

# Device Modeling Report

COMPONENTS: Power MOSFET (Model Parameter)  
PART NUMBER: SSM3J117TU  
MANUFACTURER: TOSHIBA  
Body Diode (Model Parameter) / ESD Protection Diode



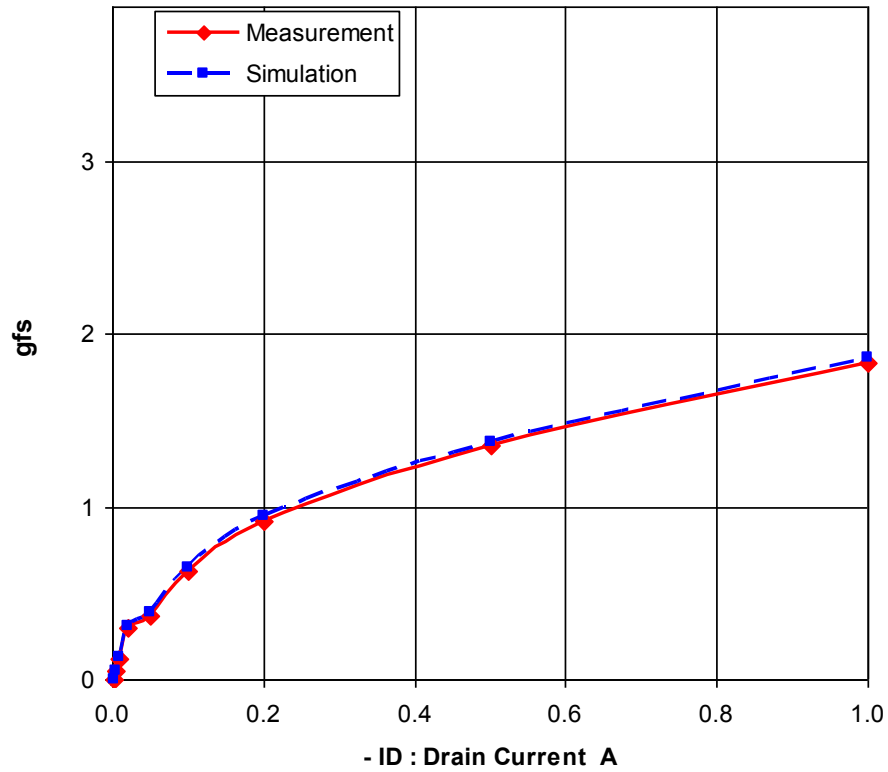
**Bee Technologies Inc.**

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

## Transconductance Characteristic

Circuit Simulation Result

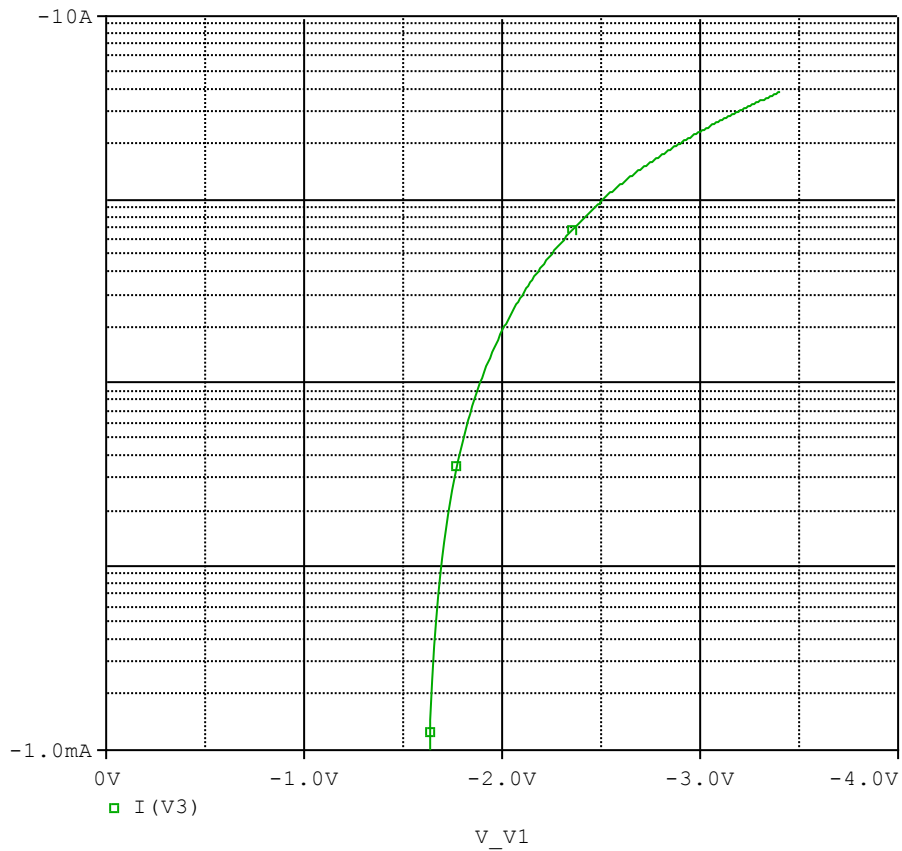


Comparison table

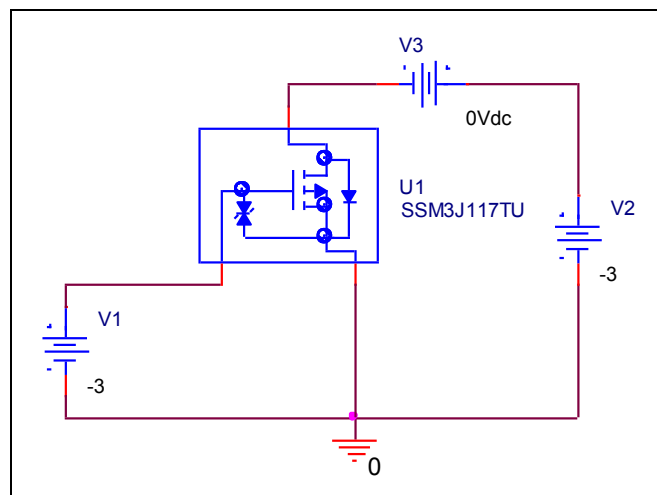
| -Id(A) | gfs         |            | Error(%) |
|--------|-------------|------------|----------|
|        | Measurement | Simulation |          |
| 0.001  | 0.062       | 0.063      | 1.613    |
| 0.002  | 0.098       | 0.100      | 2.041    |
| 0.005  | 0.148       | 0.152      | 2.703    |
| 0.010  | 0.220       | 0.227      | 3.182    |
| 0.020  | 0.400       | 0.408      | 2.000    |
| 0.050  | 0.470       | 0.485      | 3.191    |
| 0.100  | 0.725       | 0.750      | 3.448    |
| 0.200  | 1.020       | 1.050      | 2.941    |
| 0.500  | 1.460       | 1.475      | 1.027    |
| 1.000  | 1.940       | 1.969      | 1.495    |

## V<sub>gs</sub>-I<sub>d</sub> Characteristic

Circuit Simulation result

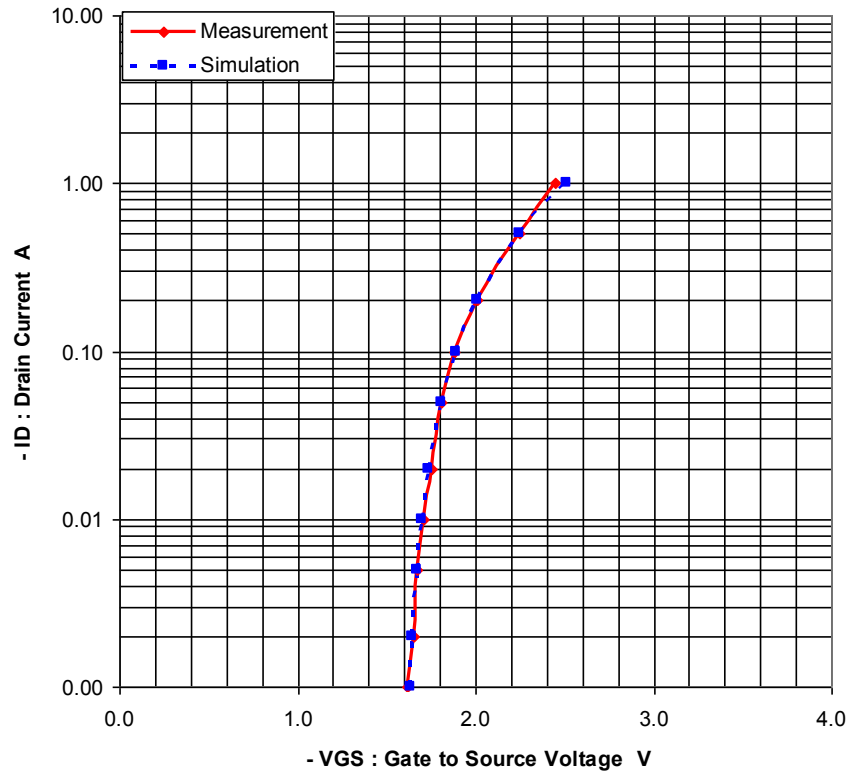


Evaluation circuit



## Comparison Graph

### Circuit Simulation Result

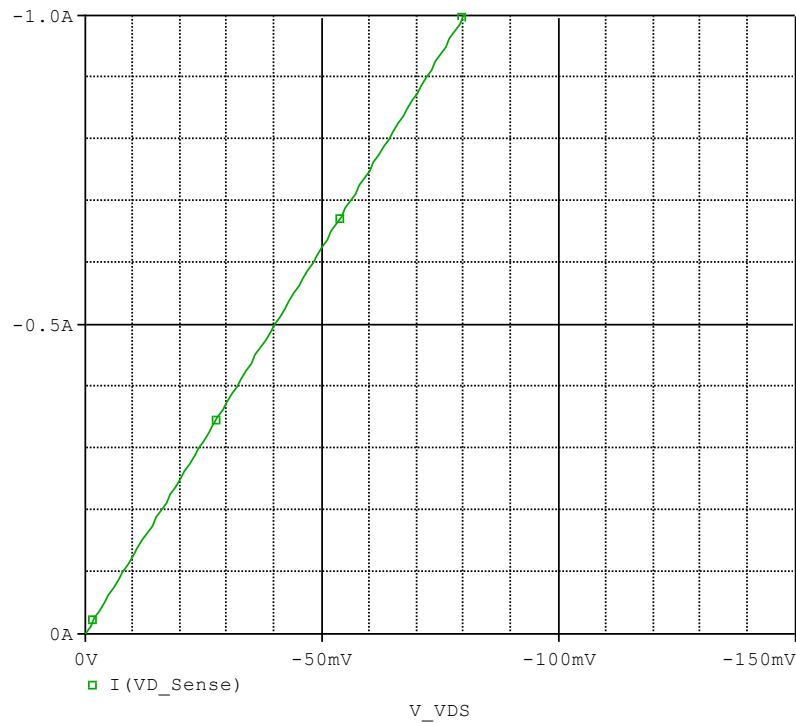


### Simulation Result

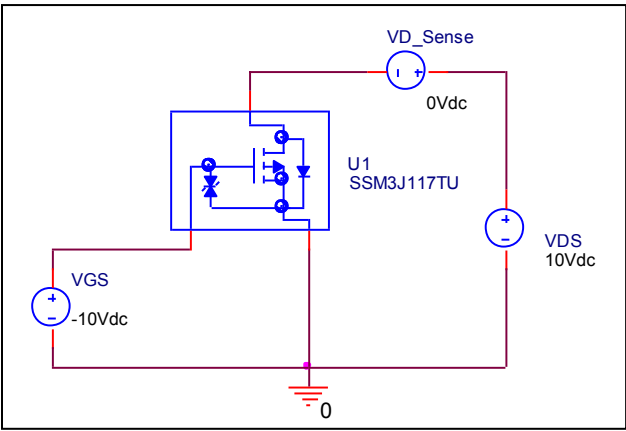
| $-I_D$ (A) | $-V_{GS}$ (V) |            | Error (%) |
|------------|---------------|------------|-----------|
|            | Measurement   | Simulation |           |
| 0.001      | 1.620         | 1.634      | 0.864     |
| 0.002      | 1.650         | 1.646      | -0.242    |
| 0.005      | 1.670         | 1.669      | -0.060    |
| 0.010      | 1.710         | 1.696      | -0.819    |
| 0.020      | 1.750         | 1.734      | -0.914    |
| 0.050      | 1.810         | 1.807      | -0.166    |
| 0.100      | 1.885         | 1.892      | 0.371     |
| 0.200      | 2.005         | 2.007      | 0.100     |
| 0.500      | 2.250         | 2.246      | -0.178    |
| 1.000      | 2.450         | 2.509      | 2.408     |

# Rds(on) Characteristic

## Circuit Simulation result



## Evaluation circuit

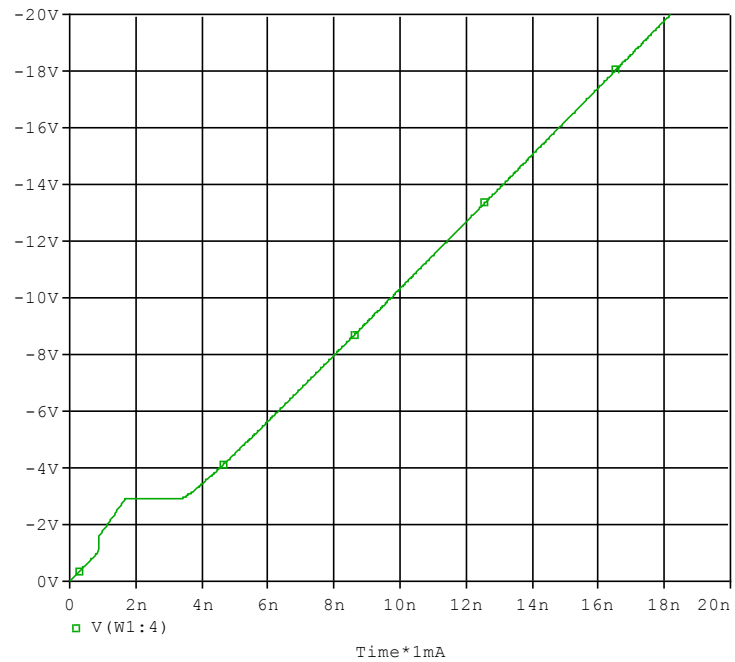


## Simulation Result

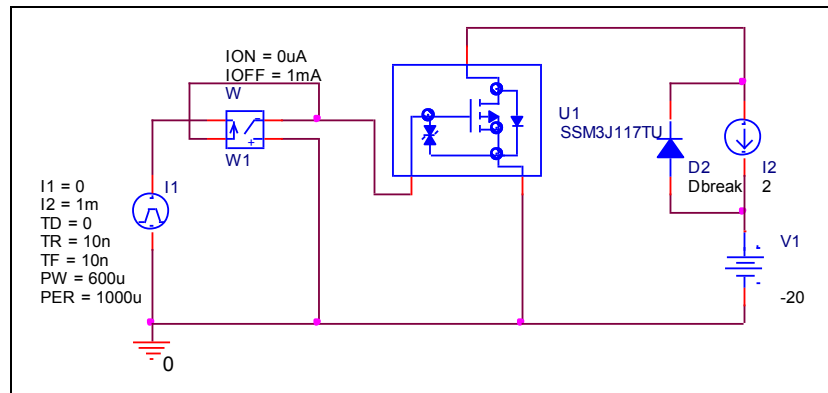
| $I_D = -1A, V_{GS} = -10V$ | Measurement | Simulation | Error (%) |
|----------------------------|-------------|------------|-----------|
| $R_{DS(on)}$ ( $\Omega$ )  | 0.080       | 0.080      | 0.000     |

## Gate Charge Characteristic

### Circuit Simulation result



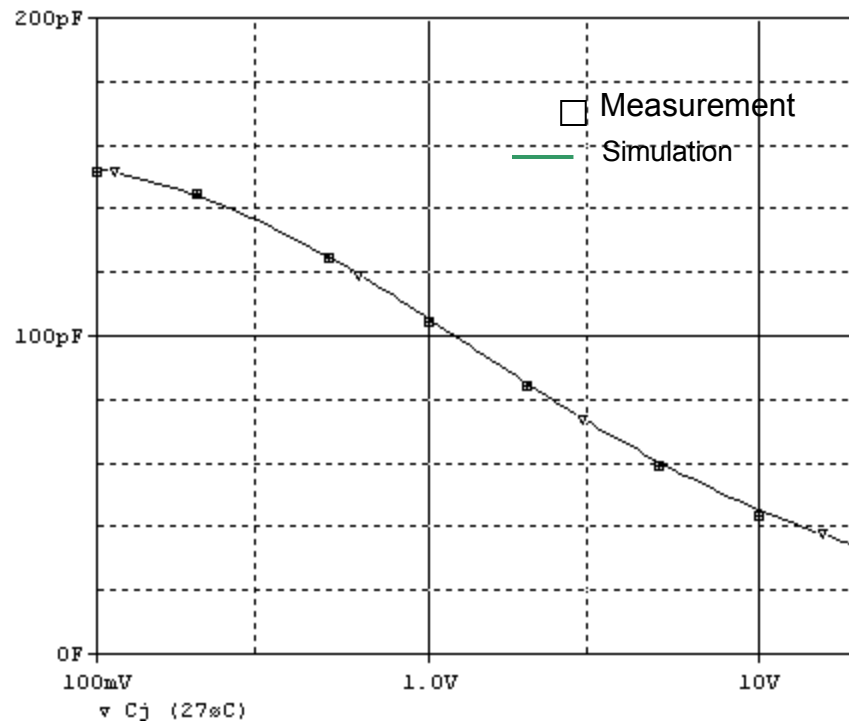
### Evaluation circuit



### Simulation Result

| $V_{DD} = -20V, I_D = -2A$<br>$V_{GS} = -10V$ | Measurement | Simulation | Error (%) |
|-----------------------------------------------|-------------|------------|-----------|
| Qgs(nc)                                       | 1.680       | 1.680      | 0.000     |
| Qgd(nc)                                       | 1.680       | 1.683      | 0.179     |
| Qg(nc)                                        | 10.000      | 9.729      | -2.710    |

## Capacitance Characteristic

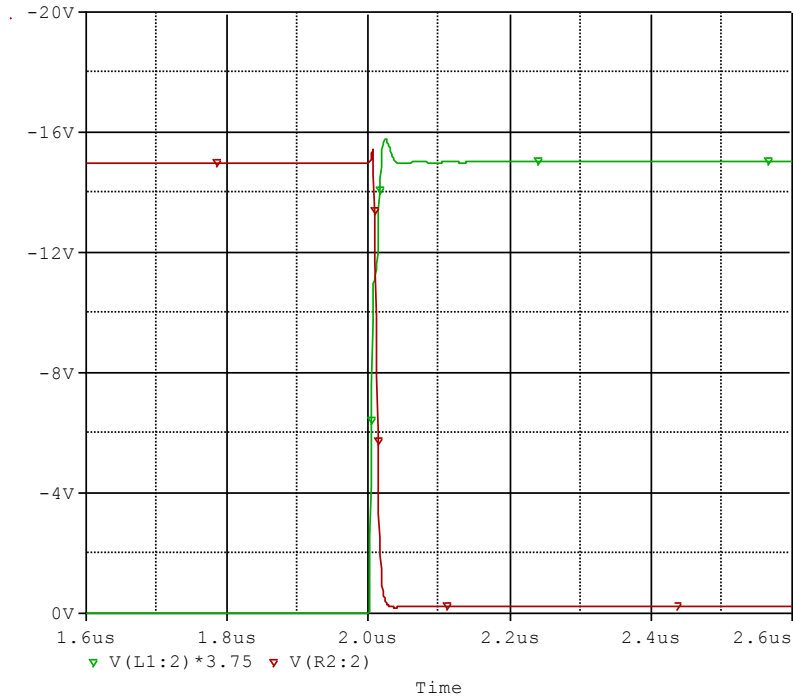


### Simulation Result

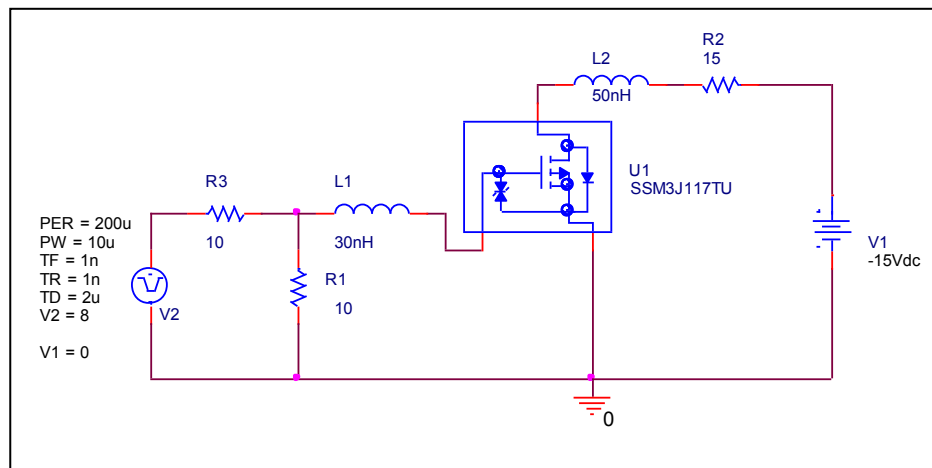
| $V_{DS}(V)$ | Cbd(pF)     |            | Error(%) |
|-------------|-------------|------------|----------|
|             | Measurement | Simulation |          |
| 0.100       | 152.000     | 152.500    | 0.329    |
| 0.200       | 145.000     | 143.000    | -1.379   |
| 0.500       | 125.000     | 125.000    | 0.000    |
| 1.000       | 105.000     | 106.000    | 0.952    |
| 2.000       | 85.000      | 85.000     | 0.000    |
| 5.000       | 60.000      | 60.500     | 0.833    |
| 10.000      | 44.000      | 45.000     | 2.273    |
| 20.000      | 35.000      | 35.000     | 0.000    |

# Switching Time Characteristic

## Circuit Simulation result



## Evaluation circuit

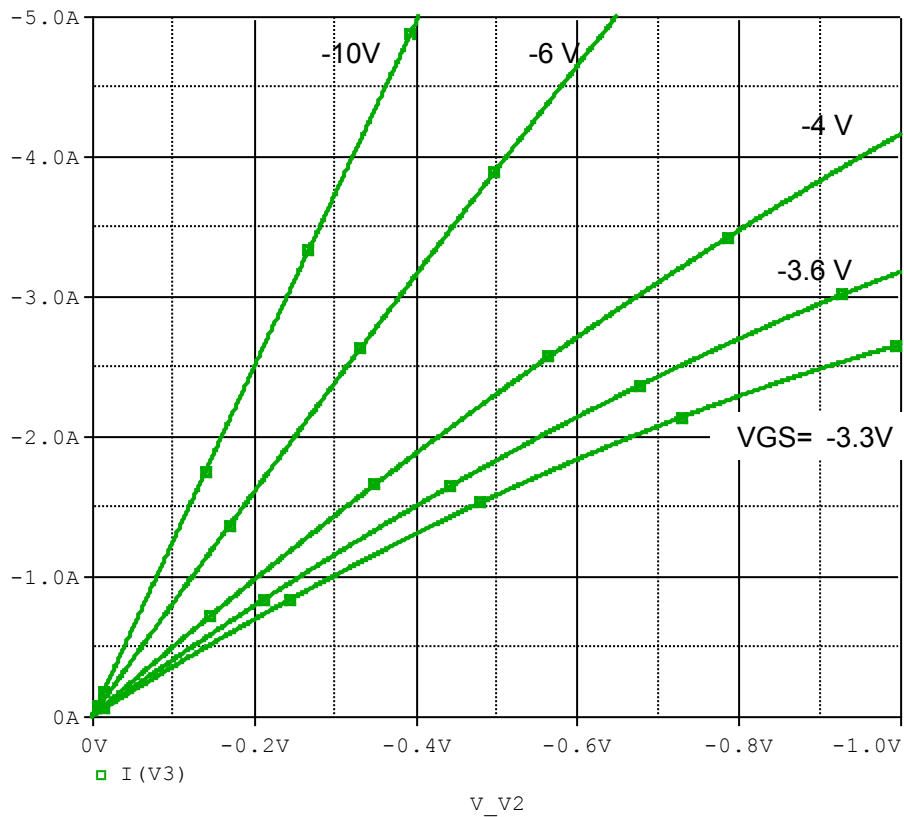


## Simulation Result

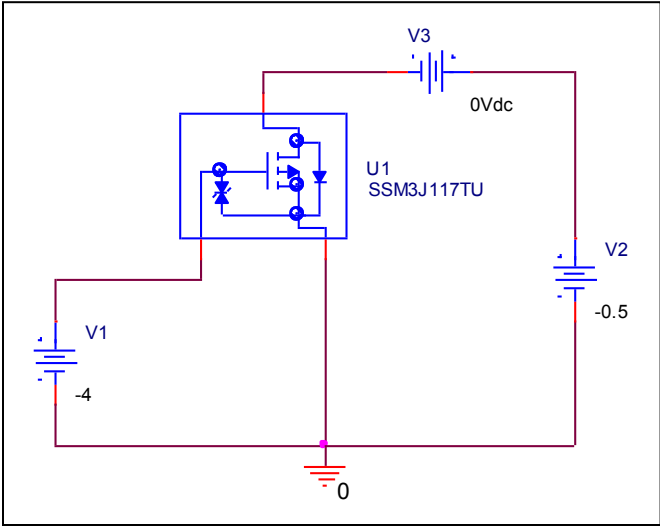
| $I_D = -1A$ , $V_{DD} = -15V$<br>$V_{GS} = -4V$ | Measurement | Simulation | Error(%) |
|-------------------------------------------------|-------------|------------|----------|
| Ton(ns)                                         | 16.000      | 16.397     | 2.481    |

# Output Characteristic

Circuit Simulation result



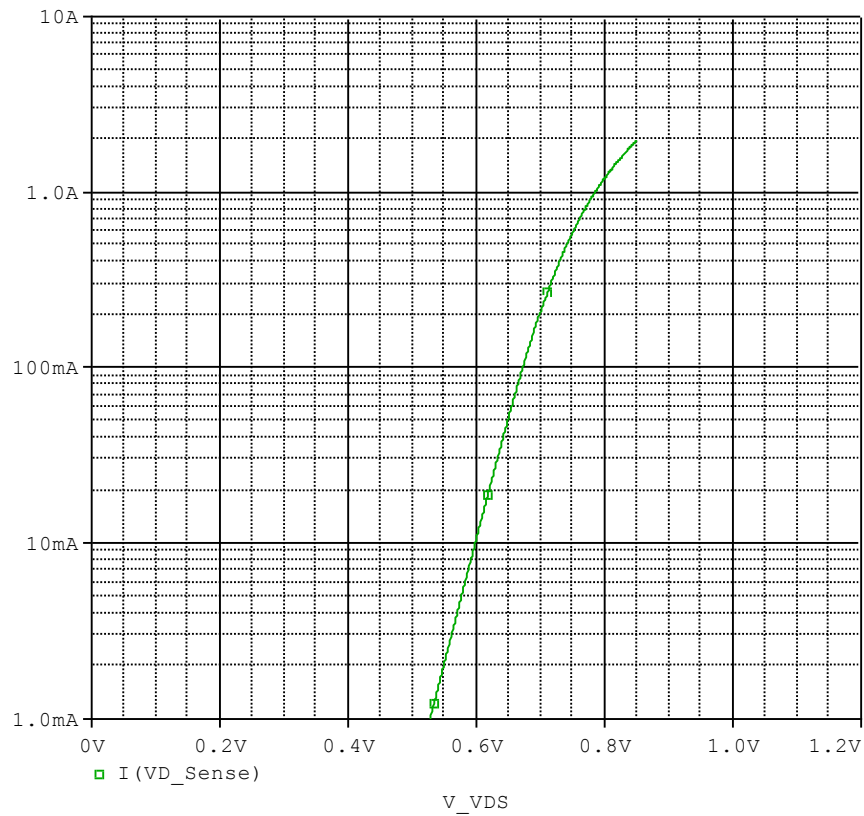
Evaluation circuit



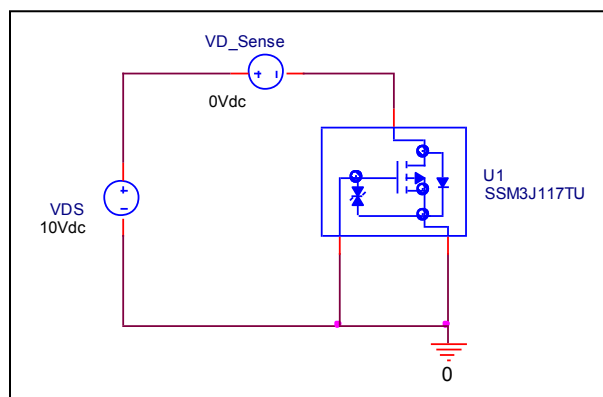
# BODY DIODE SPICE MODEL

## Forward Current Characteristic

### Circuit Simulation Result

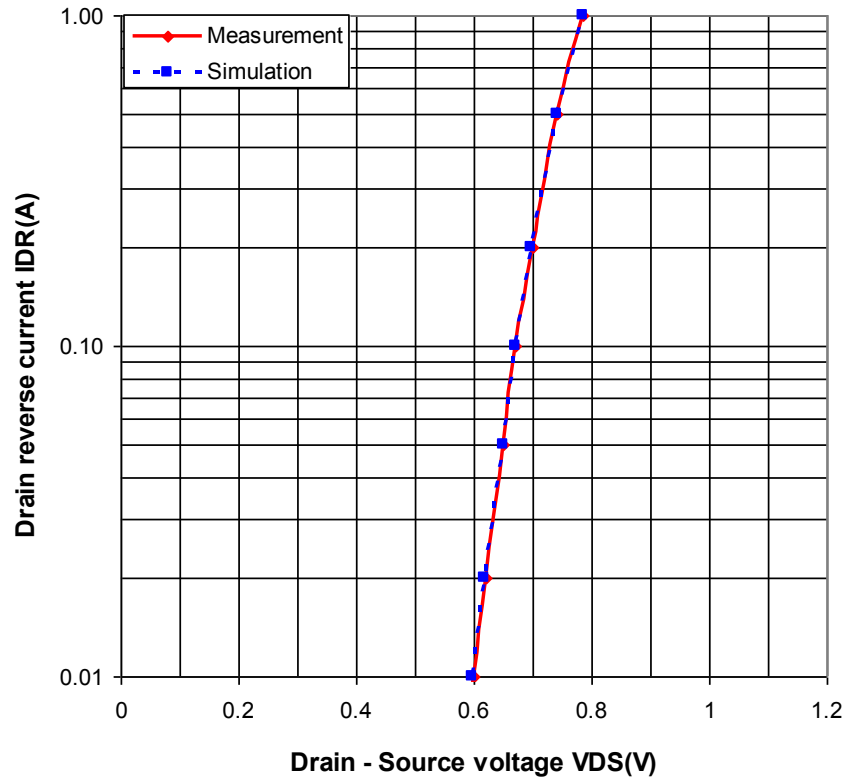


### Evaluation Circuit



## Comparison Graph

### Circuit Simulation Result

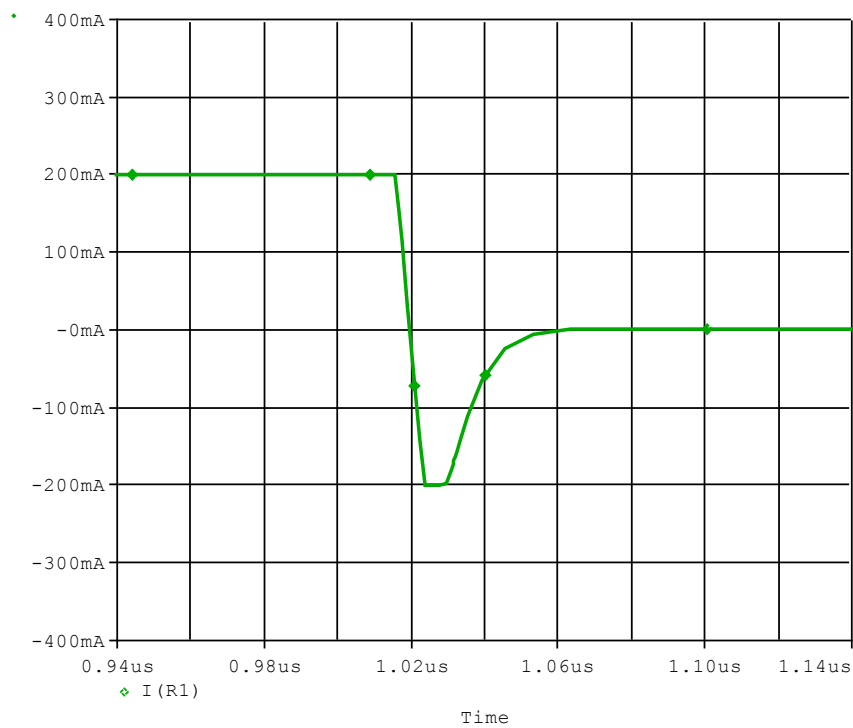


### Simulation Result

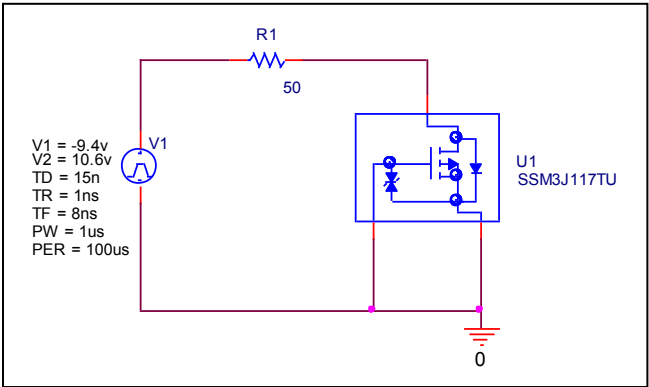
| -IDR(A) | VDS(V)<br>Measurement | VDS(V)<br>Simulation | %Error |
|---------|-----------------------|----------------------|--------|
| 0.001   | 0.530                 | 0.527                | -0.566 |
| 0.002   | 0.545                 | 0.548                | 0.550  |
| 0.005   | 0.575                 | 0.576                | 0.174  |
| 0.010   | 0.600                 | 0.598                | -0.333 |
| 0.020   | 0.620                 | 0.619                | -0.161 |
| 0.050   | 0.650                 | 0.649                | -0.154 |
| 0.100   | 0.670                 | 0.672                | 0.299  |
| 0.200   | 0.700                 | 0.698                | -0.286 |
| 0.500   | 0.740                 | 0.742                | 0.270  |
| 1.000   | 0.785                 | 0.785                | 0.000  |

# Reverse Recovery Characteristic

## Circuit Simulation Result



## Evaluation Circuit

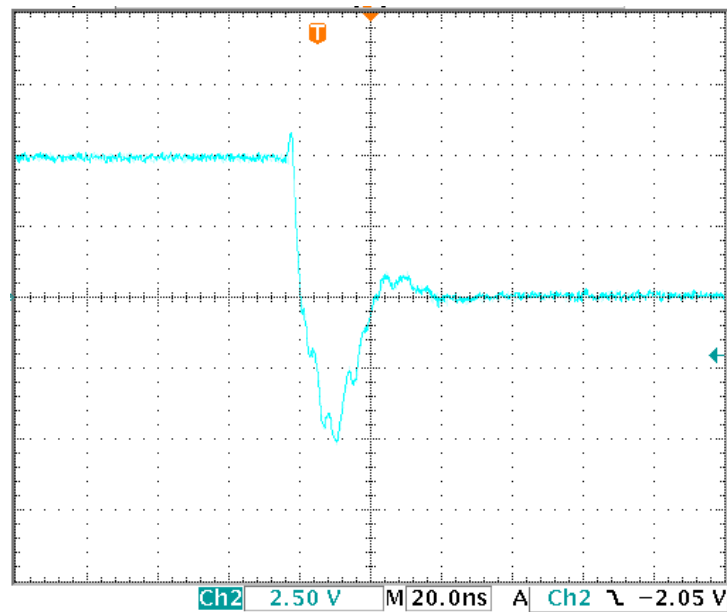


## Compare Measurement vs. Simulation

|         | Measurement | Simulation | Error (%) |
|---------|-------------|------------|-----------|
| Trj(ns) | 9.200       | 9.300      | 1.087     |

## Reverse Recovery Characteristic

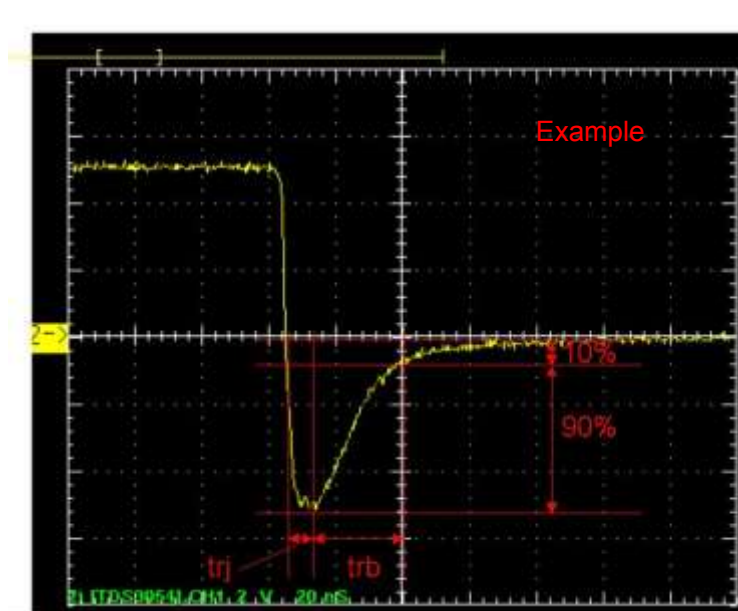
## Reference



$t_{rj} = 9.2 \text{ (ns)}$

$t_{rb} = 9.6 \text{ (ns)}$

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

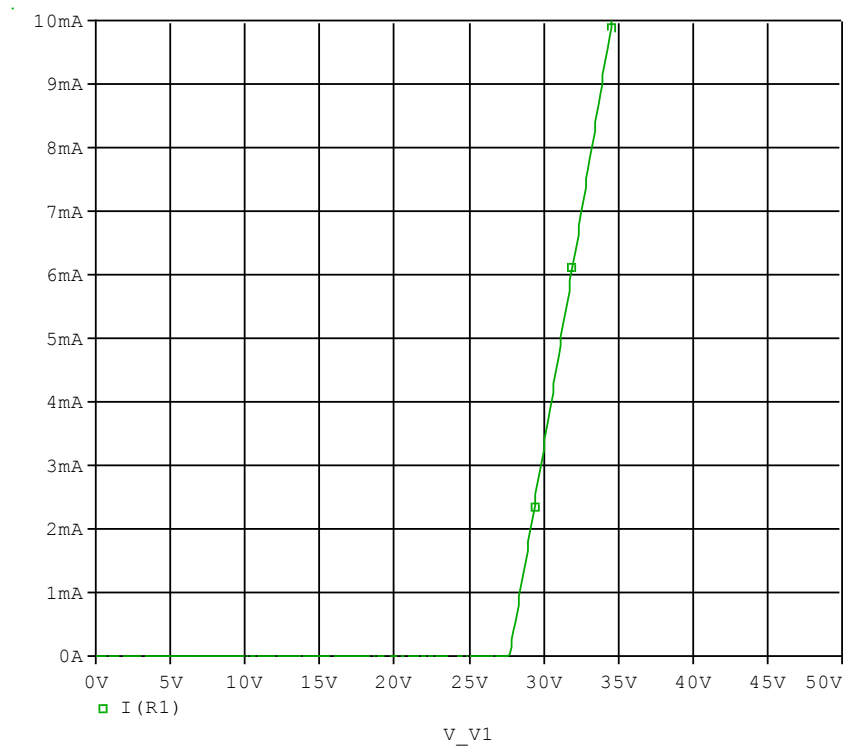


Relation between  $t_{rj}$  and  $t_{rb}$

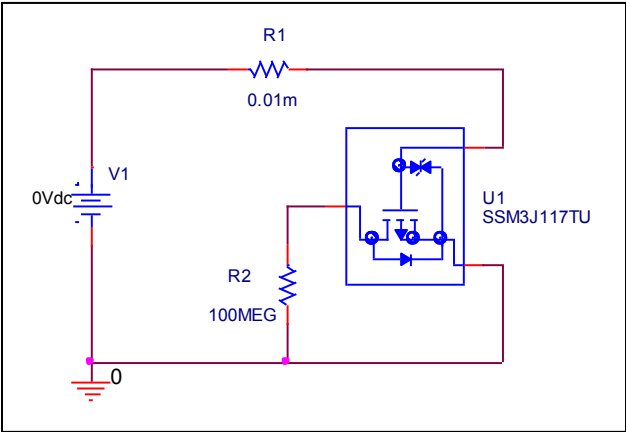
# ESD PROTECTION DIODE SPICE MODEL

## Zener Voltage Characteristic

### Circuit Simulation Result



### Evaluation Circuit



Zener Voltage Characteristic

Reference

