Device Modeling Report

COMPONENTS: Power MOSFET (Model parameter)
PART NUMBER: TPCP8401
MANUFACTURER: TOSHIBA
Body Diode (Model parameter) / ESD Protection Diode
REMARK: Silicon N&P Channel MOS Type

Bee Technologies Inc.

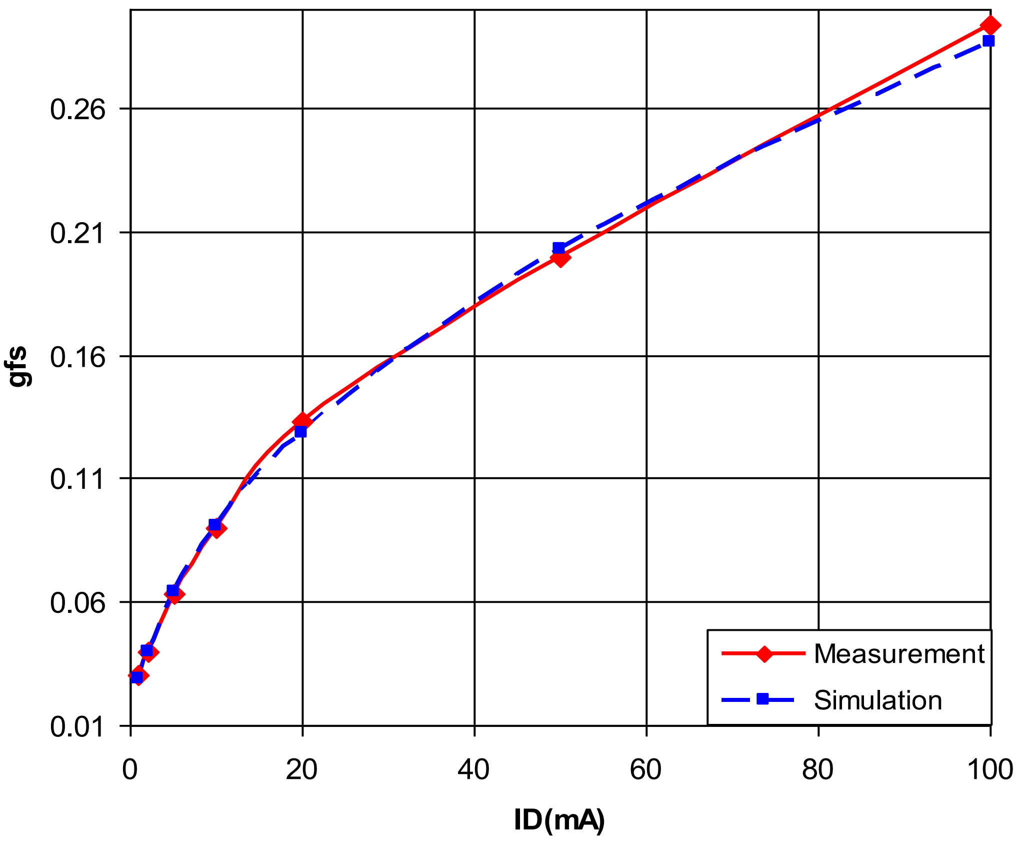
MOSFET MODEL

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

N-Channel Model

Transconductance Characteristic

Circuit Simulation Result

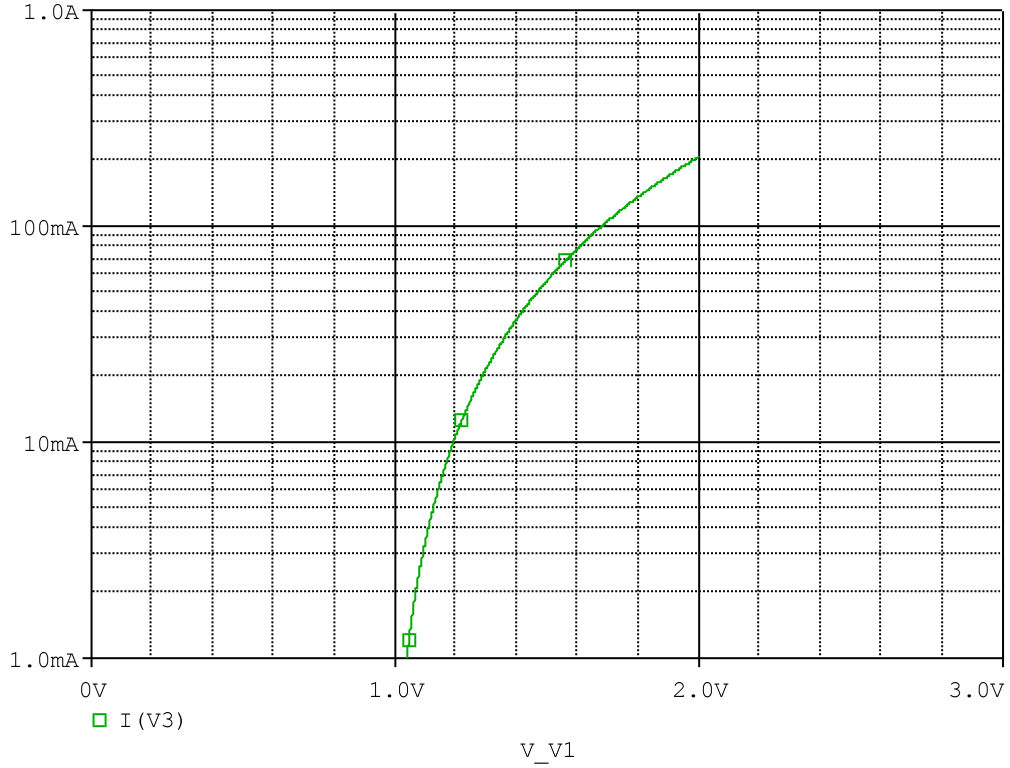


Comparison table

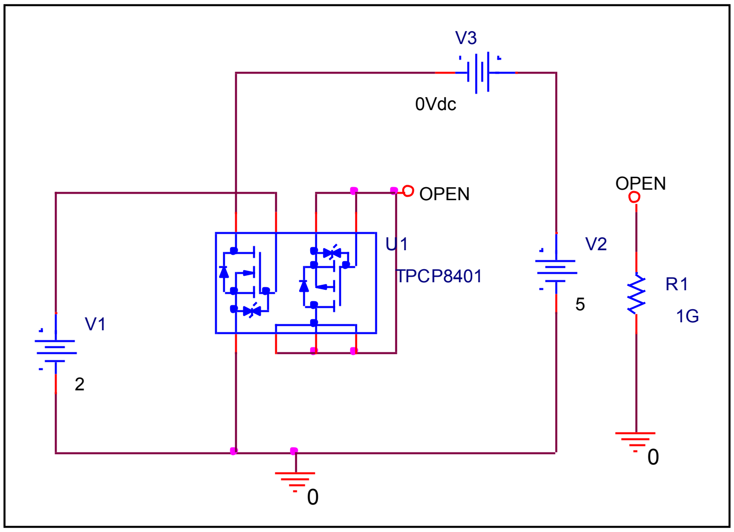
Id(mA)	gfs		Error (%)
	Measurement	Simulation	
1	0.030	0.029	-3.333
2	0.040	0.040	0
5	0.063	0.064	1.587
10	0.090	0.091	1.111
20	0.133	0.128	-3.759
50	0.200	0.203	1.500
100	0.294	0.287	-2.381

Vgs-Id Characteristic

Circuit Simulation result

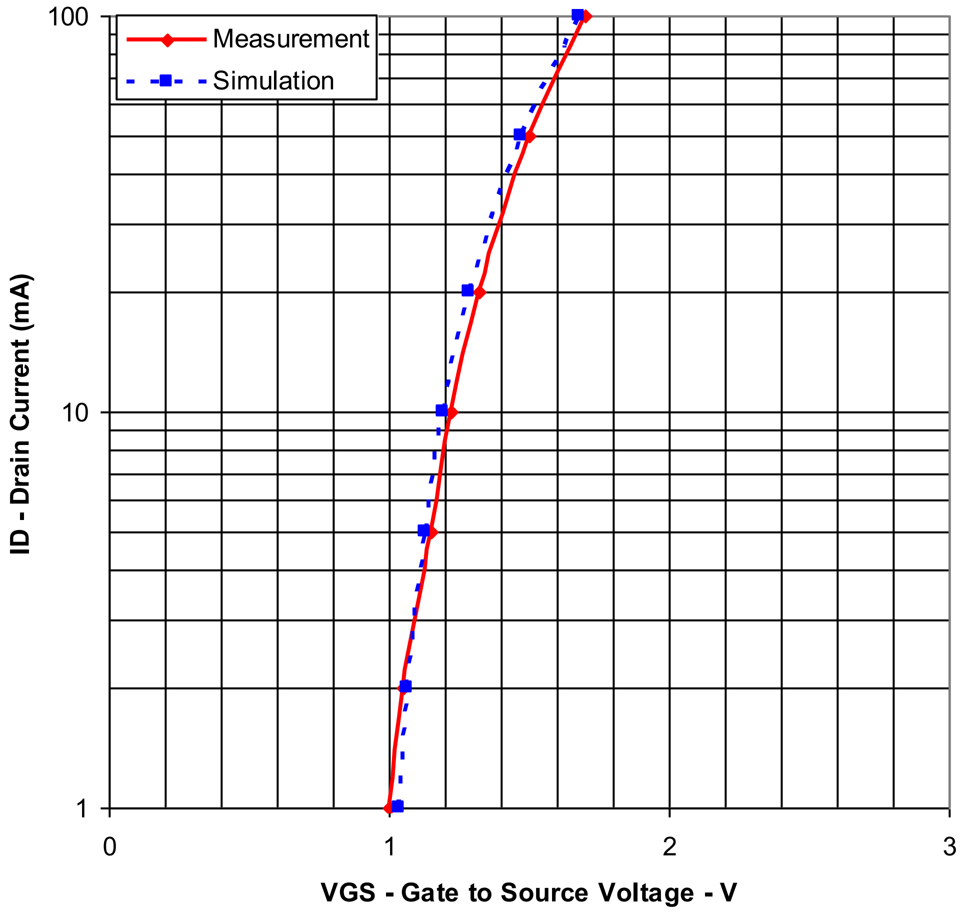


Evaluation circuit



Comparison Graph

Circuit Simulation Result

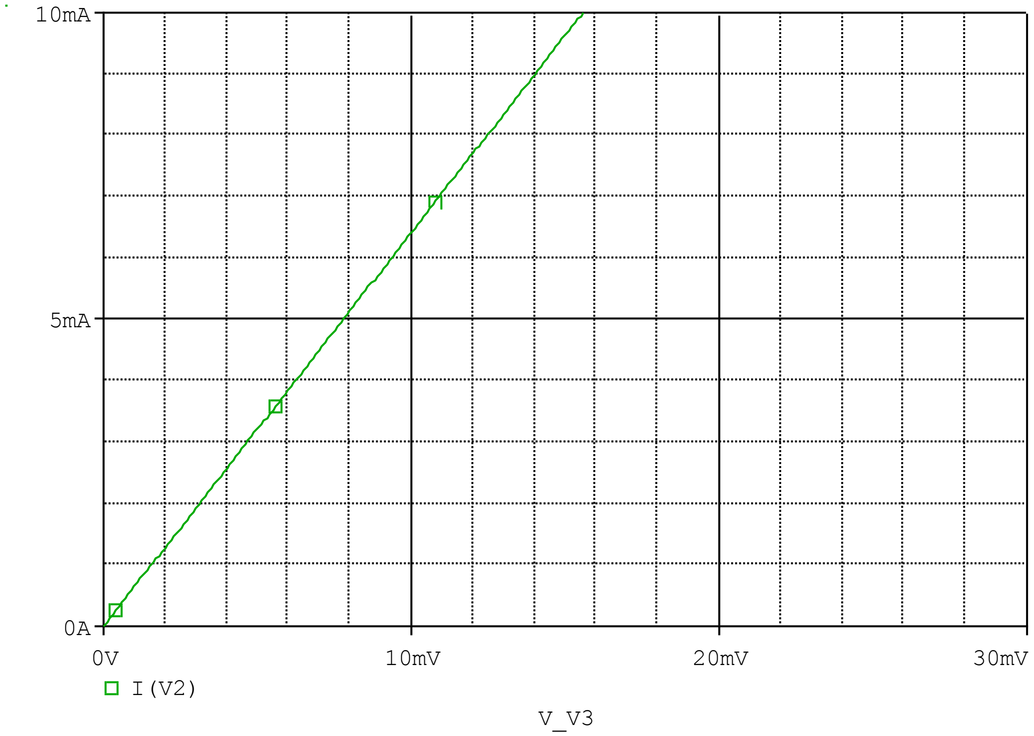


Simulation Result

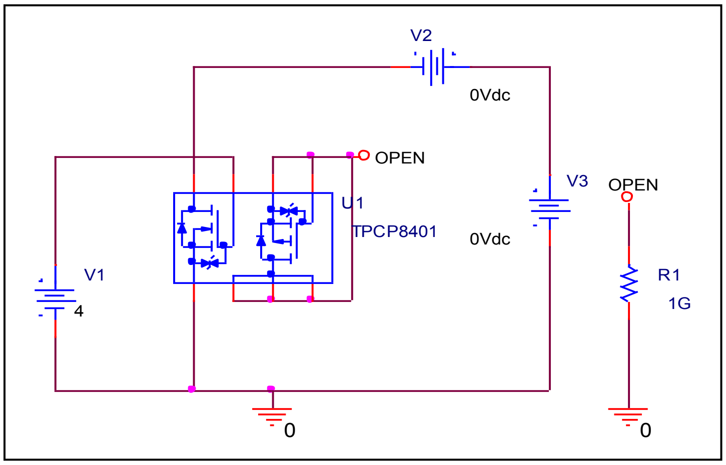
I_D(mA)	V_{GS}(V)		Error (%)
	Measurement	Simulation	
1	1	1.0373	3.730
2	1.05	1.0668	1.600
5	1.15	1.1254	-2.139
10	1.22	1.1914	-2.344
20	1.32	1.2847	-2.674
50	1.5	1.47	-2.000
100	1.7	1.6790	-1.235

Rds(on) Characteristic

Circuit Simulation result



Evaluation circuit

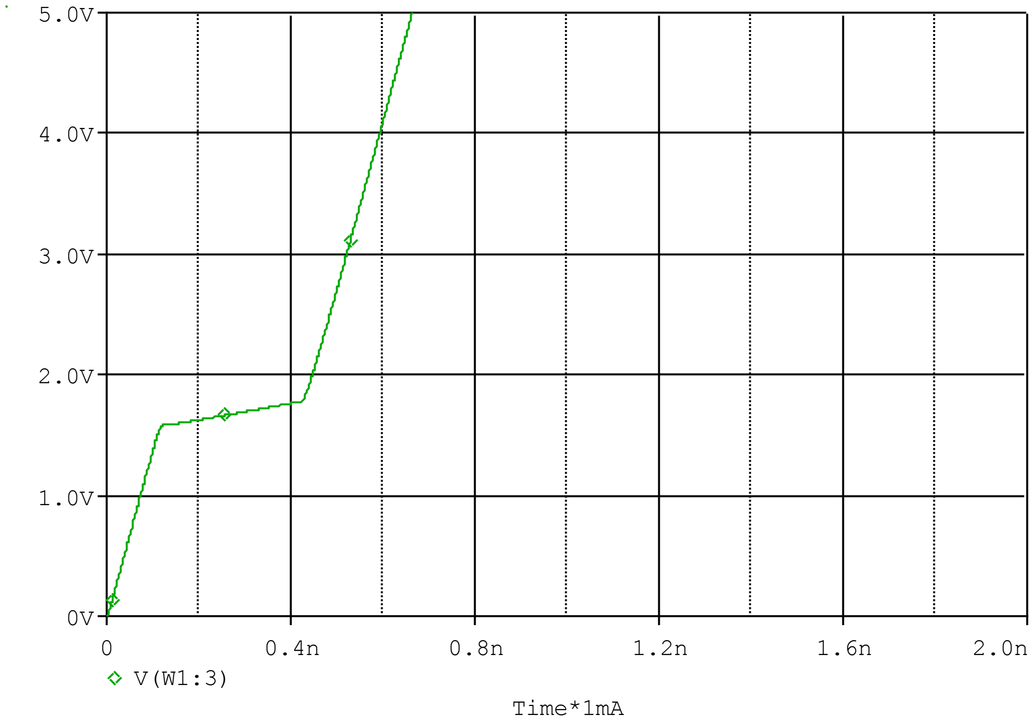


Simulation Result

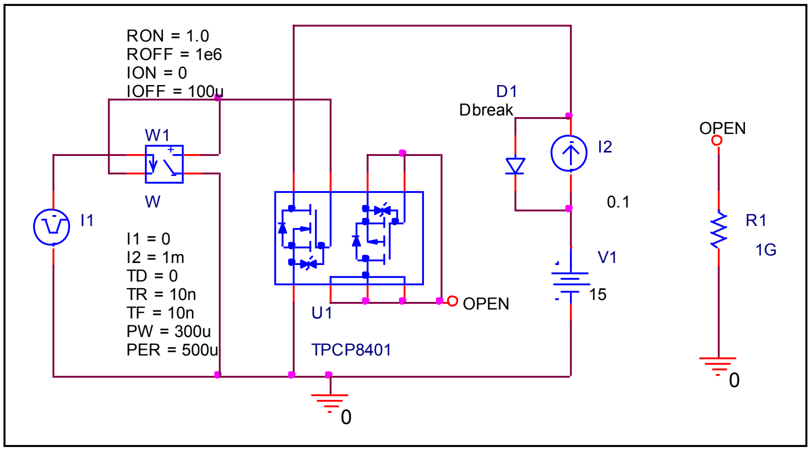
I_D=10mA, V_{GS}=4V	Measurement		Simulation		Error (%)
R_{DS} (on)	1.5	Ω	1.5577	Ω	3.847

Gate Charge Characteristic

Circuit Simulation result



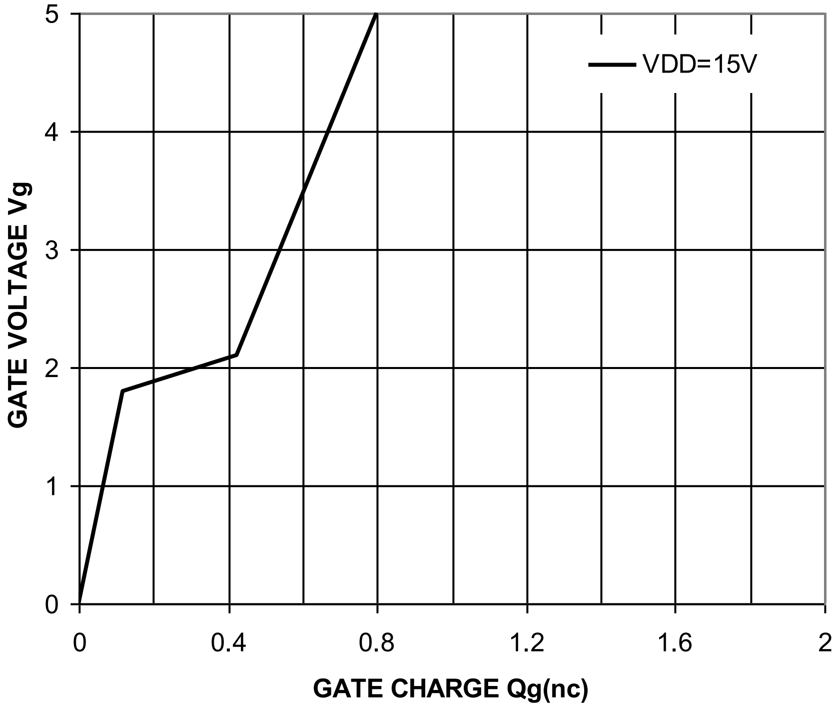
Evaluation circuit



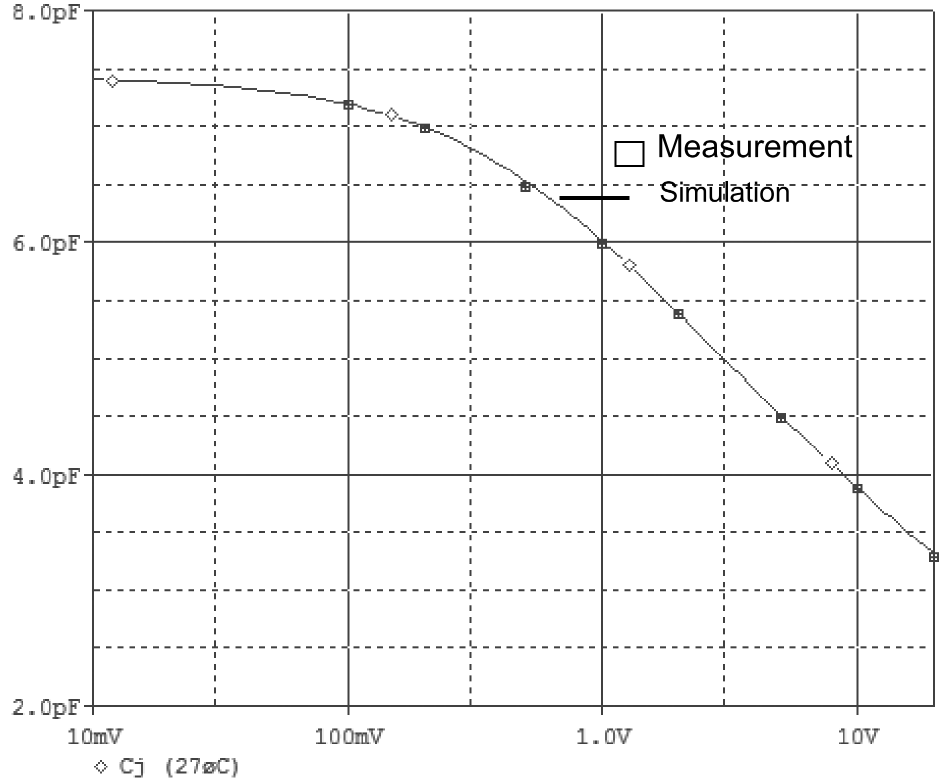
Simulation Result

V_{DD}=15V,I_D=0.1A	Measurement		Simulation		Error (%)
Qgs	0.12	nC	0.121	nC	0.833
Qgd	0.304	nC	0.303	nC	-0.329
Qg	0.8	nC	0.664	nC	-17.000

Reference



Capacitance Characteristic

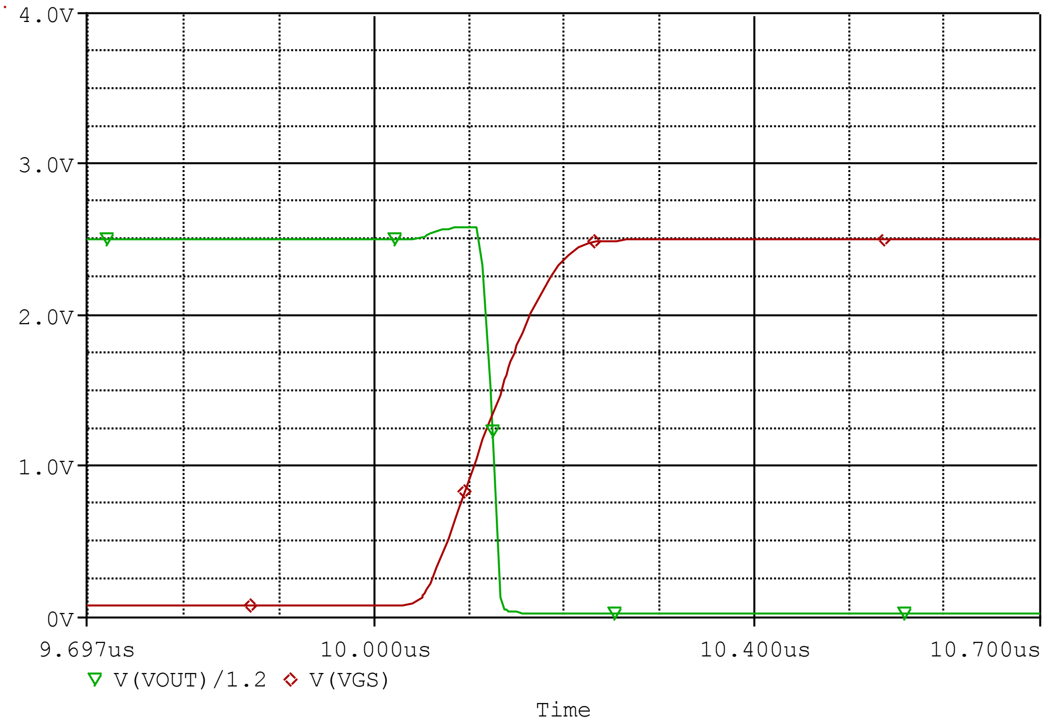


Simulation Result

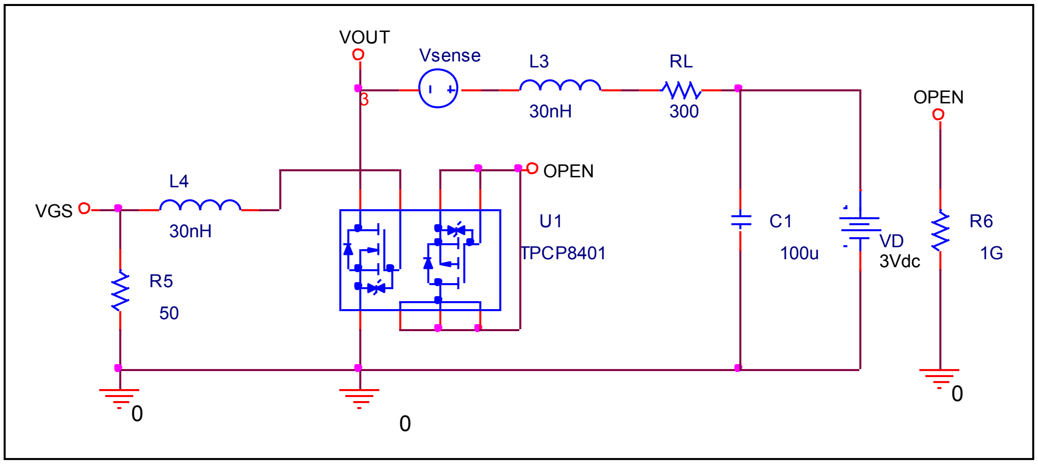
V_{DS}(V)	Cbd(pF)		Error(%)
	Measurement	Simulation	
0.1	7.2	7.19	-0.139
0.2	7	7	0
0.5	6.5	6.53	0.462
1	6	6	0.000
2	5.4	5.37	-0.556
5	4.5	4.51	0.222
10	3.9	3.88	-0.513
20	3.3	3.32	0.606

Switching Time Characteristic

Circuit Simulation result



Evaluation circuit

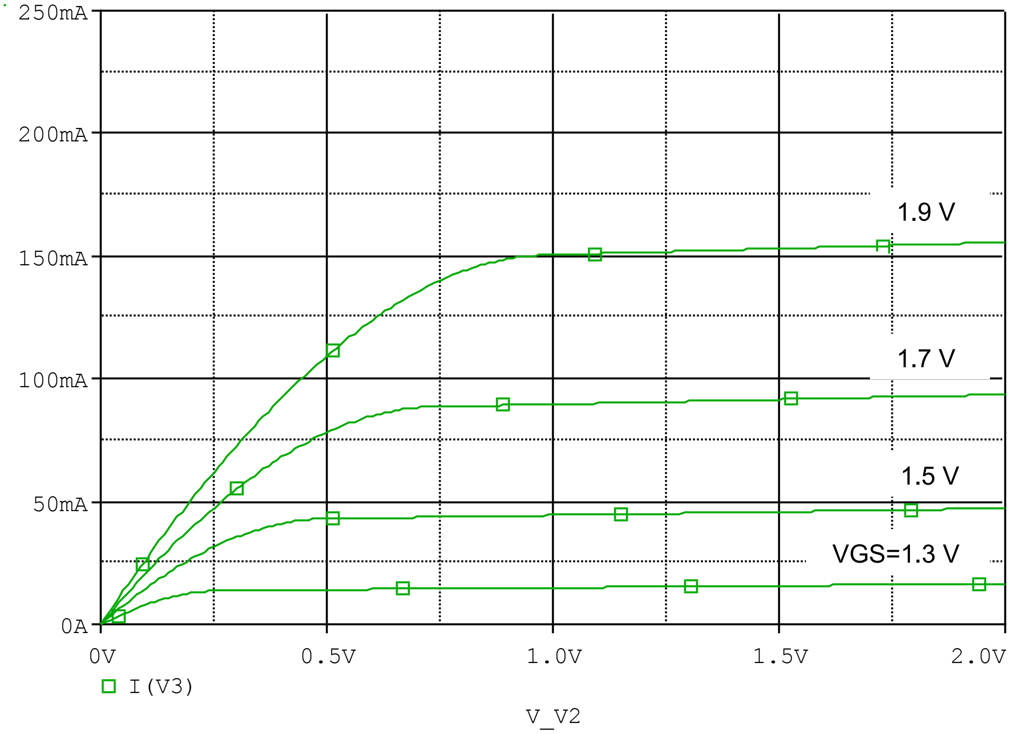


Simulation Result

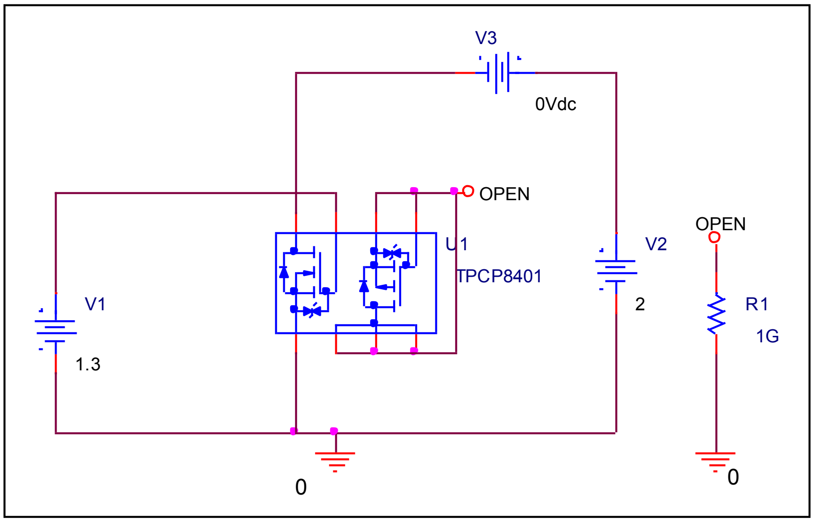
I_D=10m A, V_{DD}=3V V_{GS}=0/2.5V	Measurement		Simulation		Error(%)
ton	70.000	ns	72.251	ns	3.216

Output Characteristic

Circuit Simulation result

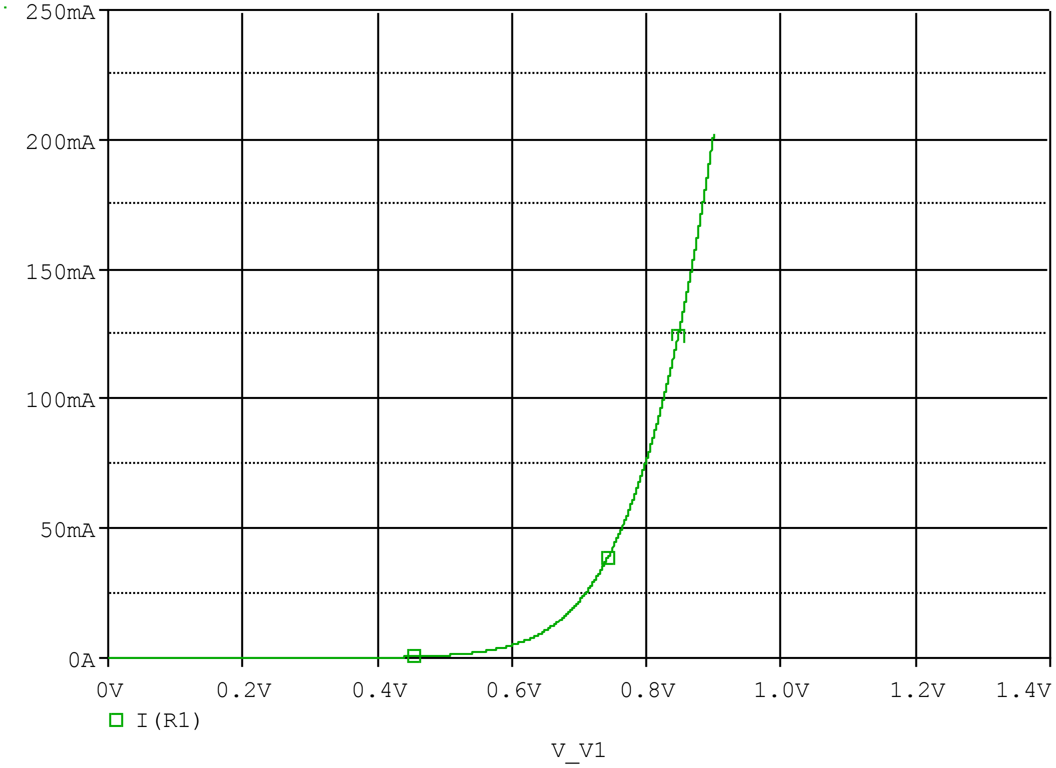


Evaluation circuit

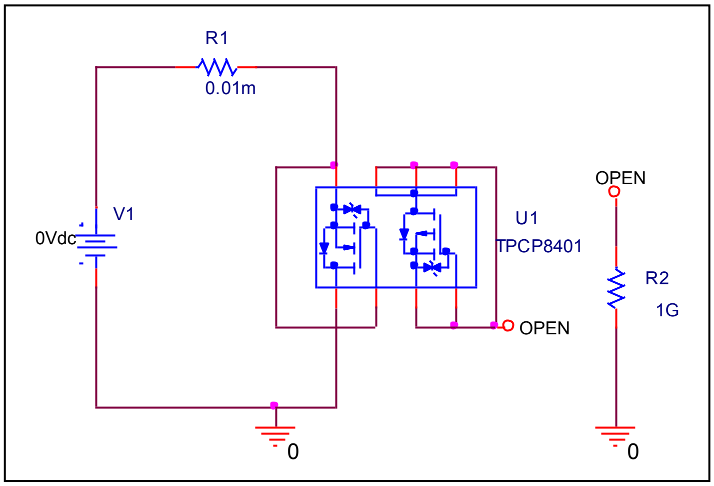


BODY DIODE
Forward Current Characteristic

Circuit Simulation Result

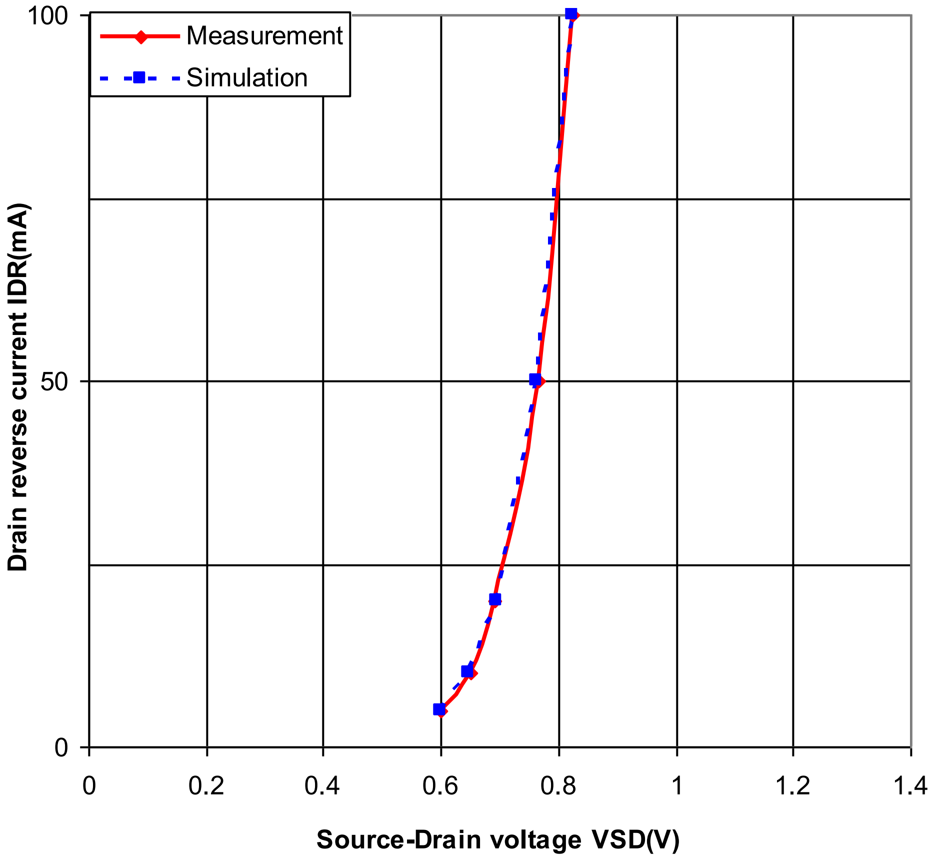


Evaluation Circuit



Comparison Graph

Circuit Simulation Result

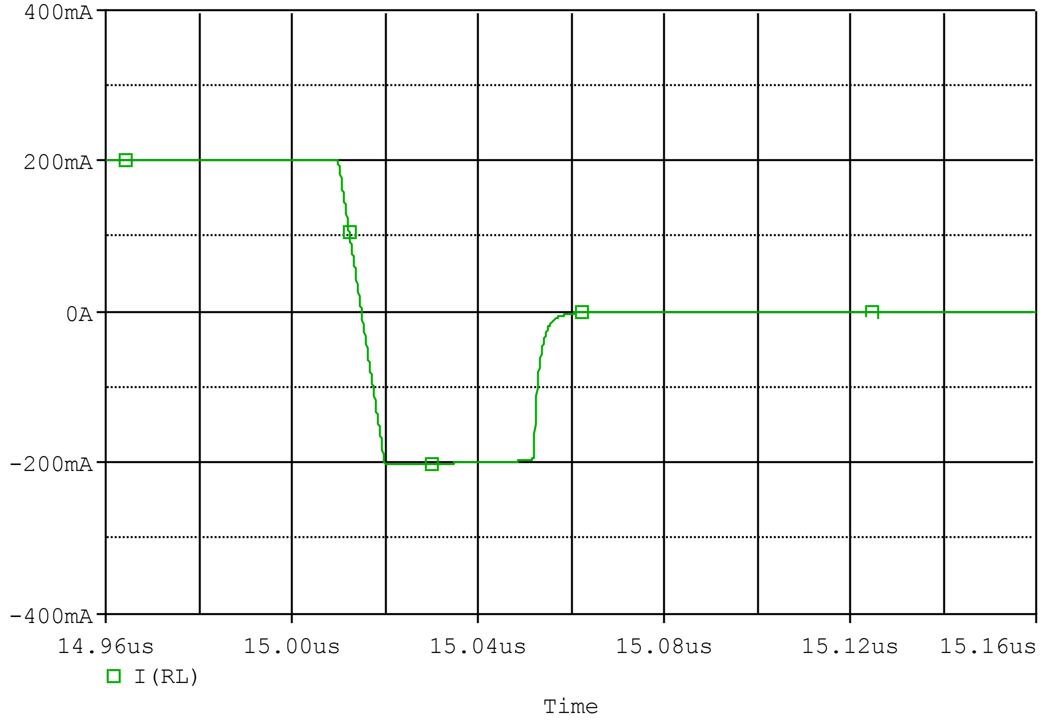


Simulation Result

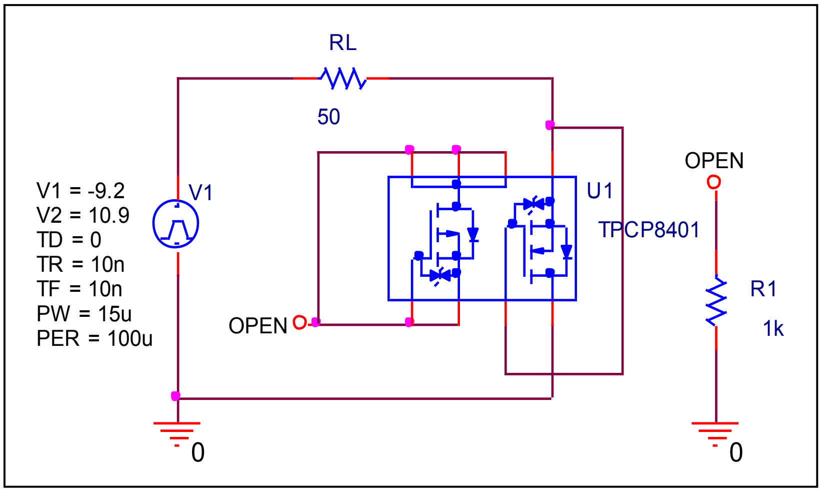
	VSD(V)		
Ifwd(mA)	**Measurement**	**Simulation**	**%Error**
5	**0.6**	**0.601**	**0.167**
10	**0.65**	**0.646**	**-0.615**
20	**0.69**	**0.694**	**0.580**
50	**0.765**	**0.763**	**-0.261**
100	**0.825**	**0.826**	**0.121**

Reverse Recovery Characteristic

Circuit Simulation Result



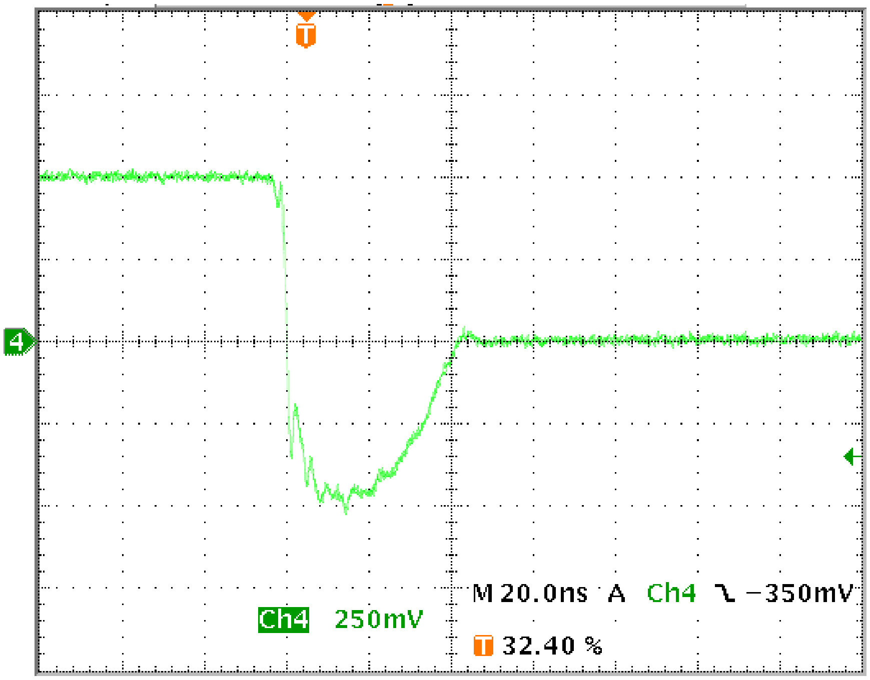
Evaluation Circuit



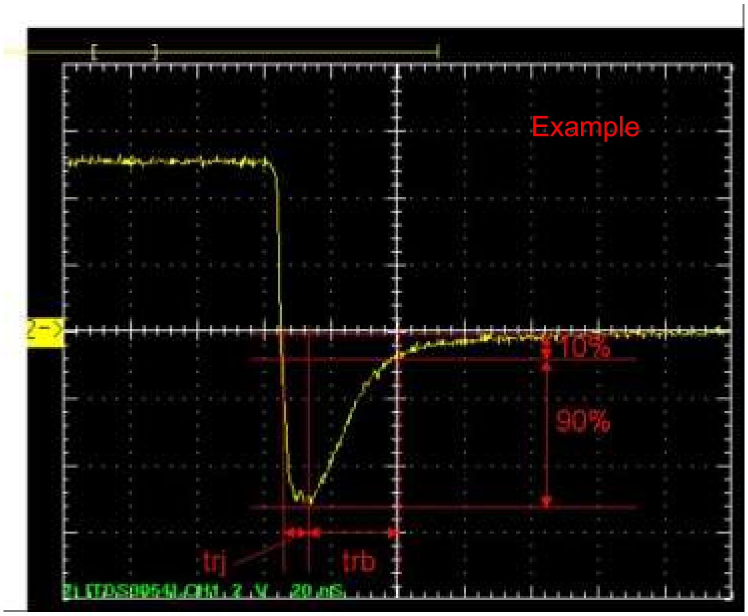
Compare Measurement vs. Simulation

Trr(ns)	Measurement	Simulation	Error (%)
Trj+Trb (ns)	39.6	39.68	0.202

Reverse Recovery Characteristic   Reference



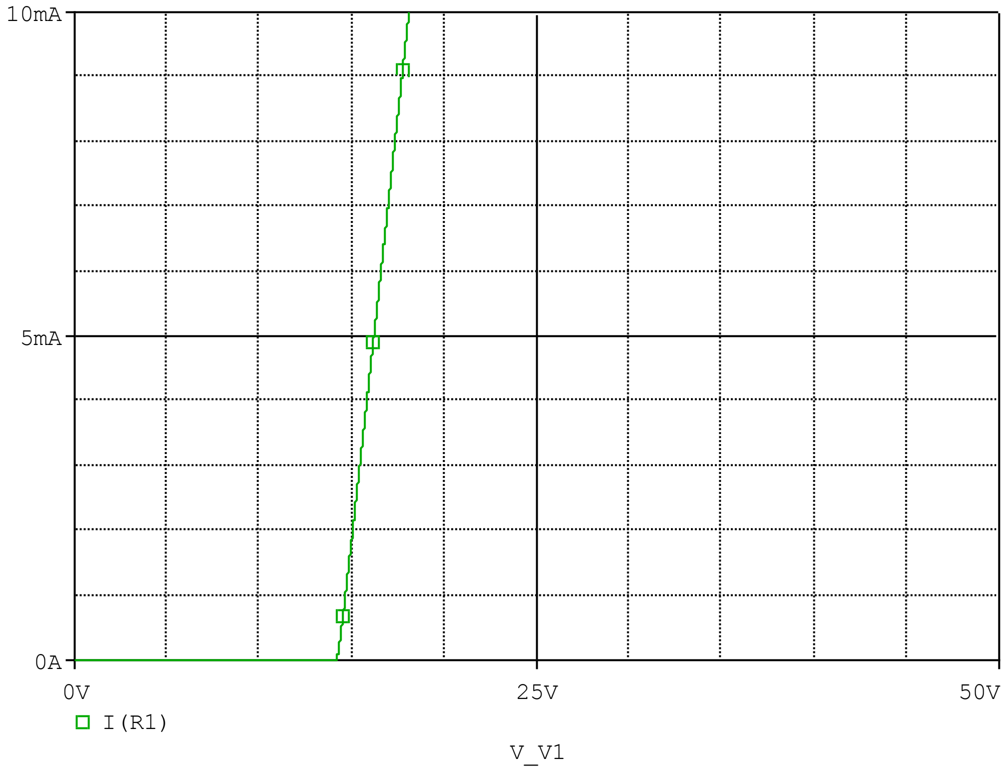
Trj=14(ns)
Trb=25.6(ns)
Conditions:Ifwd=Irev=0.02(A),Rl=50



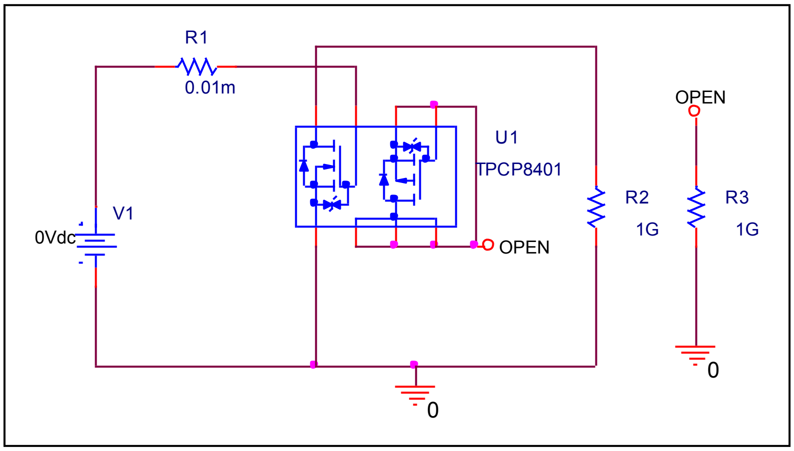
Relation between trj and trb

ESD PROTECTION DIODE
Zener Voltage Characteristic

Circuit Simulation Result

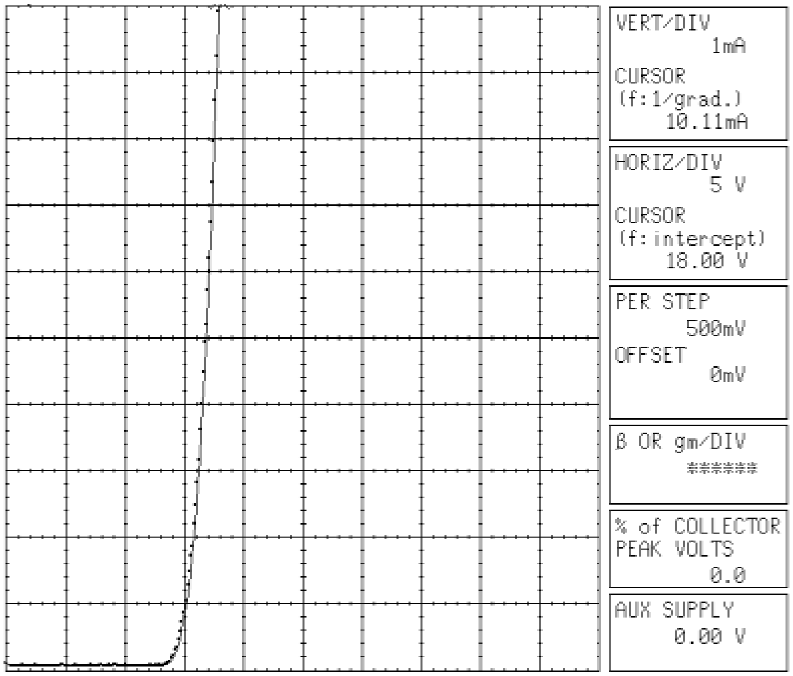


Evaluation Circuit



Zener Voltage Characteristic

Reference



VERT/DIV
1mA
CURSOR
(f:1/grad.)
10.11mA

HORIZ/DIV
5 V
CURSOR
(f:intercept)
18.00 V

PER STEP
500mV
OFFSET
0mV

β OR gm/DIV
******

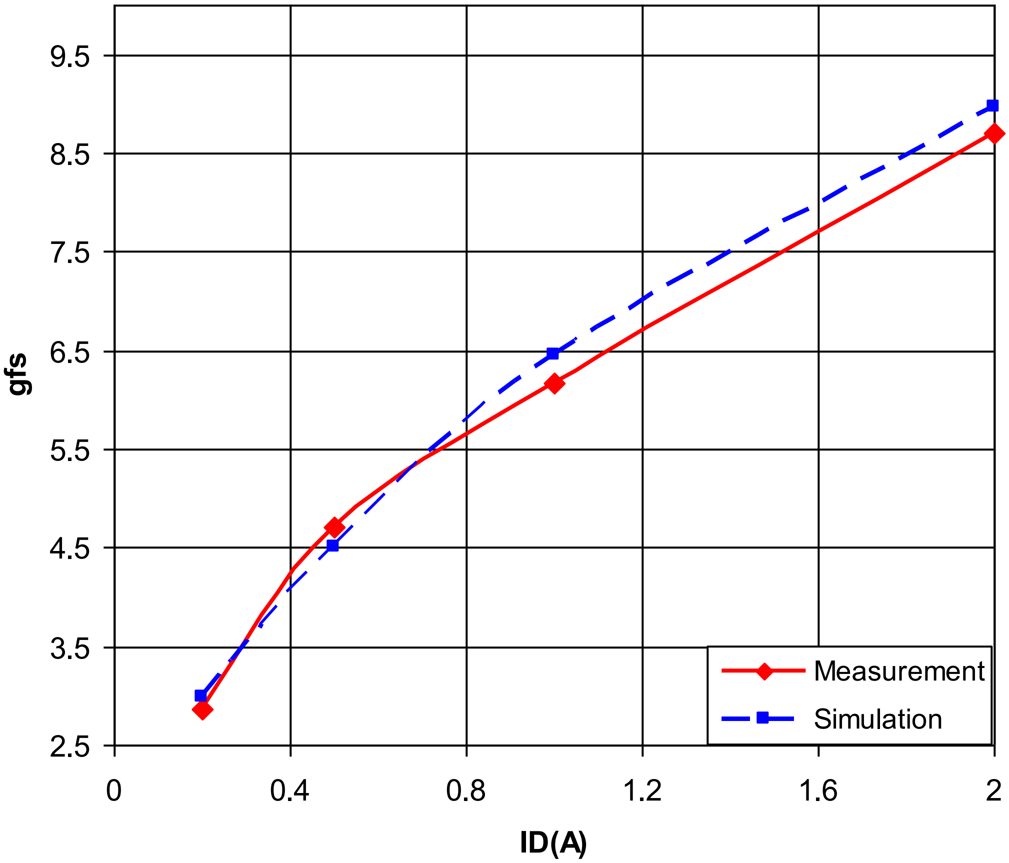
% of COLLECTOR
PEAK VOLTS
0.0

AUX SUPPLY
0.00 V

P-Channel Model

Transconductance Characteristic

Circuit Simulation Result

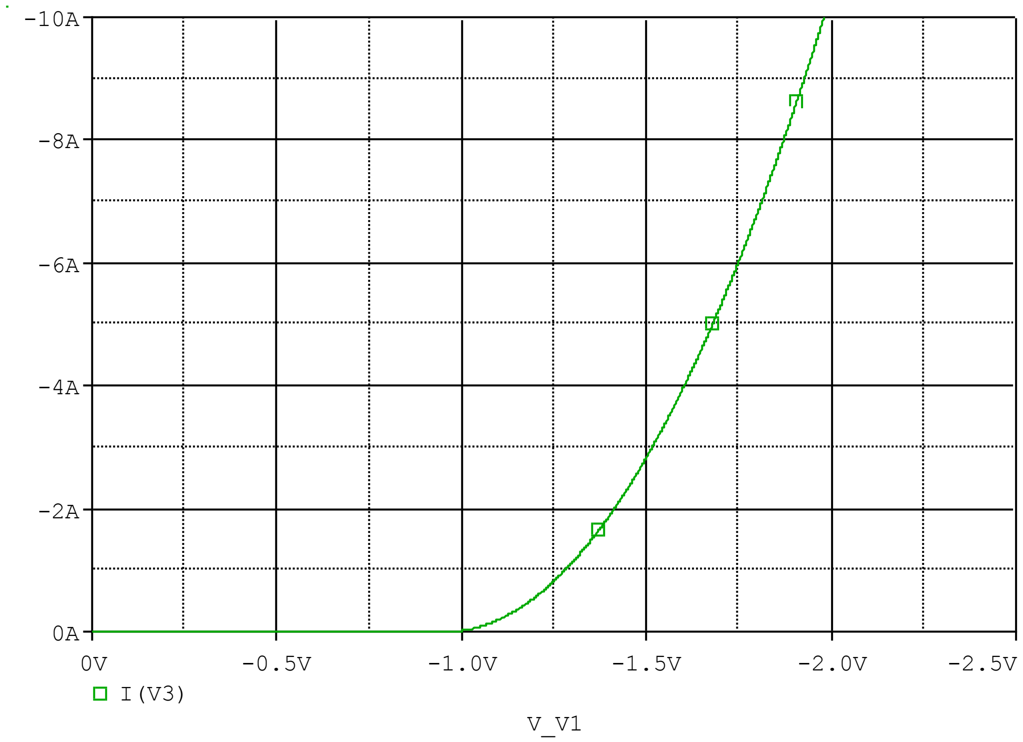


Comparison table

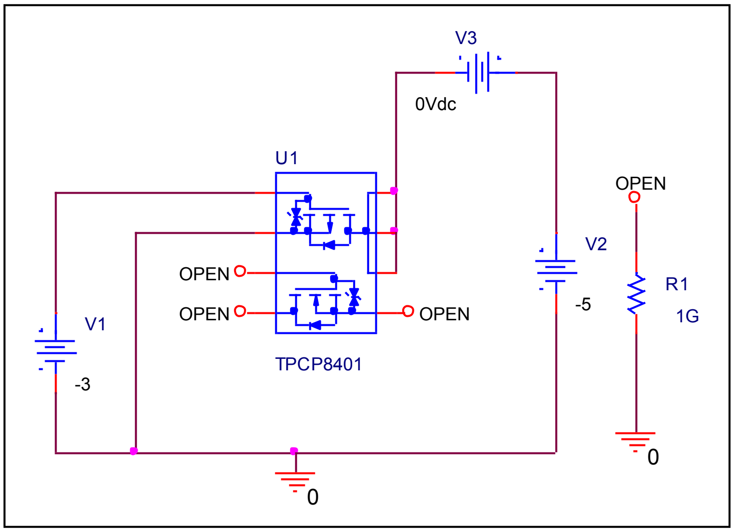
- Id(mA)	gfs		Error(%)
	Measurement	Simulation	
0.2	2.857	2.985	4.480
0.5	4.717	4.505	-4.494
1	6.173	6.452	4.520
2	8.696	8.969	3.139

Vgs-Id Characteristic

Circuit Simulation result

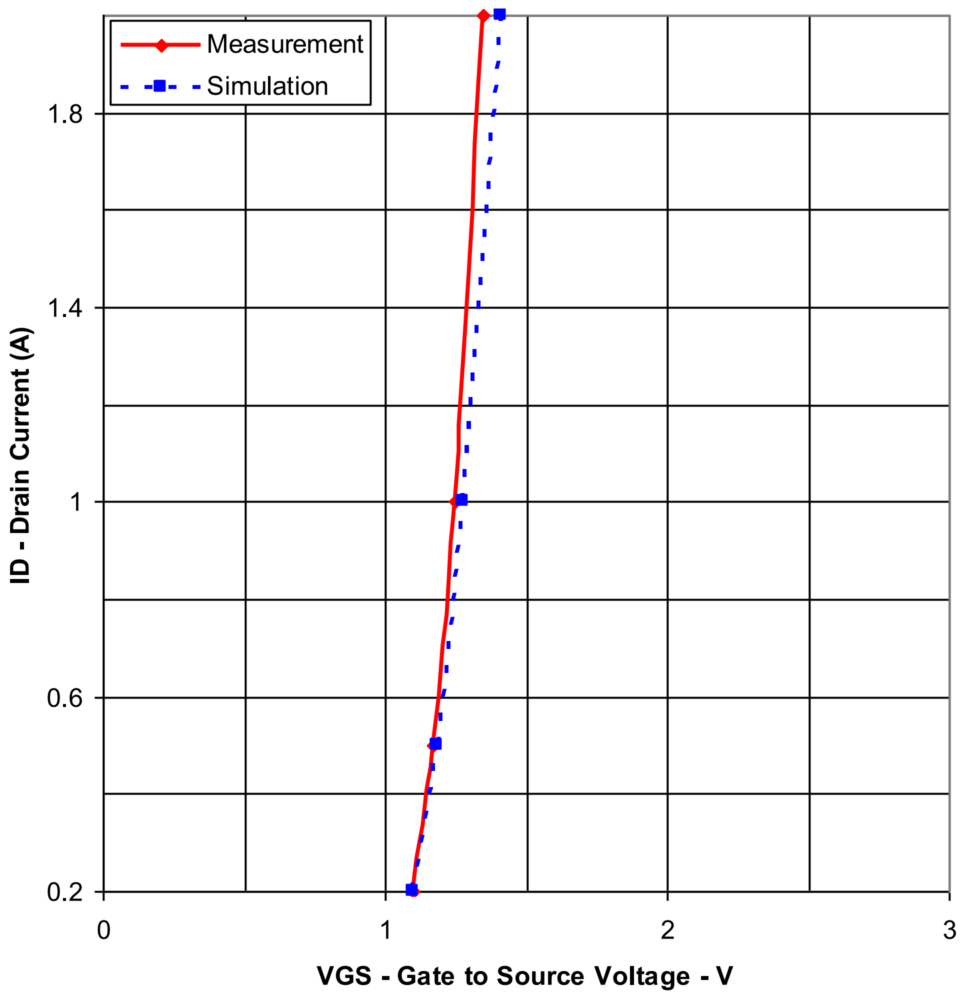


Evaluation circuit



Comparison Graph

Circuit Simulation Result

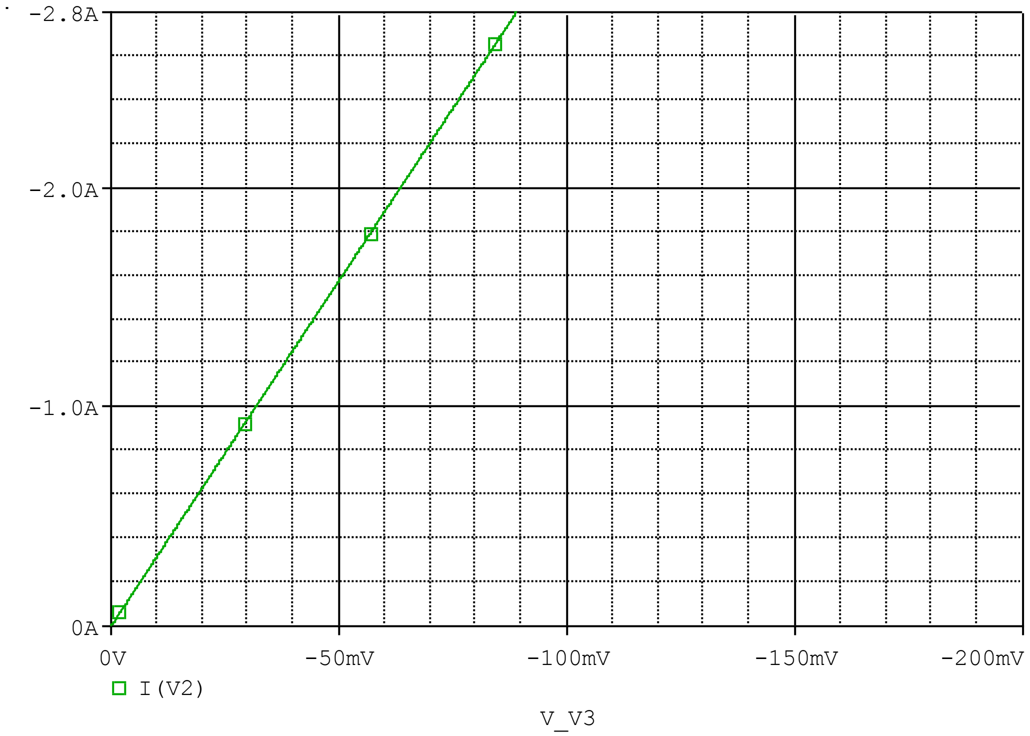


Simulation Result

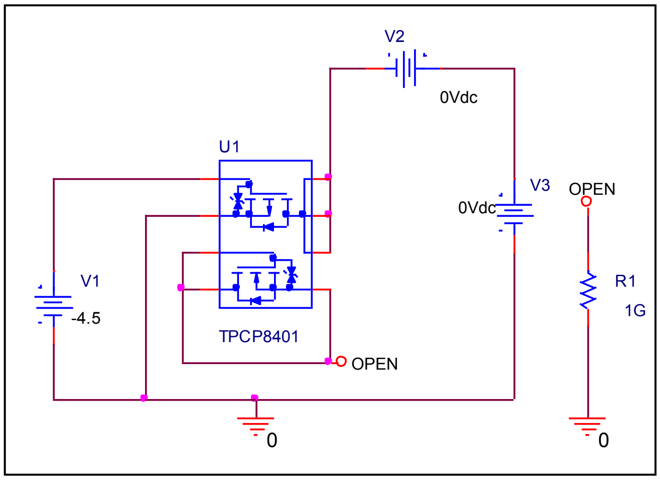
$-I_D$(mA)	$-V_{GS}$(V)		Error (%)
	Measurement	Simulation	
0.2	1.1	1.1027	0.245
0.5	1.17	1.1857	1.342
1	1.25	1.28	2.400
2	1.35	1.4131	4.674

Rds(on) Characteristic

Circuit Simulation result



Evaluation circuit

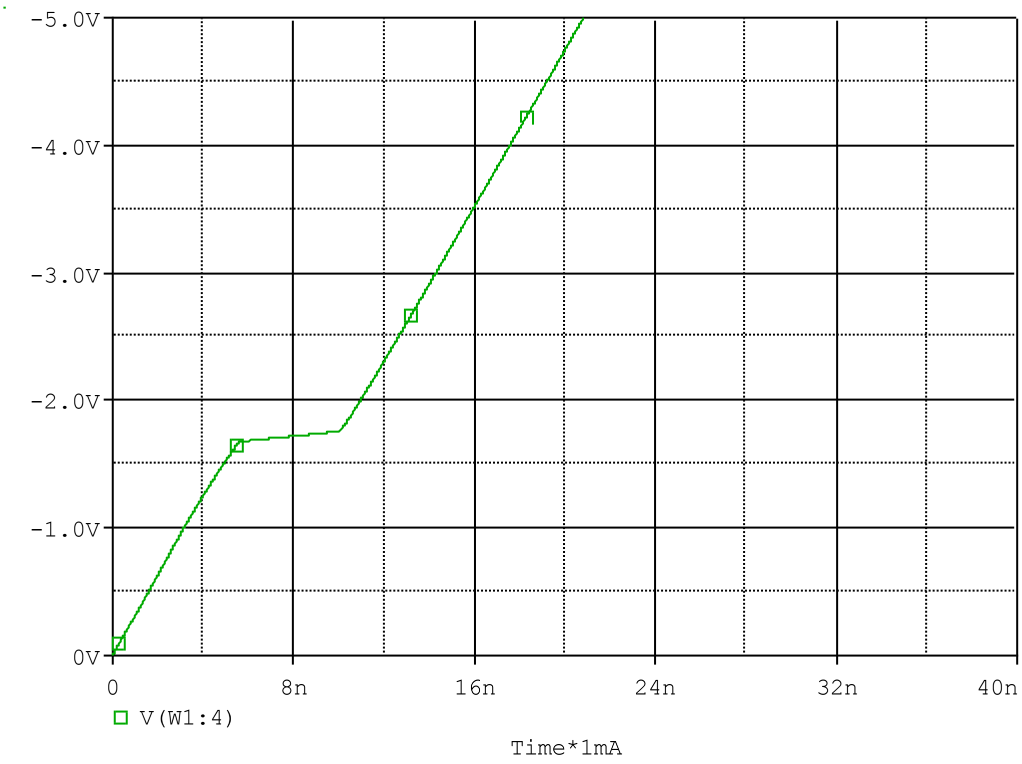


Simulation Result

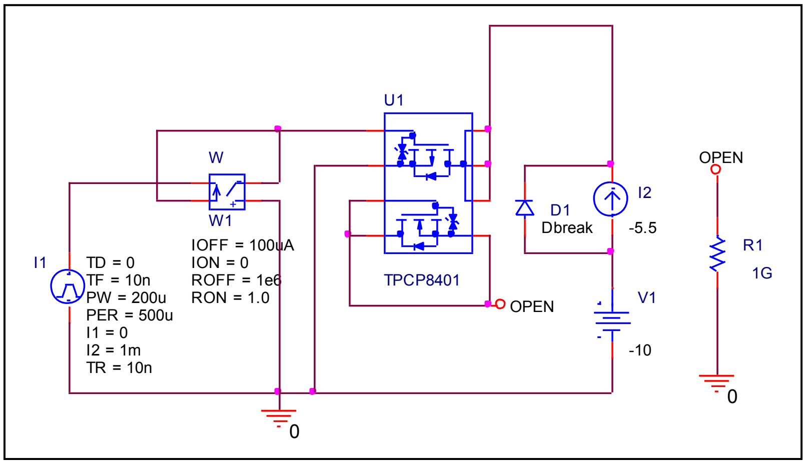
I_D=-2.8A, V_{GS}=-4.5V	Measurement		Simulation		Error (%)
R_{DS} (on)	31.000	mΩ	31.761	mΩ	2.455

Gate Charge Characteristic

Circuit Simulation result



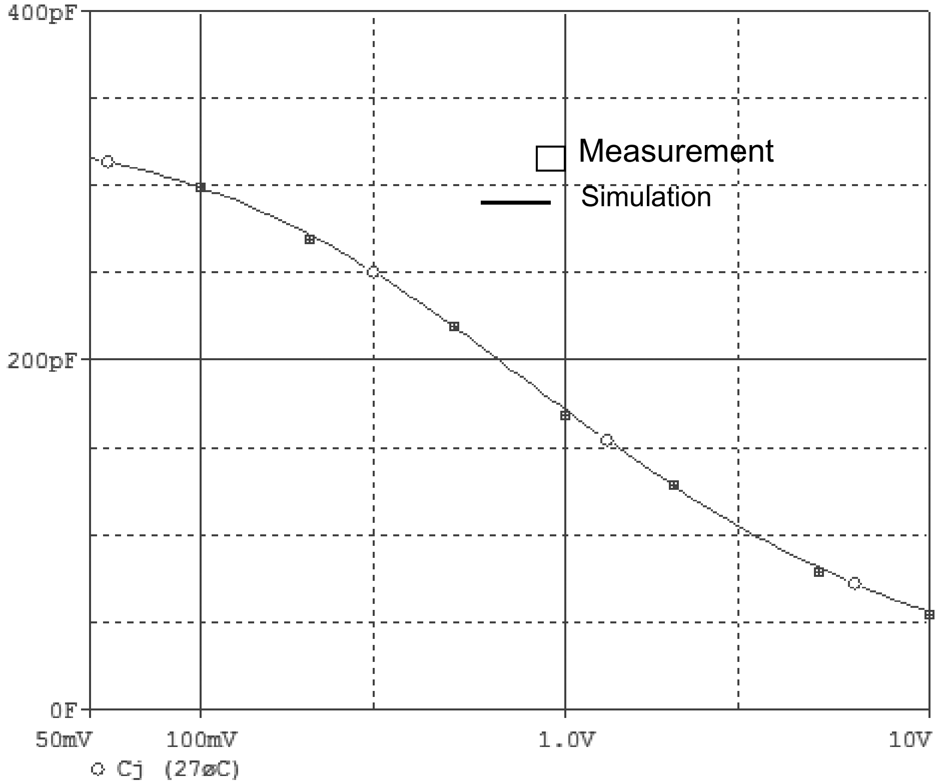
Evaluation circuit



Simulation Result

V_{DD}=-10V,I_D=-5.5A ,V_{GS}=-5V	Measurement	Simulation	Error (%)
Qgs(nC)	5.5	5.57	1.273
Qgd(nC)	4.5	4.4507	-1.096
Qg(nC)	20.5	20.827	1.595

Capacitance Characteristic

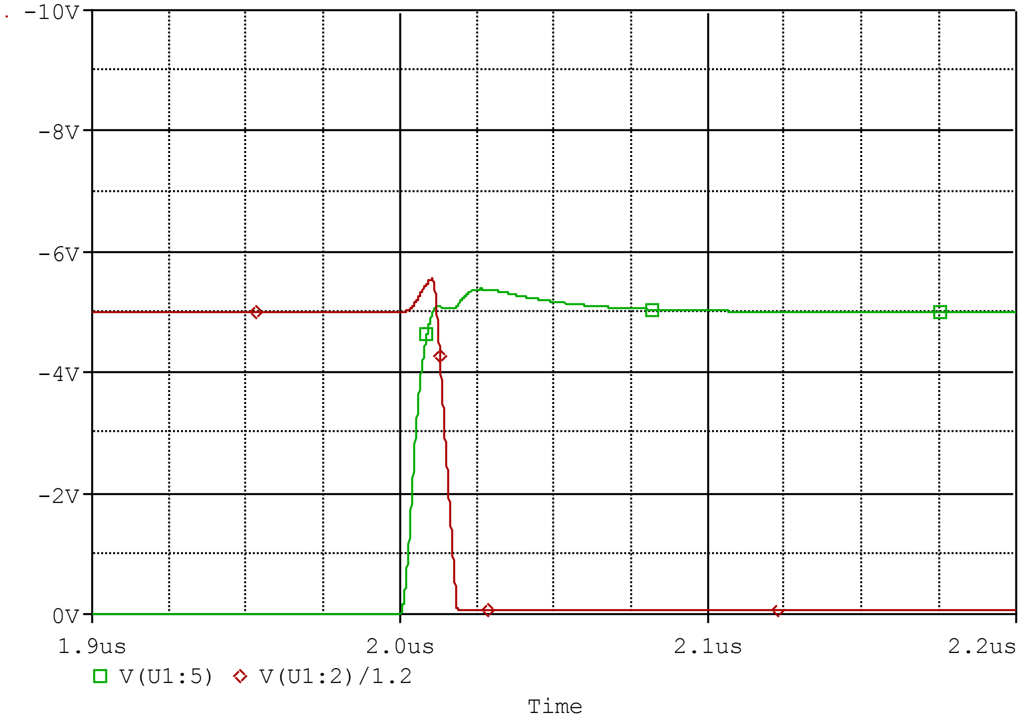


Simulation Result

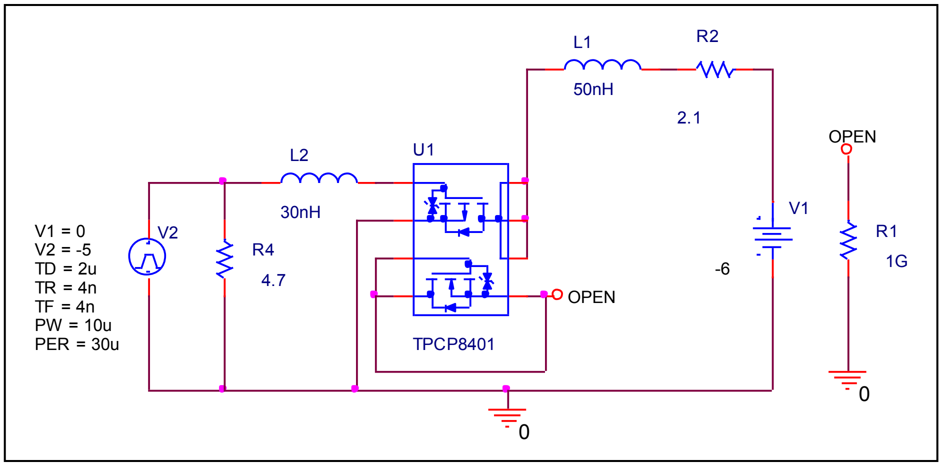
- V_{DS}(V)	Cbd(pF)		Error(%)
	Measurement	Simulation	
0.1	300	298	-0.667
0.2	270	273	1.111
0.5	220	218	-0.909
1	170	173	1.765
2	130	127	-2.308
5	80	81	1.250
10	55	56	1.818

Switching Time Characteristic

Circuit Simulation result



Evaluation circuit

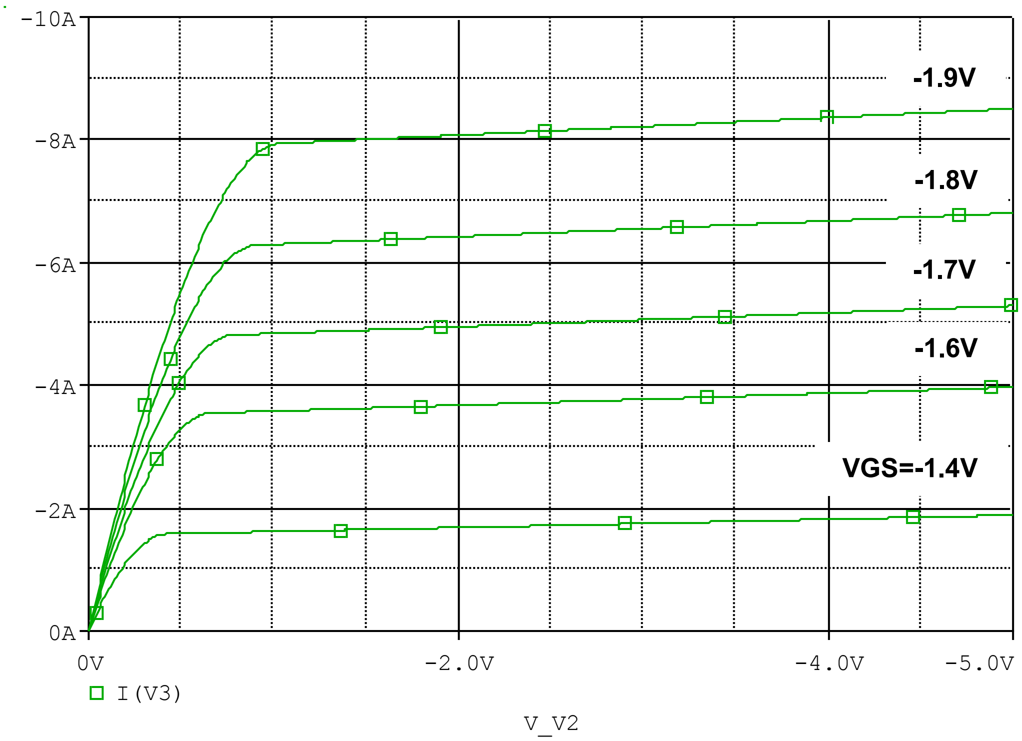


Simulation Result

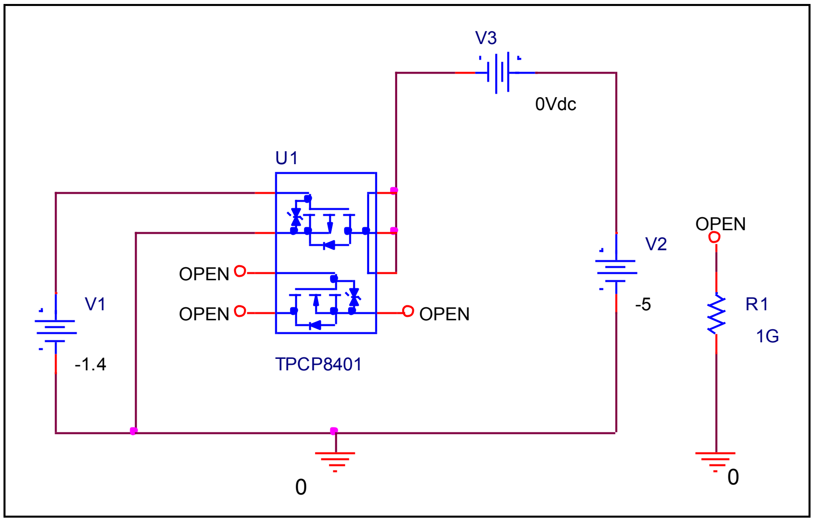
I_D=-2.8 A, V_{DD}=-6V V_{GS}=0/-5V	Measurement	Simulation	Error(%)
Ton(ns)	16	16.053	0.331

Output Characteristic

Circuit Simulation result

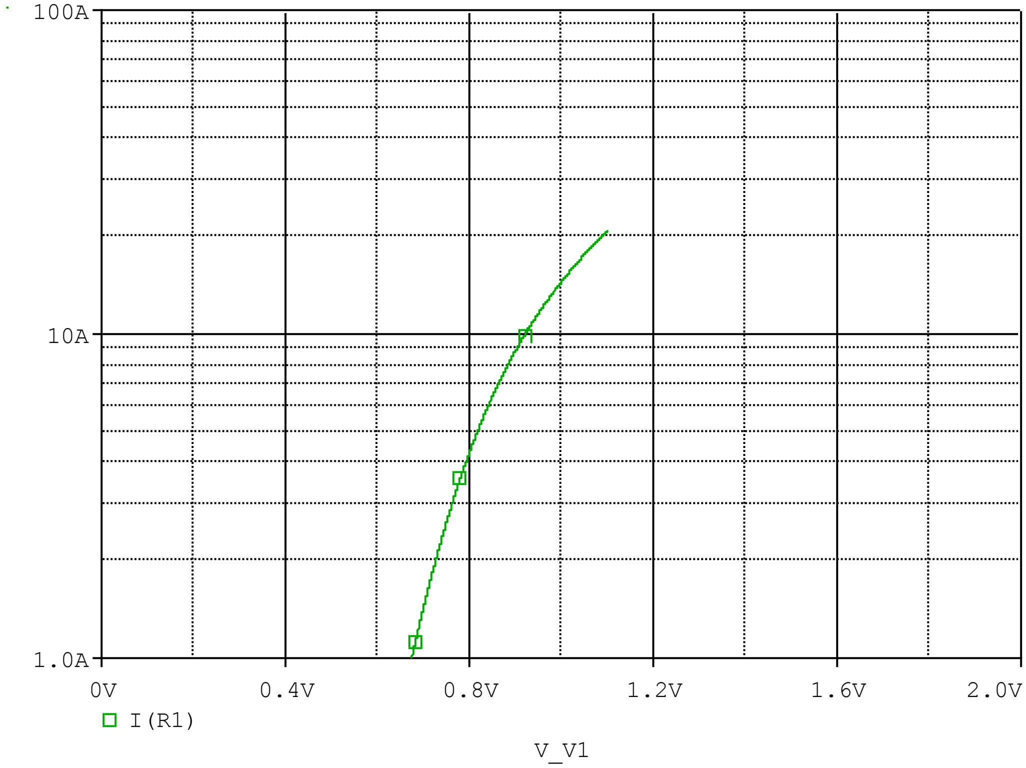


Evaluation circuit

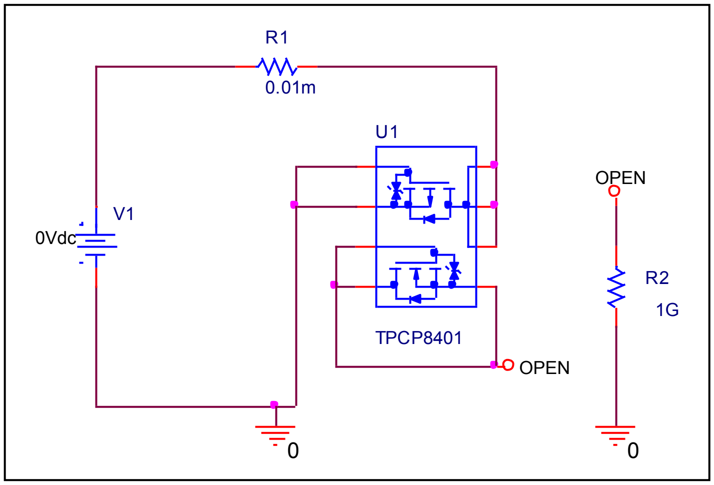


BODY DIODE
Forward Current Characteristic

Circuit Simulation Result

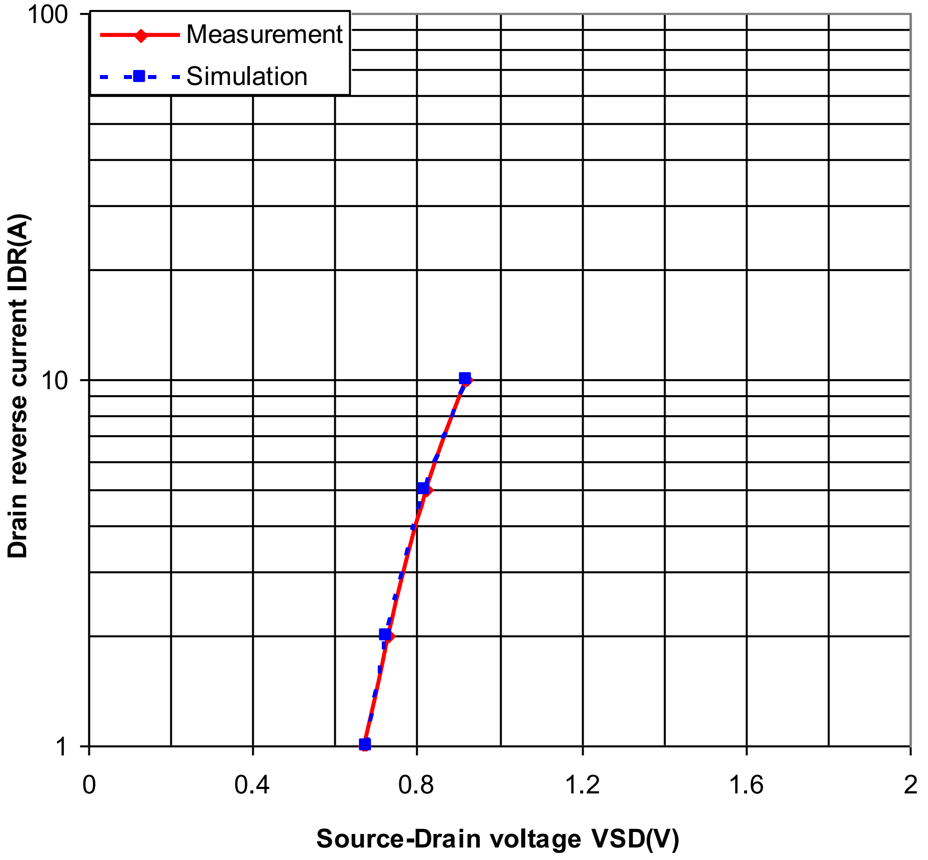


Evaluation Circuit



Comparison Graph

Circuit Simulation Result

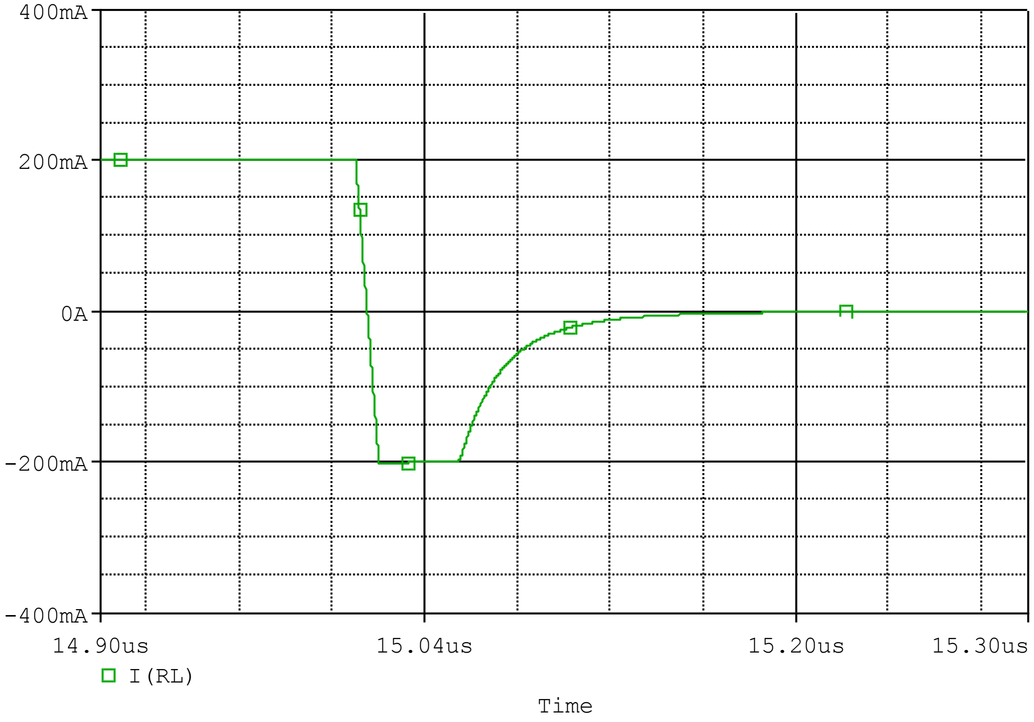


Simulation Result

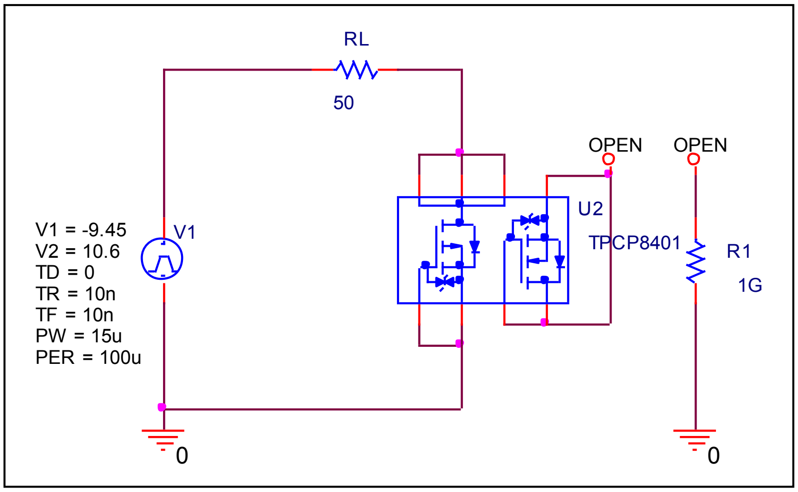
IDR(A)	VSD(V)		%Error
	Measuremen	Simulation	
1	0.67	0.675	0.746
2	0.73	0.727	-0.411
5	0.82	0.818	-0.244
10	0.92	0.922	0.217

Reverse Recovery Characteristic

Circuit Simulation Result



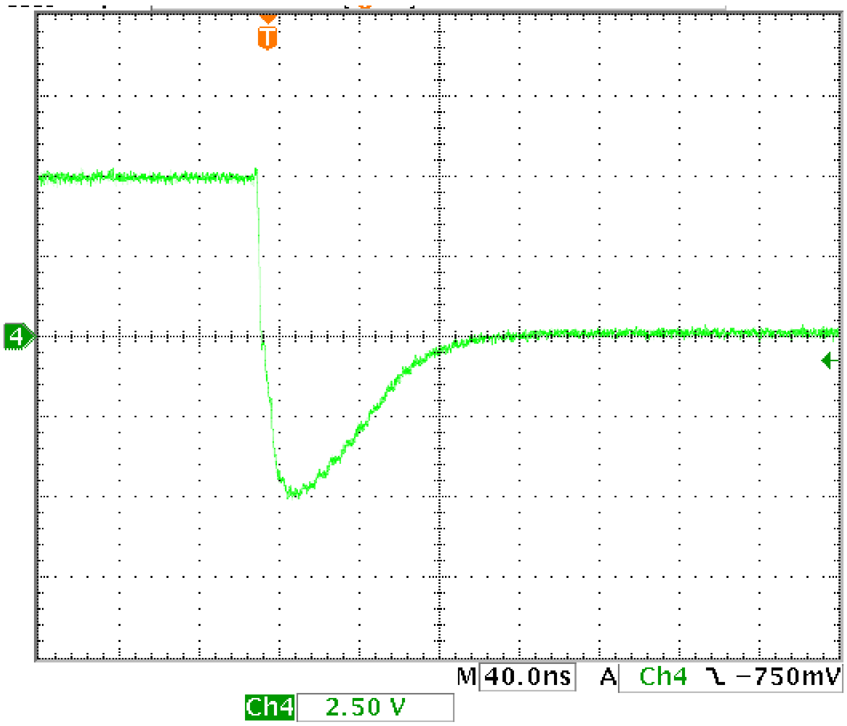
Evaluation Circuit



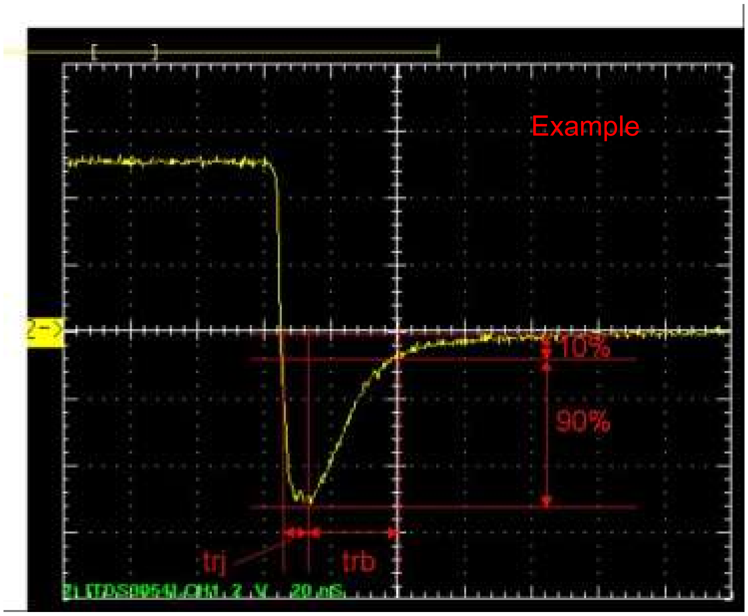
Compare Measurement vs. Simulation

Trr(ns)	Measurement	Simulation	Error (%)
Trj+Trb (ns)	88	88.021	0.024

Reverse Recovery Characteristic Reference



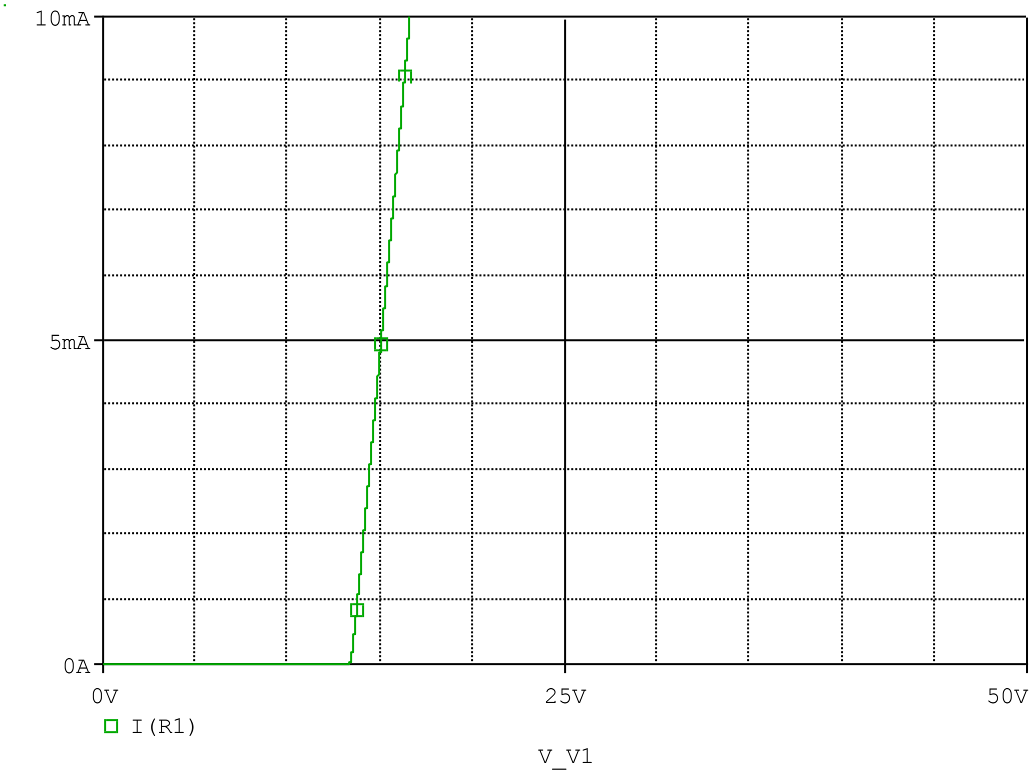
Trj=15.2(ns)
Trb=72.8(ns)
Conditions:Ifwd=Irev=0.2(A),Rl=50



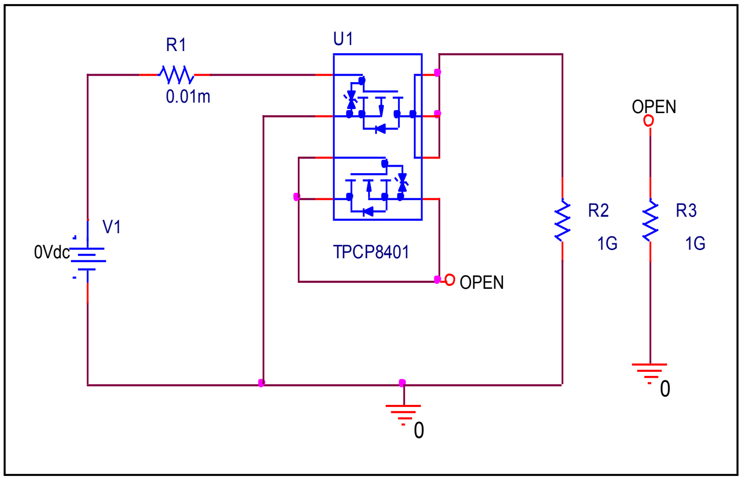
Relation between trj and trb

ESD PROTECTION DIODE
Zener Voltage Characteristic

Circuit Simulation Result

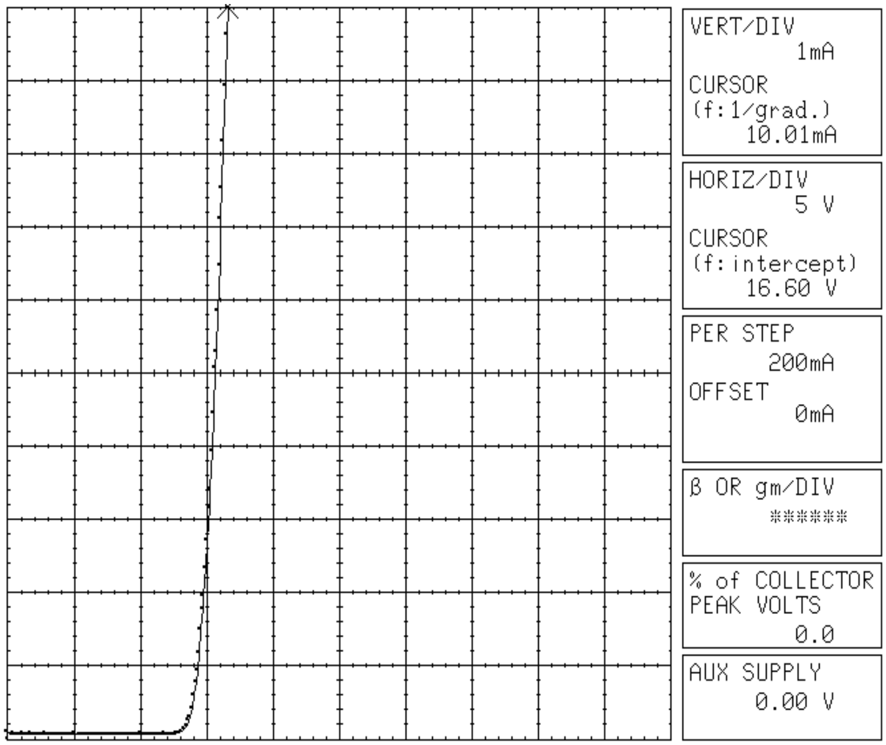


Evaluation Circuit



Zener Voltage Characteristic

Reference



VERT/DIV
1mA
CURSOR
(f:1/grad.)
10.01mA

HORIZ/DIV
5 V
CURSOR
(f:intercept)
16.60 V

PER STEP
200mA
OFFSET
0mA

β OR gm/DIV
******

% of COLLECTOR
PEAK VOLTS
0.0

AUX SUPPLY
0.00 V