

# Device Modeling Report

COMPONENTS : OPERATIONAL AMPLIFIER (CMOS)  
PART NUMBER : NJU7013  
MANUFACTURER : NEW JAPAN RADIO



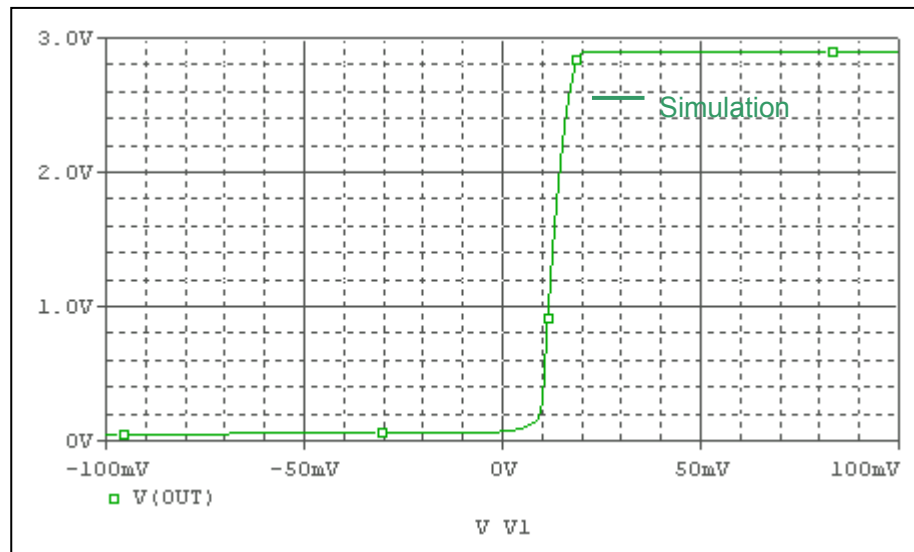
**Bee Technologies Inc.**

## MOSFET MODEL

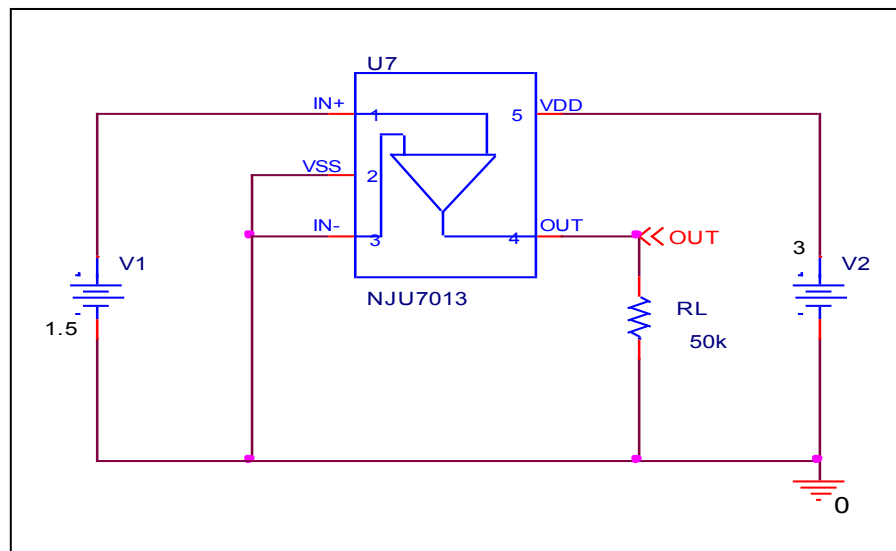
| Pspice model parameter | Model description                                  |
|------------------------|----------------------------------------------------|
| LEVEL                  |                                                    |
| L                      | Channel Length                                     |
| 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                                   |

## Output Voltage Swing

### Simulation result



### Evaluation Circuit

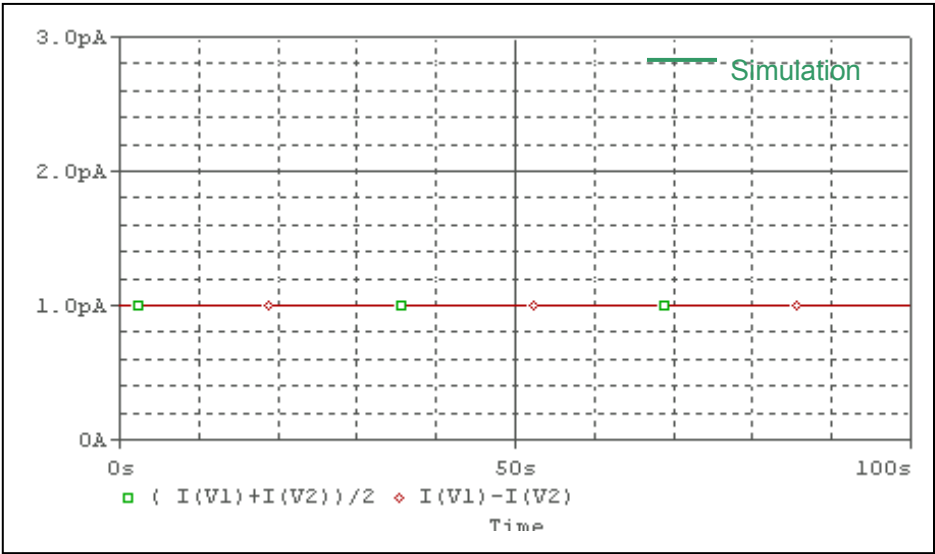


### Comparision Table

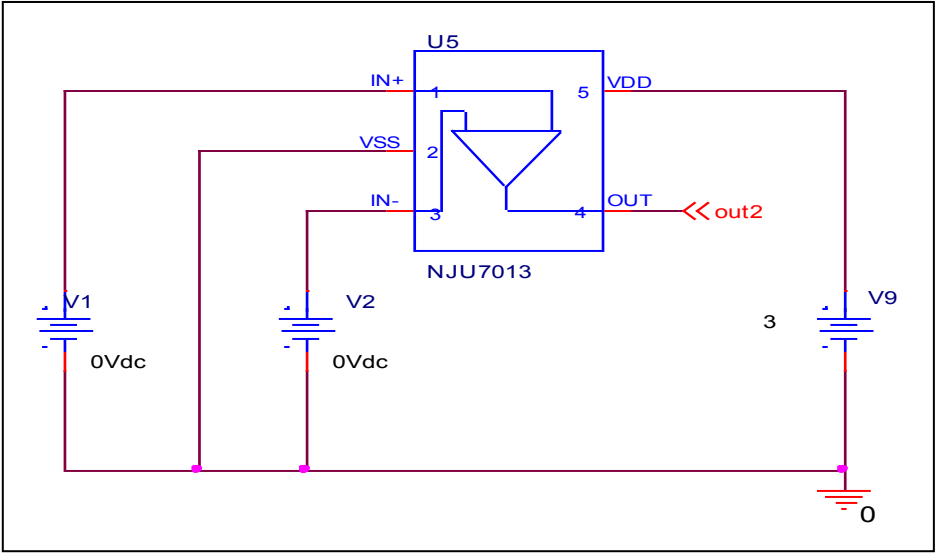
|              | Measurement | Simulation | %Error |
|--------------|-------------|------------|--------|
| $V_{OM}$ (V) | 2.9         | 2.9        | 0      |

# Input Current

## Simulation result



## Evaluation Circuit

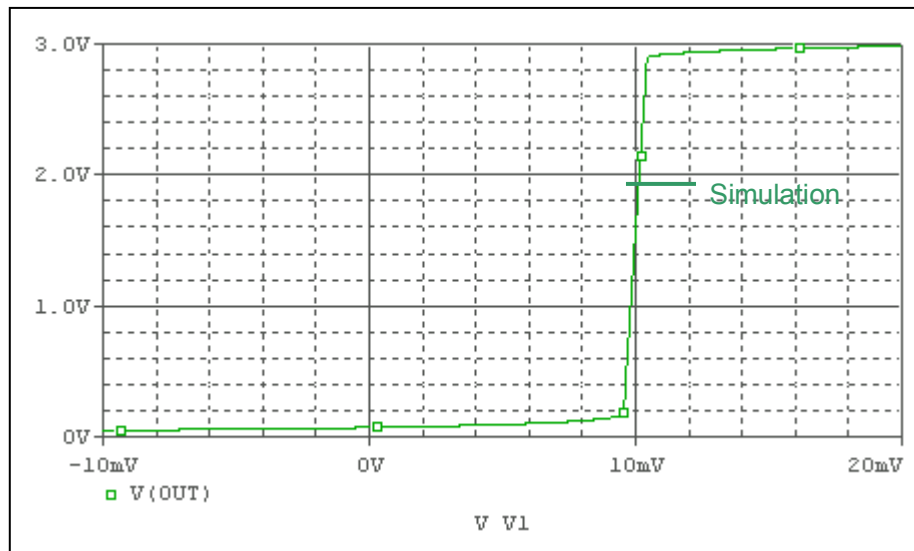


## Comparision Table

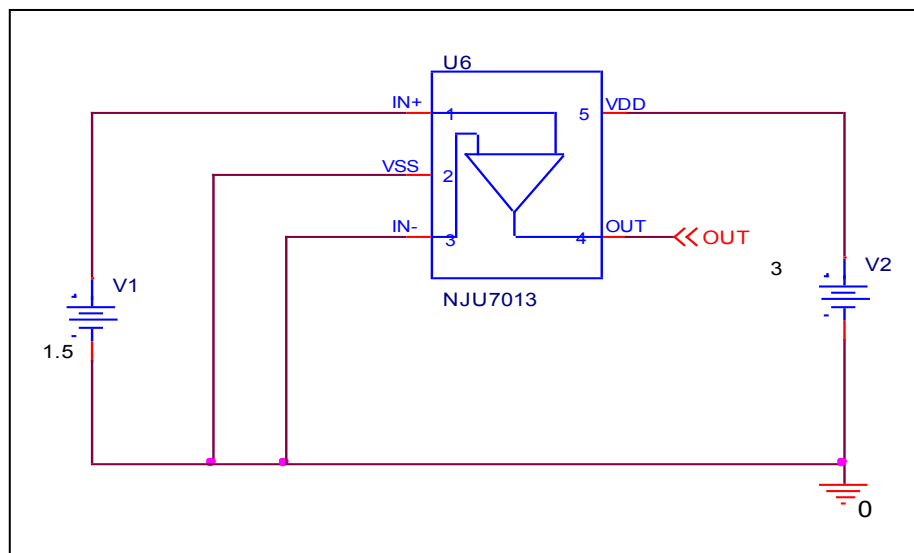
|               | Measurement | Simulation | % Error |
|---------------|-------------|------------|---------|
| $I_b$ (pA)    | 1           | 1.002      | 0.2     |
| $I_{os}$ (pA) | 1           | 0.995      | -0.5    |

# Input Offset Voltage

## Simulation result



## Evaluation Circuit

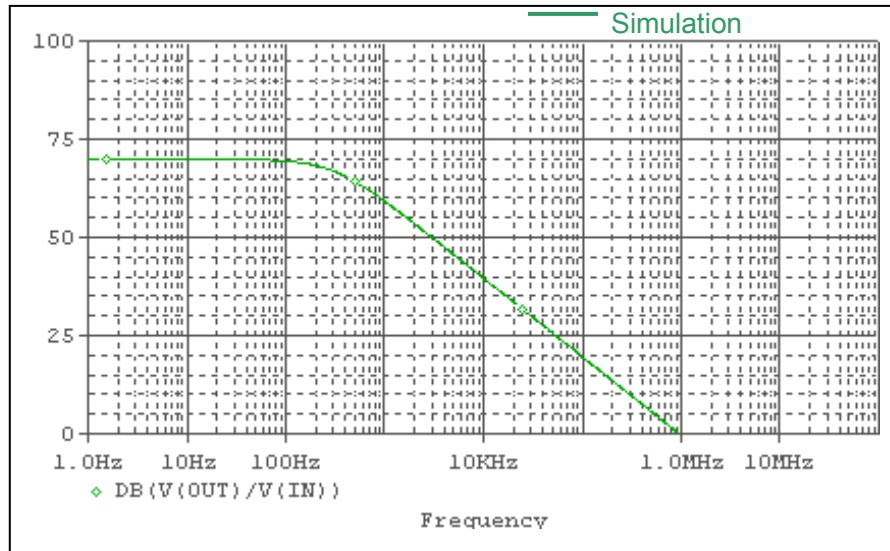


## Comparision Table

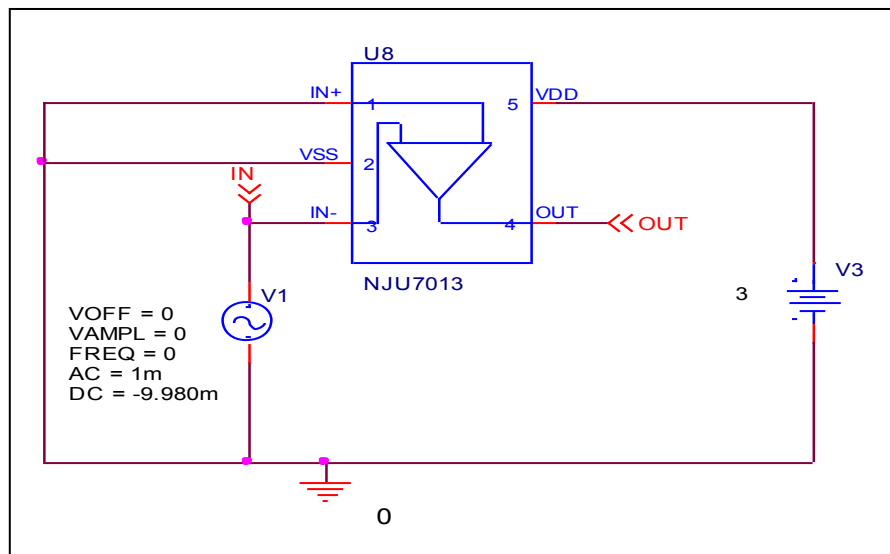
|               | Measurement | Simulation | %Error |
|---------------|-------------|------------|--------|
| $V_{os}$ (mV) | 10          | 9.980      | -0.2   |

## Open loop Voltage Gain

### Simulation result



### Evaluation Circuit

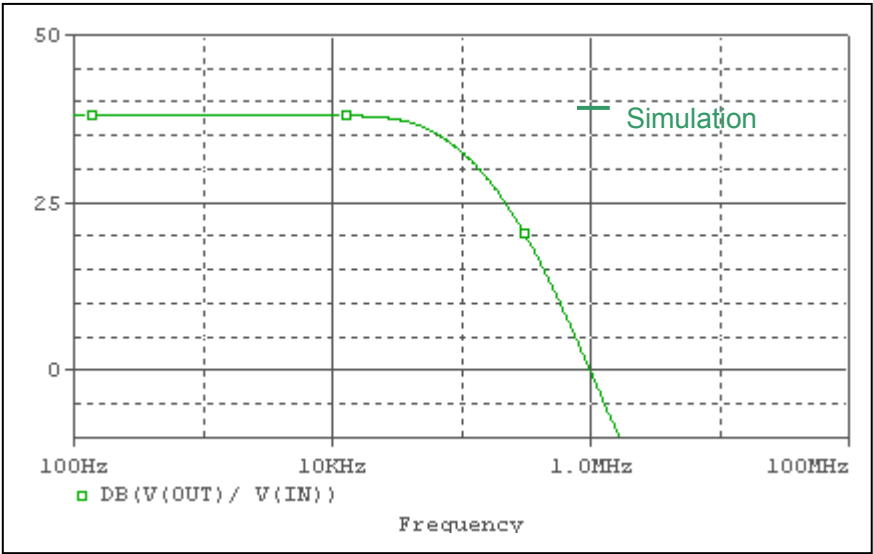


### Comparision Table

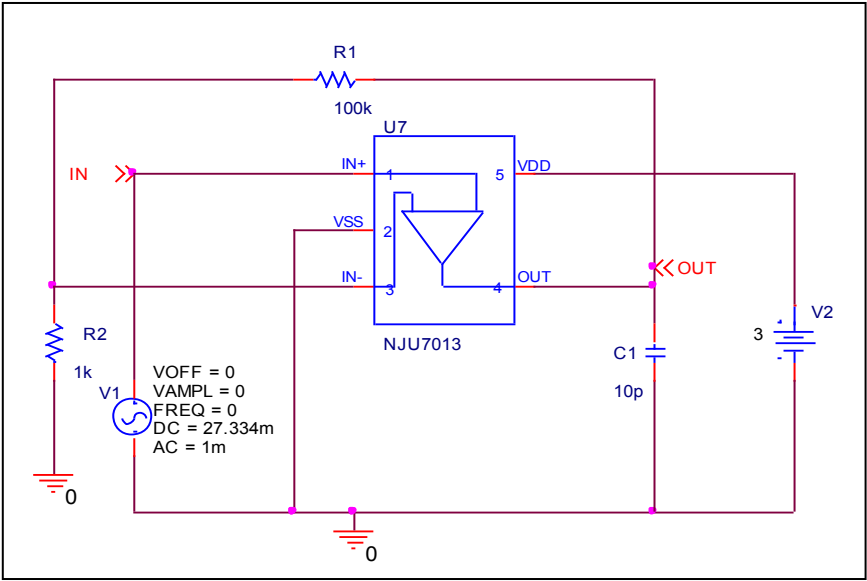
|                | Measurement | Simulation | %Error |
|----------------|-------------|------------|--------|
| <b>Av (dB)</b> | 70          | 69.859     | -0.201 |

# Unity Gain Frequency

## Simulation result



## Evaluation Circuit

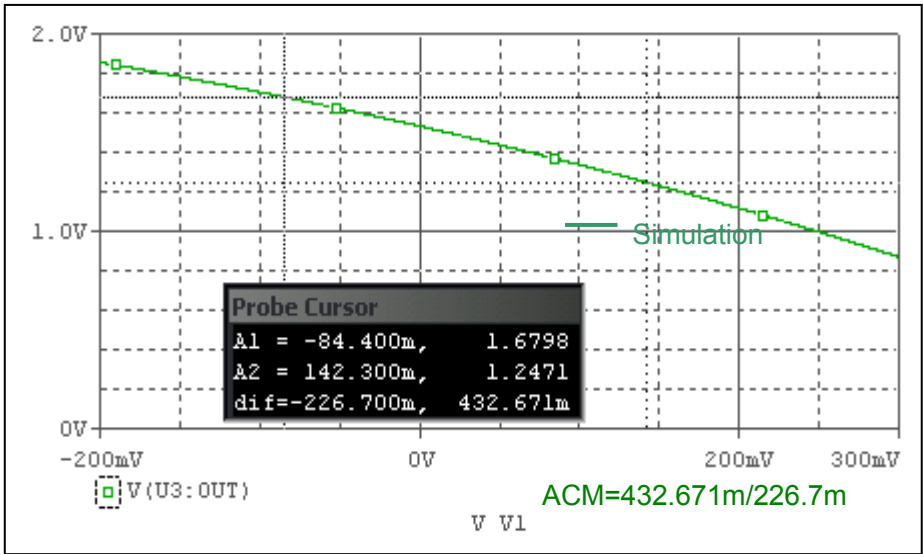


## Comparision Table

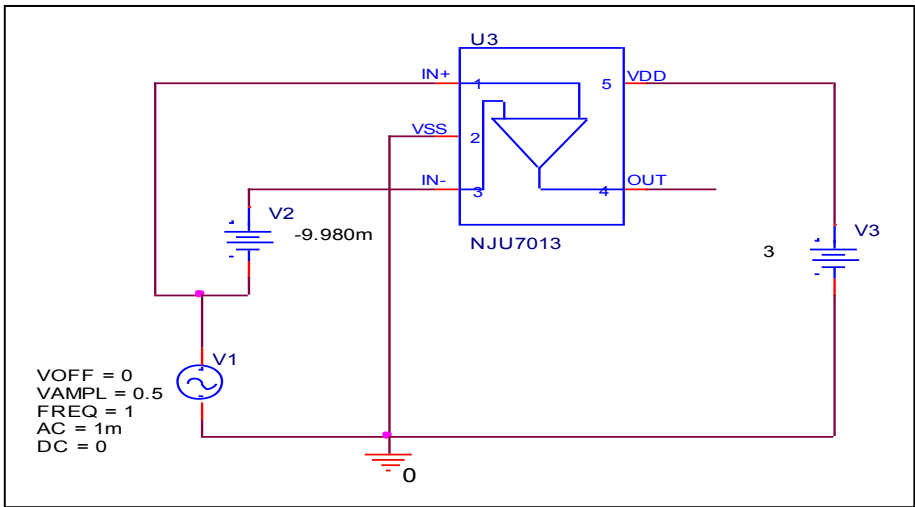
| $A_v=40\text{dB}, C_L=10\text{pF}$ | Measurement | Simulation | %Error |
|------------------------------------|-------------|------------|--------|
| <b>Ft(MHz)</b>                     | 1           | 1          | 0      |

# Common-Mode Rejection Ratio

## Simulation result



## Evaluation Circuit



$$CMRR = AV/ACM$$

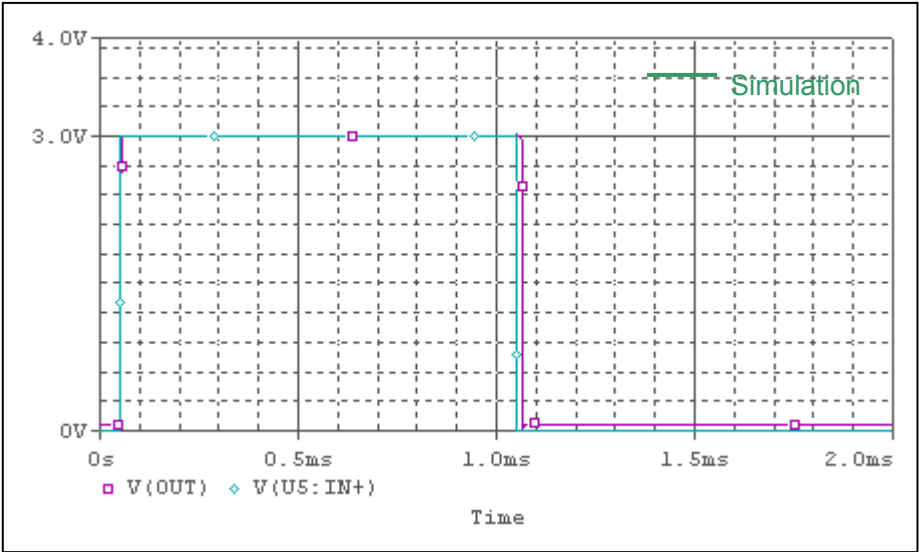
## Comparison Table

|           | Measurement | Simulation | %Error |
|-----------|-------------|------------|--------|
| CMRR (dB) | 65          | 64.24      | -1.169 |

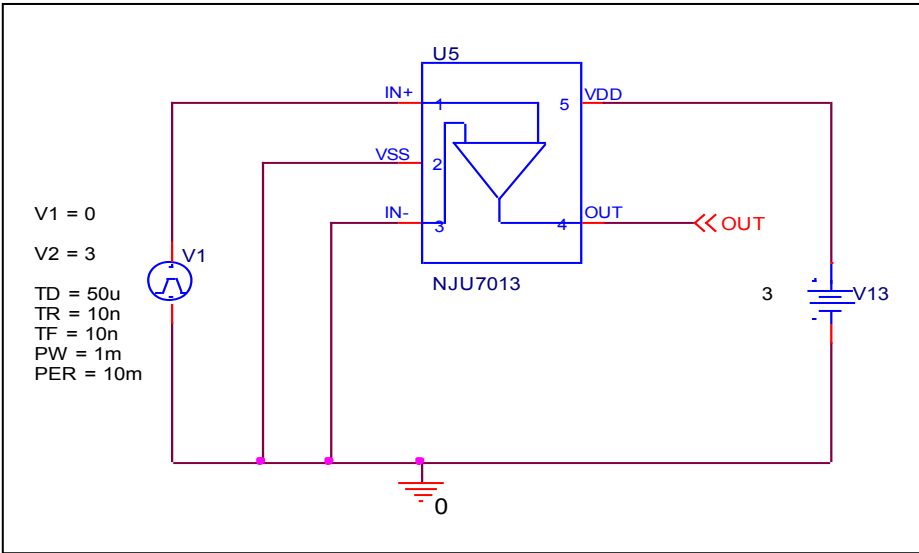


# Slew Rate

## Simulation result



## Evaluation Circuit



## Comparison Table

|           | Measurement | Simulation | % Error |
|-----------|-------------|------------|---------|
| SR (V/us) | 1           | 1          | 0       |