



# NEC's SUPER LOW NOISE HJ FET

## NE3210S01

### FEATURES

- **SUPER LOW NOISE FIGURE:**  
0.35 dB TYP at  $f = 12$  GHz
- **HIGH ASSOCIATED GAIN:**  
13.5 dB TYP at  $f = 12$  GHz
- **GATE LENGTH:**  $L_G \leq 0.20 \mu\text{m}$
- **GATE WIDTH:**  $W_G = 160 \mu\text{m}$

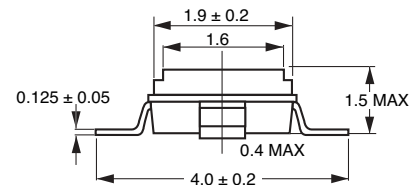
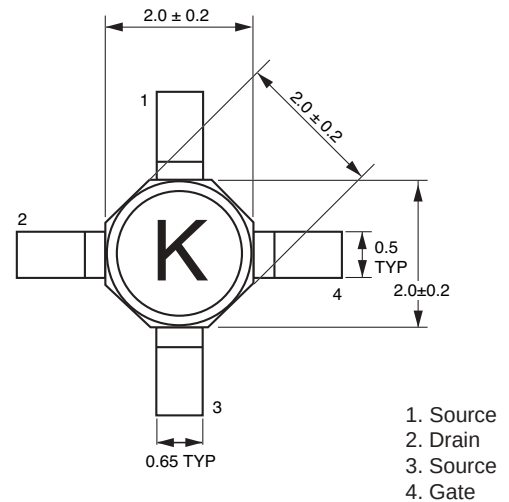
### DESCRIPTION

NEC's NE3210S01 is a pseudomorphic Hetero-Junction FET that uses the junction between Si-doped AlGaAs and undoped InGaAs to create very high mobility electrons. The device features mushroom shaped TiAl gates for decreased gate resistance and improved power handling. Its excellent low noise figure and high associated gain make it suitable for DBS and commercial systems. The NE 3210S01 is housed in a low cost plastic package which is available in tape and reel.

NEC's stringent quality assurance and test procedures assure the highest reliability and performance.

### OUTLINE DIMENSION (Units in mm)

PACKAGE OUTLINE S01



### ELECTRICAL CHARACTERISTICS ( $T_A = 25^\circ\text{C}$ )

| PART NUMBER<br>PACKAGE OUTLINE |                                                                            |               | NE3210S01<br>S01 |      |      |
|--------------------------------|----------------------------------------------------------------------------|---------------|------------------|------|------|
| SYMBOLS                        | PARAMETERS AND CONDITIONS                                                  | UNITS         | MIN              | TYP  | MAX  |
| GA                             | Associated Gain <sup>1</sup> , $V_{DS} = 2$ V, $I_D = 10$ mA, $f = 12$ GHz | dB            | 12               | 13.5 |      |
| NF                             | Noise Figure <sup>1</sup> , $V_{DS} = 2$ V, $I_D = 10$ mA, $f = 12$ GHz    | dB            |                  | 0.35 | 0.45 |
| $g_m$                          | Transconductance, $V_{DS} = 2$ V, $I_D = 10$ mA                            | mS            | 40               | 55   |      |
| $I_{DSS}$                      | Saturated Drain Current, $V_{DS} = 2$ V, $V_{GS} = 0$ V                    | mA            | 15               | 40   | 70   |
| $V_P$                          | Gate to Source Cutoff Voltage, $V_{DS} = 2$ V, $I_D = 100 \mu\text{A}$     | V             | -0.2             | -0.7 | -2.0 |
| $I_{GSO}$                      | Gate to Source Leakage Current, $V_{GS} = -3$ V                            | $\mu\text{A}$ |                  | 0.5  | 10   |

Note:

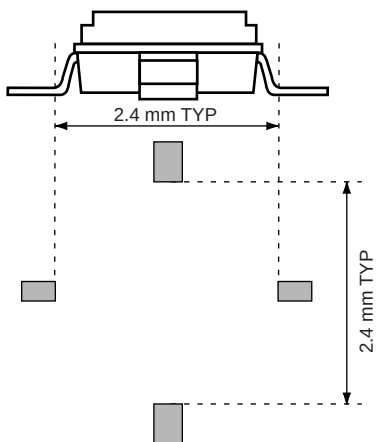
1. Typical values of noise figures and associated gain are those obtained when 50% of the devices from a large number of lots were individually measured in a circuit with the input individually tuned to obtain the minimum value. Maximum values are criteria established on the production line as a "go-no-go" screening tuned for the "generic" type but not each specimen.

**ABSOLUTE MAXIMUM RATINGS<sup>1</sup>** ( $T_A = 25^\circ\text{C}$ )

| SYMBOLS   | PARAMETERS              | UNITS            | RATINGS     |
|-----------|-------------------------|------------------|-------------|
| $V_{DS}$  | Drain to Source Voltage | V                | 4.0         |
| $V_{GS}$  | Gate to Source Voltage  | V                | -3.0        |
| $I_{DS}$  | Drain Current           | mA               | $I_{DSS}$   |
| $I_{GS}$  | Gate Current            | $\mu\text{A}$    | 100         |
| $P_T$     | Total Power Dissipation | mW               | 165         |
| $T_{CH}$  | Channel Temperature     | $^\circ\text{C}$ | 125         |
| $T_{STG}$ | Storage Temperature     | $^\circ\text{C}$ | -65 to +125 |

Note:

1. Operation in excess of any one of these parameters may result in permanent damage.

**TYPICAL MOUNT PAD LAYOUT** (Units in mm)**RECOMMENDED OPERATING CONDITIONS** ( $T_A = 25^\circ\text{C}$ )

| PART NUMBER |                         |       | NE3210S01 |     |     |
|-------------|-------------------------|-------|-----------|-----|-----|
| SYMBOLS     | PARAMETERS              | UNITS | MIN       | TYP | MAX |
| $V_{DS}$    | Drain to Source Voltage | V     |           | 2   | 3   |
| $I_{DS}$    | Drain Current           | mA    |           | 10  | 15  |
| $P_{IN}$    | Input Power             | dBm   |           |     | 0   |

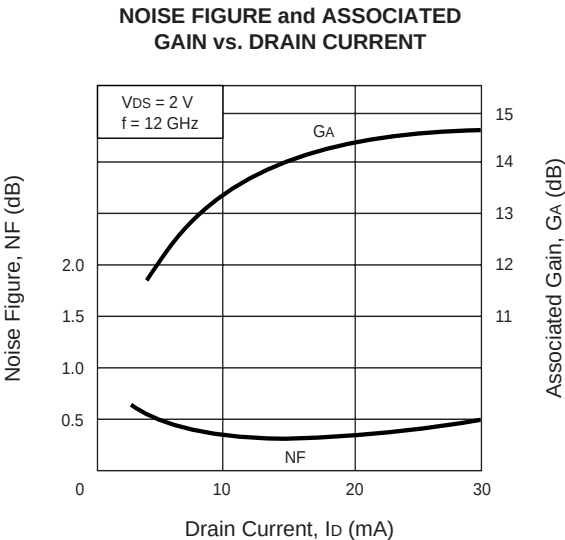
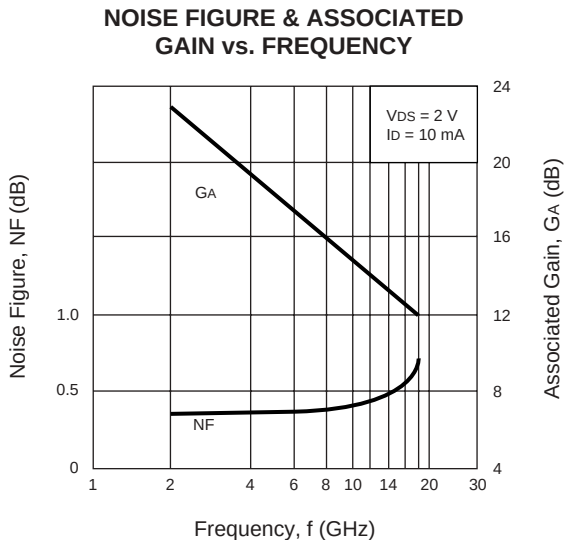
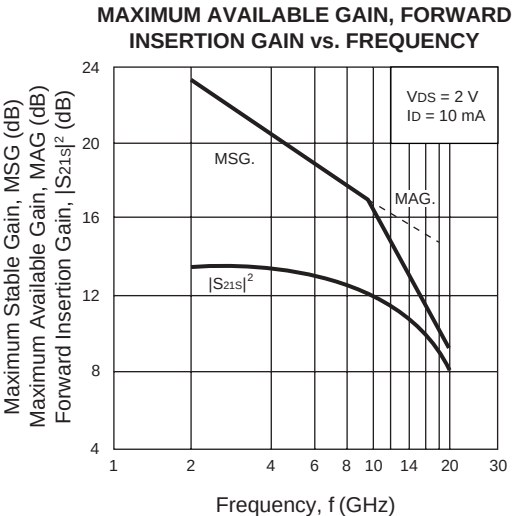
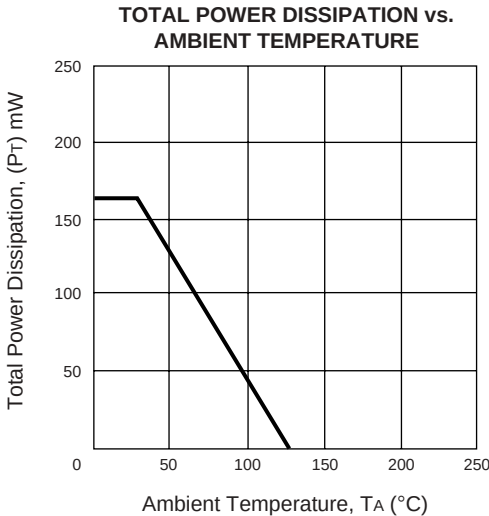
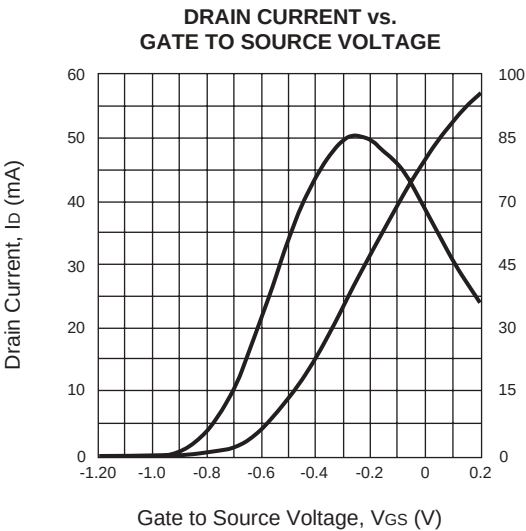
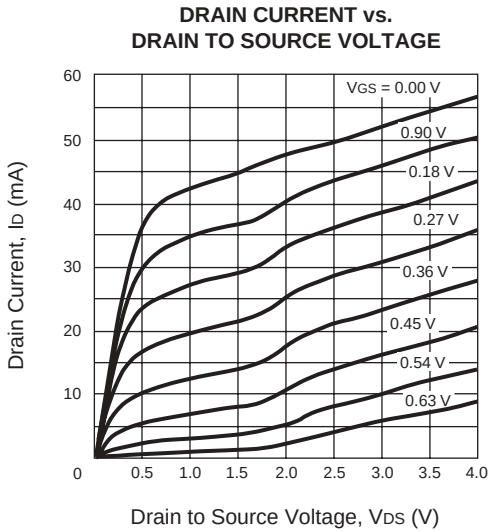
**TYPICAL NOISE PARAMETERS** ( $T_A = 25^\circ\text{C}$ )

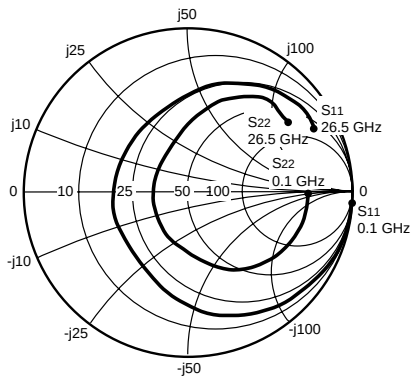
| FREQ.<br>(GHz)                                | NF <sub>MIN</sub><br>(dB) | G <sub>A</sub><br>(dB) | Γ <sub>OPT</sub> |      | Rn/50 |
|-----------------------------------------------|---------------------------|------------------------|------------------|------|-------|
|                                               |                           |                        | MAG              | ANG  |       |
| V <sub>DS</sub> = 2 V, I <sub>D</sub> = 10 mA |                           |                        |                  |      |       |
| 2.0                                           | 0.25                      | 21.2                   | 0.94             | 12   | 0.38  |
| 4.0                                           | 0.26                      | 19.5                   | 0.80             | 26   | 0.33  |
| 6.0                                           | 0.28                      | 18.2                   | 0.66             | 44   | 0.26  |
| 8.0                                           | 0.30                      | 16.2                   | 0.50             | 68   | 0.18  |
| 10.0                                          | 0.32                      | 14.7                   | 0.38             | 97   | 0.11  |
| 12.0                                          | 0.34                      | 13.5                   | 0.29             | 133  | 0.09  |
| 14.0                                          | 0.42                      | 12.9                   | 0.27             | 177  | 0.08  |
| 16.0                                          | 0.56                      | 12.3                   | 0.33             | -129 | 0.11  |
| 18.0                                          | 0.72                      | 11.9                   | 0.39             | -82  | 0.23  |

**ORDERING INFORMATION**

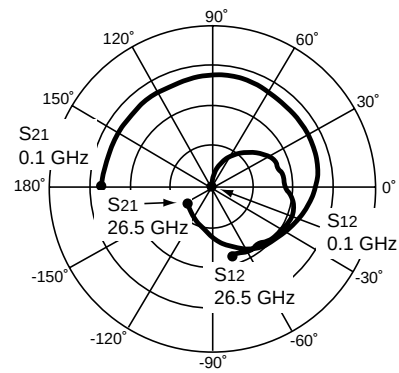
| PART NUMBER   | SUPPLY FORM               | MARKING |
|---------------|---------------------------|---------|
| NE3210S01-T1  | Tape & Reel 1000 pcs/reel |         |
| NE3210S01-T1B | Tape & Reel 4000 pcs/reel |         |

TYPICAL PERFORMANCE CURVES (T<sub>A</sub> = 25°C)



TYPICAL SCATTERING PARAMETERS (T<sub>A</sub> = 25°C)

Coordinates in Ohms  
Frequency in GHz  
V<sub>D</sub> = 2 V, I<sub>D</sub> = 5 mA



## NE3210S01

V<sub>D</sub> = 2 V, I<sub>D</sub> = 5 mA

| FREQUENCY | S <sub>11</sub> |         | S <sub>21</sub> |         | S <sub>12</sub> |        | S <sub>22</sub> |         | K     | MAG <sup>1</sup> |
|-----------|-----------------|---------|-----------------|---------|-----------------|--------|-----------------|---------|-------|------------------|
| GHz       | MAG             | ANG     | MAG             | ANG     | MAG             | ANG    | MAG             | ANG     |       | (dB)             |
| 0.10      | 1.001           | -1.14   | 3.405           | 178.54  | 0.001           | 82.96  | 0.732           | -0.85   | -0.03 | 34.20            |
| 0.20      | 1.000           | -2.12   | 3.393           | 177.73  | 0.003           | 88.10  | 0.731           | -1.97   | 0.00  | 30.64            |
| 0.30      | 1.000           | -3.08   | 3.393           | 176.83  | 0.004           | 88.76  | 0.732           | -3.04   | -0.03 | 28.99            |
| 0.40      | 0.999           | -4.18   | 3.396           | 175.50  | 0.006           | 86.87  | 0.732           | -3.93   | 0.04  | 27.65            |
| 0.50      | 0.997           | -4.94   | 3.345           | 173.68  | 0.007           | 85.87  | 0.735           | -4.73   | 0.08  | 26.76            |
| 0.70      | 0.995           | -6.83   | 3.347           | 171.18  | 0.010           | 84.12  | 0.735           | -6.68   | 0.11  | 25.30            |
| 1.00      | 0.992           | -10.11  | 3.350           | 167.44  | 0.014           | 81.51  | 0.732           | -9.24   | 0.12  | 23.77            |
| 1.50      | 0.987           | -15.20  | 3.346           | 161.27  | 0.021           | 77.55  | 0.726           | -13.91  | 0.15  | 22.03            |
| 2.00      | 0.978           | -20.81  | 3.362           | 154.97  | 0.028           | 73.36  | 0.718           | -18.29  | 0.19  | 20.82            |
| 2.50      | 0.968           | -26.46  | 3.373           | 148.74  | 0.035           | 69.02  | 0.709           | -22.77  | 0.23  | 19.89            |
| 3.00      | 0.954           | -32.09  | 3.388           | 142.45  | 0.041           | 64.57  | 0.698           | -27.41  | 0.27  | 19.15            |
| 3.50      | 0.938           | -37.61  | 3.386           | 136.09  | 0.047           | 59.71  | 0.685           | -32.00  | 0.33  | 18.54            |
| 4.00      | 0.920           | -43.04  | 3.381           | 129.89  | 0.053           | 54.85  | 0.670           | -36.40  | 0.39  | 18.06            |
| 5.00      | 0.879           | -53.83  | 3.378           | 117.91  | 0.062           | 45.72  | 0.638           | -44.54  | 0.50  | 17.34            |
| 6.00      | 0.835           | -64.32  | 3.428           | 106.08  | 0.070           | 38.30  | 0.604           | -52.54  | 0.60  | 16.93            |
| 7.00      | 0.778           | -77.53  | 3.525           | 92.97   | 0.081           | 29.68  | 0.553           | -62.26  | 0.68  | 16.40            |
| 8.00      | 0.680           | -92.29  | 3.539           | 78.21   | 0.086           | 17.34  | 0.469           | -73.32  | 0.89  | 16.15            |
| 9.00      | 0.589           | -109.87 | 3.527           | 63.32   | 0.091           | 7.85   | 0.398           | -86.69  | 1.03  | 14.86            |
| 10.00     | 0.505           | -127.92 | 3.432           | 49.90   | 0.089           | 0.93   | 0.335           | -97.84  | 1.22  | 13.05            |
| 11.00     | 0.481           | -149.57 | 3.490           | 35.80   | 0.096           | -2.08  | 0.302           | -114.77 | 1.14  | 13.32            |
| 12.00     | 0.461           | -175.91 | 3.442           | 19.40   | 0.104           | -10.23 | 0.250           | -139.98 | 1.11  | 13.13            |
| 13.00     | 0.453           | 155.80  | 3.273           | 3.28    | 0.107           | -18.84 | 0.210           | -173.02 | 1.16  | 12.40            |
| 14.00     | 0.468           | 129.34  | 3.017           | -12.03  | 0.104           | -26.21 | 0.214           | -151.67 | 1.27  | 11.50            |
| 15.00     | 0.521           | 109.11  | 2.774           | -25.92  | 0.102           | -31.03 | 0.256           | 126.40  | 1.30  | 11.09            |
| 16.00     | 0.587           | 92.69   | 2.545           | -39.53  | 0.098           | -35.03 | 0.309           | 109.03  | 1.30  | 10.89            |
| 17.00     | 0.658           | 79.53   | 2.325           | -53.80  | 0.098           | -38.38 | 0.389           | 95.15   | 1.18  | 11.16            |
| 18.00     | 0.720           | 68.06   | 2.045           | -67.87  | 0.096           | -43.64 | 0.476           | 82.56   | 1.10  | 11.42            |
| 19.00     | 0.762           | 58.38   | 1.773           | -79.76  | 0.093           | -47.93 | 0.553           | 74.44   | 1.03  | 11.69            |
| 20.00     | 0.793           | 51.94   | 1.537           | -89.63  | 0.089           | -50.59 | 0.603           | 67.90   | 1.02  | 11.62            |
| 21.00     | 0.819           | 48.37   | 1.366           | -97.66  | 0.089           | -52.07 | 0.640           | 62.36   | 0.94  | 11.85            |
| 22.00     | 0.849           | 43.44   | 1.238           | -106.37 | 0.090           | -56.92 | 0.685           | 57.59   | 0.77  | 11.36            |
| 23.00     | 0.866           | 38.86   | 1.124           | -116.19 | 0.089           | -63.10 | 0.721           | 52.26   | 0.65  | 11.02            |
| 24.00     | 0.863           | 34.84   | 1.009           | -124.88 | 0.087           | -67.53 | 0.748           | 48.09   | 0.63  | 10.67            |
| 25.00     | 0.868           | 29.14   | 0.949           | -132.34 | 0.084           | -71.30 | 0.751           | 46.97   | 0.60  | 10.54            |
| 26.00     | 0.865           | 28.40   | 0.918           | -138.91 | 0.086           | -71.66 | 0.736           | 40.30   | 0.66  | 10.26            |
| 26.50     | 0.859           | 28.76   | 0.895           | -143.63 | 0.084           | -74.09 | 0.744           | 34.46   | 0.69  | 10.25            |

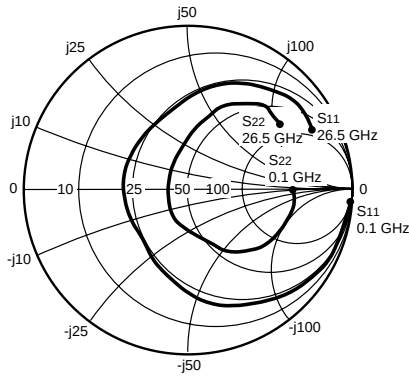
Note:

1. Gain Calculation:

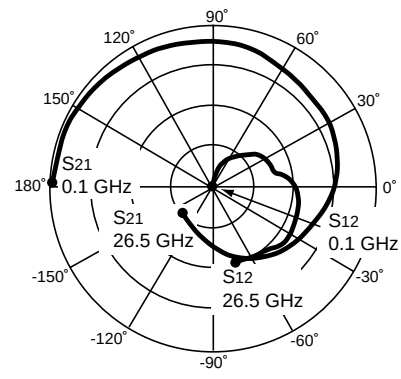
$$\text{MAG} = \frac{|S_{21}|}{|S_{12}|} \left( K \pm \sqrt{K^2 - 1} \right). \text{ When } K \leq 1, \text{ MAG is undefined and MSG values are used. } \text{MSG} = \frac{|S_{21}|}{|S_{12}|}, K = \frac{1 + |\Delta|^2 - |S_{11}|^2 - |S_{22}|^2}{2 |S_{12} S_{21}|}, \Delta = S_{11} S_{22} - S_{21} S_{12}$$

MAG = Maximum Available Gain

MSG = Maximum Stable Gain

TYPICAL SCATTERING PARAMETERS (T<sub>A</sub> = 25°C)

Coordinates in Ohms  
Frequency in GHz  
V<sub>D</sub> = 2 V, I<sub>D</sub> = 10 mA



## NE3210S01

V<sub>D</sub> = 2 V, I<sub>D</sub> = 10 mA

| FREQUENCY | S <sub>11</sub> |         | S <sub>21</sub> |         | S <sub>12</sub> |        | S <sub>22</sub> |         | K     | MAG <sup>1</sup> |
|-----------|-----------------|---------|-----------------|---------|-----------------|--------|-----------------|---------|-------|------------------|
| GHz       | MAG             | ANG     | MAG             | ANG     | MAG             | ANG    | MAG             | ANG     |       | (dB)             |
| 0.10      | 1.000           | -1.27   | 4.899           | 178.46  | 0.001           | 88.31  | 0.654           | -0.82   | -0.03 | 36.47            |
| 0.20      | 1.000           | -2.34   | 4.887           | 177.42  | 0.003           | 87.85  | 0.653           | -2.00   | -0.01 | 32.67            |
| 0.30      | 1.000           | -3.43   | 4.884           | 176.29  | 0.004           | 88.67  | 0.653           | -3.07   | -0.01 | 31.02            |
| 0.40      | 0.999           | -4.65   | 4.886           | 174.90  | 0.005           | 86.60  | 0.654           | -3.96   | 0.04  | 29.78            |
| 0.50      | 0.996           | -5.48   | 4.814           | 172.98  | 0.006           | 85.34  | 0.658           | -4.64   | 0.10  | 28.83            |
| 0.70      | 0.993           | -7.58   | 4.812           | 170.21  | 0.009           | 84.29  | 0.657           | -6.56   | 0.13  | 27.34            |
| 1.00      | 0.989           | -11.19  | 4.806           | 166.08  | 0.013           | 81.96  | 0.654           | -9.07   | 0.16  | 25.79            |
| 1.50      | 0.980           | -16.80  | 4.787           | 159.23  | 0.019           | 78.12  | 0.647           | -13.65  | 0.19  | 24.05            |
| 2.00      | 0.967           | -22.91  | 4.785           | 152.33  | 0.025           | 74.21  | 0.638           | -17.91  | 0.25  | 22.83            |
| 2.50      | 0.951           | -29.06  | 4.770           | 145.49  | 0.031           | 70.41  | 0.628           | -22.27  | 0.30  | 21.88            |
| 3.00      | 0.931           | -35.15  | 4.754           | 138.61  | 0.037           | 65.91  | 0.614           | -26.72  | 0.36  | 21.12            |
| 3.50      | 0.908           | -41.09  | 4.713           | 131.78  | 0.042           | 61.37  | 0.599           | -31.08  | 0.43  | 20.49            |
| 4.00      | 0.882           | -46.86  | 4.663           | 125.12  | 0.047           | 56.77  | 0.583           | -35.15  | 0.50  | 19.99            |
| 5.00      | 0.825           | -58.15  | 4.565           | 112.41  | 0.055           | 48.65  | 0.549           | -42.36  | 0.64  | 19.22            |
| 6.00      | 0.766           | -68.97  | 4.529           | 100.03  | 0.061           | 42.30  | 0.515           | -49.21  | 0.75  | 18.73            |
| 7.00      | 0.694           | -82.82  | 4.537           | 86.54   | 0.070           | 34.76  | 0.463           | -57.82  | 0.84  | 18.10            |
| 8.00      | 0.582           | -97.90  | 4.418           | 71.98   | 0.074           | 24.44  | 0.380           | -66.37  | 1.06  | 16.21            |
| 9.00      | 0.488           | -116.40 | 4.301           | 57.78   | 0.079           | 16.93  | 0.314           | -77.56  | 1.18  | 14.77            |
| 10.00     | 0.407           | -135.11 | 4.109           | 45.24   | 0.080           | 12.32  | 0.261           | -85.89  | 1.33  | 13.66            |
| 11.00     | 0.394           | -158.15 | 4.111           | 31.91   | 0.091           | 9.33   | 0.230           | -102.84 | 1.21  | 13.79            |
| 12.00     | 0.391           | 173.89  | 3.994           | 16.52   | 0.102           | 1.30   | 0.173           | -129.97 | 1.15  | 13.56            |
| 13.00     | 0.406           | 144.90  | 3.761           | 1.58    | 0.108           | -7.33  | 0.132           | -172.68 | 1.16  | 12.97            |
| 14.00     | 0.441           | 119.35  | 3.455           | -12.50  | 0.109           | -14.99 | 0.151           | 140.72  | 1.21  | 12.22            |
| 15.00     | 0.507           | 101.09  | 3.183           | -25.26  | 0.111           | -21.27 | 0.208           | 114.68  | 1.20  | 11.89            |
| 16.00     | 0.578           | 86.36   | 2.934           | -37.87  | 0.109           | -26.89 | 0.269           | 98.87   | 1.18  | 11.74            |
| 17.00     | 0.652           | 74.71   | 2.701           | -51.30  | 0.110           | -32.42 | 0.352           | 87.44   | 1.09  | 12.09            |
| 18.00     | 0.718           | 64.03   | 2.400           | -64.66  | 0.108           | -39.12 | 0.440           | 76.72   | 1.02  | 12.66            |
| 19.00     | 0.761           | 54.95   | 2.110           | -75.90  | 0.105           | -44.73 | 0.517           | 69.92   | 0.97  | 13.03            |
| 20.00     | 0.790           | 48.81   | 1.857           | -85.48  | 0.100           | -48.33 | 0.564           | 64.15   | 0.96  | 12.68            |
| 21.00     | 0.812           | 45.64   | 1.679           | -93.42  | 0.100           | -50.92 | 0.597           | 59.30   | 0.91  | 12.25            |
| 22.00     | 0.841           | 41.18   | 1.540           | -102.29 | 0.100           | -56.31 | 0.640           | 55.17   | 0.77  | 11.86            |
| 23.00     | 0.857           | 36.68   | 1.418           | -112.28 | 0.098           | -62.75 | 0.675           | 50.52   | 0.67  | 11.60            |
| 24.00     | 0.851           | 32.71   | 1.291           | -121.28 | 0.095           | -67.41 | 0.702           | 46.98   | 0.65  | 11.32            |
| 25.00     | 0.856           | 27.01   | 1.229           | -129.13 | 0.092           | -71.40 | 0.706           | 46.39   | 0.61  | 11.24            |
| 26.00     | 0.849           | 26.42   | 1.202           | -136.41 | 0.094           | -72.43 | 0.688           | 40.12   | 0.65  | 11.05            |
| 26.50     | 0.843           | 26.81   | 1.180           | -141.30 | 0.093           | -74.92 | 0.694           | 34.43   | 0.66  | 11.04            |

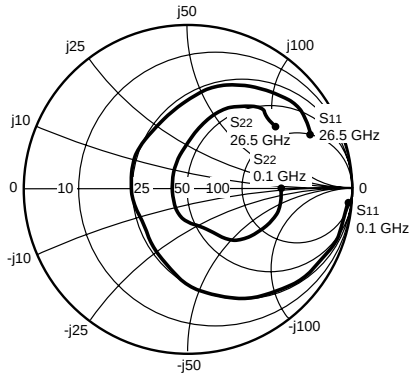
Note:

1. Gain Calculation:

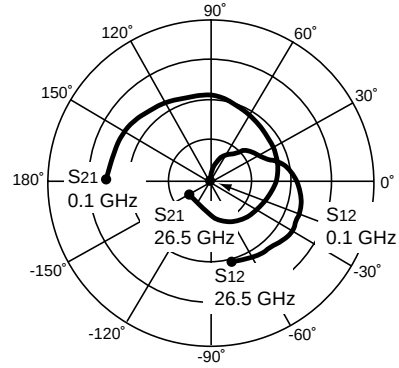
$$\text{MAG} = \frac{|S_{21}|}{|S_{12}|} \left( K \pm \sqrt{K^2 - 1} \right). \text{ When } K \leq 1, \text{ MAG is undefined and MSG values are used. } \text{MSG} = \frac{|S_{21}|}{|S_{12}|}, K = \frac{1 + |\Delta|^2 - |S_{11}|^2 - |S_{22}|^2}{2 |S_{12}| |S_{21}|}, \Delta = S_{11} S_{22} - S_{21} S_{12}$$

MAG = Maximum Available Gain

MSG = Maximum Stable Gain

TYPICAL SCATTERING PARAMETERS (T<sub>A</sub> = 25°C)

Coordinates in Ohms  
Frequency in GHz  
V<sub>D</sub> = 2 V, I<sub>D</sub> = 20 mA



## NE3210S01

V<sub>D</sub> = 2 V, I<sub>D</sub> = 20 mA

| FREQUENCY | S <sub>11</sub> |         | S <sub>21</sub> |         | S <sub>12</sub> |        | S <sub>22</sub> |         | K     | MAG <sup>1</sup> |
|-----------|-----------------|---------|-----------------|---------|-----------------|--------|-----------------|---------|-------|------------------|
| GHz       | MAG             | ANG     | MAG             | ANG     | MAG             | ANG    | MAG             | ANG     |       | (dB)             |
| 0.10      | 1.001           | -1.35   | 6.350           | 178.44  | 0.001           | 100.26 | 0.592           | -0.73   | -0.17 | 36.97            |
| 0.20      | 1.000           | -2.51   | 6.337           | 177.12  | 0.002           | 90.28  | 0.589           | -1.97   | -0.01 | 34.46            |
| 0.30      | 1.000           | -3.69   | 6.331           | 175.80  | 0.004           | 87.69  | 0.589           | -2.99   | 0.01  | 32.52            |
| 0.40      | 0.998           | -4.98   | 6.330           | 174.36  | 0.005           | 87.54  | 0.590           | -3.85   | 0.05  | 31.37            |
| 0.50      | 0.995           | -5.88   | 6.237           | 172.35  | 0.006           | 86.52  | 0.594           | -4.39   | 0.11  | 30.44            |
| 0.70      | 0.991           | -8.15   | 6.225           | 169.31  | 0.008           | 84.90  | 0.594           | -6.19   | 0.15  | 28.93            |
| 1.00      | 0.986           | -11.99  | 6.204           | 164.85  | 0.011           | 82.77  | 0.591           | -8.54   | 0.19  | 27.38            |
| 1.50      | 0.974           | -17.98  | 6.159           | 157.43  | 0.017           | 79.05  | 0.584           | -12.82  | 0.24  | 25.64            |
| 2.00      | 0.956           | -24.42  | 6.120           | 150.06  | 0.022           | 75.64  | 0.575           | -16.80  | 0.31  | 24.38            |
| 2.50      | 0.934           | -30.87  | 6.063           | 142.74  | 0.028           | 71.93  | 0.564           | -20.81  | 0.38  | 23.41            |
| 3.00      | 0.908           | -37.20  | 5.992           | 135.43  | 0.033           | 67.90  | 0.551           | -24.92  | 0.45  | 22.62            |
| 3.50      | 0.878           | -43.32  | 5.895           | 128.25  | 0.037           | 63.92  | 0.536           | -28.84  | 0.53  | 21.97            |
| 4.00      | 0.845           | -49.17  | 5.779           | 121.34  | 0.042           | 59.78  | 0.521           | -32.40  | 0.61  | 21.43            |
| 5.00      | 0.777           | -60.41  | 5.554           | 108.25  | 0.049           | 52.66  | 0.491           | -38.43  | 0.76  | 20.57            |
| 6.00      | 0.709           | -70.94  | 5.407           | 95.77   | 0.054           | 47.49  | 0.464           | -44.02  | 0.88  | 19.97            |
| 7.00      | 0.630           | -84.63  | 5.307           | 82.35   | 0.063           | 40.74  | 0.417           | -51.35  | 0.96  | 19.23            |
| 8.00      | 0.513           | -99.19  | 5.065           | 68.31   | 0.067           | 32.02  | 0.342           | -57.35  | 1.16  | 16.31            |
| 9.00      | 0.420           | -117.65 | 4.867           | 54.88   | 0.074           | 25.26  | 0.284           | -66.38  | 1.25  | 15.21            |
| 10.00     | 0.342           | -136.22 | 4.607           | 43.14   | 0.077           | 21.16  | 0.239           | -72.34  | 1.34  | 14.25            |
| 11.00     | 0.334           | -159.96 | 4.577           | 30.55   | 0.090           | 17.65  | 0.210           | -88.57  | 1.21  | 14.32            |
| 12.00     | 0.340           | 170.90  | 4.426           | 15.93   | 0.102           | 9.26   | 0.146           | -113.66 | 1.14  | 14.09            |
| 13.00     | 0.368           | 141.32  | 4.158           | 1.81    | 0.110           | 0.21   | 0.090           | -161.41 | 1.13  | 13.54            |
| 14.00     | 0.412           | 115.91  | 3.825           | -11.53  | 0.114           | -8.01  | 0.112           | 135.76  | 1.16  | 12.85            |
| 15.00     | 0.485           | 98.43   | 3.540           | -23.59  | 0.117           | -15.36 | 0.177           | 108.58  | 1.14  | 12.57            |
| 16.00     | 0.560           | 84.46   | 3.281           | -35.66  | 0.117           | -21.73 | 0.242           | 93.80   | 1.11  | 12.45            |
| 17.00     | 0.638           | 73.45   | 3.045           | -48.59  | 0.118           | -28.19 | 0.327           | 83.95   | 1.04  | 12.92            |
| 18.00     | 0.709           | 63.12   | 2.727           | -61.63  | 0.116           | -35.54 | 0.419           | 74.18   | 0.98  | 13.70            |
| 19.00     | 0.755           | 54.05   | 2.418           | -72.63  | 0.113           | -41.78 | 0.496           | 67.89   | 0.94  | 13.32            |
| 20.00     | 0.787           | 47.82   | 2.146           | -82.09  | 0.108           | -46.06 | 0.543           | 62.26   | 0.92  | 12.99            |
| 21.00     | 0.807           | 44.84   | 1.962           | -89.92  | 0.107           | -49.01 | 0.573           | 57.59   | 0.88  | 12.63            |
| 22.00     | 0.837           | 40.34   | 1.815           | -98.91  | 0.107           | -54.84 | 0.614           | 53.81   | 0.77  | 12.29            |
| 23.00     | 0.852           | 35.93   | 1.686           | -109.02 | 0.105           | -61.41 | 0.648           | 49.53   | 0.67  | 12.07            |
| 24.00     | 0.846           | 31.86   | 1.548           | -118.22 | 0.102           | -66.55 | 0.675           | 46.40   | 0.64  | 11.83            |
| 25.00     | 0.849           | 26.10   | 1.488           | -126.33 | 0.099           | -70.76 | 0.677           | 46.14   | 0.59  | 11.77            |
| 26.00     | 0.840           | 25.54   | 1.467           | -134.00 | 0.101           | -72.25 | 0.655           | 40.16   | 0.62  | 11.62            |
| 26.50     | 0.835           | 26.02   | 1.446           | -139.10 | 0.099           | -74.52 | 0.660           | 34.52   | 0.63  | 11.63            |

Note:

1. Gain Calculation:

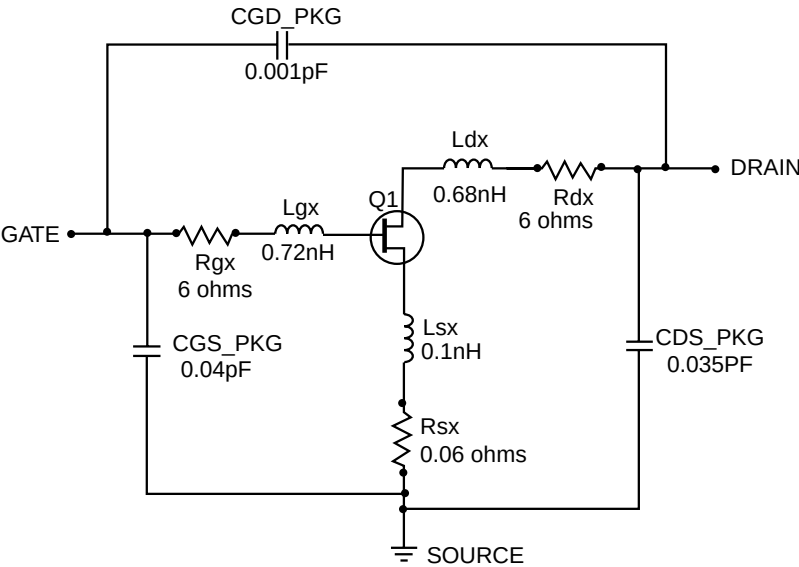
$$\text{MAG} = \frac{|S_{21}|}{|S_{12}|} \left( K \pm \sqrt{K^2 - 1} \right). \text{ When } K \leq 1, \text{ MAG is undefined and MSG values are used. } \text{MSG} = \frac{|S_{21}|}{|S_{12}|}, K = \frac{1 + |\Delta|^2 - |S_{11}|^2 - |S_{22}|^2}{2 |S_{12} S_{21}|}, \Delta = S_{11} S_{22} - S_{21} S_{12}$$

MAG = Maximum Available Gain

MSG = Maximum Stable Gain

NE3210S01 NONLINEAR MODEL

SCHEMATIC



FET NONLINEAR MODEL PARAMETERS <sup>(1)</sup>

| Parameters | Q1        | Parameters | Q1   |
|------------|-----------|------------|------|
| VTO        | -0.798    | RG         | 8    |
| VTOSC      | 0         | RD         | 0.5  |
| ALPHA      | 8         | RS         | 3    |
| BETA       | 0.0952    | RGMET      | 0    |
| GAMMA      | 0.072     | KF         | 0    |
| GAMMADC    | 0.065     | AF         | 1    |
| Q          | 2.5       | TNOM       | 27   |
| DELTA      | 0.5       | XTI        | 3    |
| VBI        | 0.6       | EG         | 1.43 |
| IS         | 1e-14     | VTOTC      | 0    |
| N          | 1         | BETATCE    | 0    |
| RIS        | 0         | FFE        | 1    |
| RID        | 0         |            |      |
| TAU        | 4e-12     |            |      |
| CDS        | 0.12e-12  |            |      |
| RDB        | 5000      |            |      |
| CBS        | 1e-9      |            |      |
| CGSO       | 0.36e-12  |            |      |
| CGDO       | 0.014e-12 |            |      |
| DELTA1     | 0.3       |            |      |
| DELTA2     | 0.6       |            |      |
| FC         | 0.5       |            |      |
| VBR        | Infinity  |            |      |

(1) Series IV Libra TOM Model

Life Support Applications

These NEC products are not intended for use in life support devices, appliances, or systems where the malfunction of these products can reasonably be expected to result in personal injury. The customers of CEL using or selling these products for use in such applications do so at their own risk and agree to fully indemnify CEL for all damages resulting from such improper use or sale.

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DATA SUBJECT TO CHANGE WITHOUT NOTICE

UNITS

| Parameter   | Units   |
|-------------|---------|
| time        | seconds |
| capacitance | farads  |
| inductance  | henries |
| resistance  | ohms    |
| voltage     | volts   |
| current     | amps    |

MODEL RANGE

Frequency: 0.1 to 22.5 GHz  
Bias:  $V_{DS} = 1\text{ V to }3\text{ V}$ ,  $I_D = 5\text{ mA to }30\text{ mA}$   
Date: 1/99

07/01/2004