# Device Modeling Report

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

**Bee Technologies Inc.**

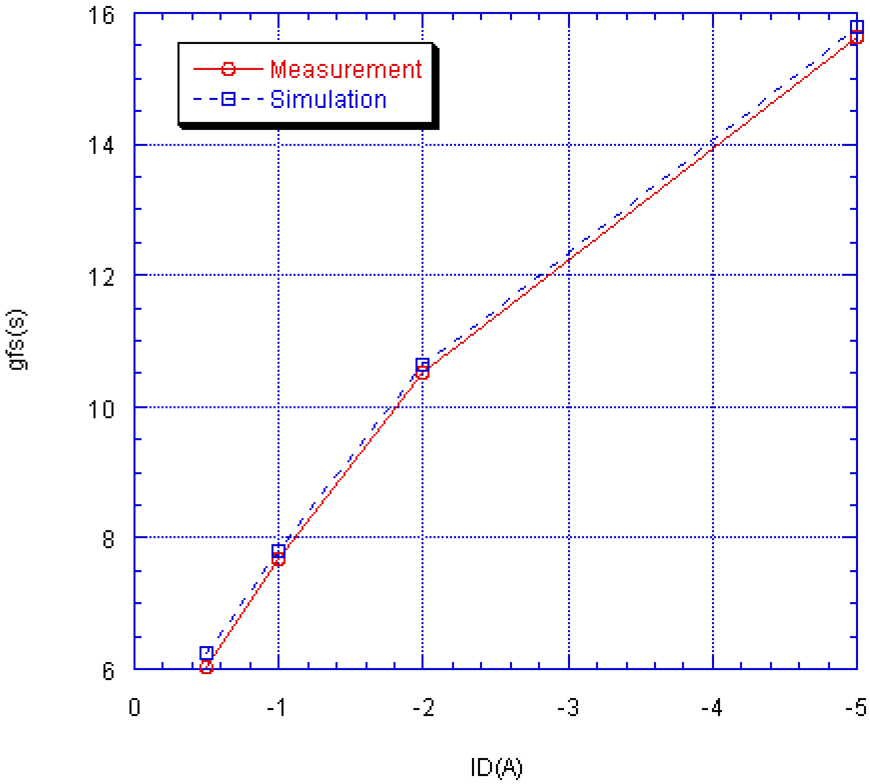
## MOSFET MODEL

| 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

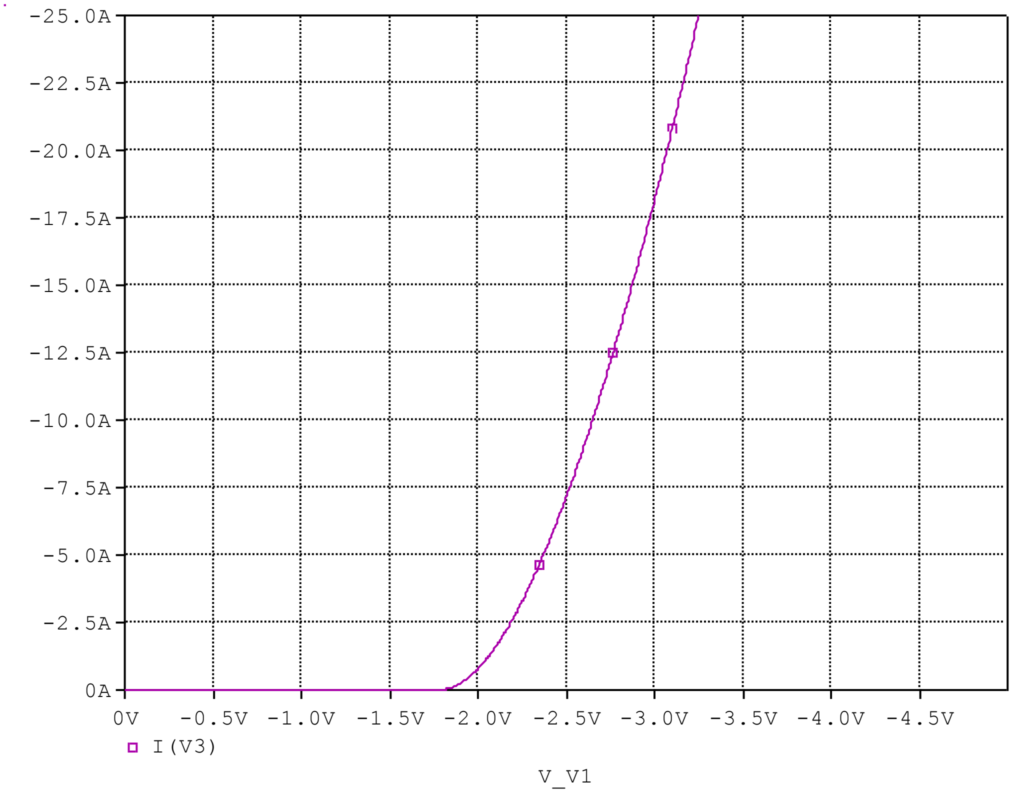


Comparison table

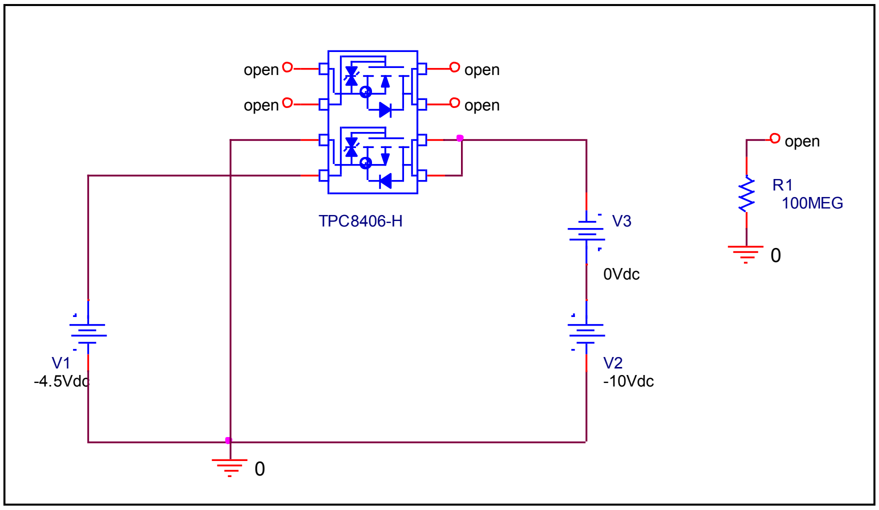
| Id(A) | gfs | | Error(%) |
|---|---|---|---|
| | Measurement | Simulation | |
| -0.500 | 6.024 | 6.250 | 3.752 |
| -1.000 | 7.692 | 7.813 | 1.563 |
| -2.000 | 10.526 | 10.638 | 1.067 |
| -5.000 | 15.625 | 15.773 | 0.947 |

# Vgs-Id Characteristic

## Circuit Simulation result

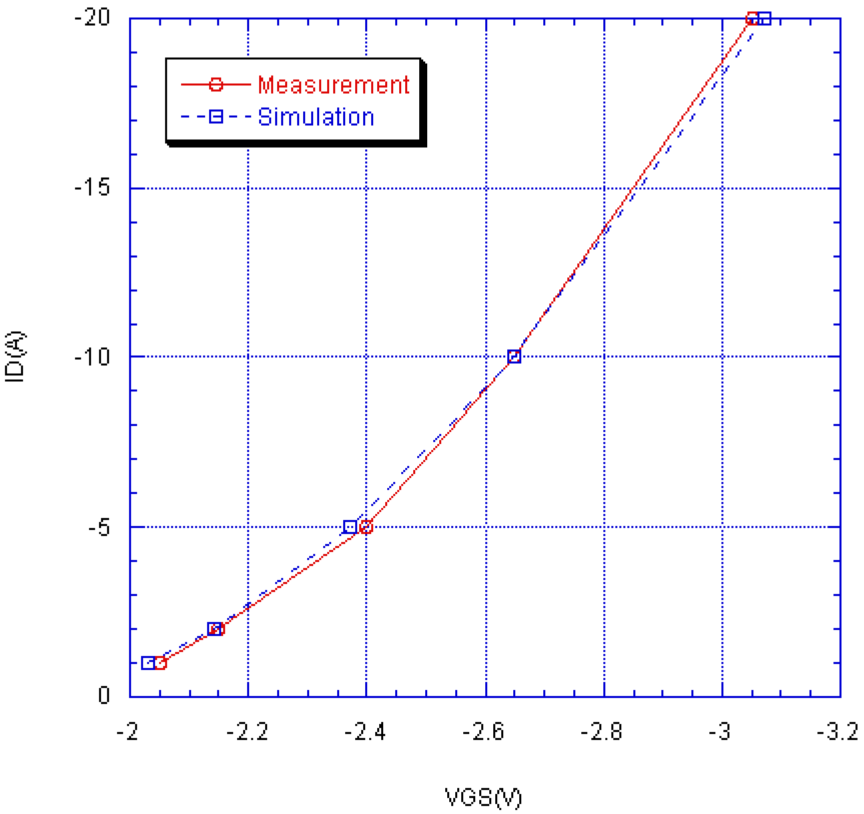


## Evaluation circuit



## Comparison Graph

Circuit Simulation Result

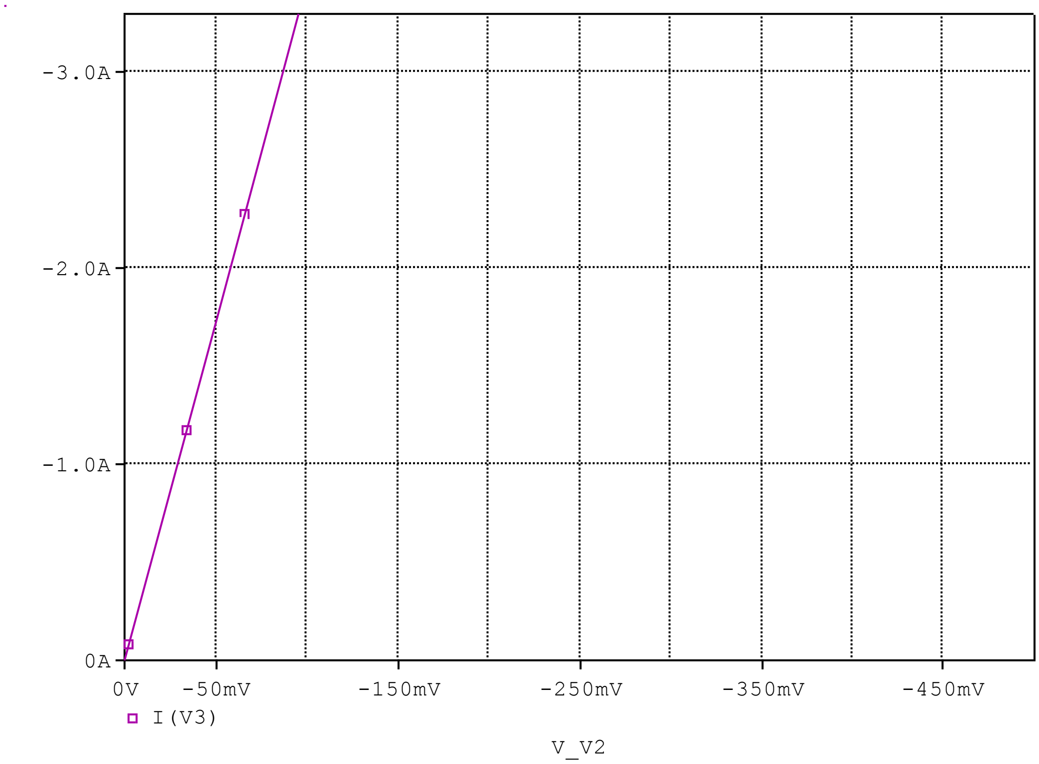


Simulation Result

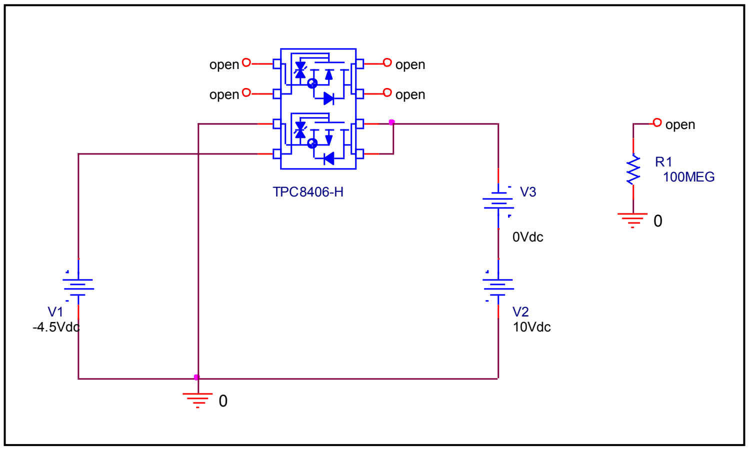
| $I_D$(A) | $V_{GS}$(V) | | Error (%) |
|---|---|---|---|
| | Measurement | Simulation | |
| -1.000 | -2.050 | -2.030 | -0.985 |
| -2.000 | -2.150 | -2.141 | -0.428 |
| -5.000 | -2.400 | -2.372 | -1.183 |
| -10.000 | -2.650 | -2.649 | -0.053 |
| -20.000 | -3.050 | -3.071 | 0.679 |

## Rds(on) Characteristic

Circuit Simulation result



Evaluation circuit

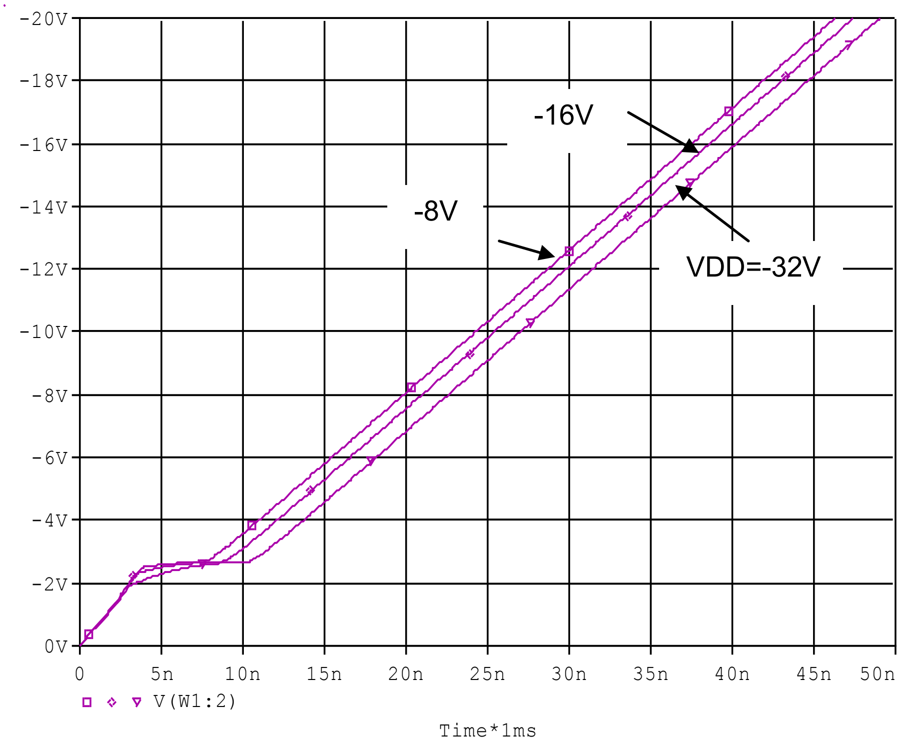


Simulation Result

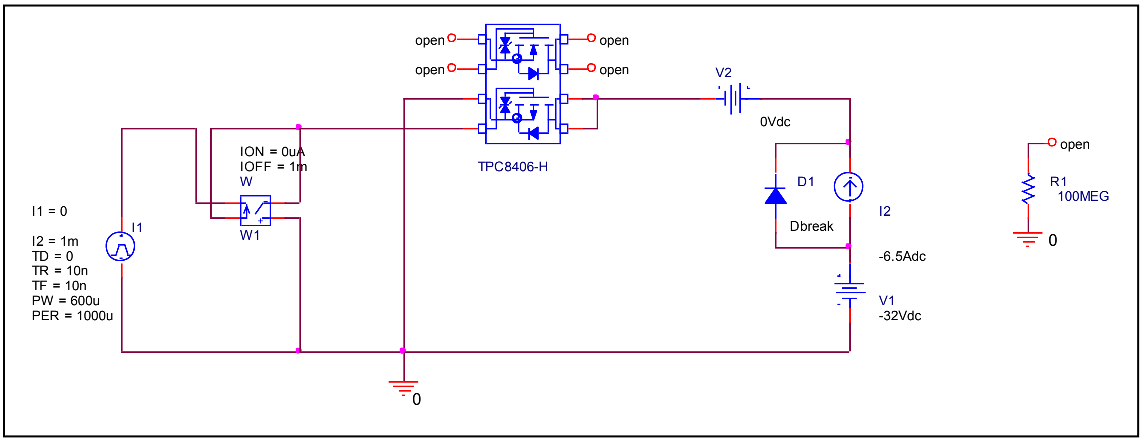
| $I_D$=-3.3A, $V_{GS}$=-4.5V | Measurement | | Simulation | | Error (%) |
|---|---|---|---|---|---|
| $R_{DS}$ (on) | 29.000 | mΩ | 29.000 | mΩ | 0.000 |

# Gate Charge Characteristic

## Circuit Simulation result



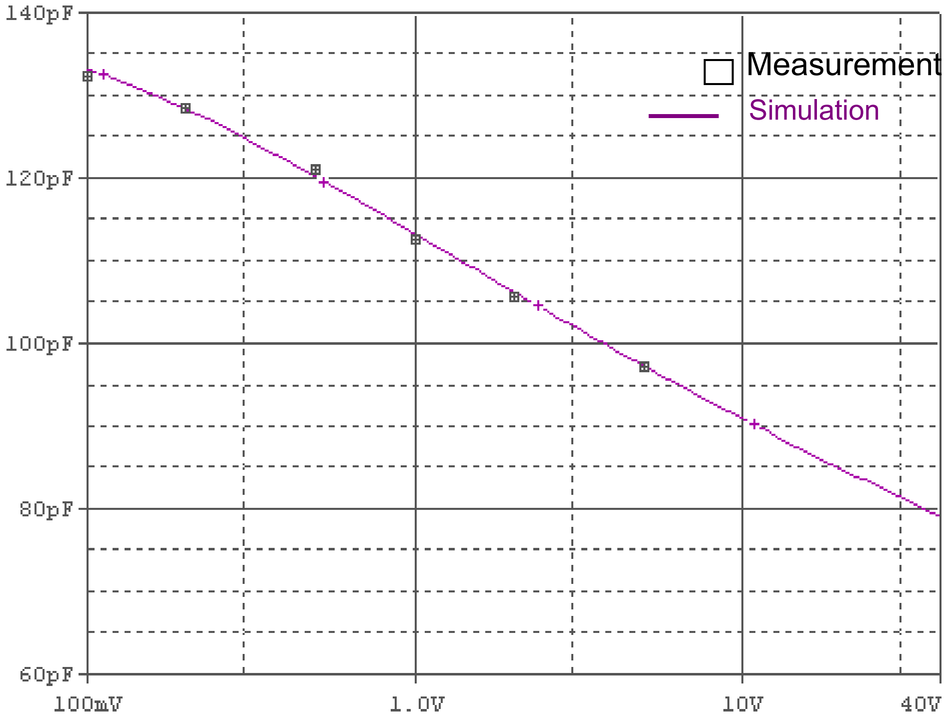
## Evaluation circuit



## Simulation Result

| $V_{DD}$=-32V,$I_D$=-6.5A ,$V_{GS}$=-10V | Measurement | | Simulation | | Error (%) |
|---|---|---|---|---|---|
| Qgs | 3.200 | nC | 3.261 | nC | 1.903 |
| Qgd | 8.100 | nC | 7.935 | nC | -2.040 |
| Qg | 27.000 | nC | 27.065 | nC | 0.241 |

## Capacitance Characteristic

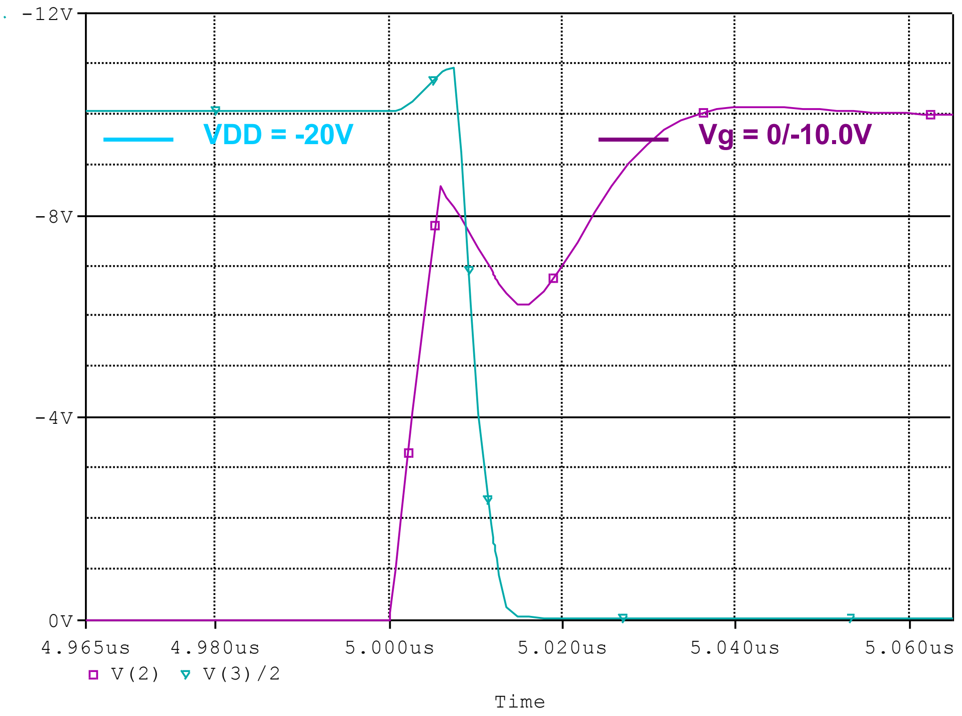


Simulation Result

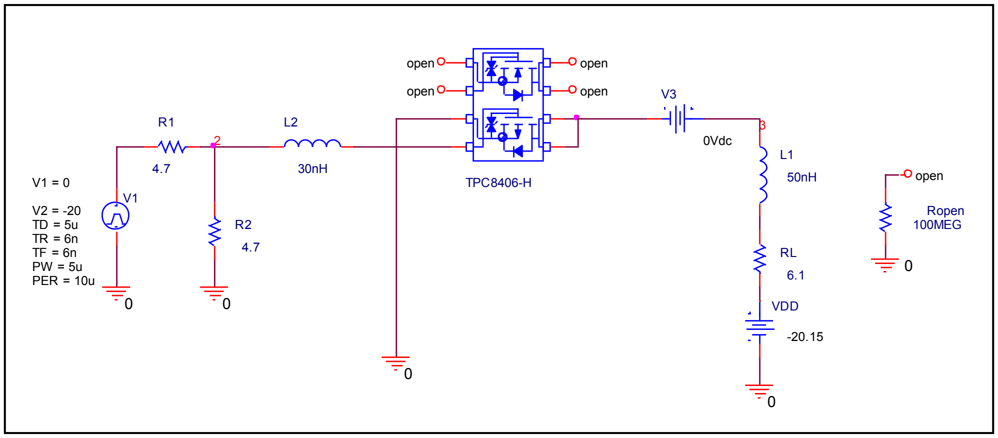
| $V_{SD}$(V) | Cbd(pF) | | Error(%) |
|---|---|---|---|
| | Measurement | Simulation | |
| 0.100 | 132.620 | 132.900 | 0.211 |
| 0.200 | 128.800 | 127.500 | -1.009 |
| 0.500 | 121.200 | 120.500 | -0.578 |
| 1.000 | 112.750 | 113.500 | 0.665 |
| 2.000 | 105.950 | 106.300 | 0.330 |
| 5.000 | 97.450 |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

# Switching Time Characteristic

## Circuit Simulation result



## Evaluation circuit

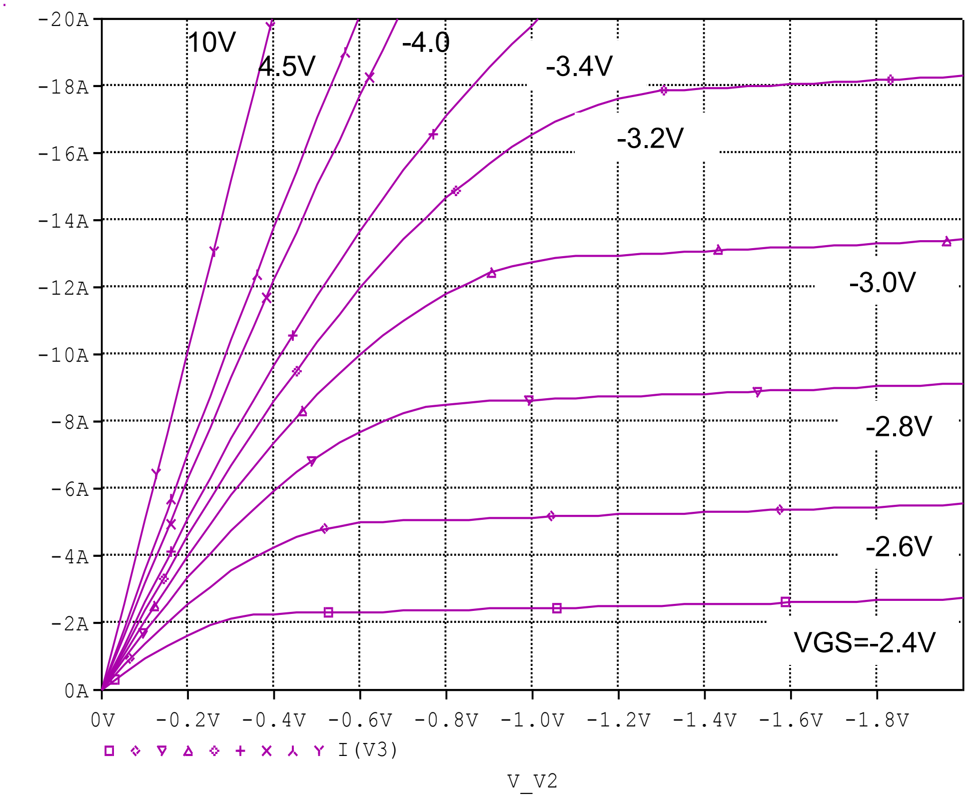


## Simulation Result

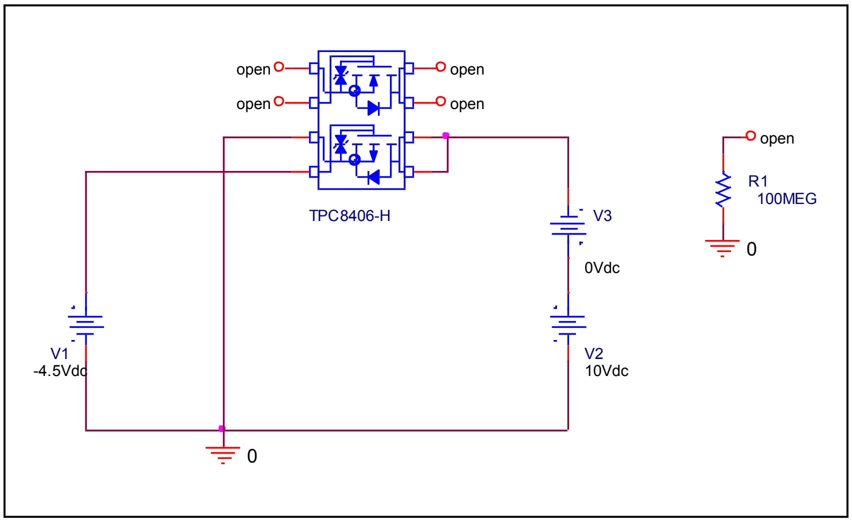
| $I_D$=-3.3 A, $V_{DD}$=-20V<br>$V_{GS}$=0/-10V | Measurement | | Simulation | | Error(%) |
|---|---|---|---|---|---|
| ton | 12.000 | ns | 11.985 | ns | -0.125 |

# Output Characteristic

## Circuit Simulation result

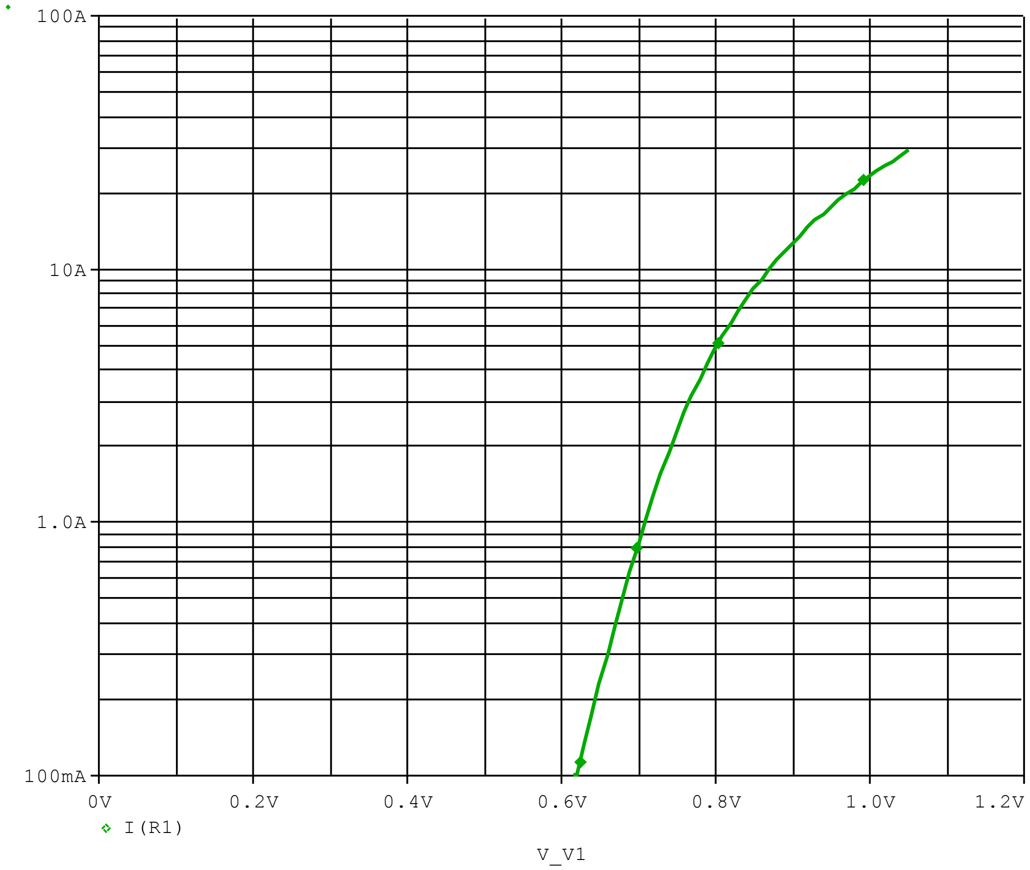


## Evaluation circuit

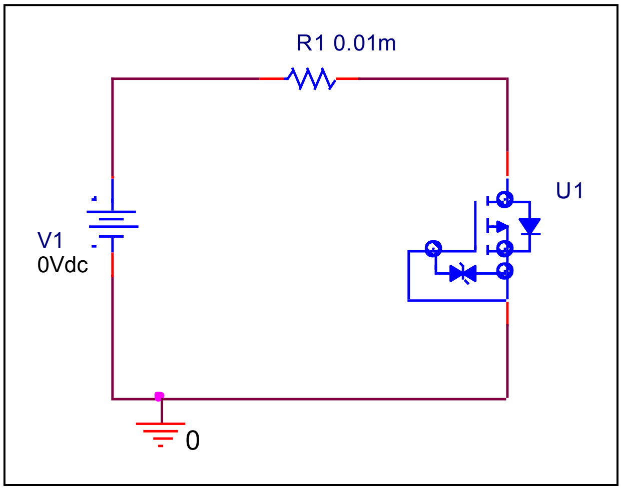


# Forward Current Characteristic

## Circuit Simulation Result

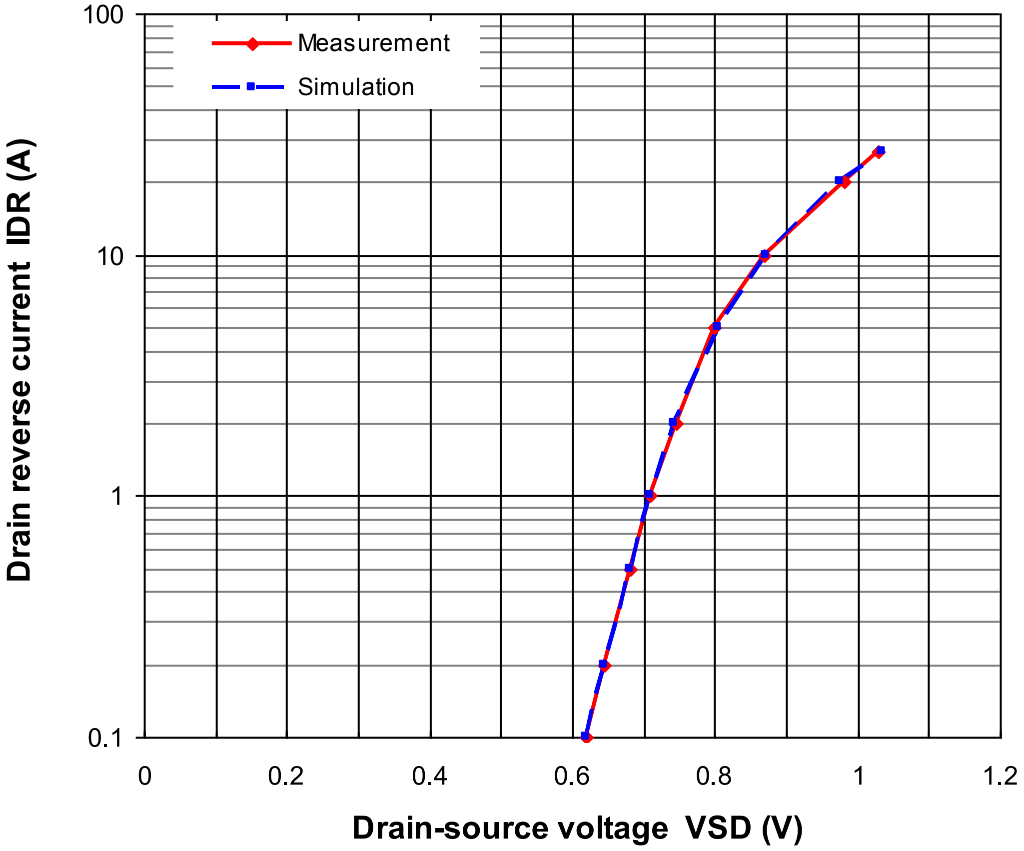


## Evaluation Circuit



## Comparison Graph

Circuit Simulation Result

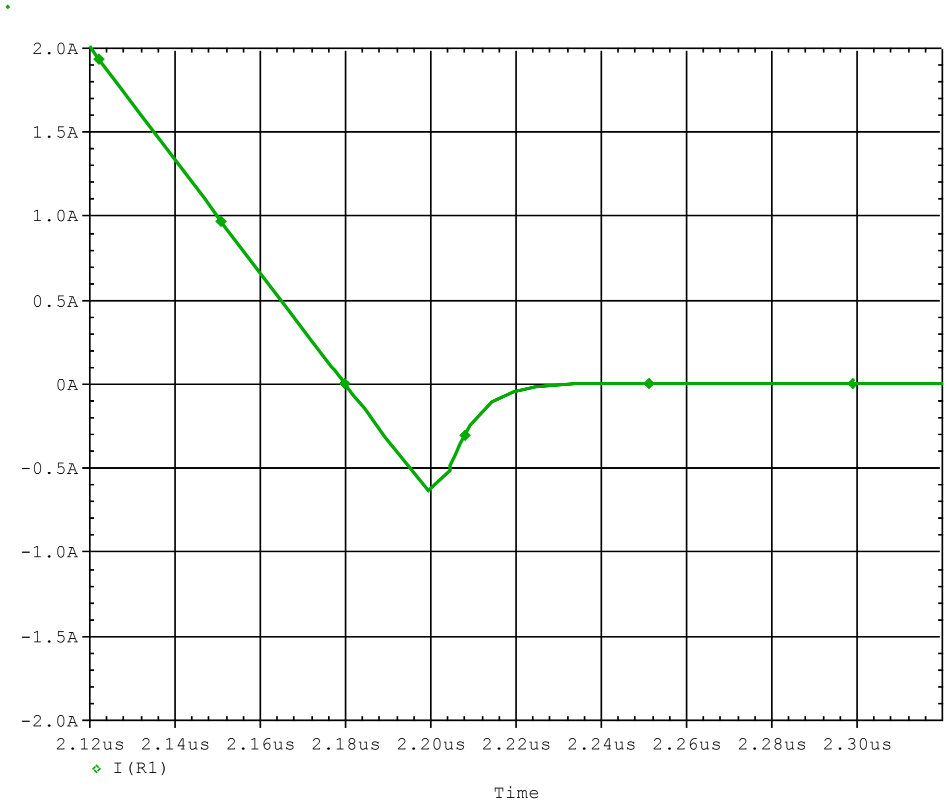


Simulation Result

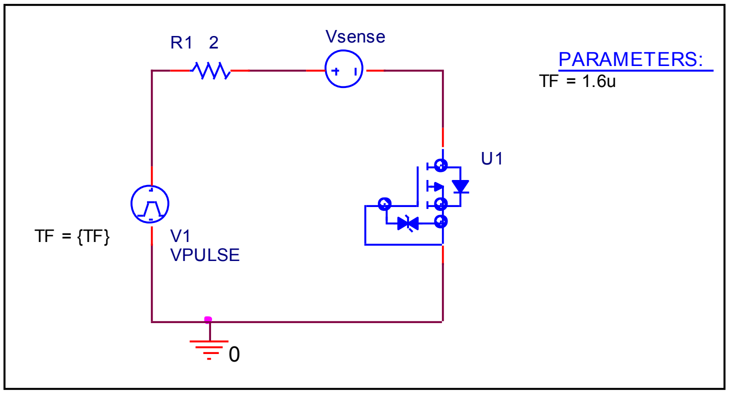
| IDR(A) | VSD(V) | | %Error |
|---|---|---|---|
| | Measurement | Simulation | |
| 0.1 | 0.6200 | 0.6199 | -0.0161 |
| 0.2 | 0.6450 | 0.6449 | -0.0155 |
| 0.5 | 0.6800 | 0.6801 | 0.0147 |
| 1 | 0.7100 | 0.7092 | -0.1127 |
| 2 | 0.7450 | 0.7430 | -0.2685 |
| 5 | 0.8000 | 0.8034 | 0.4250 |
| 10 | 0.8700 | 0.8716 | 0.1839 |
| 20 | 0.9800 | 0.9743 | -0.5816 |

# Reverse Recovery Characteristics (Body Diode)

## Circuit Simulation Result



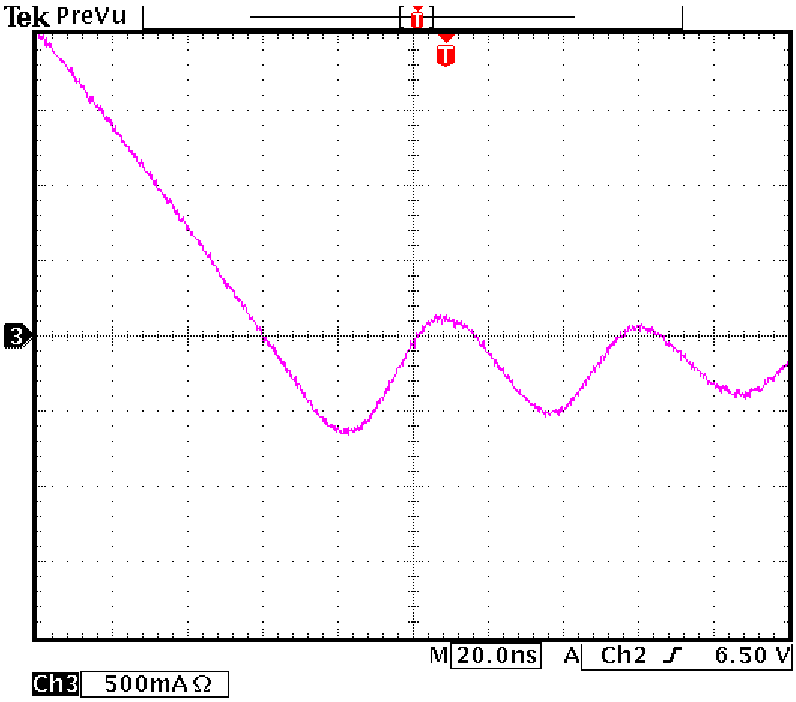
## Evaluation Circuit



## Compare Measurement vs. Simulation

| | Measurement | | Simulation | | Error (%) |
|---|---|---|---|---|---|
| **trr** | **36.8** | **ns** | **36.782** | **ns** | **-0.05** |

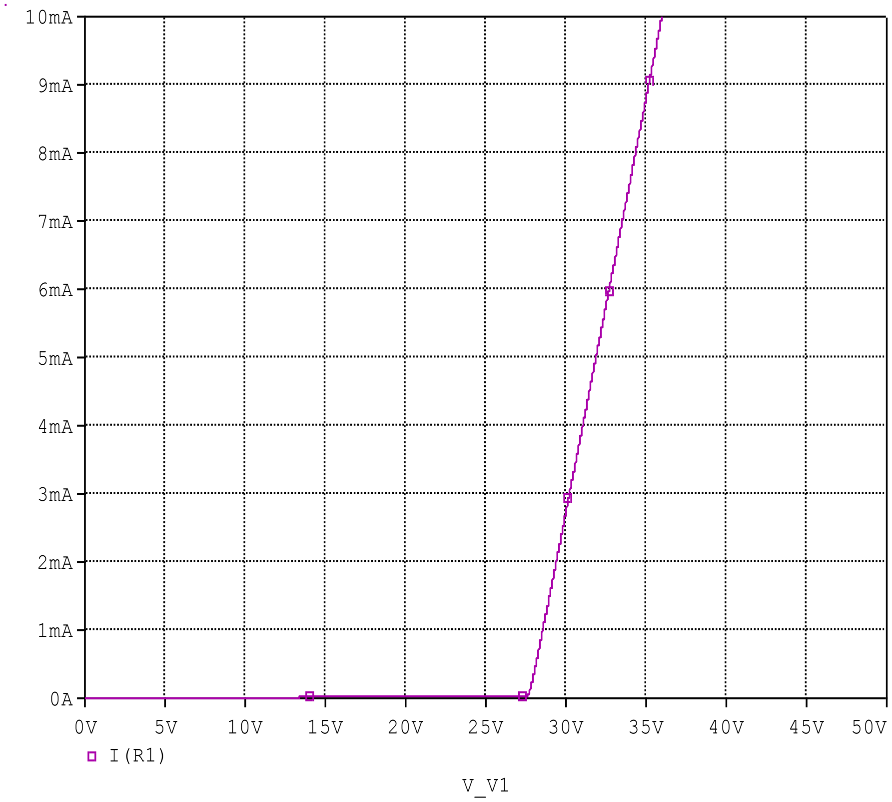
# Reverse Recovery Characteristic (Body Diode) Reference



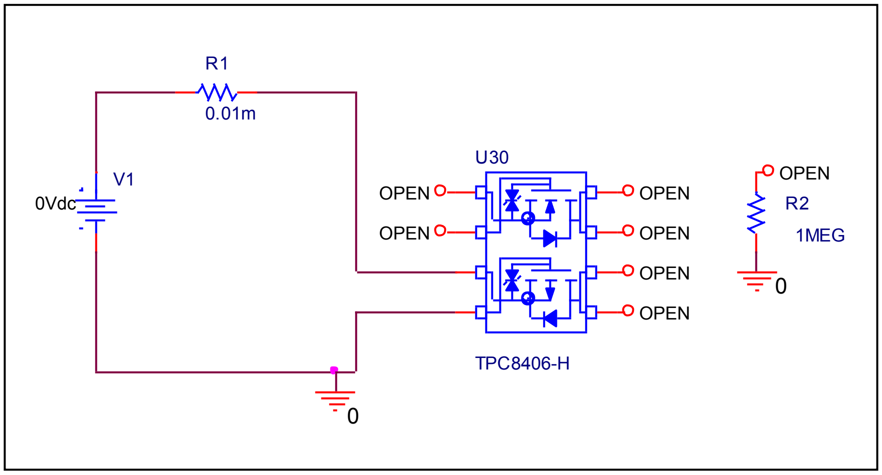
Trr=36.8ns
Conditions:Ifwd=di/dt=30A/us

# Zener Voltage Characteristic

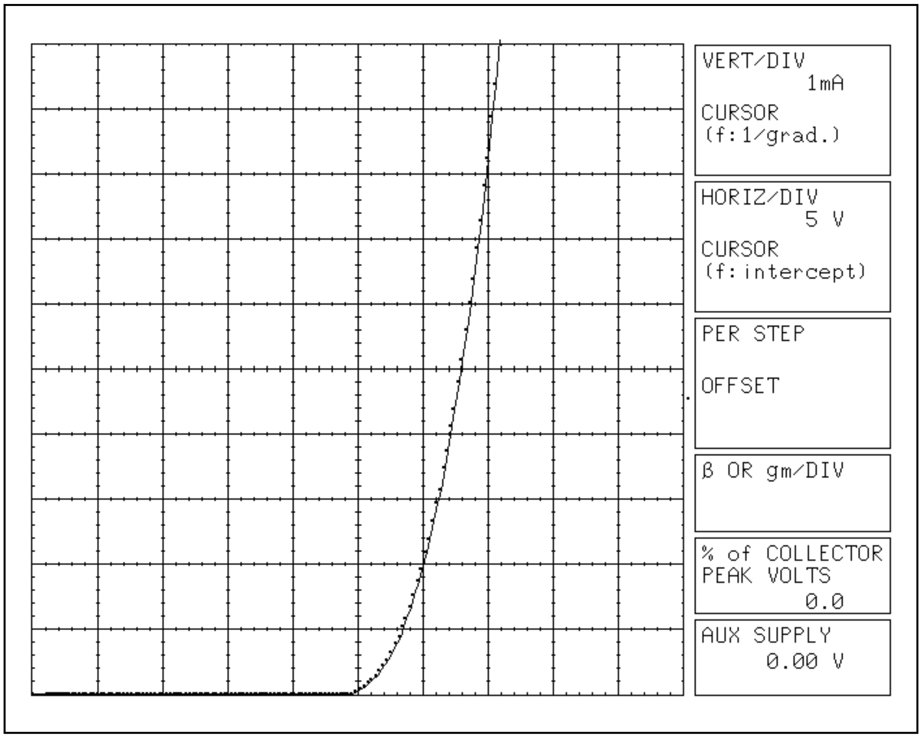
## Circuit Simulation Result



## Evaluation Circuit



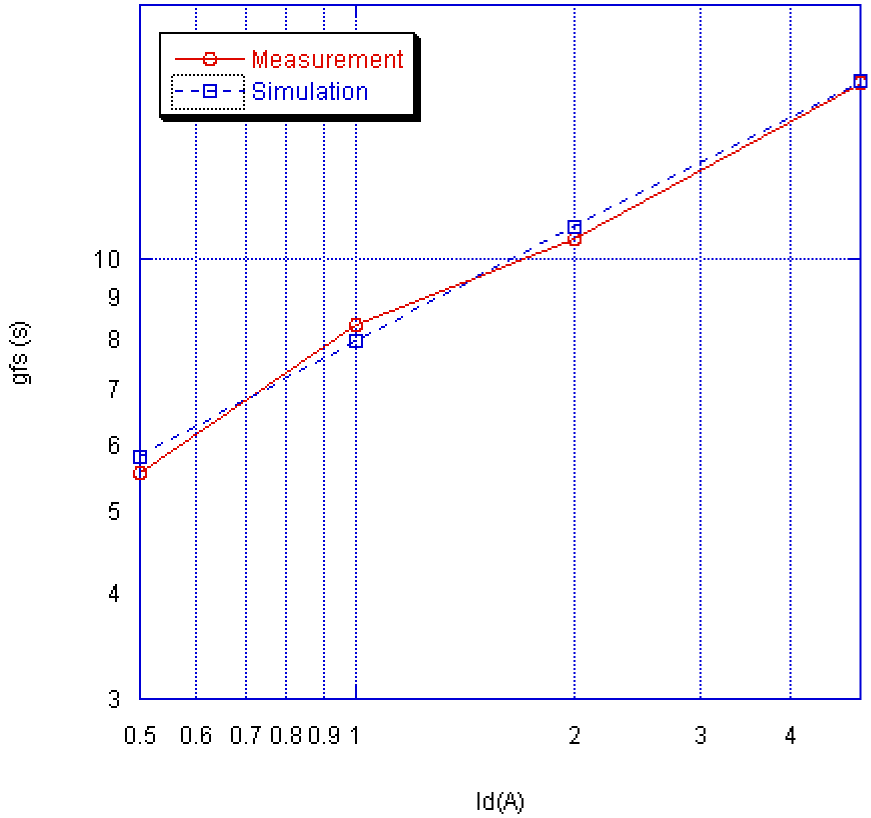
## Zener Voltage Characteristic Reference



# N-Channel Model

## Transconductance Characteristic

Circuit Simulation Result

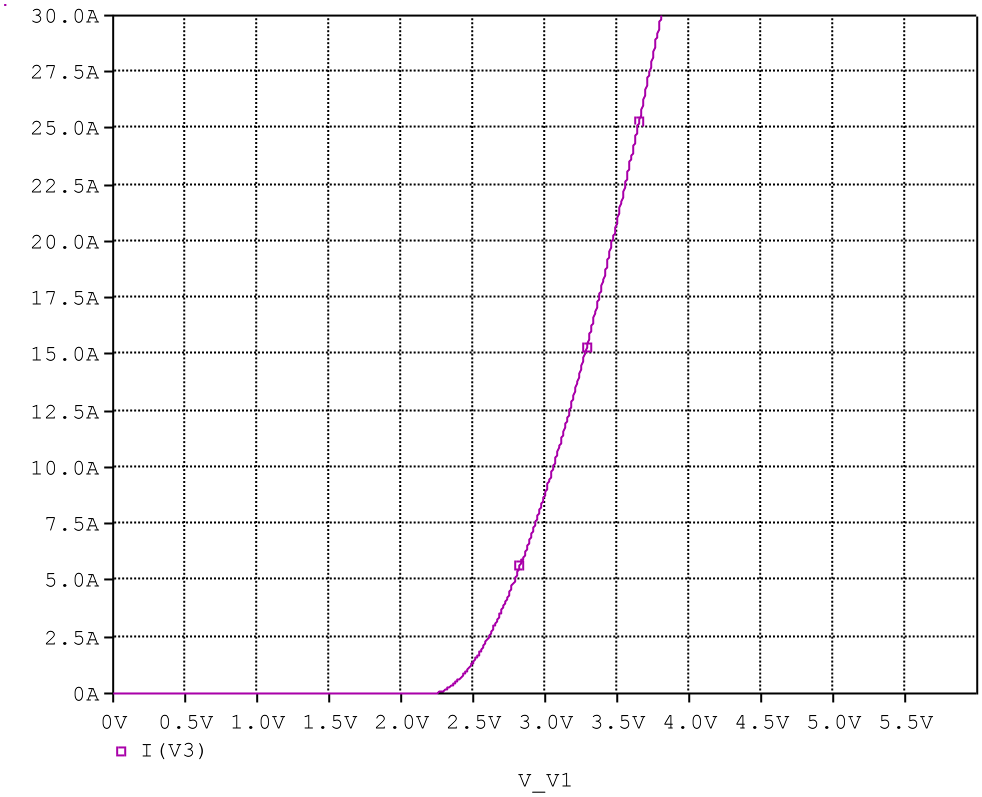


Comparison table

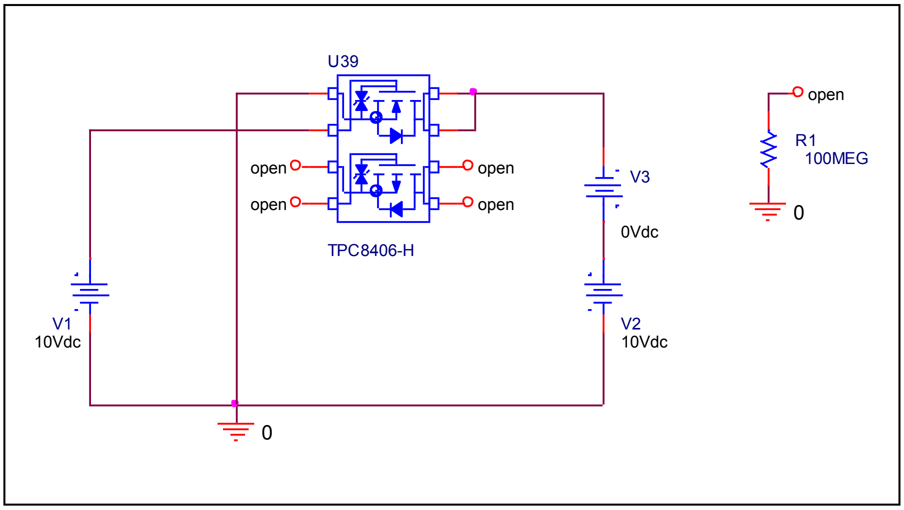
| Id(A) | gfs |  | Error(%) |
|---|---|---|---|
|  | Measurement | Simulation |  |
| 0.500 | 5.556 | 5.814 | 4.643 |
| 1.000 | 8.333 | 8.000 | -3.996 |
| 2.000 | 10.530 | 10.929 | 3.788 |
| 5.000 | 16.129 | 16.234 | 0.649 |

## Vgs-Id Characteristic

### Circuit Simulation result

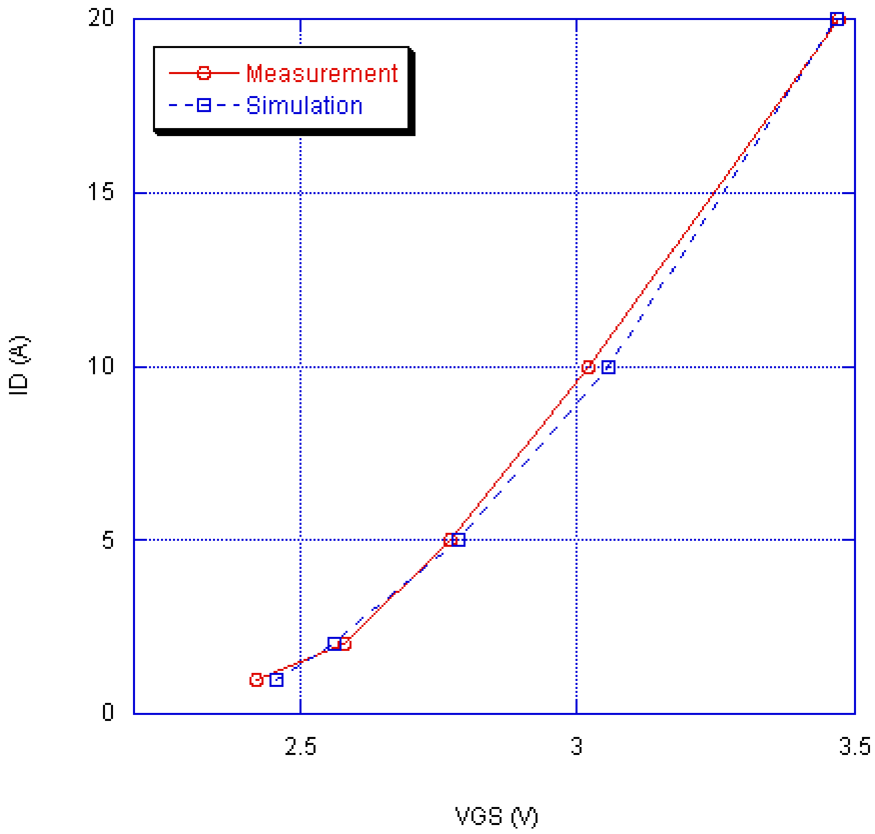


### Evaluation circuit



## Comparison Graph

Circuit Simulation Result

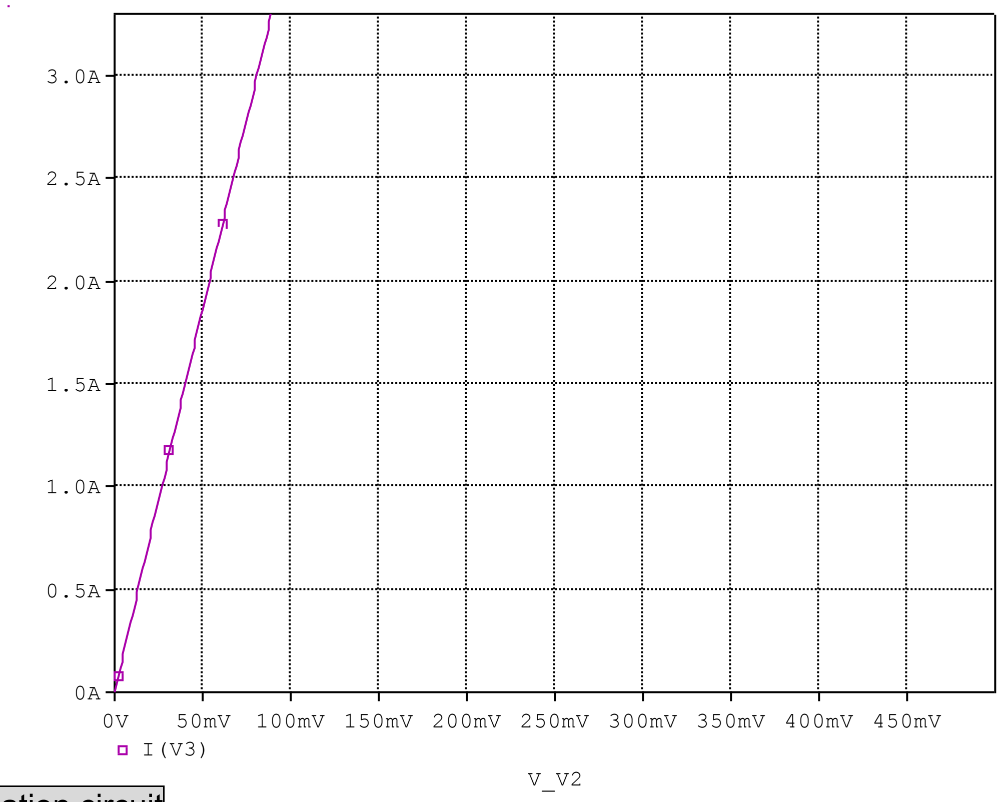


Simulation Result

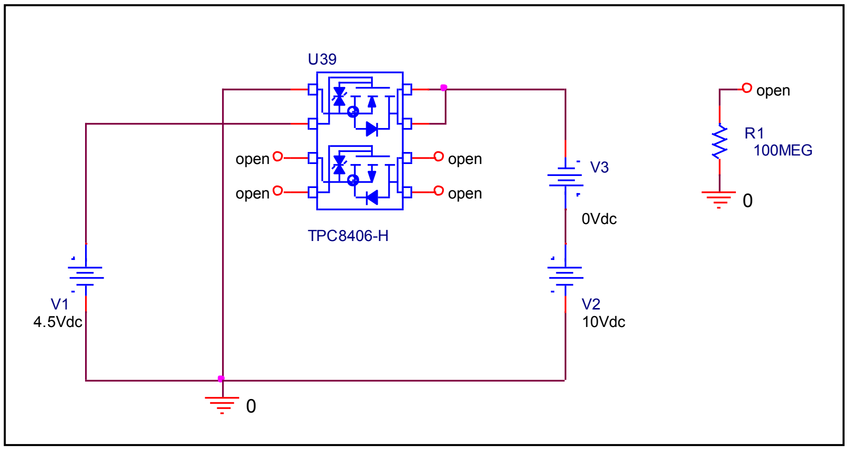
| $I_D$(A) | $V_{GS}$(V) | | Error (%) |
|---|---|---|---|
| | Measurement | Simulation | |
| 1.000 | 2.420 | 2.455 | 1.426 |
| 2.000 | 2.580 | 2.562 | -0.694 |
| 5.000 | 2.770 | 2.786 | 0.585 |
| 10.000 | 3.020 | 3.055 | 1.169 |
| 20.000 | 3.470 | 3.469 | -0.032 |

## Rds(on) Characteristic

### Circuit Simulation result



### Evaluation circuit

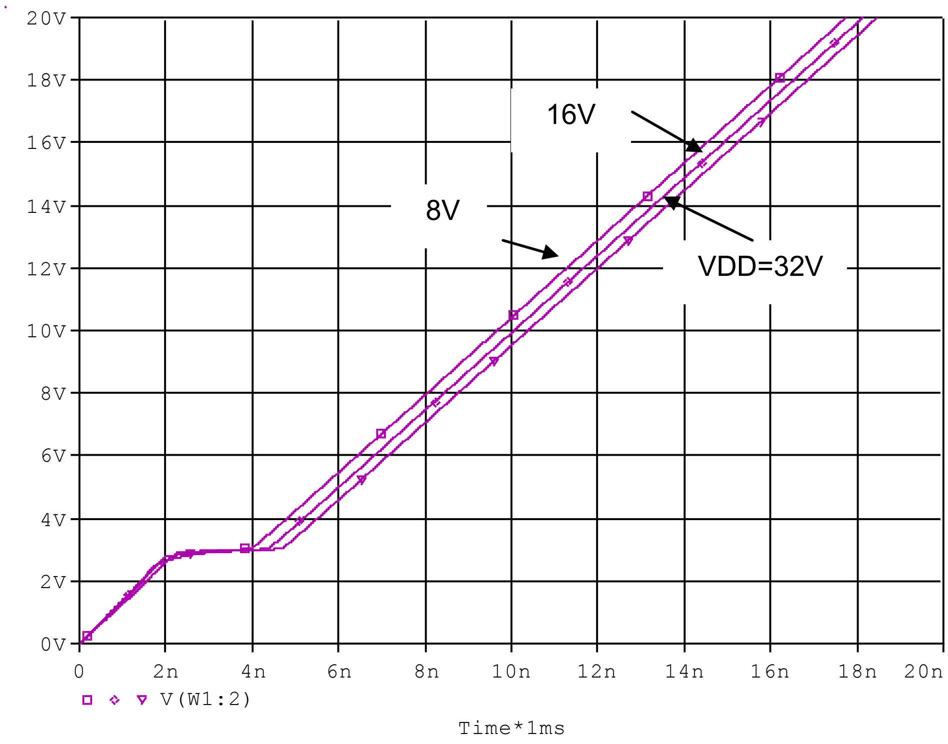


### Simulation Result

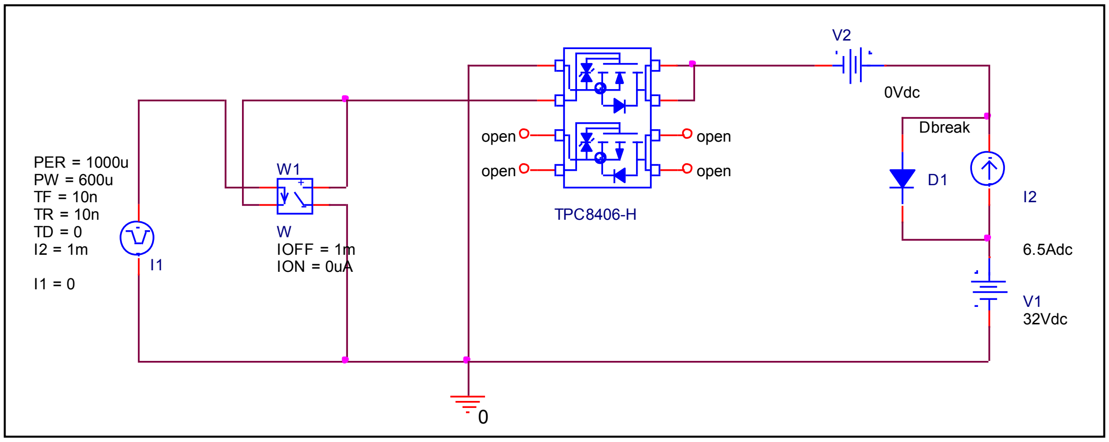
| $I_D$=3.3A, $V_{GS}$=4.5V | Measurement | | Simulation | | Error (%) |
|---|---|---|---|---|---|
| $R_{DS}$ (on) | 27.000 | mΩ | 27.000 | mΩ | 0.000 |

## Gate Charge Characteristic

### Circuit Simulation result



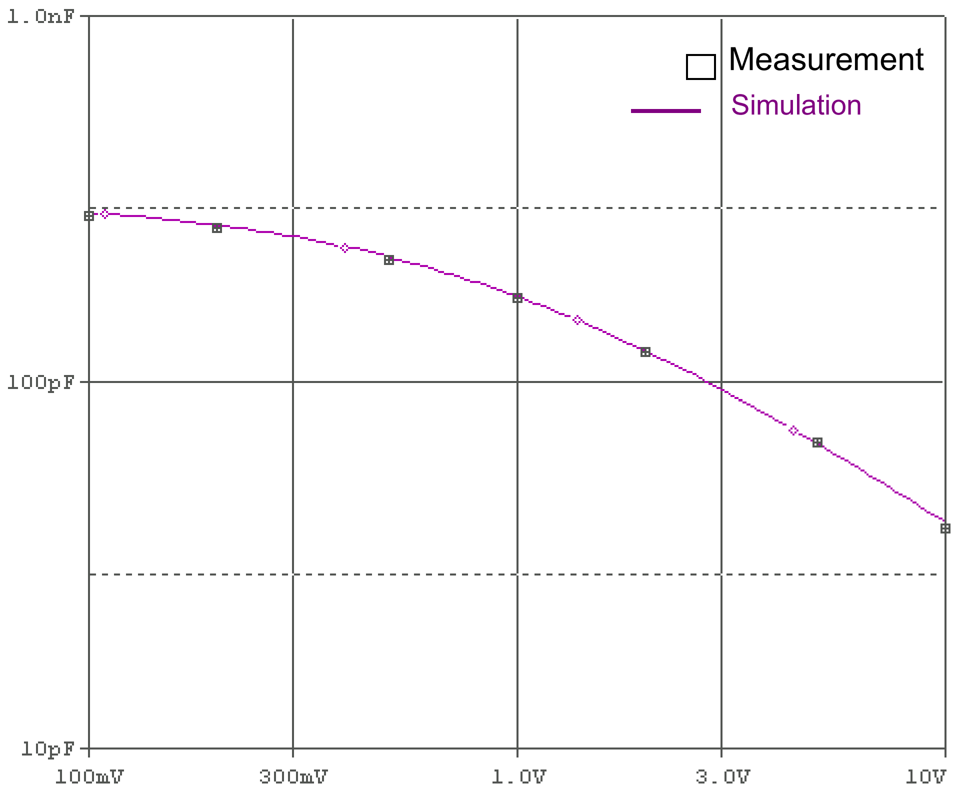
### Evaluation circuit



### 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

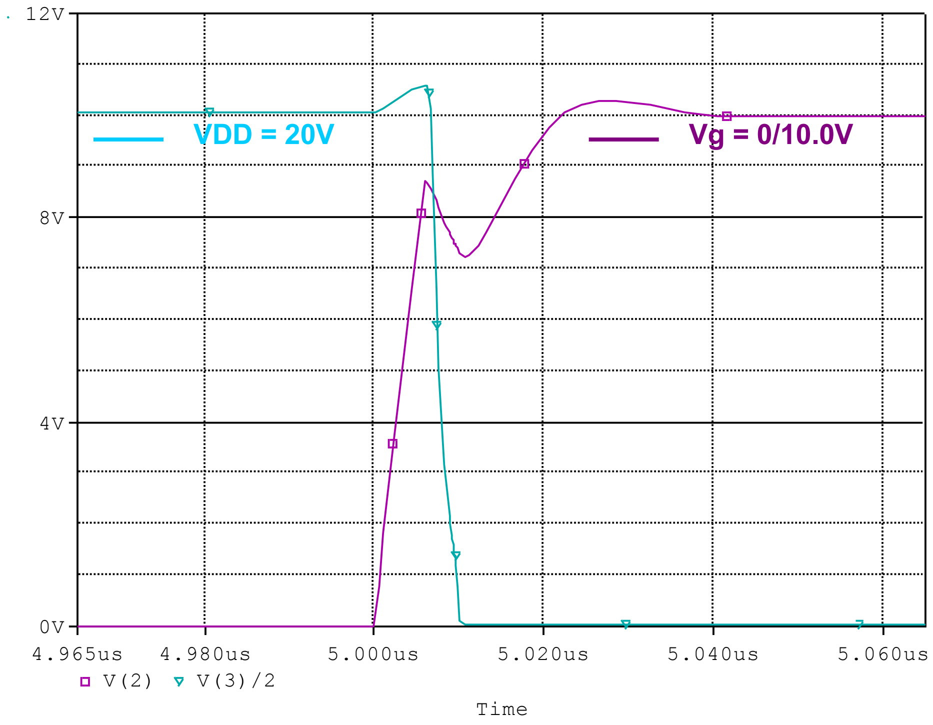


Simulation Result

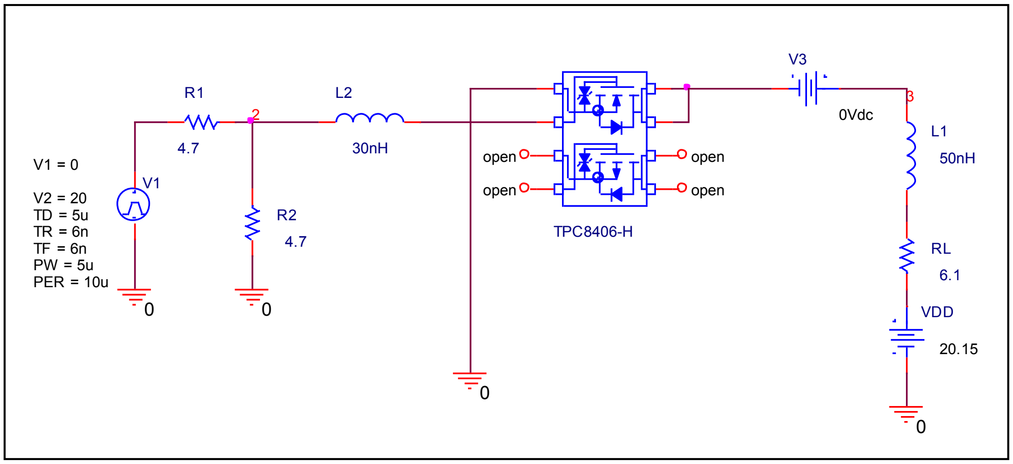
| $V_{DS}$(V) | Cbd(pF) | | Error(%) |
|---|---|---|---|
| | **Measurement** | **Simulation** | |
| 0.100 | 288.8 | 290.000 | 0.416 |
| 0.300 | 267.75 | 268.000 | 0.093 |
| 0.600 | 217.5 | 220.000 | 1.149 |
| 1.000 | 172.5 | 172.000 | -0.290 |
| 3.000 | 122.3 | 121.200 | -0.899 |
| 6.000 | 69.48 | 68.000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

# Switching Time Characteristic

## Circuit Simulation result



## Evaluation circuit

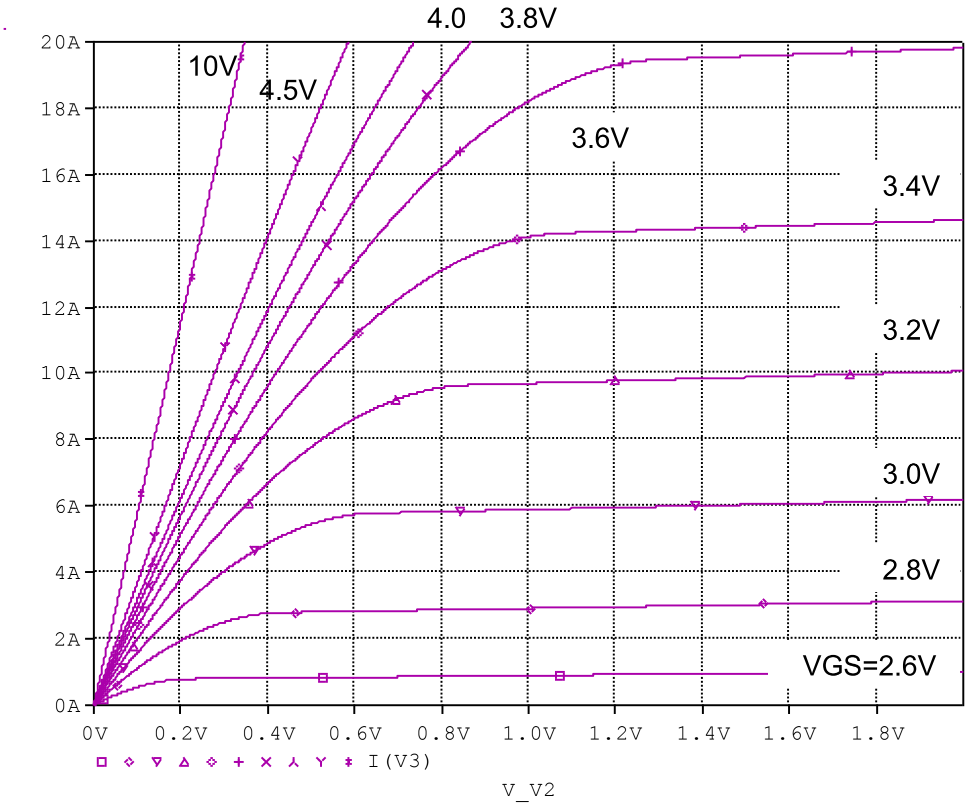


## Simulation Result

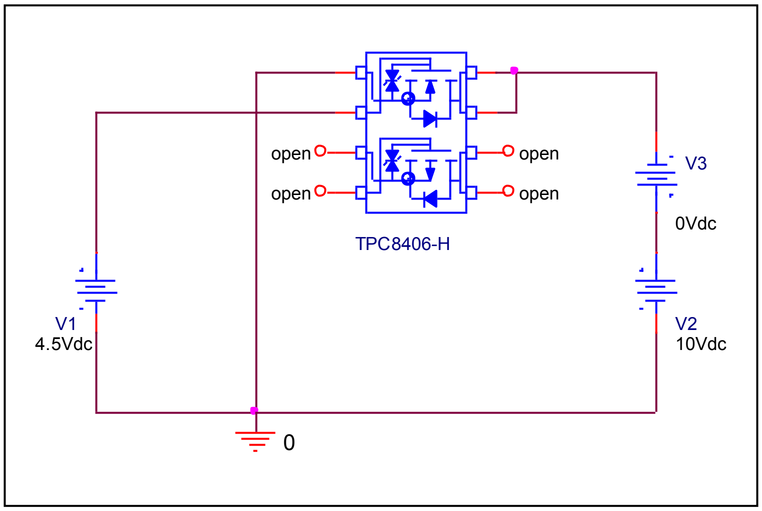
| $I_D$=3.3 A, $V_{DD}$=20V<br>$V_{GS}$=0/10V | Measurement | | Simulation | | Error(%) |
|---|---|---|---|---|---|
| ton | 9.000 | ns | 9.039 | ns | 0.433 |

# Output Characteristic

## Circuit Simulation result

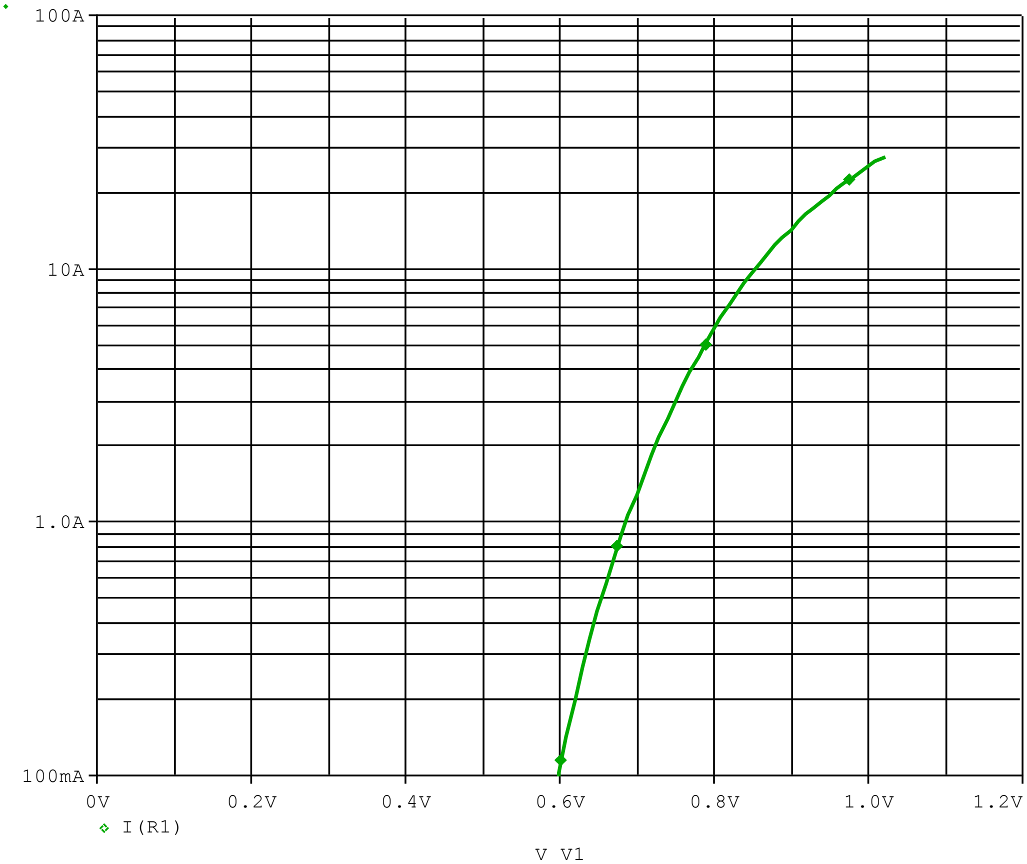


## Evaluation circuit

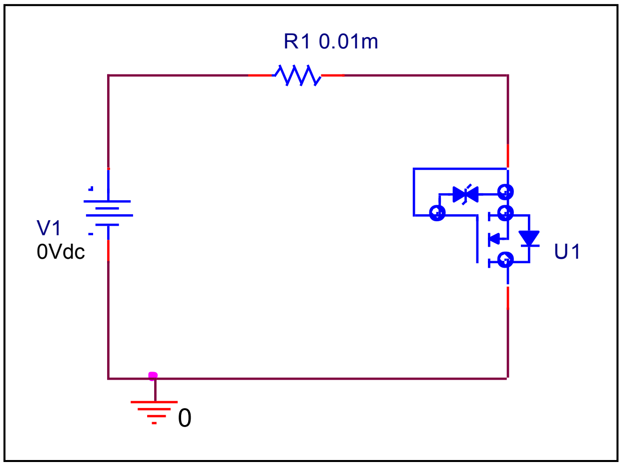


# Forward Current Characteristic

## Circuit Simulation Result

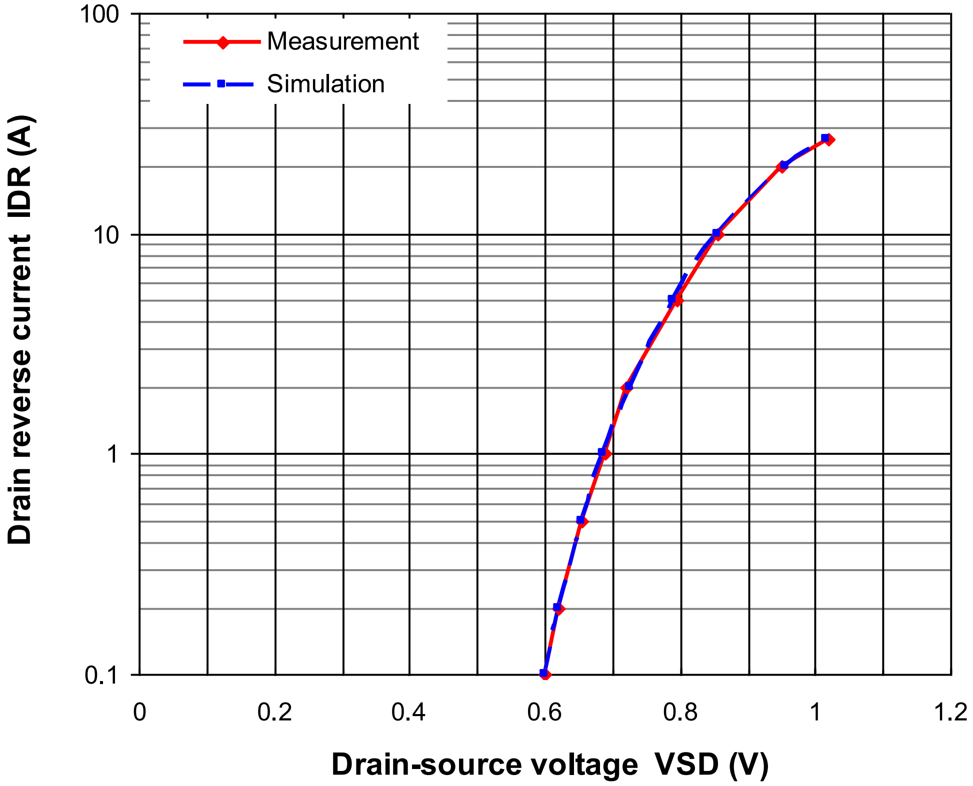


## Evaluation Circuit



## Comparison Graph

Circuit Simulation Result

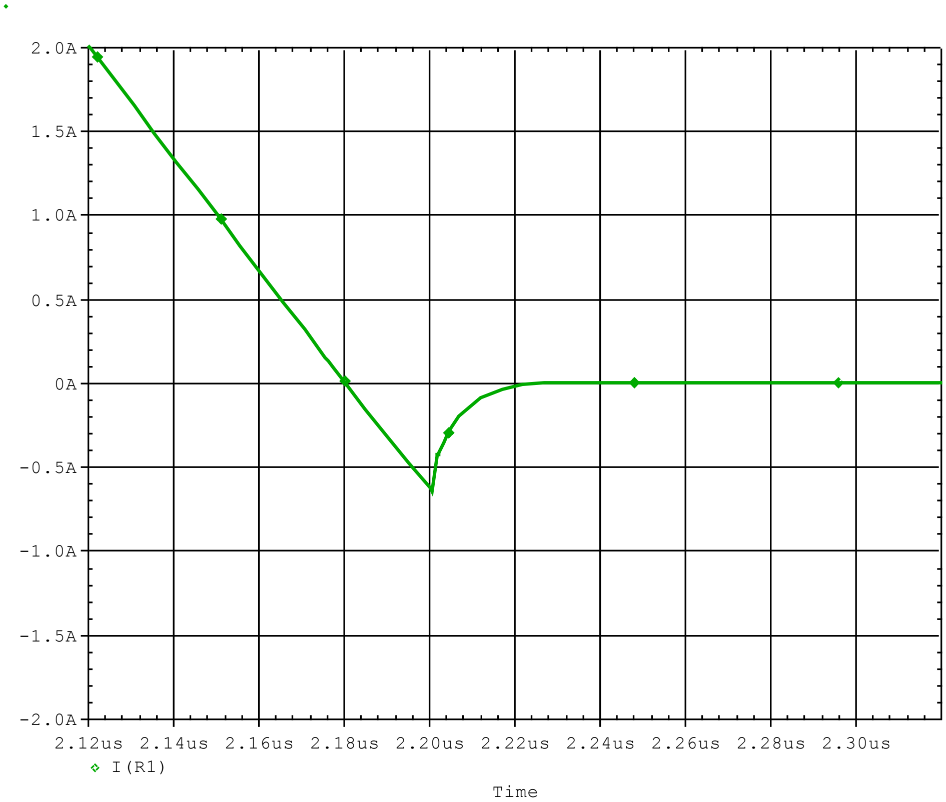


Simulation Result

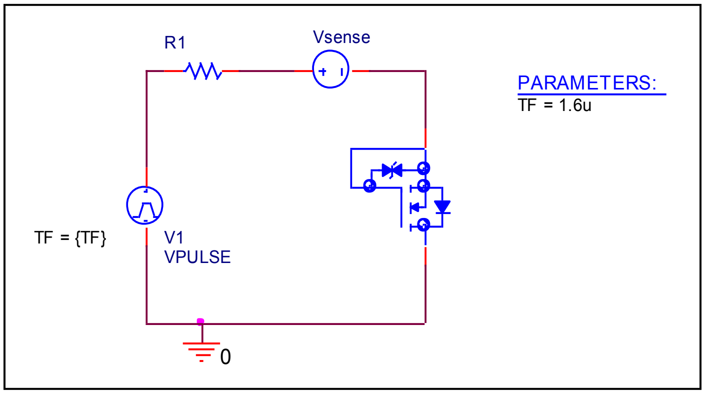
| IDR(A) | VSD(V) | | %Error |
|---|---|---|---|
| | Measurement | Simulation | |
| 0.1 | 0.6000 | 0.5995 | -0.08 |
| 0.2 | 0.6200 | 0.6206 | 0.10 |
| 0.5 | 0.6550 | 0.6548 | -0.03 |
| 1 | 0.6900 | 0.6874 | -0.38 |
| 2 | 0.7200 | 0.7257 | 0.79 |
| 5 | 0.7950 | 0.7890 | -0.75 |
| 10 | 0.8550 | 0.8554 | 0.05 |
| 20 | 0.9500 | 0.9556 | 0.59 |

# Reverse Recovery Characteristics (Body Diode)

## Circuit Simulation Result



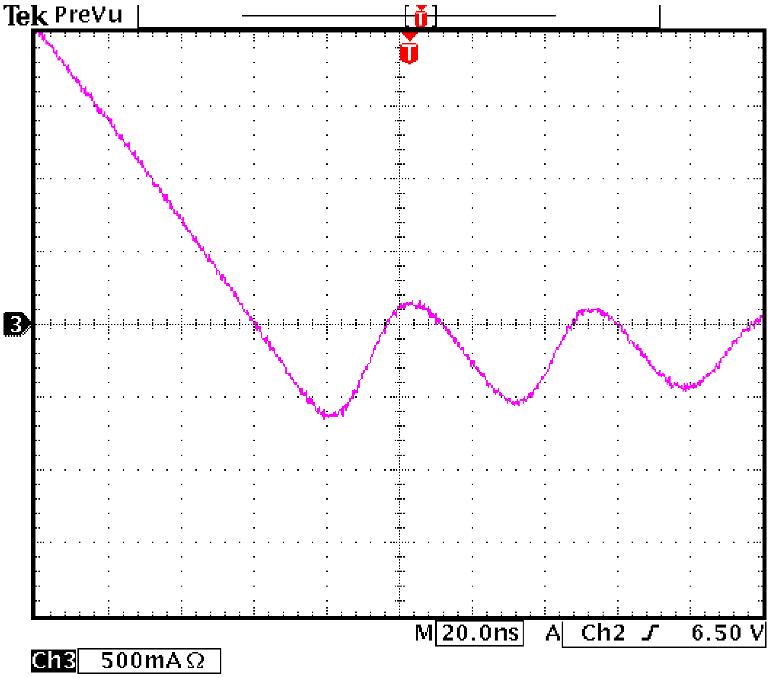
## Evaluation Circuit



## Compare Measurement vs. Simulation

| | Measurement | | Simulation | | Error (%) |
|---|---|---|---|---|---|
| trr | 32.8 | ns | 31.954 | ns | -2.58 |

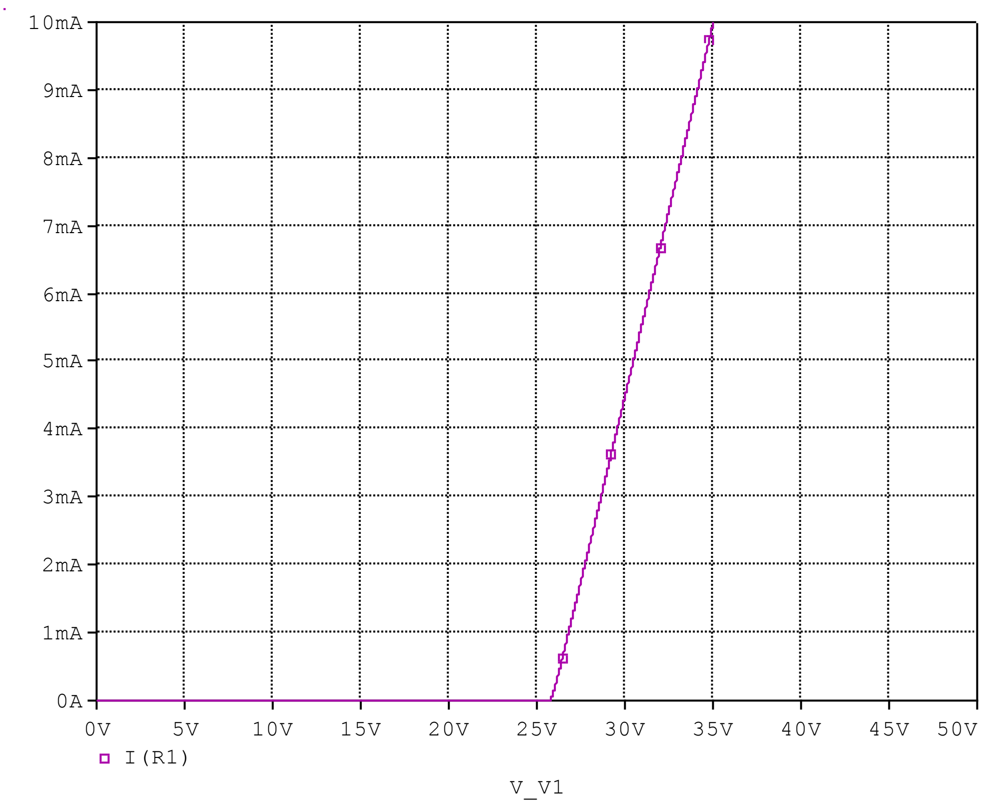
## Reverse Recovery Characteristic (Body Diode) Reference



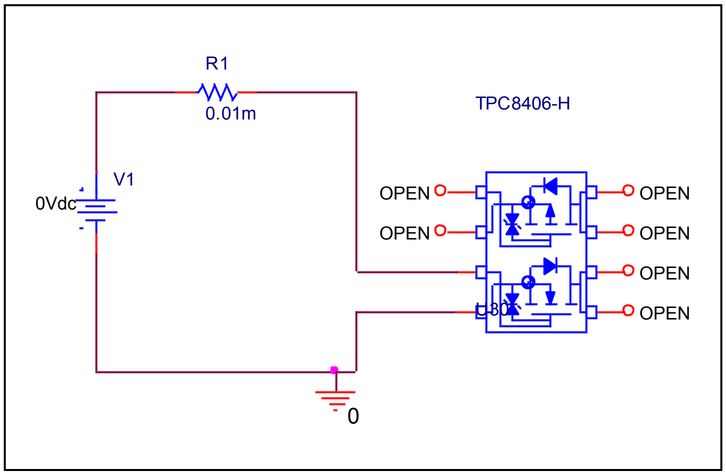
Trr=32.8ns
Conditions:Ifwd=di/dt=30A/us

# Zener Voltage Characteristic

## Circuit Simulation Result



## Evaluation Circuit



## Zener Voltage Characteristic Reference