possible to reach a rate current value of 100A or greater by parallel several die together in one package. This provides evidence that there were no complications with parallel devices in order to achieve higher current ratings. While the turn-on time of the final device increased by a factor of two, the final switching performance of this high current device maintains a maximum switching capability of 6 Mhz.