

# Device Modeling Report

COMPONENTS: MOSFET (Model Parameters)  
PART NUMBER: 2SK2414  
MANUFACTURER: NEC Corporation  
REMARK: Body Diode (Model Parameters) /  
ESD Protection Diode



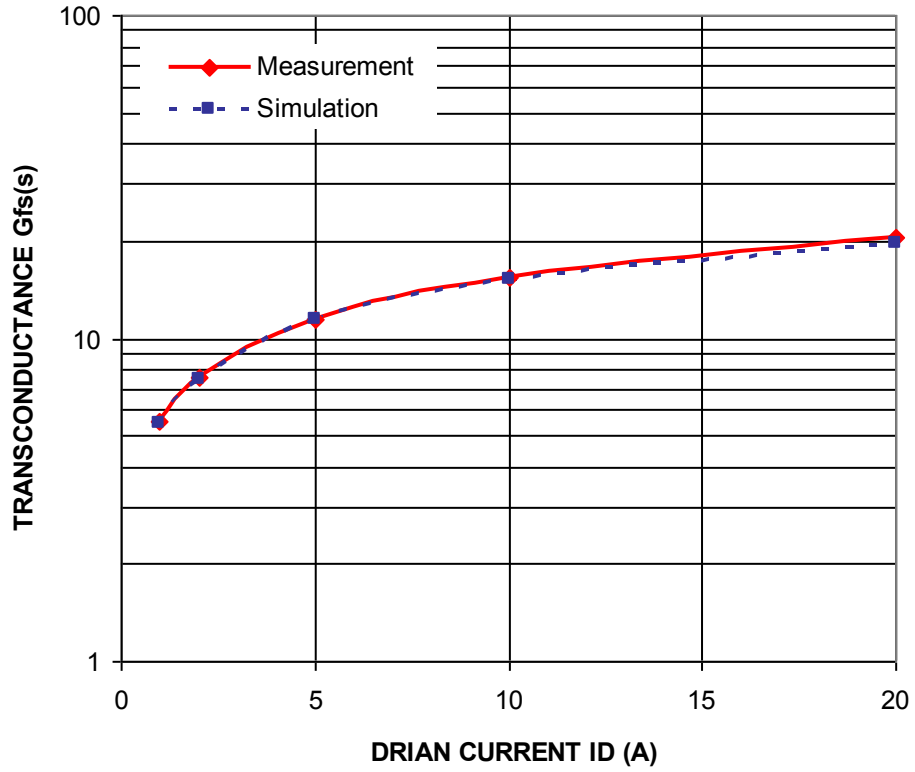
**Bee Technologies Inc.**

## MOSFET MODEL

<b>PSpice model parameter</b>	<b>Model description</b>
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

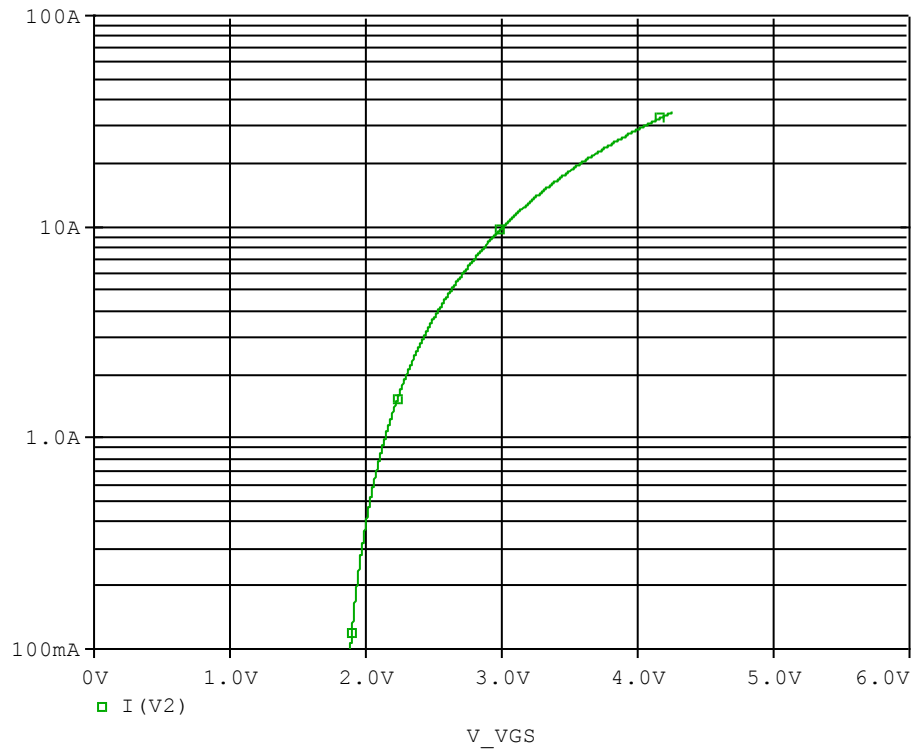


Comparison table

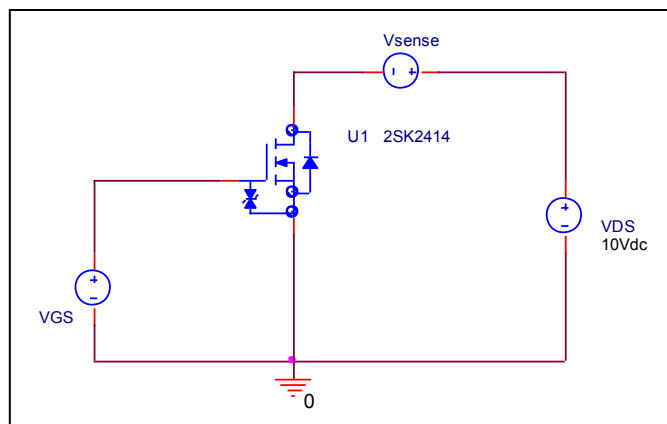
Id(A)	gfs(s)		Error(%)
	Measurement	Simulation	
1	5.535	5.435	-1.807
2	7.591	7.491	-1.317
5	11.390	11.499	0.961
10	15.385	15.212	-1.120
20	20.665	19.802	-4.176

# Vgs-Id Characteristics

## Circuit Simulation Result

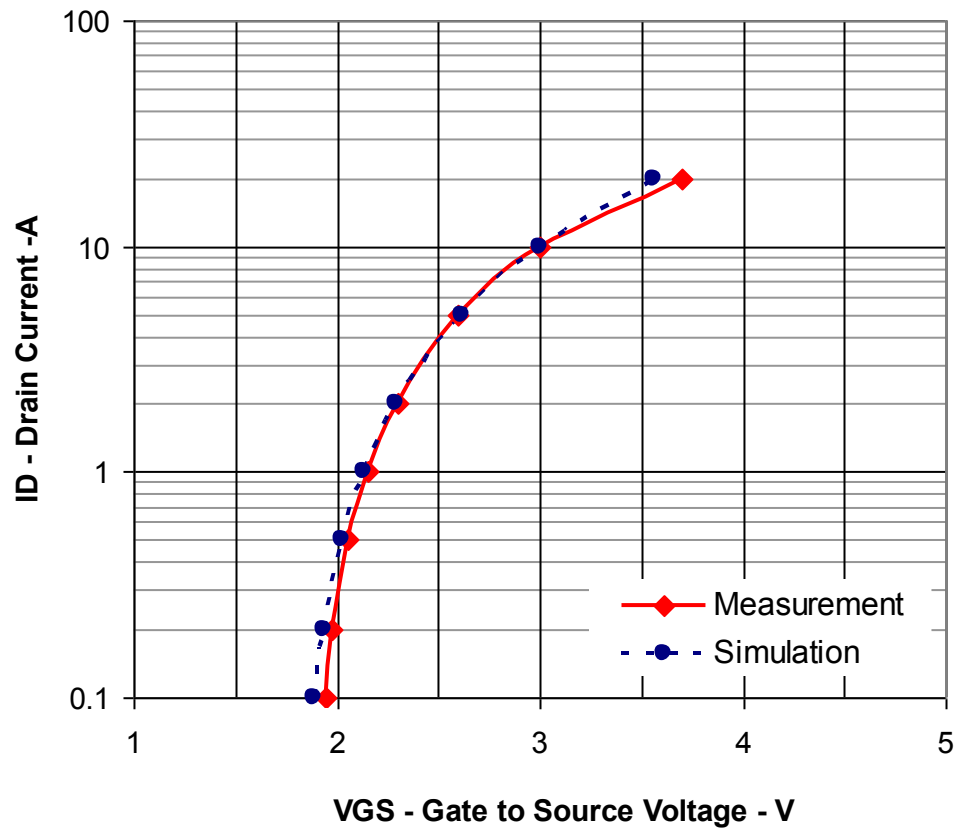


## Evaluation circuit



## Comparison Graph

Circuit Simulation Result

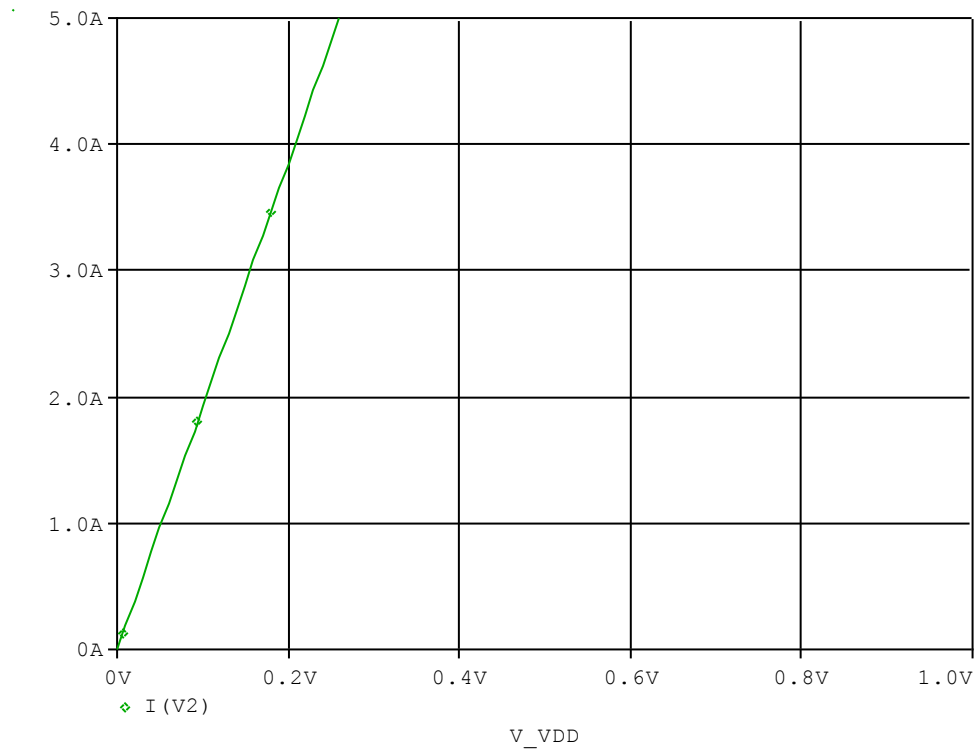


Comparison table

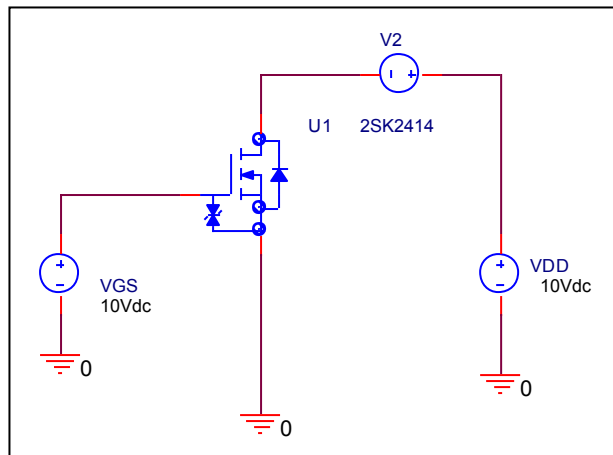
$I_D$ (A)	$V_{GS}$ (V)		Error (%)
	Measurement	Simulation	
0.1	1.950	1.884	-3.369
0.2	1.980	1.932	-2.424
0.5	2.050	2.028	-1.088
1	2.150	2.137	-0.595
2	2.300	2.295	-0.222
5	2.600	2.618	0.696
10	3.000	2.999	-0.050
20	3.700	3.563	-3.716

## \*Rds(on) Characteristic

### Circuit Simulation result



### Evaluation circuit

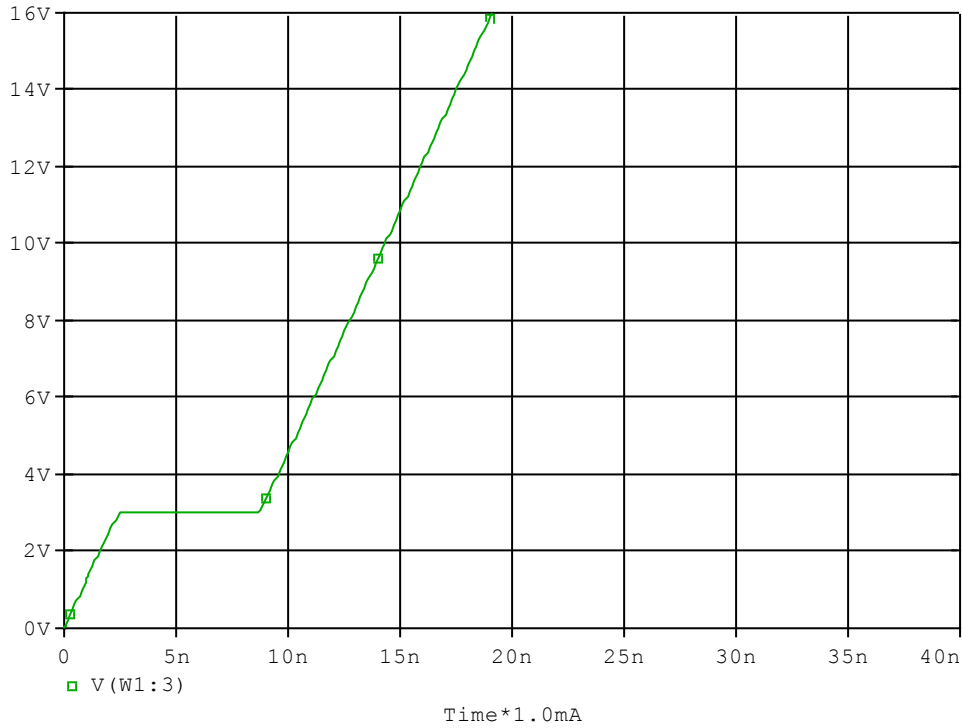


### Simulation Result

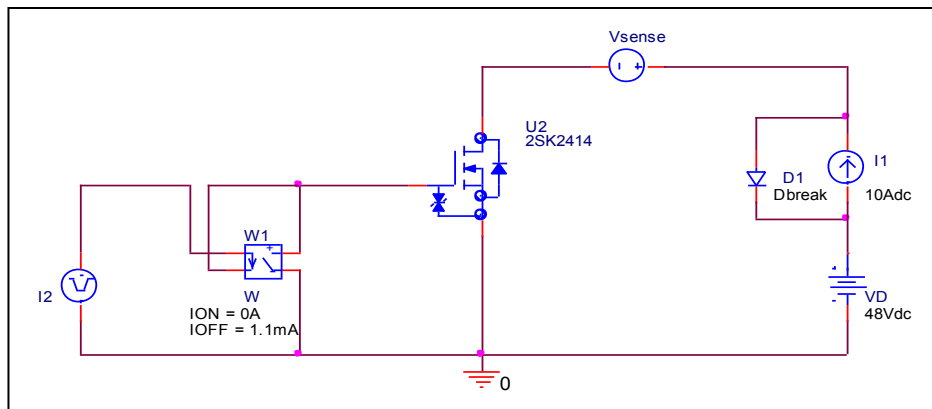
<b><math>I_D=5.0A, V_{GS}=10V</math></b>	<b>Measurement</b>		<b>Simulation</b>		<b>Error (%)</b>
<b><math>R_{DS} (on)</math></b>	<b>52.00</b>	<b>mΩ</b>	<b>52.00</b>	<b>mΩ</b>	<b>0.00</b>

# Gate Charge Characteristic

## Circuit Simulation result



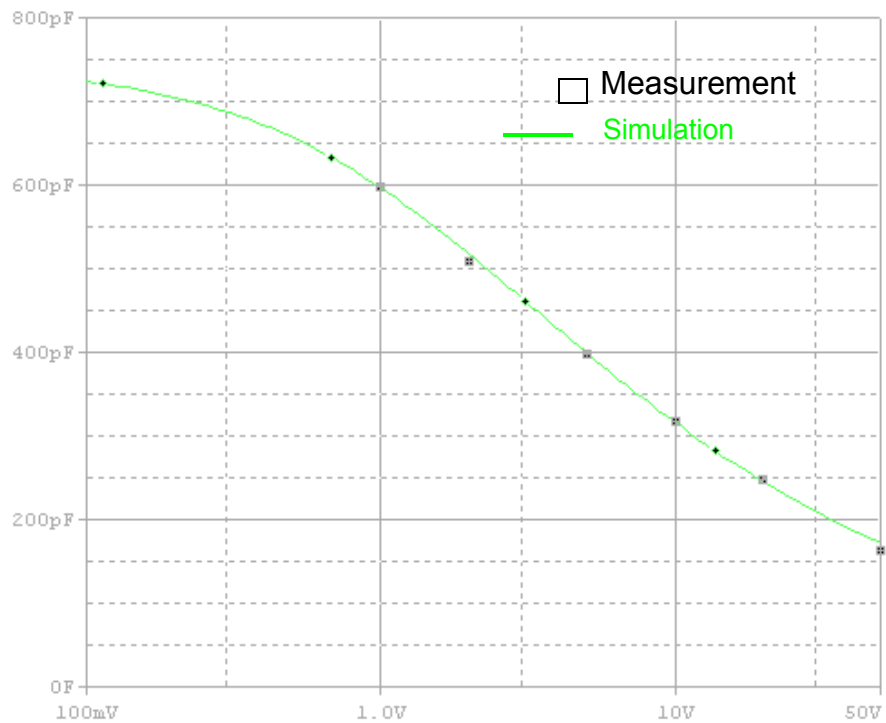
## Evaluation circuit



## Simulation Result

$V_{DD}=48V, I_D=10A,$ $V_{GS}=10V$		Measurement	Simulation	Error (%)
<b>QGS</b>	<b>nC</b>	<b>2.60</b>	<b>2.55</b>	<b>-1.92</b>
<b>GGD</b>	<b>nC</b>	<b>6.00</b>	<b>6.09</b>	<b>1.50</b>

## Capacitance Characteristic



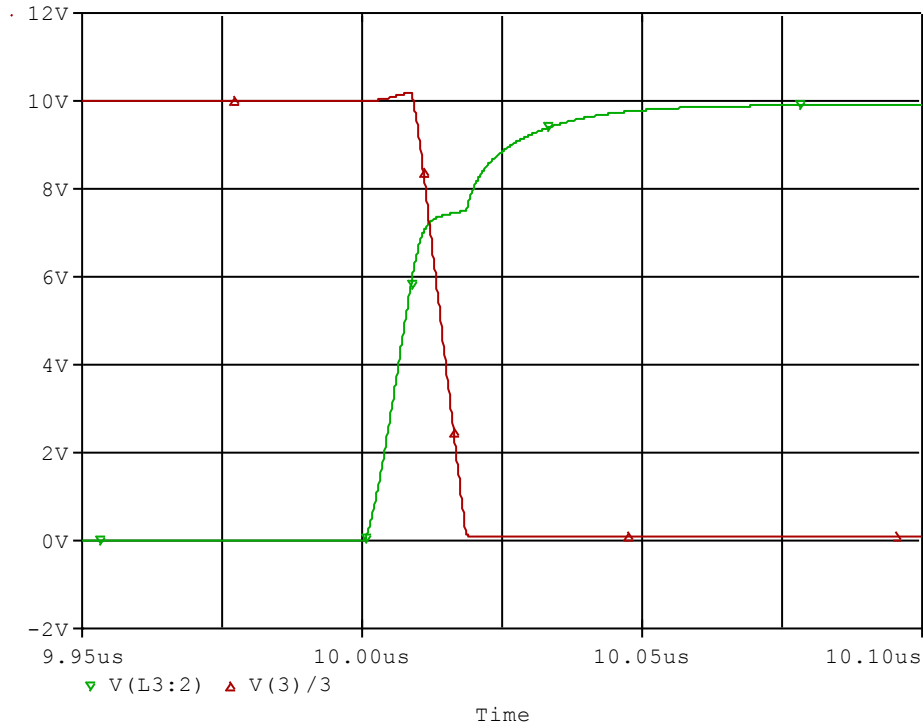
### Simulation Result

V <sub>ds</sub> (V)	Cbd(pF)		Error(%)
	Measurement	Simulation	
1	600.00	600.00	0.00
2	510.00	508.00	-0.39
5	400.00	388.00	-3.00
10	320.00	309.00	-3.44
20	250.00	248.00	-0.80
50	165.00	160.00	-3.03

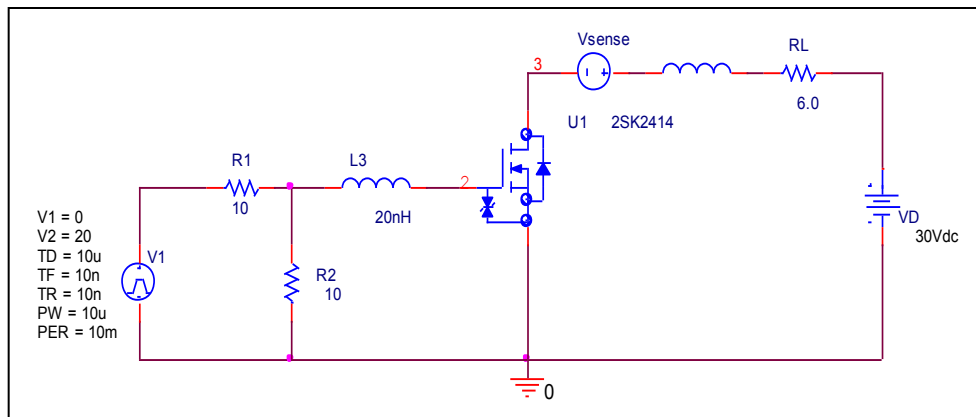


# Switching Time Characteristic

## Circuit Simulation result



## Evaluation circuit

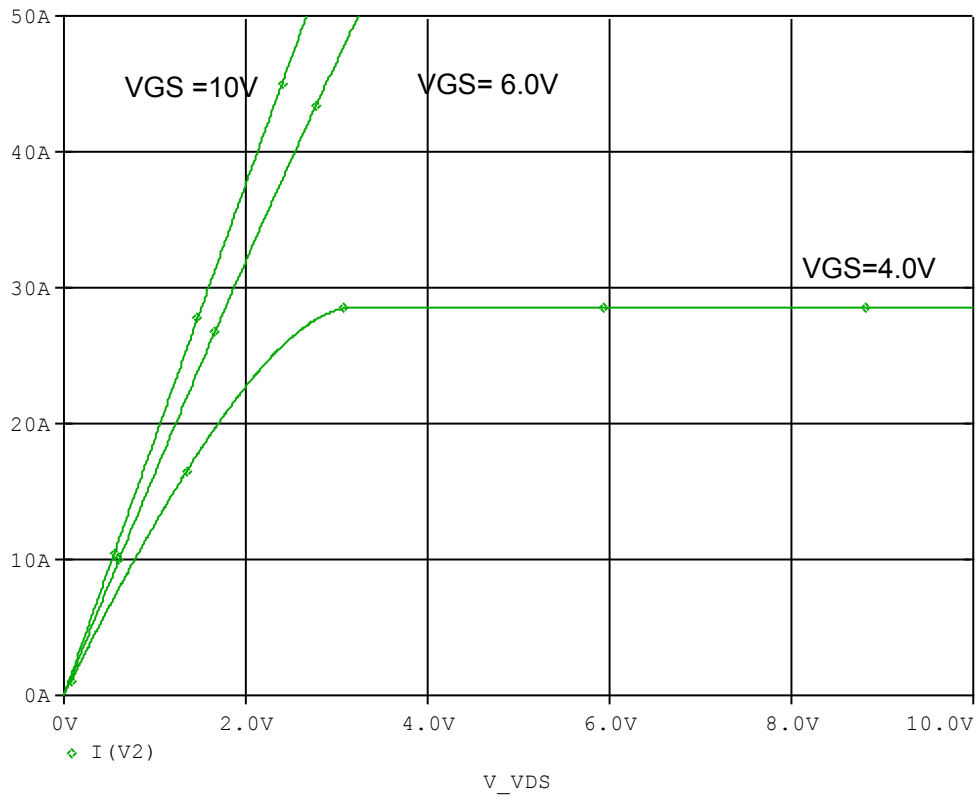


## Simulation Result

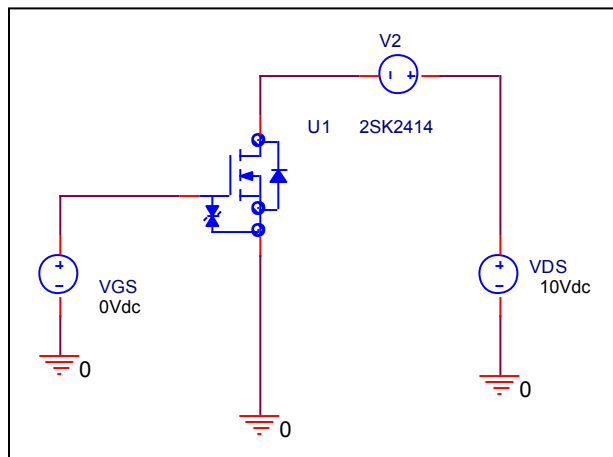
$I_D=5.0A, V_{DD}=30V$ $V_{GS}=0/10V$		Measurement	Simulation	Error(%)
<b>td(on)</b>	<b>ns</b>	<b>15.00</b>	<b>15.02</b>	<b>0.133</b>

# Output Characteristic

## Circuit Simulation result

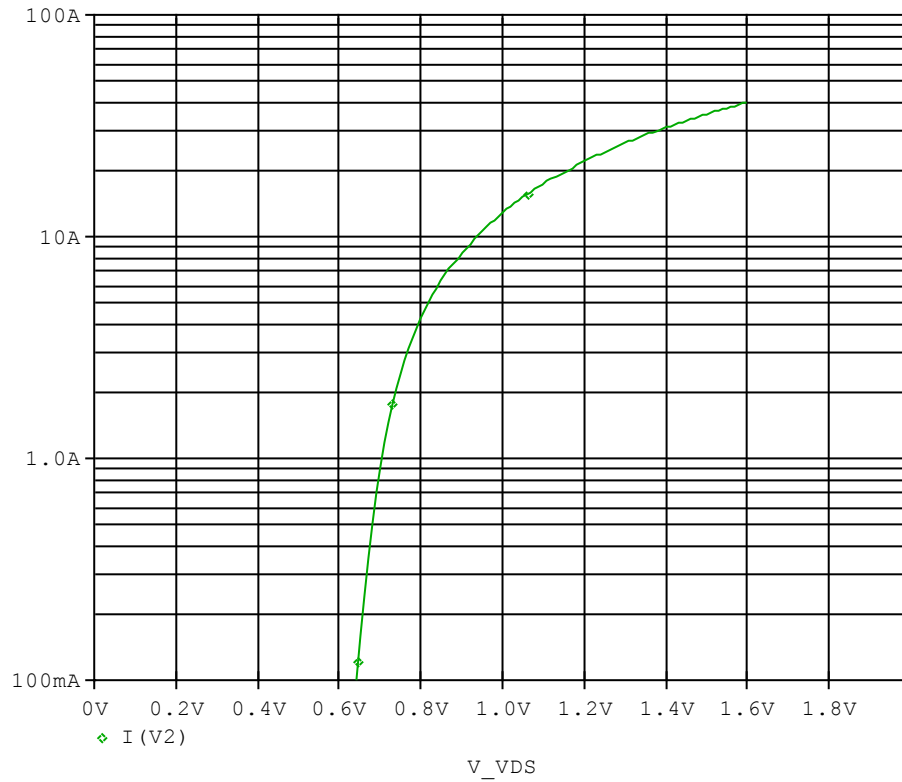


## Evaluation circuit

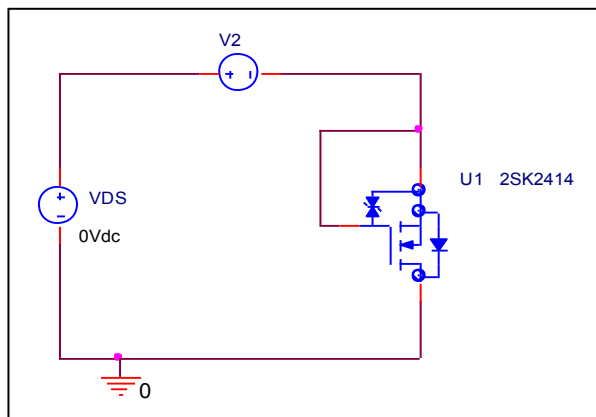


# BODY DIODE SPICE MODEL Forward Current Characteristic

## Circuit Simulation Result

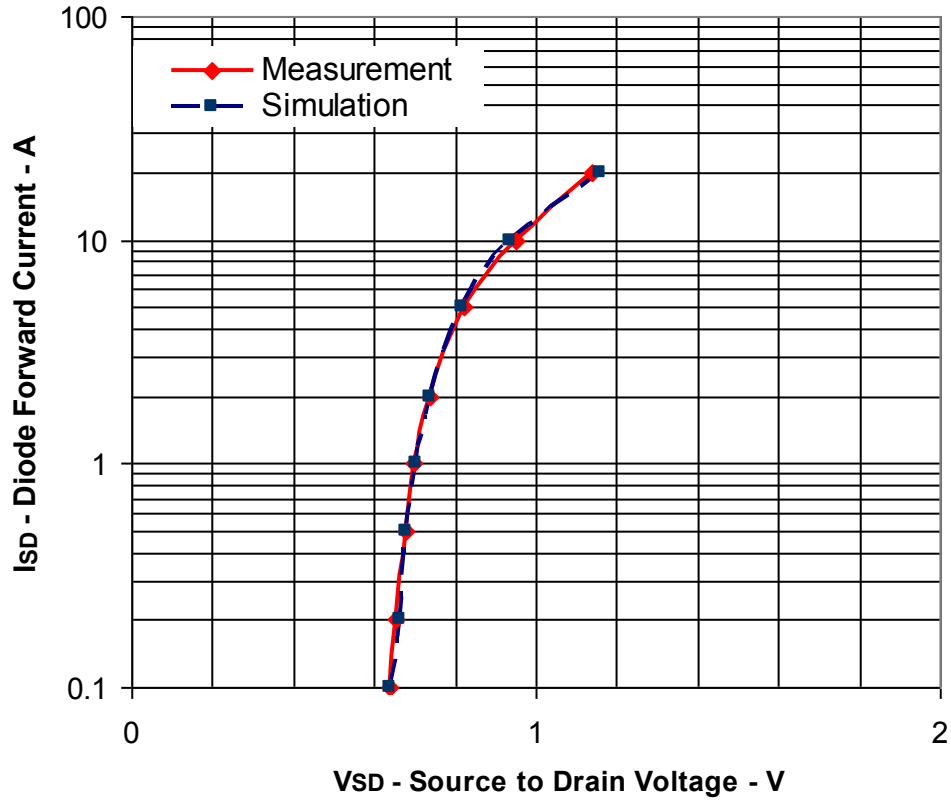


## Evaluation Circuit



## Comparison Graph

### Circuit Simulation Result

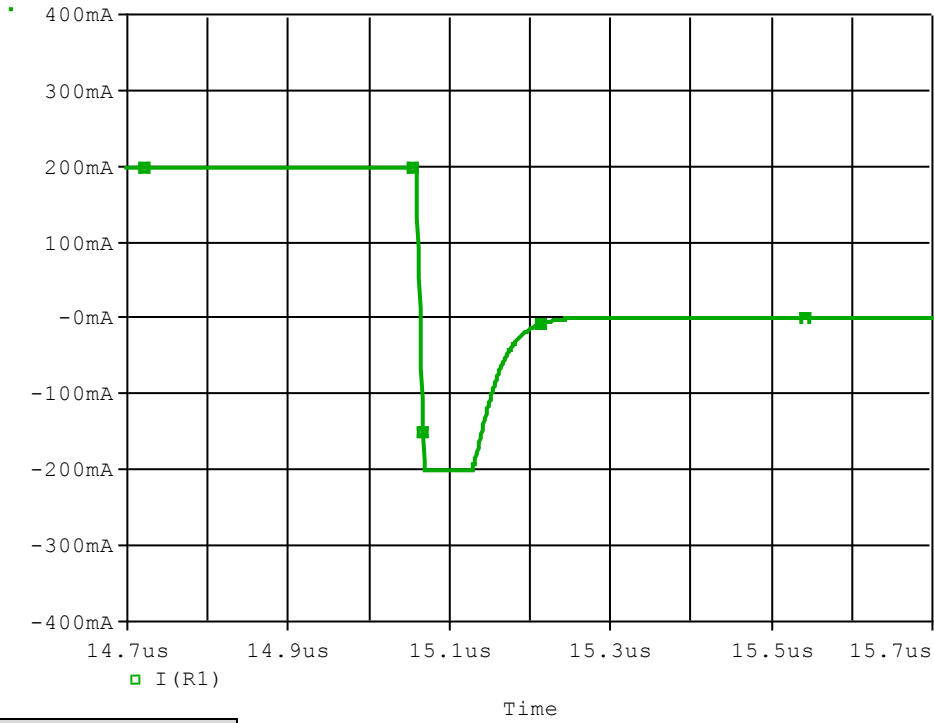


### Simulation Result

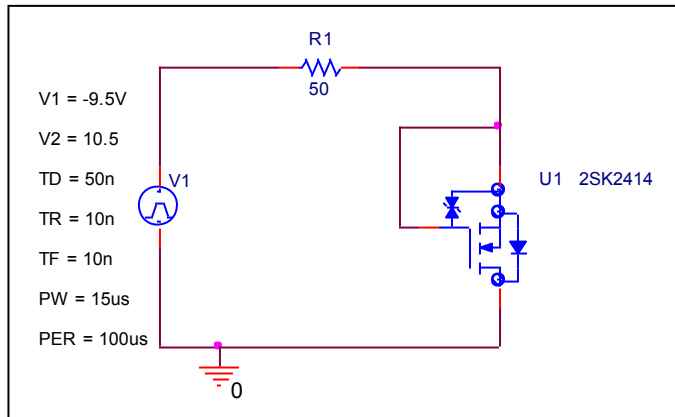
ISD(A)	VDS(V)		%Error
	Measurement	Simulation	
0.1	0.6400	0.6401	0.0156
0.2	0.6550	0.6652	1.5573
0.5	0.6800	0.6794	-0.0882
1	0.7000	0.7032	0.4571
2	0.7400	0.7376	-0.3243
5	0.8200	0.8182	-0.2195
10	0.9500	0.9365	-1.4211
20	1.1400	1.1601	1.7632

# Reverse Recovery Characteristic

## Circuit Simulation Result



## Evaluation Circuit

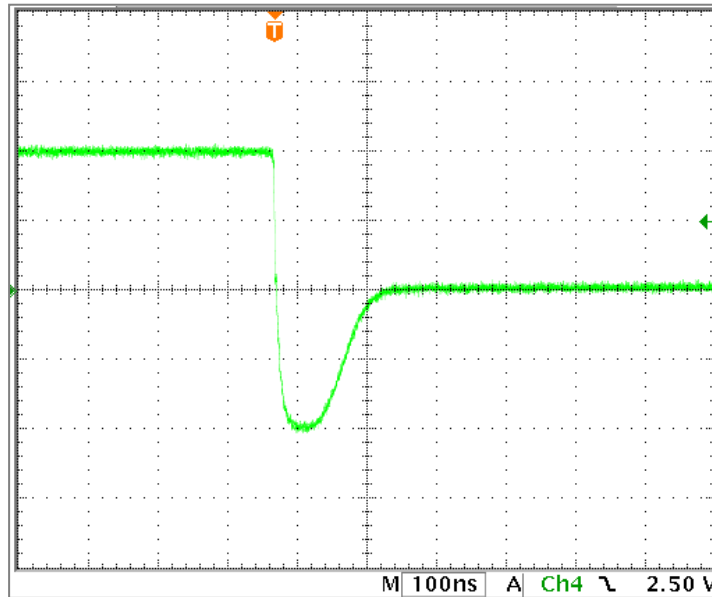


## Compare Measurement vs. Simulation

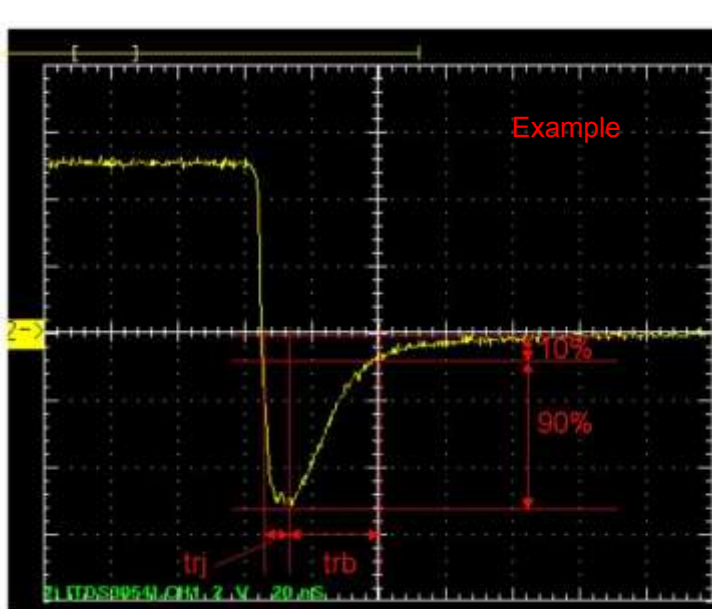
	Measurement	Simulation	Error (%)
<b>trr (ns)</b>	<b>130.00</b>	<b>130.10</b>	<b>0.077</b>

# Reverse Recovery Characteristic

# Reference



Trj=60.0(ns)  
Trb=70.0(ns)  
Conditions: Ifwd=Irev=0.2(A), RI=50

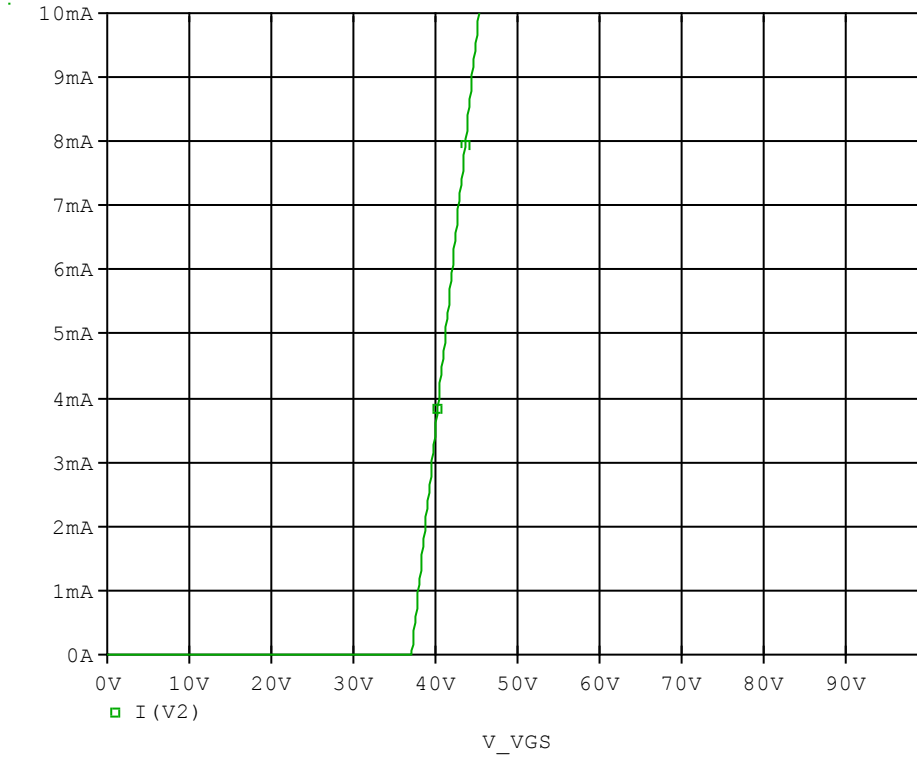


Relation between trj and trb

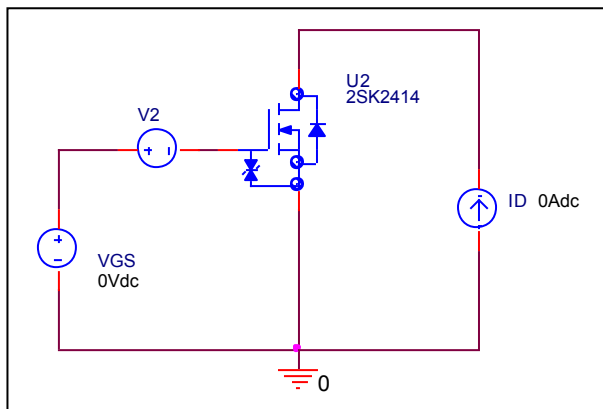
# ESD PROTECTION DIODE SPICE MODEL

## Zener Voltage Characteristic

### Circuit Simulation Result



### Evaluation Circuit



# Zener Voltage Characteristic

# Reference

