

Device Modeling Report

COMPONENTS: Power MOSFET (Professional)
PART NUMBER: TPC8406-H
MANUFACTURER: TOSHIBA
Body Diode (Professional) / ESD Protection Diode
Remark: Silicon N&P Channel MOS Type



Bee Technologies Inc.

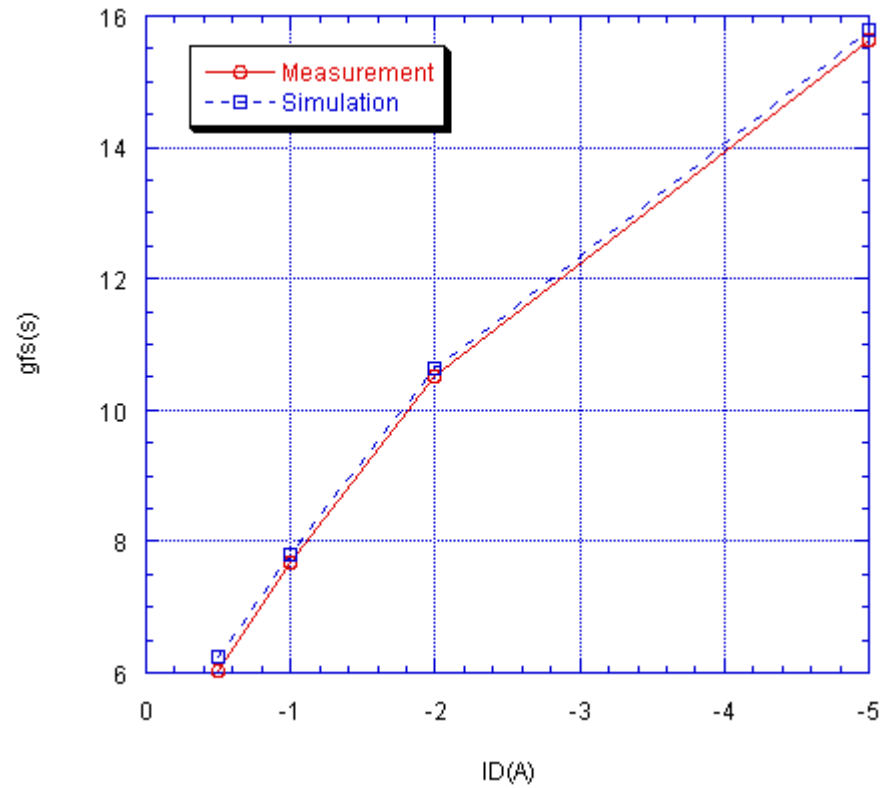
MOSFET MODEL

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	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

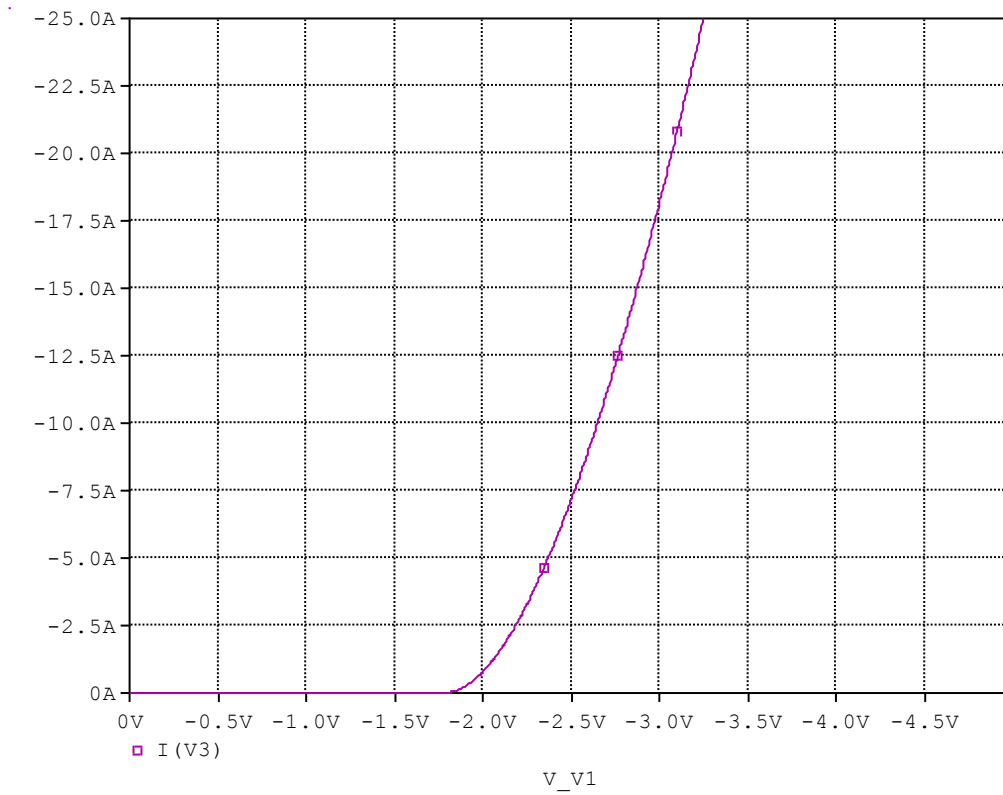


Comparison table

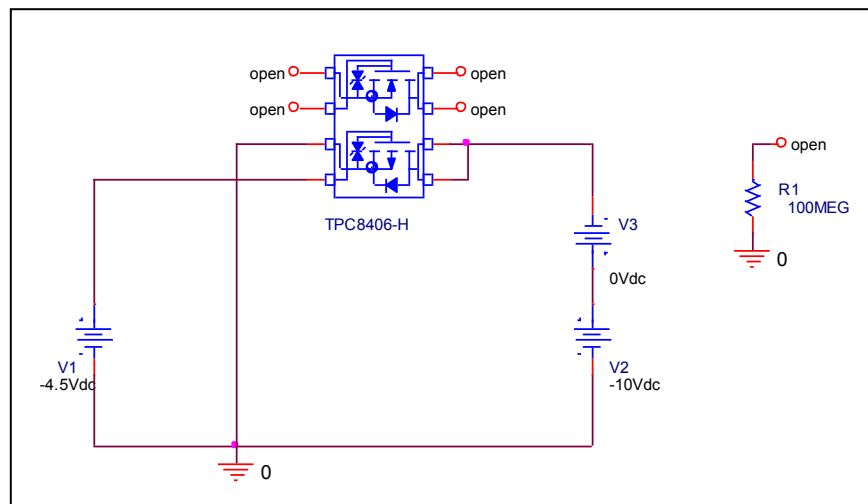
Id(A)	gfs		Error(%)
	Measurement	Simulation	
-0.500	6.024	6.250	3.752
-1.000	7.692	7.813	1.563
-2.000	10.526	10.638	1.067
-5.000	15.625	15.773	0.947

V_{gs}-I_d Characteristic

Circuit Simulation result

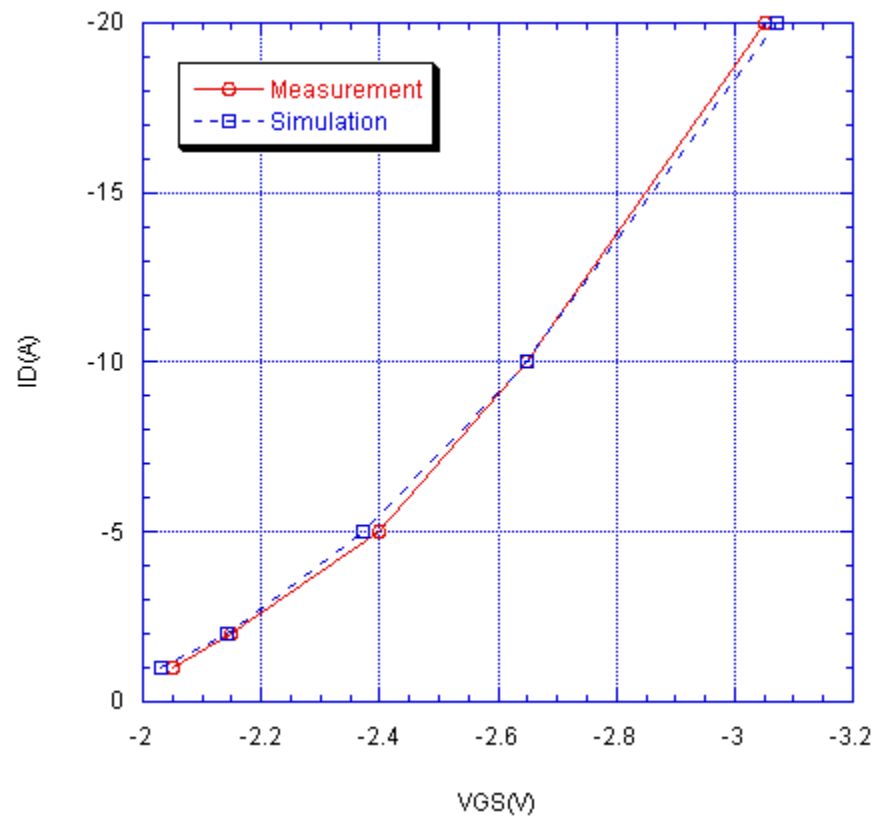


Evaluation circuit



Comparison Graph

Circuit Simulation Result

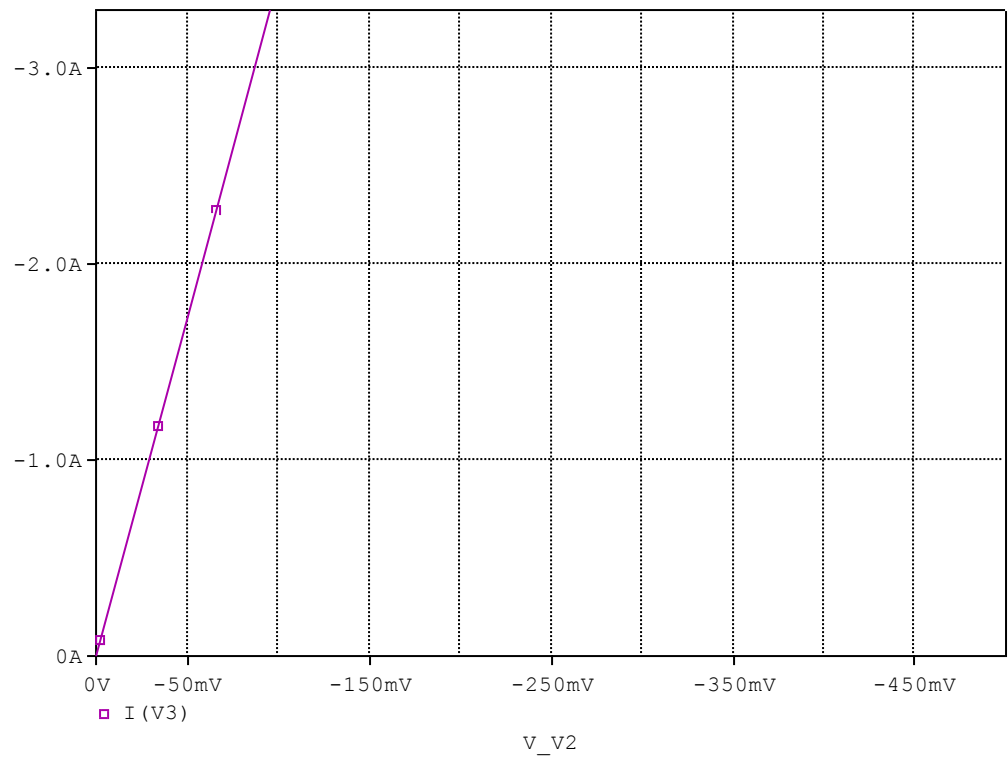


Simulation Result

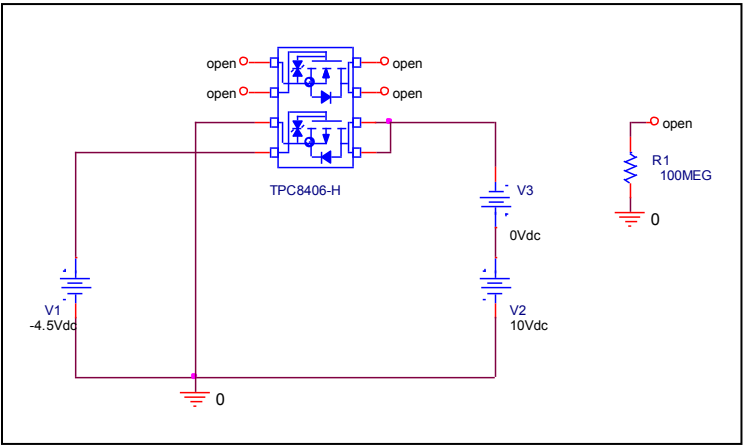
I_D (A)	V_{GS} (V)		Error (%)
	Measurement	Simulation	
-1.000	-2.050	-2.030	-0.985
-2.000	-2.150	-2.141	-0.428
-5.000	-2.400	-2.372	-1.183
-10.000	-2.650	-2.649	-0.053
-20.000	-3.050	-3.071	0.679

Rds(on) Characteristic

Circuit Simulation result



Evaluation circuit

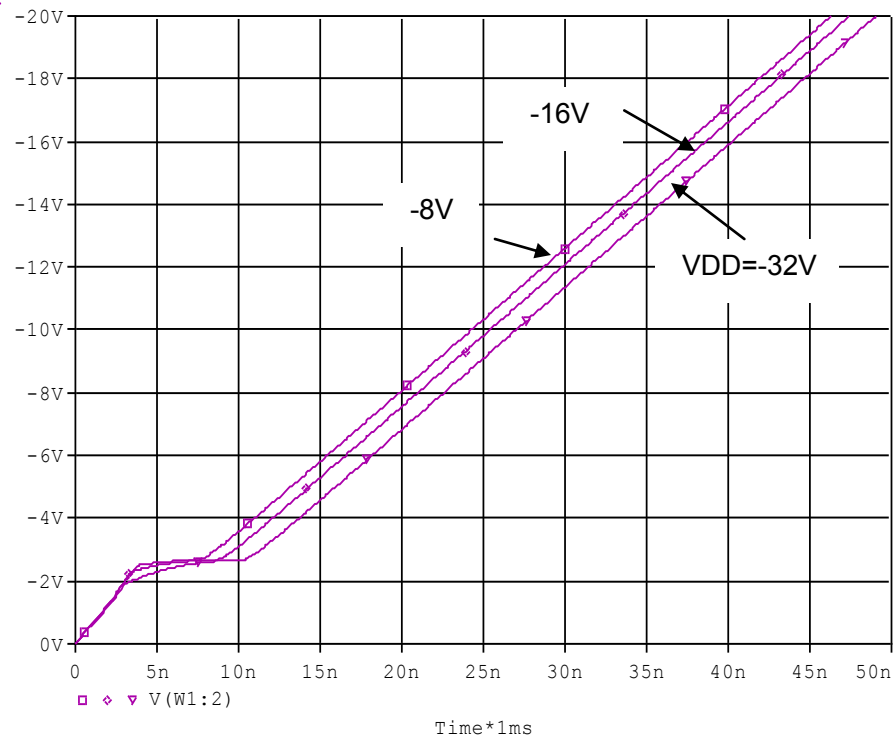


Simulation Result

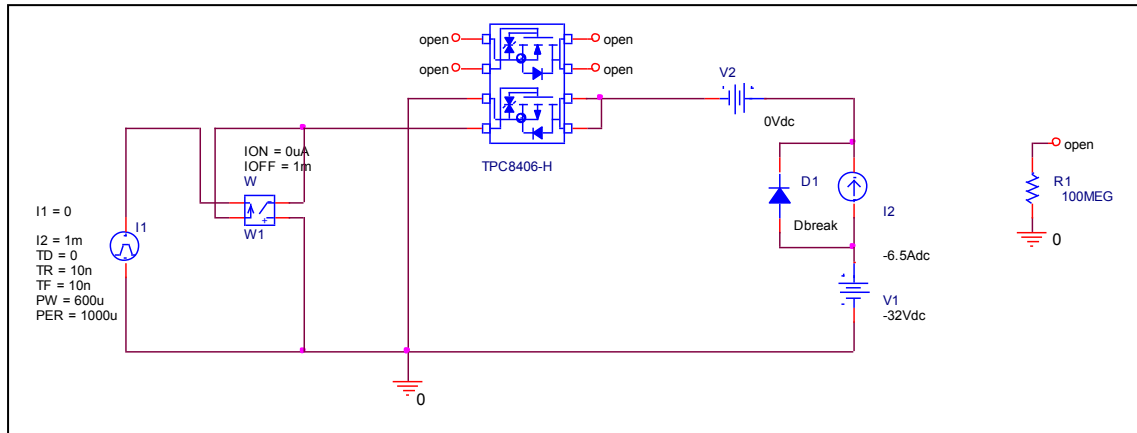
$I_D = -3.3A, V_{GS} = -4.5V$	Measurement		Simulation		Error (%)
$R_{DS(on)}$	29.000	mΩ	29.000	mΩ	0.000

Gate Charge Characteristic

Circuit Simulation result



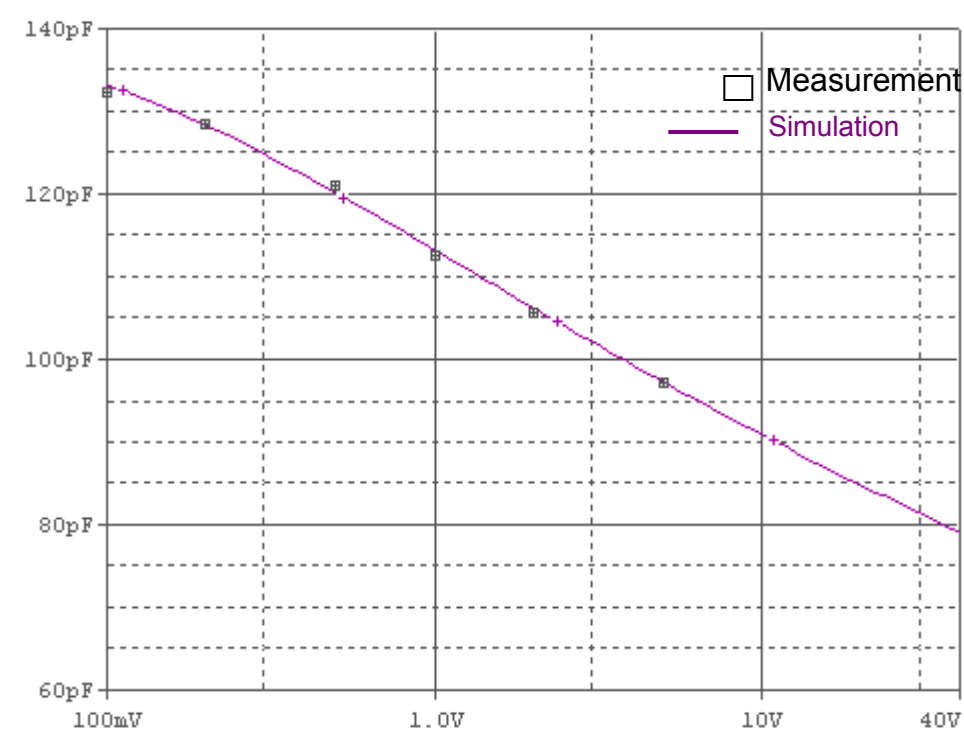
Evaluation circuit



Simulation Result

V _{DD} = -32V, I _D = -6.5A, V _{GS} = -10V	Measurement		Simulation		Error (%)
Q _{gs}	3.200	nC	3.261	nC	1.903
Q _{gd}	8.100	nC	7.935	nC	-2.040
Q _g	27.000	nC	27.065	nC	0.241

Capacitance Characteristic

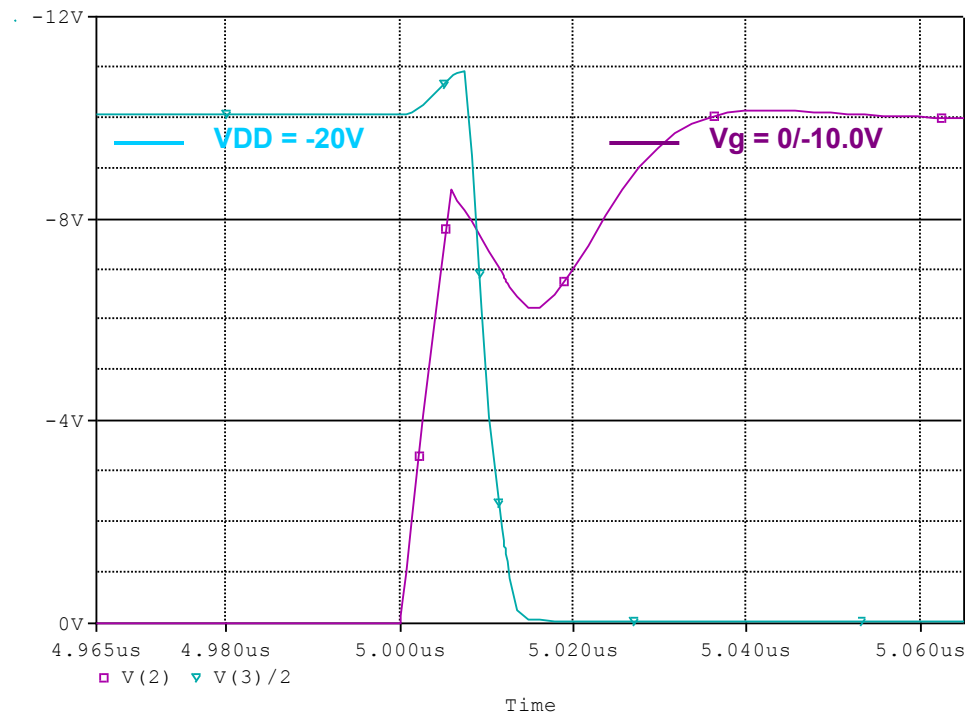


Simulation Result

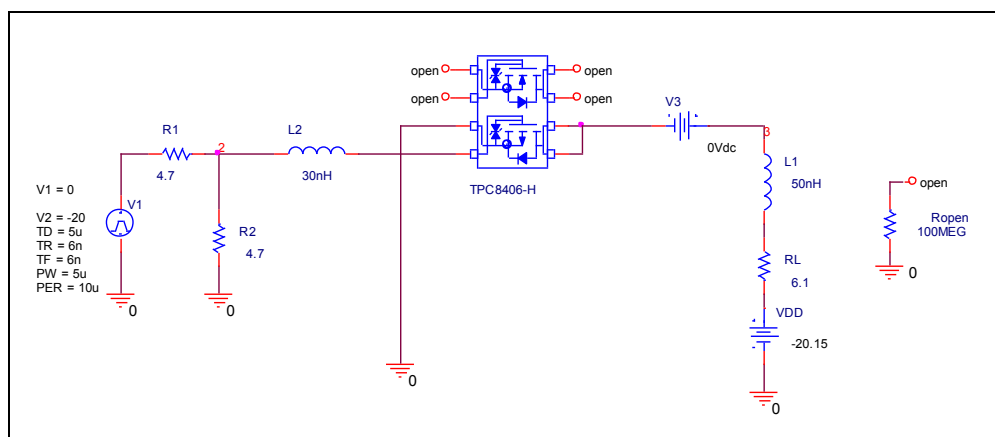
V _{sd} (V)	Cbd(pF)		Error(%)
	Measurement	Simulation	
0.100	132.620	132.900	0.211
0.200	128.800	127.500	-1.009
0.500	121.200	120.500	-0.578
1.000	112.750	113.500	0.665
2.000	105.950	106.300	0.330
5.000	97.450	96.000	-1.488
0.100	132.620	132.900	0.211

Switching Time Characteristic

Circuit Simulation result



Evaluation circuit

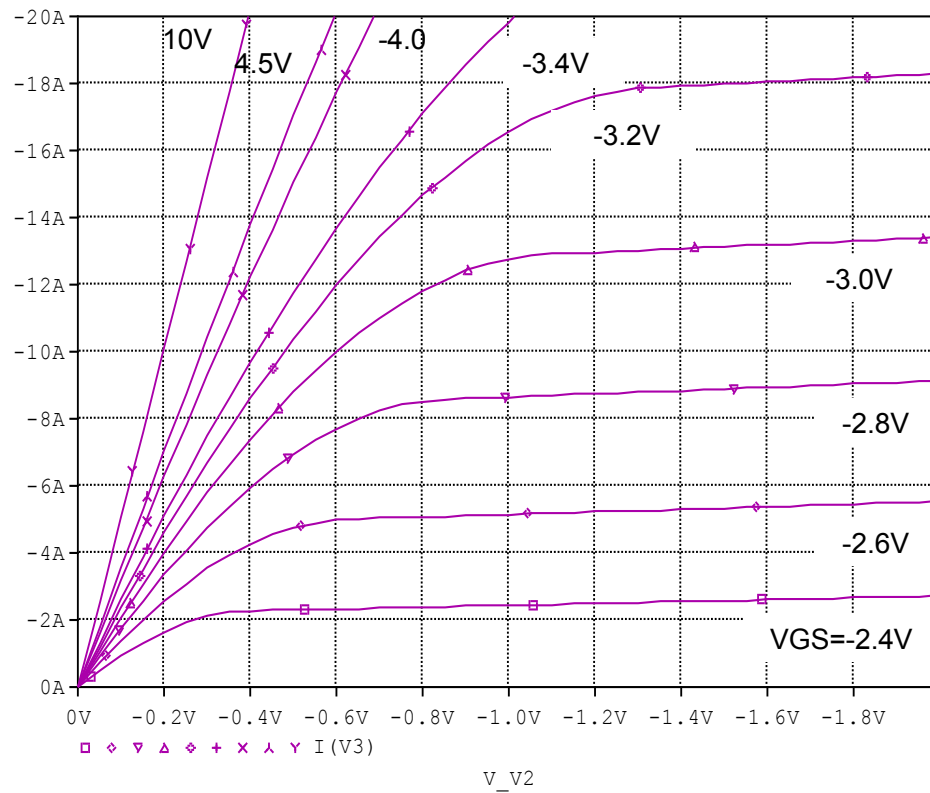


Simulation Result

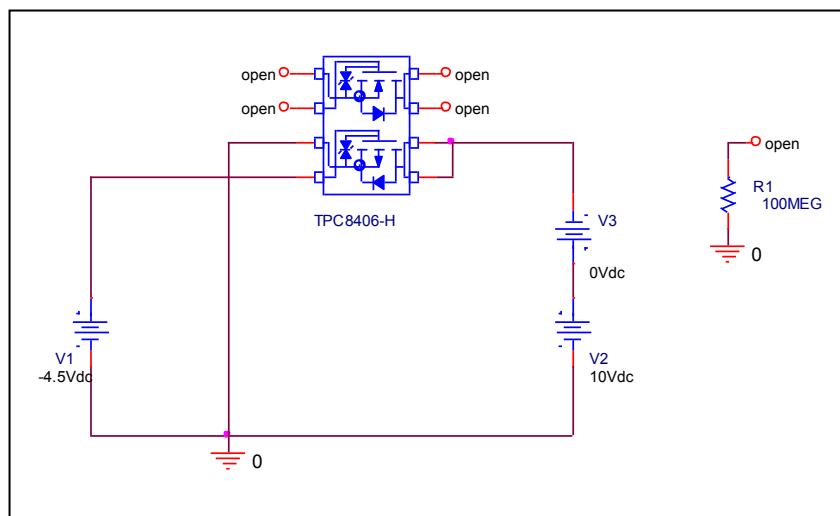
$I_D = -3.3\text{ A}$, $V_{DD} = -20V$ $V_{GS} = 0/-10V$	Measurement		Simulation		Error(%)
	ton	ns	11.985	ns	
					-0.125

Output Characteristic

Circuit Simulation result

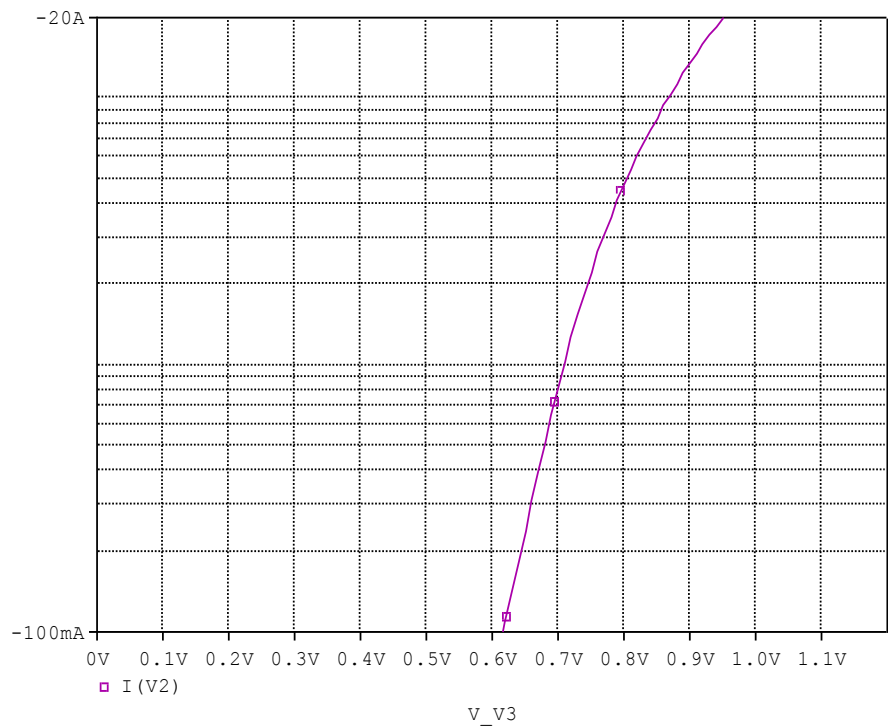


Evaluation circuit

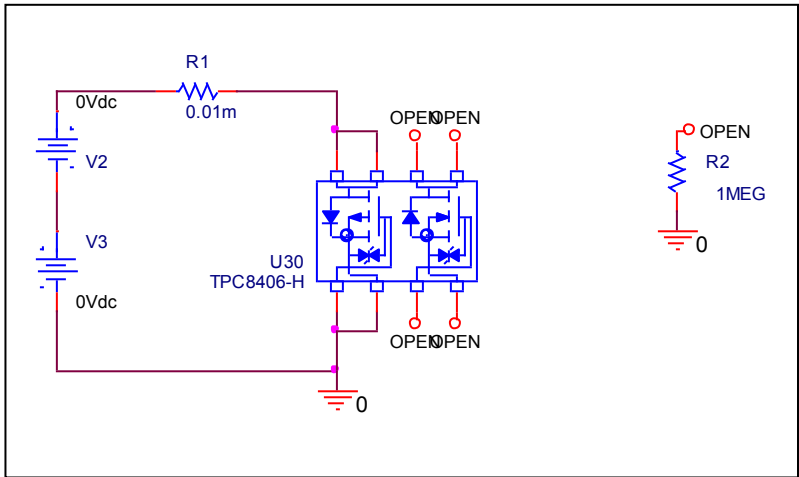


Forward Current Characteristic

Circuit Simulation Result

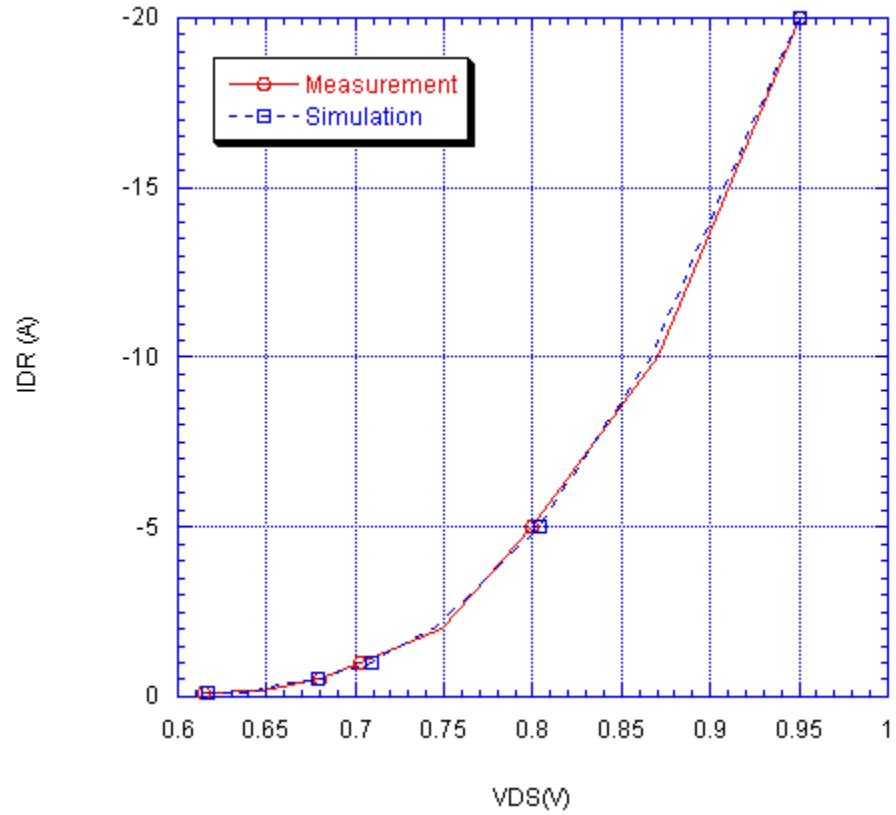


Evaluation Circuit



Comparison Graph

Circuit Simulation Result

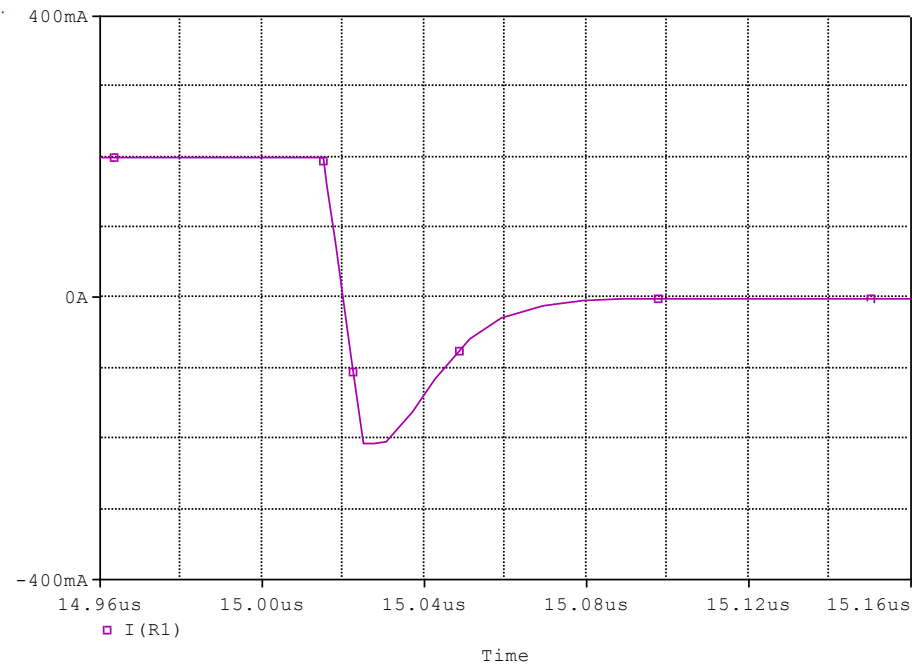


Simulation Result

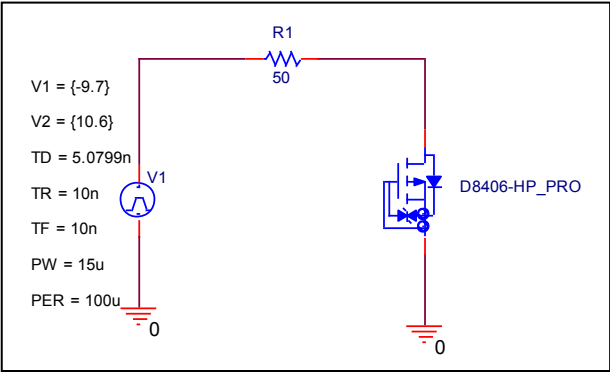
Ifwd(A)	Vfwd(V) Measurement	Vfwd(V) Simulation	%Error
-0.100	0.615	0.617	0.325
-0.200	0.647	0.643	-0.618
-0.500	0.680	0.679	-0.147
-1.000	0.703	0.709	0.853
-2.000	0.749	0.744	-0.668
-5.000	0.800	0.804	0.500
-10.000	0.870	0.867	-0.345
-20.000	0.950	0.951	0.105

Reverse Recovery Characteristic

Circuit Simulation Result



Evaluation Circuit

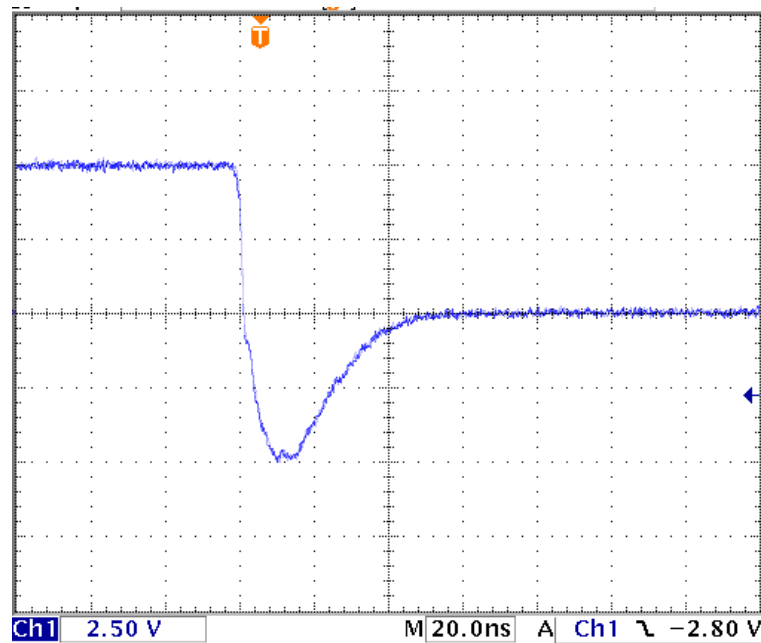


Compare Measurement vs. Simulation

	Measurement		Simulation		Error (%)
trj	8.800	ns	42.800	ns	0.011
trb	34.000	ns	42.800	ns	-0.062
trr	42.800	ns	42.800	ns	-0.047

Reverse Recovery Characteristic

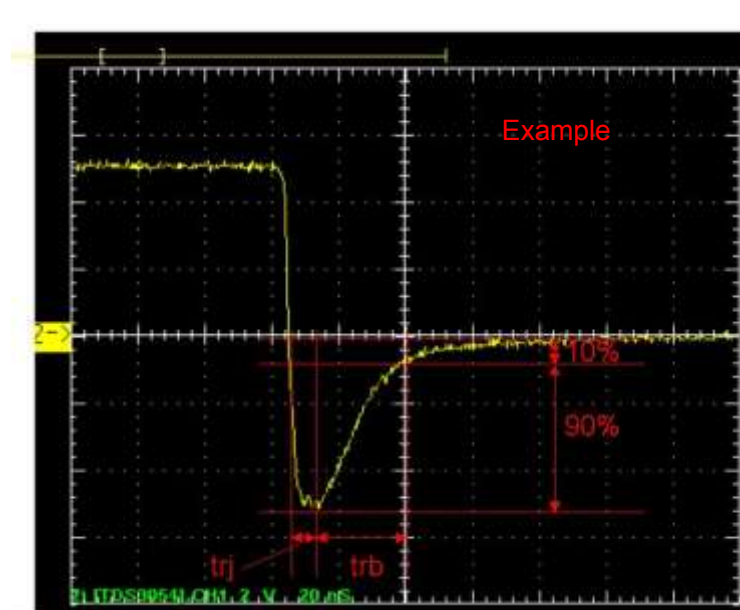
Reference



$Trj=8.8(ns)$

$Trb=34.0(ns)$

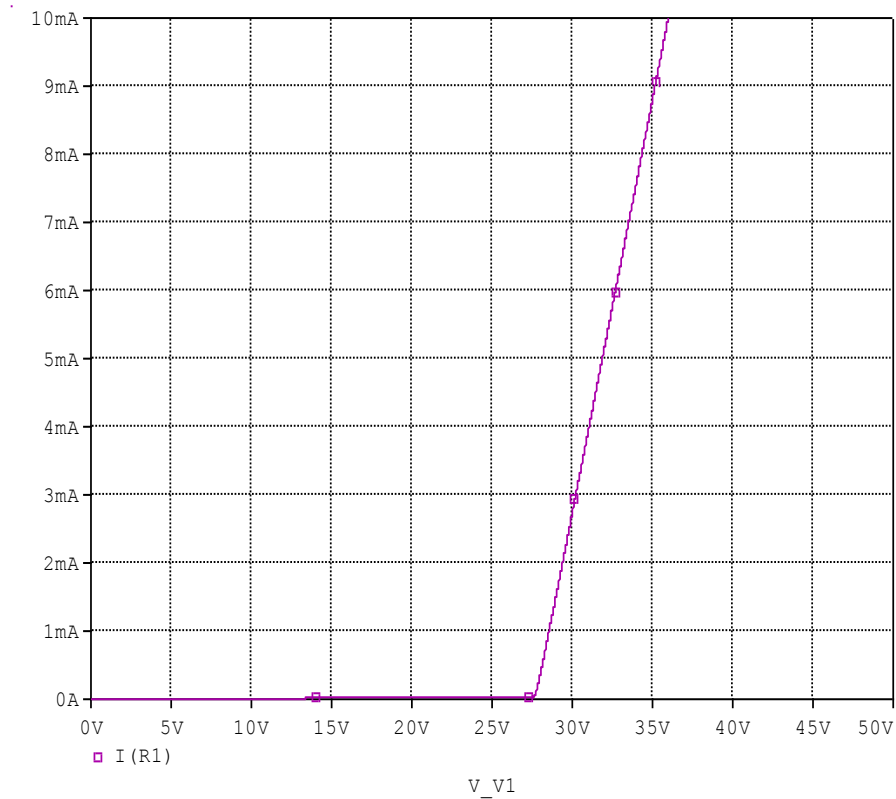
Conditions: $I_{fwd}=I_{rev}=0.2(A)$, $R_I=50$



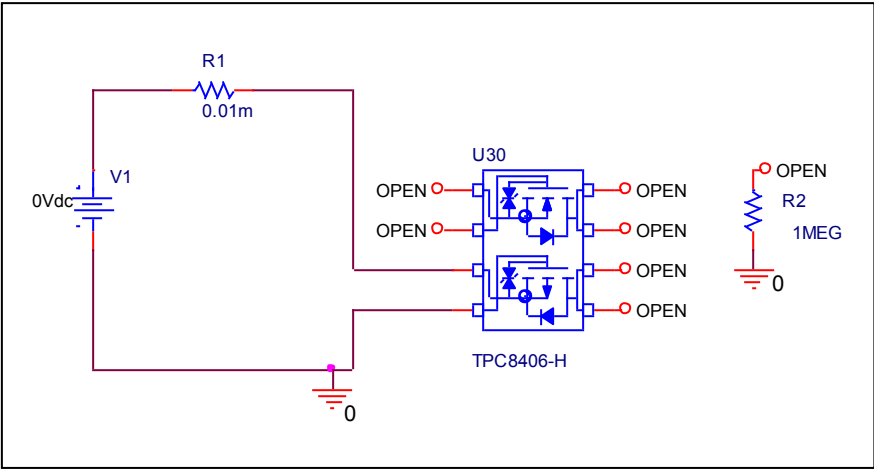
Relation between trj and trb

Zener Voltage Characteristic

Circuit Simulation Result

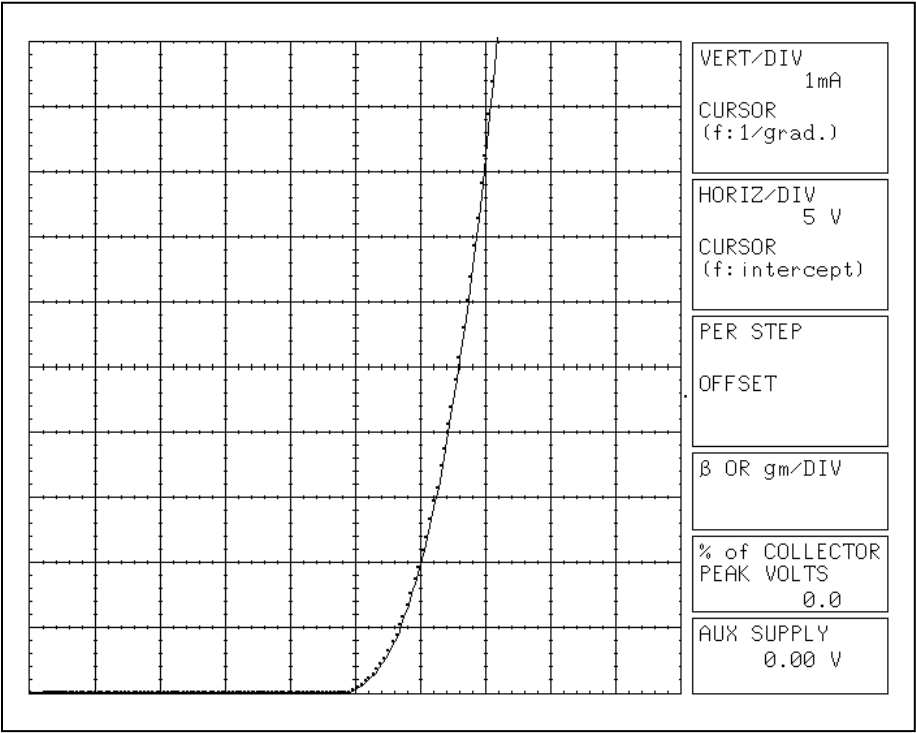


Evaluation Circuit



Zener Voltage Characteristic

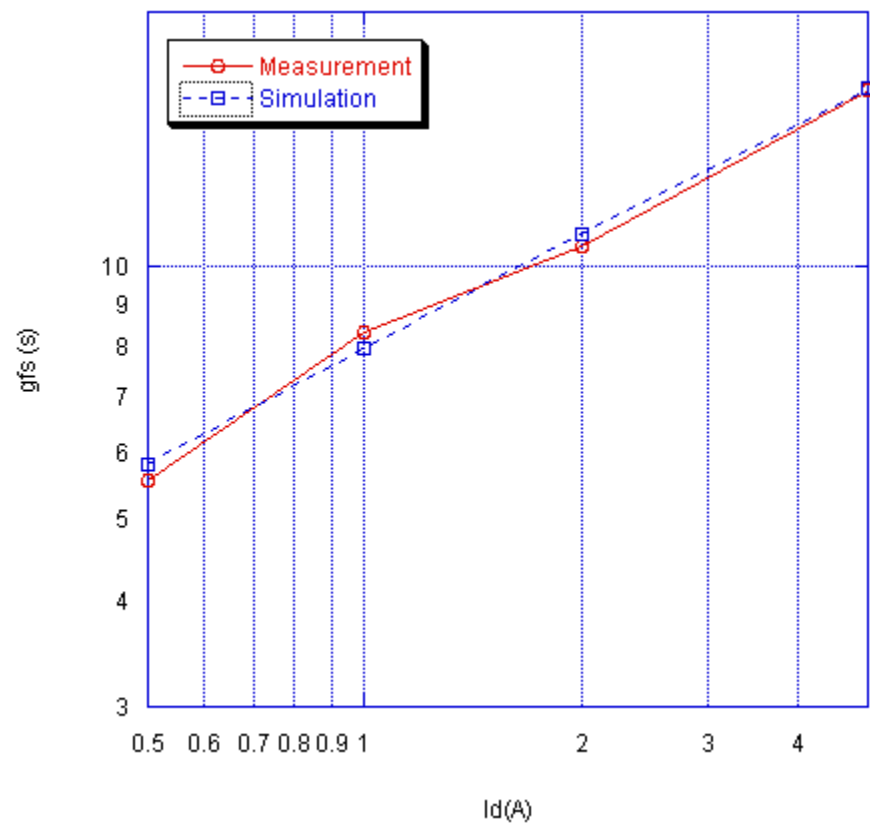
Reference



N-Channel Model

Transconductance Characteristic

Circuit Simulation Result

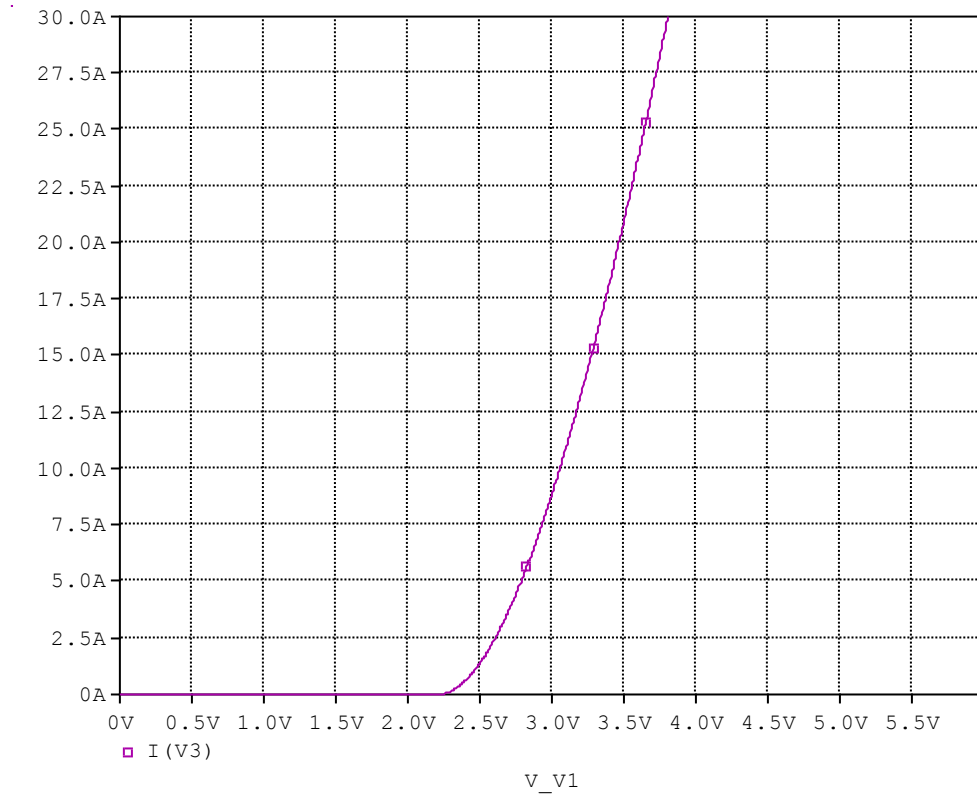


Comparison table

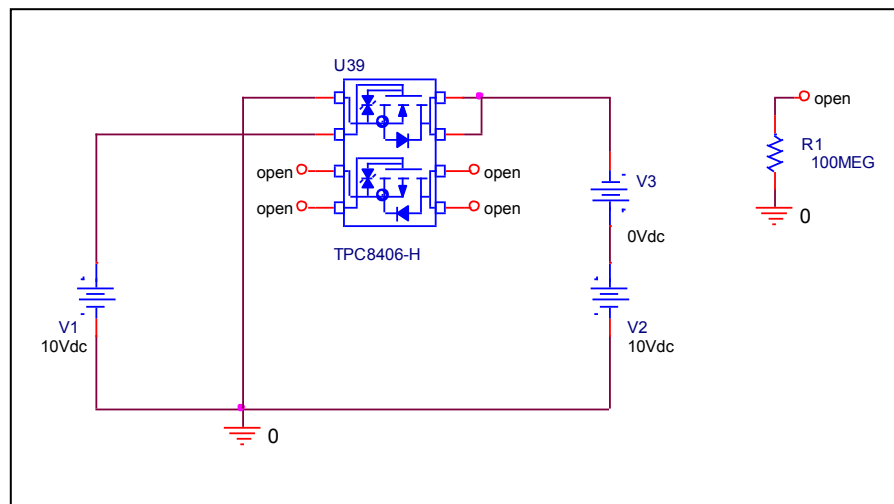
Id(A)	gfs		Error(%)
	Measurement	Simulation	
0.500	5.556	5.814	4.643
1.000	8.333	8.000	-3.996
2.000	10.530	10.929	3.788
5.000	16.129	16.234	0.649

V_{gs}-I_d Characteristic

Circuit Simulation result

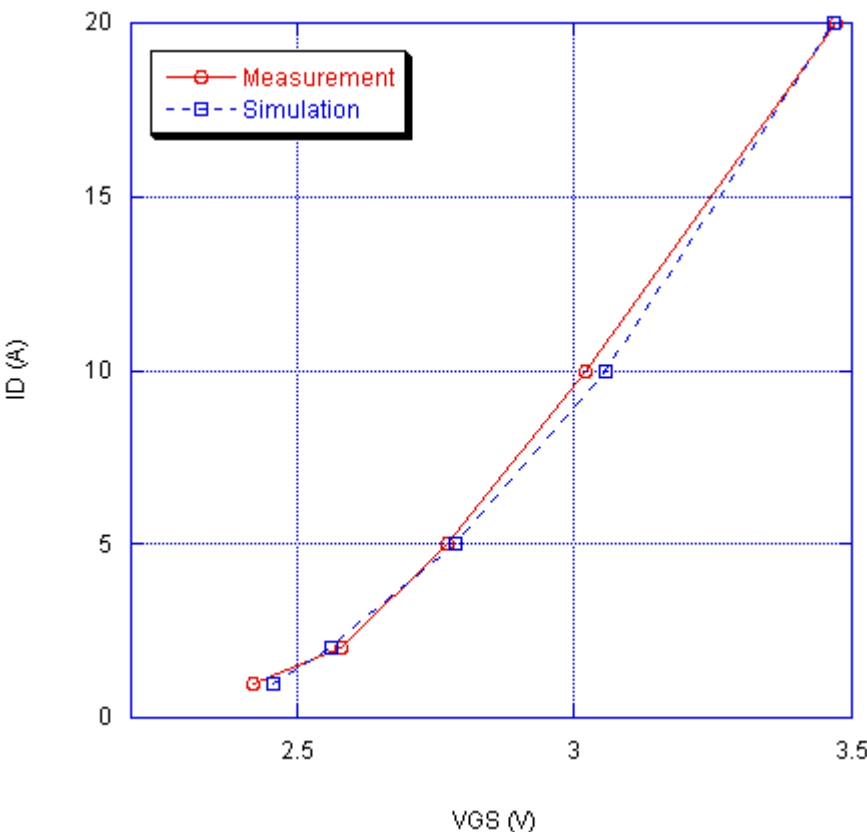


Evaluation circuit



Comparison Graph

Circuit Simulation Result

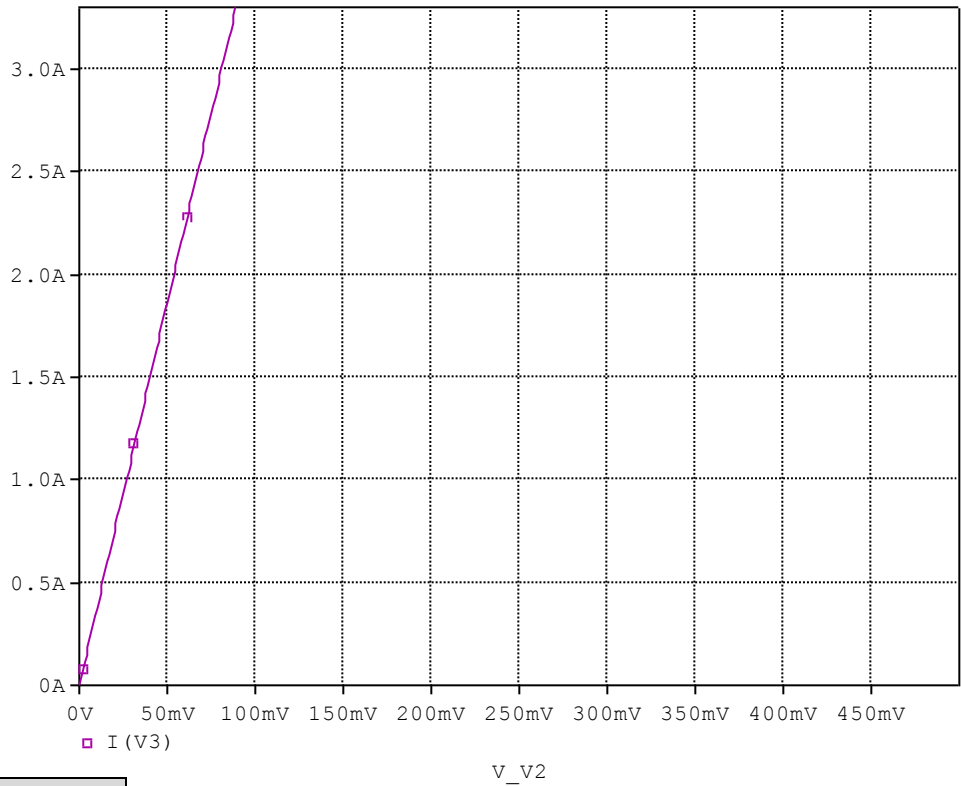


Simulation Result

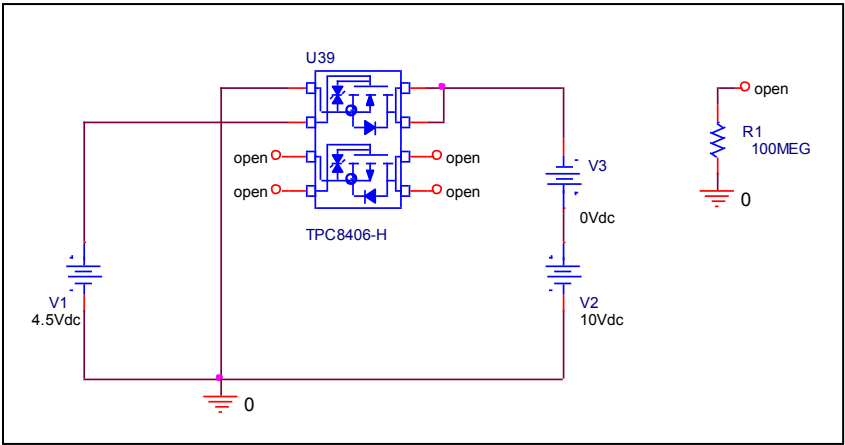
I_D (A)	V_{GS} (V)		Error (%)
	Measurement	Simulation	
1.000	2.420	2.455	1.426
2.000	2.580	2.562	-0.694
5.000	2.770	2.786	0.585
10.000	3.020	3.055	1.169
20.000	3.470	3.469	-0.032

Rds(on) Characteristic

Circuit Simulation result



Evaluation circuit

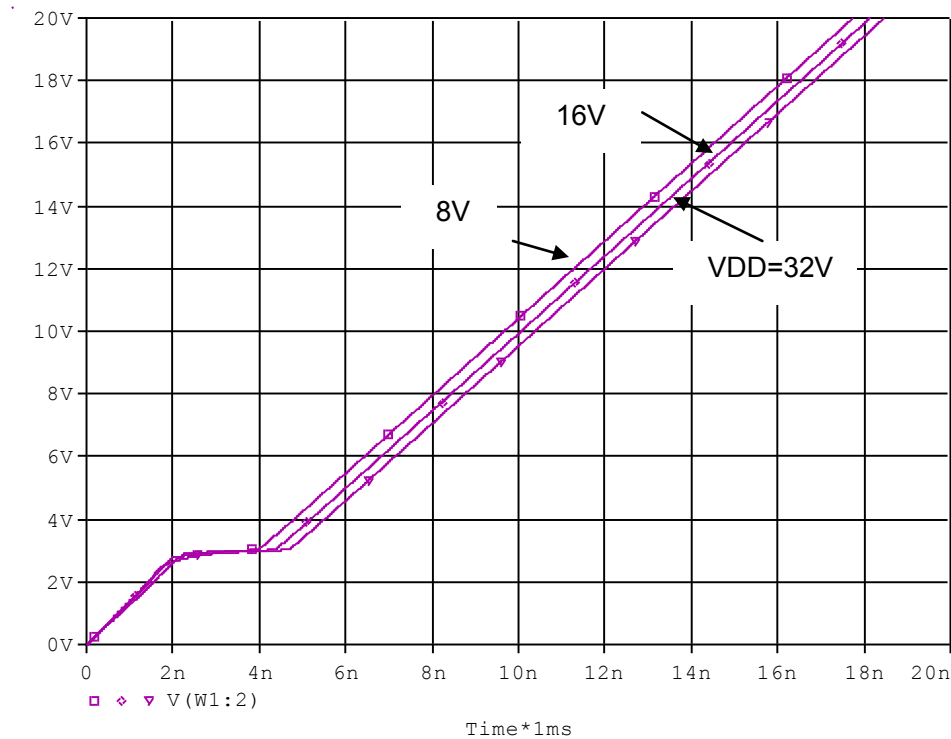


Simulation Result

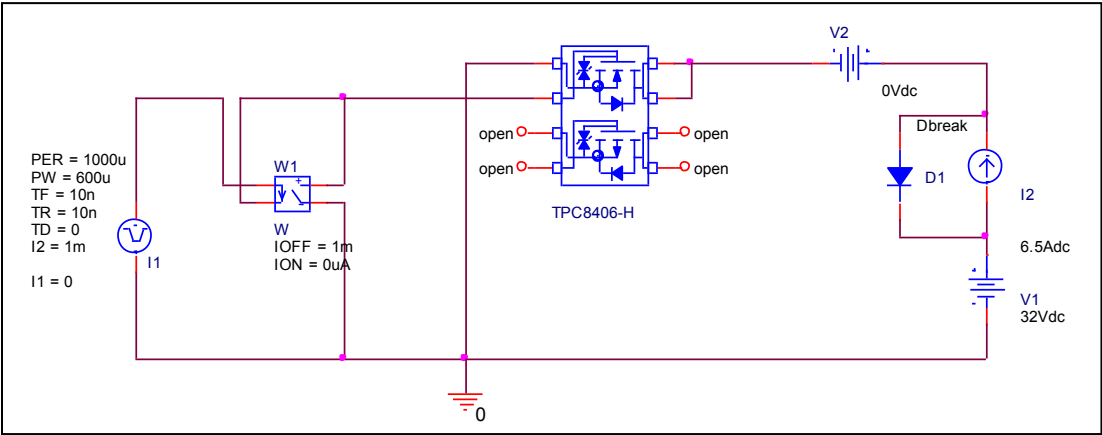
$I_D=3.3A, V_{GS}=4.5V$	Measurement		Simulation		Error (%)
$R_{DS(on)}$	27.000	mΩ	27.000	mΩ	0.000

Gate Charge Characteristic

Circuit Simulation result



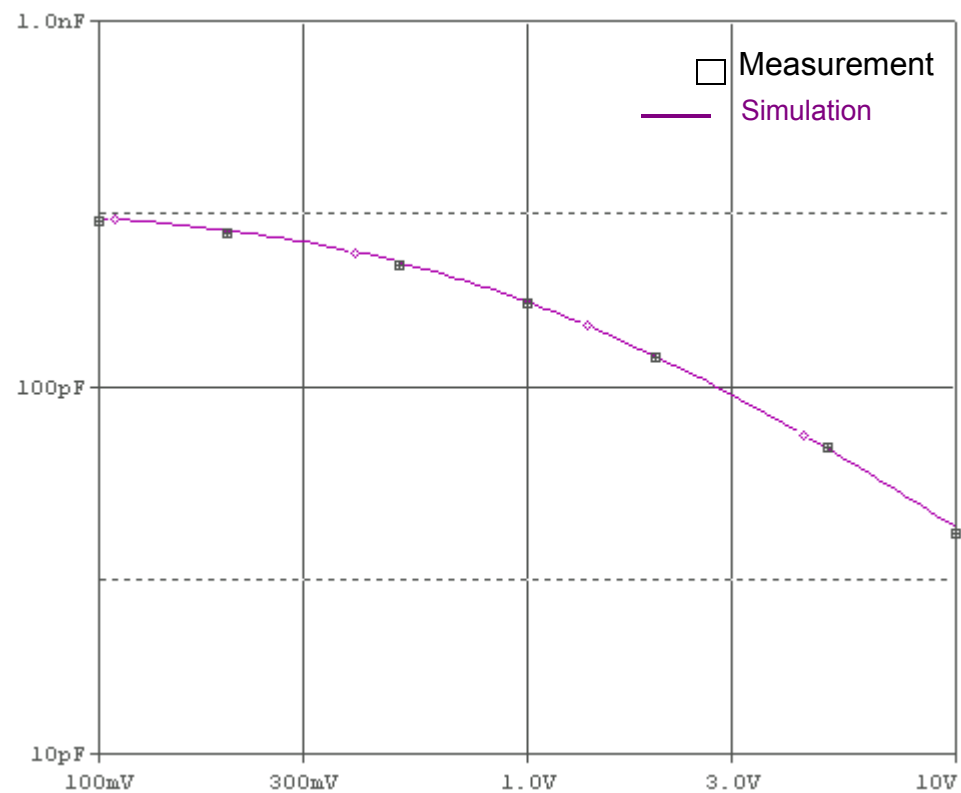
Evaluation circuit



Simulation Result

$V_{DD}=32V, I_D=6.5A$ $V_{GS}=10V$	Measurement		Simulation		Error (%)
Qgs	2.100	nC	2.117	nC	0.810
Qgd	2.700	nC	2.703	nC	0.111
Qg	11.000	nC	11.036	nC	0.327

Capacitance Characteristic

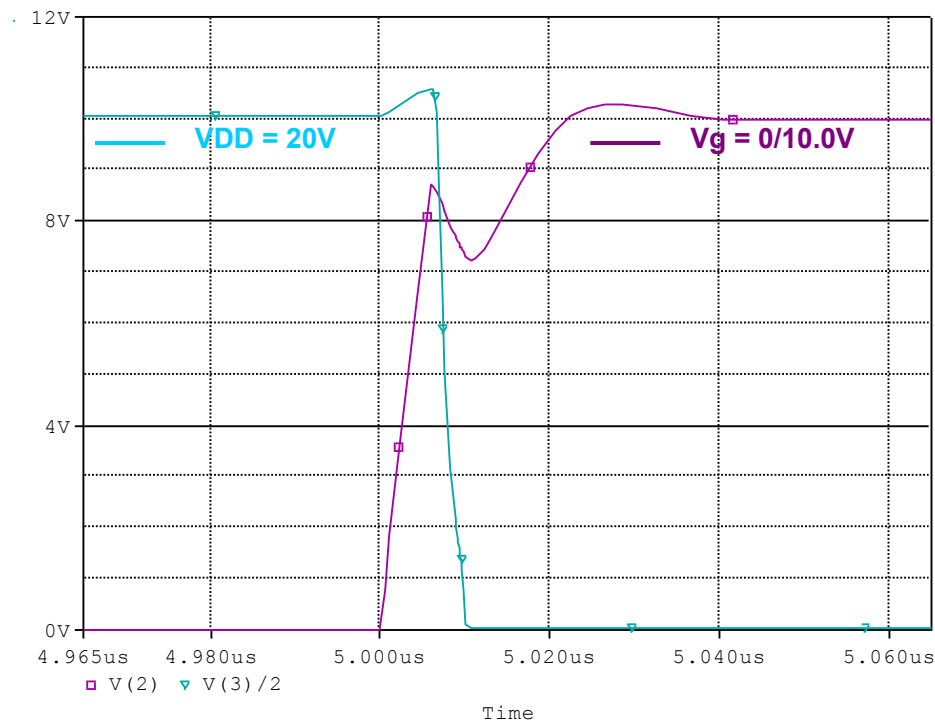


Simulation Result

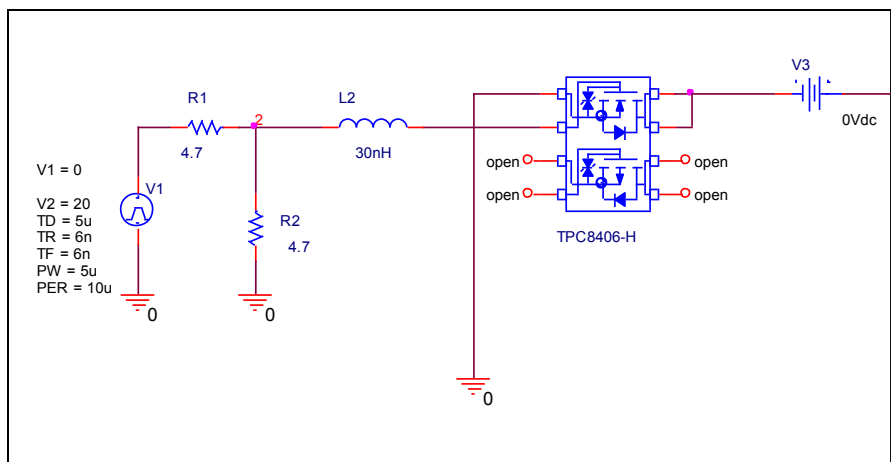
V _{DS} (V)	Cbd(pF)		Error(%)
	Measurement	Simulation	
0.100	288.8	290.000	0.416
0.300	267.75	268.000	0.093
0.600	217.5	220.000	1.149
1.000	172.5	172.000	-0.290
3.000	122.3	121.200	-0.899
6.000	69.48	68.000	-2.130
10.000	40.59	41.490	2.217

Switching Time Characteristic

Circuit Simulation result



Evaluation circuit

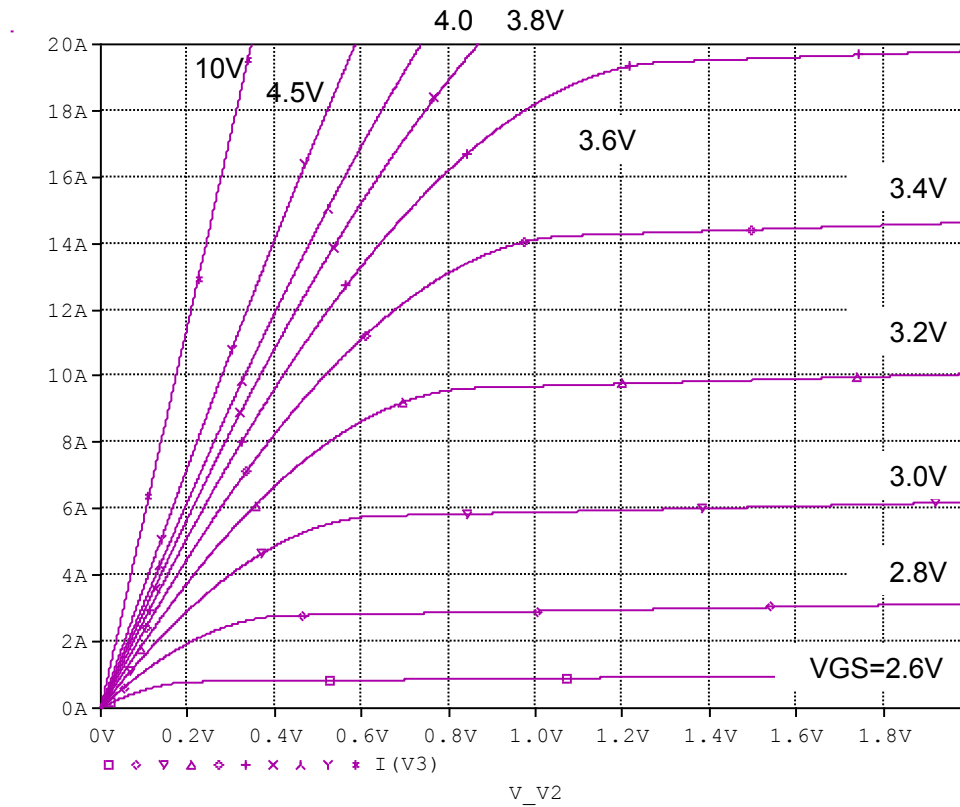


Simulation Result

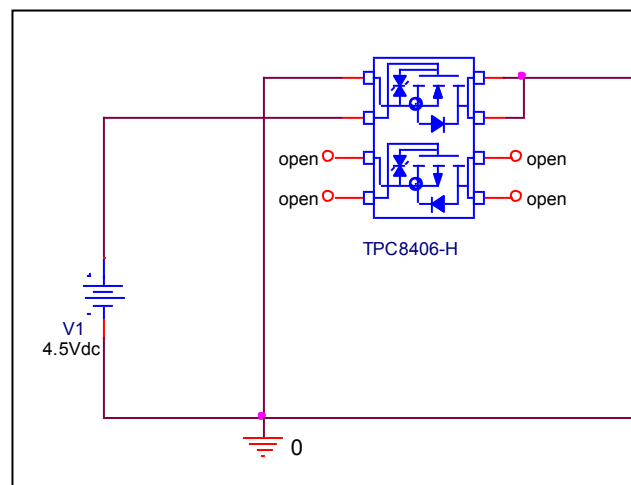
$I_D=3.3\text{ A}$, $V_{DD}=20\text{ V}$ $V_{GS}=0/10\text{ V}$	Measurement		Simulation		Error(%)
	ton	9.000 ns	9.039 ns	ns	

Output Characteristic

Circuit Simulation result

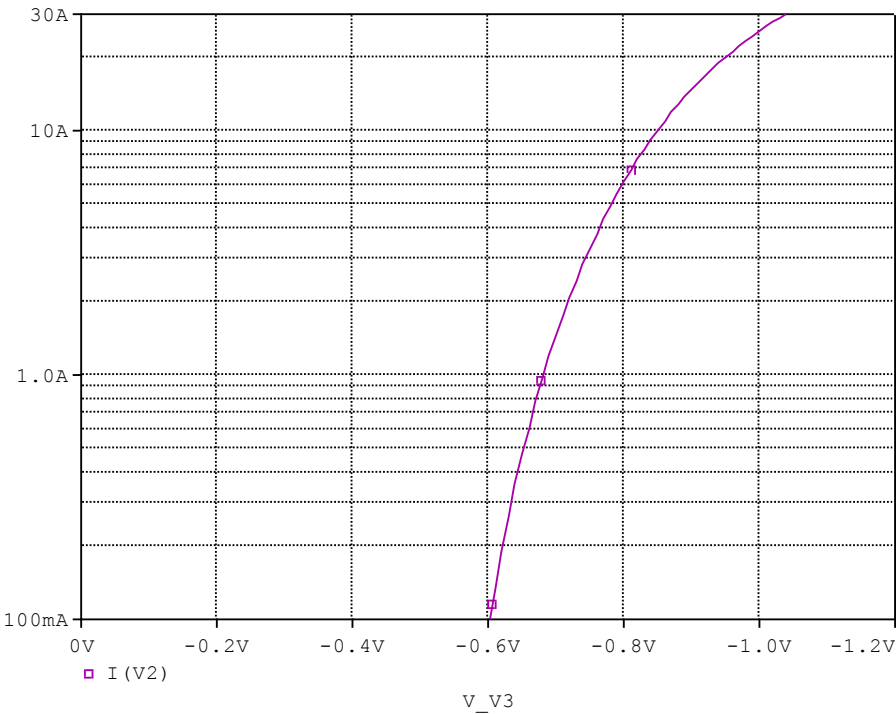


Evaluation circuit

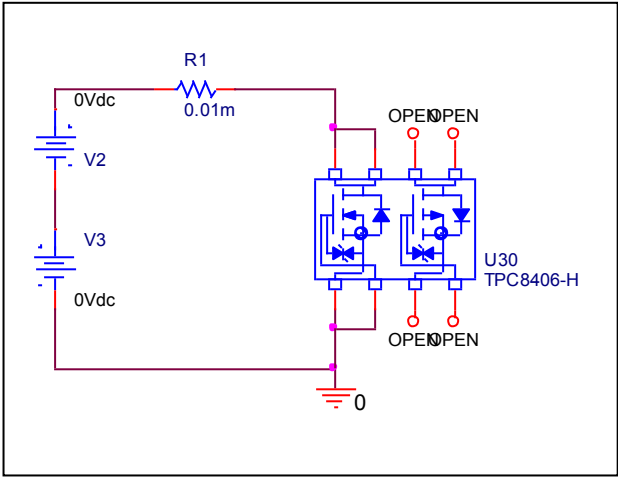


Forward Current Characteristic

Circuit Simulation Result

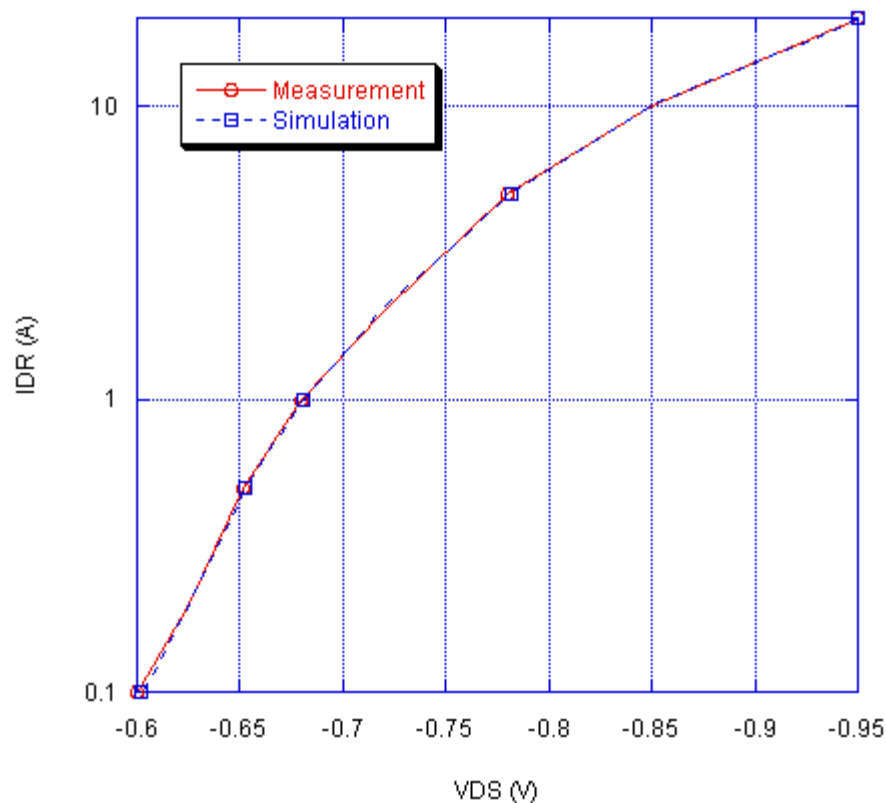


Evaluation Circuit



Comparison Graph

Circuit Simulation Result

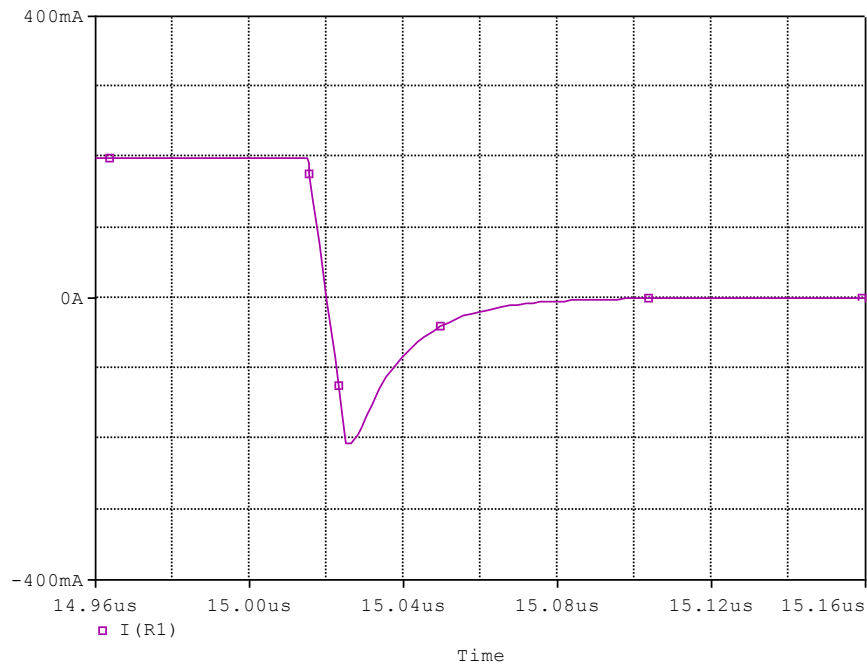


Simulation Result

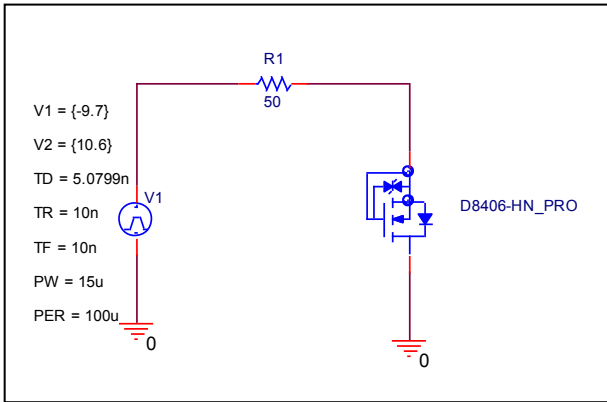
lfwd(A)	Vfwd(V) Measurement	Vfwd(V) Simulation	%Error
0.100	-0.600	-0.602	0.275
0.200	-0.625	-0.625	-0.062
0.500	-0.652	-0.652	0.099
1.000	-0.680	-0.681	0.161
2.000	-0.720	-0.718	-0.305
5.000	-0.780	-0.782	0.224
10.000	-0.850	-0.849	-0.073
20.000	-0.950	-0.950	0.000

Reverse Recovery Characteristic

Circuit Simulation Result



Evaluation Circuit

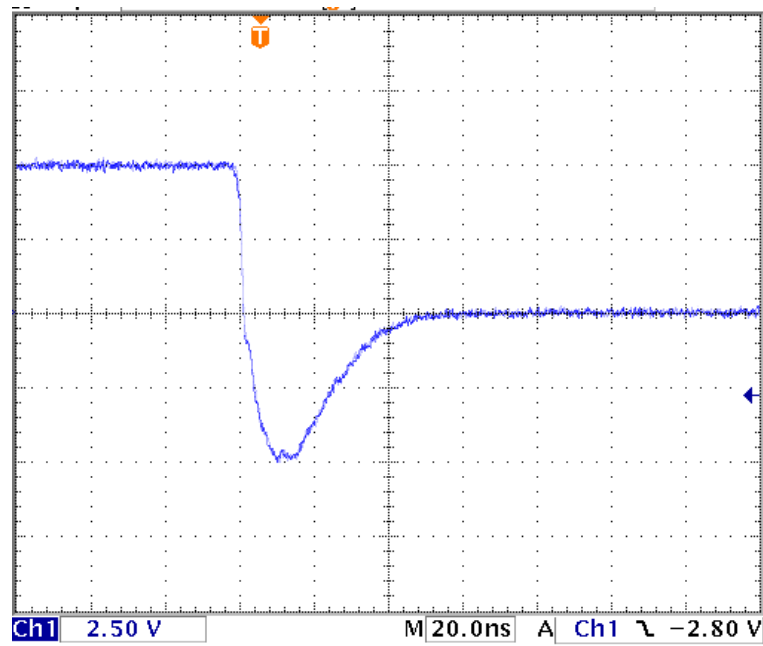


Compare Measurement vs. Simulation

	Measurement		Simulation		Error (%)
trj	7.200	ns	7.237	ns	0.514
trb	32.000	ns	31.591	ns	-1.278
trr	39.200	ns	38.828	ns	-0.949

Reverse Recovery Characteristic

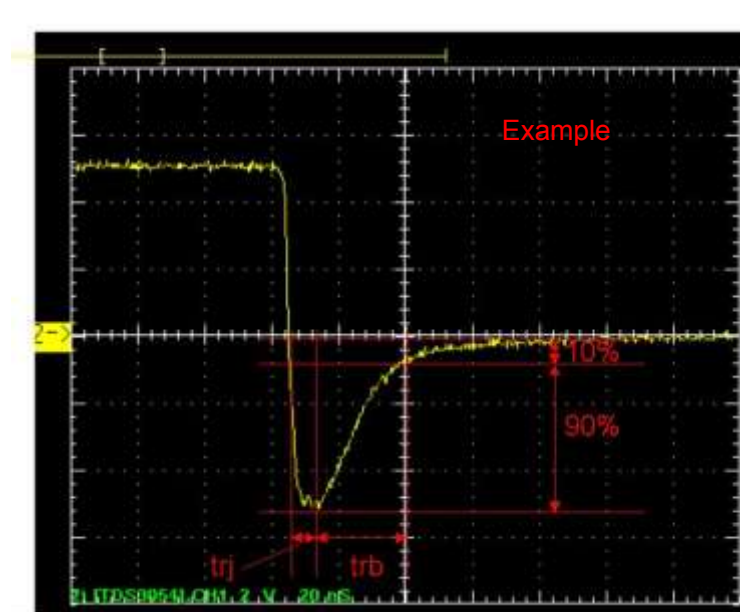
Reference



$Trj=7.2(ns)$

$Trb=32.0(ns)$

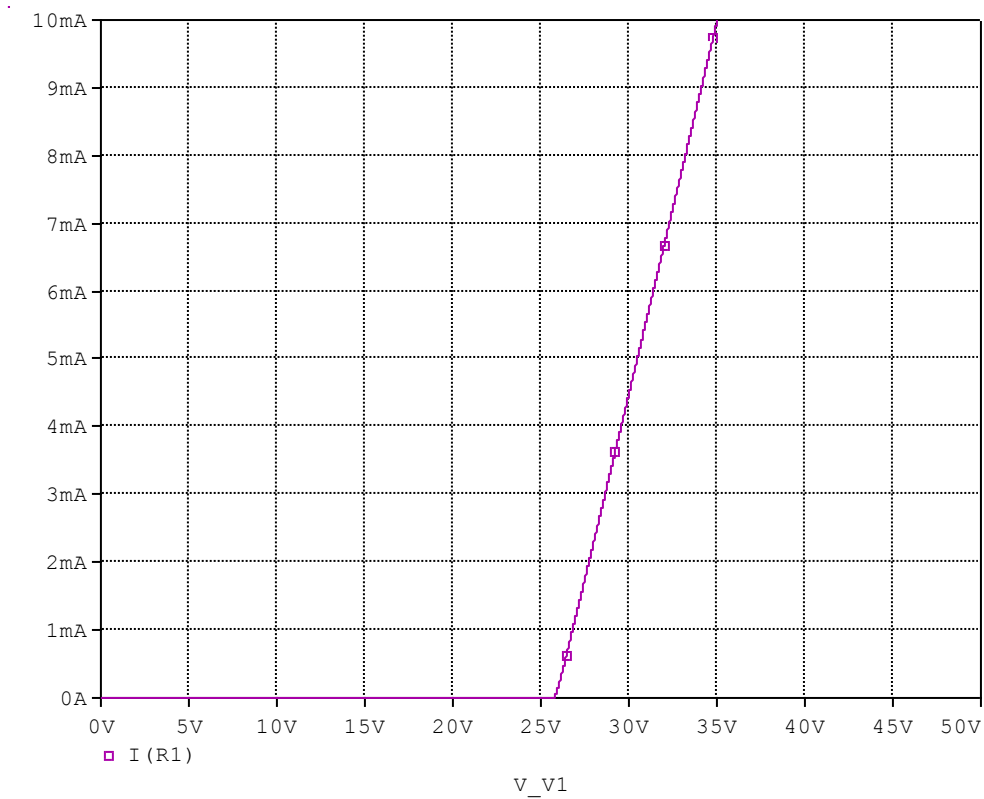
Conditions: $I_{fwd}=I_{rev}=0.2(A)$, $R_I=50$



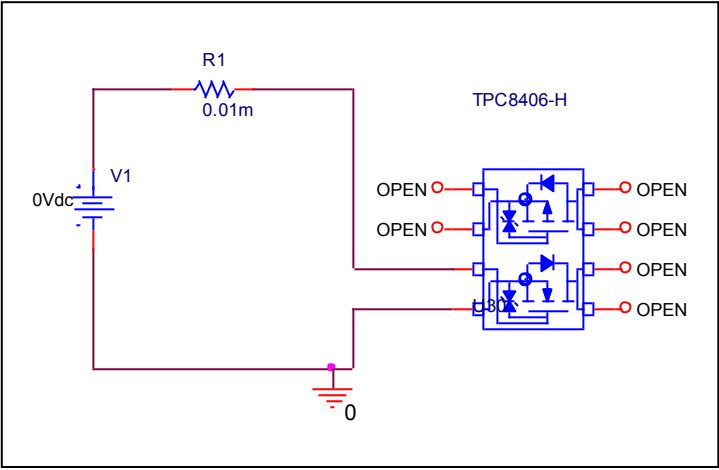
Relation between trj and trb

Zener Voltage Characteristic

Circuit Simulation Result



Evaluation Circuit



Zener Voltage Characteristic

Reference

