Device Modeling Report

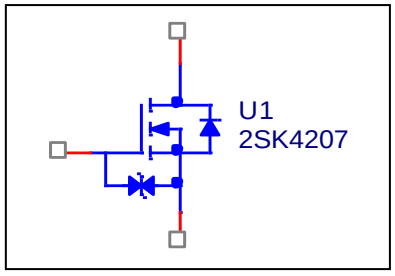
COMPONENTS: MOSFET (Professional Model)
PART NUMBER: 2SK4207
MANUFACTURER: TOSHIBA
REMARK: Body Diode (Professional Model)

Bee Technologies Inc.

SPICE MODEL

```
*$
* PART NUMBER: 2SK4207
* MANUFACTURER: TOSHIBA
* VDS=900V, ID=13A
* All Rights Reserved Copyright (C) Bee Technologies Inc. 2013
.SUBCKT 2SK4207 1 2 3
X_U1     2 1 3      M2SK4207_p
X_U2     3 2        D2SK4207_p
X_U3     1 3        DZ2SK4207
.ENDS
*$
```

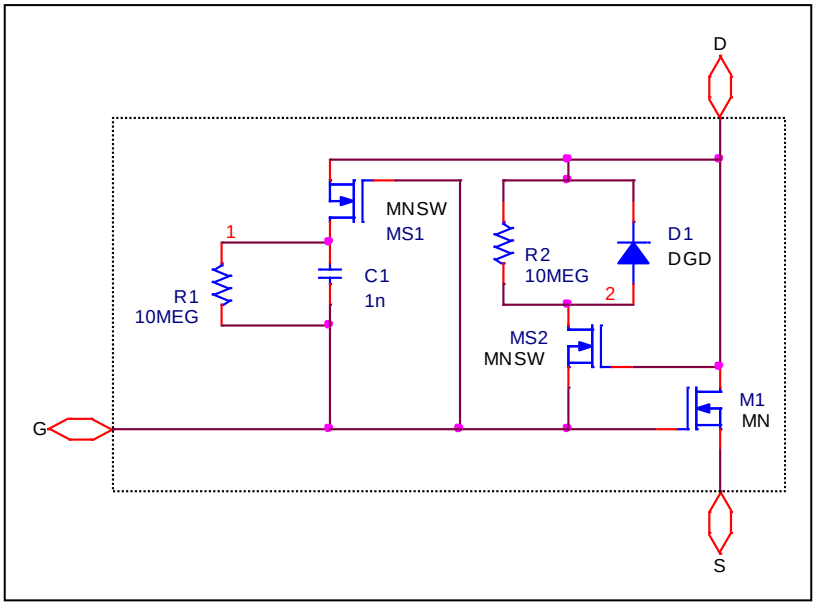
Circuit Configuration



POWER MOSFET SPICE MODEL

```
*$
.SUBCKT M2SK4207_p   D G S
RD      D D0            0.75371
CGD     1       G       0.6n
R1      1       G       10MEG
MS1     1 G D0 D0       MNSW
D1      2       D0      DGD
R2      D0      2       10MEG
MS2     2 D0 G G        MNSW
M1      D0 G S S        M2SK4207
.MODEL MNSW NMOS Vto=-0.01 KP=100 N=1Meg Rds=1e12
.MODEL DGD D (CJO=1.0651E-9 M=.65179 VJ=.36366)
.MODEL M2SK4207 NMOS
+ LEVEL=3 L=1u W=1u KP=7.97 RS=10.00E-6 RD=0
+ VTO=3.65 RDS=7.20E6 TOX=2.00E-6
+ CGSO=3010u CGDO=10p CBD=3.6625E-9
+ MJ=0.7154 PB=1.8102 RG=38.8 IS=1.0E-15 N=5 RB=1
+ GAMMA=0 THETA=50m KAPPA=0 ETA=0.03m
.ENDS
*$
```

Equivalent Circuit

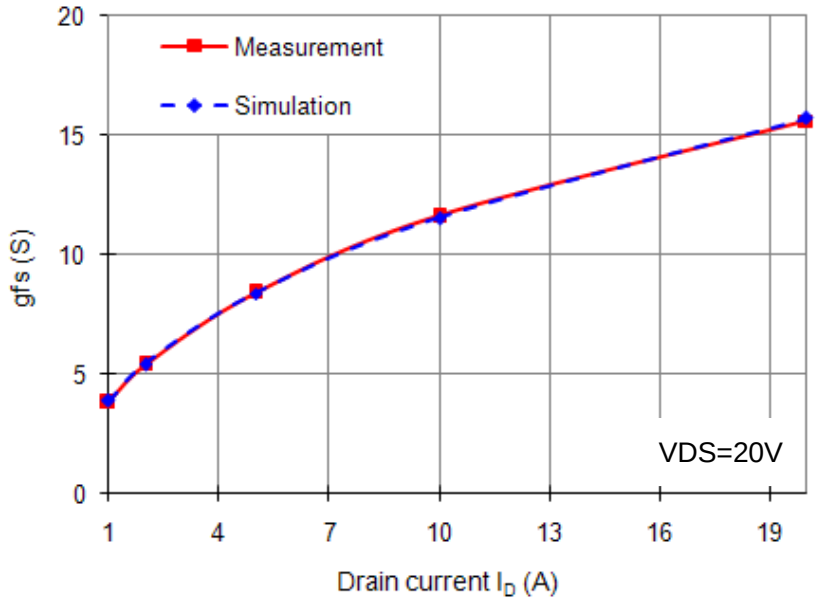


MOSFET MODEL

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 Characteristics

Circuit Simulation result

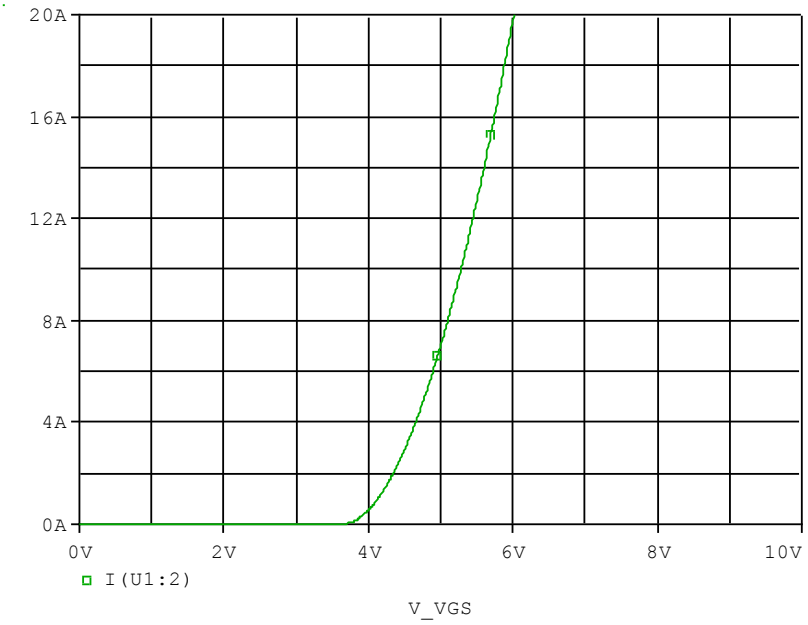


Comparison table

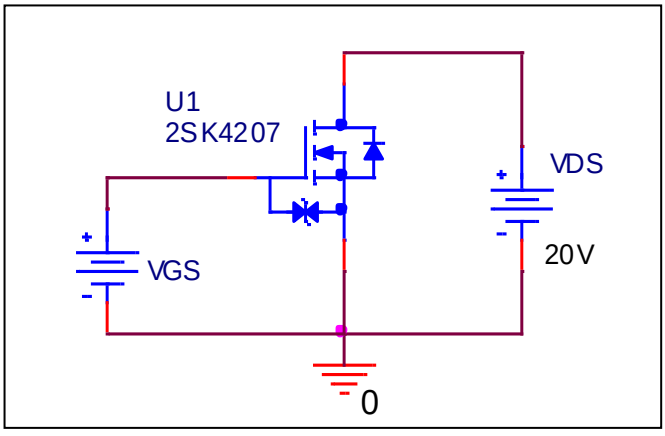
I_D (A)	gfs (S)		%Error
	Measurement	Simulation	
1	3.830	3.877	1.23
2	5.392	5.413	0.39
5	8.408	8.379	-0.34
10	11.609	11.528	-0.70
20	15.594	15.719	0.80

Vgs-Id Characteristics

Circuit Simulation result

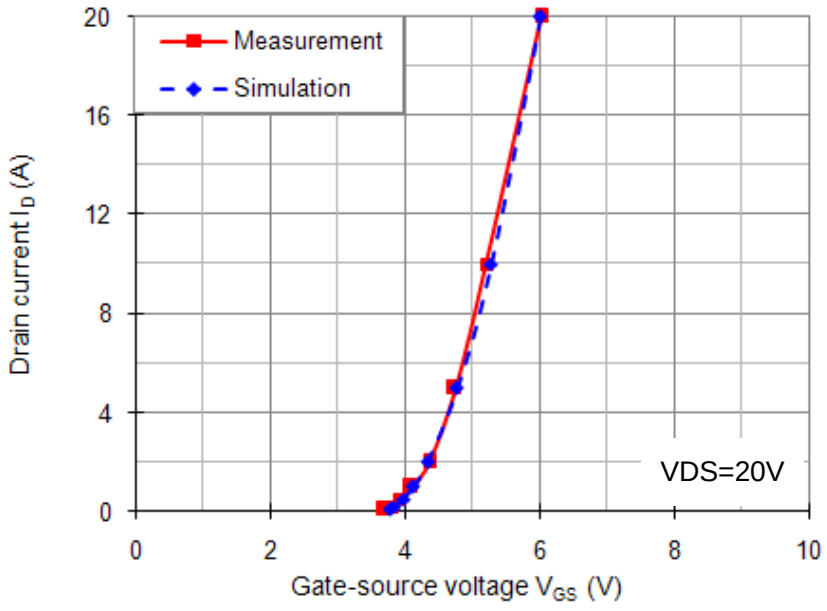


Evaluation circuit



Comparison Graph

Circuit Simulation result

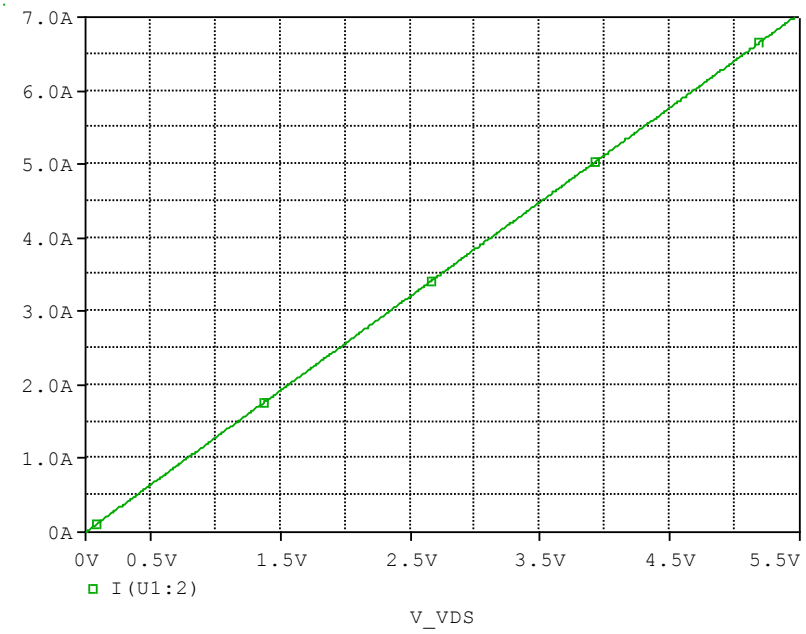


Comparison table

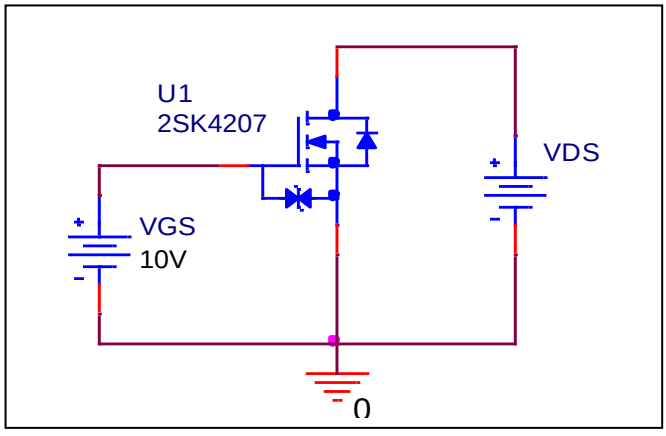
I_D (A)	V_{GS} (V)		%Error
	Measurement	Simulation	
0.1	3.700	3.781	2.18
0.2	3.800	3.847	1.24
0.5	3.920	3.980	1.52
1	4.100	4.130	0.73
2	4.370	4.345	-0.57
5	4.755	4.779	0.50
10	5.210	5.281	1.36
20	6.030	6.013	-0.29

Rds(on) Characteristics

Circuit Simulation result



Evaluation circuit

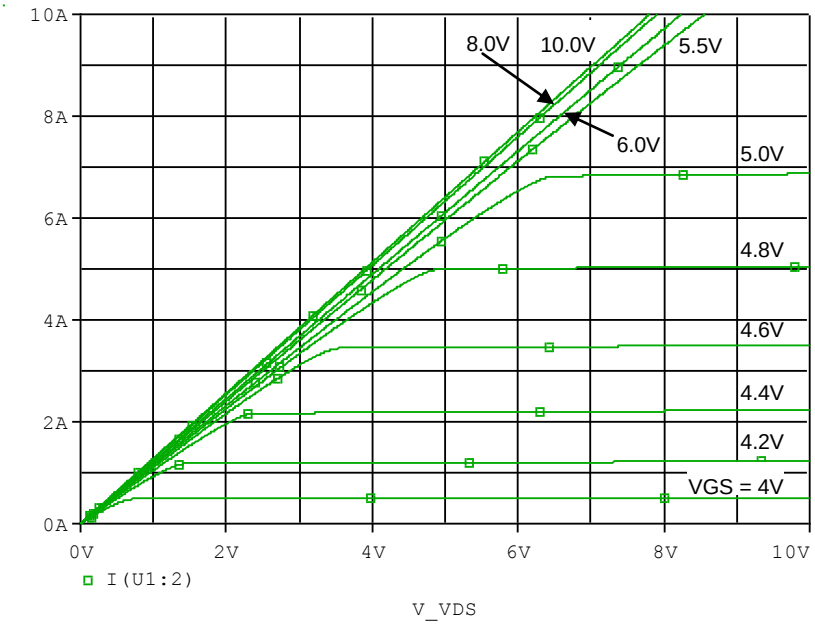


Test condition: V_{GS}=10(V), I_D=6.5(A)

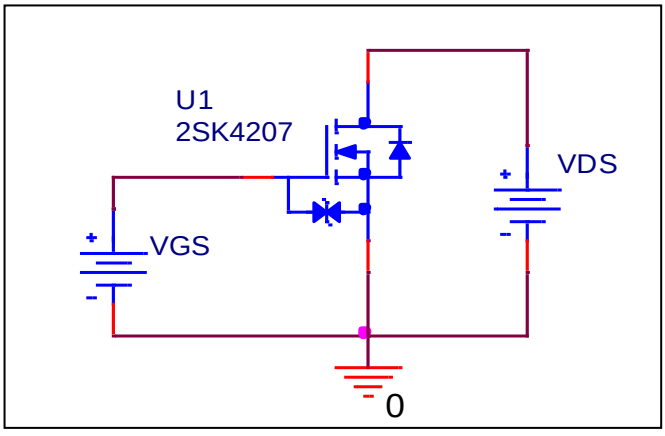
Parameter	Unit	Measurement	Simulation	%Error
R_{DS}(on)	Ω	0.780	0.780	0

Output Characteristics

Circuit Simulation result

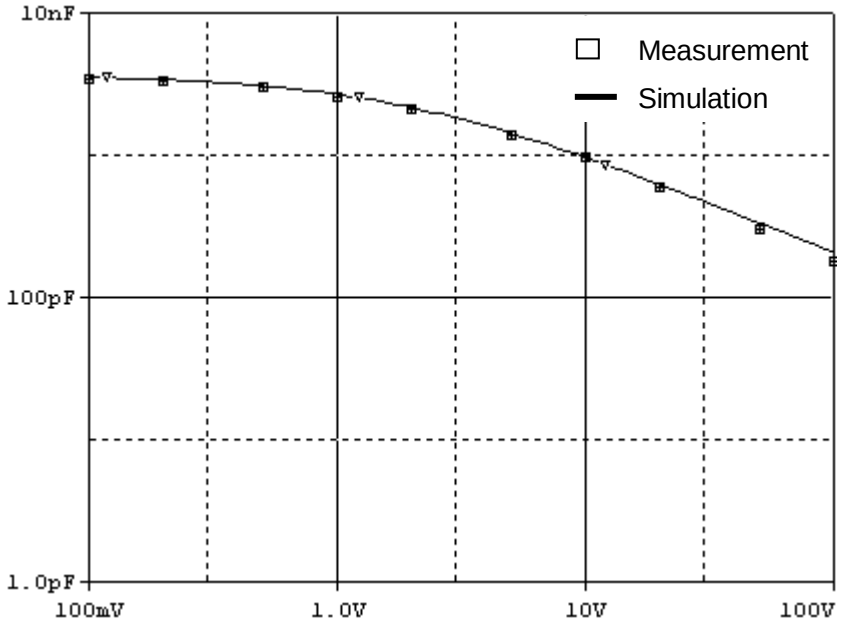


Evaluation circuit



Capacitance Characteristics

Simulation result

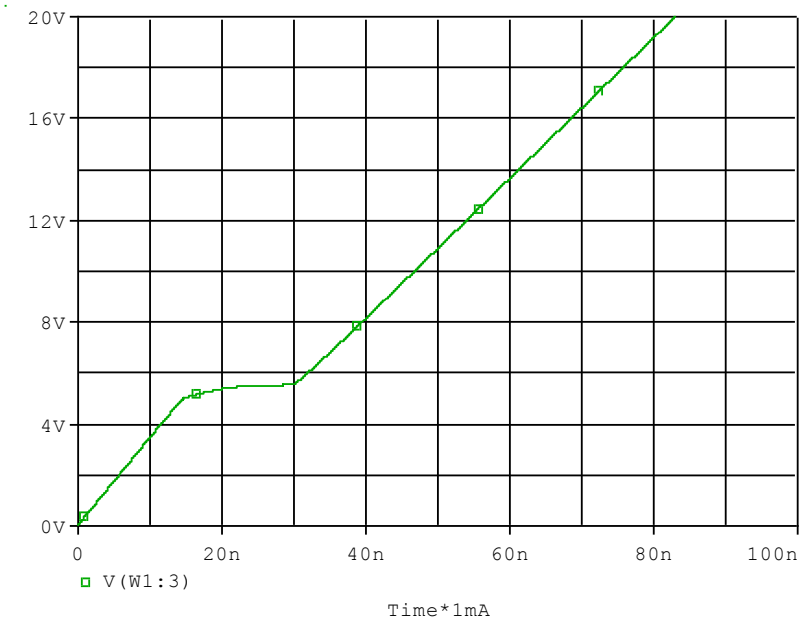


Comparison table

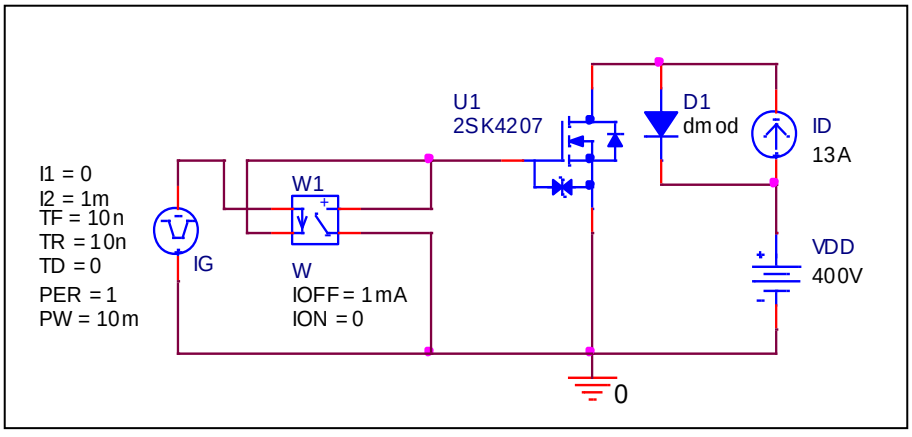
V_{DS} (V)	Cbd (pF)		%Error
	Measurement	Simulation	
0.1	3560.000	3524.000	-1.01
0.2	3395.000	3398.000	0.09
0.5	3070.000	3076.000	0.20
1	2695.000	2673.000	-0.82
2	2143.000	2150.500	0.35
5	1440.000	1419.530	-1.42
10	986.000	957.470	-2.89
20	605.000	617.400	2.05
50	315.000	330.400	4.89
100	186.500	195.700	4.93

Gate Charge Characteristics

Circuit Simulation result



Evaluation circuit

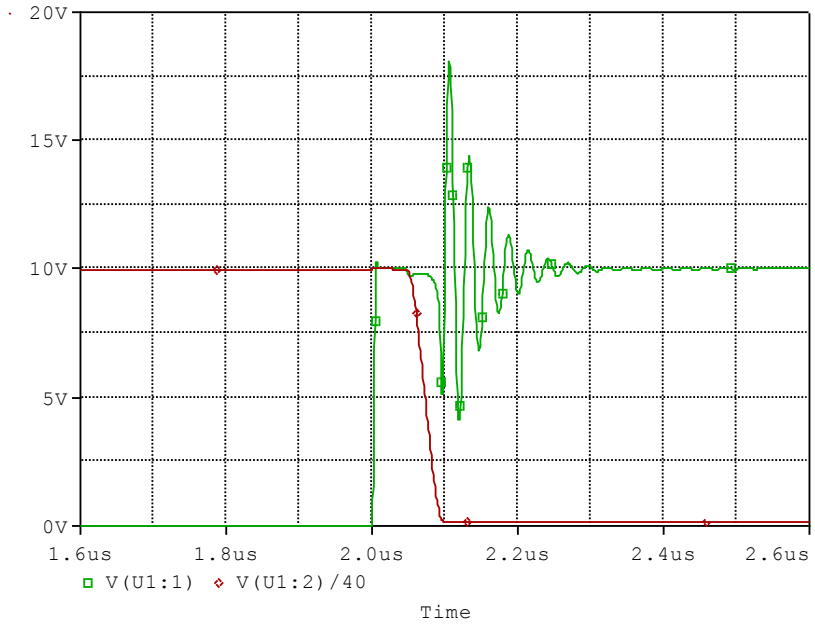


Test condition: V_{DD}=400(V), V_{GS}=10(V), I_D=13(A)

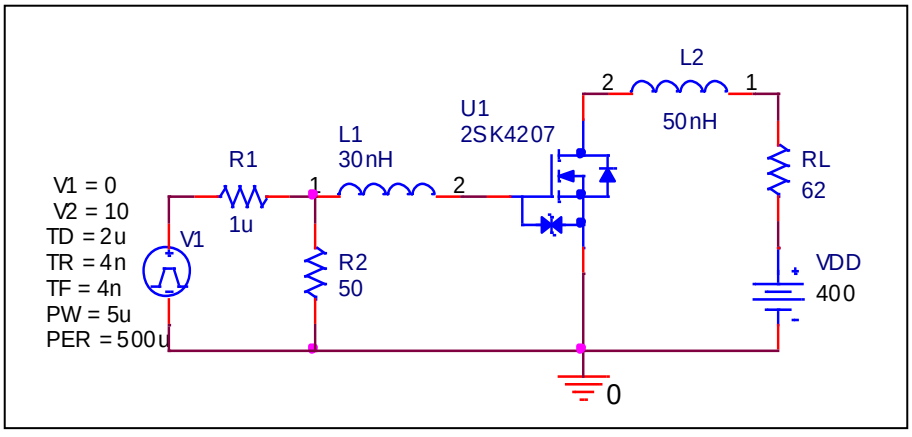
Parameter	Unit	Measurement	Simulation	%Error
Qgs	nC	16.200	16.138	-0.38
Qgd	nC	13.900	13.777	-0.88
Qg	nC	46.500	46.729	0.49

Switching Time Characteristics

Circuit Simulation result



Evaluation circuit



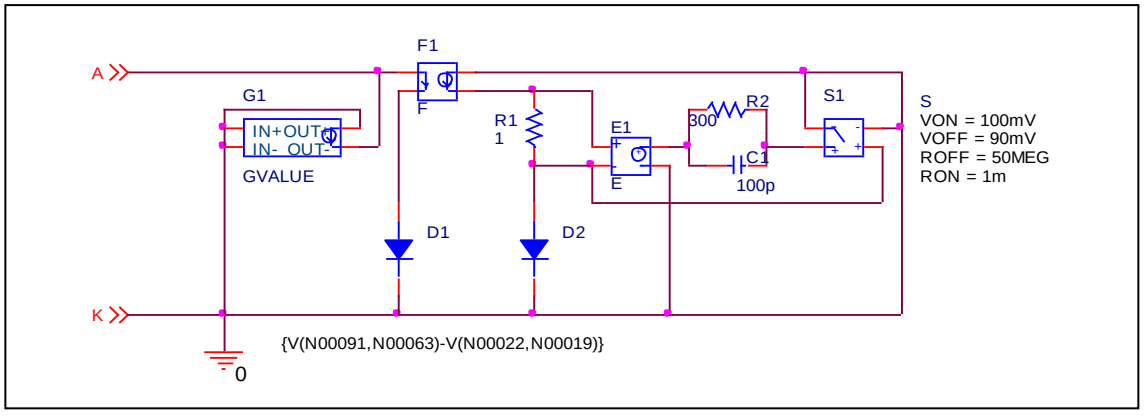
Test condition: V_{DD}=400(V), V_{GS}=0/10(V), I_D=6.5(A), RG=50Ω, RL=62Ω

Parameter	Unit	Measurement	Simulation	%Error
ton	ns	88.000	87.943	-0.06

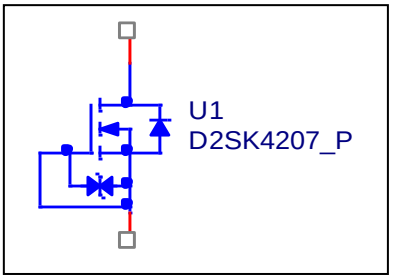
BODY DIODE SPICE MODEL

```
*$
.SUBCKT D2SK4207_p    A K
R_R2    5       6       100.07
R_R1    3       4       1
C_C1    5       6       4212p
E_E1    5 K 3 4  1
M_S1    6 4 K K MNSW
RS_S1 4         K       0.1G
.MODEL MNSW NMOS Vto=90m KP=1 N=1Meg Rds=50e6
G_G1    K       A VALUE { V(3,4)-V(5,6) }
D_D1    2       K D2SK4207
D_D2    4       K D2SK4207
F_F1    K       3 VF_F1 1
VF_F1 A         2 0V
.MODEL D2SK4207 D
+ IS=1.00E-12 N=.89328 RS=14.921E-3 IKF=71.547E-3
+ CJO=1E-12 ISR=0 BV=945 IBV=100u TT=727n
.ENDS
*$
```

Equivalent Circuit

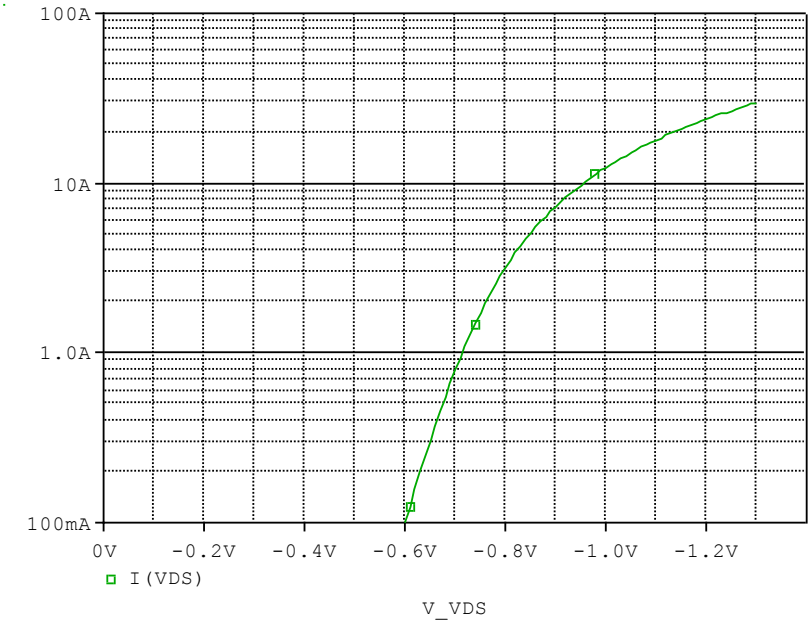


Circuit Configuration

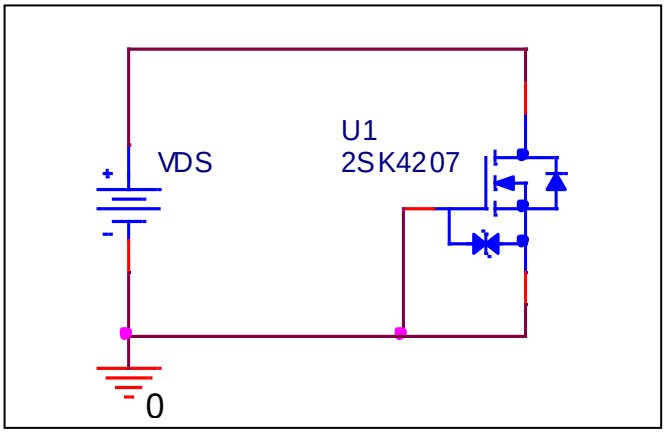


Body Diode Forward Current Characteristics

Circuit Simulation result

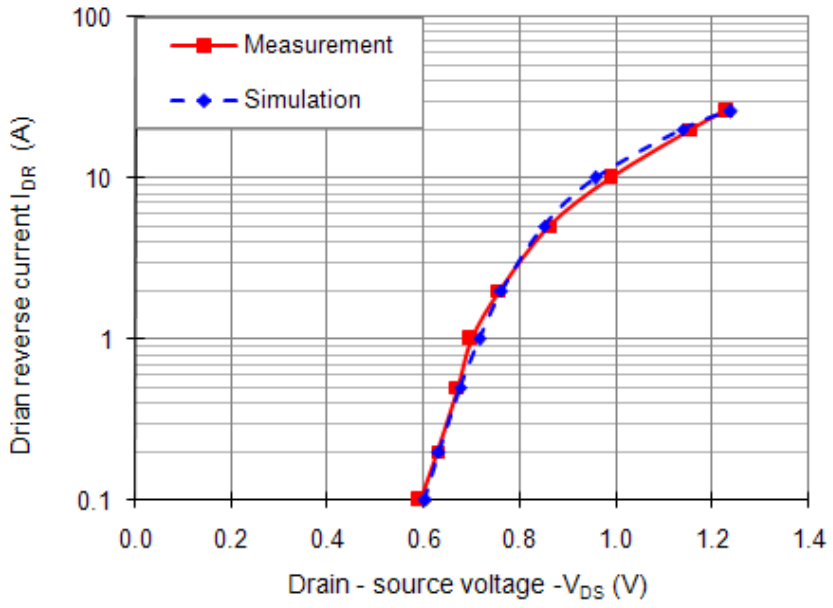


Evaluation circuit



Comparison Graph

Simulation result

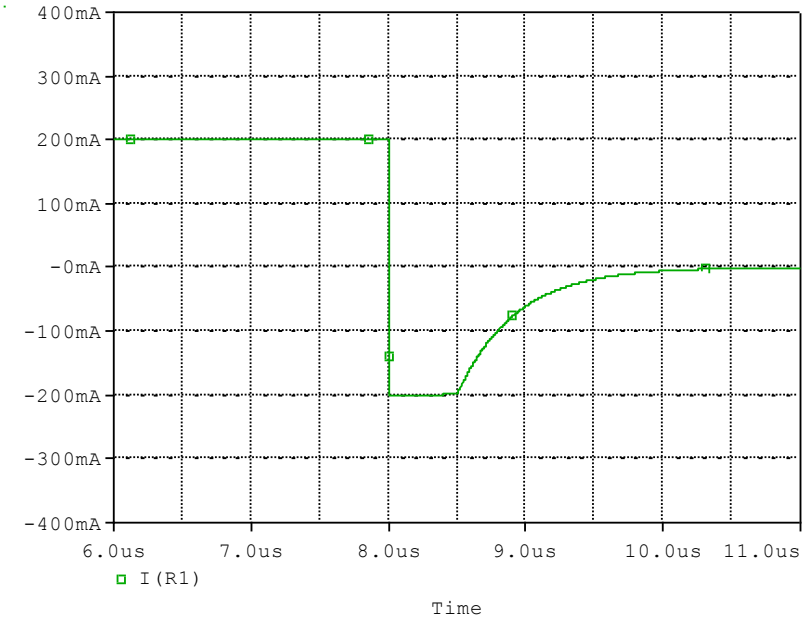


Comparison table

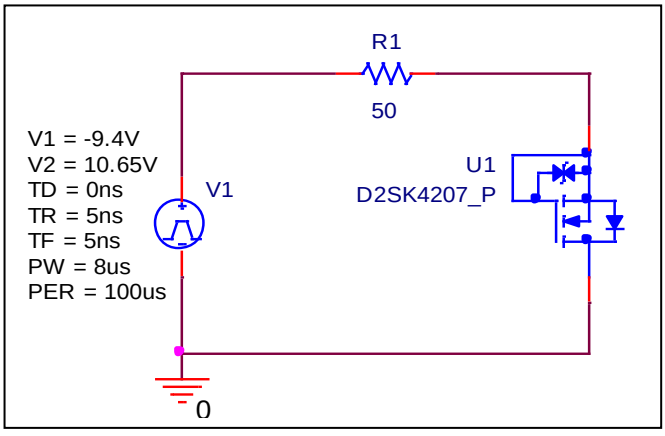
I_{DR} (A)	$-V_{DS}$ (V)		%Error
	Measurement	Simulation	
0.1	0.590	0.601	1.86
0.2	0.628	0.630	0.32
0.5	0.670	0.675	0.75
1	0.698	0.714	2.29
2	0.756	0.761	0.66
5	0.860	0.848	-1.40
10	0.986	0.955	-3.14
20	1.155	1.136	-1.65
26	1.228	1.238	0.80

Reverse Recovery Characteristics

Circuit Simulation result



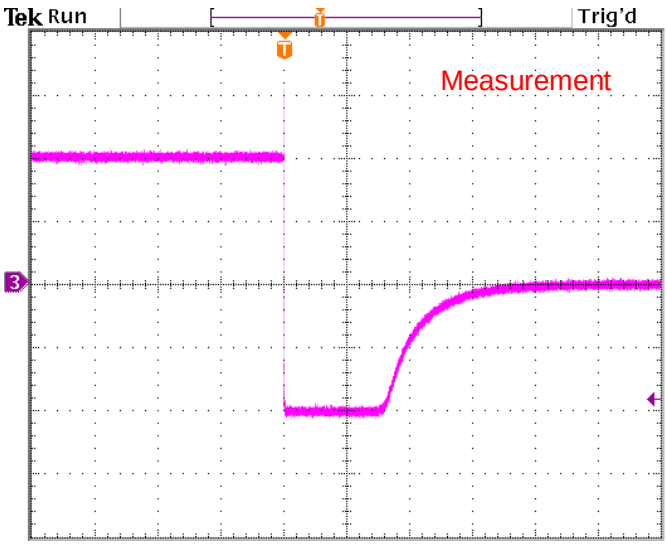
Evaluation circuit



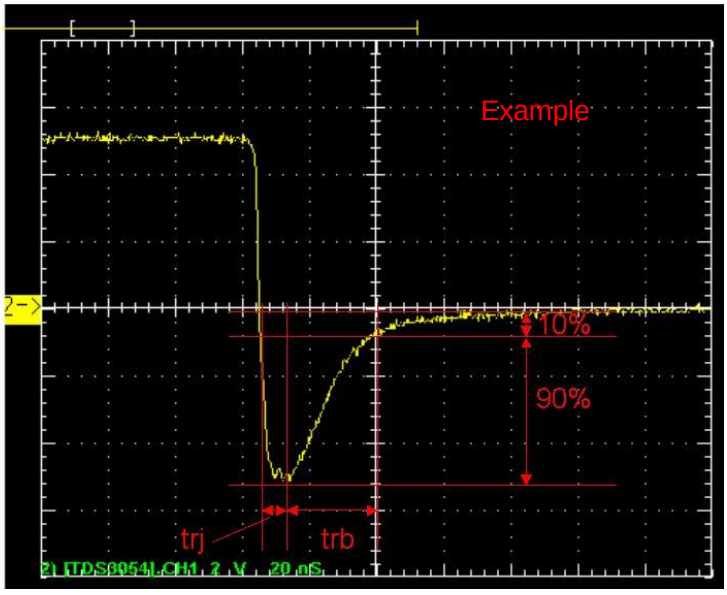
Comparison Measurement vs. Simulation

Parameter	Unit	Measurement	Simulation	%Error
trj	ns	500.000	496.787	-0.64
trb	ns	970.000	964.775	-0.54
trr	ns	1470.000	1461.562	-0.57

Reverse Recovery Characteristics Reference



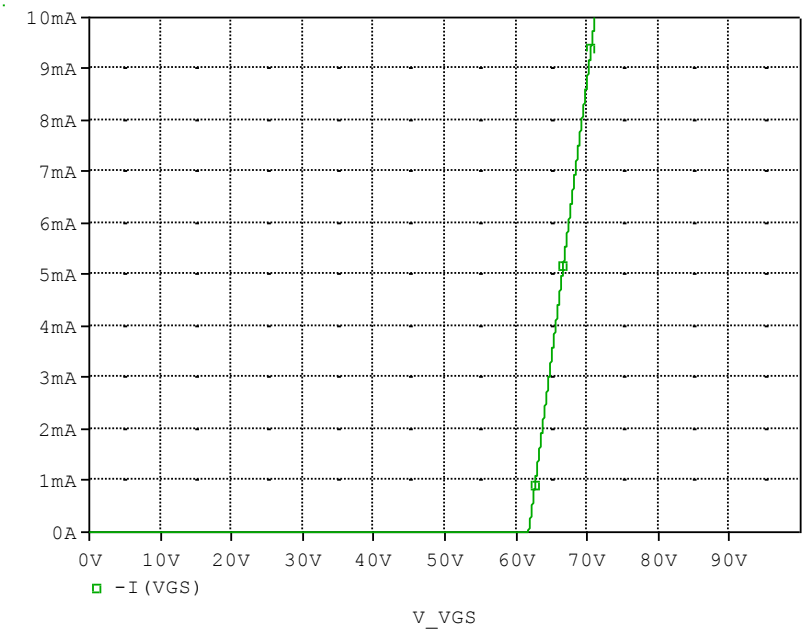
trj = 500(ns)
trb = 970(ns)
Conditions: Ifwd = Irev = 0.2(A), Rl = 50



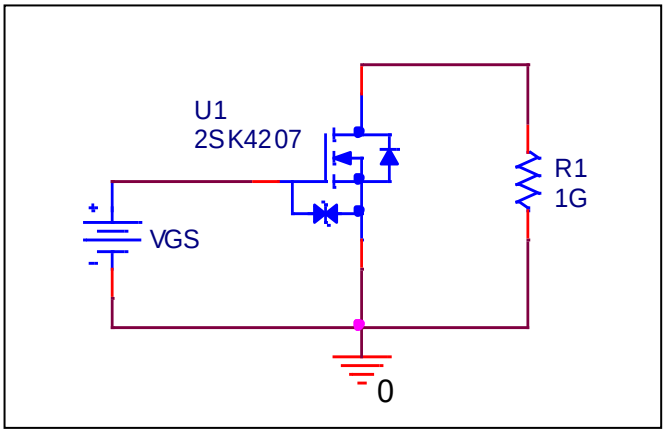
Relation between trj and trb

ESD PROTECTION DIODE
Zener Voltage Characteristics

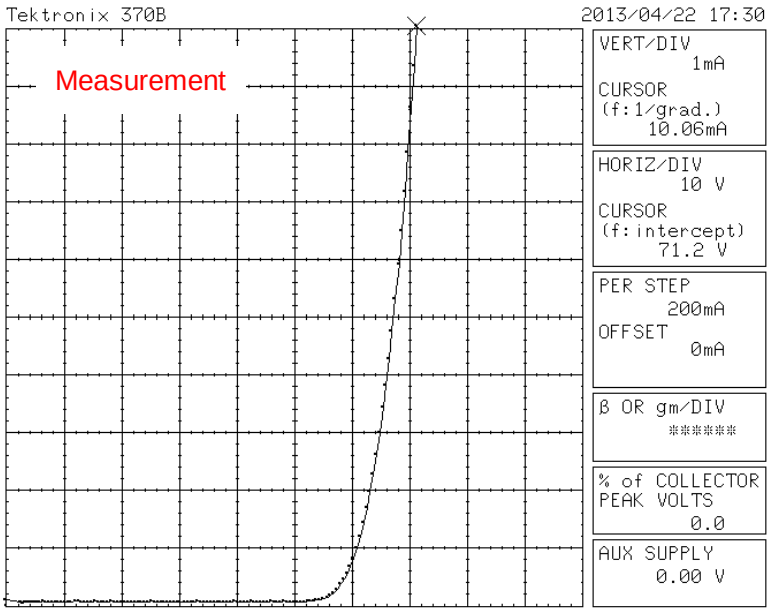
Circuit Simulation result



Evaluation circuit



Zener Voltage Characteristics Reference



I_Z = 1(mA)
V_Z =61.75(V) at I_Z=1mA