

Device Modeling Report

COMPONENTS: MOSFET (Professional Model)
PART NUMBER: 2SK2409
MANUFACTURER: NEC Corporation
REMARK: Body Diode (Professional) /
ESD Protection Diode



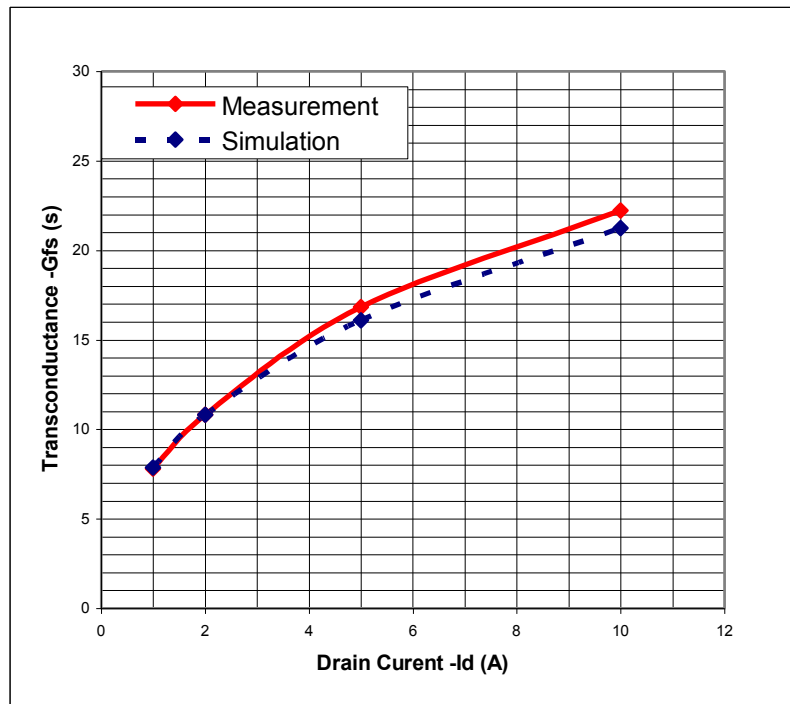
Bee Technologies Inc.

MOSFET MODEL PARAMETERS

PSpice model parameter	Model description
LEVEL	
L	Channel Length
W	Channel Width
KP	Transconductance
RS	Source Ohmic Resistance
RD	Ohmic Drain Resistance
VTO	Zero-bias Threshold Voltage
RDS	Drain-Source Shunt Resistance
TOX	Gate Oxide Thickness
CGSO	Zero-bias Gate-Source Capacitance
CGDO	Zero-bias Gate-Drain Capacitance
CBD	Zero-bias Bulk-Drain Junction Capacitance
MJ	Bulk Junction Grading Coefficient
PB	Bulk Junction Potential
FC	Bulk Junction Forward-bias Capacitance Coefficient
RG	Gate Ohmic Resistance
IS	Bulk Junction Saturation Current
N	Bulk Junction Emission Coefficient
RB	Bulk Series Resistance
PHI	Surface Inversion Potential
GAMMA	Body-effect Parameter
DELTA	Width effect on Threshold Voltage
ETA	Static Feedback on Threshold Voltage
THETA	Mobility Modulation
KAPPA	Saturation Field Factor
VMAX	Maximum Drift Velocity of Carriers
XJ	Metallurgical Junction Depth
UO	Surface Mobility

Transconductance Characteristics

Circuit Simulation Result

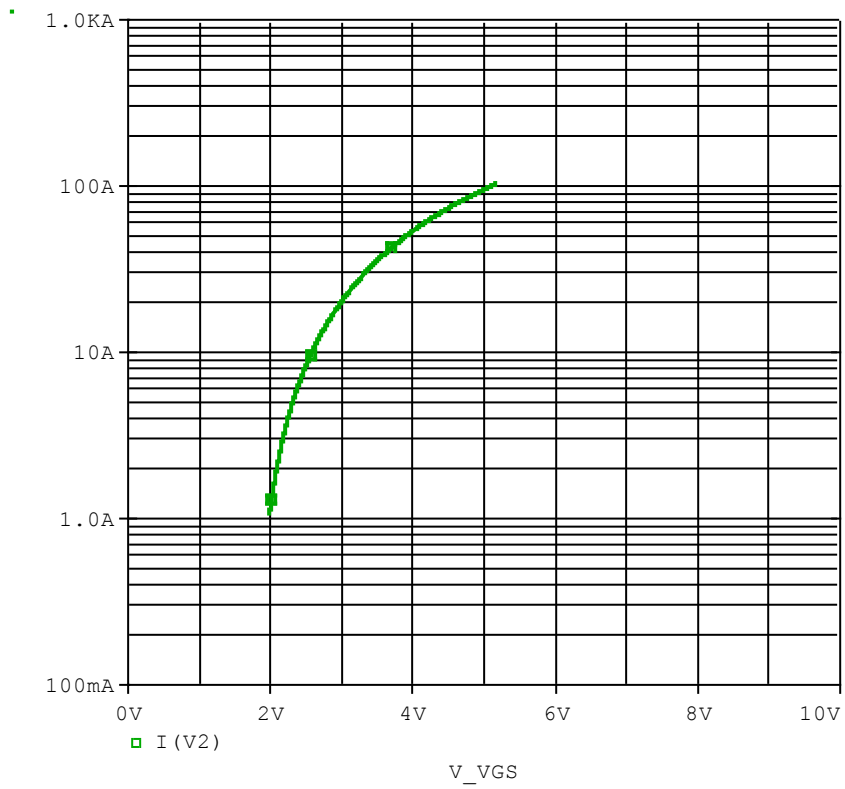


Comparison table

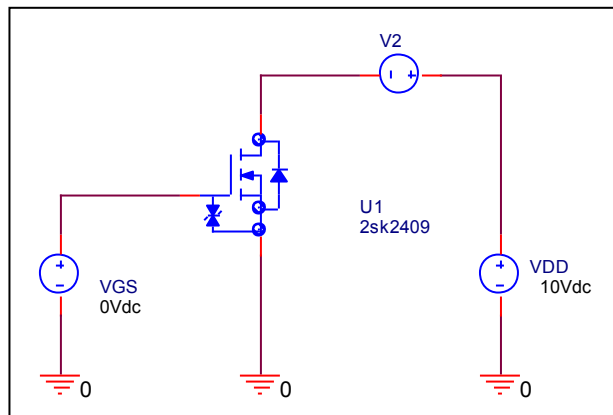
Id(A)	gfs(s)		Error(%)
	Measurement	Simulation	
1.000	7.813	7.874	0.787
2.000	10.811	10.811	0.000
5.000	16.835	16.077	-4.502
10.000	22.222	21.231	-4.459

Vgs-Id Characteristics

Circuit Simulation Result

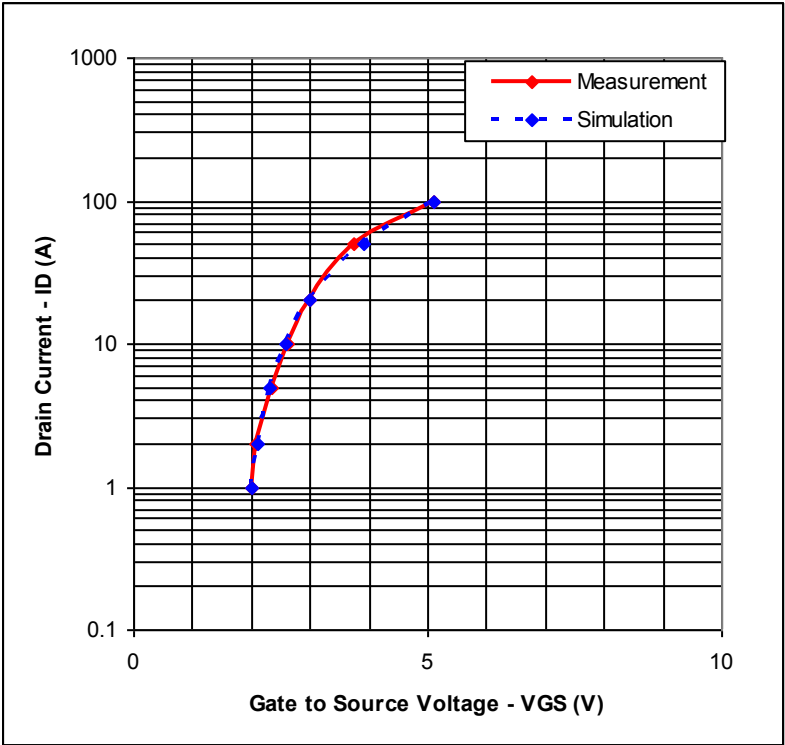


Evaluation circuit



Comparison Graph

Circuit Simulation Result

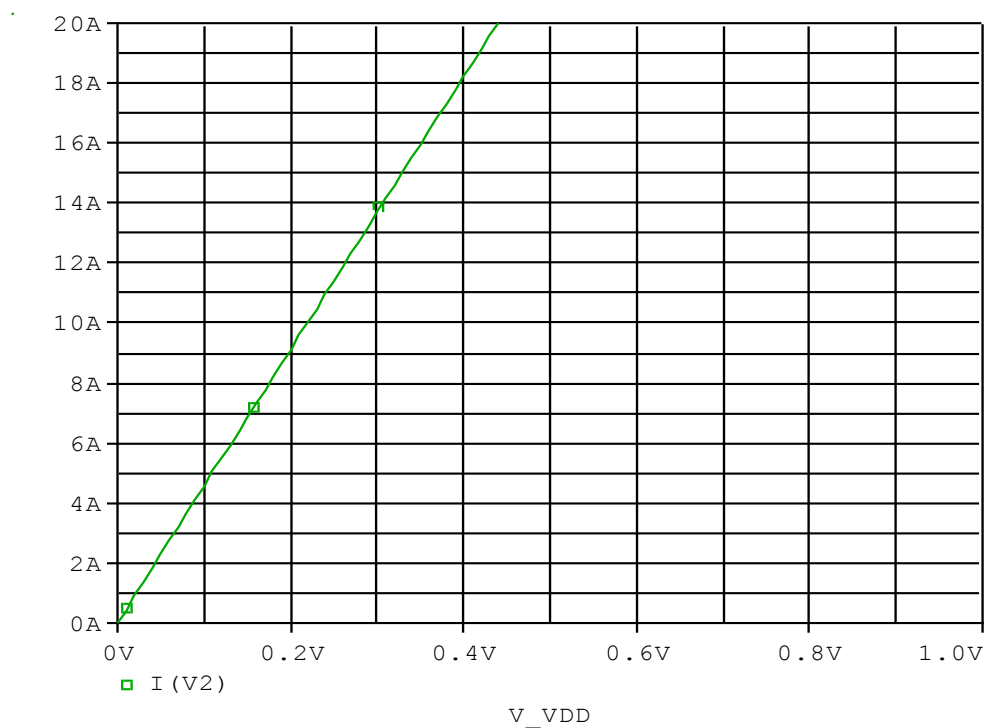


Comparison table

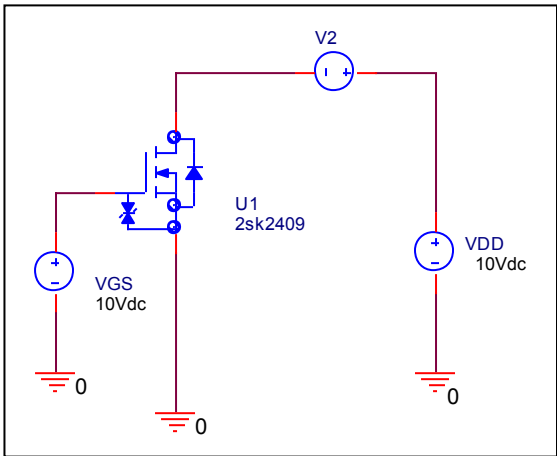
ID(A)	V _{GS} (V)		Error (%)
	Measurement	Simulation	
1.000	2.000	1.994	-0.300
2.000	2.080	2.103	1.106
5.000	2.350	2.392	1.787
10.000	2.620	2.601	-0.725
20.000	3.000	3.014	0.467
50.000	3.850	3.935	2.208
100.000	5.180	5.000	-3.475

***Rds(on) Characteristic**

Circuit Simulation result



Evaluation circuit

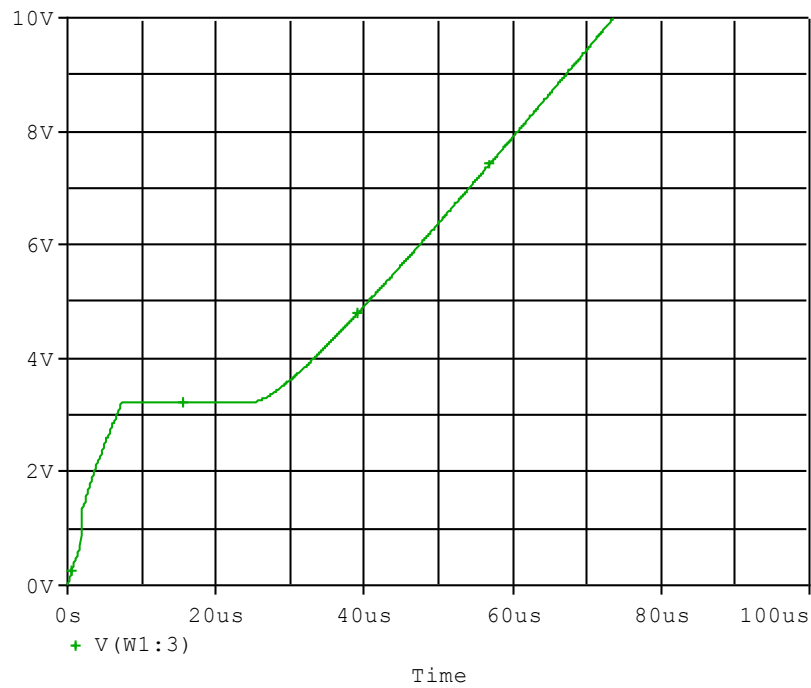


Simulation Result

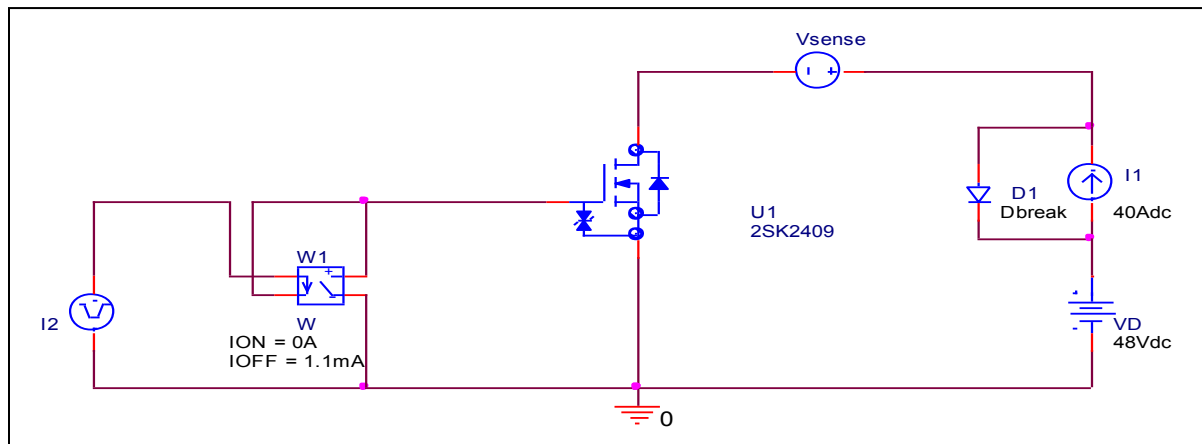
$I_D=20A, V_{GS}=10V$	Measurement		Simulation		Error (%)
$R_{DS} (on)$	22	mΩ	22.022	mΩ	0.100

Gate Charge Characteristic

Circuit Simulation result



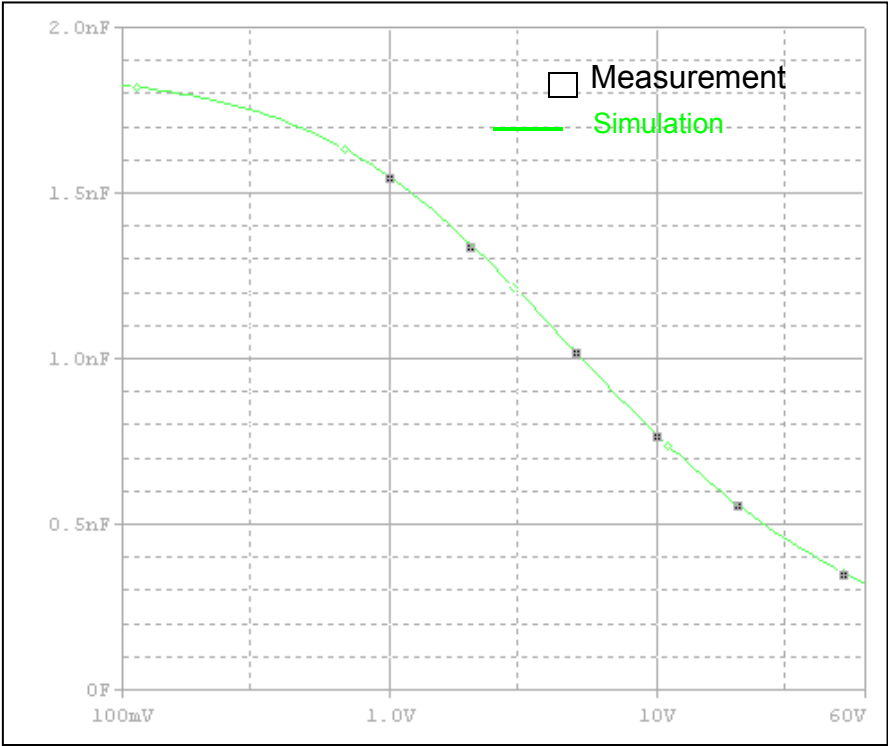
Evaluation circuit



Simulation Result

$V_{DD}=48V, I_D=40A$ $V_{GS}=-10V$	Measurement		Simulation		Error (%)
Qgs	5.00	nC	5.22	nC	4.400
Qgd	25.00	nC	25.00	nC	0.640
Qg	7.30	nC	7.31	nC	0.137

Capacitance Characteristic

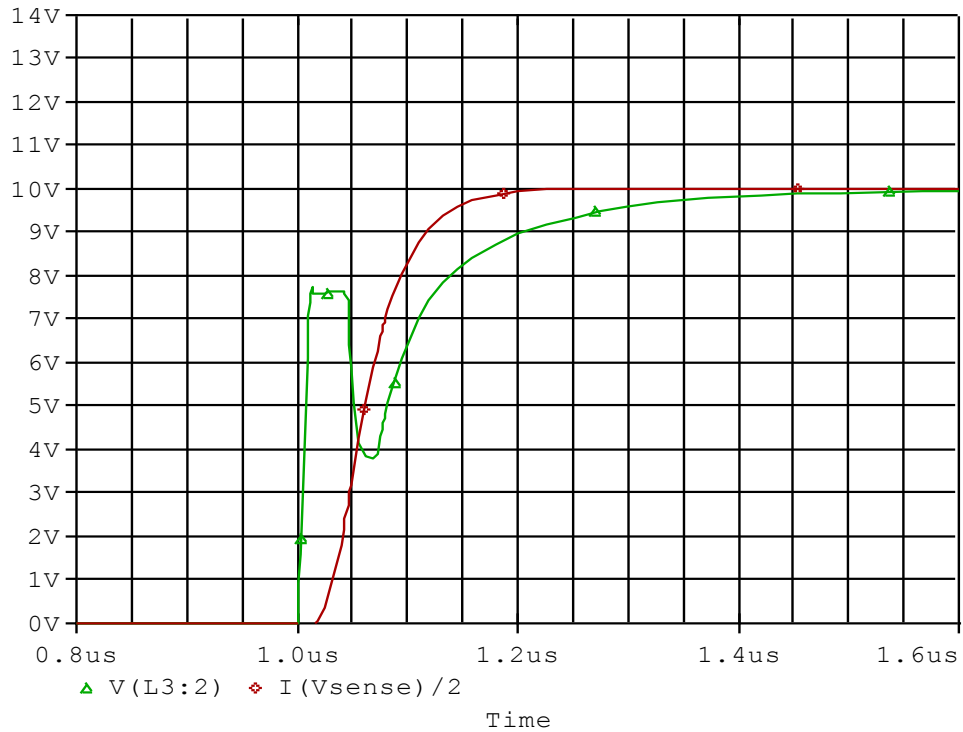


Simulation Result

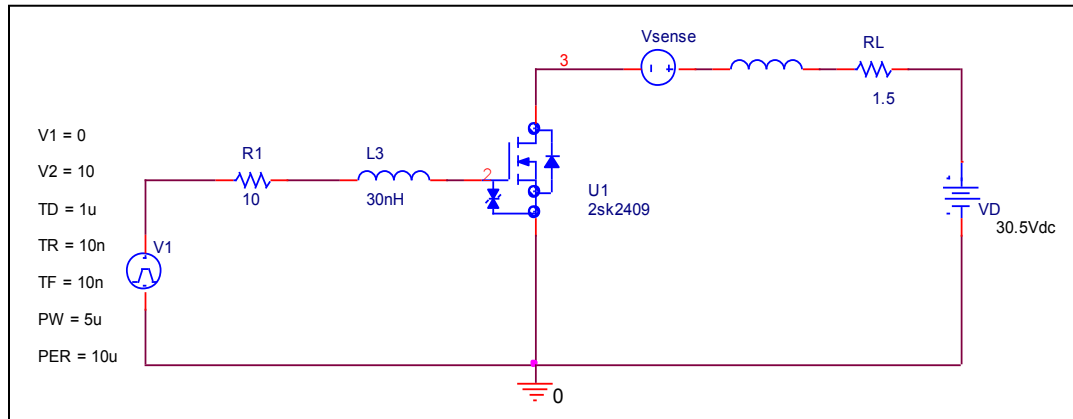
V _{DS} (V)	Cbd(pF)		Error(%)
	Measurement	Simulation	
1	1550	1500	0.065
2	1340	1320	0.075
5	1020	1030	0.098
10	770	775	0.130
20	560	550	0.179
50	350	340	0.286

Switching Time Characteristic

Circuit Simulation result



Evaluation circuit

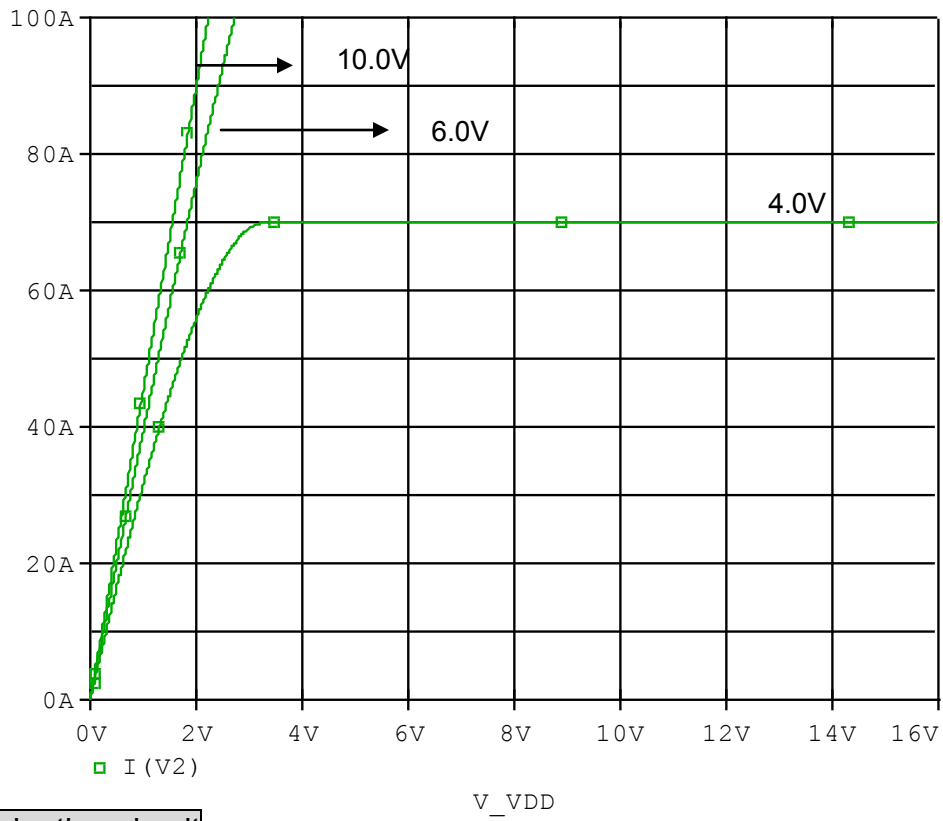


Simulation Result

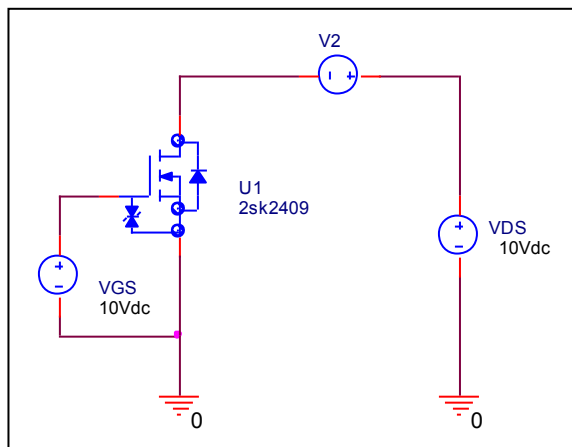
$I_D=20A$, $V_{DD}=30V$ $V_{GS}=0/10V$	Measurement		Simulation		Error(%)
td(on)	30	ns	30.01	ns	0.063

Output Characteristic

Circuit Simulation result



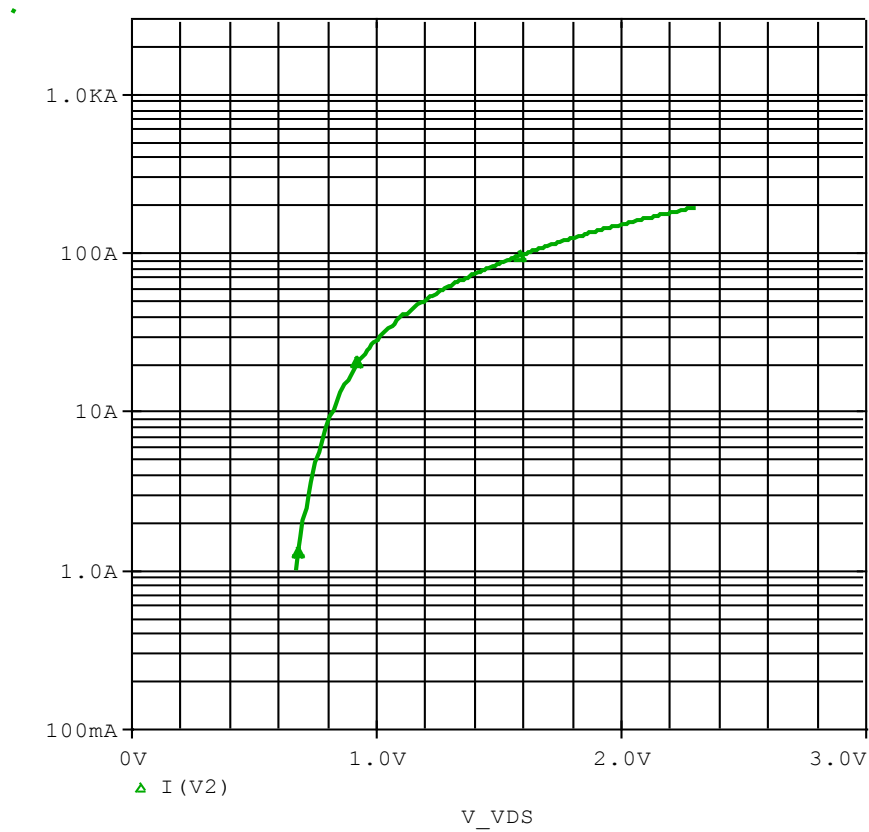
Evaluation circuit



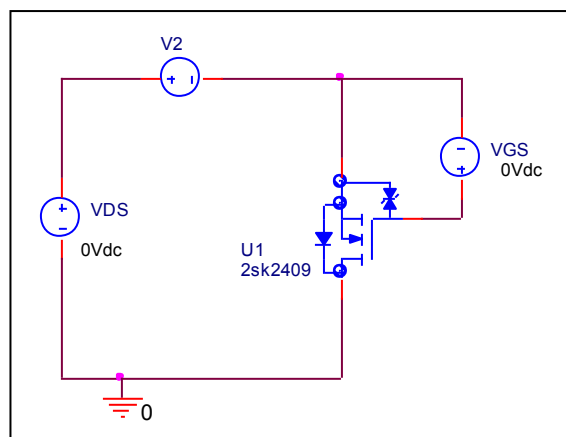
BODY DIODE SPICE MODEL

Forward Current Characteristic

Circuit Simulation Result

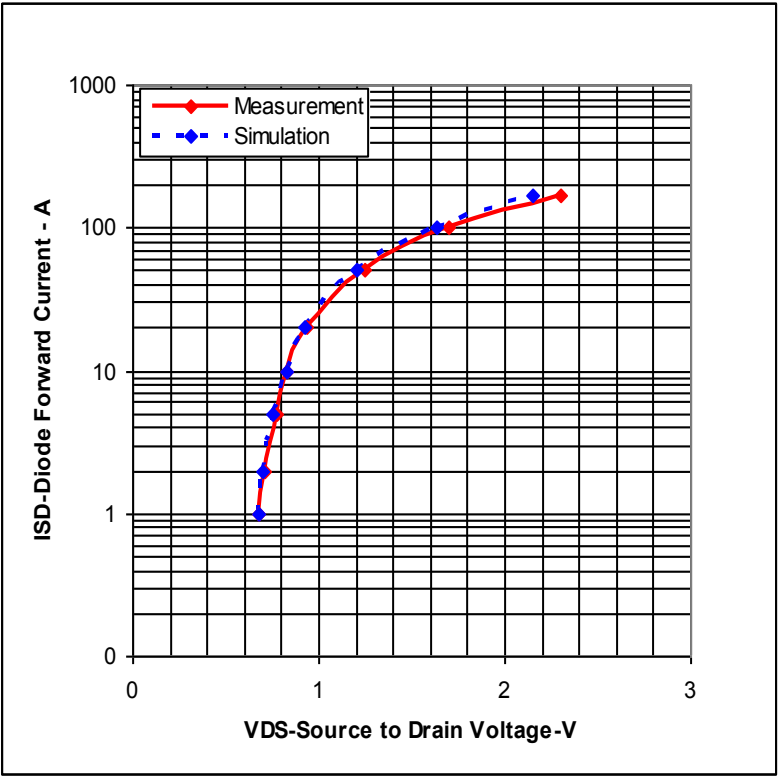


Evaluation Circuit



Comparison Graph

Circuit Simulation Result

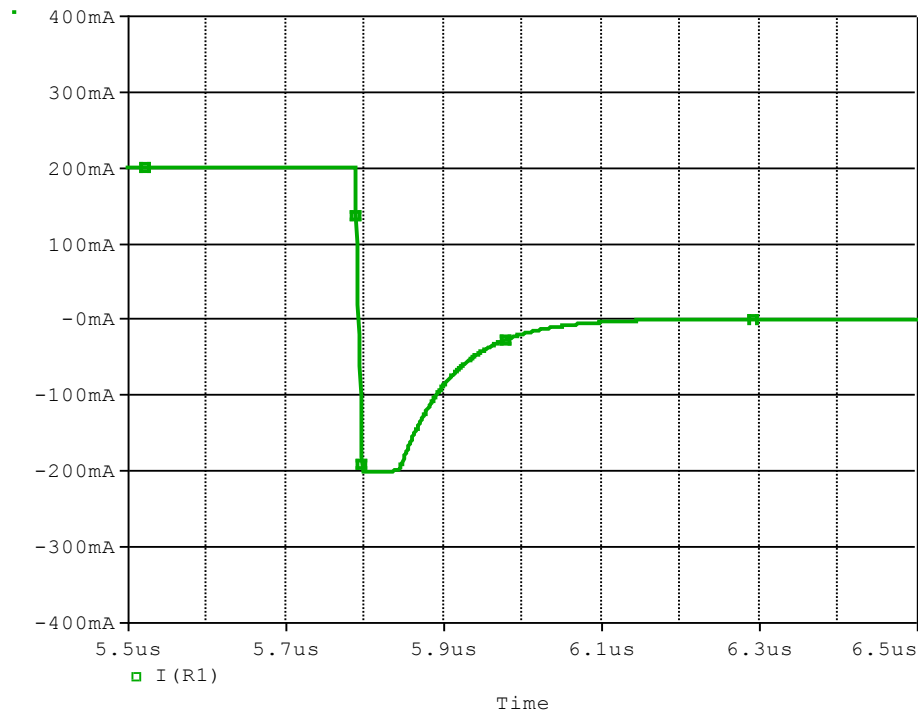


Simulation Result

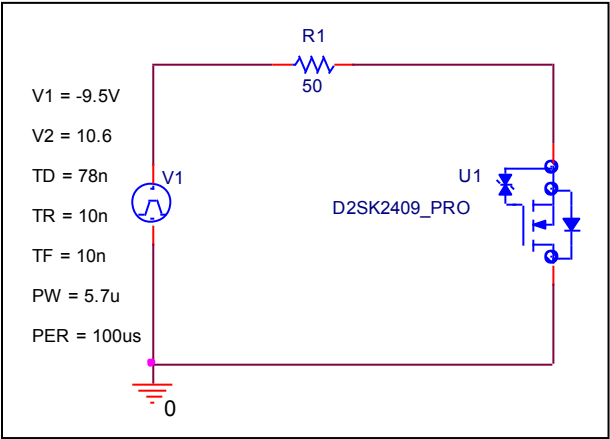
ISD(A)	VDS(V)		%Error
	Measurement	Simulation	
1.000	0.675	0.675	0.000
2.000	0.705	0.704	-0.142
5.000	0.770	0.758	-1.558
10.000	0.830	0.823	-0.843
20.000	0.940	0.927	-1.383
50.000	1.250	1.202	-3.840
100.000	1.700	1.630	-4.118
170.000	2.300	2.155	-6.304

Reverse Recovery Characteristic

Circuit Simulation Result



Evaluation Circuit

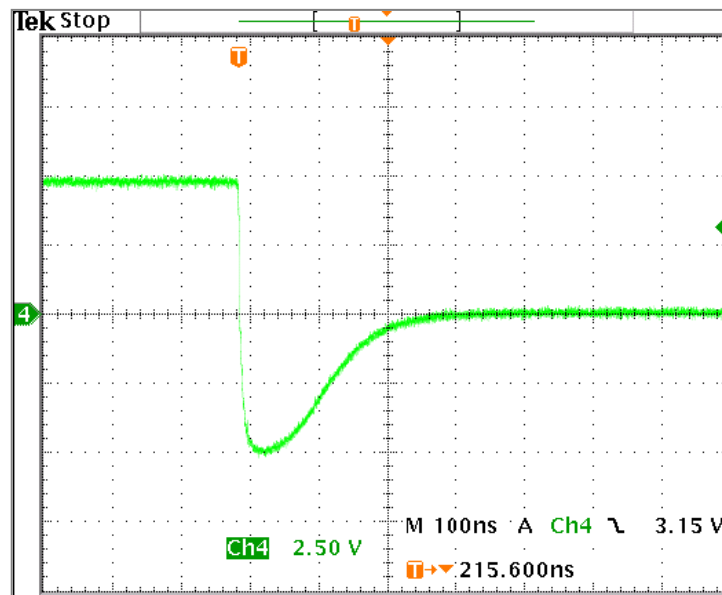


Compare Measurement vs. Simulation

	Measurement		Simulation		Error (%)
trj	57.200	ns	56.710	ns	-0.857
trb	152.000	ns	151.360	ns	-0.421
trr	209.200	ns	208.070	ns	-0.540

Reverse Recovery Characteristic

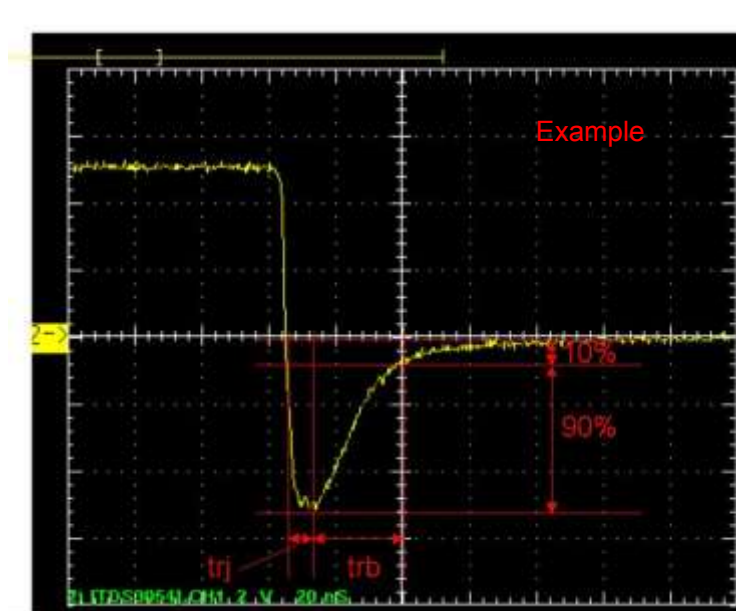
Reference



$T_{rj}=57.2(\text{ns})$

$T_{rb}=152(\text{ns})$

Conditions: $I_{fwd}=I_{rev}=0.2(\text{A})$, $R_I=50$

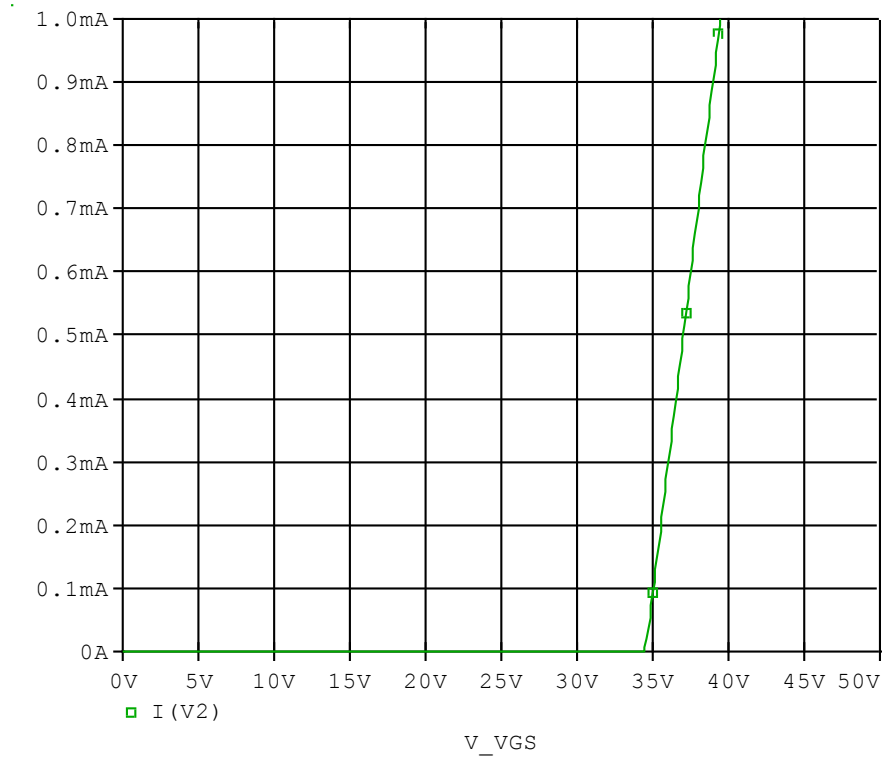


Relation between t_{rj} and t_{rb}

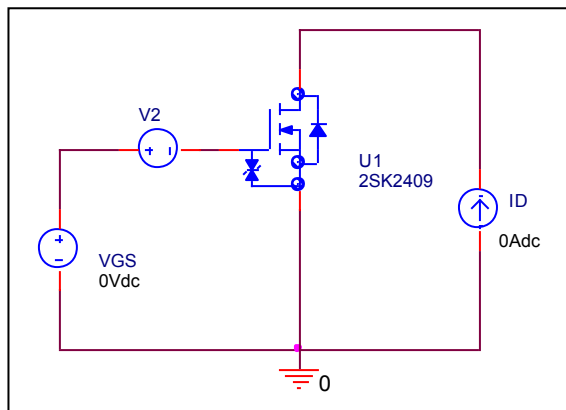
ESD PROTECTION DIODE SPICE MODEL

Zener Voltage Characteristic

Circuit Simulation Result



Evaluation Circuit



Zener Voltage Characteristic

Reference

