Device Modeling Report

COMPONENTS: Power MOSFET (Professional)
PART NUMBER: MP4212
MANUFACTURER: TOSHIBA
Body Diode (Professional) / ESD Protection Diode
REMARK: N&P Channel Model

Bee Technologies Inc.

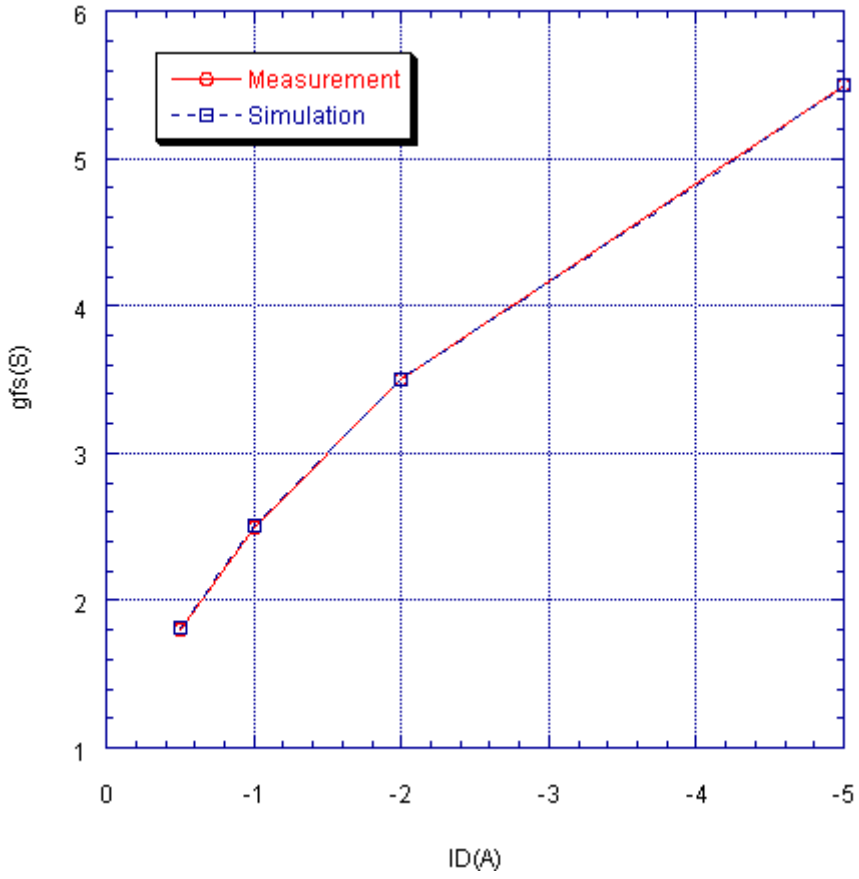
MOSFET MODEL

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	Modility Modulation
KAPPA	Saturation Field Factor
VMAX	Maximum Drift Velocity of Carriers
XJ	Metallurgical Junction Depth
UO	Surface Mobility

P-Channel Model

Transconductance Characteristic

Circuit Simulation Result

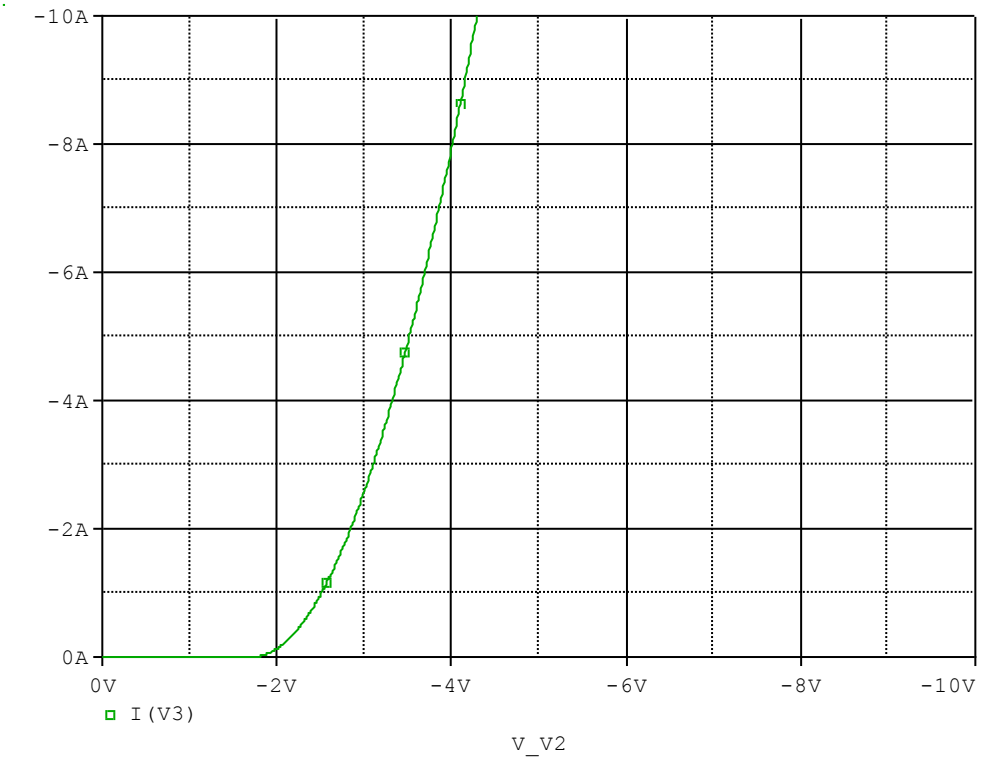


Comparison table

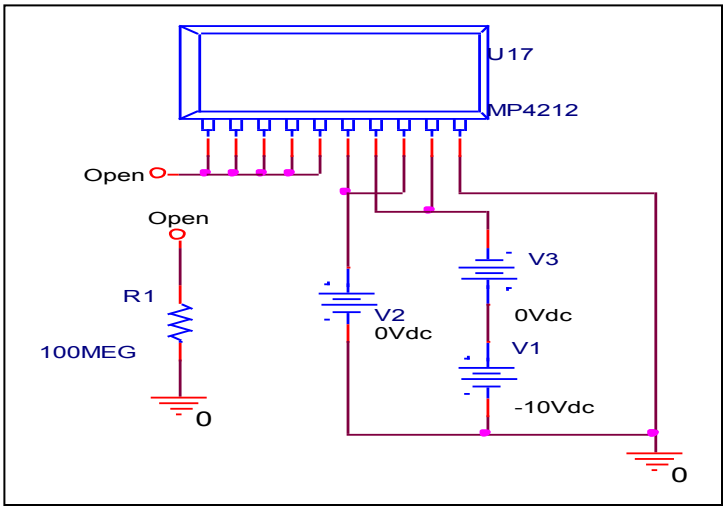
Id(A)	gfs		Error(%)
	Measurement	Simulation	
-0.500	1.800	1.810	0.556
-1.000	2.500	2.505	0.200
-2.000	3.500	3.500	0.000
-5.000	5.500	5.505	0.091

Vgs-Id Characteristic

Circuit Simulation result

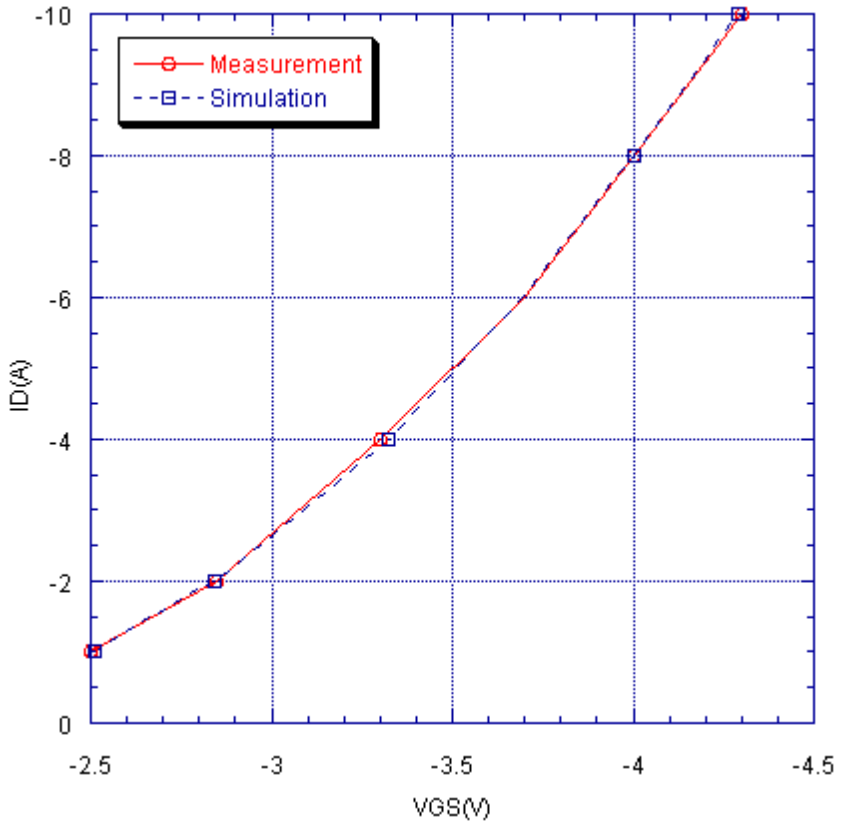


Evaluation circuit



Comparison Graph

Circuit Simulation Result

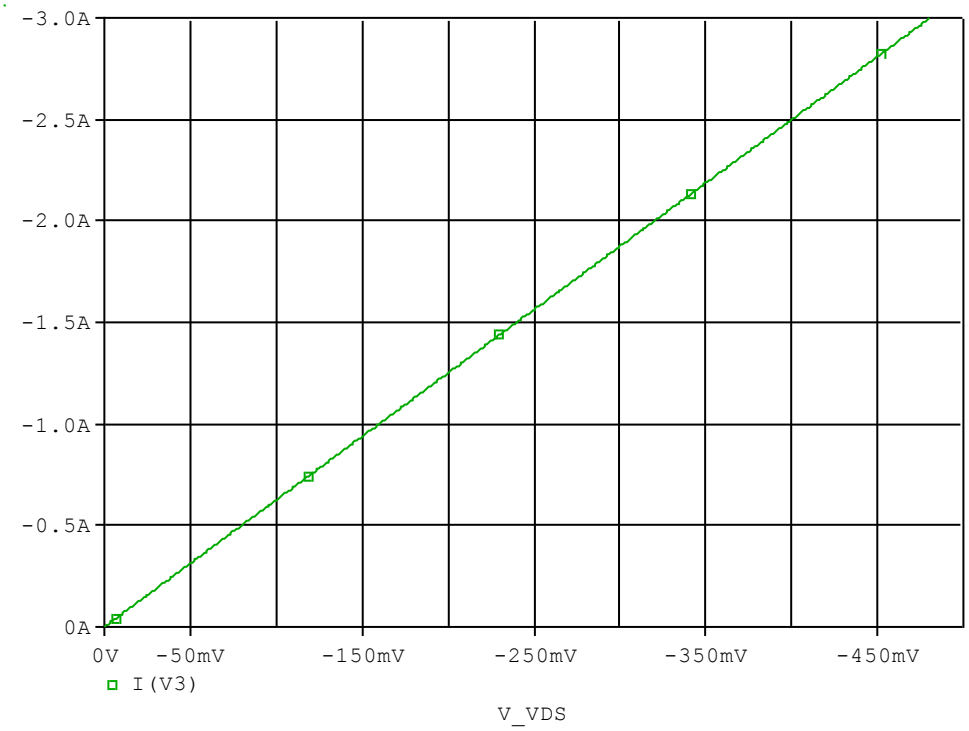


Simulation Result

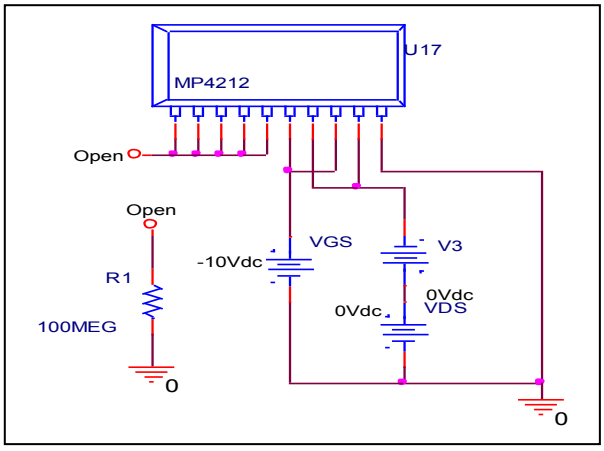
I_D(A)	V_{GS}(V)		Error (%)
	Measurement	Simulation	
-1.000	-2.500	-2.511	0.440
-2.000	-2.850	-2.844	-0.211
-4.000	-3.300	-3.324	0.727
-6.000	-3.700	-3.695	-0.135
-8.000	-4.000	-4.004	0.100
-10.000	-4.300	-4.291	-0.209

Rds(on) Characteristic

Circuit Simulation result



Evaluation circuit

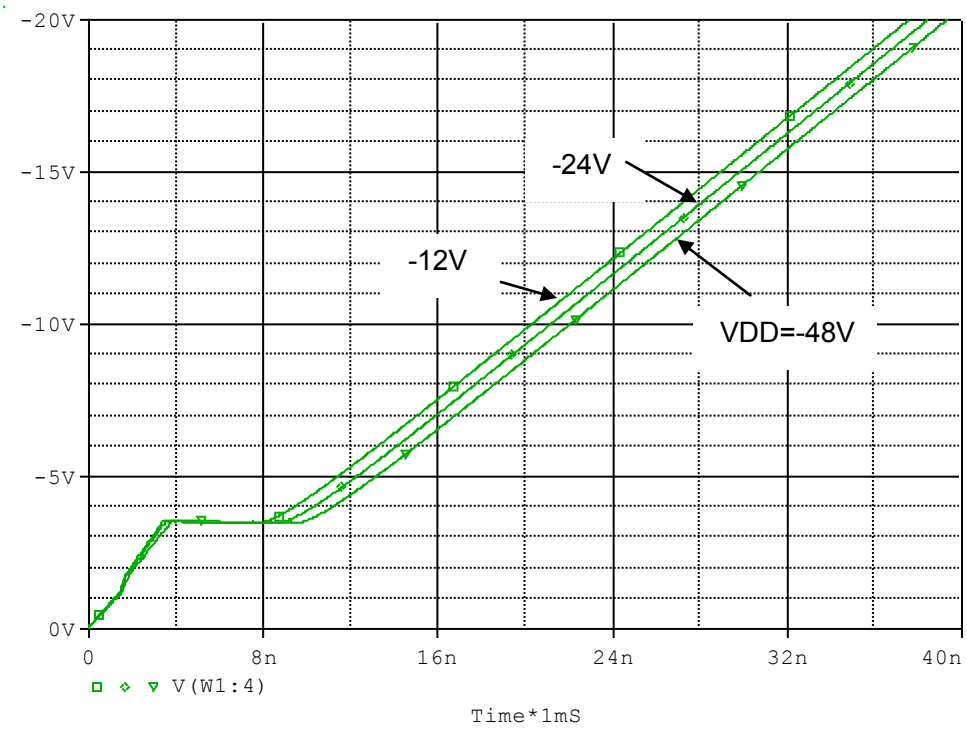


Simulation Result

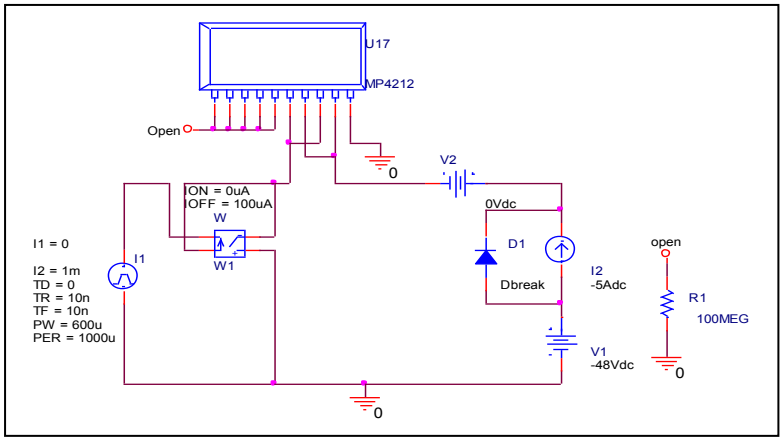
I_D=-2.5A, V_{GS}=-10V	Measurement		Simulation		Error (%)
R_{DS} (on)	400.000	mΩ	400.000	mΩ	0.000

Gate Charge Characteristic

Circuit Simulation result



Evaluation circuit



Simulation Result

V_{DD}=-48V,I_D=-5A ,V_{GS}=-10V	Measurement		Simulation		Error (%)
Qgs	3.500	nC	3.500	nC	0.000
Qgd	10.000	nC	10.046	nC	0.460
Qg	22.000	nC	22.000	nC	0.000

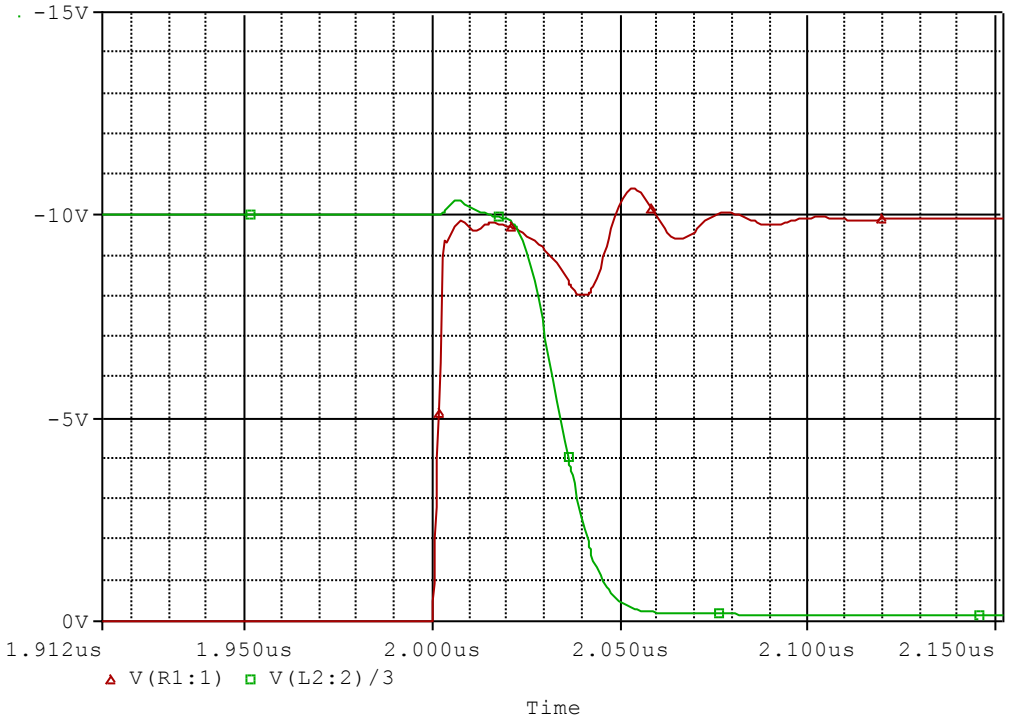
Capacitance Characteristic

Simulation Result

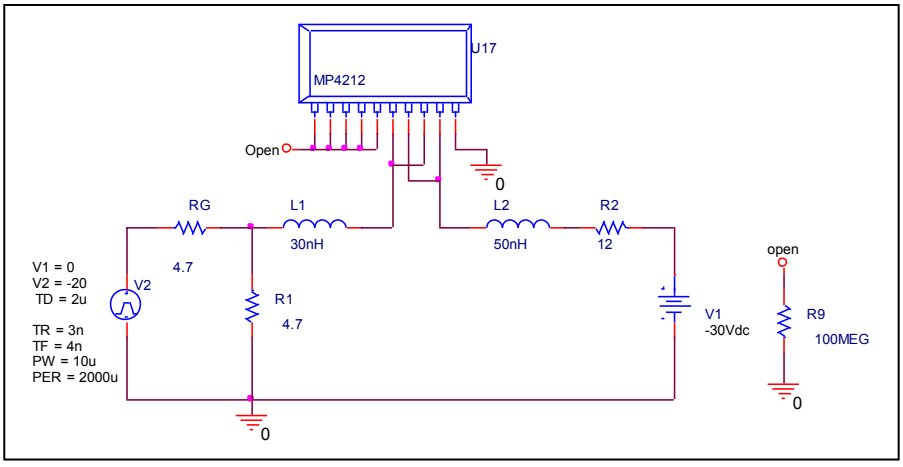
V_{DS}(V)	Cbd(pF)		Error(%)
	Measurement	Simulation	
0.100	475.000	471.000	-0.842
0.200	465.000	462.000	-0.645
0.500	440.000	438.000	-0.455
1.000	400.000	403.000	0.750
2.000	350.000	351.000	0.286
5.000	255.000	260.000	1.961
10.000	188.000	190.000	1.064
20.000	134.000	135.000	0.746
50.000	75.000	75.000	0.000

Switching Time Characteristic

Circuit Simulation result



Evaluation circuit

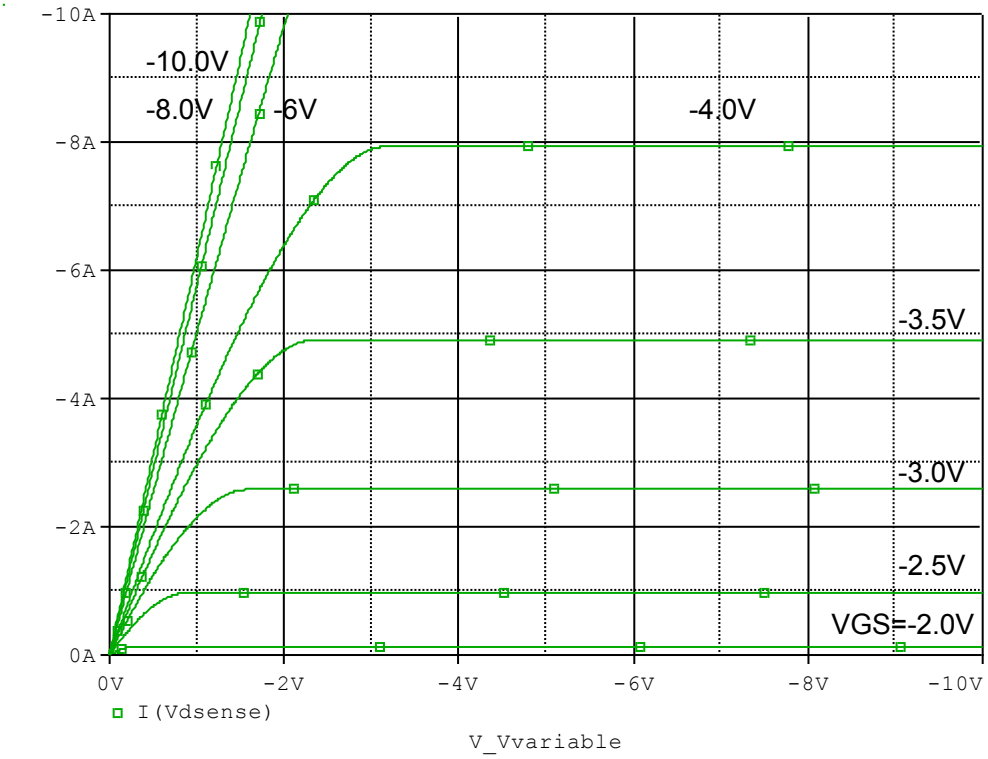


Simulation Result

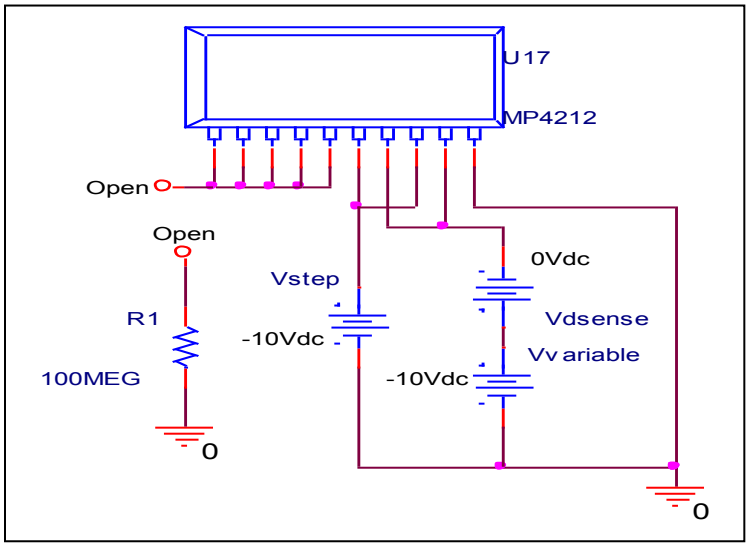
I_D=-2.5A, V_{DD}=-30V V_{GS}=0/10V	Measurement		Simulation		Error(%)
ton	45.000	ns	44.955	ns	-0.100

Output Characteristic

Circuit Simulation result

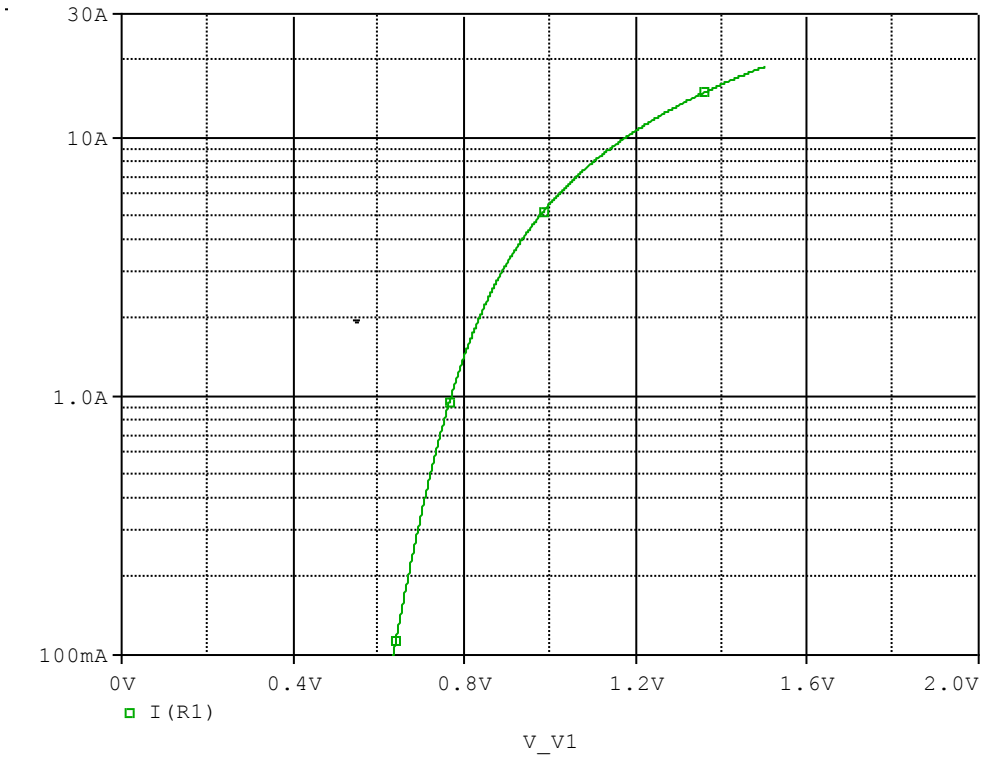


Evaluation circuit

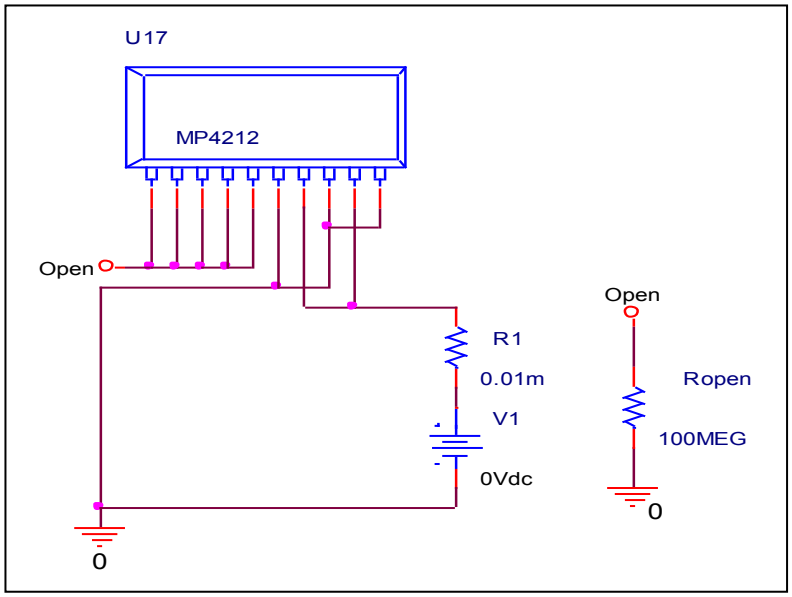


Forward Current Characteristic

Circuit Simulation Result

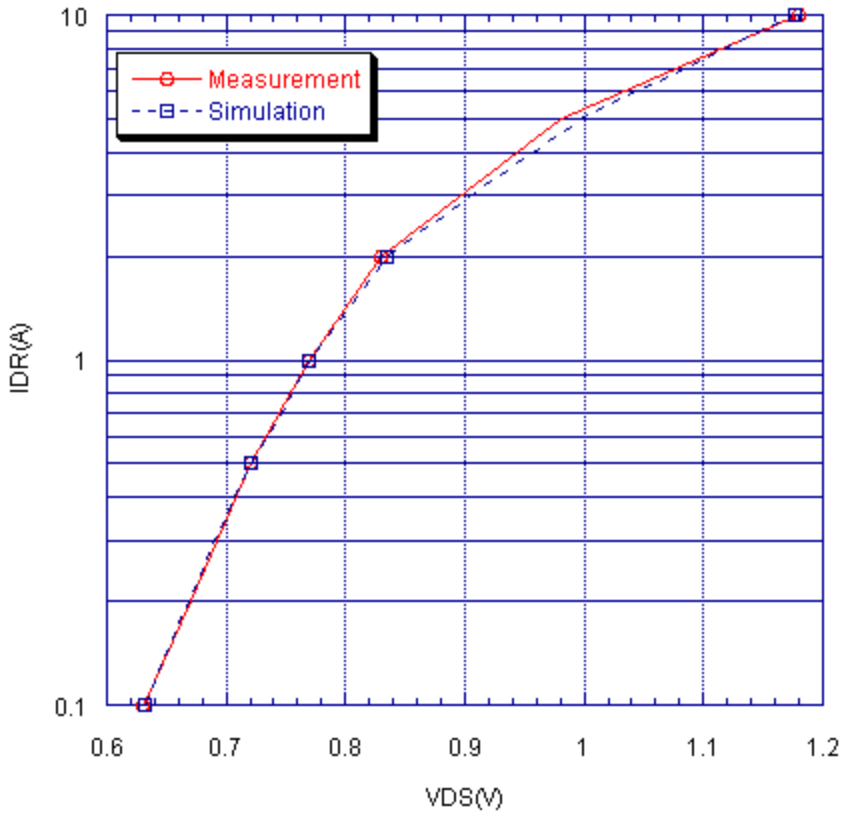


Evaluation Circuit



Comparison Graph

Circuit Simulation Result

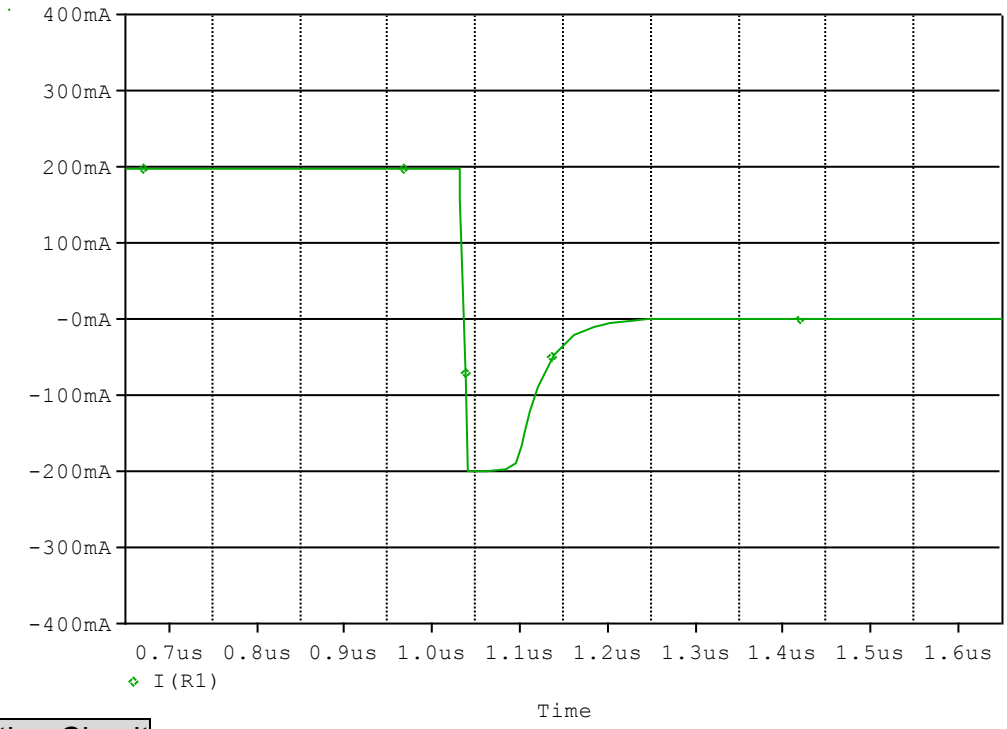


Simulation Result

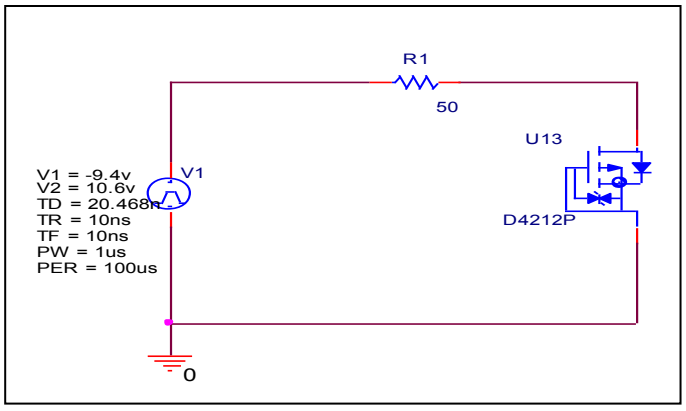
IDR(A)	VDS(V) Measurement	VDS(V) Simulation	%Error
0.100	0.630	0.632	0.317
0.200	0.670	0.668	-0.299
0.500	0.720	0.720	0.000
1.000	0.770	0.769	-0.130
2.000	0.830	0.834	0.482
5.000	0.980	0.997	1.735
10.000	1.180	1.177	-0.254

Reverse Recovery Characteristic

Circuit Simulation Result



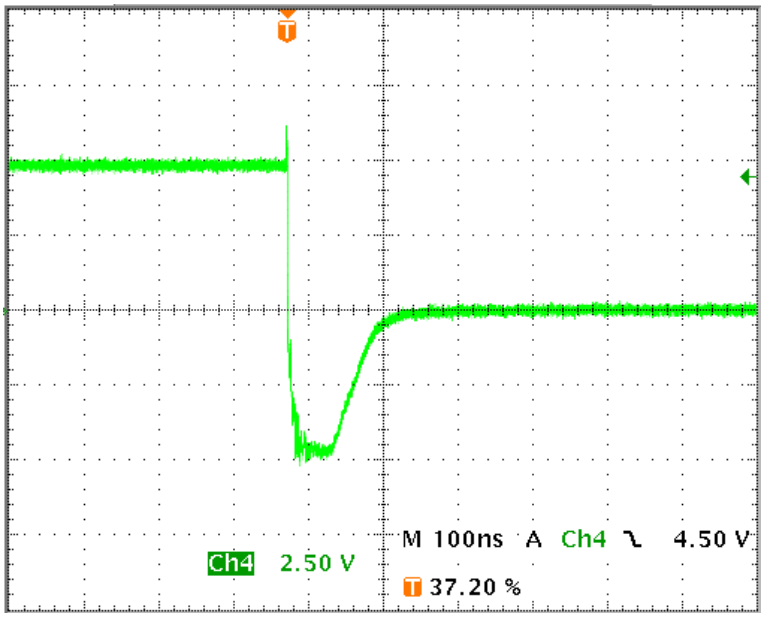
Evaluation Circuit



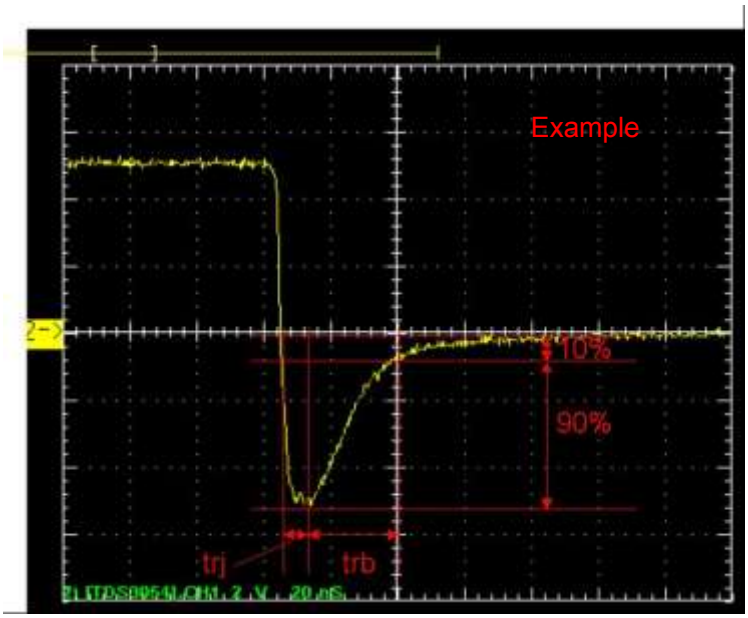
Compare Measurement vs. Simulation

	Measurement		Simulation		Error (%)
trj	**50.000**	**ns**	**49.878**	**ns**	**-0.244**
trb	**76.000**	**ns**	**76.557**	**ns**	**0.733**
trr	**126.000**	**ns**	**126.435**	**ns**	**0.345**

Reverse Recovery Characteristic Reference



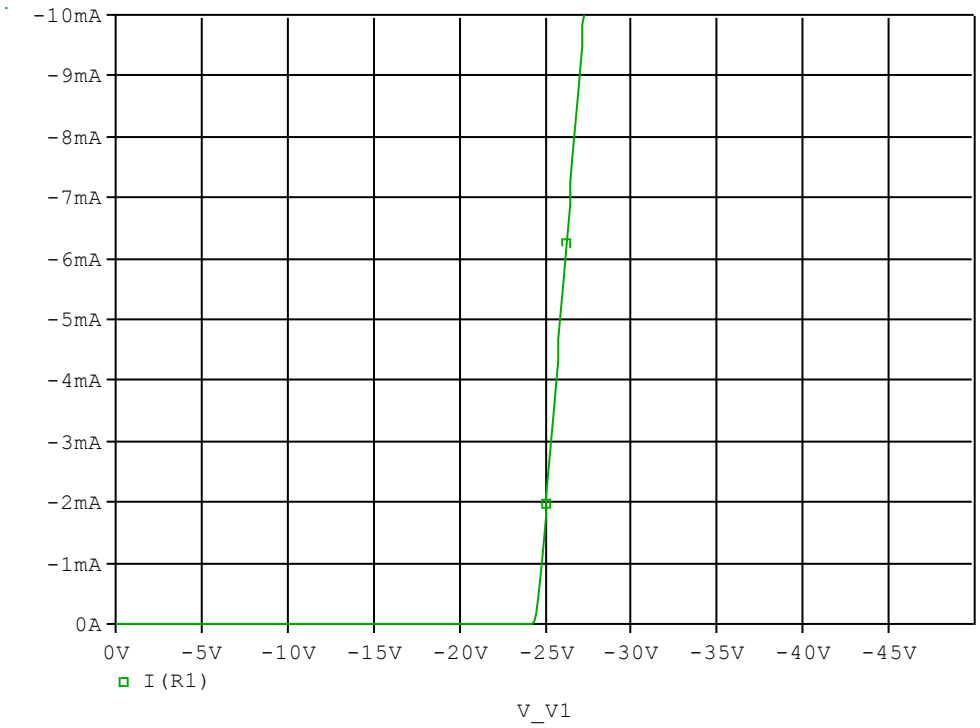
Trj=50(ns)
Trb=76(ns)
Conditions:Ifwd=Irev=0.2(A),Rl=50



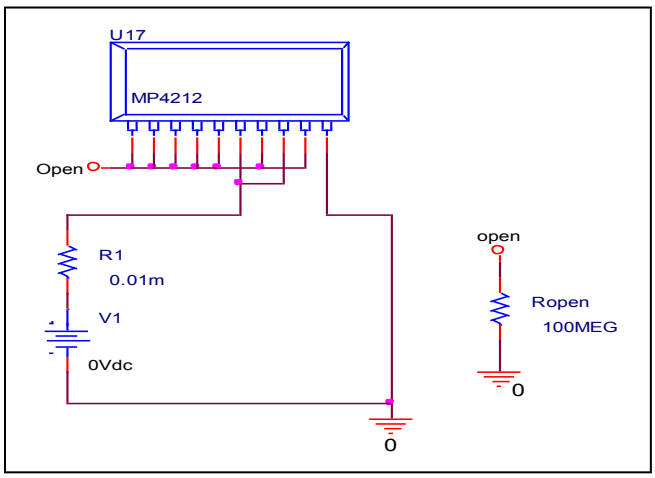
Relation between trj and trb

Zener Voltage Characteristic

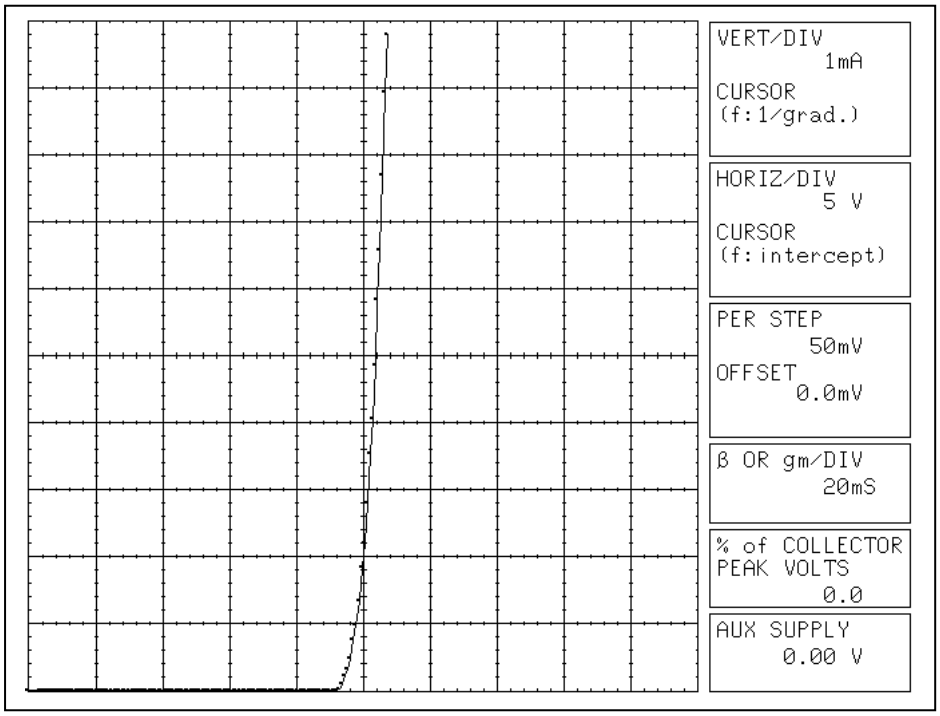
Circuit Simulation Result



Evaluation Circuit



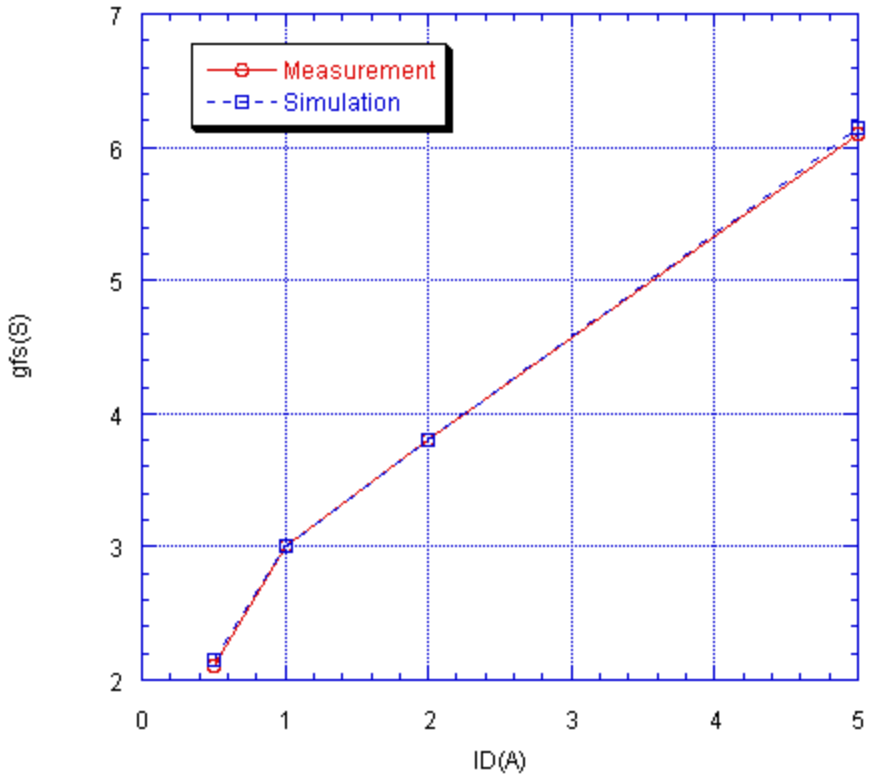
Zener Voltage Characteristic Reference



N-Channel Model

Transconductance Characteristic

Circuit Simulation Result

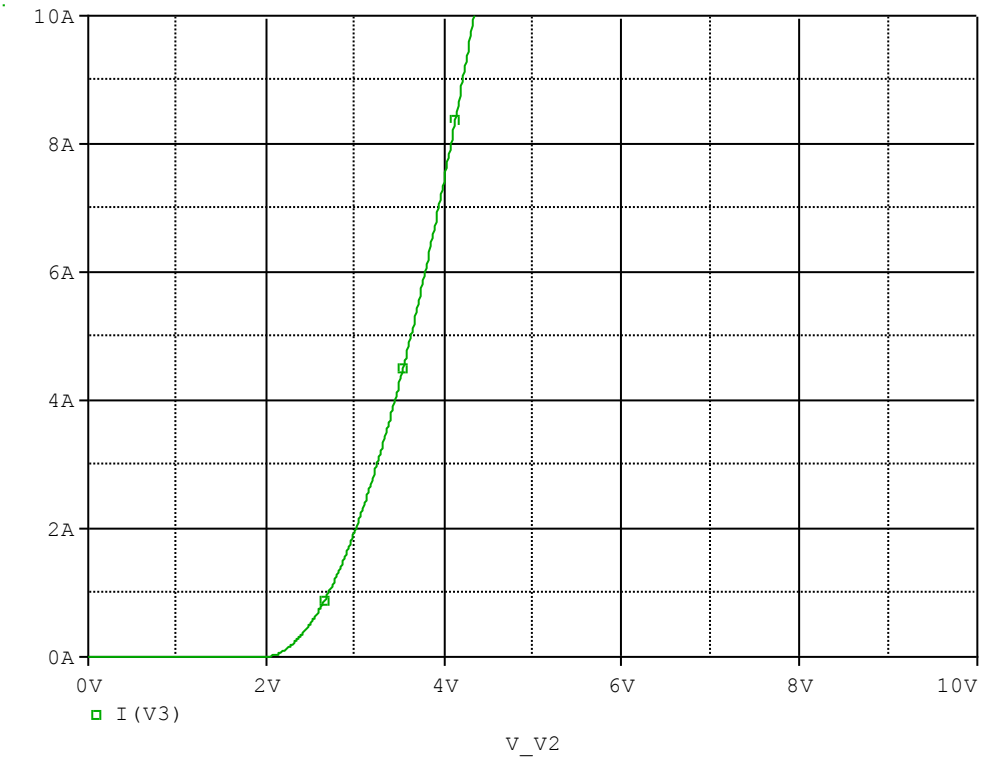


Comparison table

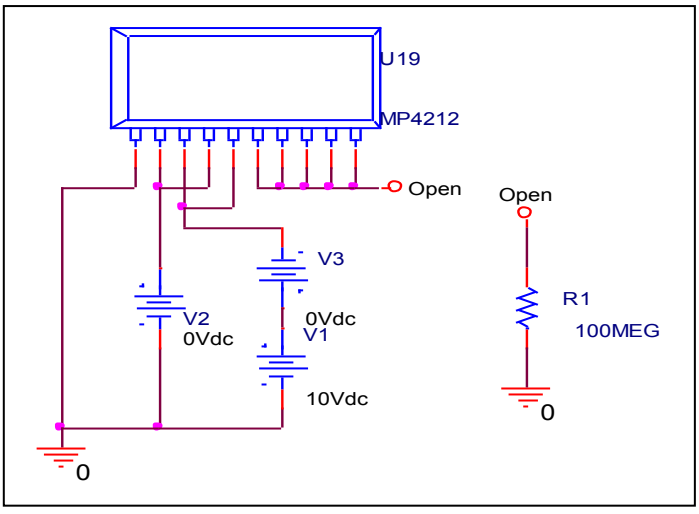
Id(A)	gfs		Error(%)
	Measurement	Simulation	
0.500	2.100	2.150	2.381
1.000	3.000	3.010	0.333
2.000	3.800	3.800	0.000
5.000	6.100	6.150	0.820

Vgs-Id Characteristic

Circuit Simulation result

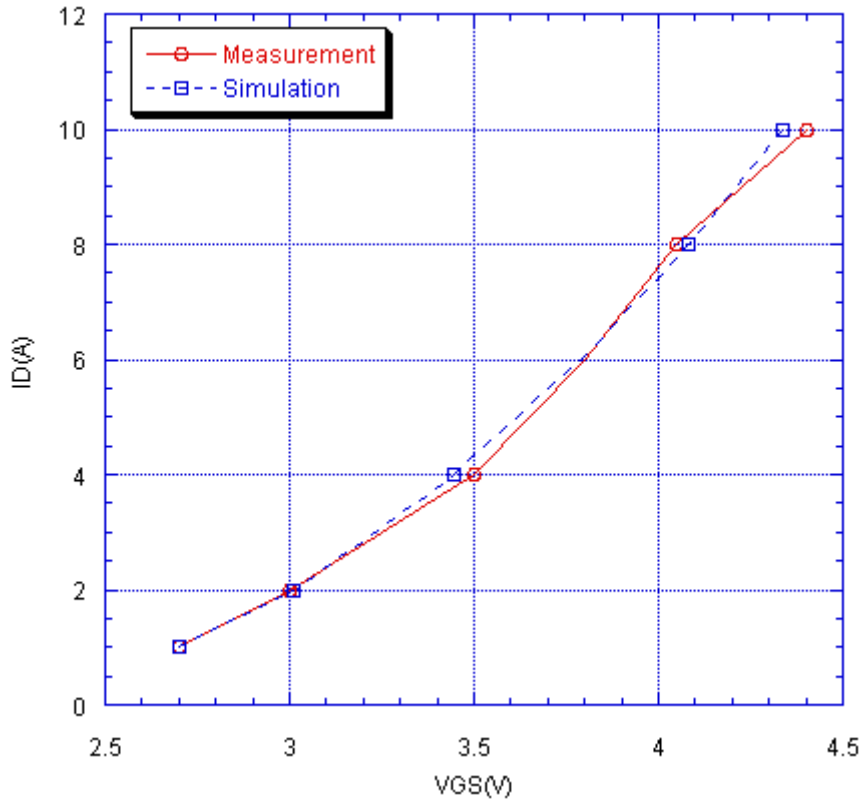


Evaluation circuit



Comparison Graph

Circuit Simulation Result

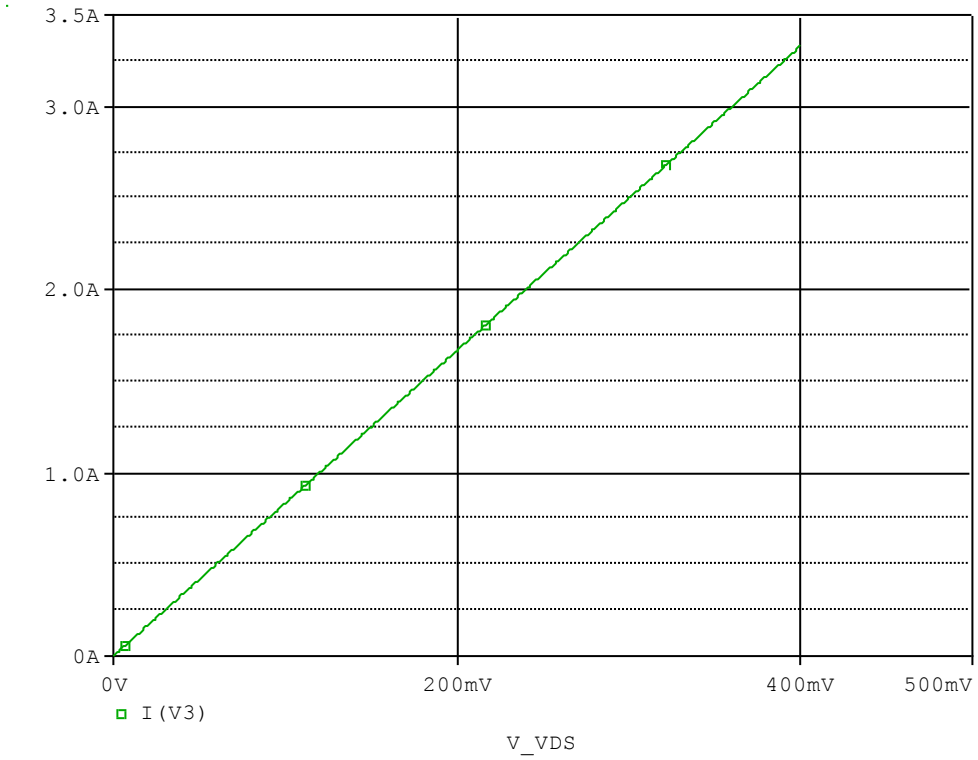


Simulation Result

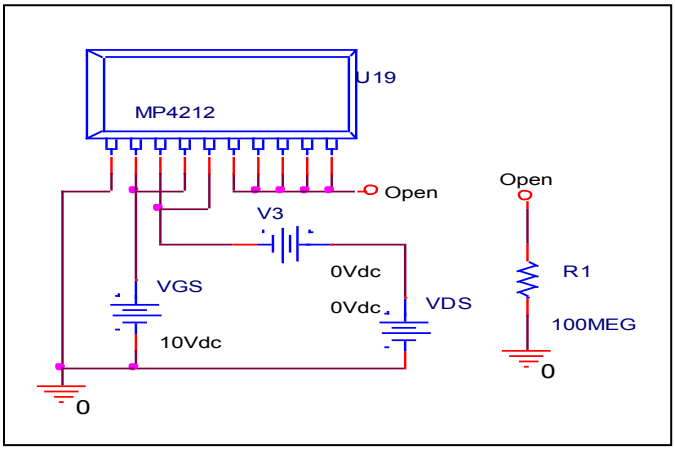
I_D(A)	V_{GS}(V)		Error (%)
	Measurement	Simulation	
1.000	2.700	2.701	0.037
2.000	3.000	3.011	0.367
4.000	3.500	3.446	-1.543
6.000	3.800	3.790	-0.263
8.000	4.000	4.081	2.025
10.000	4.400	4.339	-1.386

Rds(on) Characteristic

Circuit Simulation result



Evaluation circuit

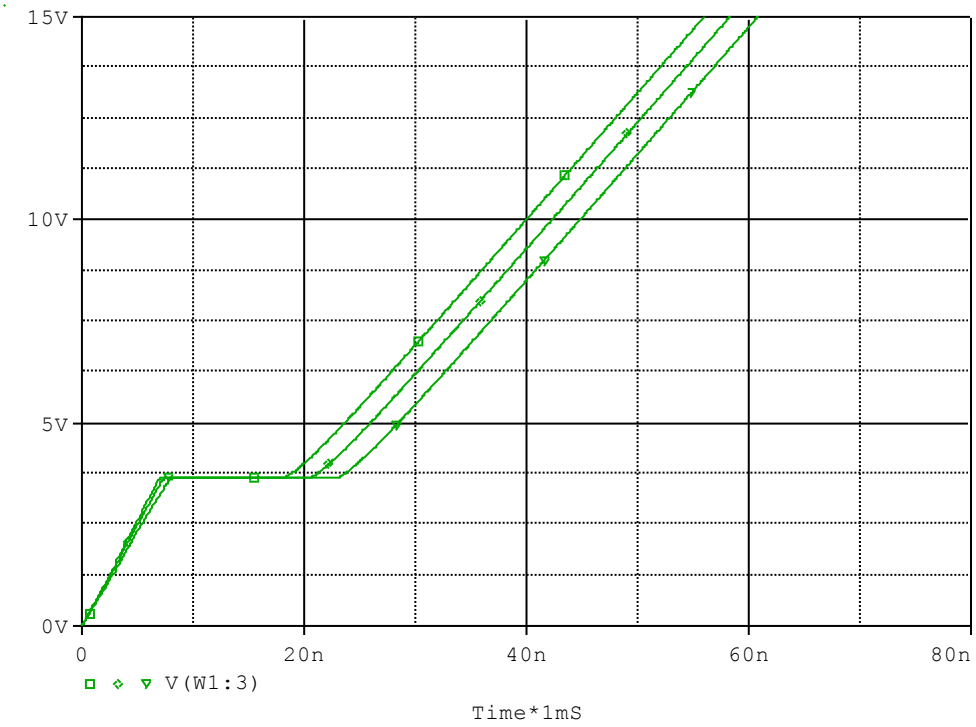


Simulation Result

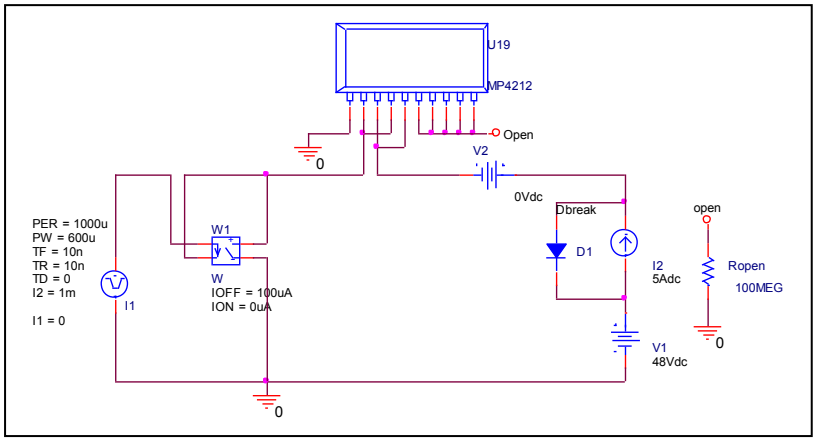
I_D=2.5A, V_{GS}=10V	Measurement		Simulation		Error (%)
R_{DS} (on)	300.000	mΩ	300.000	mΩ	0.000

Gate Charge Characteristic

Circuit Simulation result



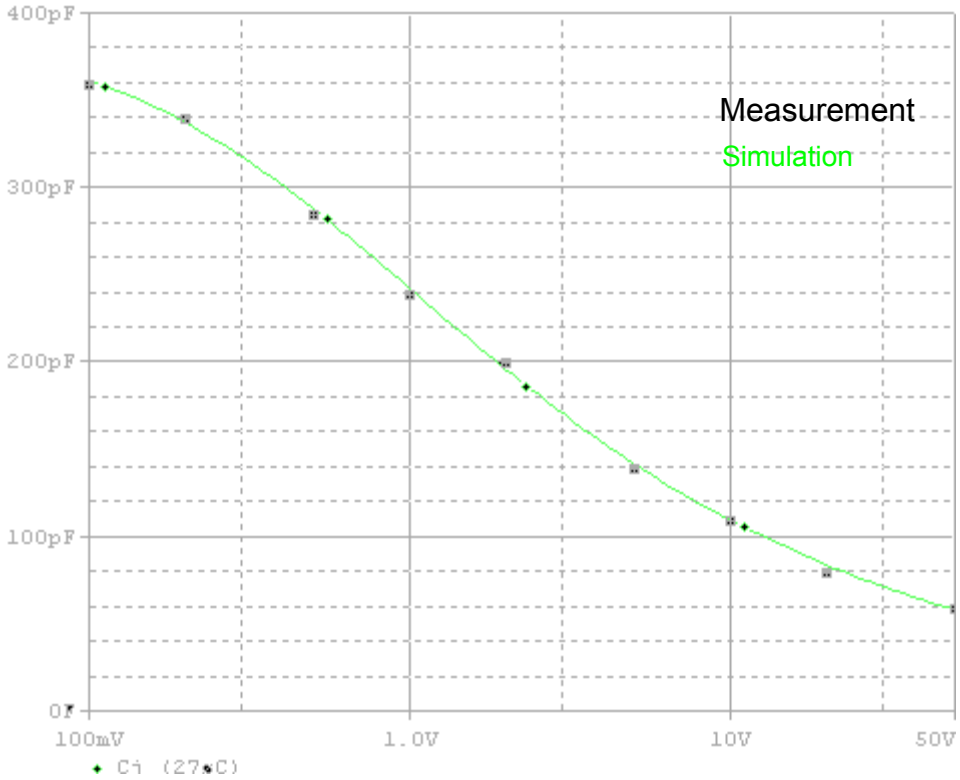
Evaluation circuit



Simulation Result

V_{DD}=48V,I_D=5A ,V_{GS}=10V	Measurement		Simulation		Error (%)
Qgs	7.000	nC	7.026	nC	0.371
Qgd	16.000	nC	15.946	nC	-0.338
Qg	45.000	nC	44.865	nC	-0.300

Capacitance Characteristic

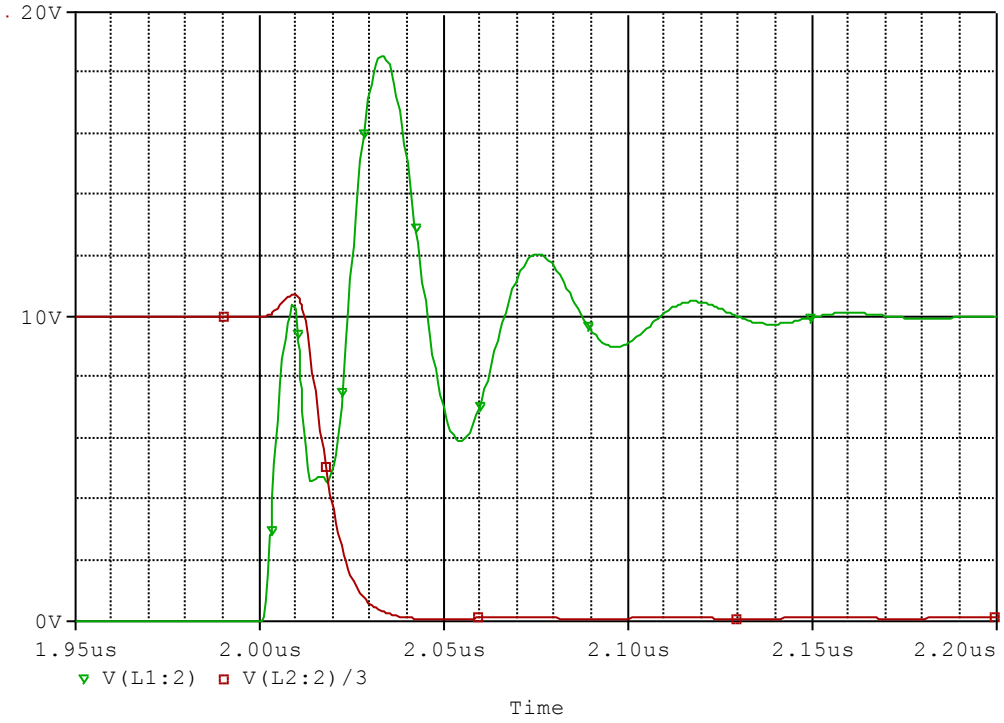


Simulation Result

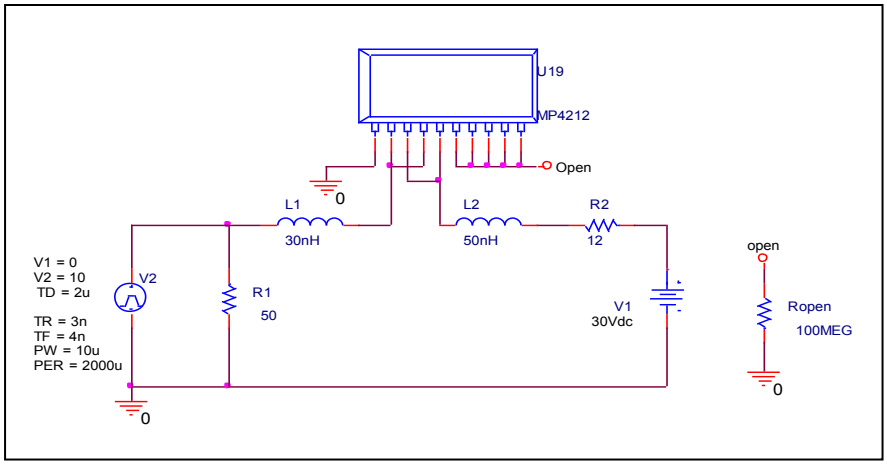
V_{DS}(V)	Cbd(pF)		Error(%)
	Measurement	Simulation	
0.100	360.000	362.000	0.556
0.200	340.000	337.000	-0.882
0.500	285.000	288.000	1.053
1.000	240.000	243.000	1.250
2.000	200.000	198.000	-1.000
5.000	140.000	142.000	1.429
10.000	110.000	110.000	0.000
20.000	80.000	83.000	3.750
50.000	60.000	61.000	1.667

Switching Time Characteristic

Circuit Simulation result



Evaluation circuit

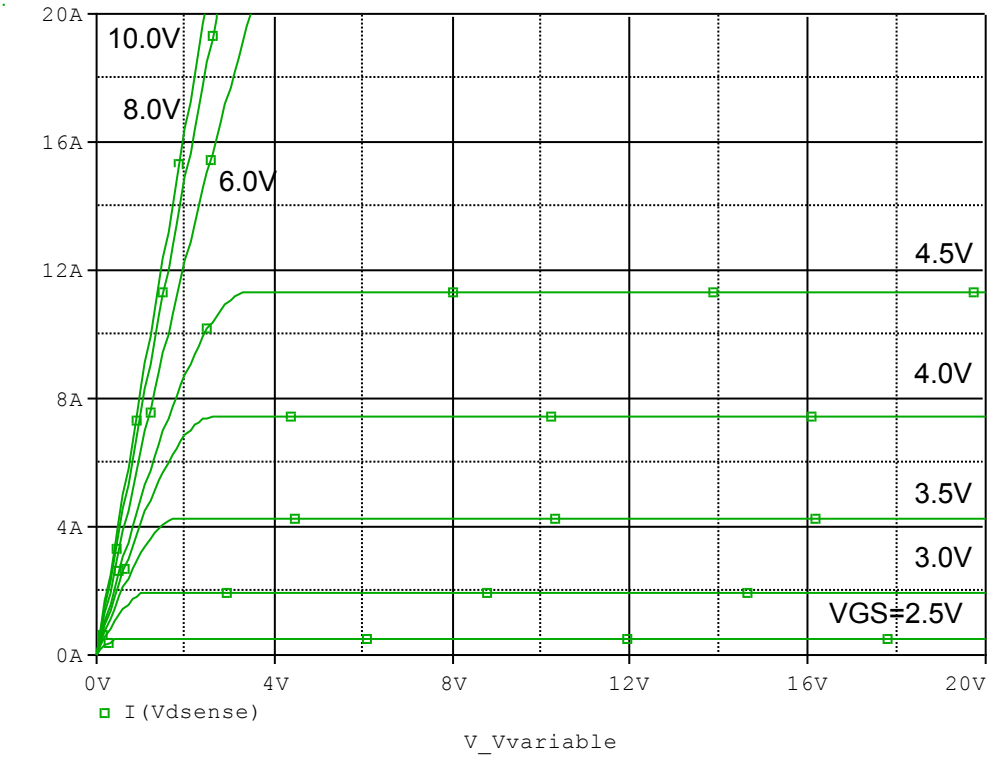


Simulation Result

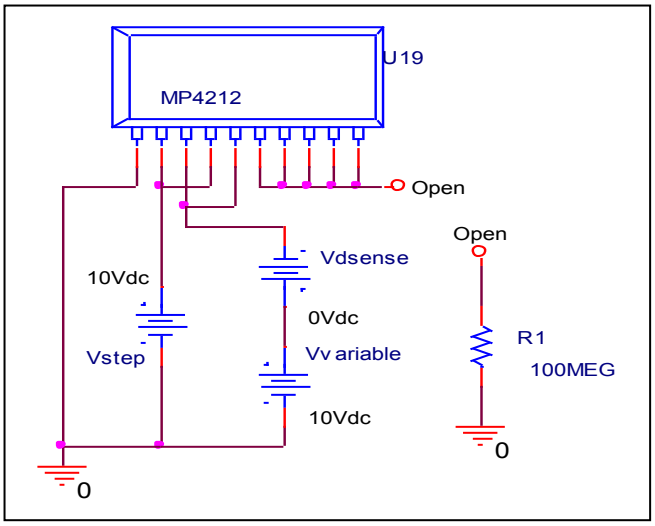
I_D=2.5 A, V_{DD}=30V V_{GS}=0/10V	Measurement		Simulation		Error(%)
ton	25.000	ns	24.966	ns	-0.136

Output Characteristic

Circuit Simulation result

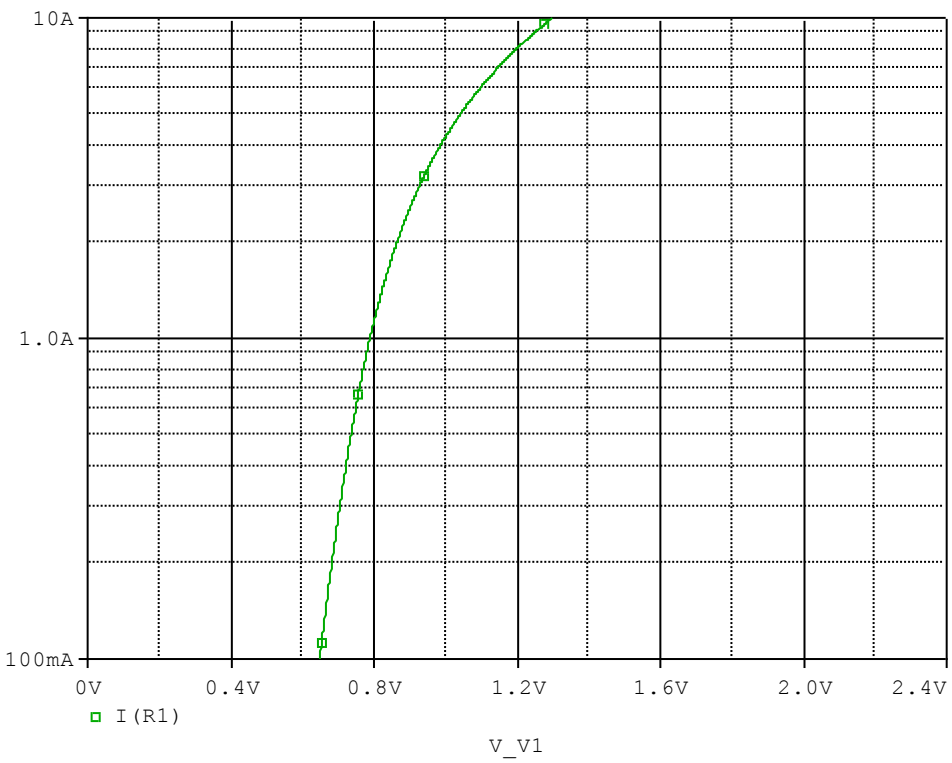


Evaluation circuit

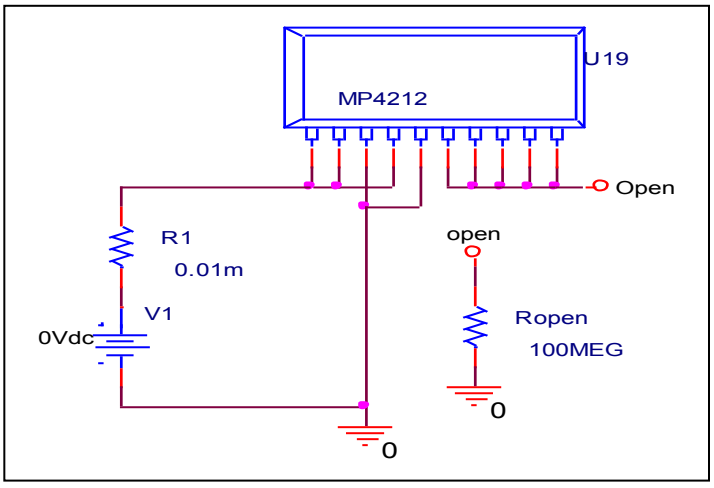


Forward Current Characteristic

Circuit Simulation Result

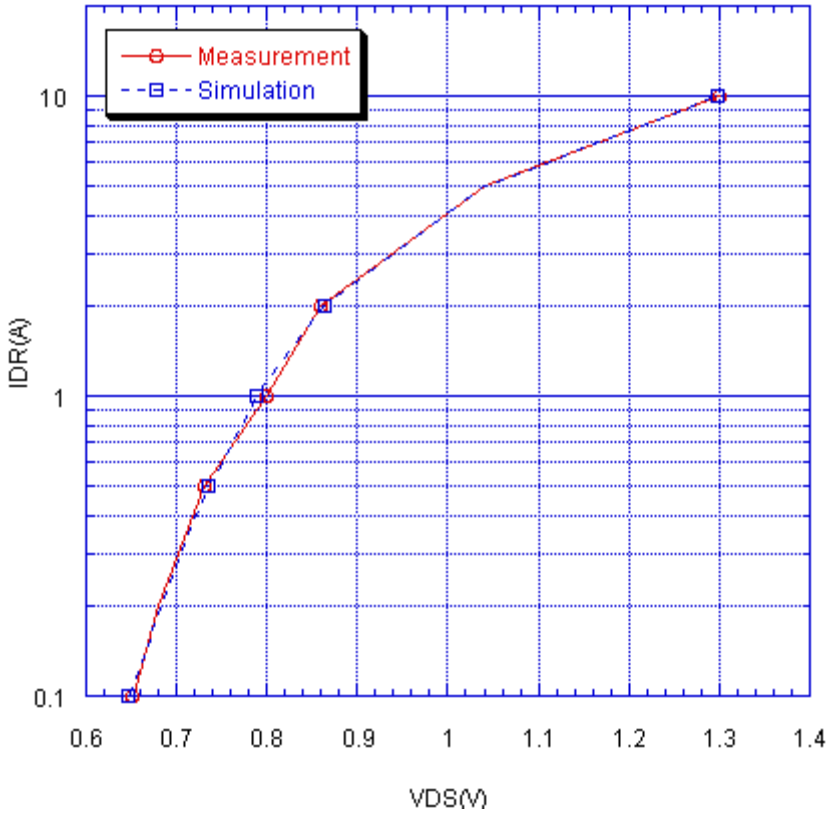


Evaluation Circuit



Comparison Graph

Circuit Simulation Result

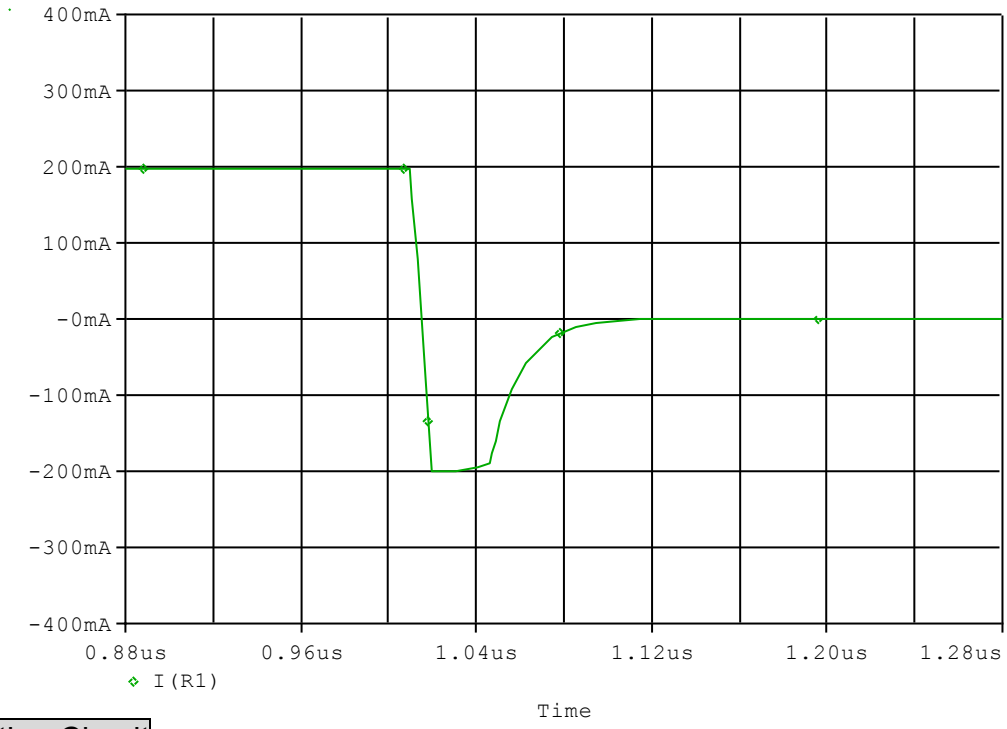


Simulation Result

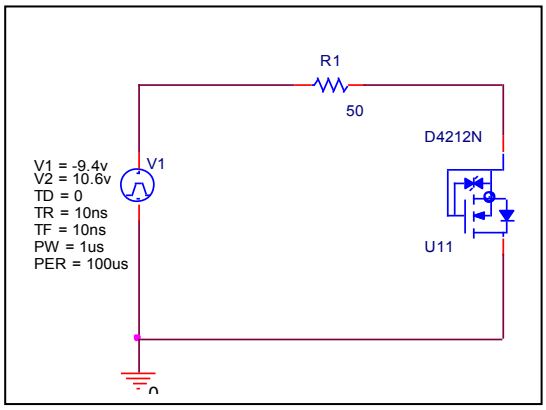
IDR(A)	VSD(V) Measurement	VSD(V) Simulation	%Error
0.100	0.650	0.647	-0.462
0.200	0.680	0.682	0.294
0.500	0.730	0.736	0.822
1.000	0.800	0.789	-1.375
2.000	0.860	0.864	0.465
5.000	1.040	1.041	0.096
10.000	1.300	1.299	-0.077

Reverse Recovery Characteristic

Circuit Simulation Result



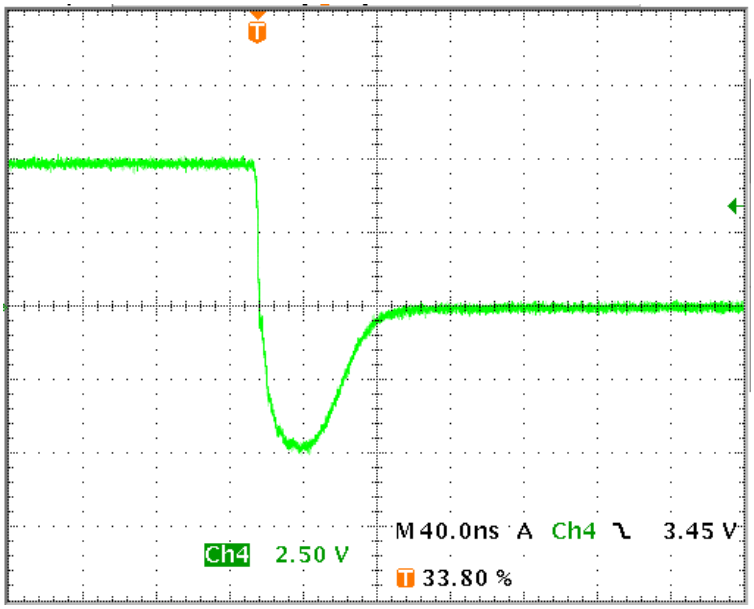
Evaluation Circuit



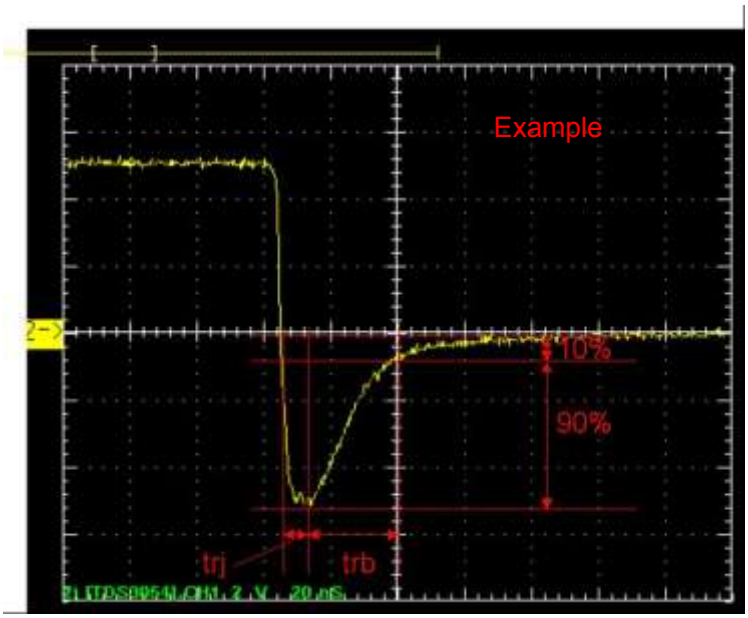
Compare Measurement vs. Simulation

	Measurement		Simulation		Error (%)
trj	**22.400**	**ns**	**22.530**	**ns**	**0.580**
trb	**40.000**	**ns**	**40.183**	**ns**	**0.458**
trr	**62.400**	**ns**	**62.713**	**ns**	**0.502**

Reverse Recovery Characteristic Reference



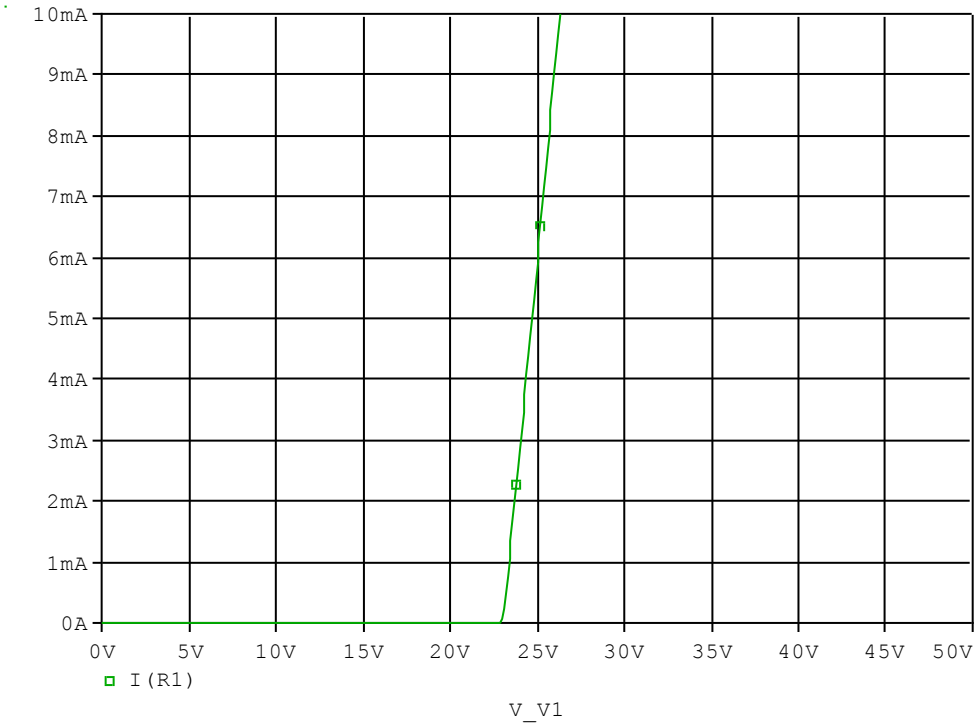
Trj=22.0(ns)
Trb=40.0(ns)
Conditions:Ifwd=Irev=0.2(A),Rl=50



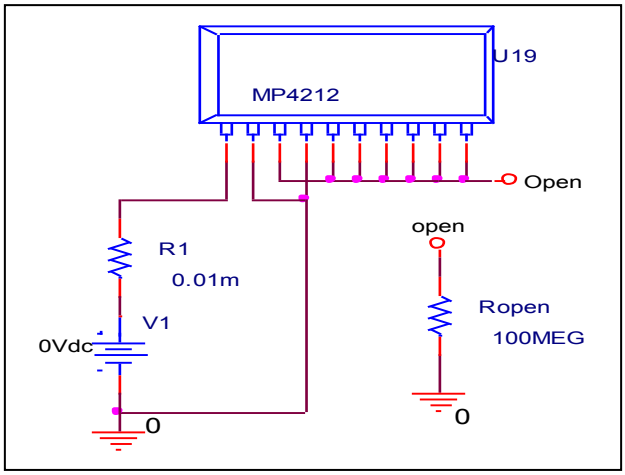
Relation between trj and trb

Zener Voltage Characteristic

Circuit Simulation Result



Evaluation Circuit



Zener Voltage Characteristic Reference