# Device Modeling Report
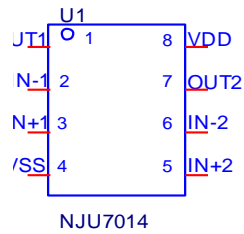
COMPONENTS : OPERATIONAL   AMPLIFIER (CMOS)
PART NUMBER : NJU7014
MANUFACTURER : NEW JAPAN RADIO

**Bee Technologies Inc.**

## Spice Model

**U1**

```
       U1
JT1  O  1        8  VDD
N-1     2        7  OUT2
N+1     3        6  IN-2
/SS     4        5  IN+2
```

NJU7014

```
*$
*PART NUMBER: NJU7014
*MANUFACTURER: NEW JAPAN RADIO
*CMOS OPAMP
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.SUBCKT nju7014    OUT1 IN-1 IN+1 VSS IN+2 IN-2 OUT2 VDD
X_U1 IN+1 VSS IN-1 OUT1 VDD nju7014_s
X_U2 IN+2 VSS IN-2 OUT2 VDD nju7014_s
.ENDS nju7014
.SUBCKT nju7014_s    IN+ VSS IN- OUT VDD
M1          2 IN- 3 VDD MbreakPD3
M2          2 IN+ 4 VDD MbreakPD2
M3          VDD 1 2 VDD MbreakPD
M4          VDD 1 5 VDD MbreakPD
M5          VDD 1 6 VDD MbreakPD
M6          VDD 1 1 VDD MbreakPD
M7          5 5 VSS VSS MbreakND    W=3.2m    L=6u
M8          5 4 VSS VSS MbreakND3
M9          3 3 IN1 VSS MbreakND1
M10         4 3 IN2 VSS MbreakND1
M11         1 6 11 11 MbreakND        W=9m     L=6u
M12         6 6 VSS VSS MbreakND3
M13         7 5 VSS VSS MbreakND1
M14         VDD 7 7 VDD MbreakPD
M15         VDD 7 OUT VDD MbreakPD1
M16         OUT 4 VSS VSS MbreakND2
C1          OUT 1 5p
C2          OUT IN- 37p
C3          OUT 3 1p
C4          OUT 4 2p
R1          11 VSS   1.522k
R2          IN1 VSS 2.0k
R3          IN2 VSS   2.423k
I1          0 IN-   0.505p
I2          0 IN+   1.5p
```

```
X_U1          VSS 3 DbreakZ
X_U2          VSS 4 DbreakZ
.model MbreakND NMOS (LEVEL=3 VTO=0.9 RS=10.000E-3 RD=10.000E-3
+ RDS=1.0000E6 TOX=2.0000E-6 CGSO=4.000E-12 CGDO=1.000E-12
+ CBD=1.000E-12 RG=5 RB=1.0000E-3 KP=10E-6)
.model MbreakND1 NMOS (LEVEL=3 L=6u W=0.5 VTO=1 RS=10.000E-3
+ RD=10.000E-3 RDS=1.0000E6 TOX=2.0000E-6 CGSO=1.00E-12
+ CGDO=1.000E-12 CBD=8.000E-11 RG=5 RB=1.0000E-3 KP=10E-6)
.model MbreakND2 NMOS (LEVEL=3 L=6u W=0.14m VTO=0.9 RS=10.000E-3
+ RD=10.000E-3 RDS=1.0000E6 TOX=2.0000E-6 CGSO=4.000E-12
+ CGDO=1.00E-12 CBD=1.000E-12 RG=5 RB=1.0000E-3 KP=10E-6)
.model MbreakND3 NMOS (LEVEL=3 L=6u W=3.2m VTO=0.9 RS=10.000E-3
+ RD=10.000E-3 RDS=1.0000E6 TOX=2.0000E-6 CGSO=1.000E-12
+ CGDO=1.000E-12 CBD=1.000E-12 RG=5 RB=1.0000E-3 KP=10E-6)
.model MbreakPD PMOS (LEVEL=3 L=6u W=0.023 VTO=-1 RS=10.000E-3
+ RD=10.000E-3 RDS=1.0000E6 TOX=2.0000E-6 CGSO=4.000E-12
+ CGDO=1.000E-12 CBD=1.000E-12 RG=5 RB=1.0000E-3 KP=1E-6)
.MODEL MbreakPD1 PMOS (LEVEL=3 L=6u W=0.00414 VTO=-0.9
+ RS=10.000E-3 RD=10.000E-3 RDS=1.00E6 TOX=2.0000E-6
+ CGSO=4.000E-12 CGDO=1.000E-12 CBD=1.000E-12 RG=5
+ RB=1.0000E-3 KP=1E-6)
.MODEL MbreakPD2 PMOS (LEVEL=3 L=6u W=0.0038 VTO=-1.5
+ RS=10.000E-3 RD=10.00E-3 RDS=1.015E6 TOX=2.0000E-6
+ CGSO=4.000E-12 CGDO=1.000E-12 CBD=1.00E-12 RG=5
+ RB=1.0000E-3 KP=1E-6)
.MODEL MbreakPD3 PMOS (LEVEL=3 L=6u W=0.004112 VTO=-1.5
+ RS=10.000E-3 RD=10.00E-3 RDS=1.E6 TOX=2.0000E-6 CGSO=4.000E-12
+ CGDO=1.000E-12 CBD=1.00E-12 RG=5 RB=1.0000E-3 KP=1E-6)
.ENDS nju7014_s
.SUBCKT DbreakZ   A K
D1 A K DF
DZ A2 A DR
VZ K A2 1
.MODEL DF D
.MODEL DR D
.ENDS DbreakZ
*$
```

## 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
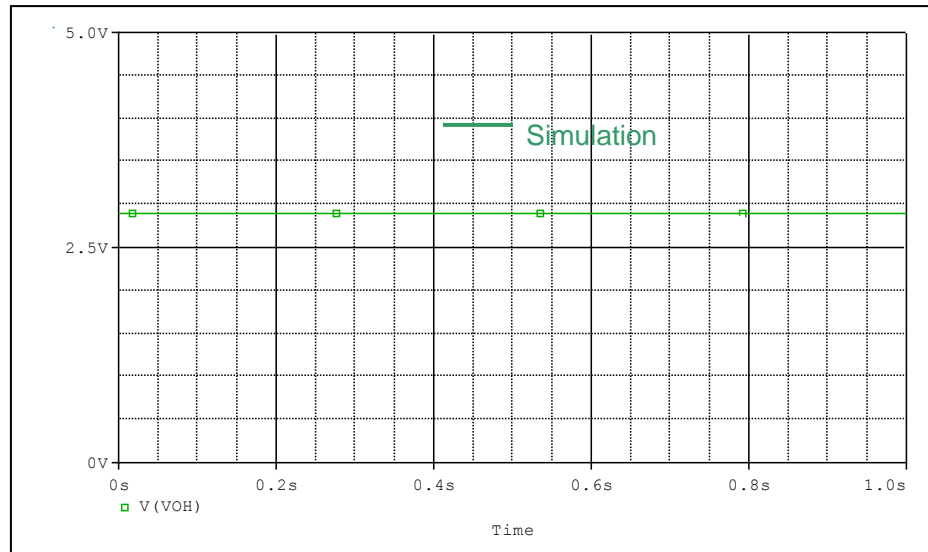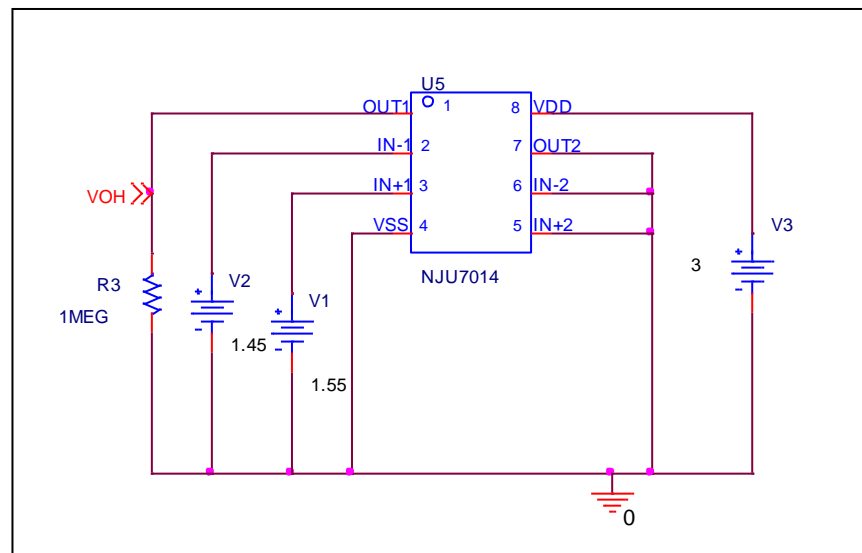
## Comparison Table

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

# Input Current

Simulation result
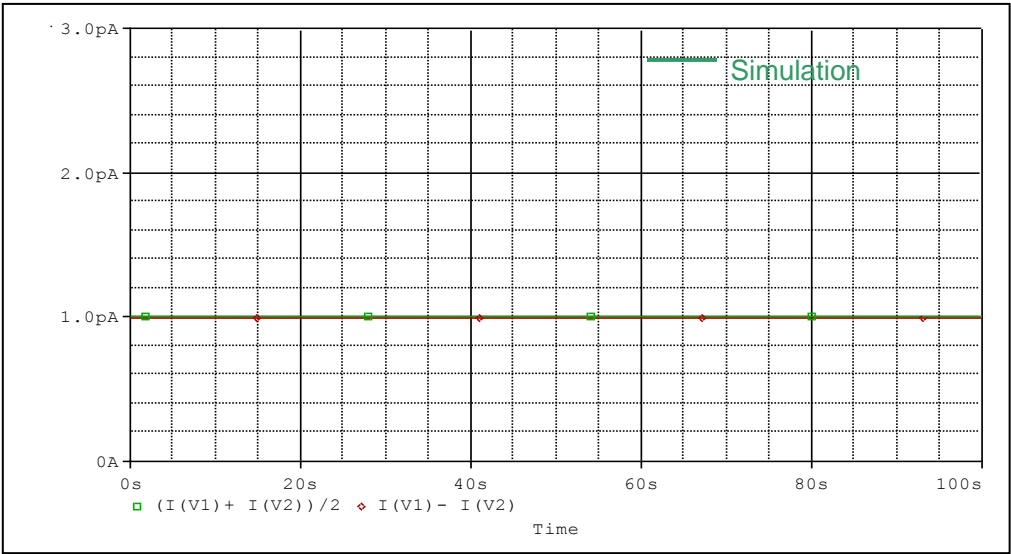


Evaluation Circuit
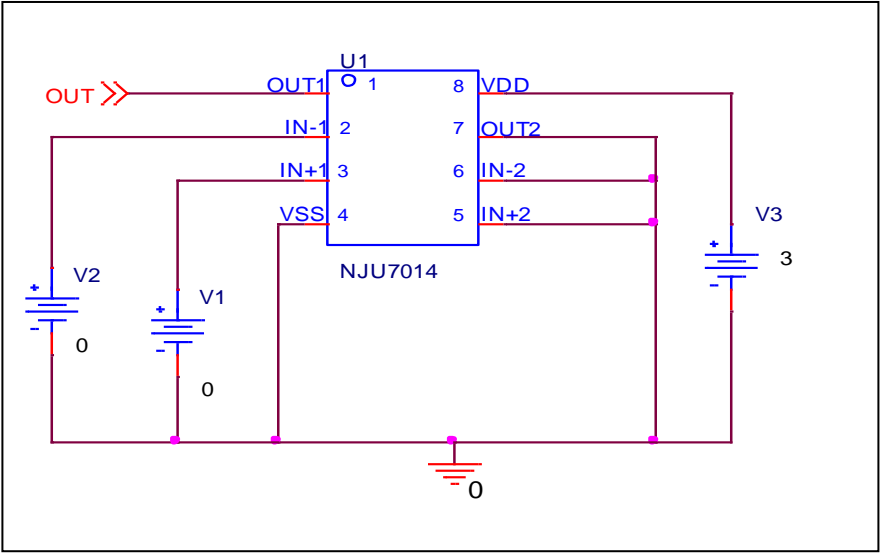


Comparison Table

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

# Input Offset Voltage

Simulation result
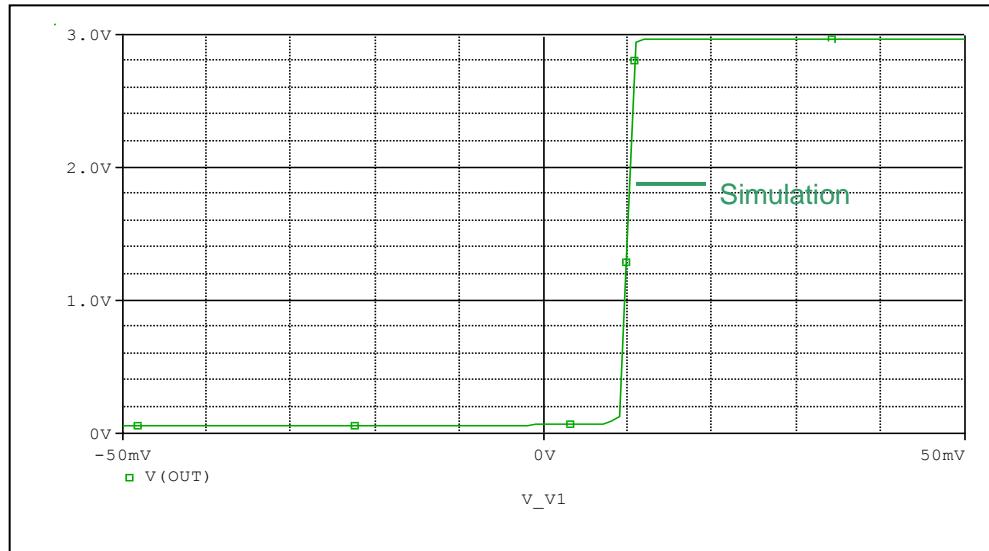


Evaluation Circuit
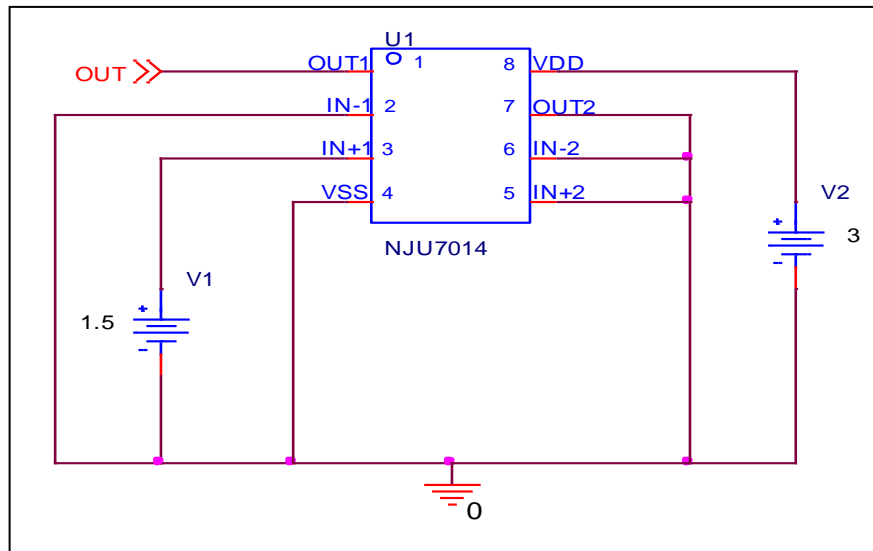


Comparison Table

|  | Measurement | Simulation | %Error |
|---|---|---|---|
| $V_{OS}$ (mV) | 10 | 9.957 | -0.43 |

# Open loop Voltage Gain

+ DB(V(OUT)/V(IN))
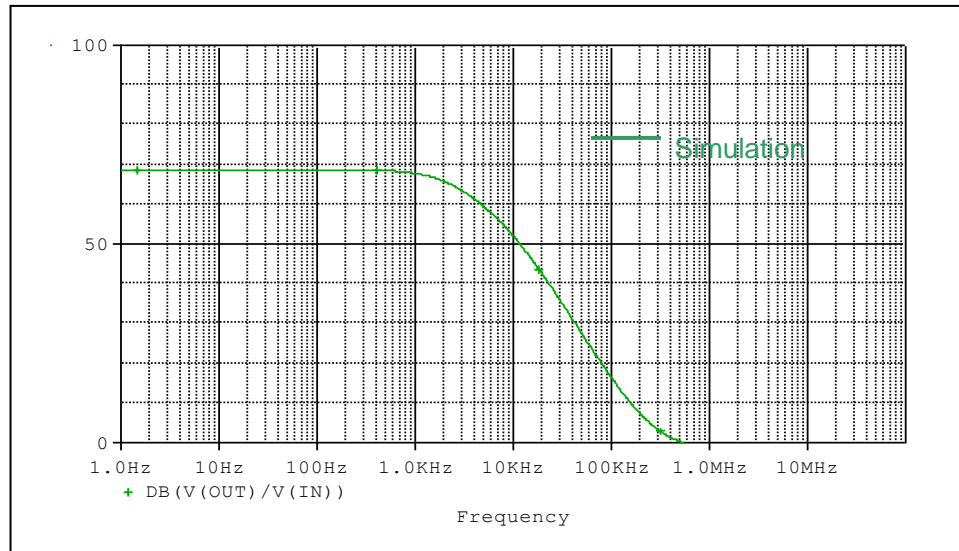
Evaluation Circuit
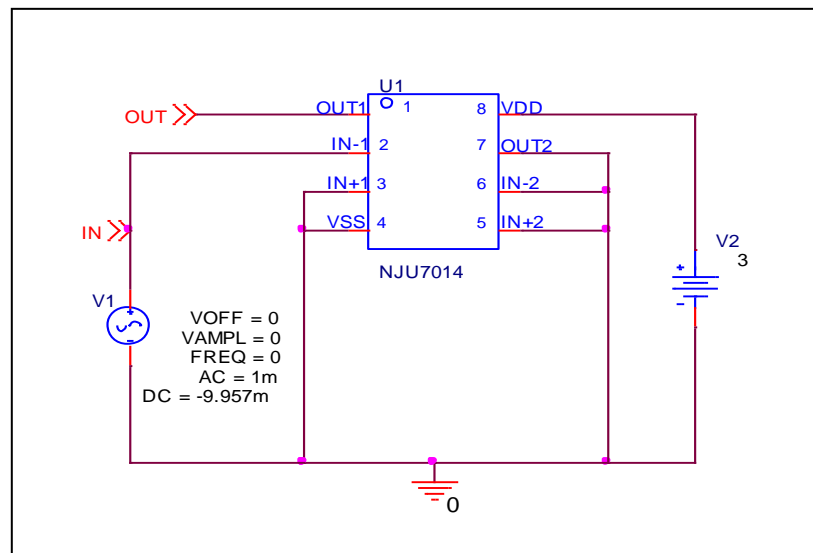


Comparison Table

| | Measurement | Simulation | %Error |
|---|---|---|---|
| **Av (dB)** | 70 | 68.714 | -1.837 |

# Unity Gain Frequency

DB(V(out)/ V(IN))
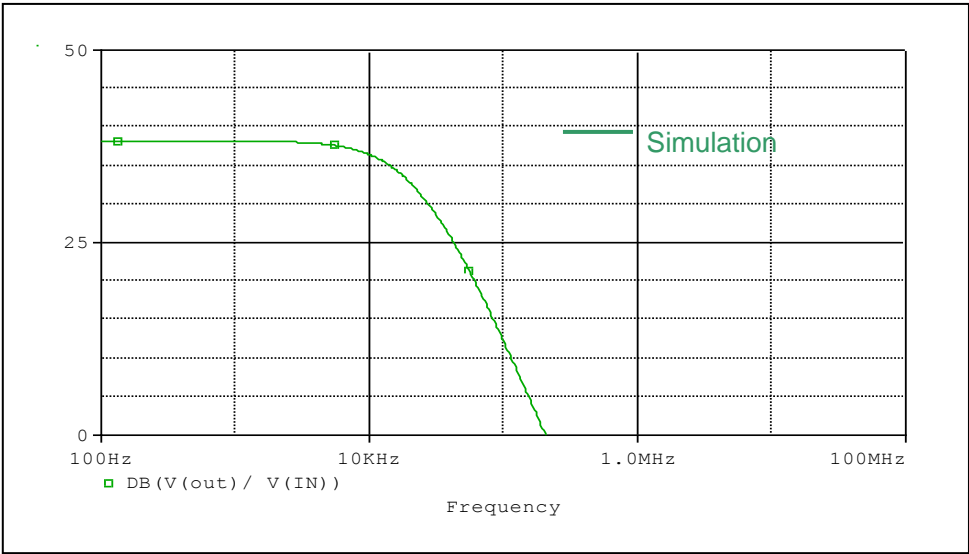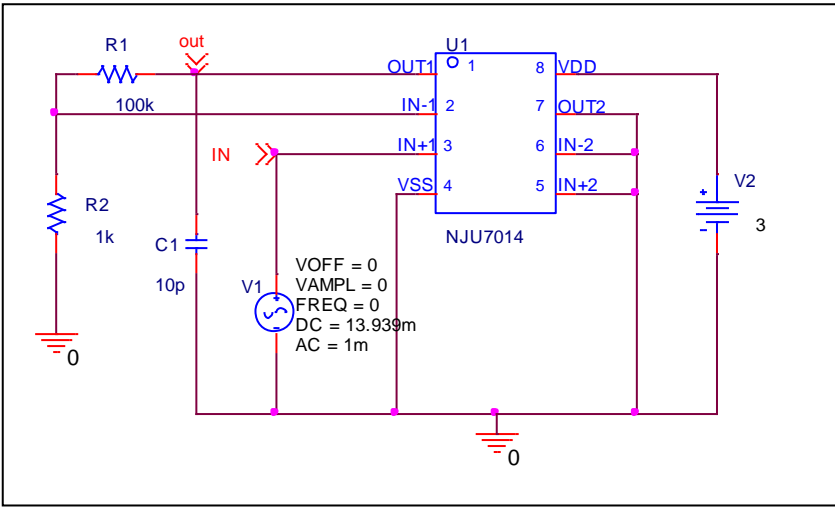
| $A_V$=40dB,$C_L$=10pF | Measurement | Simulation | %Error |
|:---:|:---:|:---:|:---:|
| Ft(MHz) | 0.2 | 0.206 | -3 |

# Common-Mode Rejection Ratio
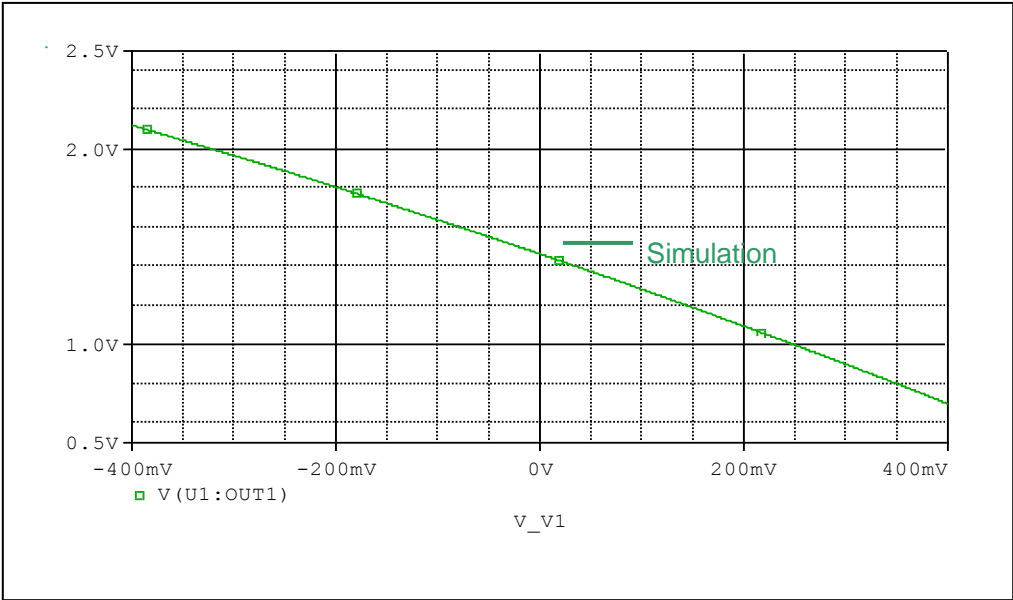
## Evaluation Circuit
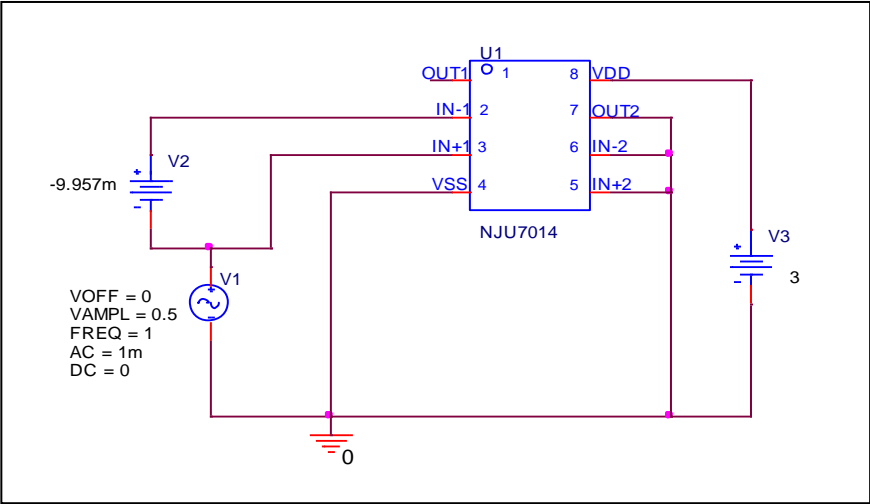


CMRR   = AV/ACM

Comparison Table

|  | Measurement | Simulation | %Error |
|---|---|---|---|
| **CMRR (dB)** | 65 | 63.915 | -1.669 |

## Slew Rate

### Simulation result
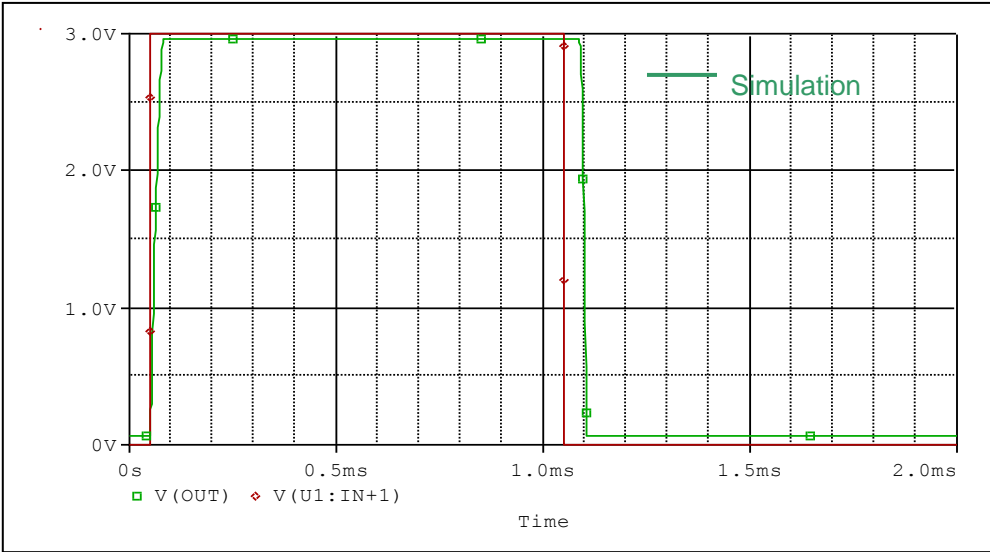


### Evaluation Circuit
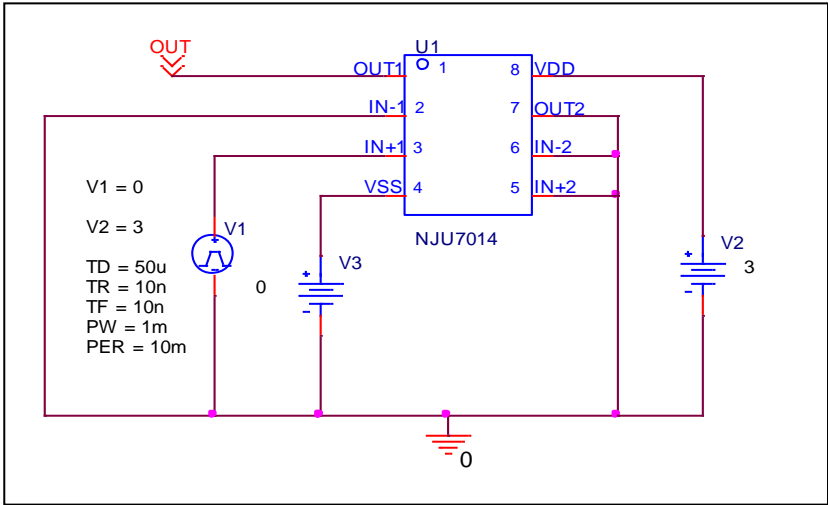


### Comparison Table

|  | Measurement | Simulation | % Error |
|---|---|---|---|
| **SR (V/us)** | 0.1 | 0.095 | -4 |