# Device Modeling Report

COMPONENTS: Power MOSFET (Model Parameters)
PART NUMBER: 2SJ509
MANUFACTURER: TOSHIBA
Body Diode (Model Parameters) / ESD Protection Diode

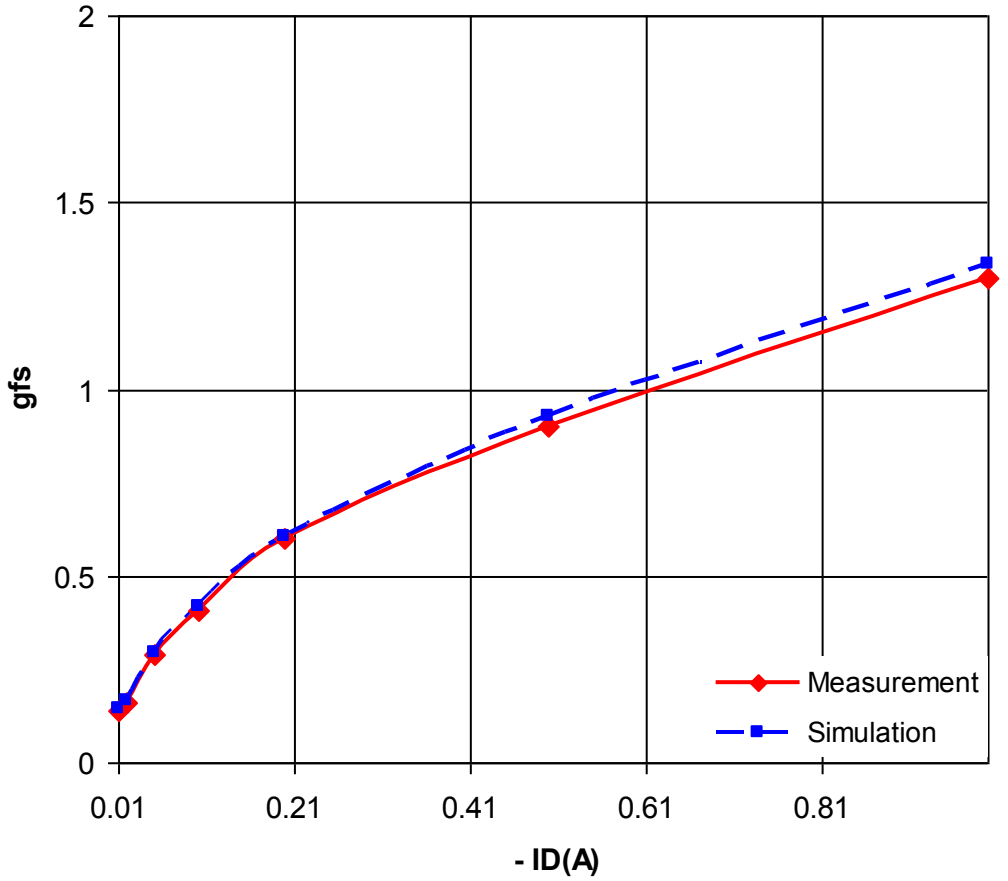
Bee Technologies Inc.

## 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

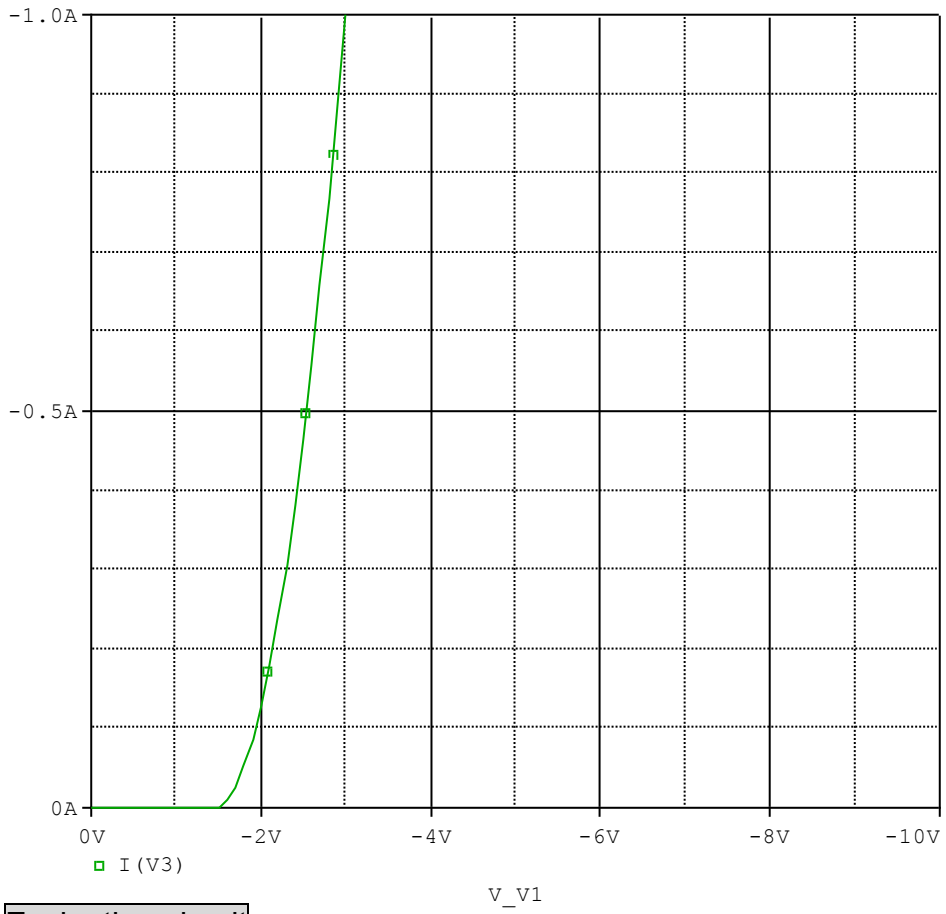



Comparison table

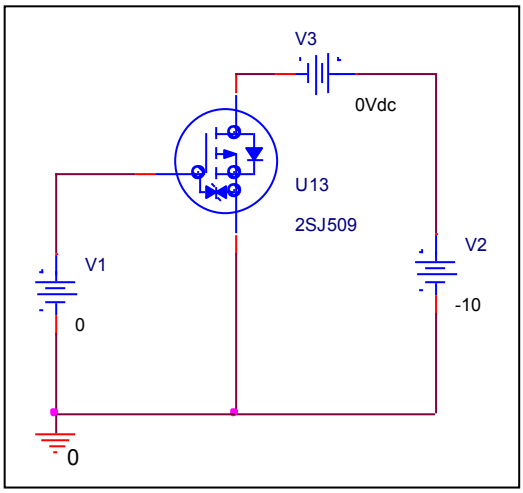
| -Id(A) | gfs | | Error(%) |
|---|---|---|---|
| | Measurement | Simulation | |
| 0.01 | 0.140 | 0.143 | 2.143 |
| 0.02 | 0.160 | 0.167 | 4.375 |
| 0.05 | 0.290 | 0.294 | 1.379 |
| 0.1 | 0.405 | 0.417 | 2.963 |
| 0.2 | 0.600 | 0.606 | 1.000 |
| 0.5 | 0.900 | 0.926 | 2.889 |
| 1 | 1.300 | 1.333 | 2.538 |

## Vgs-Id Characteristic

Circuit Simulation result

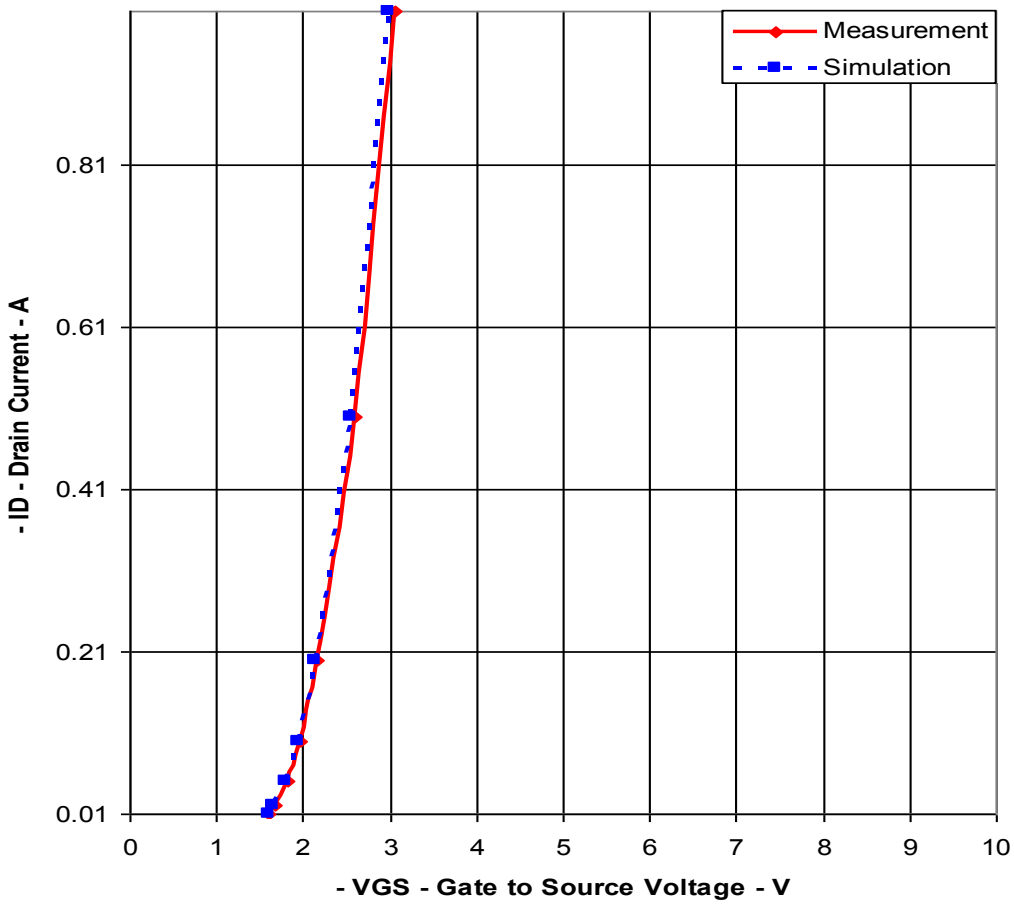



Evaluation circuit



## Comparison Graph

Circuit Simulation Result

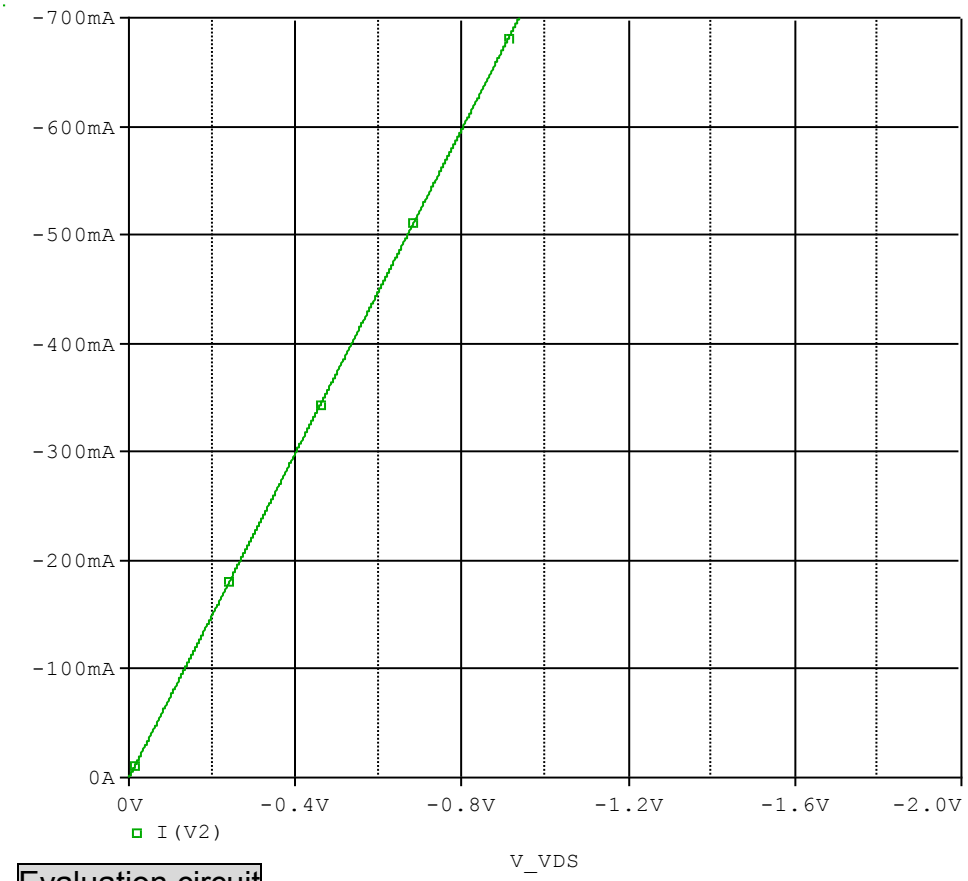



Simulation Result

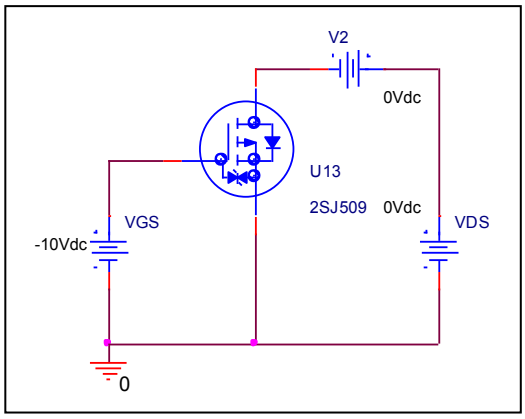
| $-I_D$(A) | $-V_{GS}$(V) | | Error (%) |
|---|---|---|---|
| | Measurement | Simulation | |
| 0.01 | 1.609 | 1.602 | -0.435 |
| 0.02 | 1.673 | 1.661 | -0.717 |
| 0.05 | 1.809 | 1.792 | -0.940 |
| 0.1 | 1.957 | 1.933 | -1.226 |
| 0.2 | 2.169 | 2.136 | -1.521 |
| 0.5 | 2.591 | 2.537 | -2.084 |
| 1 | 3.067 | 2.992 | -2.445 |

## Rds(on) Characteristic

Circuit Simulation result




Evaluation circuit

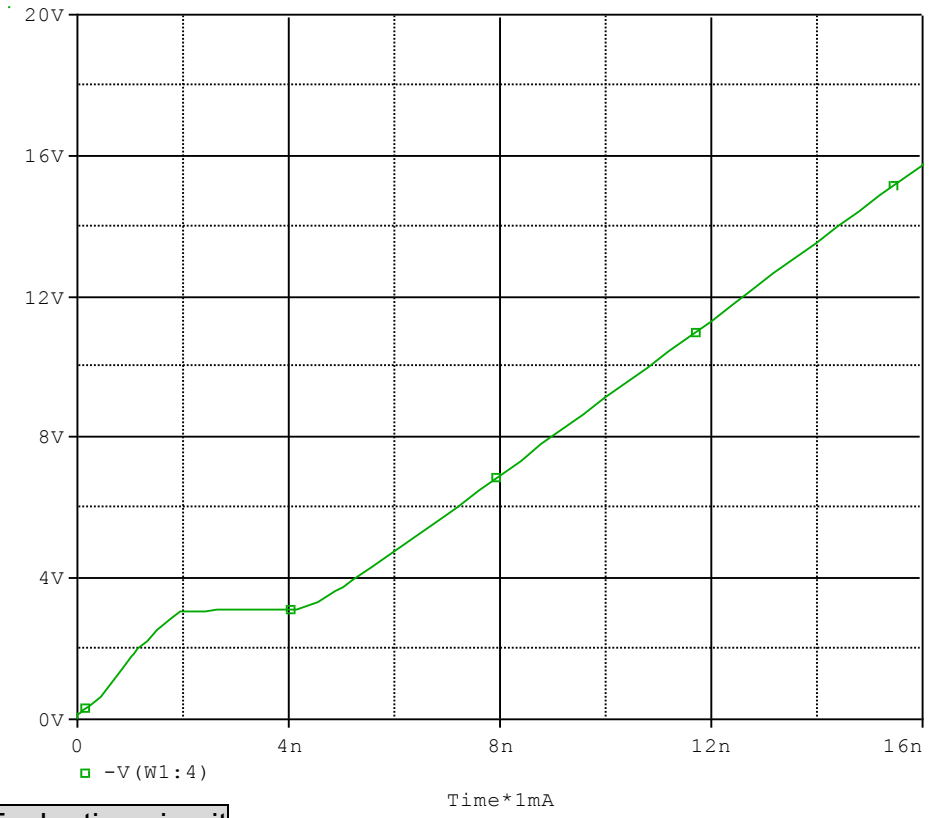



Simulation Result

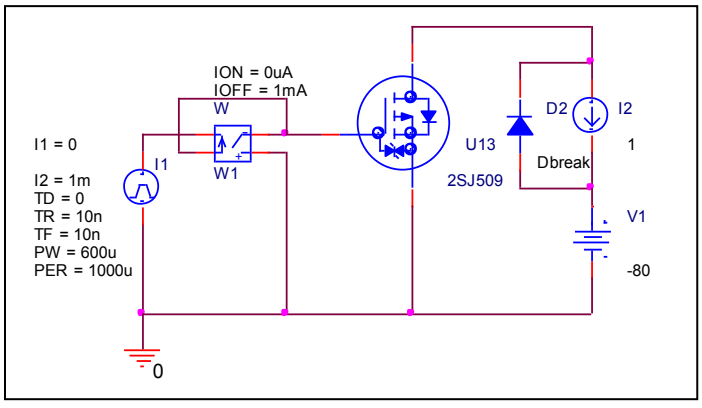
| $I_D$=-0.5A, $V_{GS}$=-10V | Measurement | | Simulation | | Error (%) |
|---|---|---|---|---|---|
| $R_{DS}$ (on) | 1.340 | Ω | 1.340 | Ω | 0 |

## Gate Charge Characteristic

Circuit Simulation result



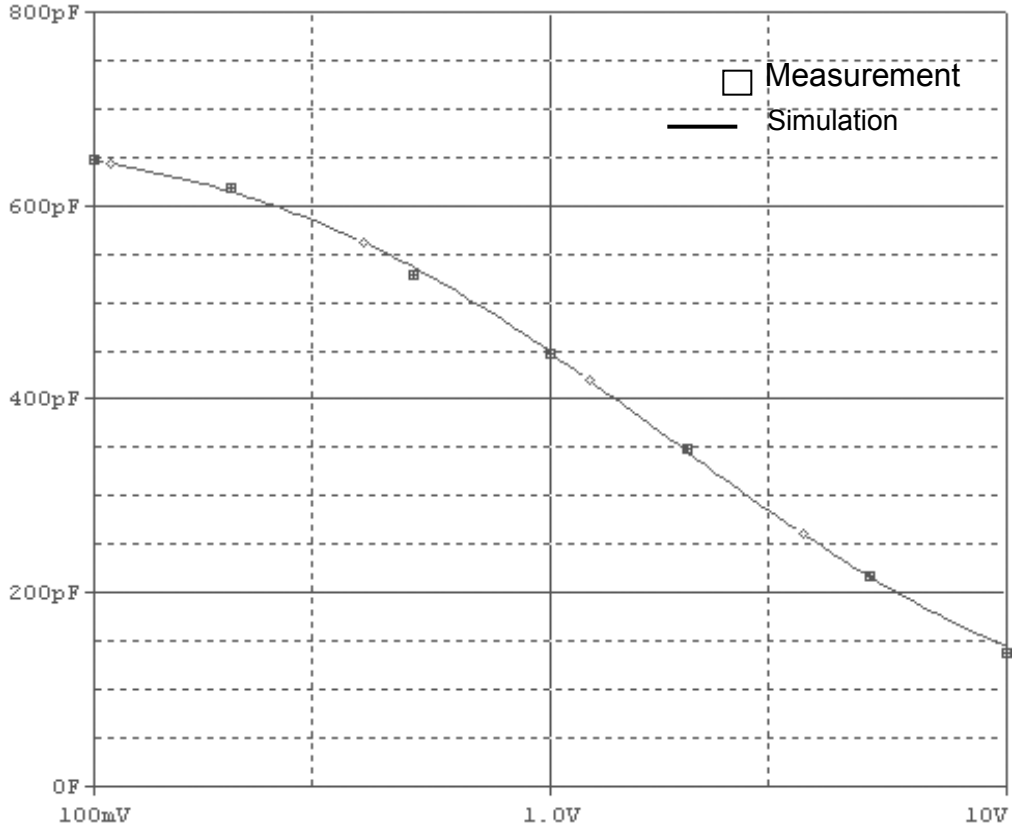

Evaluation circuit




Simulation Result

| $V_{DD}$=-80V,$I_D$=-1A ,$V_{GS}$=-10V | Measurement | Simulation | Error (%) |
|---|---|---|---|
| Qgs(nC) | 1.900 | 1.908 | 0.421 |
| Qgd(nC) | 2.200 | 2.202 | 0.091 |
| Qg | 10.400 | 10.606 | 1.923 |

## Capacitance Characteristic

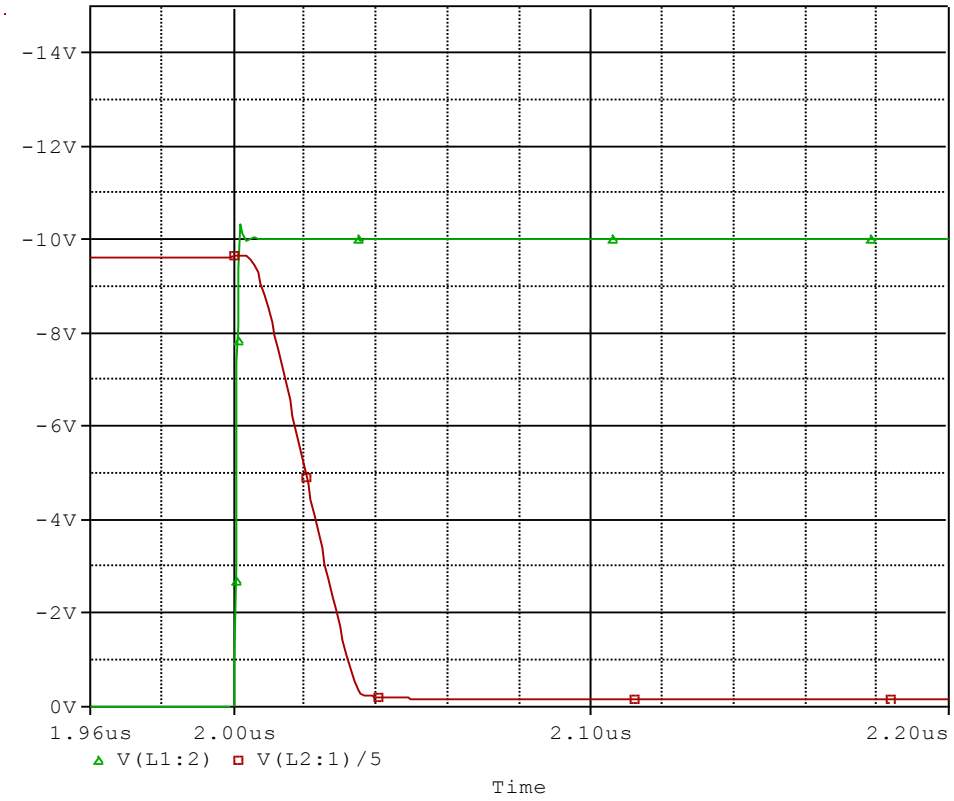



Simulation Result

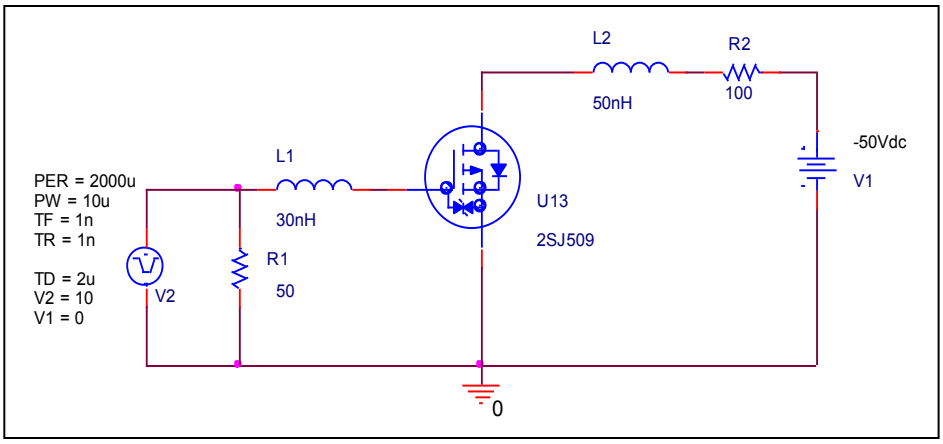
| $V_{DS}$(V) | Cbd(pF) | | Error(%) |
|---|---|---|---|
| | Measurement | Simulation | |
| 0.1 | 650 | 650 | 0.000 |
| 0.2 | 620 | 616 | -0.645 |
| 0.5 | 530 | 535 | 0.943 |
| 1 | 450 | 451 | 0.222 |
| 2 | 350 | 348 | -0.571 |
| 5 | 220 | 221 | 0.455 |
| 10 | 140 | 142 | 1.429 |

## Switching Time Characteristic

Circuit Simulation result




Evaluation circuit

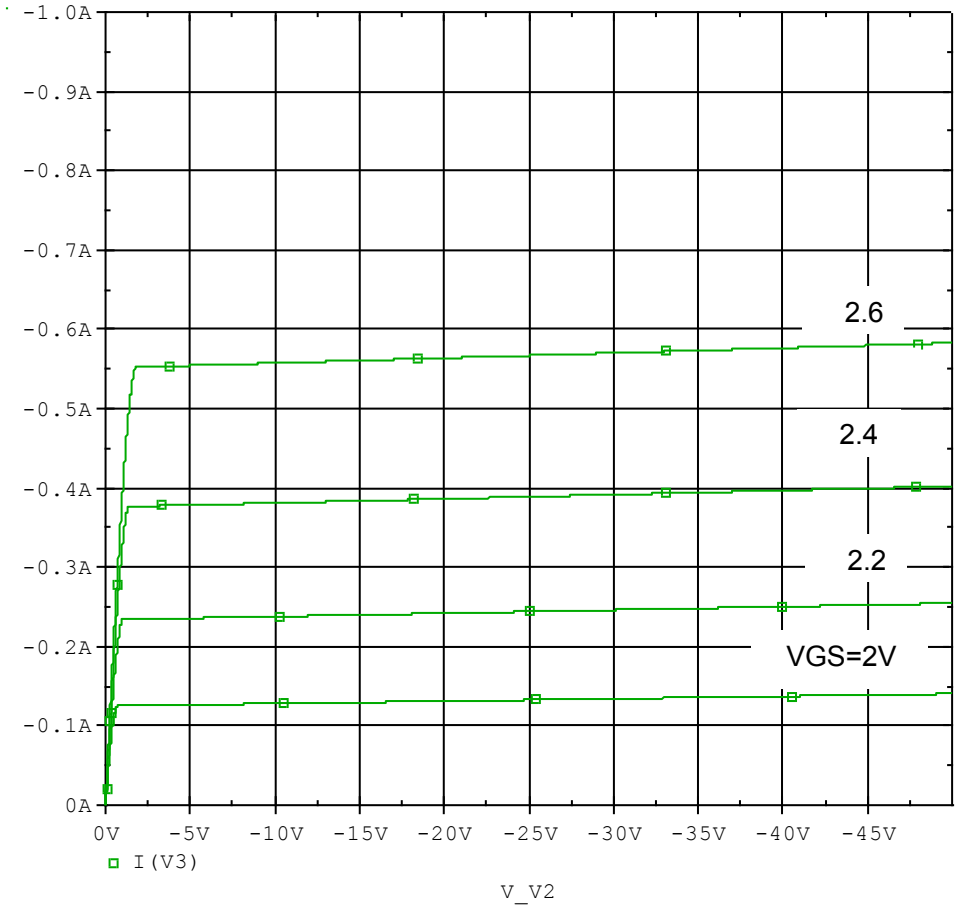



Simulation Result

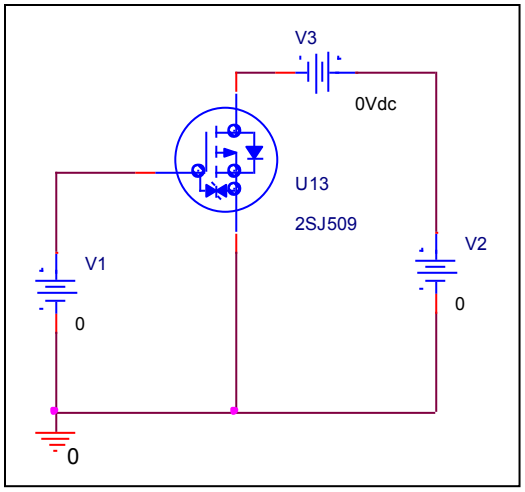
| $I_D$=-0.5A, $V_{DD}$=-50V $V_{GS}$=0/-10V | Measurement | Simulation | Error(%) |
|---|---|---|---|
| Ton(ns) | 32.000 | 31.849 | -0.472 |

## Output Characteristic

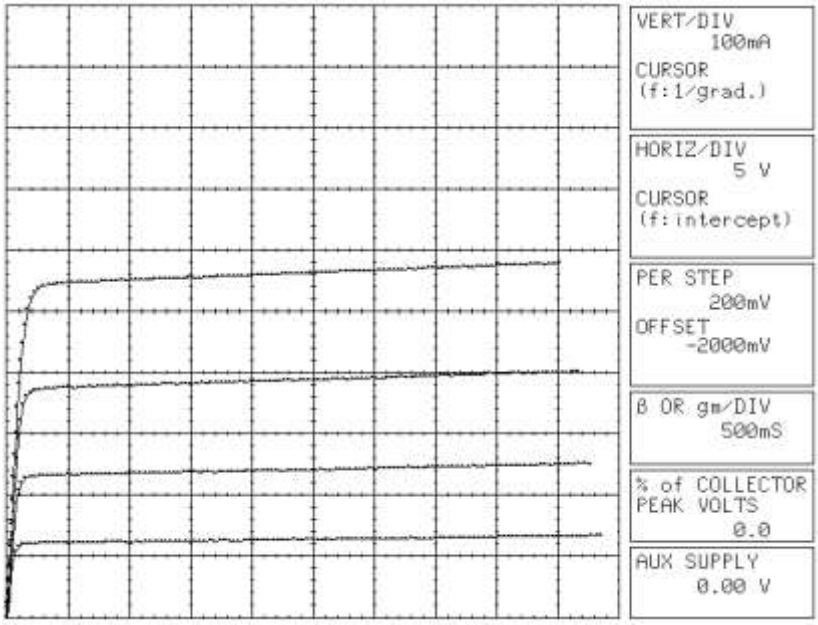
Circuit Simulation result




Evaluation circuit

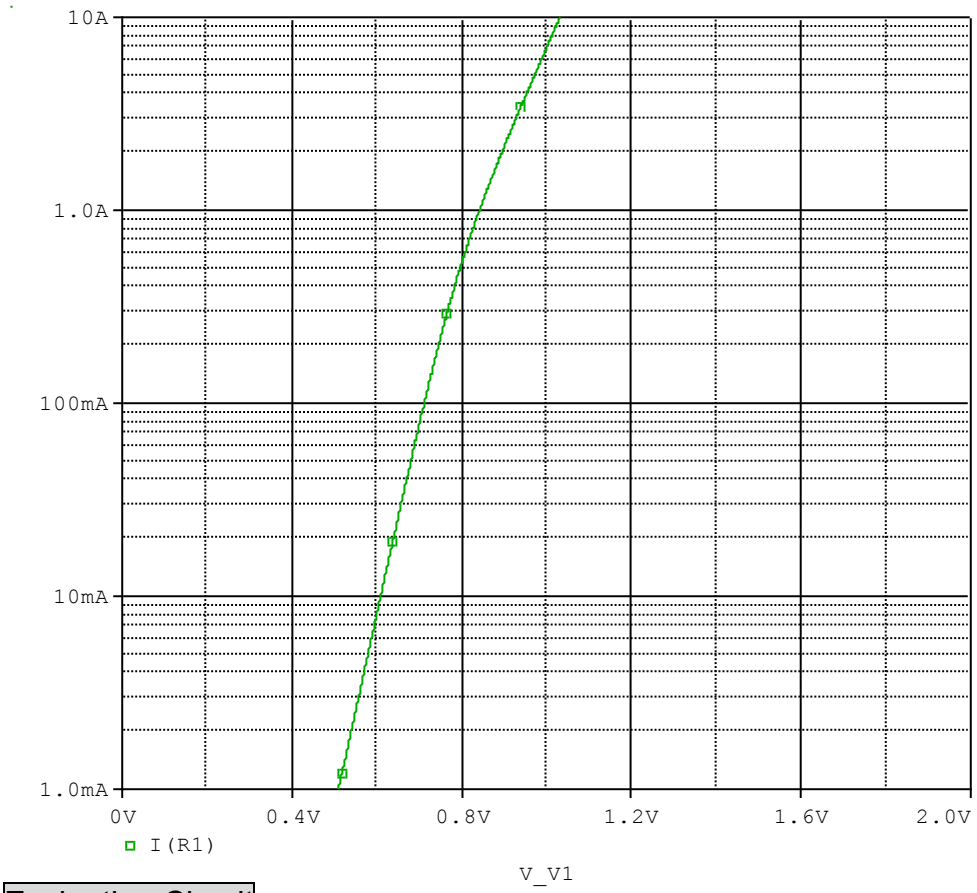


## Output Characteristic Reference

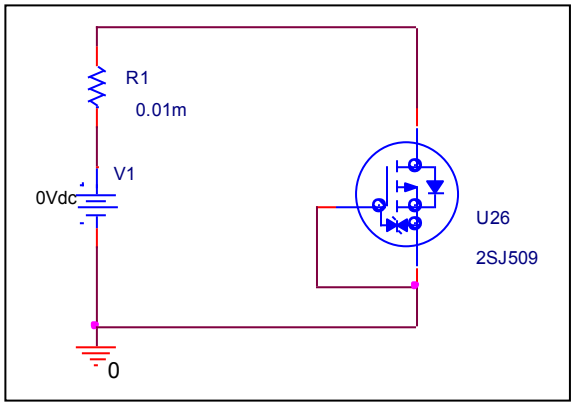


# BODY DIODE
# Forward Current Characteristic

## Circuit Simulation Result

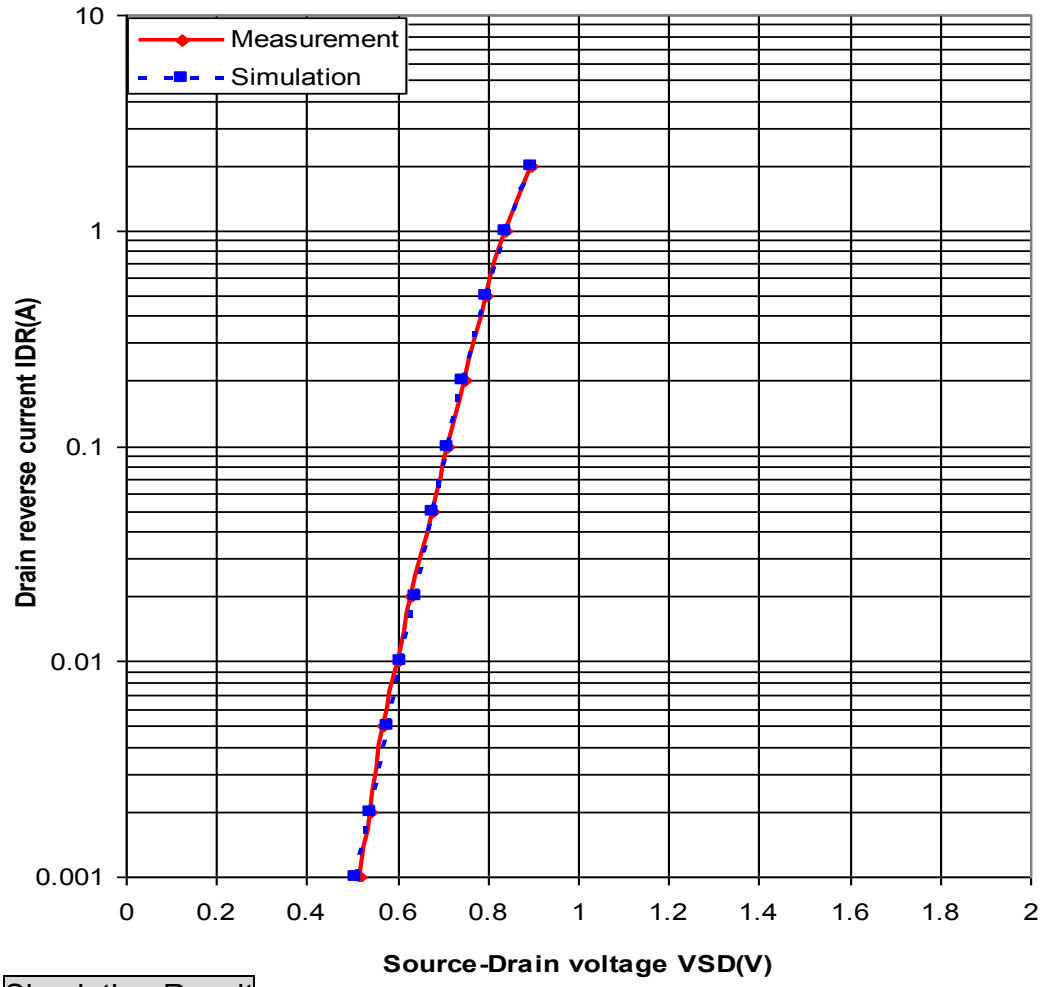



## Evaluation Circuit



## Comparison Graph

Circuit Simulation Result

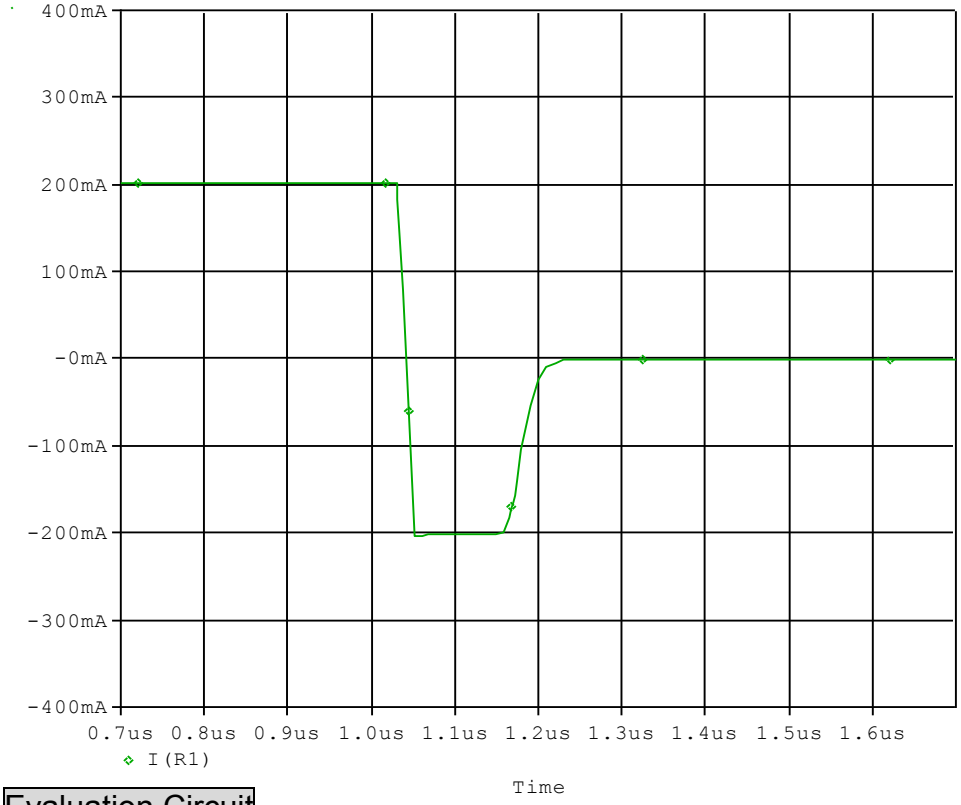



Simulation Result

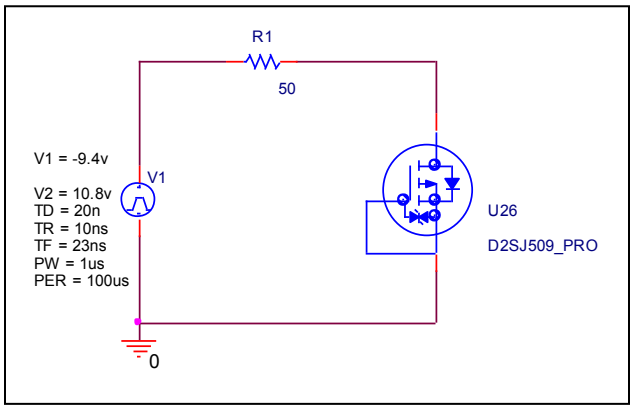
| IDR(A) | VSD(V) | | %Error |
|---|---|---|---|
| | Measuremen | Simulation | |
| 0.001 | 0.516 | 0.509 | -1.357 |
| 0.002 | 0.542 | 0.540 | -0.369 |
| 0.005 | 0.570 | 0.578 | 1.404 |
| 0.01 | 0.600 | 0.609 | 1.500 |
| 0.02 | 0.632 | 0.639 | 1.108 |
| 0.05 | 0.676 | 0.680 | 0.592 |
| 0.1 | 0.710 | 0.711 | 0.141 |
| 0.2 | 0.748 | 0.746 | -0.267 |
| 0.5 | 0.798 | 0.796 | -0.251 |
| 1 | 0.840 | 0.841 | 0.119 |

## Reverse Recovery Characteristic

Circuit Simulation Result



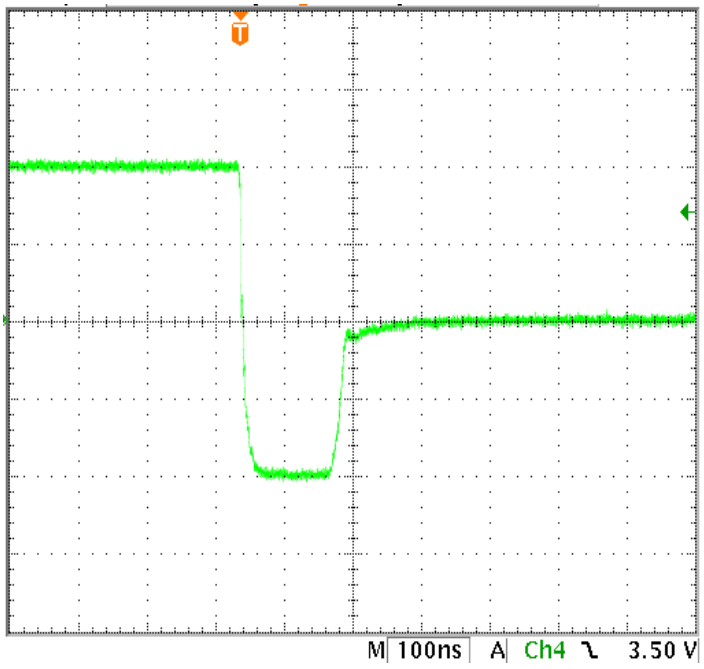

Evaluation Circuit



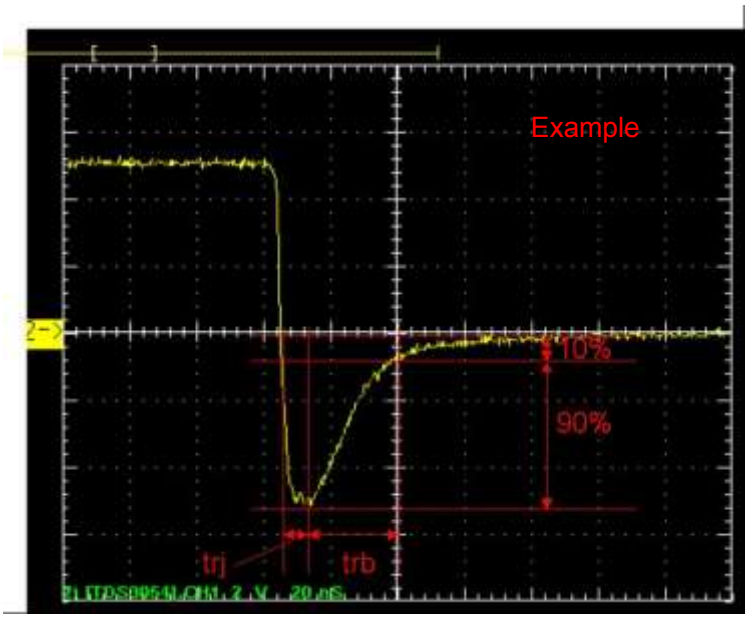

Compare Measurement vs. Simulation

| Trr | Measurement | Simulation | Error (%) |
|---|---|---|---|
| Trj+Trb(ns) | 160.000 | 160.586 | 0.366 |

## Reverse Recovery Characteristic Reference



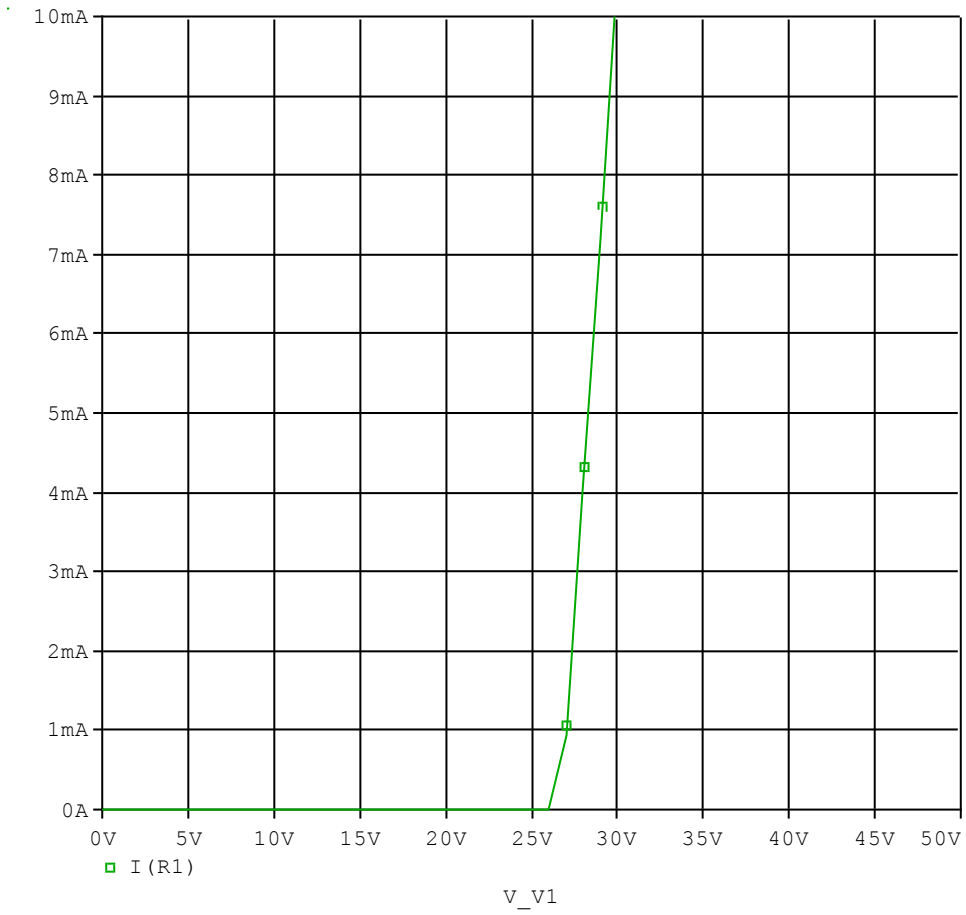

Trj=120 (ns)
Trb=40(ns)
Conditions:Ifwd=Irev=0.2(A),Rl=50



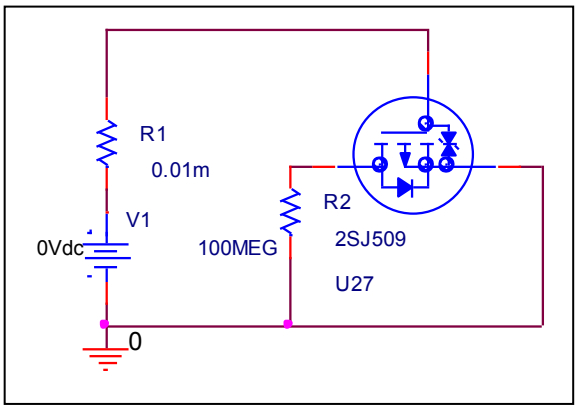

Relation between trj and trb

# ESD PROTECTION DIODE
## Zener Voltage Characteristic

Circuit Simulation Result




Evaluation Circuit



## Zener Voltage Characteristic Reference