Device Modeling Report

COMPONENTS: MOSFET (Professional)
PART NUMBER: 2SK2415
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	Modility Modulation
KAPPA	Saturation Field Factor
VMAX	Maximum Drift Velocity of Carriers
XJ	Metallurgical Junction Depth
UO	Surface Mobility

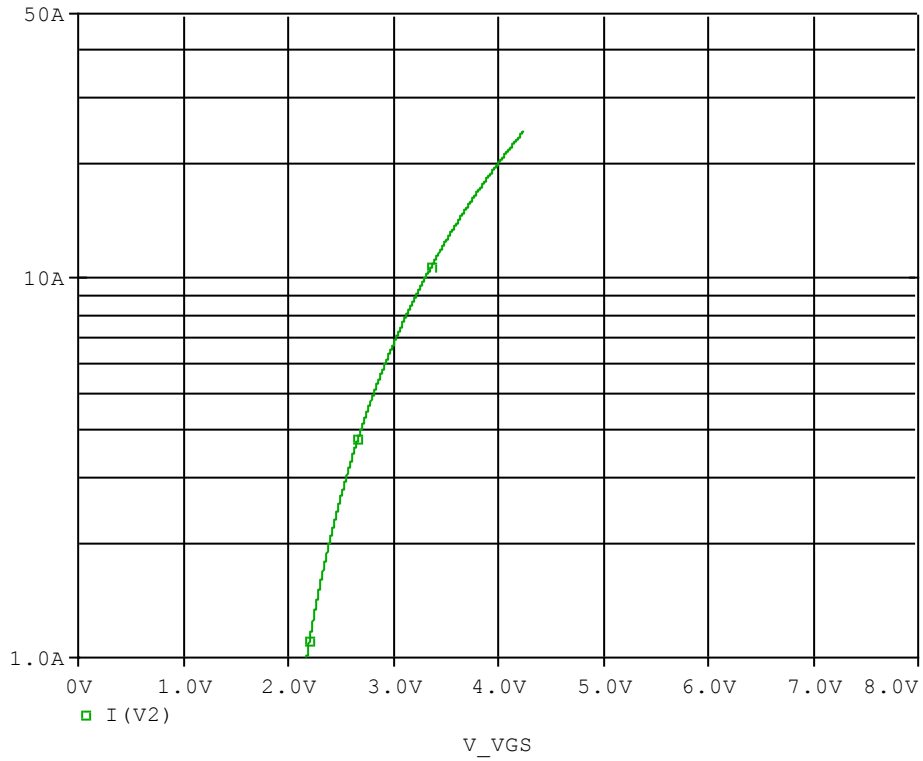# Transconductance Characteristics

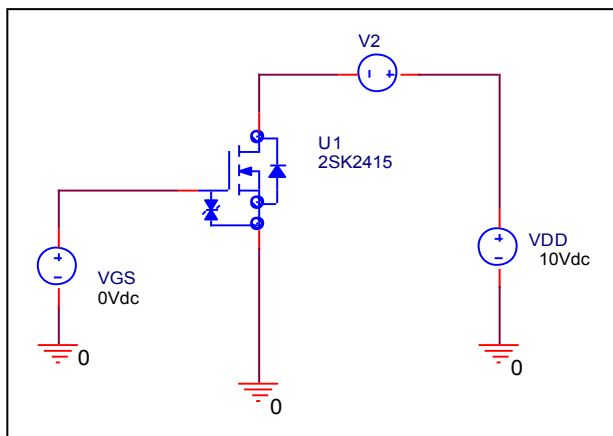## Circuit Simulation Result
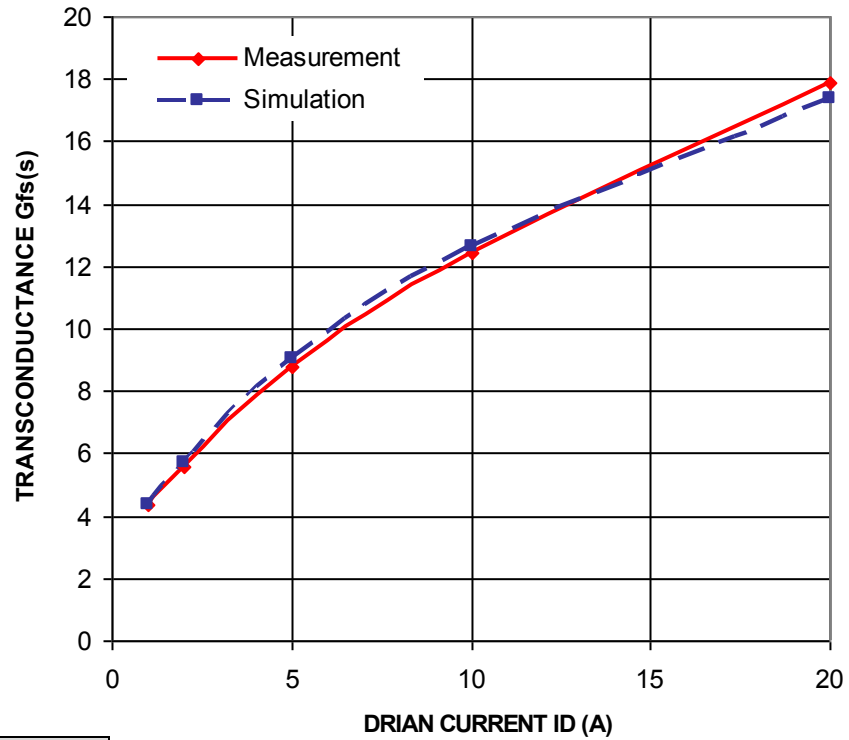
Comparison table

Id(A)	gfs(s)		Error(%)
	Measurement	**Simulation**	
1	4.390	4.348	-0.956
2	5.602	5.711	1.943
5	8.787	9.025	2.704
10	12.407	12.654	1.991
20	17.899	17.346	-3.087

Vgs-Id Characteristics

Circuit Simulation Result

Evaluation circuit

Comparison Graph

Comparison table
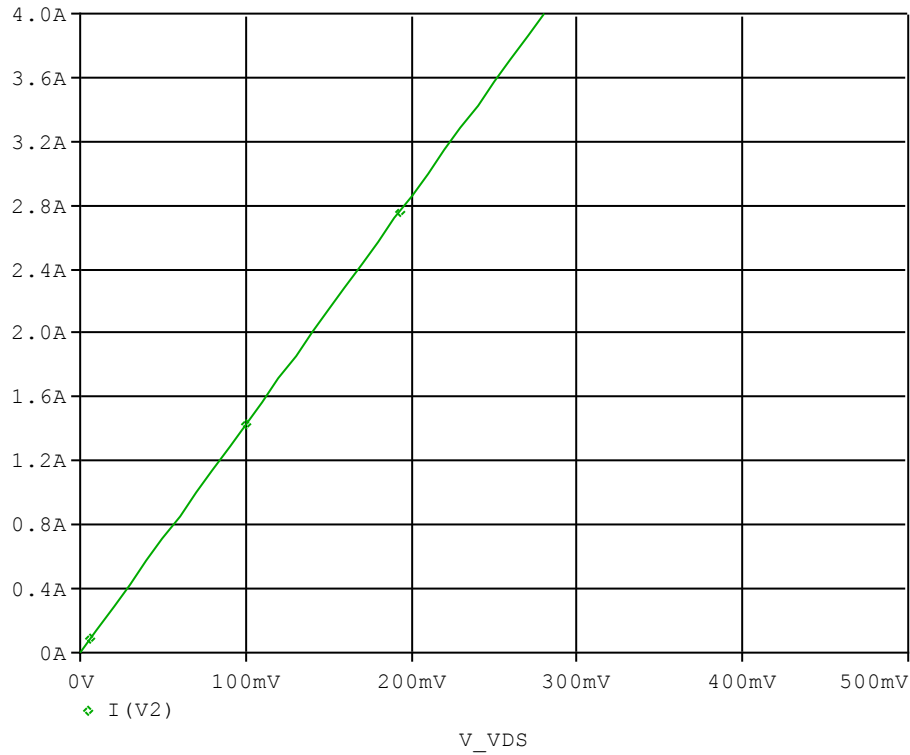
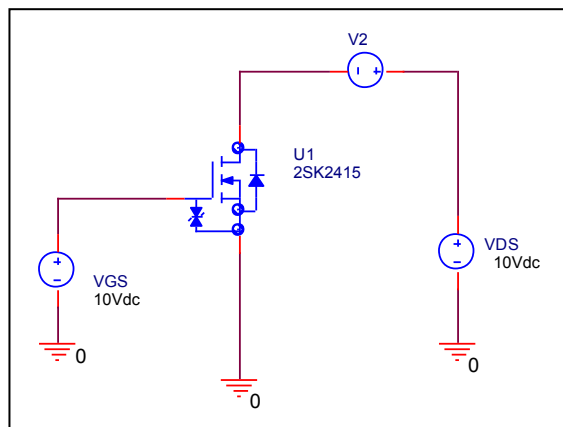| Id(A)	gfs(s)		Error(%)
	Measurement	Simulation	
1	2.180	2.177	-0.147
2	2.350	2.391	1.745
5	2.730	2.818	3.223
10	3.250	3.303	1.615
20	4.150	3.994	-3.771

*Rds(on) Characteristic

Circuit Simulation result

◇ I(V2)

V_VDS

Evaluation circuit

Simulation Result

I$_D$=4.0A, V$_{GS}$=10V	Measurement		Simulation		Error (%)
R$_{DS}$ (on)	0.07	Ω	0.07	Ω	0.000

Gate Charge Characteristic

Circuit Simulation result

Time*1mA
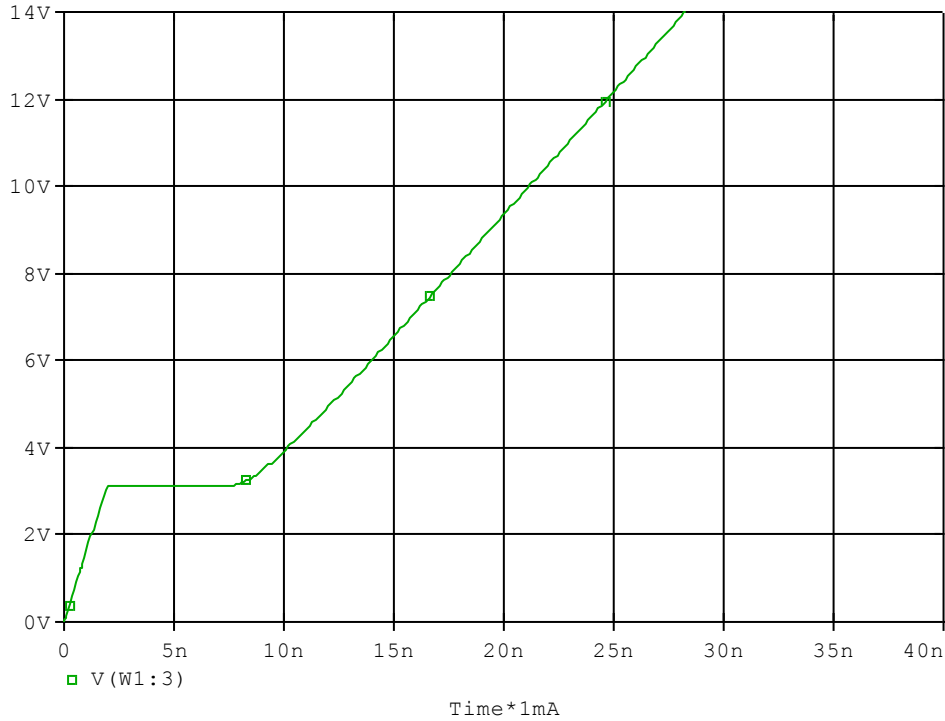
Evaluation circuit
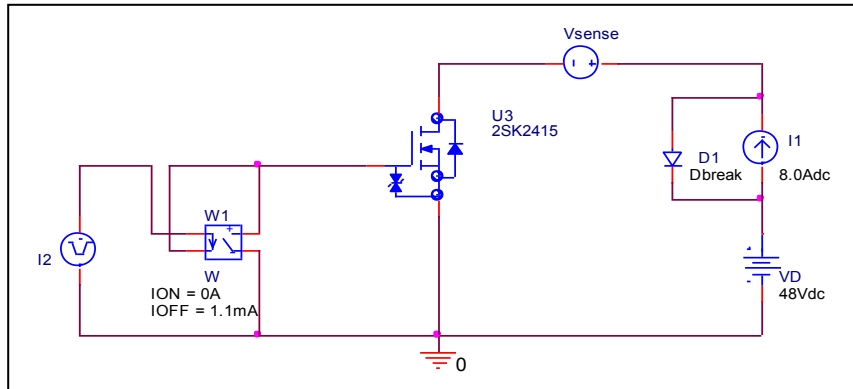
Simulation Result

V_{DD}=48V,I_D=8.0A ,V_{GS}=10V		Measurement	Simulation	Error (%)
Qgs	ns	2.000	2.00	0.000
Qgd	ns	6.500	6.49	-0.154
Qg	ns	21.00	20.98	-0.095

Capacitance Characteristic
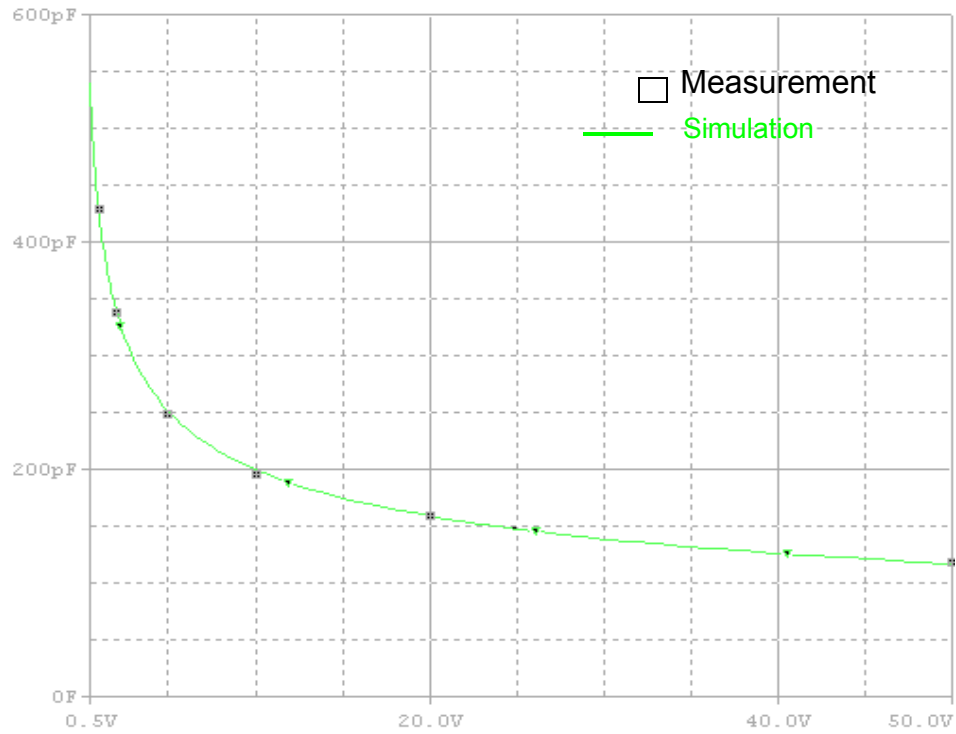
Simulation Result

V$_{DS}$(V)	Cbd(pF)		Error(%)
	Measurement	Simulation	
1	430.000	428.422	-0.367
2	340.000	340.880	0.259
5	250.000	251.181	0.472
10	197.000	199.927	1.486
20	160.000	158.600	-0.875
50	120.000	116.986	-2.512

Switching Time Characteristic

Circuit Simulation result


```
        12V
        10V  △━━━━━━━━━━━△━━━━━━△╮
                                 ╲
         8V                       ┃
                                  ┃
         6V                       △
                                  ┃
         4V                       ┃
                              ╭╮  ┃        ◆━━━━◆━━━━━━
         2V              ◆━━━◆╯┃  ┃      ◆
                       ◆╱       ┃  ┃    ◆
         0V  ◆━━━━━━◆━━◆        △━━△━━━△
        −2V
            0.97us    0.99us    1.01us    1.03us    1.05us
        △ V(3)/3.0  ◇ V(L3:2)
                              Time
```
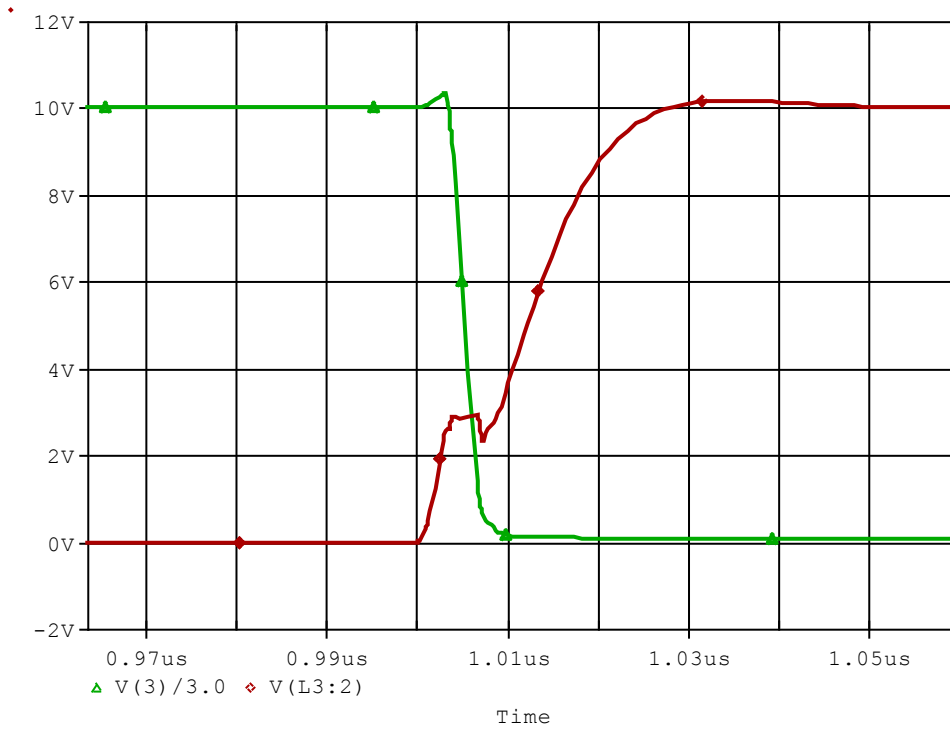
Evaluation circuit
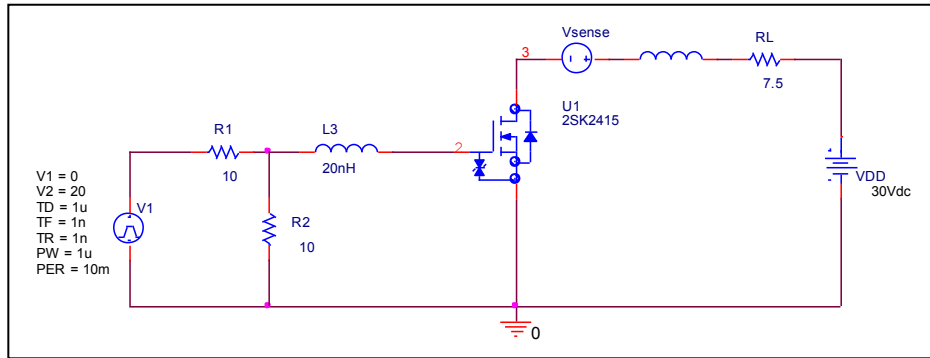
Simulation Result

I$_D$=4A, V$_{DD}$=30V V$_{GS}$=0/10V		Measurement	Simulation	Error(%)
td (on)	ns	5.000	5.050	1.000

Output Characteristic

I(V2)

V_VDS
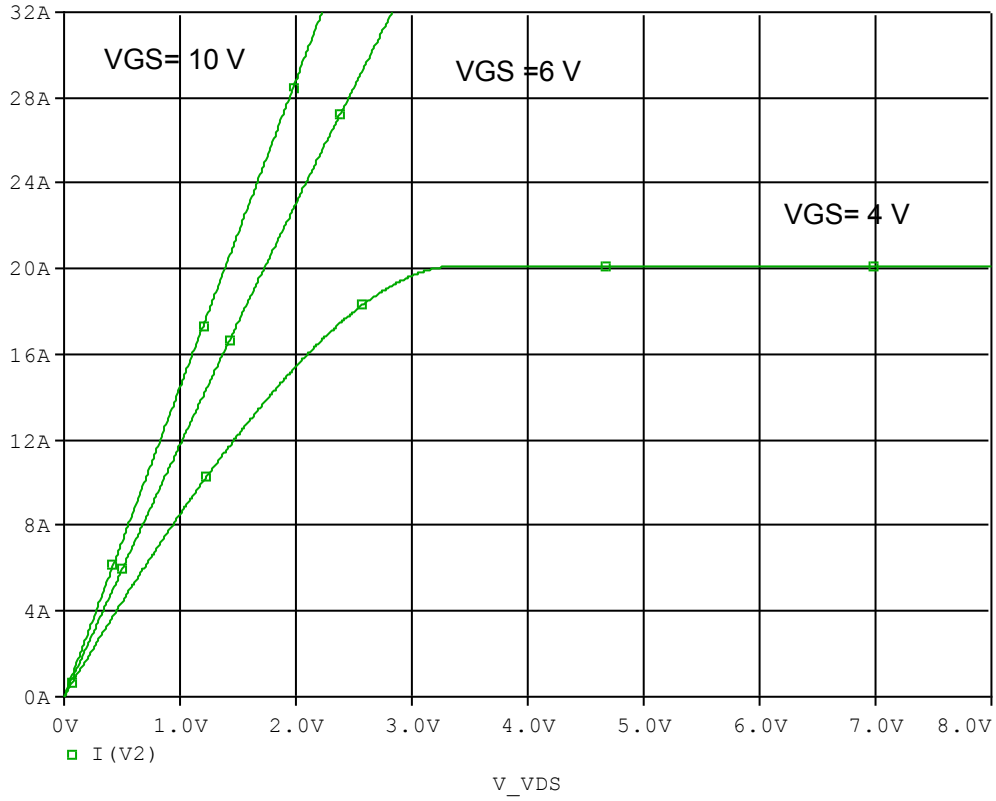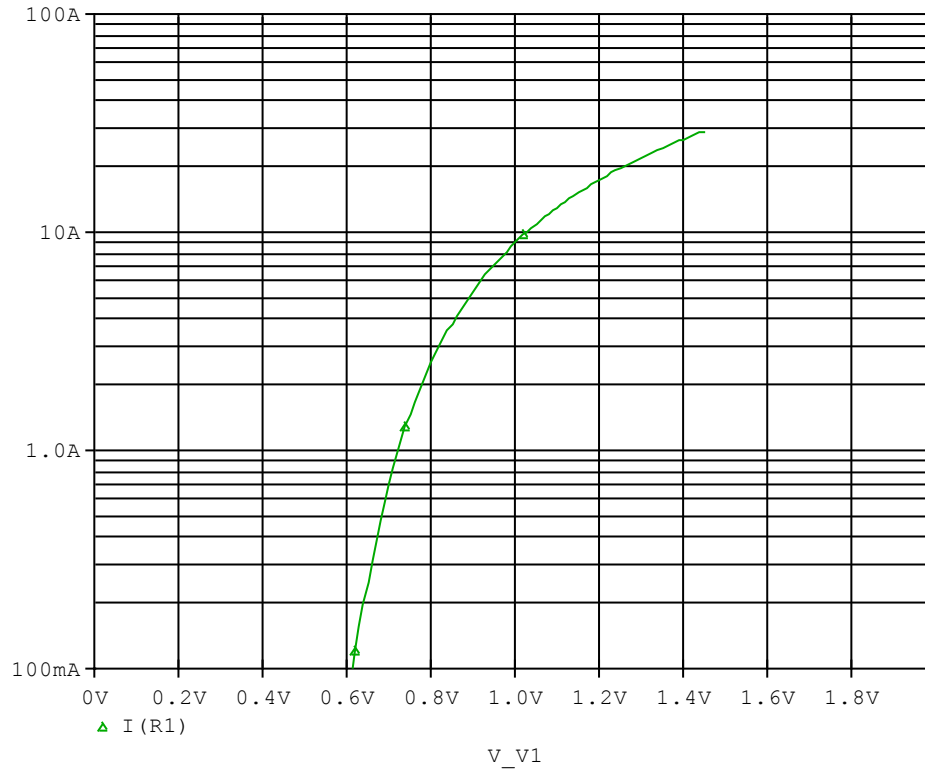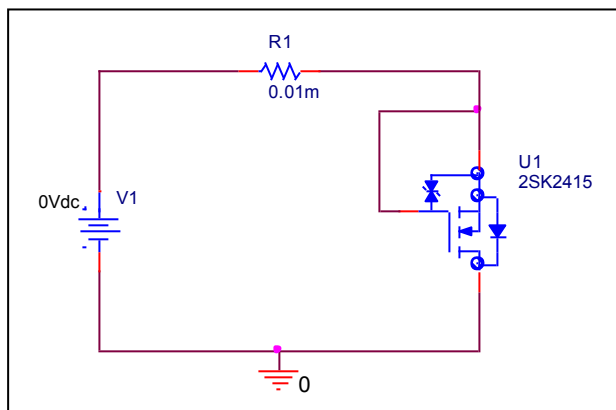
Evaluation circuit
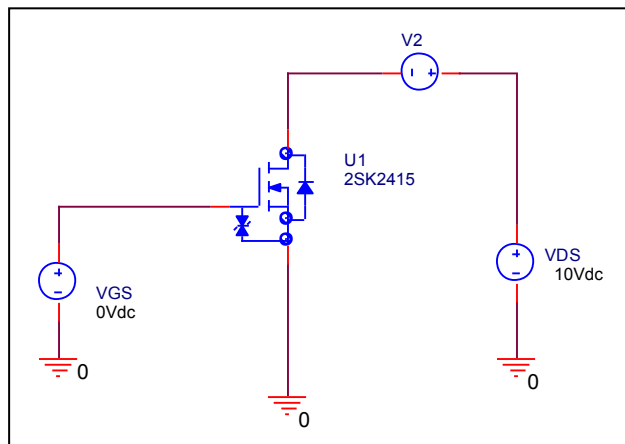
BODY DIODE SPICE MODEL
Forward Current Characteristic

Circuit Simulation Result

Evaluation Circuit
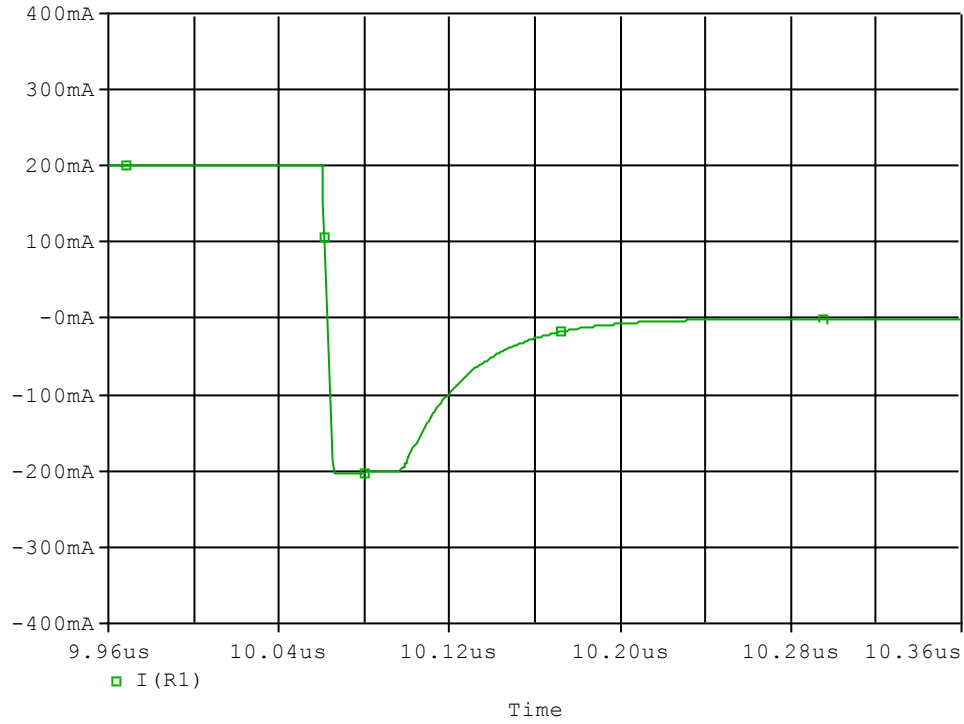
Comparison Graph
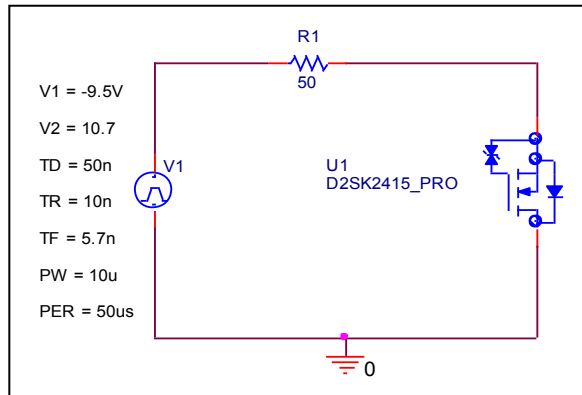
Circuit Simulation Result
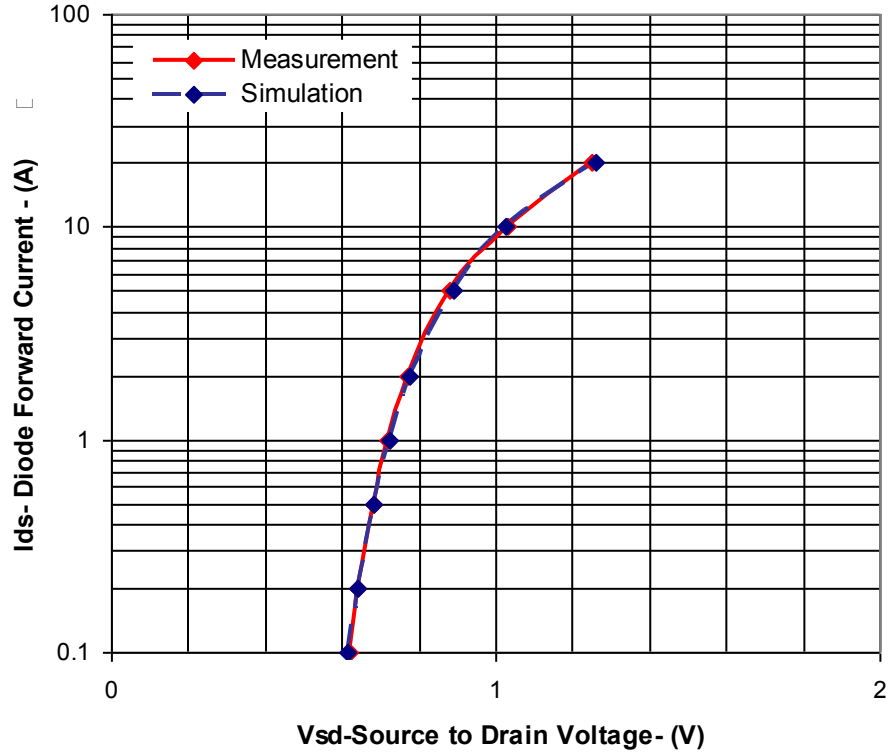
Simulation Result

IDR(A)	VDS(V)		%Error
	Measurement	Simulation	
0.1	0.620	0.6129	-1.145
0.2	0.640	0.6404	0.062
0.5	0.680	0.6820	0.294
1	0.720	0.7223	0.319
2	0.770	0.7770	0.909
5	0.880	0.8890	1.022
10	1.030	1.0274	-0.252
20	1.250	1.2584	0.672

Reverse Recovery Characteristic

Circuit Simulation Result

Evaluation Circuit
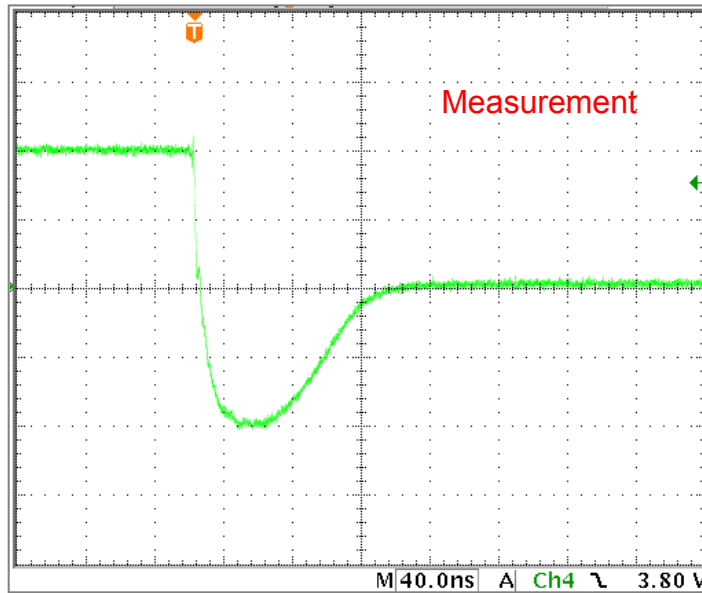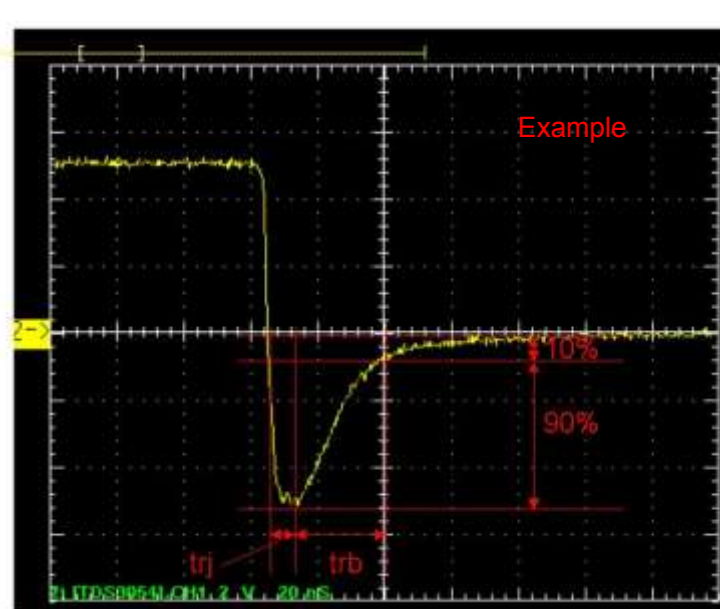

Compare Measurement vs. Simulation

		Measurement	Simulation	Error (%)
trj	ns)	35.00	34.50	-1.429
Trb	ns	70.00	69.86	-0.200
Trr	ns	105.00	104.36	-0.610

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Reverse Recovery Characteristic   Reference

Measurement

Trj=35 (ns)
Trb=70 (ns)
Conditions:Ifwd=Irev=0.2(A),Rl=50
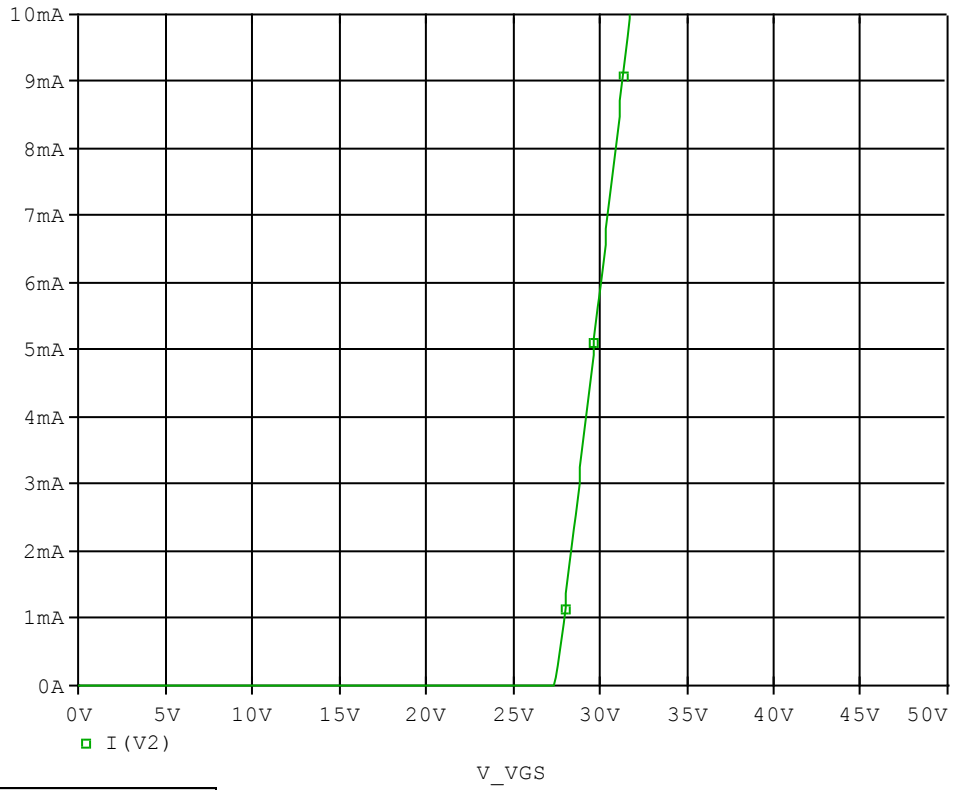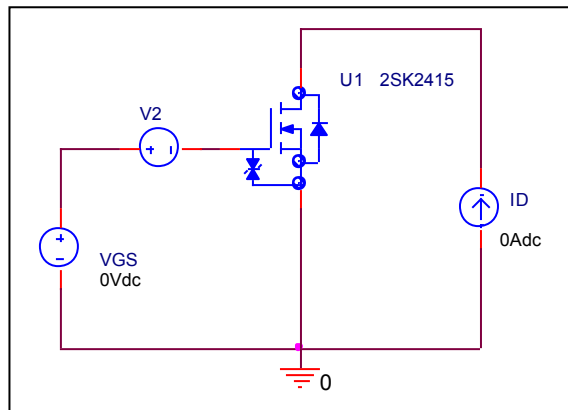

Relation between trj and trb

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ESD PROTECTION DIODE SPICE MODEL
Zener Voltage Characteristic

Circuit Simulation Result

Evaluation Circuit

Zener Voltage Characteristic

<div align="right">

Reference

</div>

VERT/DIV	1mA
CURSOR (f:1/grad.)	9.95mA
HORIZ/DIV	5 V
CURSOR (f:intercept)	31.70 V
PER STEP	50mV
OFFSET	0.0mV
β OR gm/DIV	******
% of COLLECTOR PEAK VOLTS	0.0
AUX SUPPLY	0.00 V