

# Device Modeling Report

COMPONENTS: MOSFET (Model Parameters)  
PART NUMBER: 2SK1826  
MANUFACTURER: TOSHIBA  
Body Diode (Standard Model) / Source-Gate Diode (DSG)



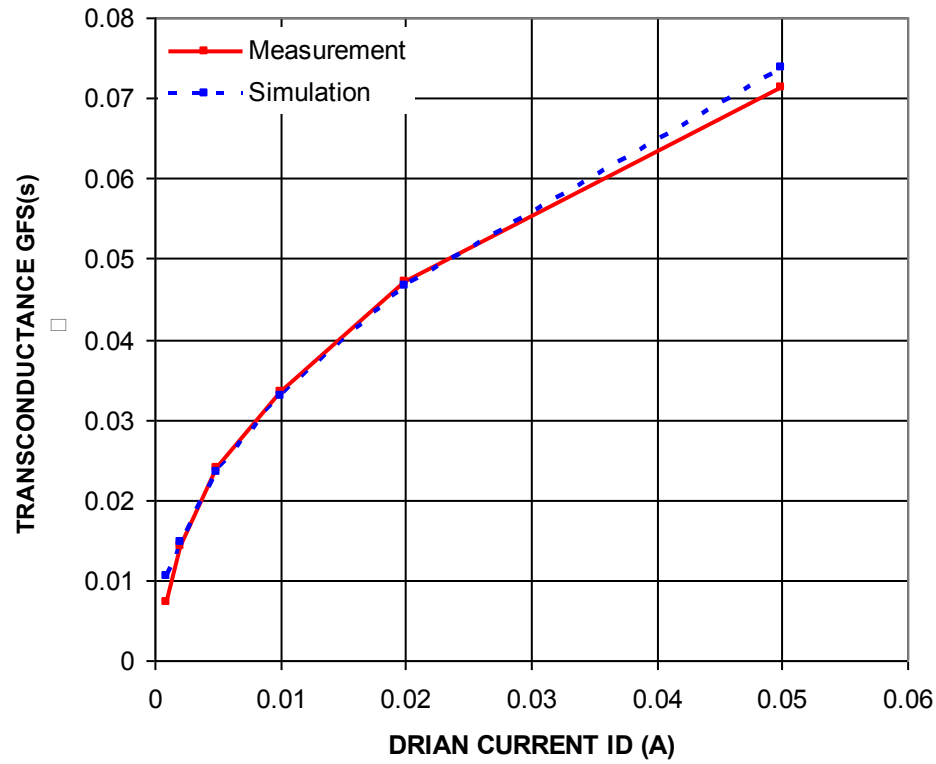
**Bee Technologies Inc.**

## MOSFET MODEL PARAMETERS

| PSpice model parameters | 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

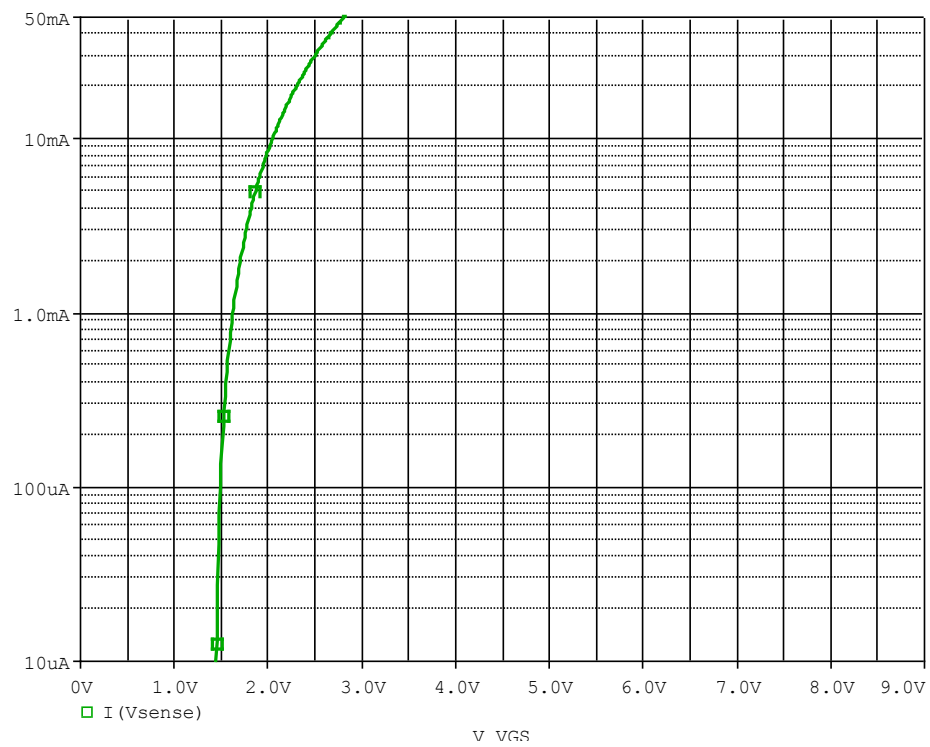


### Comparison table

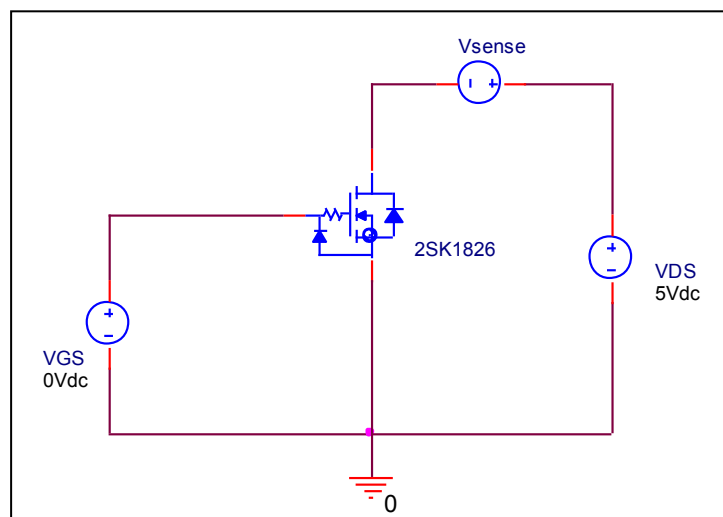
| Id(A) | Gfs(S)      |            | Error(%) |
|-------|-------------|------------|----------|
|       | Measurement | Simulation |          |
| 0.002 | 0.0143      | 0.0147     | 2.9412   |
| 0.005 | 0.0240      | 0.0234     | -2.6480  |
| 0.01  | 0.0333      | 0.0330     | -0.8910  |
| 0.02  | 0.0470      | 0.0466     | -0.8084  |
| 0.05  | 0.0714      | 0.0737     | 3.2862   |

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

### Circuit Simulation result

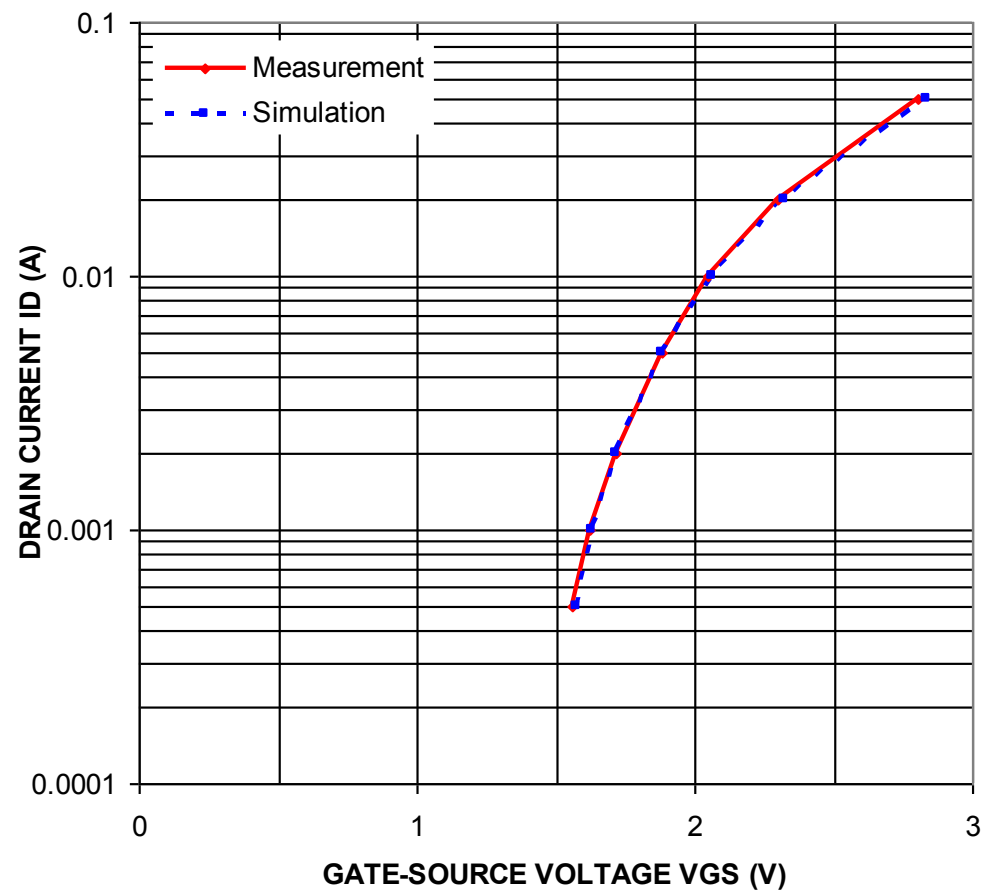


### Evaluation circuit



# Comparison Graph

Circuit Simulation Result

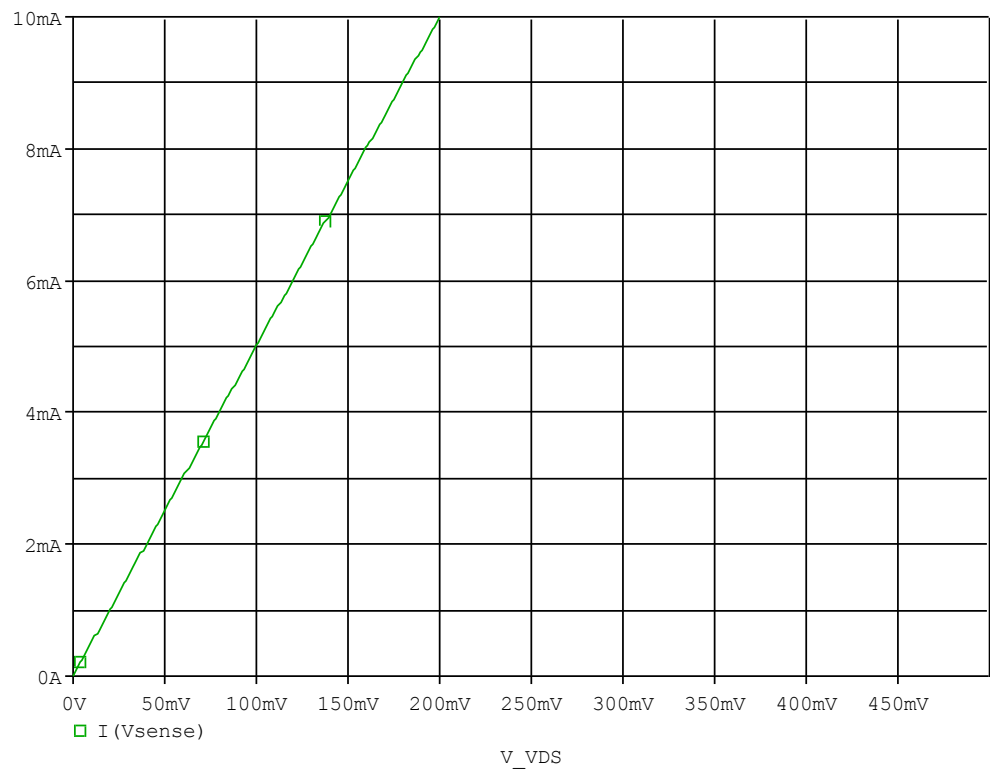


Simulation Result

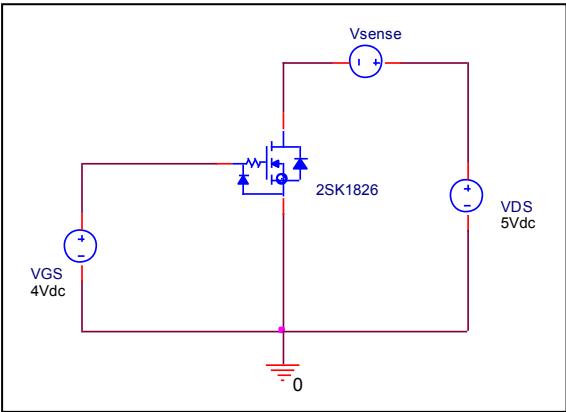
| $I_D$ (A) | $V_{GS}$ (V) |            | Error (%) |
|-----------|--------------|------------|-----------|
|           | Measurement  | Simulation |           |
| 0.0005    | 1.5600       | 1.5760     | 1.0256    |
| 0.001     | 1.6200       | 1.6330     | 0.8025    |
| 0.002     | 1.7200       | 1.7203     | 0.0174    |
| 0.005     | 1.8800       | 1.8818     | 0.0957    |
| 0.01      | 2.0500       | 2.0636     | 0.6634    |
| 0.02      | 2.3000       | 2.3209     | 0.9087    |
| 0.05      | 2.8000       | 2.8312     | 1.1143    |

# Rds(on) Characteristic

## Circuit Simulation result



## Evaluation circuit

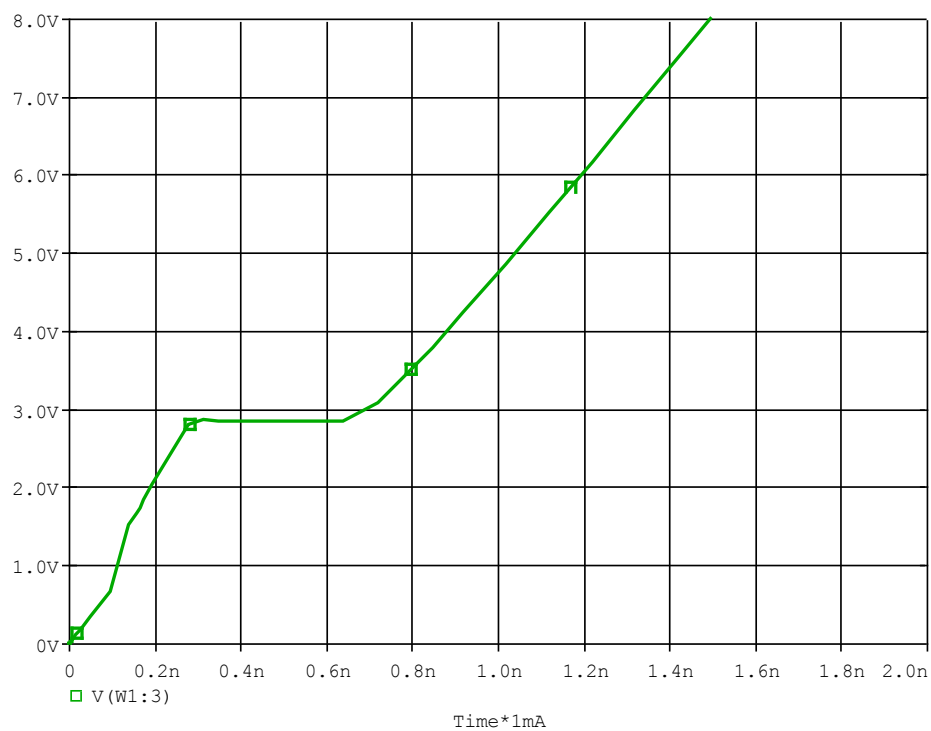


## Simulation Result

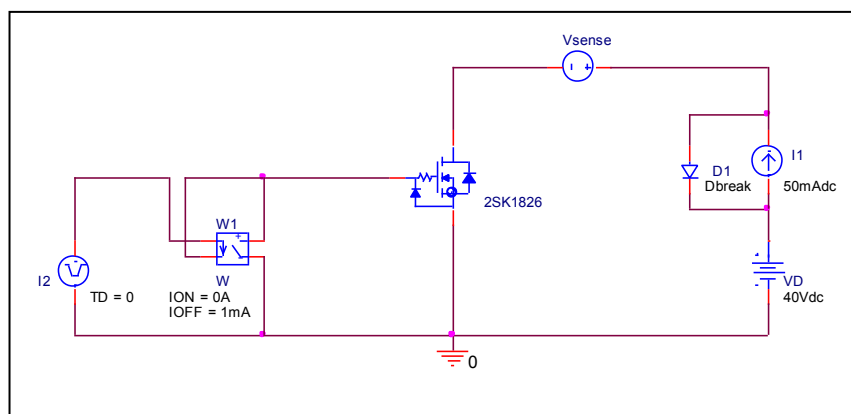
| $I_D=10mA, V_{GS}=4V$ | Measurement |          | Simulation |          | Error (%) |
|-----------------------|-------------|----------|------------|----------|-----------|
| $R_{DS(on)}$          | 20.0        | $\Omega$ | 20.0       | $\Omega$ | 0.0       |

## Gate Charge Characteristic

### Circuit Simulation result



### Evaluation circuit

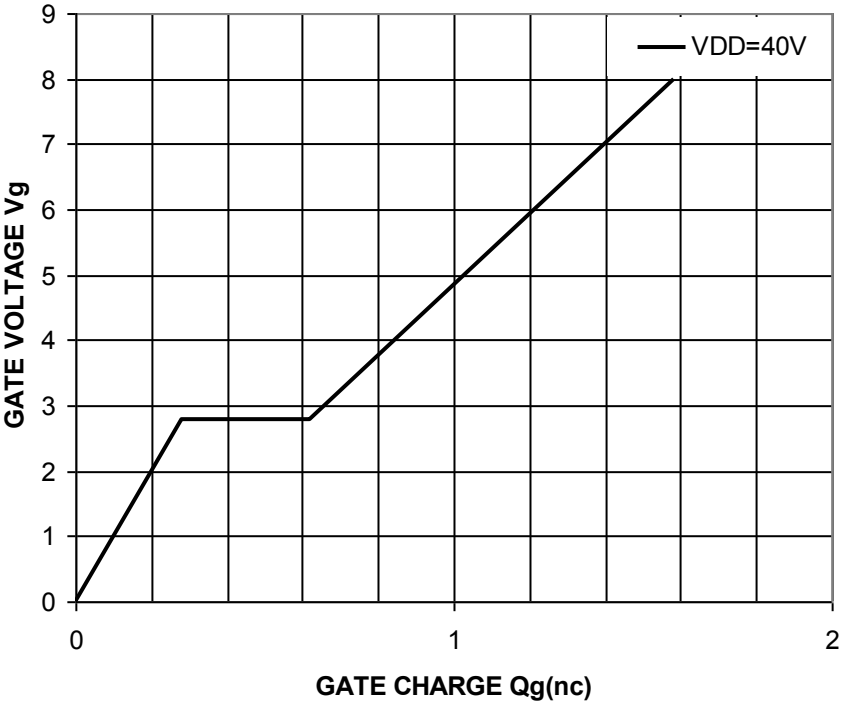


### Simulation Result

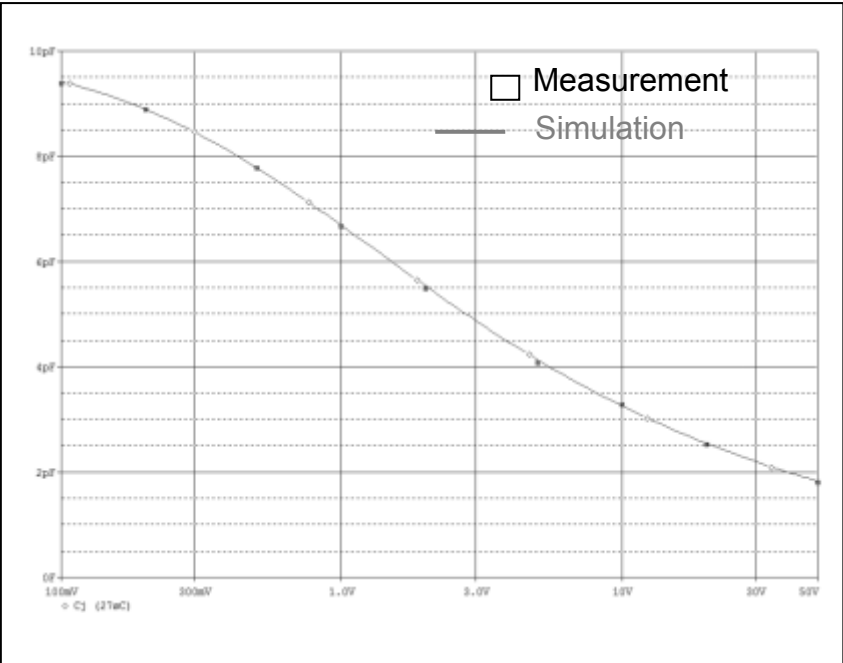
| $V_{DD}=40V$ ,<br>$I_D=50mA$ ,<br>$V_{GS}=5V$ | Measurement |           | Simulation   |           | Error (%)       |
|-----------------------------------------------|-------------|-----------|--------------|-----------|-----------------|
| <b>Qgs</b>                                    | <b>0.28</b> | <b>nC</b> | <b>0.279</b> | <b>nC</b> | <b>- 0.3571</b> |
| <b>Qgd</b>                                    | <b>0.36</b> | <b>nC</b> | <b>0.364</b> | <b>nC</b> | <b>1.1111</b>   |

Gate Charge Characteristic

Reference



# Capacitance Characteristic

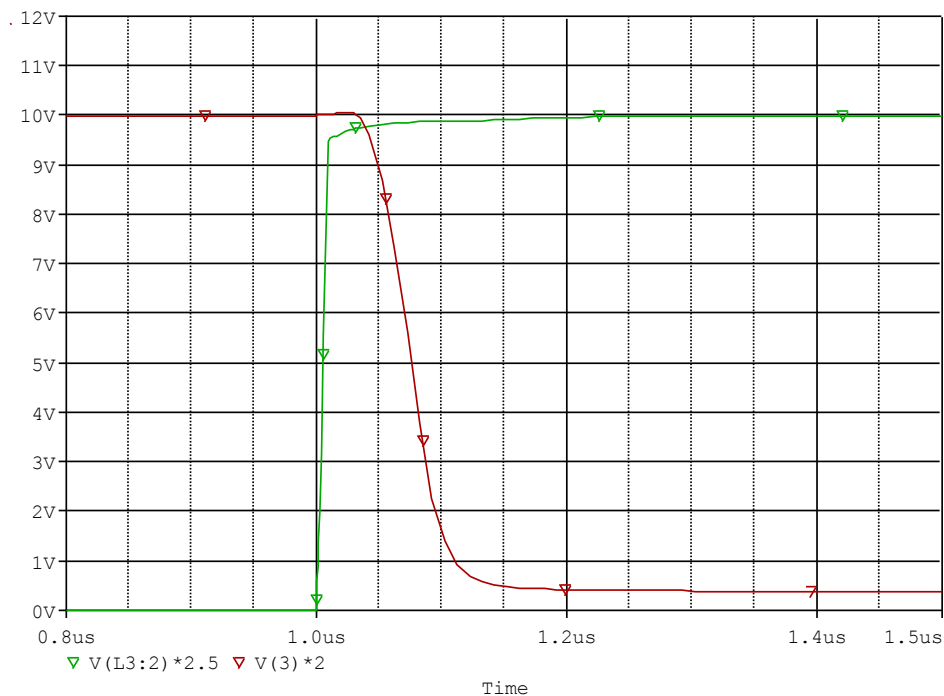


## Simulation Result

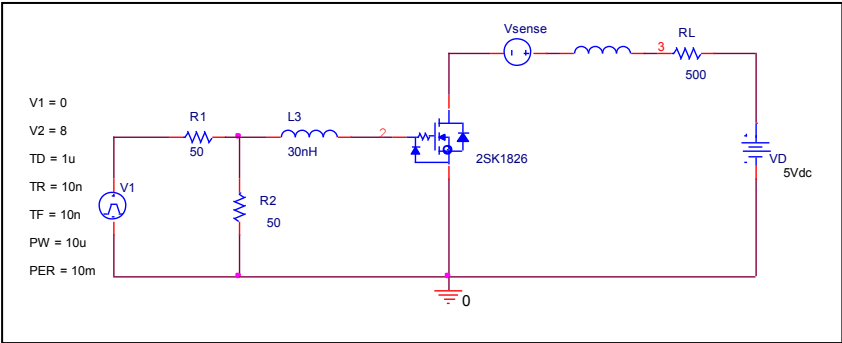
| $V_{DS}(V)$ | Cbd(pF)     |            | Error(%) |
|-------------|-------------|------------|----------|
|             | Measurement | Simulation |          |
| 0.100       | 9.400       | 9.414      | 0.148    |
| 0.200       | 8.900       | 8.852      | - 0.542  |
| 0.500       | 7.800       | 7.699      | - 1.290  |
| 1.000       | 6.680       | 6.664      | - 0.234  |
| 2.000       | 5.500       | 5.531      | 0.555    |
| 5.000       | 4.100       | 4.140      | 0.973    |
| 10.000      | 3.300       | 3.258      | - 1.270  |
| 20.000      | 2.540       | 2.539      | - 0.059  |
| 50.000      | 1.820       | 1.829      | 0.495    |

# Switching Time Characteristic

## Circuit Simulation result



## Evaluation circuit

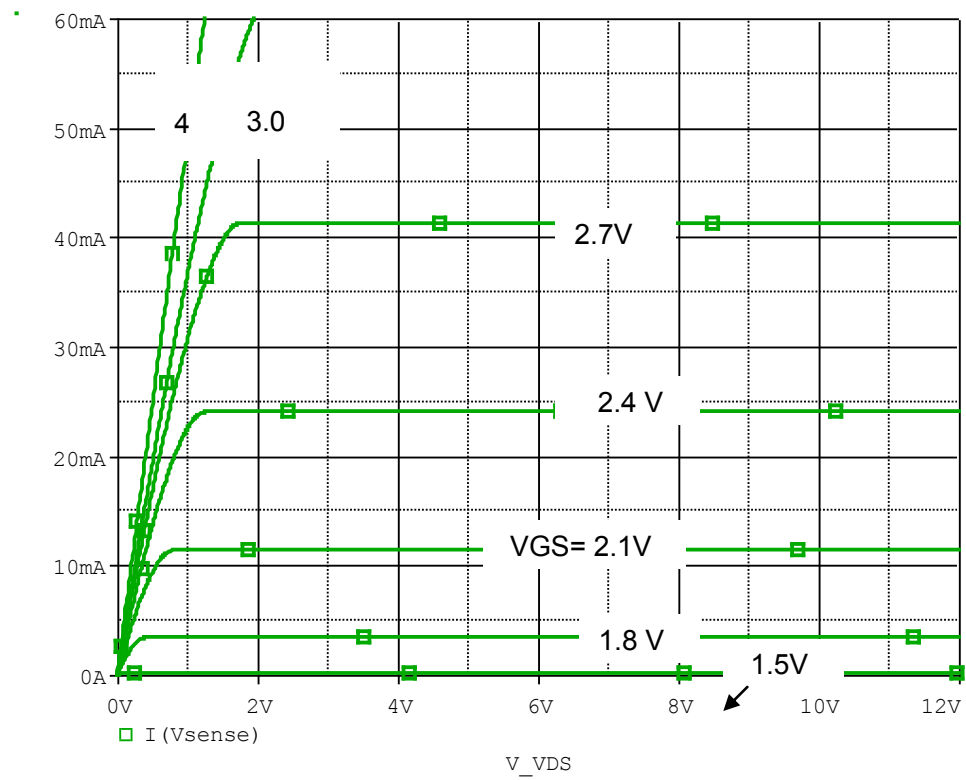


## Simulation Result

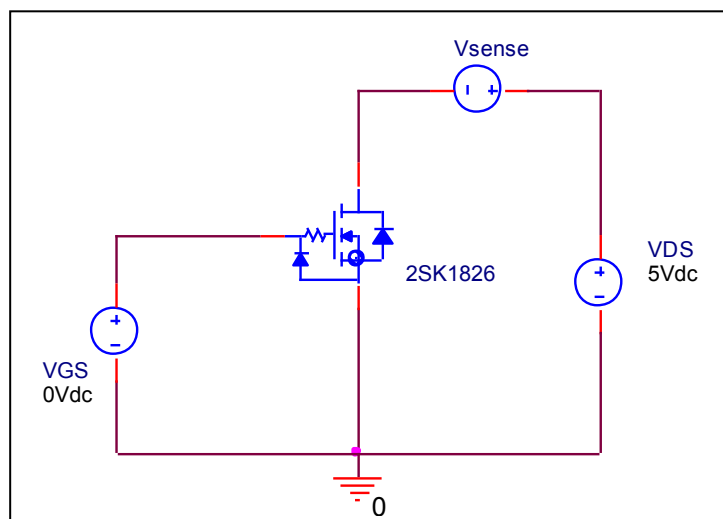
| $I_D=10\text{mA}$ ,<br>$V_{DD}=5\text{V}$ ,<br>$V_{GS}=0/4\text{V}$ | Measurement |    | Simulation |    | Error(%) |
|---------------------------------------------------------------------|-------------|----|------------|----|----------|
| Td(on)                                                              | 110.000     | ns | 109.785    | ns | - 0.20   |

## Output Characteristic

### Circuit Simulation result



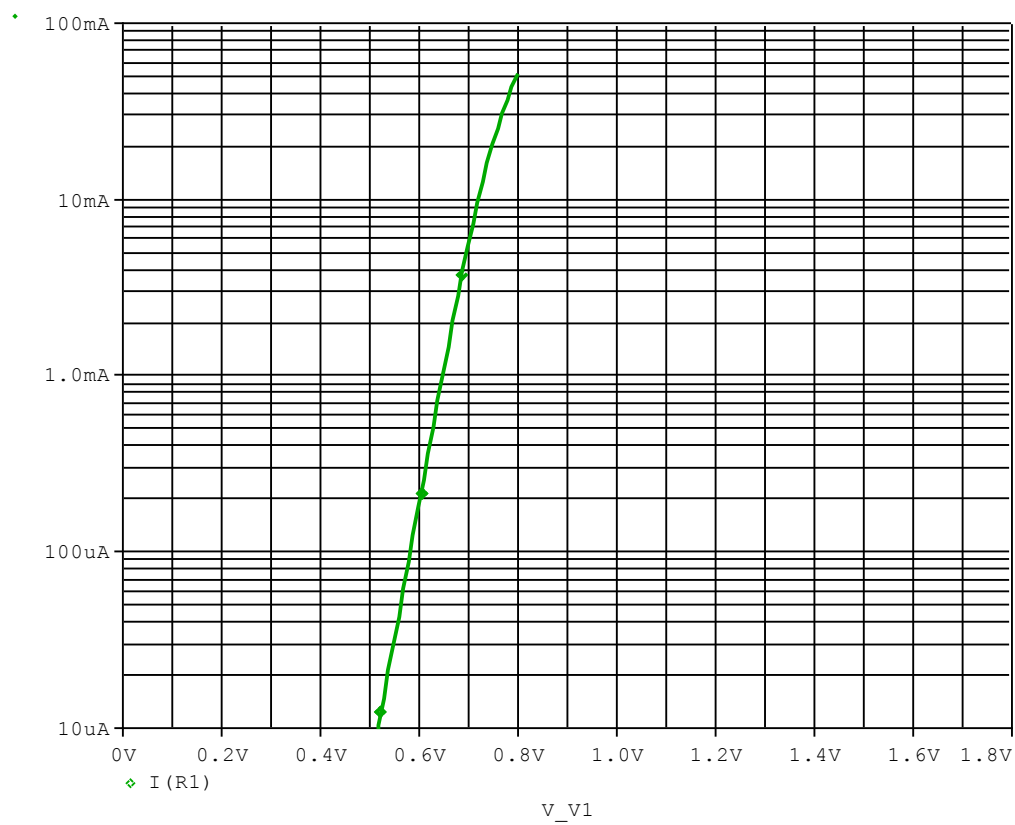
### Evaluation circuit



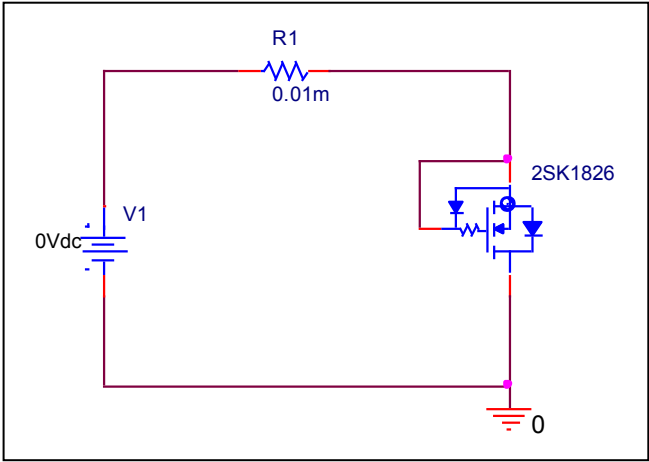
# BODY DIODE SPICE MODEL

## Forward Current Characteristic

### Circuit Simulation Result

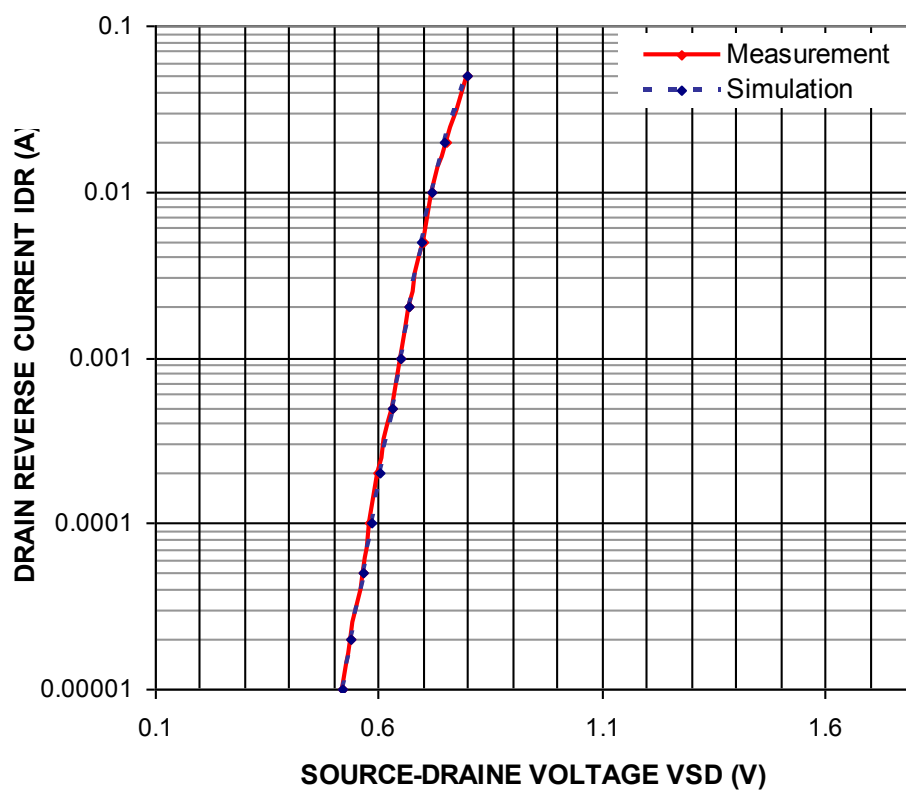


### Evaluation Circuit



## Comparison Graph

### Circuit Simulation Result

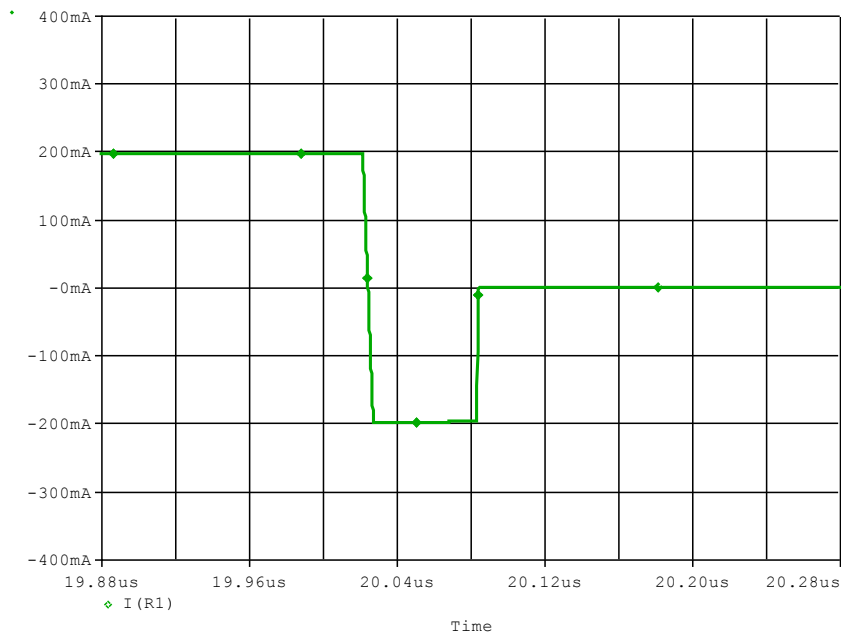


### Simulation Result

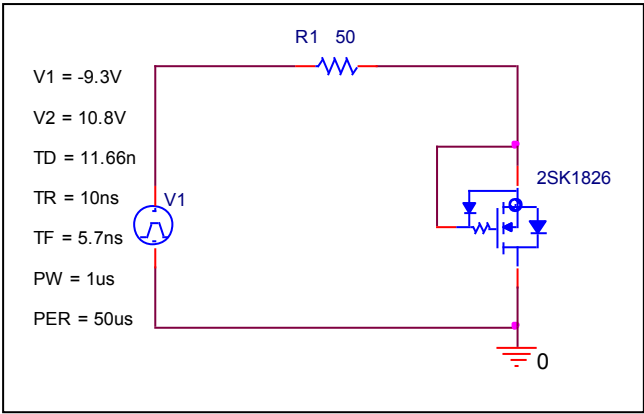
| IDR(A) | VSD(V)      |            | %Error  |
|--------|-------------|------------|---------|
|        | Measurement | Simulation |         |
| 0.0001 | 0.5800      | 0.5835     | 0.6034  |
| 0.0002 | 0.6000      | 0.6031     | 0.5167  |
| 0.0005 | 0.6300      | 0.6294     | -0.0952 |
| 0.001  | 0.6500      | 0.6493     | -0.1077 |
| 0.002  | 0.6700      | 0.6696     | -0.0597 |
| 0.005  | 0.7000      | 0.6977     | -0.3286 |
| 0.01   | 0.7200      | 0.7214     | 0.1944  |
| 0.02   | 0.7500      | 0.7493     | -0.0933 |
| 0.05   | 0.8000      | 0.8000     | 0.0000  |

# Reverse Recovery Characteristic (Body Diode)

## Circuit Simulation Result



## Evaluation Circuit

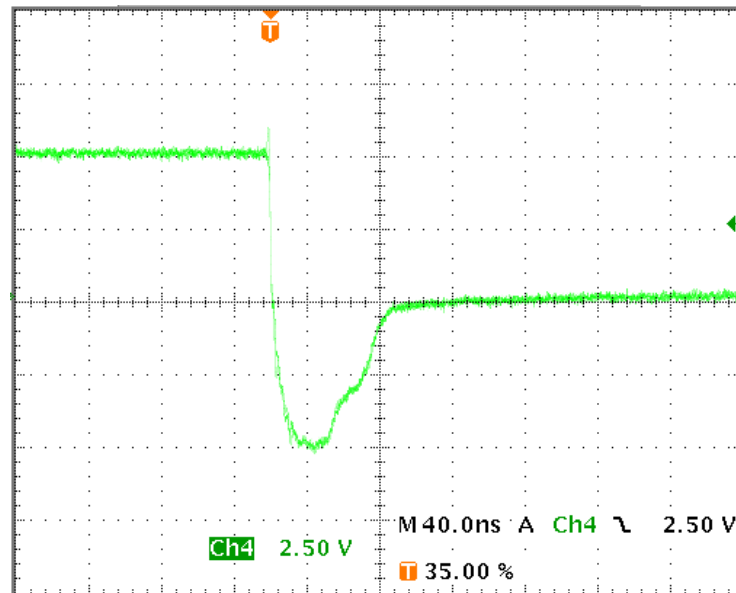


## Compare Measurement vs. Simulation

|                    | Measurement  |           | Simulation   |           | Error (%)       |
|--------------------|--------------|-----------|--------------|-----------|-----------------|
| <b>trj+trb=trr</b> | <b>61.60</b> | <b>ns</b> | <b>61.01</b> | <b>ns</b> | <b>-0.95779</b> |

## Reverse Recovery Characteristic (Body Diode)

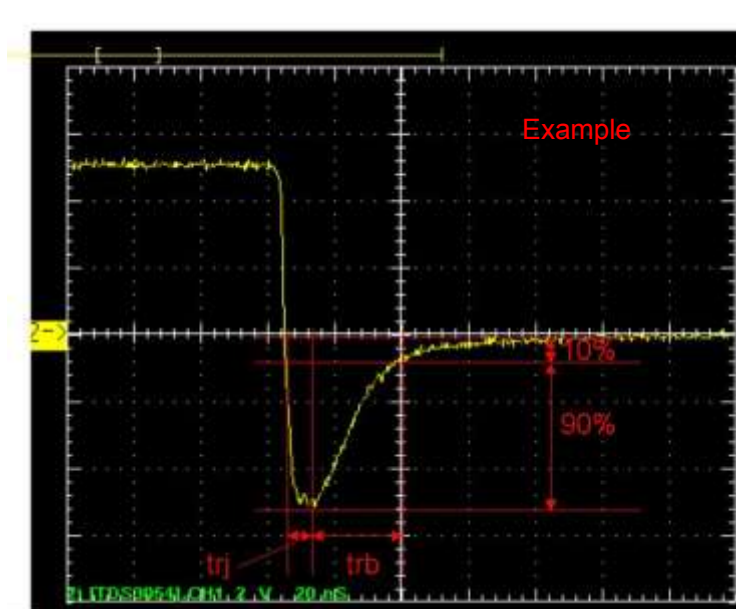
## Reference



$T_{rj} = (25.6\text{ns})$

$T_{rb} = (36.0\text{ns})$

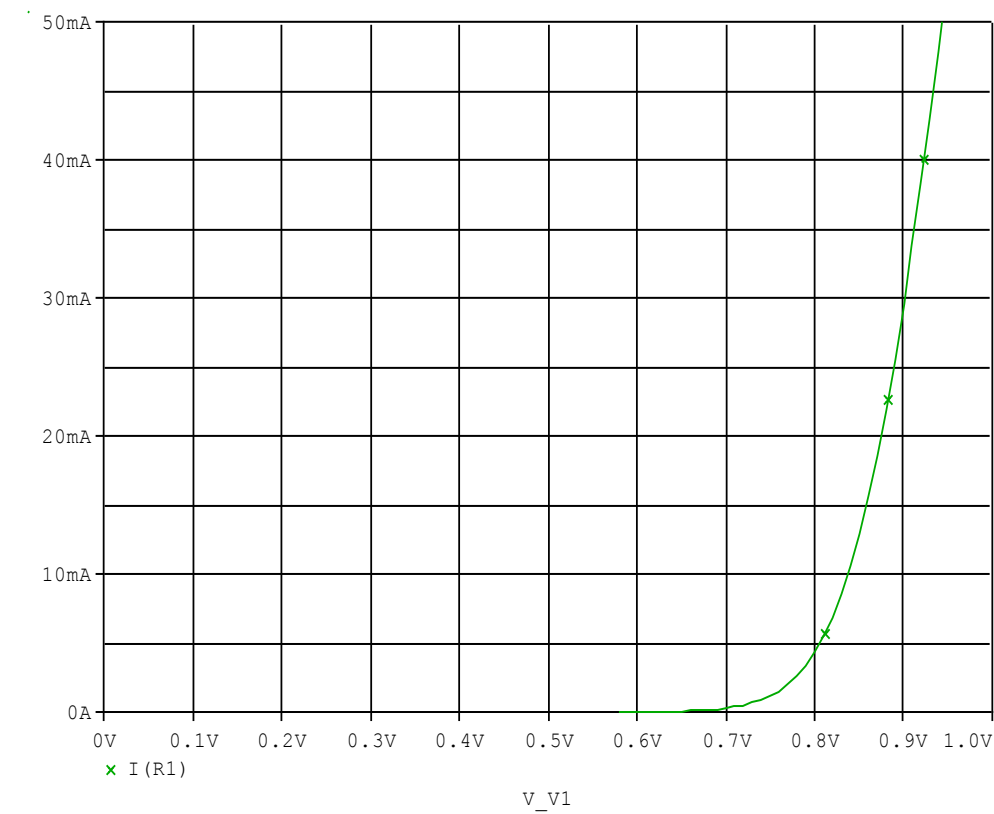
Conditions:  $I_{fwd} = I_{rev} = 0.2(\text{A})$ ,  $R_I = 50$



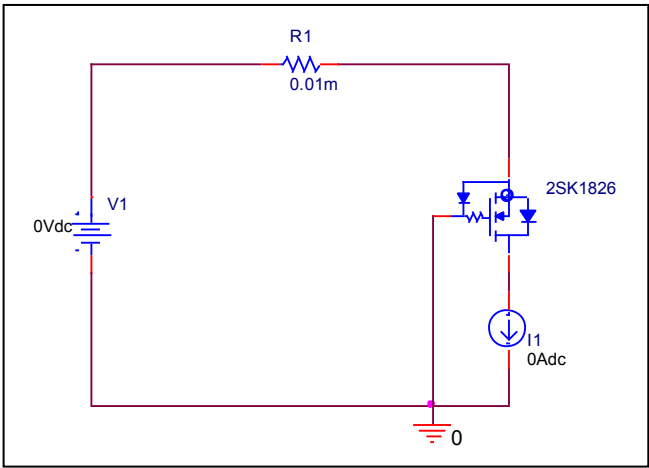
Relation between  $t_{rj}$  and  $t_{rb}$

**SOURCE-GATE DIODE SPICE MODEL (DSG)**  
**Forward Current Characteristic**

**Circuit Simulation Result**

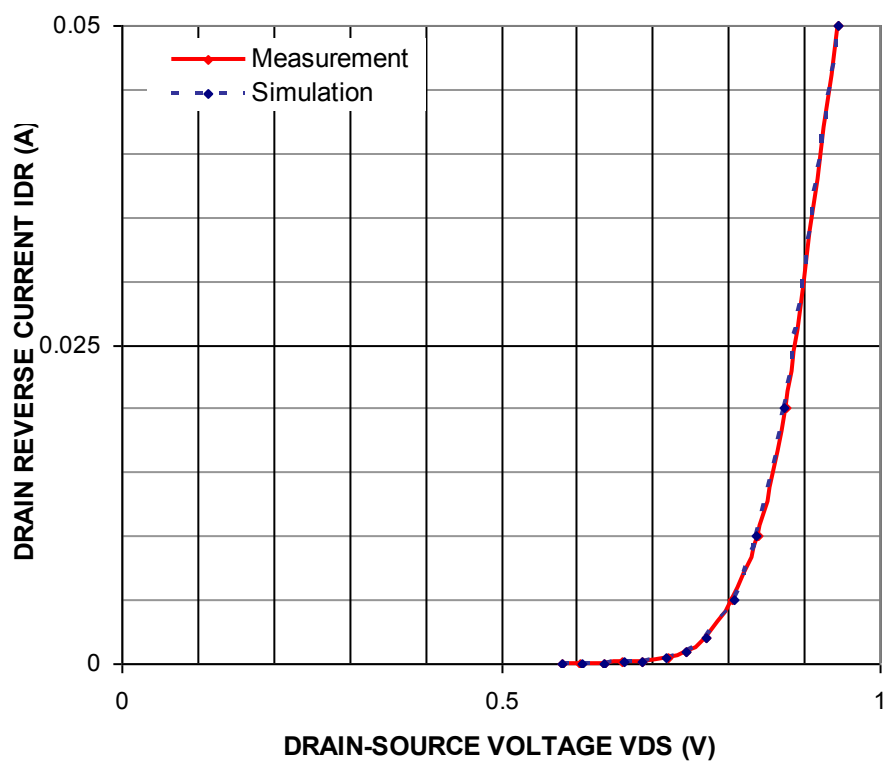


**Evaluation Circuit**



## Comparison Graph

### Circuit Simulation Result



### Simulation Result

| ISG(A)  | VSG(V)      |            | %Error   |
|---------|-------------|------------|----------|
|         | Measurement | Simulation |          |
| 0.00001 | 0.5800      | 0.5793     | - 0.1207 |
| 0.00002 | 0.6050      | 0.6071     | 0.3471   |
| 0.00005 | 0.6350      | 0.6363     | 0.2047   |
| 0.0001  | 0.6600      | 0.6611     | 0.1667   |
| 0.0002  | 0.6870      | 0.6857     | - 0.1892 |
| 0.0005  | 0.7200      | 0.7188     | - 0.1667 |
| 0.001   | 0.7440      | 0.7438     | - 0.0269 |
| 0.002   | 0.7700      | 0.7700     | 0.0000   |
| 0.005   | 0.8050      | 0.8061     | 0.1366   |
| 0.01    | 0.8380      | 0.8370     | - 0.1193 |
| 0.02    | 0.8750      | 0.8741     | - 0.1029 |
| 0.05    | 0.9440      | 0.9442     | 0.0212   |

**SOURCE-GATE DIODE SPICE MODEL (DSG)**

**Reference**

