NEC®

# LOW NOISE Ku-BAND GaAs MESFET

# NE13700 NE13783

## FEATURES

- **VERY HIGH $f_{MAX}$: 80 GHz**
- **LOW NOISE FIGURE**
  0.7 dB, GA = 14 dB at 4 GHz
  1.2 dB, GA = 11 dB at 8 GHz
  1.8 dB, GA = 9.5 dB at 12 GHz
  2.5 dB, GA = 7.5 dB at 18 GHz
- **0.5 MICRON RECESSED GATE**
- **PROVEN RELIABILITY AND STABILITY**
- **SPACE QUALIFIED**

## DESCRIPTION AND APPLICATIONS

The NE137 features low noise figure and high associated gain thru 18 GHz by employing a recessed 0.5 micron gate.

The device is available as a chip (NE13700) and in a hermetically sealed package (NE13783). The chip's gate and channel are glassivated with a thin layer of $SiO_2$ for mechanical protection only. The NE13783 is a low cost packaged device for industrial, military and space applications. The NE13783-4 is selected for $NF_{OPT}$ performance at 4 GHz. The NE13783S is selected for $NF_{OPT}$ performance at 12 GHz.

## PERFORMANCE SPECIFICATIONS ($T_A$ = 25°C)

| PART NUMBER<br>EIAJ[1] REGISTERED NUMBER<br>PACKAGE OUTLINE | | | NE13700<br>00 (CHIP) | | | NE13783<br>2SK280<br>83 | | | NE13783-4[2]<br>83 | | | NE13783S<br>83 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SYMBOLS | PARAMETERS AND CONDITIONS | UNITS | MIN | TYP | MAX | MIN | TYP | MAX | MIN | TYP | MAX | MIN | TYP | MAX |
| $f_{MAX}$ | Maximum Frequency of Oscillation at $V_{DS}$ = 3 V, $I_{DS}$ = 30 mA | GHz | | 80 | | | 80 | | | 80 | | | 80 | |
| MAG | Maximum Available Gain[3] at $V_{DS}$ = 3 V, $I_{DS}$ = 30 mA,<br>f = 8 GHz<br>f = 12 GHz<br>f = 18 GHz | <br>dB<br>dB<br>dB | | <br>16<br>11<br>8 | | | <br>16<br>11<br>8 | | | <br>16<br>11<br>8 | | | <br>16<br>11<br>8 | |
| $NF_{OPT}$ | Optimum Noise Figure[4] at $V_{DS}$ = 3 V, $I_{DS}$ = 10 mA,<br>f = 4 GHz<br>f = 8 GHz<br>f = 12 GHz<br>f = 18 GHz | <br>dB<br>dB<br>dB<br>dB | | <br>0.7<br>1.2<br>1.8<br>2.5 | <br><br>2.3[5] | | <br>0.7<br>1.2<br>1.8 | <br><br>2.3 | | <br>0.7<br>1.2<br>1.8 | <br>0.8 | | <br>0.7<br>1.2<br>1.6 | <br><br>1.8 |
| GA | Associated Gain at Optimum Noise Figure at $V_{DS}$ = 3 V, $I_{DS}$ = 10 mA,<br>f = 4 GHz<br>f = 8 GHz<br>f = 12 GHz<br>f = 18 GHz | <br>dB<br>dB<br>dB<br>dB | <br><br><br>8[5] | <br>14<br>11<br>9.5<br>7.5 | | <br><br><br>8 | <br>14<br>11<br>9 | | | <br>14<br>11<br>9 | | <br><br><br>8.5 | <br>14<br>11<br>9.5 | |
| $P_{1\,dB}$ | Output Power at 1 dB Compression Point at $V_{DS}$ = 4 V, $I_{DS}$ = 30 mA,<br>f = 12 GHz | dBm | | 15 | | | 15 | | | 15 | | | 15 | |

**Notes:**

1. Electronic Industrial Association of Japan.
2. NE13783-4 is tested for $NF_{OPT}$ at 4 GHz. The standard NE13783 is not tested at 4 GHz.
3. Gain Calculations: $MAG = \frac{|S_{21}|}{|S_{12}|}\,(K \pm \sqrt{K^2 - 1})$, $K = \frac{1 + |\Delta|^2 - |S_{11}|^2 - |S_{22}|^2}{2|S_{12}|\,|S_{21}|}$, $\Delta = S_{11}S_{22} - S_{21}S_{12}$
4. Typical values of noise figures 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 test with the fixture tuned for the "generic" type but not for each specimen.
5. RF performance is determined by packaging and testing 10 samples per wafer; wafer rejection criteria for standard devices is 2 rejects for 10 samples.

## ELECTRICAL CHARACTERISTICS ($T_A$ = 25°C)

| PART NUMBER<br>EIAJ[1] REGISTERED NUMBER<br>PACKAGE OUTLINE | | | NE13700<br>00 (CHIP) | | | NE13783<br>2SK280<br>83 | | |
|---|---|---|---|---|---|---|---|---|
| SYMBOLS | PARAMETERS AND CONDITIONS | UNITS | MIN | TYP | MAX | MIN | TYP | MAX |
| $I_{DSS}$ | Drain Current at $V_{DS}$ = 3 V, $V_{GS}$ = 0 | mA | 20 | 50 | 100 | 20 | 50 | 100 |
| $V_P$ | Pinch-off Voltage at $V_{DS}$ = 3 V, $I_{DS}$ = 0.1 mA | V | -0.5 | -1.1 | -6 | -0.5 | -1.1 | -6 |
| $g_M$ | Transconductance at $V_{DS}$ = 3 V, $I_{DS}$ = 10 mA | mS | 20 | 45 | 100 | 20 | 45 | 100 |
| $I_{GS}$ | Gate to Source Leakage Current at $V_{GS}$ = -5 V | μA | | 1 | 10 | | 1 | 10 |
| $R_{TH}$ | Thermal Resistance (Channel-to-Ambient) | °C/W | | | 190[2] | | | 450 |
| $P_T$ | Total Power Dissipation | mW | | | 400[2,3] | | | 270[4] |

**Notes:**

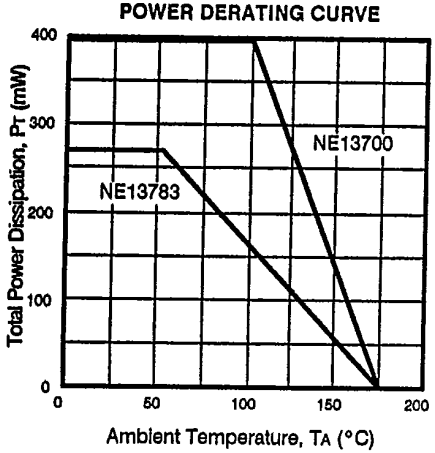
1. Electronic Industrial Association of Japan.
2. $R_{TH}$ (channel to case) for chips mounted on a copper heatsink.
3. $T_A$ = 100°C
4. $T_A$ = 50°C

## ABSOLUTE MAXIMUM RATINGS ($T_A$ = 25°C)

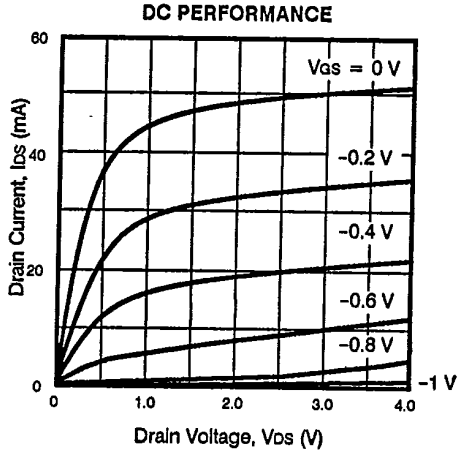
| SYMBOLS | PARAMETERS | UNITS | RATINGS |
|---|---|---|---|
| $V_{DS}$ | Drain to Source Voltage | V | 5 |
| $V_{GS}$ | Gate to Source Voltage | V | -6 |
| $I_{DS}$ | Drain Current | mA | 100 |
| $P_{IN}$ | RF Input Power | mW | 40 |
| $T_{CH}$ | Channel Temperature | °C | 175 |
| $T_{STG}$ | Storage Temperature | °C | -65 to +175 |

## TYPICAL DEVICE CHARACTERISTICS ($T_A$ = 25°C)

POWER DERATING CURVE

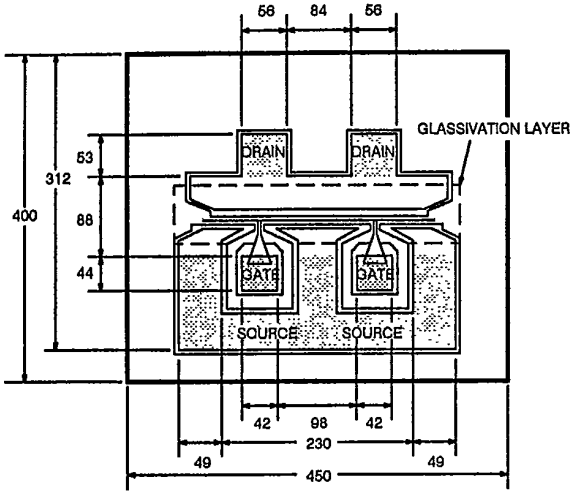



DC PERFORMANCE



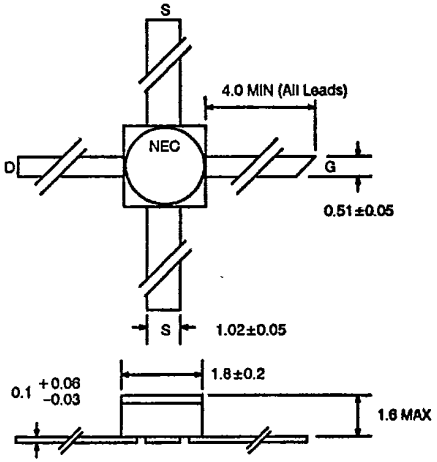
## OUTLINE DIMENSIONS

**NE13700 (CHIP)**
(Units in µm)



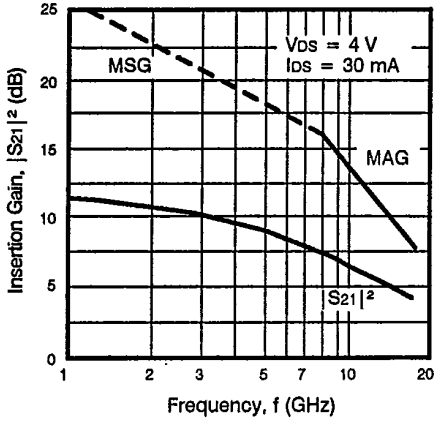

Bonding Pad Area. Chip Thickness: 140 µm

**83 OUTLINE**
(Units in mm)

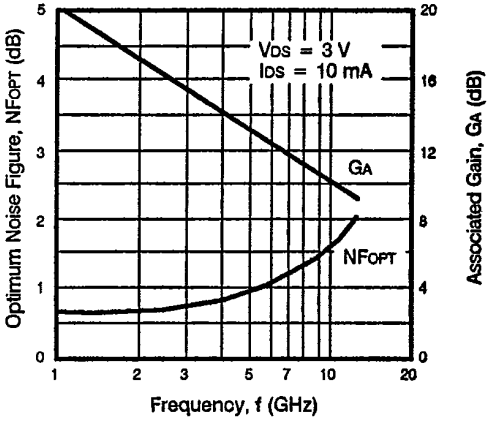



## TYPICAL PERFORMANCE CHARACTERISTICS ($T_A$ = 25°C)

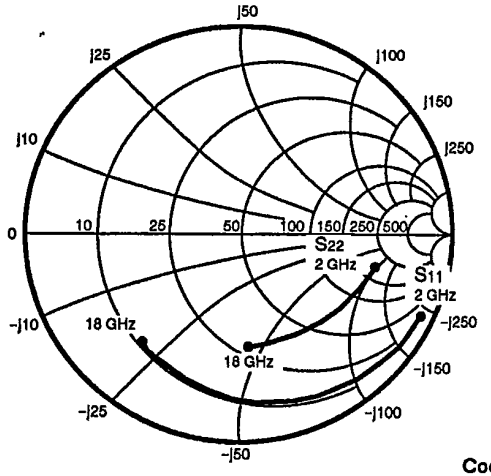
**NE13783**
**TYPICAL GAIN vs. FREQUENCY**

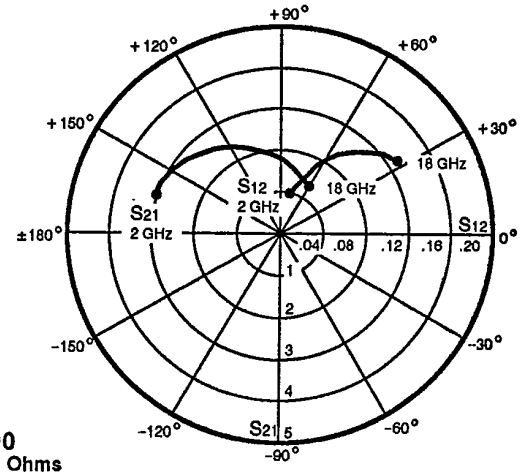



**NE13783**
**NOISE FIGURE AND**
**ASSOCIATED GAIN vs. FREQUENCY**



## TYPICAL COMMON SOURCE SCATTERING PARAMETERS




**NE13700**
**Coordinates in Ohms**
**Frequency in GHz**
**($V_{DS}$ = 3 V, $I_{DS}$ = 10 mA)**

## S-MAGN AND ANGLES:

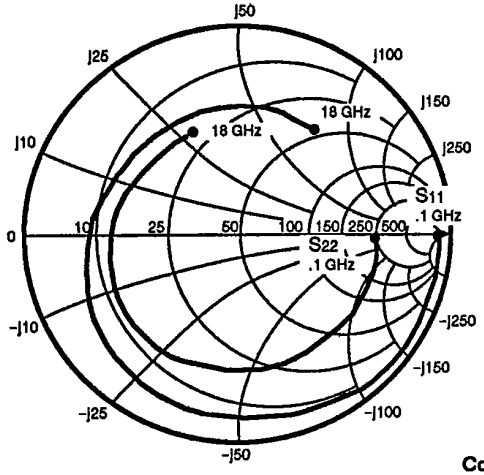
**$V_{DS}$ = 3 V, $I_{DS}$ = 10 mA**

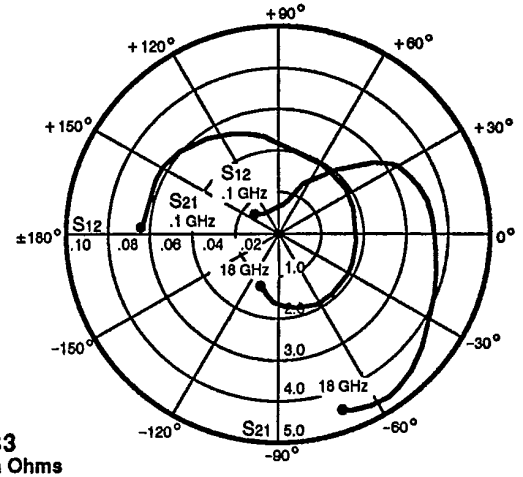
| FREQUENCY (MHz) | $S_{11}$ | | $S_{21}$ | | $S_{12}$ | | $S_{22}$ | |
|---|---|---|---|---|---|---|---|---|
| 2000 | .97 | -24 | 3.02 | 159 | .04 | 77 | .71 | -14 |
| 3000 | .94 | -36 | 2.92 | 149 | .06 | 69 | .70 | -20 |
| 4000 | .91 | -48 | 2.75 | 138 | .07 | 63 | .69 | -26 |
| 5000 | .87 | -57 | 2.64 | 130 | .08 | 57 | .66 | -31 |
| 6000 | .85 | -66 | 2.48 | 123 | .09 | 55 | .66 | -36 |
| 7000 | .81 | -74 | 2.37 | 115 | .10 | 50 | .62 | -40 |
| 8000 | .78 | -81 | 2.23 | 109 | .11 | 45 | .60 | -43 |
| 9000 | .76 | -89 | 2.07 | 103 | .11 | 43 | .59 | -47 |
| 10000 | .73 | -96 | 1.97 | 97 | .12 | 40 | .61 | -51 |
| 11000 | .72 | -104 | 1.88 | 90 | .12 | 37 | .55 | -55 |
| 12000 | .71 | -109 | 1.76 | 85 | .12 | 36 | .54 | -59 |
| 13000 | .70 | -114 | 1.70 | 80 | .12 | 33 | .53 | -64 |
| 14000 | .68 | -110 | 1.62 | 78 | .12 | 35 | .53 | -68 |
| 15000 | .68 | -124 | 1.53 | 71 | .12 | 31 | .53 | -73 |
| 16000 | .67 | -126 | 1.46 | 68 | .13 | 30 | .54 | -77 |
| 17000 | .64 | -130 | 1.42 | 63 | .12 | 32 | .55 | -80 |
| 18000 | .65 | -133 | 1.32 | 60 | .13 | 33 | .57 | -82 |

**$V_{DS}$ = 3 V, $I_{DS}$ = 30 mA**

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 2000 | .95 | -26 | 3.57 | 157 | .04 | 76 | .66 | -14 |
| 3000 | .93 | -40 | 3.53 | 147 | .05 | 69 | .65 | -20 |
| 4000 | .89 | -52 | 3.23 | 136 | .06 | 62 | .63 | -26 |
| 5000 | .86 | -63 | 3.08 | 127 | .07 | 56 | .60 | -31 |
| 6000 | .83 | -71 | 2.88 | 121 | .08 | 55 | .59 | -36 |
| 7000 | .80 | -80 | 2.70 | 113 | .09 | 50 | .58 | -40 |
| 8000 | .78 | -87 | 2.58 | 108 | .09 | 47 | .57 | -42 |
| 9000 | .75 | -95 | 2.31 | 101 | .09 | 44 | .56 | -46 |
| 10000 | .73 | -102 | 2.23 | 96 | .10 | 42 | .54 | -49 |
| 11000 | .68 | -109 | 2.07 | 88 | .10 | 41 | .51 | -52 |
| 12000 | .70 | -116 | 2.01 | 84 | .10 | 39 | .48 | -56 |
| 13000 | .70 | -122 | 1.84 | 78 | .10 | 37 | .49 | -64 |
| 14000 | .74 | -126 | 1.83 | 77 | .11 | 40 | .51 | -70 |
| 15000 | .68 | -129 | 1.01 | 68 | .10 | 36 | .52 | -74 |
| 16000 | .67 | -130 | 1.62 | 68 | .12 | 36 | .53 | -75 |
| 17000 | .61 | -134 | 1.53 | 61 | .12 | 38 | .51 | -76 |
| 18000 | .65 | -136 | 1.48 | 57 | .11 | 40 | .54 | -73 |

## TYPICAL COMMON SOURCE SCATTERING PARAMETERS




**NE13783**
**Coordinates in Ohms**
**Frequency in GHz**
**($V_{DS}$ = 3 V, $I_{DS}$ = 10 mA)**

## S-MAGN AND ANGLES:

**$V_{DS}$ = 3 V, $I_{DS}$ = 10 mA**

| FREQUENCY (MHz) | $S_{11}$ | | $S_{21}$ | | $S_{12}$ | | $S_{22}$ | |
|---|---|---|---|---|---|---|---|---|
| 100 | 1.00 | -3 | 3.07 | 176 | .01 | 134 | .74 | -2 |
| 500 | .99 | -11 | 3.14 | 167 | .01 | 76 | .74 | -7 |
| 1000 | .99 | -24 | 3.05 | 159 | .01 | 79 | .75 | -17 |
| 1500 | .98 | -35 | 2.97 | 147 | .02 | 60 | .74 | -23 |
| 2000 | .97 | -44 | 2.95 | 137 | .03 | 52 | .75 | -32 |
| 4000 | .88 | -76 | 2.40 | 108 | .06 | 33 | .66 | -56 |
| 6000 | .84 | -100 | 2.14 | 80 | .07 | 19 | .68 | -76 |
| 8000 | .77 | -124 | 1.93 | 54 | .07 | 6 | .66 | -93 |
| 10000 | .68 | -147 | 1.80 | 32 | .07 | -4 | .63 | -108 |
| 12000 | .58 | 180 | 1.72 | 1 | .07 | -14 | .60 | -125 |
| 14000 | .54 | 134 | 1.60 | -28 | .08 | -27 | .53 | -150 |
| 16000 | .61 | 87 | 1.21 | -63 | .09 | -41 | .48 | 167 |
| 18000 | .65 | 49 | 1.15 | -102 | .09 | -68 | .50 | 109 |

**$V_{DS}$ = 3 V, $I_{DS}$ = 30 mA**

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 100 | 1.00 | -3 | 3.83 | 176 | .02 | 58 | .69 | -3 |
| 500 | .99 | -14 | 3.92 | 166 | .01 | 75 | .69 | -6 |
| 1000 | .99 | -25 | 3.80 | 158 | .01 | 76 | .70 | -16 |
| 1500 | .97 | -37 | 3.69 | 146 | .02 | 61 | .70 | -23 |
| 2000 | .97 | -48 | 3.64 | 135 | .02 | 64 | .70 | -32 |
| 4000 | .89 | -80 | 3.02 | 105 | .04 | 38 | .62 | -55 |
| 6000 | .81 | -103 | 2.62 | 78 | .05 | 25 | .63 | -73 |
| 8000 | .73 | -127 | 2.29 | 51 | .06 | 16 | .63 | -90 |
| 10000 | .64 | -148 | 2.15 | 29 | .06 | 11 | .61 | -104 |
| 12000 | .52 | 178 | 2.10 | -2 | .07 | 4 | .58 | -119 |
| 14000 | .50 | 131 | 1.99 | -32 | .09 | -9 | .52 | -141 |
| 16000 | .57 | 84 | 1.90 | -66 | .11 | -24 | .44 | 179 |
| 18000 | .64 | 46 | 1.59 | -104 | .11 | -54 | .44 | 118 |