

Device Modeling Report

COMPONENTS: Power MOSFET (Model parameter)
PART NUMBER: 2SK3940
MANUFACTURER: TOSHIBA
Body Diode (Model parameter) / ESD Protection Diode



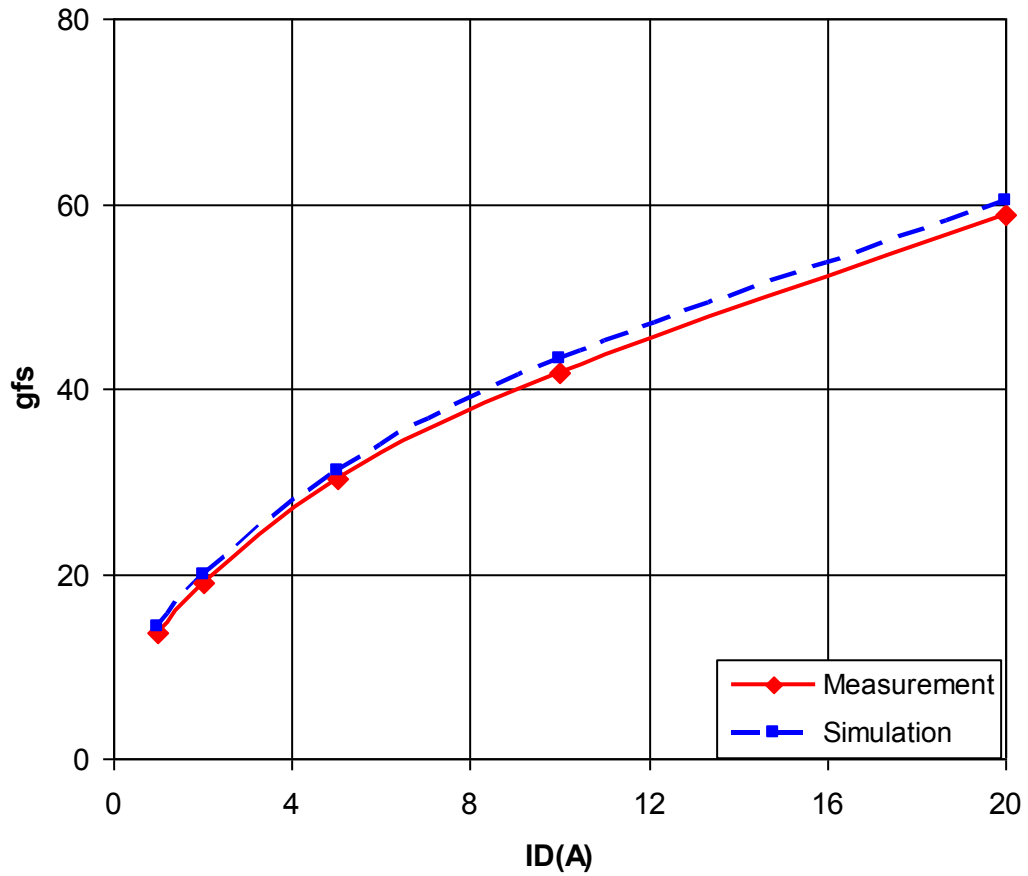
Bee Technologies Inc.

MOSFET MODEL

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 Characteristic

Circuit Simulation Result

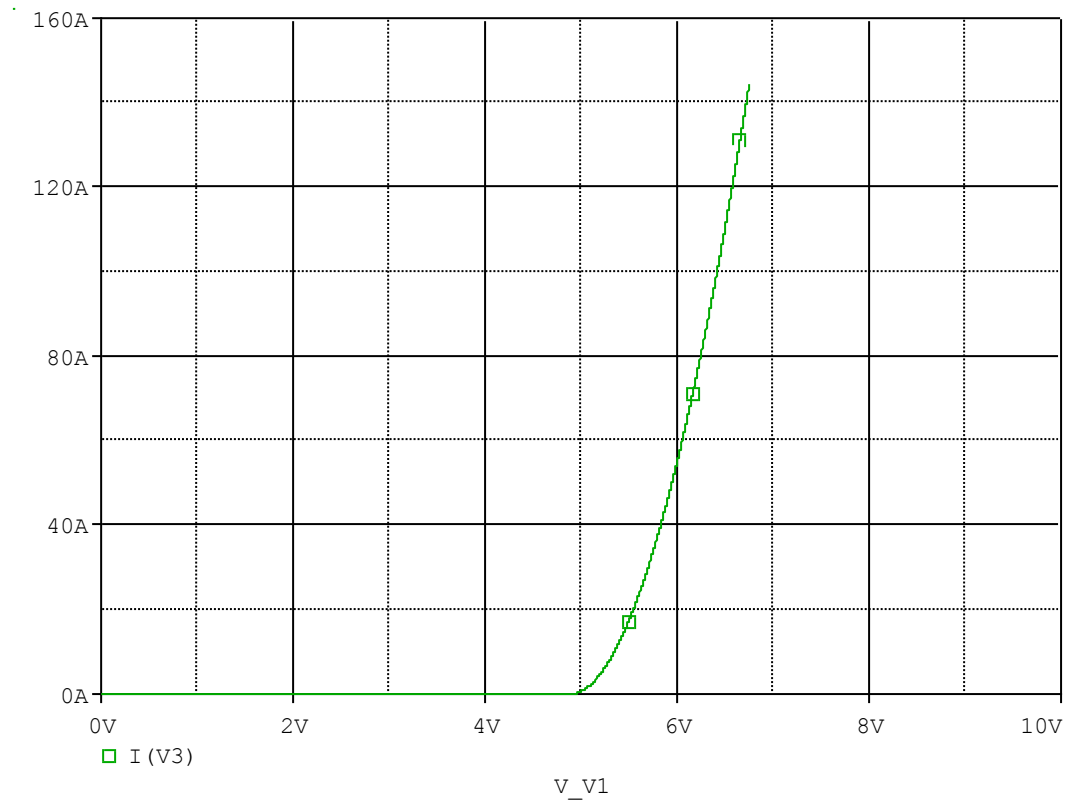


Comparison table

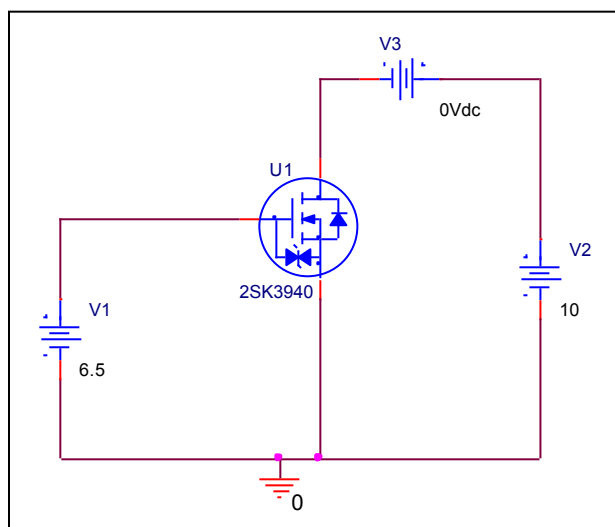
Id(A)	gfs		Error (%)
	Measurement	Simulation	
1	13.699	14.286	4.285
2	19.048	19.802	3.958
5	30.303	31.056	2.485
10	41.667	43.290	3.895
20	58.824	60.241	2.409

V_{gs}-I_d Characteristic

Circuit Simulation result

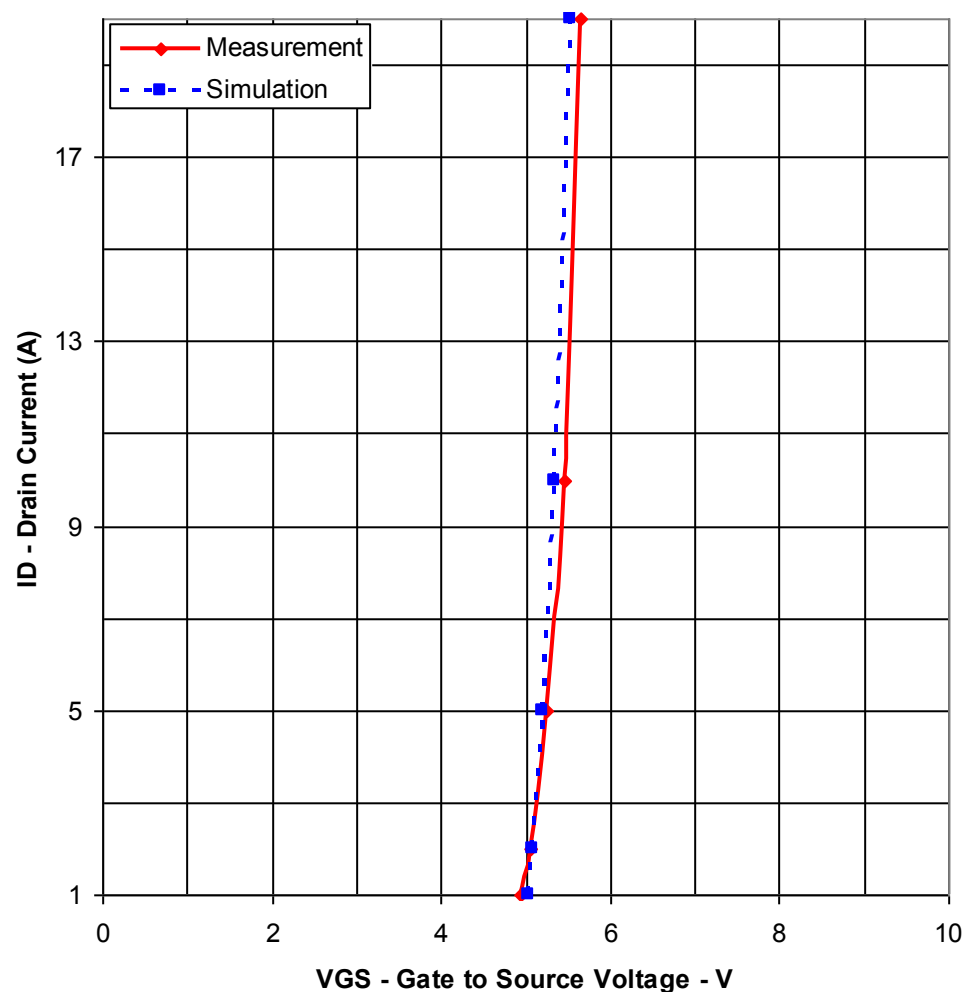


Evaluation circuit



Comparison Graph

Circuit Simulation Result

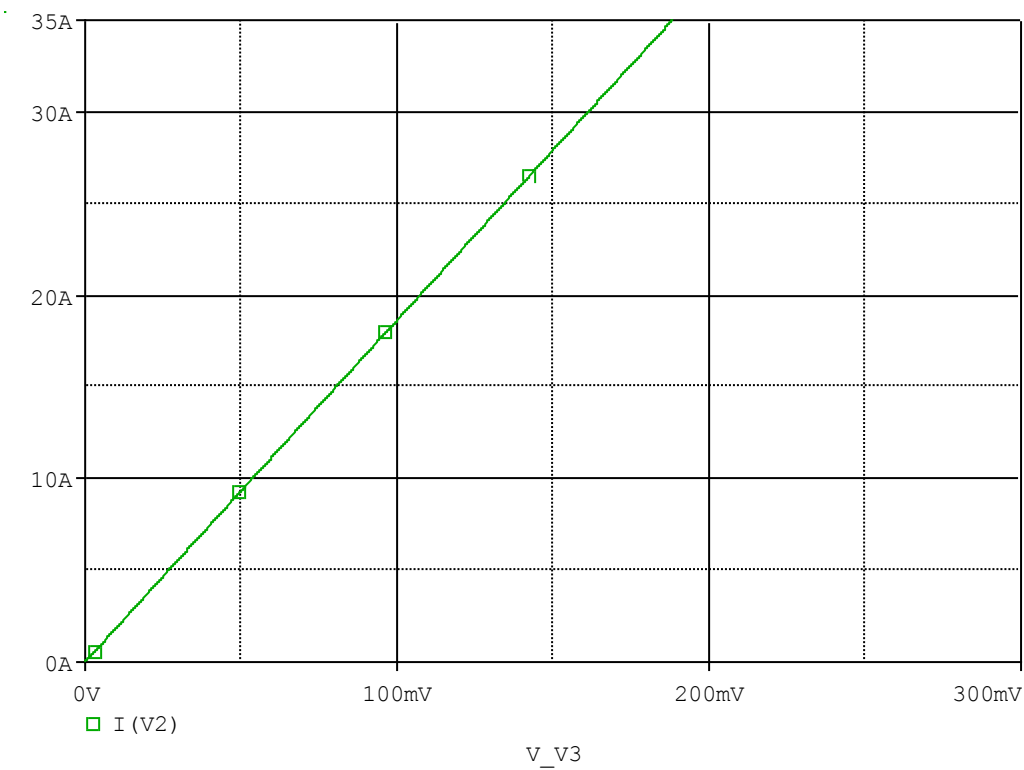


Simulation Result

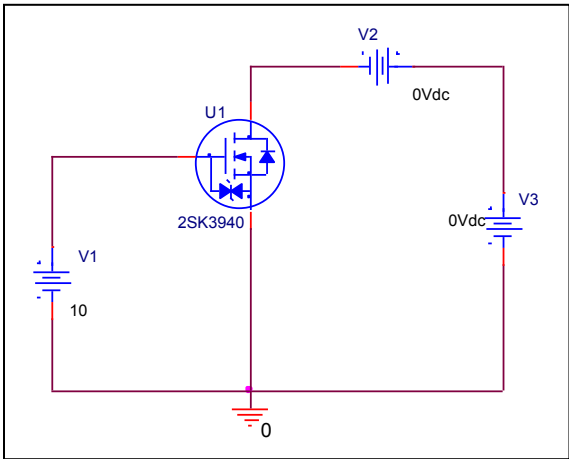
ID(A)	VGS(V)		Error (%)
	Measurement	Simulation	
1	4.95	5.0274	1.564
2	5.05	5.0876	0.745
5	5.25	5.2083	-0.794
10	5.45	5.3460	-1.908
20	5.65	5.5437	-1.881

Rds(on) Characteristic

Circuit Simulation result



Evaluation circuit

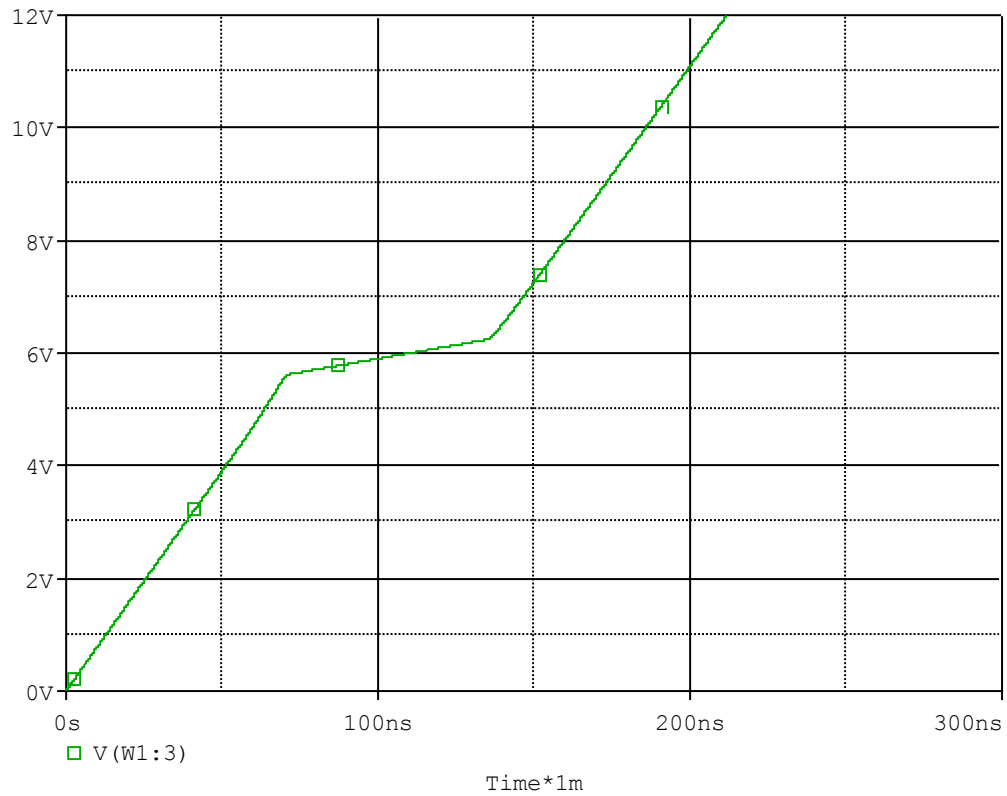


Simulation Result

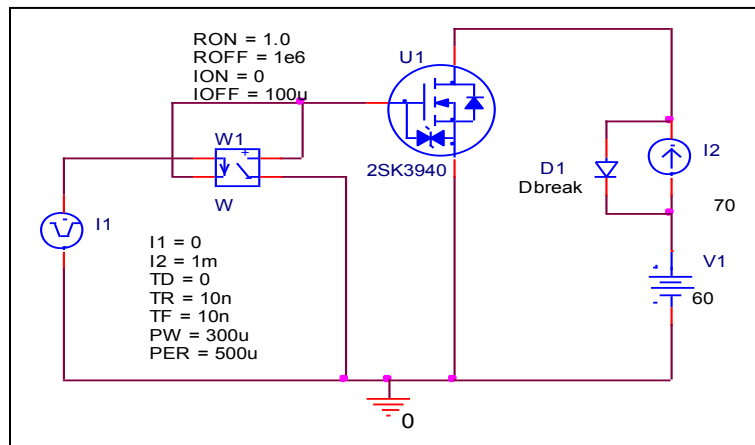
$I_D=35A, V_{GS}=10V$	Measurement		Simulation		Error (%)
$R_{DS(on)}$	5.6	mΩ	5.379	mΩ	-3.946

Gate Charge Characteristic

Circuit Simulation result



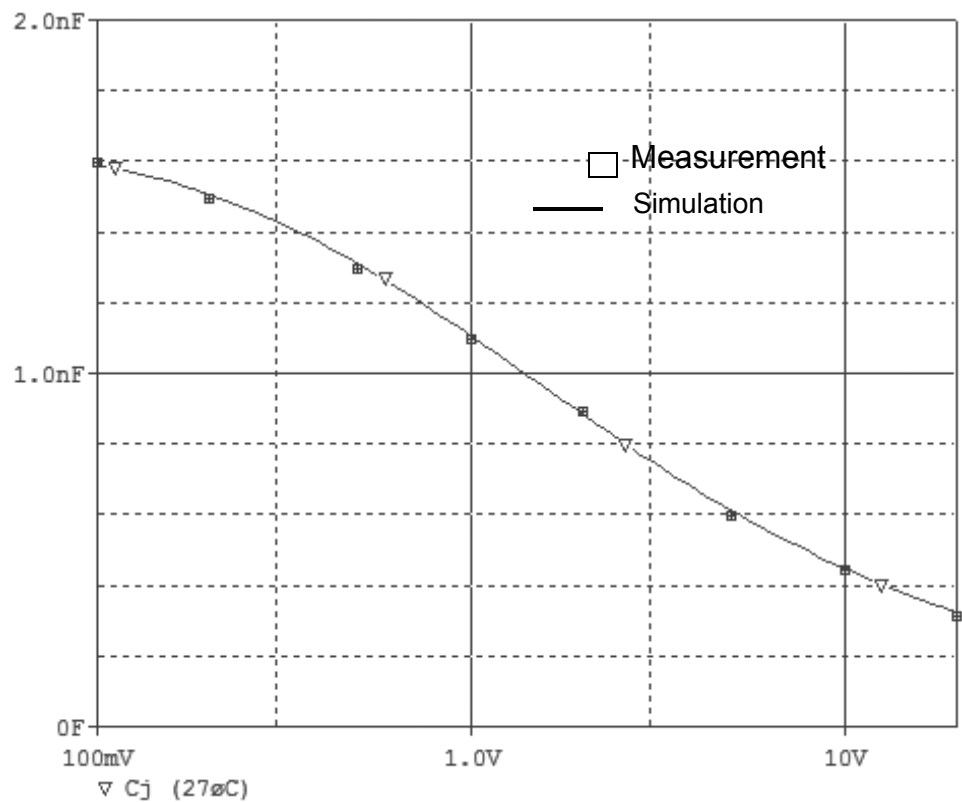
Evaluation circuit



Simulation Result

$V_{DD}=60V, I_D=70A$	Measurement		Simulation		Error (%)
Qgs	70	nC	70.648	nC	0.926
Qgd	65	nC	64.983	nC	-0.026
Qg	205	nC	185.984	nC	-9.276

Capacitance Characteristic

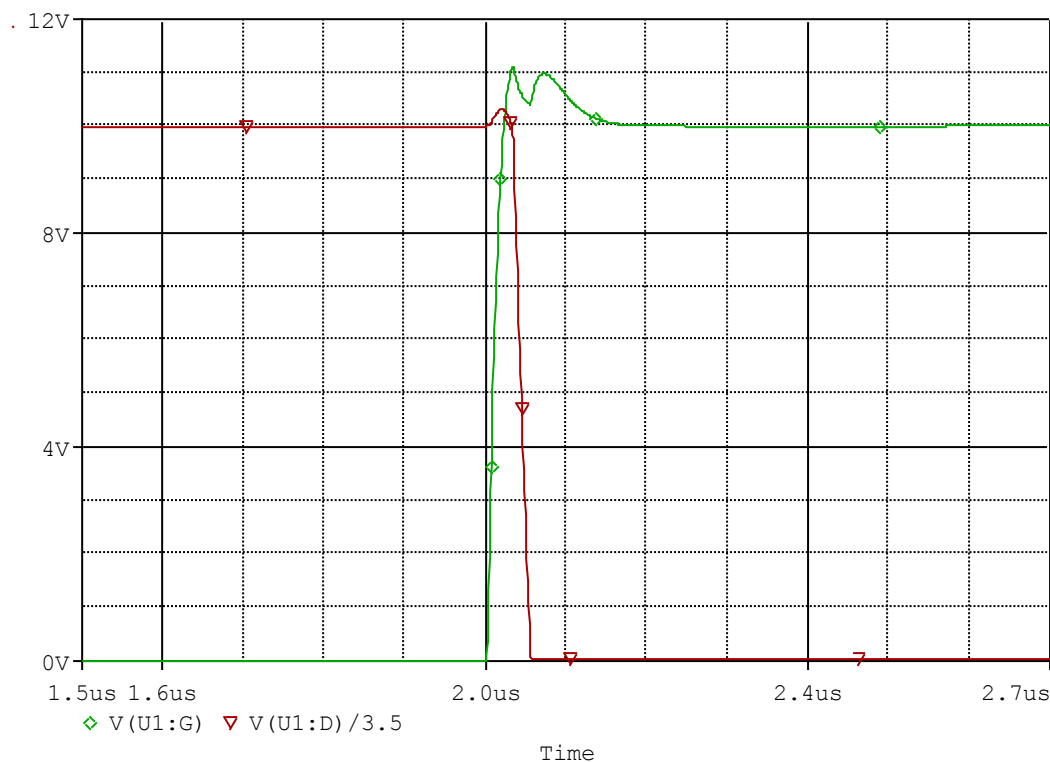


Simulation Result

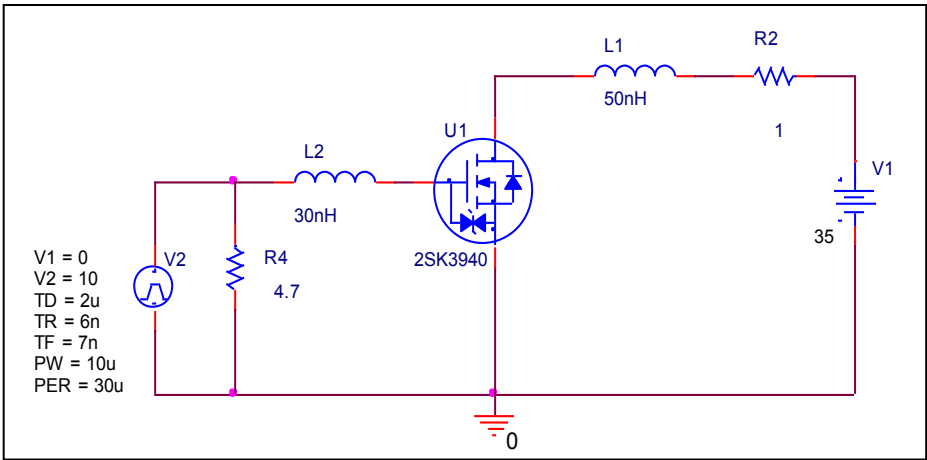
V _{ds} (V)	Cbd(pF)		Error(%)
	Measurement	Simulation	
0.1	1600	1590	-0.625
0.2	1500	1505	0.333
0.5	1300	1305	0.385
1	1100	1140	3.636
2	900	870	-3.333
5	600	610	1.667
10	450	445	-1.111
20	320	323	0.938

Switching Time Characteristic

Circuit Simulation result



Evaluation circuit

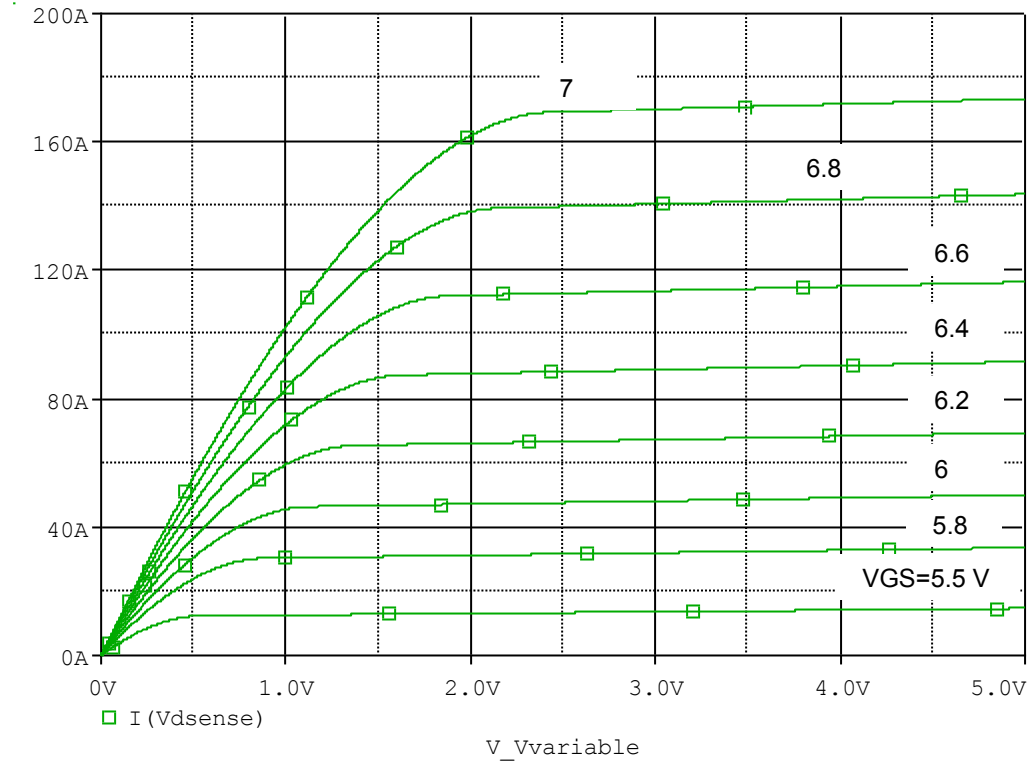


Simulation Result

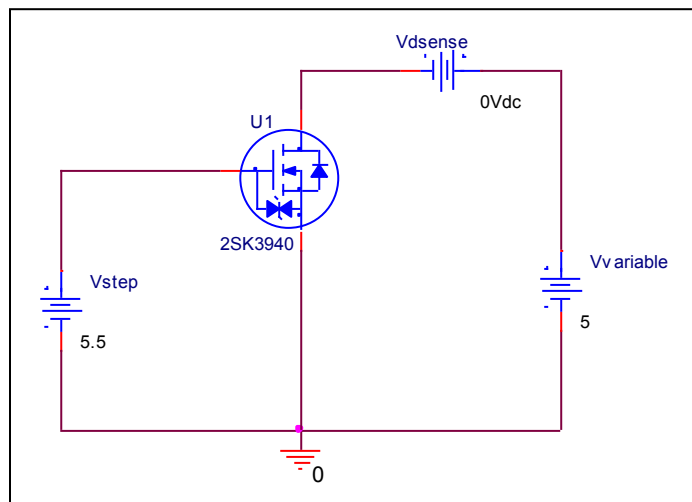
$I_D=35\text{ A}$, $V_{DD}=35\text{ V}$ $V_{GS}=0/10\text{ V}$	Measurement		Simulation		Error(%)
	ton	50.000 ns	49.938 ns	ns	

Output Characteristic

Circuit Simulation result



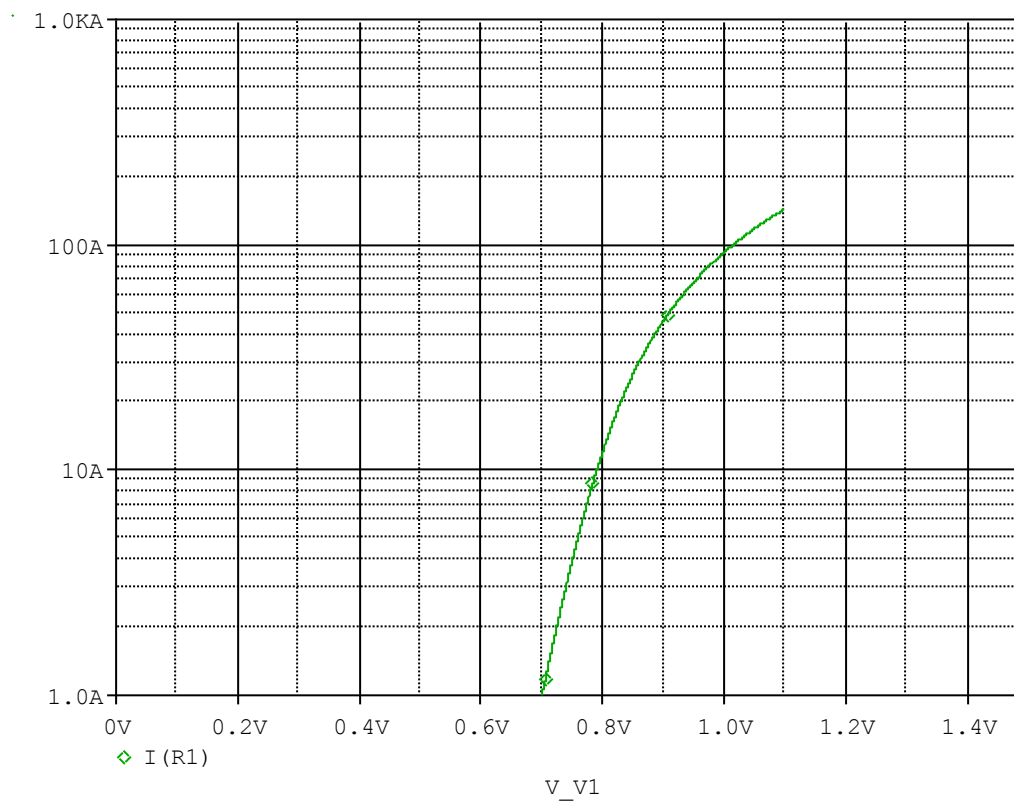
Evaluation circuit



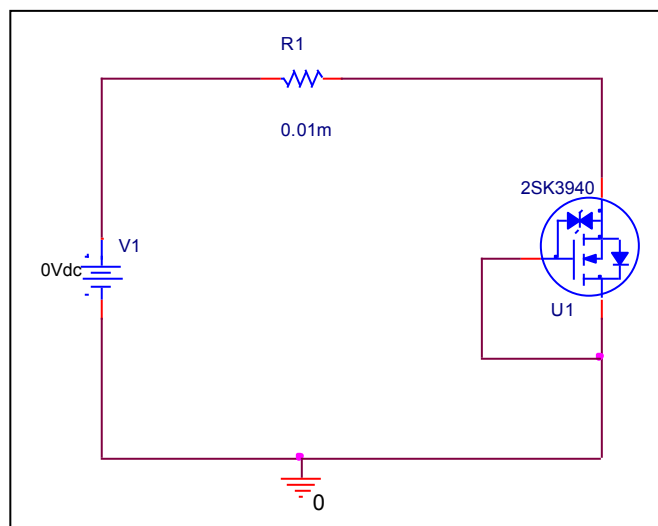
BODY DIODE

Forward Current Characteristic

Circuit Simulation Result

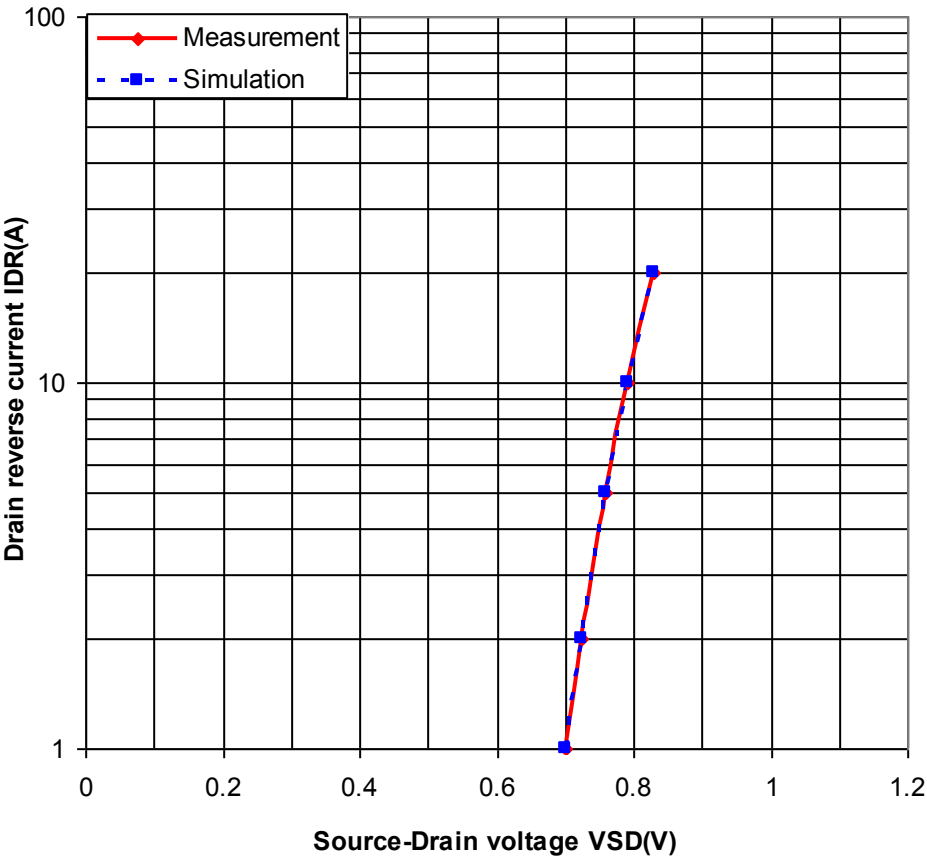


Evaluation Circuit



Comparison Graph

Circuit Simulation Result

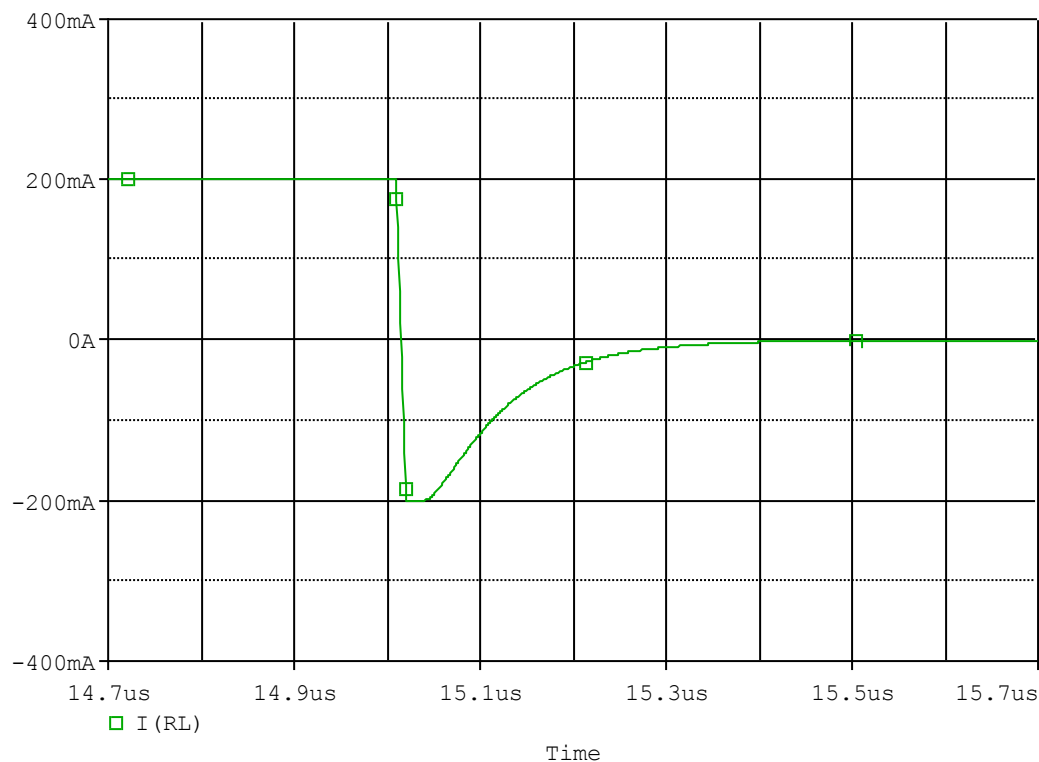


Simulation Result

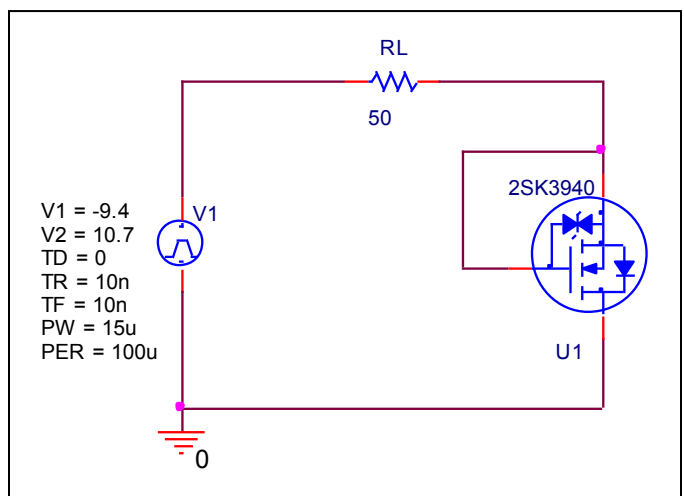
Ifwd(A)	VSD(V)		%Error
	Measurement	Simulation	
1	0.7	0.7	0
2	0.725	0.7247	-0.041
5	0.76	0.7597	-0.039
10	0.79	0.791	0.127
20	0.83	0.830	0

Reverse Recovery Characteristic

Circuit Simulation Result



Evaluation Circuit

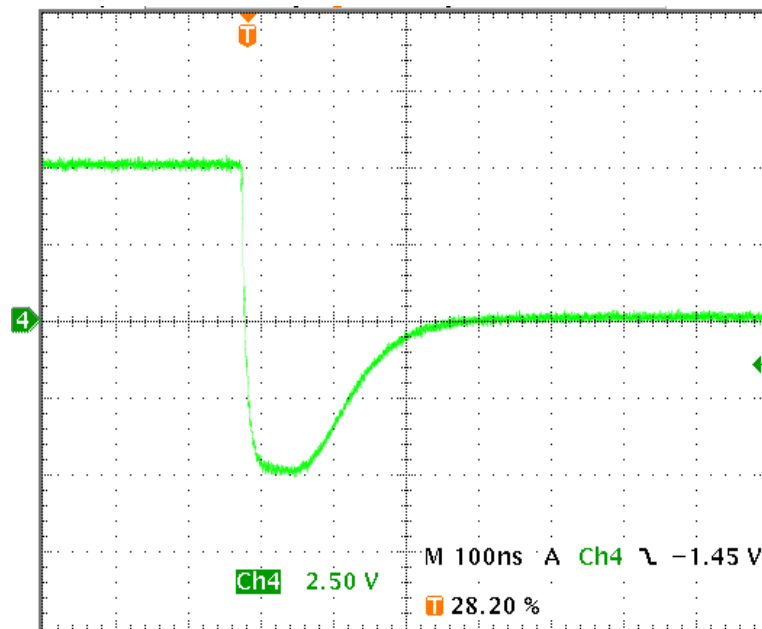


Compare Measurement vs. Simulation

Trr(ns)	Measurement	Simulation	Error (%)
Trj+Trb (ns)	222	222.344	0.155

Reverse Recovery Characteristic

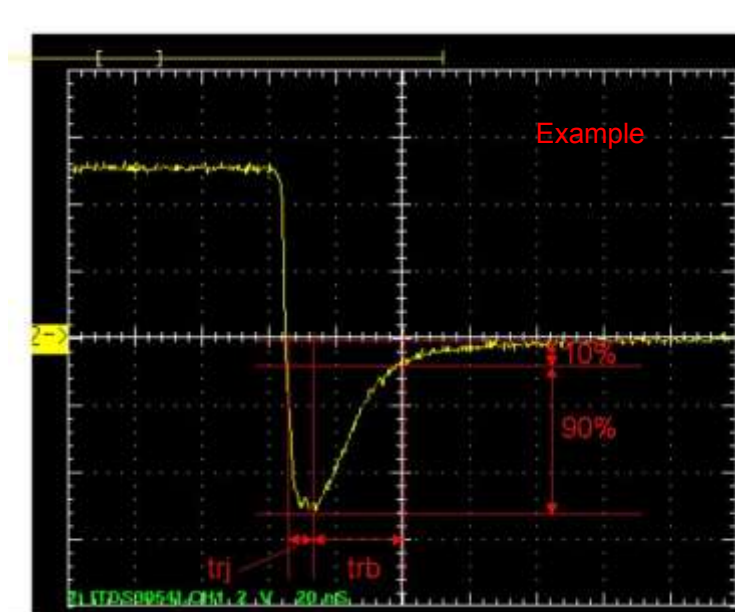
Reference



$T_{rr}=66(\text{ns})$

$T_{rb}=156(\text{ns})$

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

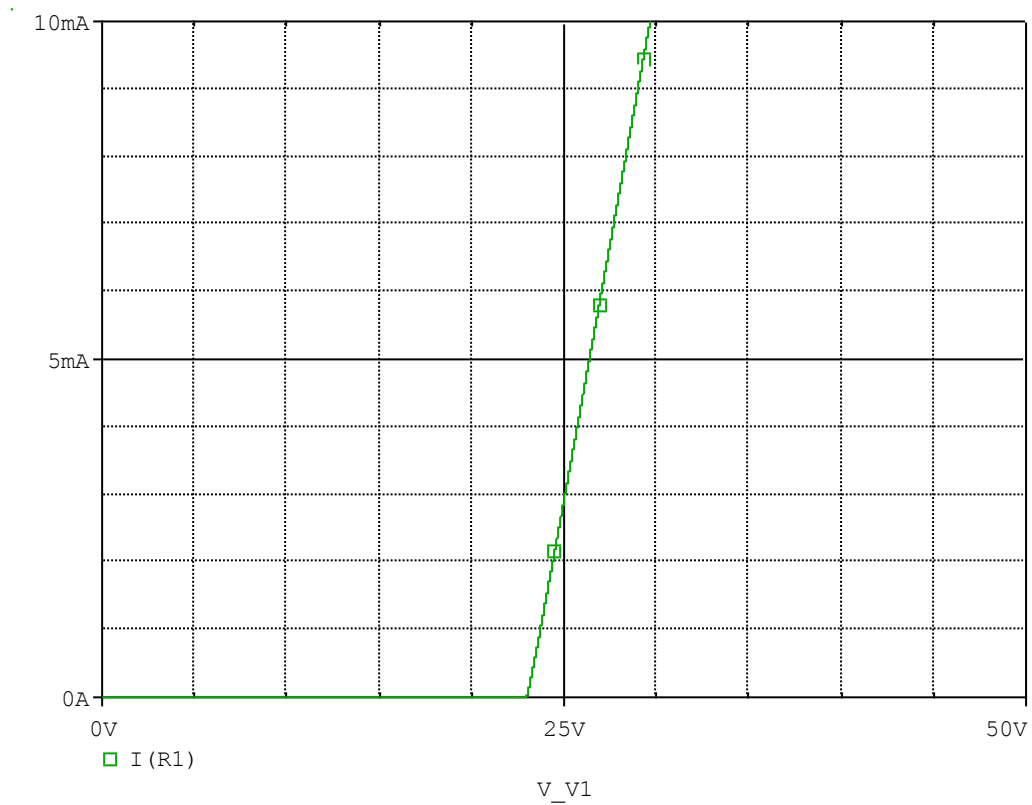


Relation between t_{rr} and t_{rb}

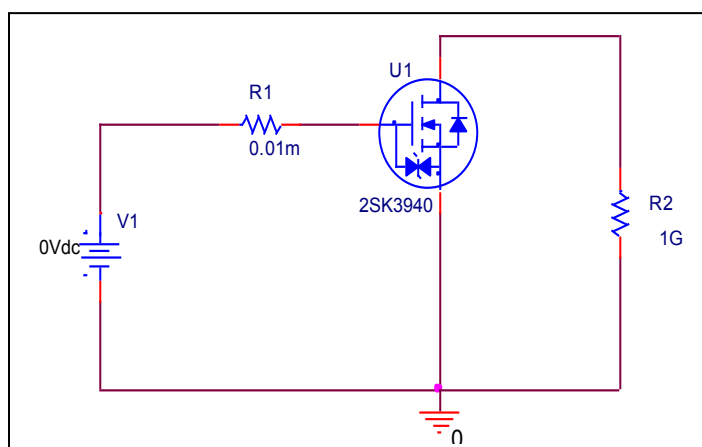
ESD PROTECTION DIODE

Zener Voltage Characteristic

Circuit Simulation Result



Evaluation Circuit



Zener Voltage Characteristic

Reference

