

# Device Modeling Report

COMPONENTS: Power MOSFET (Model Parameters)  
PART NUMBER: 2SK2700  
MANUFACTURER: TOSHIBA  
Body Diode (Model Parameters) / ESD Protection Diode



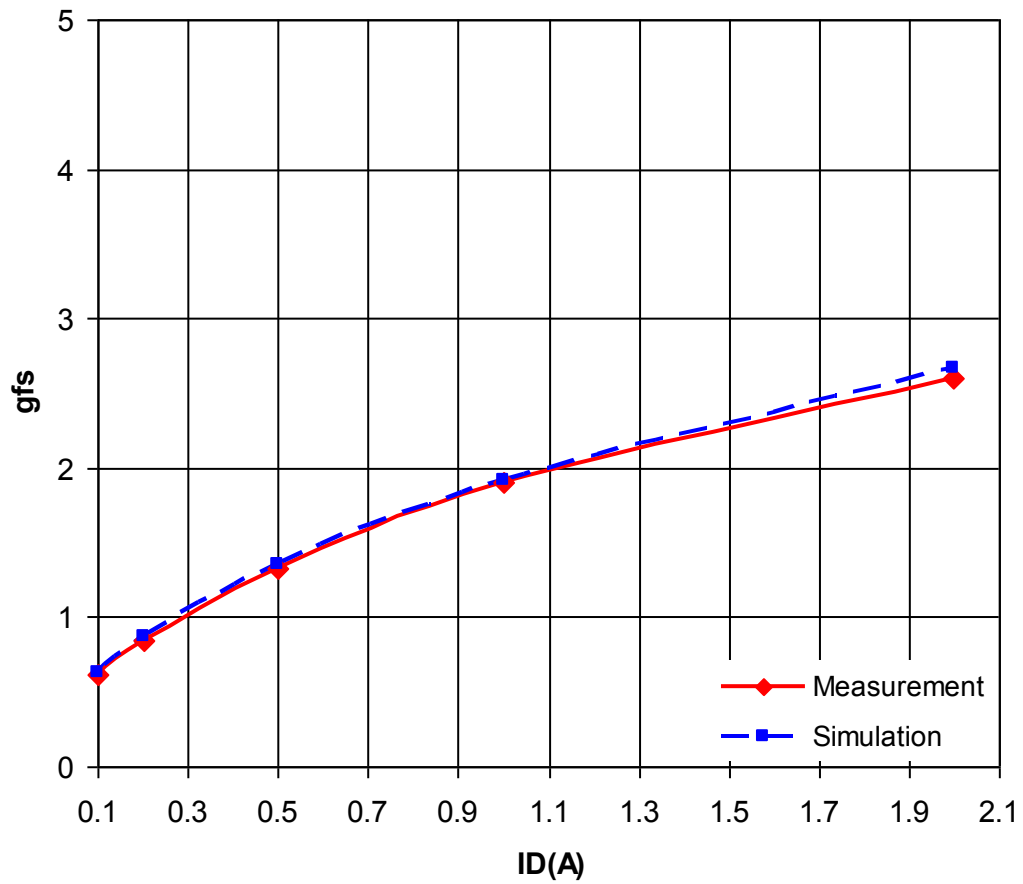
**Bee Technologies Inc.**

## 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

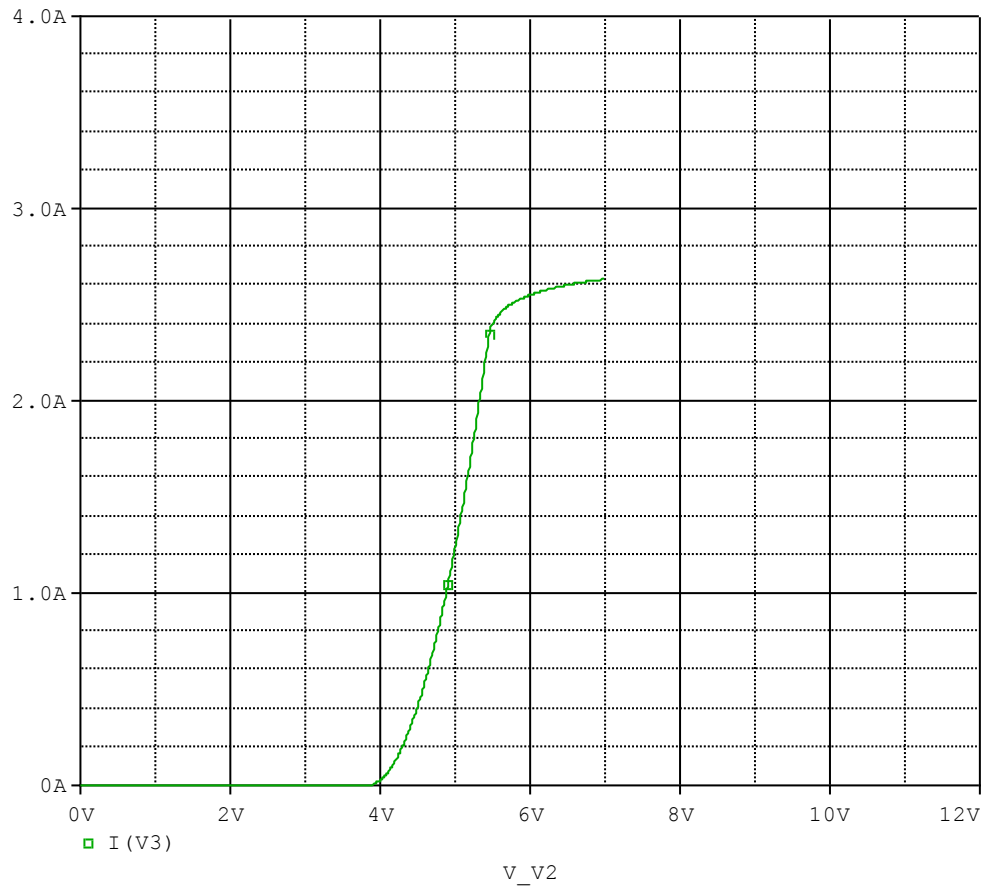


Comparison table

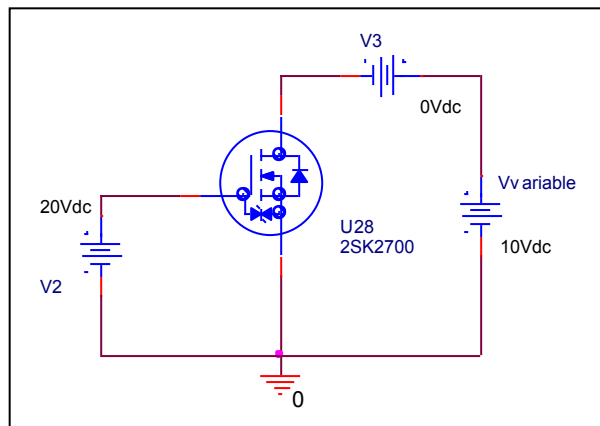
| Id(A) | gfs         |            | Error(%) |
|-------|-------------|------------|----------|
|       | Measurement | Simulation |          |
| 0.1   | 0.610       | 0.625      | 2.459    |
| 0.2   | 0.850       | 0.870      | 2.353    |
| 0.5   | 1.330       | 1.351      | 1.579    |
| 1     | 1.900       | 1.923      | 1.211    |
| 2     | 2.600       | 2.667      | 2.577    |

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

Circuit Simulation result

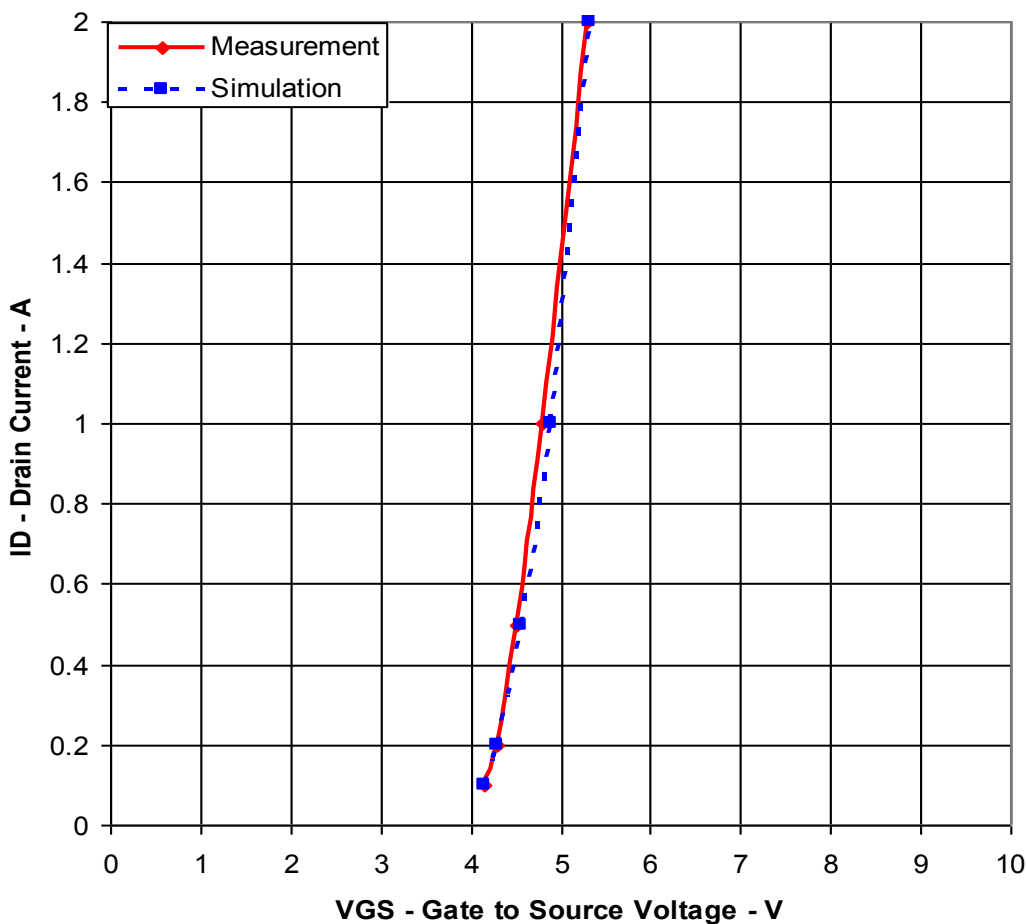


Evaluation circuit



# Comparison Graph

Circuit Simulation Result

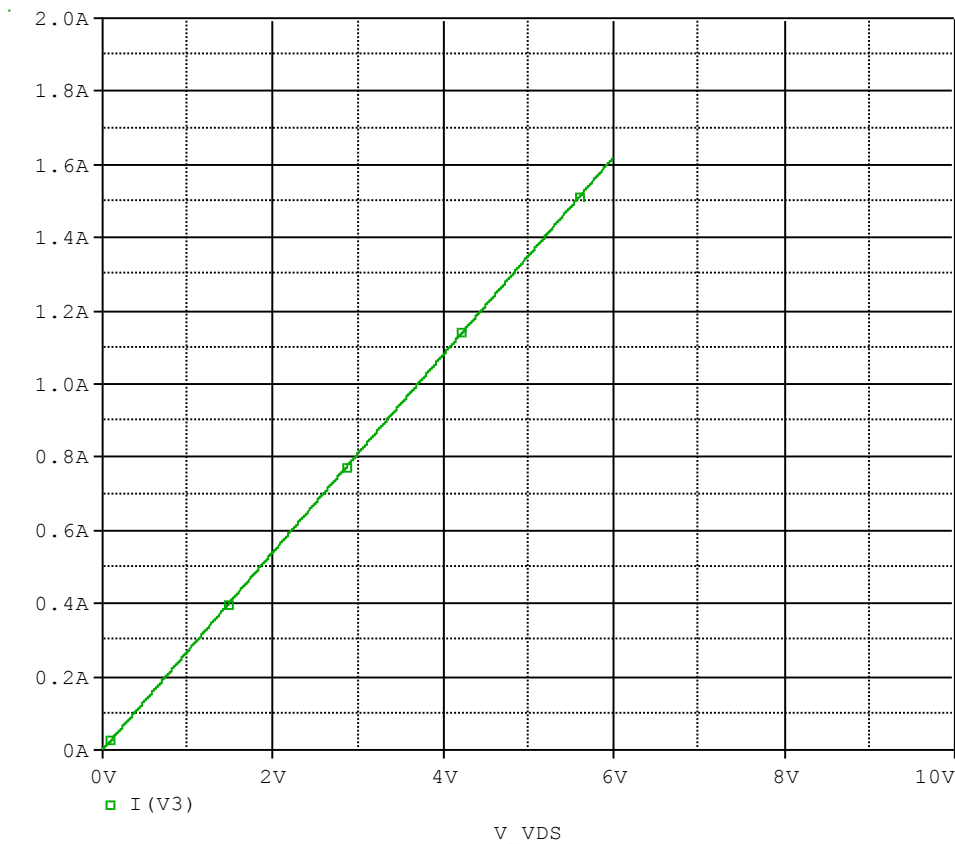


Simulation Result

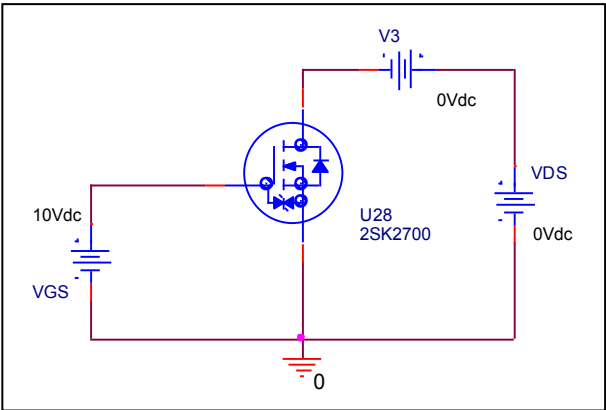
| I <sub>D</sub> (A) | V <sub>GS</sub> (V) |            | Error (%) |
|--------------------|---------------------|------------|-----------|
|                    | Measurement         | Simulation |           |
| 0.1                | 4.150               | 4.158      | 0.193     |
| 0.2                | 4.300               | 4.296      | -0.093    |
| 0.5                | 4.500               | 4.570      | 1.556     |
| 1                  | 4.800               | 4.881      | 1.688     |
| 2                  | 5.300               | 5.325      | 0.472     |

# Rds(on) Characteristic

## Circuit Simulation result



## Evaluation circuit

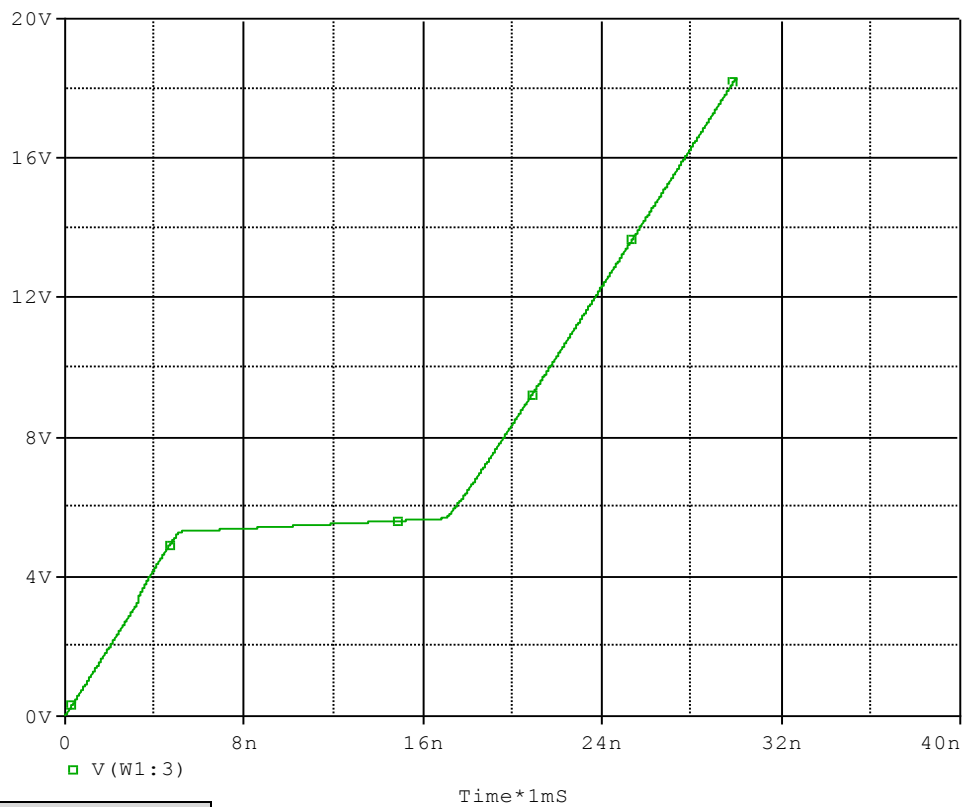


## Simulation Result

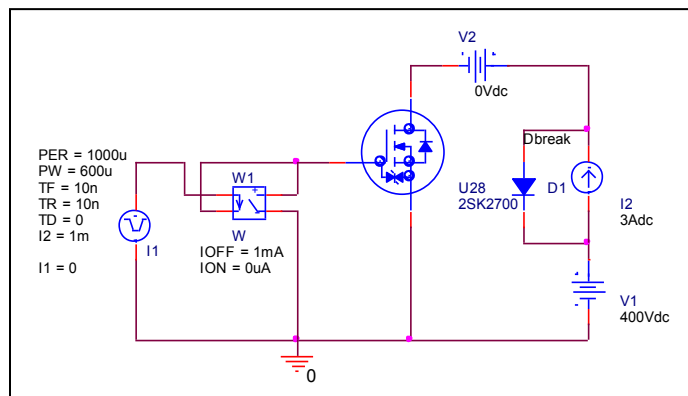
| $I_D=1.5A, V_{GS}=10V$ | Measurement |          | Simulation |          | Error (%) |
|------------------------|-------------|----------|------------|----------|-----------|
| $R_{DS(on)}$           | 0.370       | $\Omega$ | 0.3667     | $\Omega$ | -0.892    |

## Gate Charge Characteristic

### Circuit Simulation result



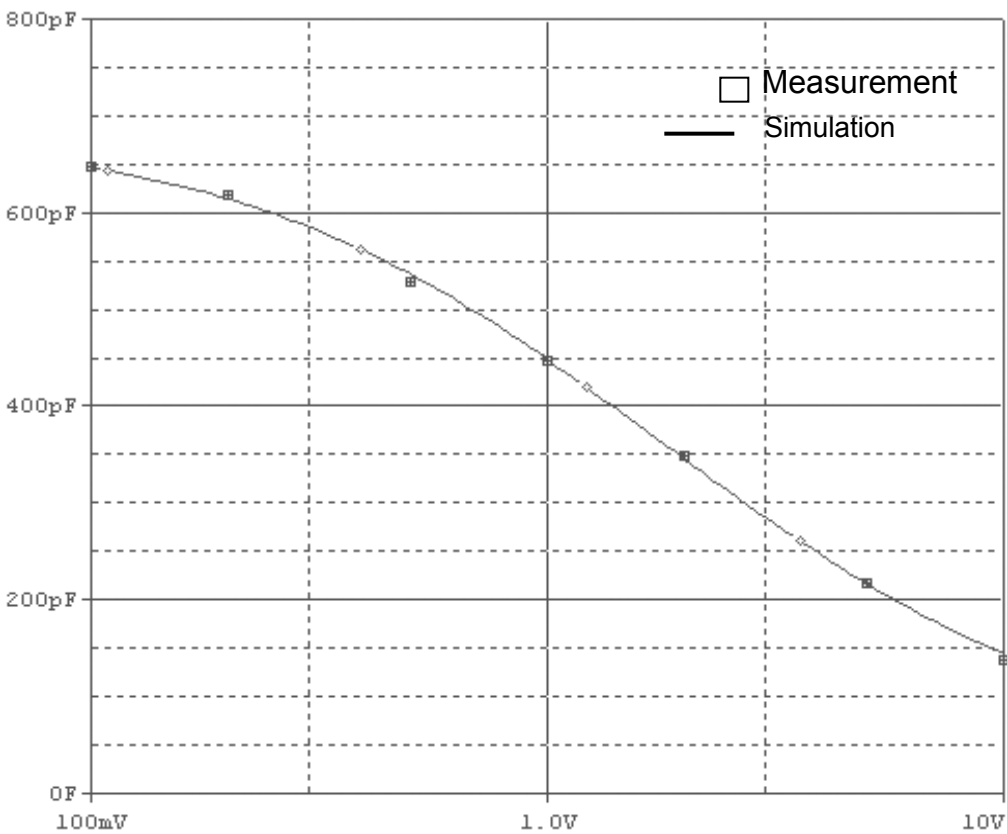
## Evaluation circuit



## Simulation Result

| <b>V<sub>DD</sub>=400V,I<sub>D</sub>=15A<br/>,V<sub>GS</sub>=10V</b> | <b>Measurement</b> | <b>Simulation</b> | <b>Error (%)</b> |
|----------------------------------------------------------------------|--------------------|-------------------|------------------|
| <b>Q<sub>gs</sub>(nC)</b>                                            | <b>5.000</b>       | <b>4.912</b>      | <b>-1.760</b>    |
| <b>Q<sub>gd</sub>(nC)</b>                                            | <b>12.000</b>      | <b>12.018</b>     | <b>0.150</b>     |
| <b>Q<sub>g</sub></b>                                                 | <b>25.500</b>      | <b>21.657</b>     | <b>-15.071</b>   |

# Capacitance Characteristic

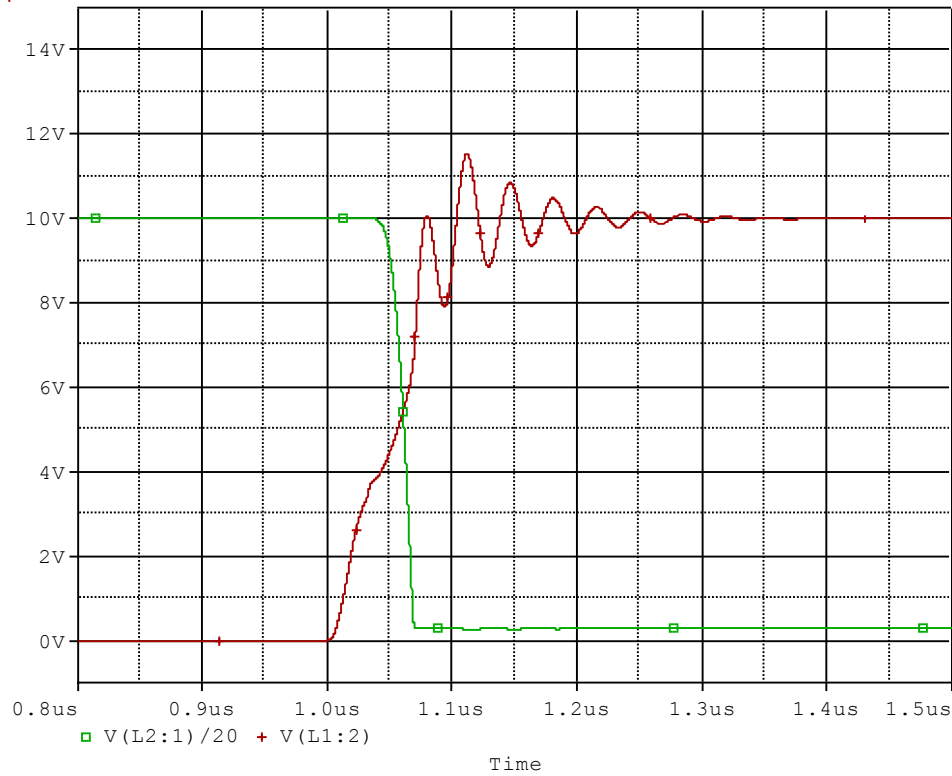


## Simulation Result

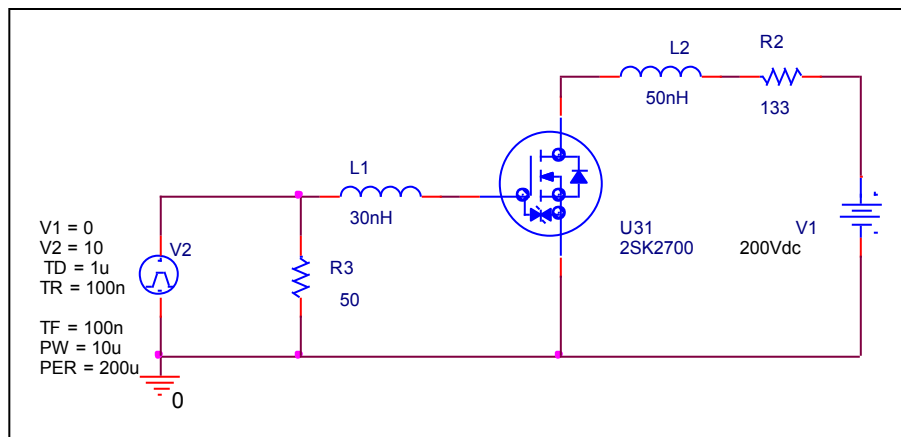
| V <sub>DS</sub> (V) | Cbd(pF)     |            | Error(%) |
|---------------------|-------------|------------|----------|
|                     | Measurement | Simulation |          |
| 0.1                 | 650         | 650        | 0.000    |
| 0.2                 | 620         | 616        | -0.645   |
| 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

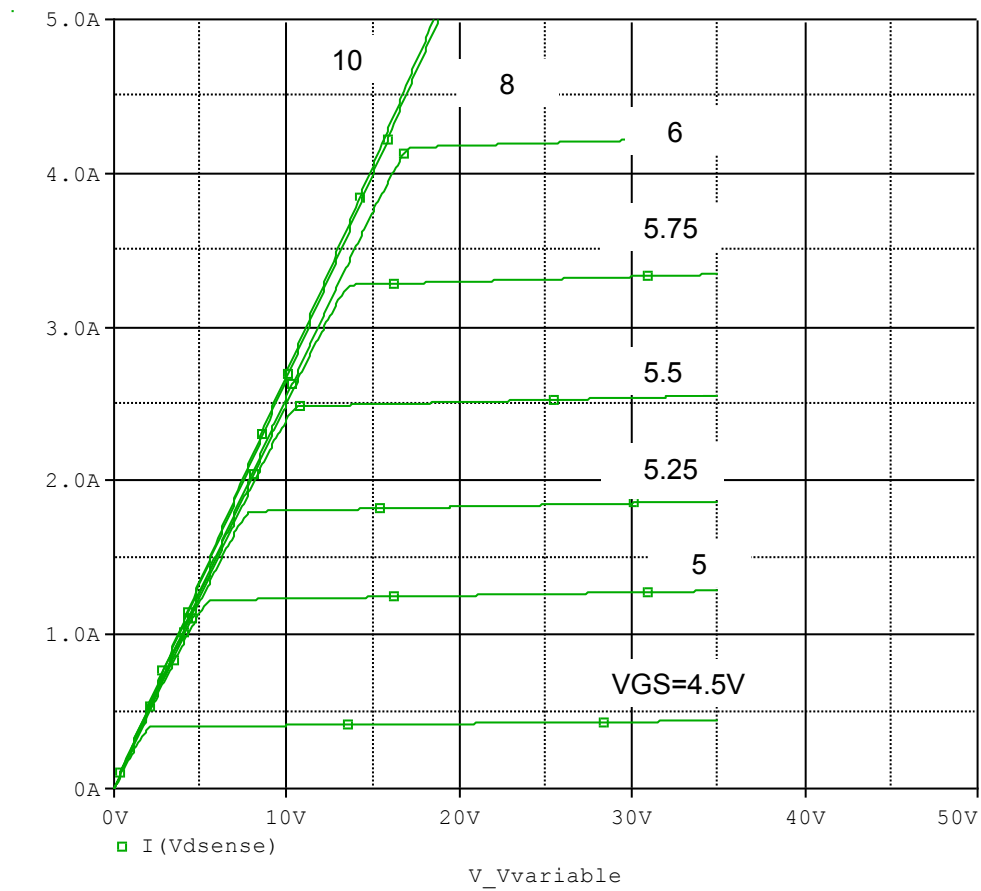


### Simulation Result

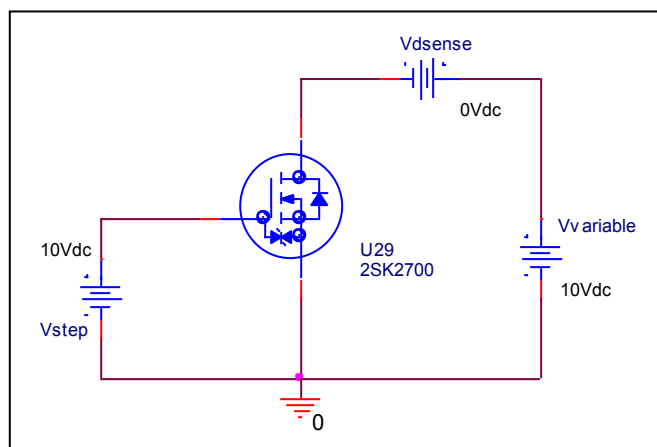
| $I_D=7A$ , $V_{DD}=210V$<br>$V_{GS}=0/10V$ | Measurement   | Simulation    | Error(%)     |
|--------------------------------------------|---------------|---------------|--------------|
| <b>Ton(ns)</b>                             | <b>55.000</b> | <b>55.206</b> | <b>0.375</b> |

## Output Characteristic

### Circuit Simulation result



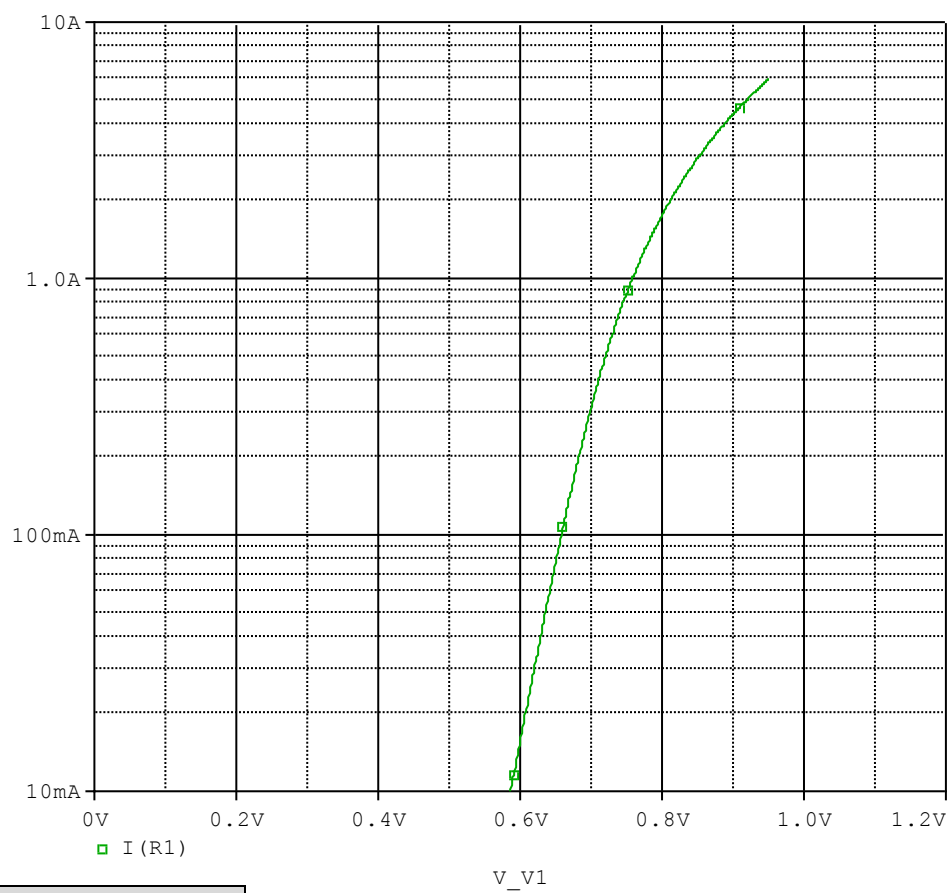
### Evaluation circuit



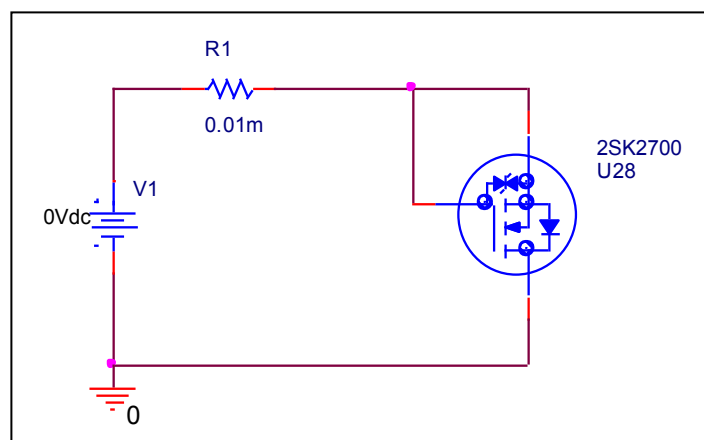
# BODY DIODE

## Forward Current Characteristic

### Circuit Simulation Result

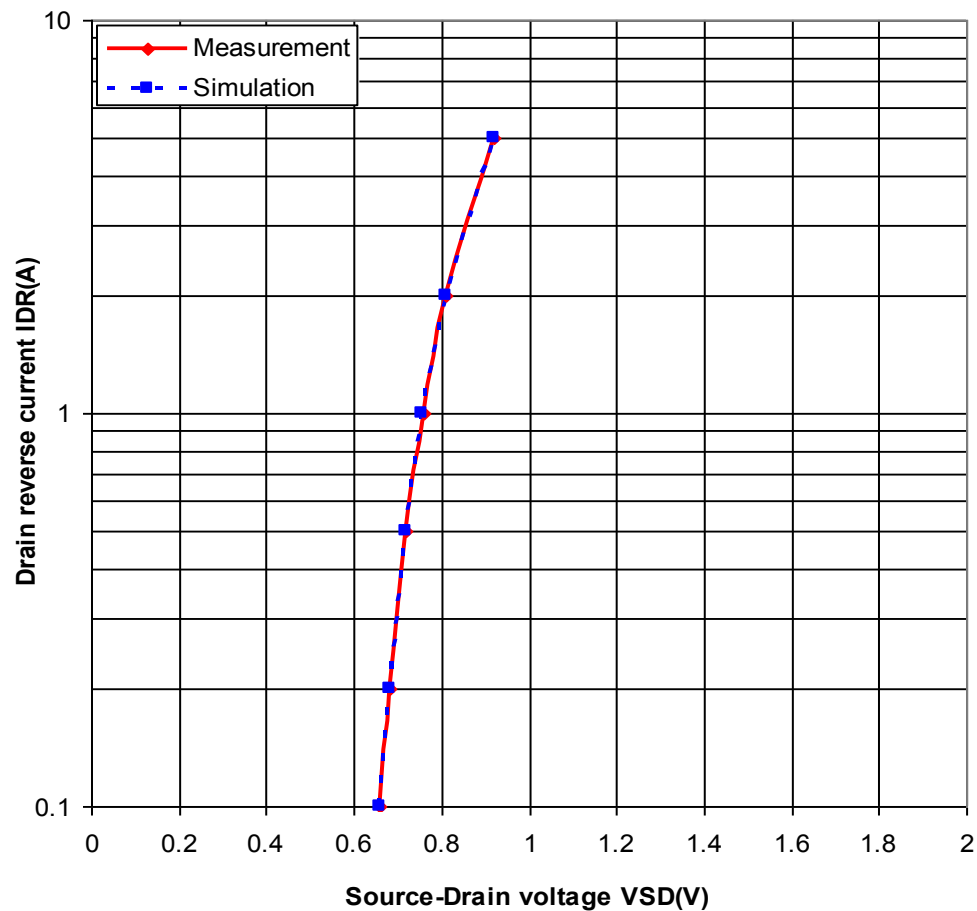


### Evaluation Circuit



# Comparison Graph

## Circuit Simulation Result

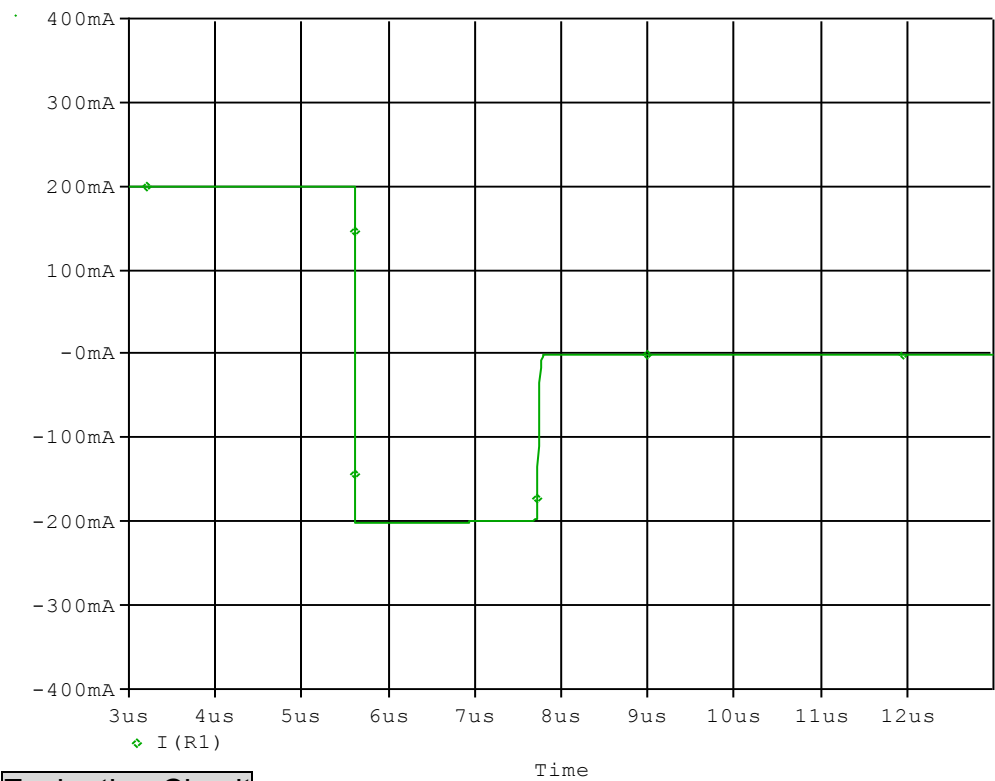


## Simulation Result

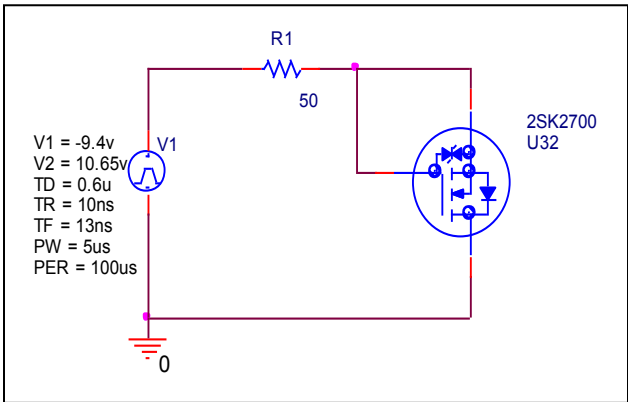
| IDR(A) | VSD(V)     |            | %Error |
|--------|------------|------------|--------|
|        | Measuremen | Simulation |        |
| 0.01   | 0.590      | 0.586      | -0.678 |
| 0.02   | 0.600      | 0.607      | 1.167  |
| 0.05   | 0.640      | 0.636      | -0.625 |
| 0.1    | 0.660      | 0.658      | -0.303 |
| 0.2    | 0.680      | 0.682      | 0.294  |
| 0.5    | 0.720      | 0.720      | 0.000  |
| 1      | 0.760      | 0.757      | -0.395 |
| 2      | 0.810      | 0.810      | 0.000  |
| 5      | 0.920      | 0.920      | 0.000  |

# Reverse Recovery Characteristic

## Circuit Simulation Result



## Evaluation Circuit

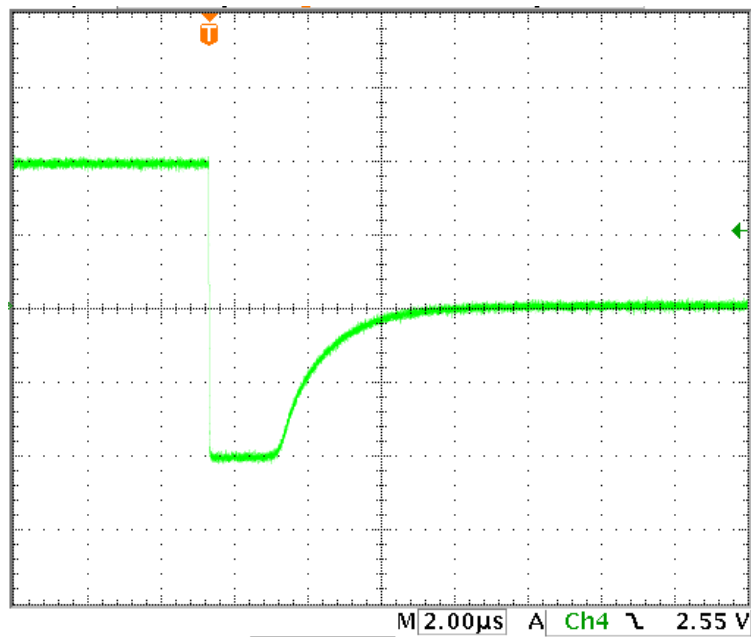


## Compare Measurement vs. Simulation

|         | Measurement | Simulation | Error (%) |
|---------|-------------|------------|-----------|
| Trr(us) | 2.155       | 2.146      | -0.418    |

## Reverse Recovery Characteristic

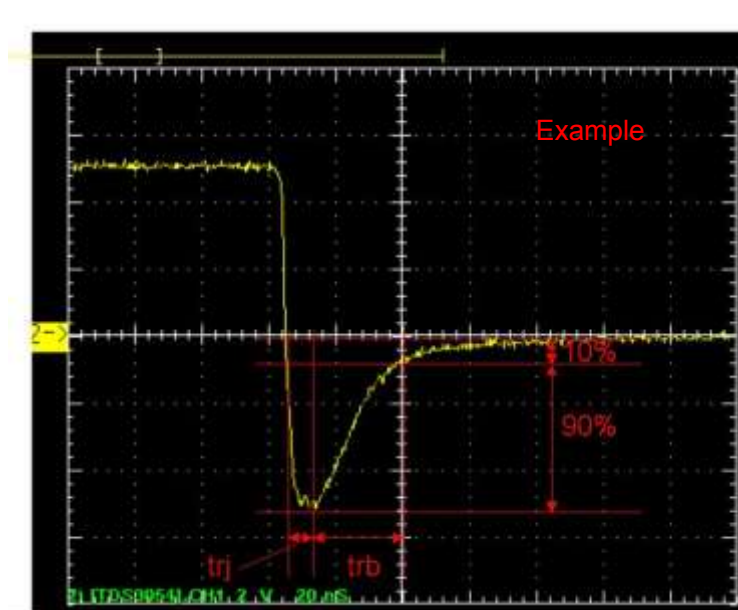
## Reference



$T_{rr}=0.975$  (us)

$T_{rb}=1.180$ (us)

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

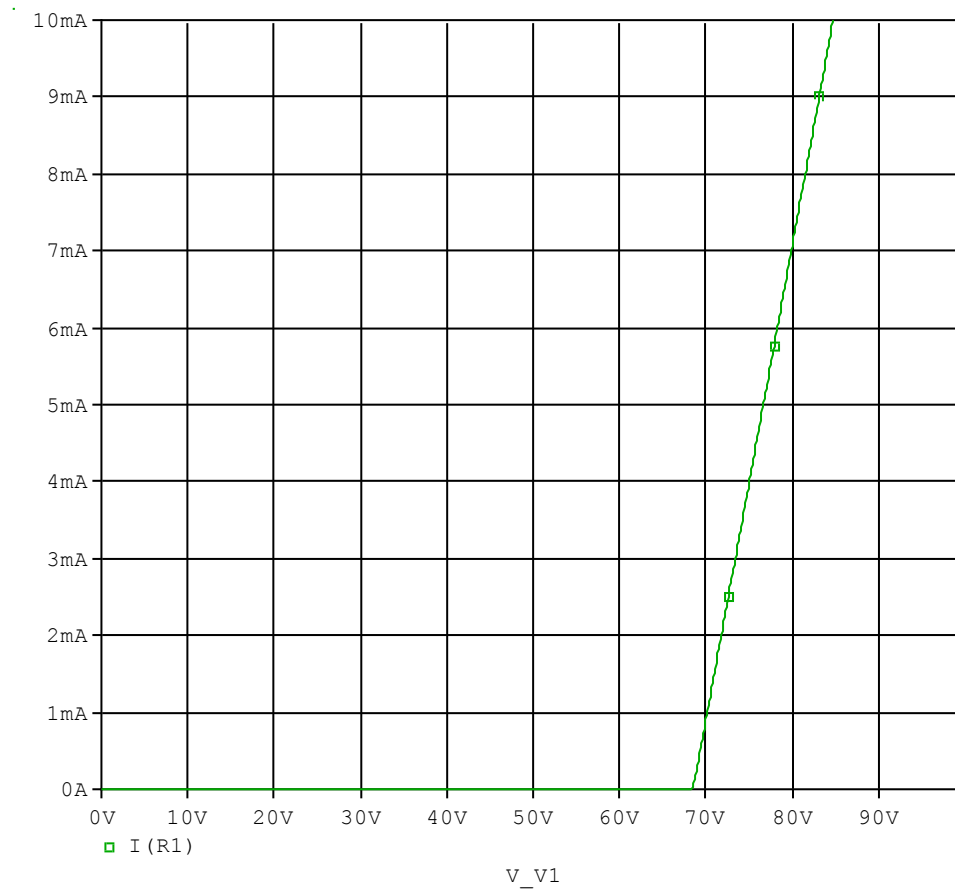


Relation between  $t_{rr}$  and  $t_{rb}$

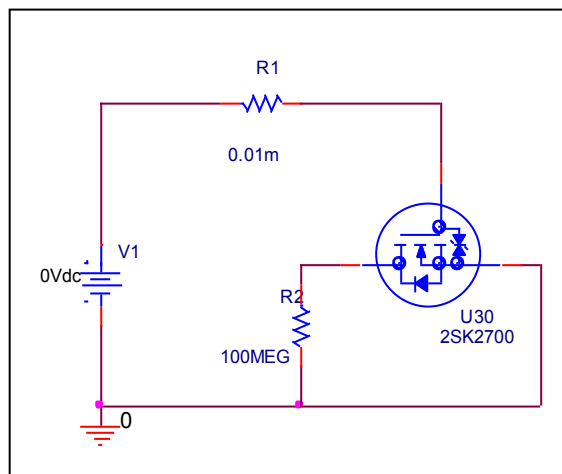
# ESD PROTECTION DIODE

## Zener Voltage Characteristic

### Circuit Simulation Result



### Evaluation Circuit



Zener Voltage Characteristic

Reference

