

# CGH40006P

## 6 W, RF Power GaN HEMT

Cree's CGH40006P is an unmatched, gallium nitride (GaN) high electron mobility transistor (HEMT). The CGH40006P, operating from a 28 volt rail, offers a general purpose, broadband solution to a variety of RF and microwave applications. GaN HEMTs offer high efficiency, high gain and wide bandwidth capabilities making the CGH40006P ideal for linear and compressed amplifier circuits. The transistor is available in a solder-down, pill package.



Package Types: 440109  
PN's: CGH40006P

### FEATURES

- Up to 6 GHz Operation
- 13 dB Small Signal Gain at 2.0 GHz
- 11 dB Small Signal Gain at 6.0 GHz
- 8 W typical at  $P_{IN} = 32$  dBm
- 65 % Efficiency at  $P_{IN} = 32$  dBm
- 28 V Operation

### APPLICATIONS

- 2-Way Private Radio
- Broadband Amplifiers
- Cellular Infrastructure
- Test Instrumentation
- Class A, AB, Linear amplifiers suitable for OFDM, W-CDMA, EDGE, CDMA waveforms



## Absolute Maximum Ratings (not simultaneous) at 25°C Case Temperature

| Parameter                                         | Symbol          | Rating    | Units | Conditions |
|---------------------------------------------------|-----------------|-----------|-------|------------|
| Drain-Source Voltage                              | $V_{DS}$        | 84        | Volts | 25°C       |
| Gate-to-Source Voltage                            | $V_{GS}$        | -10, +2   | Volts | 25°C       |
| Storage Temperature                               | $T_{STG}$       | -65, +150 | °C    |            |
| Operating Junction Temperature                    | $T_J$           | 225       | °C    |            |
| Maximum Forward Gate Current                      | $I_{GMAX}$      | 2.1       | mA    | 25°C       |
| Maximum Drain Current <sup>1</sup>                | $I_{DMAX}$      | 0.75      | A     | 25°C       |
| Soldering Temperature <sup>2</sup>                | $T_S$           | 245       | °C    |            |
| Thermal Resistance, Junction to Case <sup>3</sup> | $R_{\theta JC}$ | 9.5       | °C/W  | 85°C       |
| Case Operating Temperature <sup>3</sup>           | $T_C$           | -40, +150 | °C    |            |

Note:

<sup>1</sup> Current limit for long term, reliable operation

<sup>2</sup> Refer to the Application Note on soldering at [www.cree.com/RF/Document-Library](http://www.cree.com/RF/Document-Library)

<sup>3</sup> Measured for the CGH40006P at  $P_{DISS} = 8$  W.

## Electrical Characteristics ( $T_C = 25^\circ\text{C}$ )

| Characteristics                                                                                                                | Symbol       | Min. | Typ. | Max.   | Units    | Conditions                                                                                 |
|--------------------------------------------------------------------------------------------------------------------------------|--------------|------|------|--------|----------|--------------------------------------------------------------------------------------------|
| <b>DC Characteristics<sup>1</sup></b>                                                                                          |              |      |      |        |          |                                                                                            |
| Gate Threshold Voltage                                                                                                         | $V_{GS(th)}$ | -3.8 | -3.0 | -2.3   | $V_{DC}$ | $V_{DS} = 10$ V, $I_D = 2.1$ mA                                                            |
| Gate Quiescent Voltage                                                                                                         | $V_{GS(Q)}$  | –    | -2.7 | –      | $V_{DC}$ | $V_{DS} = 28$ V, $I_D = 100$ mA                                                            |
| Saturated Drain Current                                                                                                        | $I_{DS}$     | 1.7  | 2.1  | –      | A        | $V_{DS} = 6.0$ V, $V_{GS} = 2.0$ V                                                         |
| Drain-Source Breakdown Voltage                                                                                                 | $V_{BR}$     | 120  | –    | –      | $V_{DC}$ | $V_{GS} = -8$ V, $I_D = 2.1$ mA                                                            |
| <b>RF Characteristics<sup>2</sup> (<math>T_C = 25^\circ\text{C}</math>, <math>F_0 = 2.0</math> GHz unless otherwise noted)</b> |              |      |      |        |          |                                                                                            |
| Small Signal Gain                                                                                                              | $G_{SS}$     | 11.5 | 13   | –      | dB       | $V_{DD} = 28$ V, $I_{DQ} = 100$ mA                                                         |
| Power Output at $P_{IN} = 32$ dBm                                                                                              | $P_{OUT}$    | 7.0  | 9    | –      | W        | $V_{DD} = 28$ V, $I_{DQ} = 100$ mA                                                         |
| Drain Efficiency <sup>3</sup>                                                                                                  | $\eta$       | 53   | 65   | –      | %        | $V_{DD} = 28$ V, $I_{DQ} = 100$ mA, $P_{IN} = 32$ dBm                                      |
| Output Mismatch Stress                                                                                                         | VSWR         | –    | –    | 10 : 1 | $\Psi$   | No damage at all phase angles,<br>$V_{DD} = 28$ V, $I_{DQ} = 100$ mA,<br>$P_{IN} = 32$ dBm |
| <b>Dynamic Characteristics</b>                                                                                                 |              |      |      |        |          |                                                                                            |
| Input Capacitance                                                                                                              | $C_{GS}$     | –    | 3.0  | –      | pF       | $V_{DS} = 28$ V, $V_{gs} = -8$ V, $f = 1$ MHz                                              |
| Output Capacitance                                                                                                             | $C_{DS}$     | –    | 1.1  | –      | pF       | $V_{DS} = 28$ V, $V_{gs} = -8$ V, $f = 1$ MHz                                              |
| Feedback Capacitance                                                                                                           | $C_{GD}$     | –    | 0.1  | –      | pF       | $V_{DS} = 28$ V, $V_{gs} = -8$ V, $f = 1$ MHz                                              |

Notes:

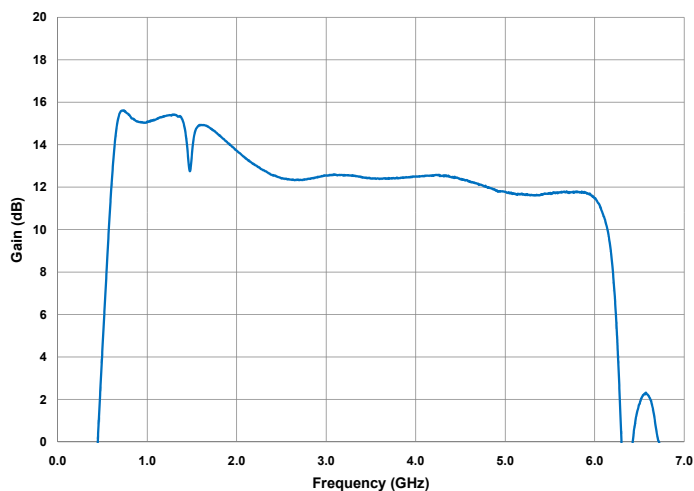
<sup>1</sup> Measured on wafer prior to packaging.

<sup>2</sup> Measured in CGH40006P-AMP.

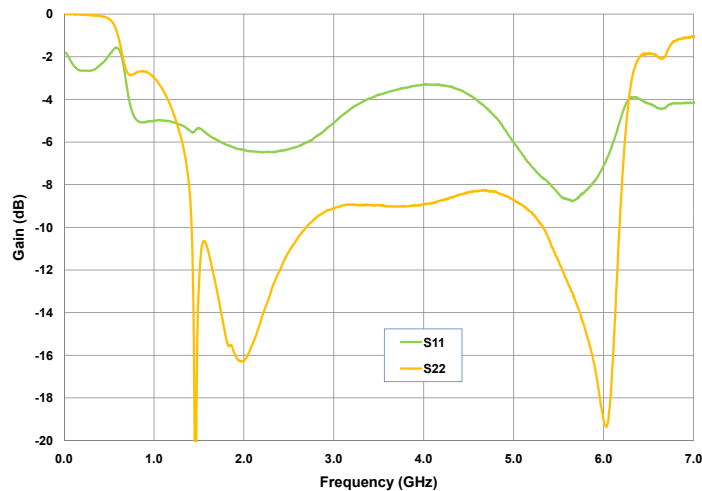
<sup>3</sup> Drain Efficiency =  $P_{OUT} / P_{DC}$

## Typical Performance

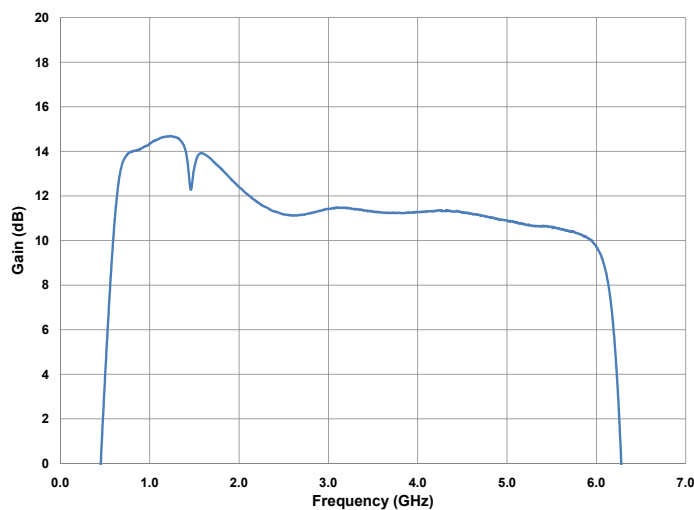
**Small Signal Gain vs Frequency at 28 V  
of the CGH40006P in the CGH40006P-AMP**



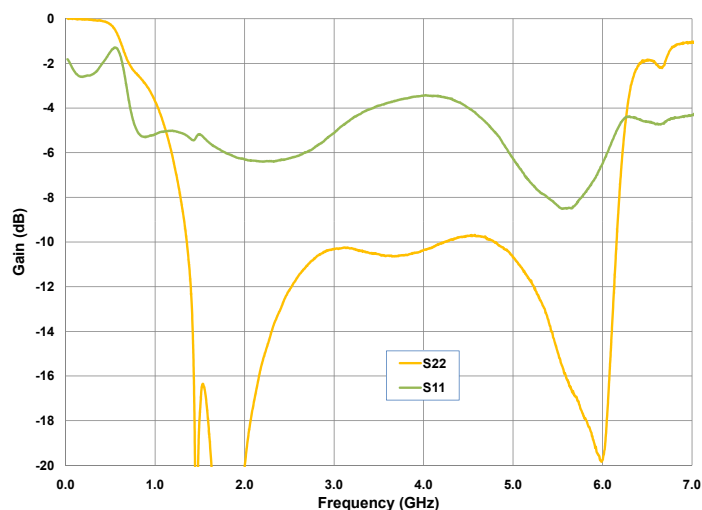
**Input & Output Return Losses vs Frequency  
28 V of the CGH40006P in the CGH40006P-AMP**



**Small Signal Gain vs Frequency at 20 V  
CGH40006P in the CGH40006P-AMP**



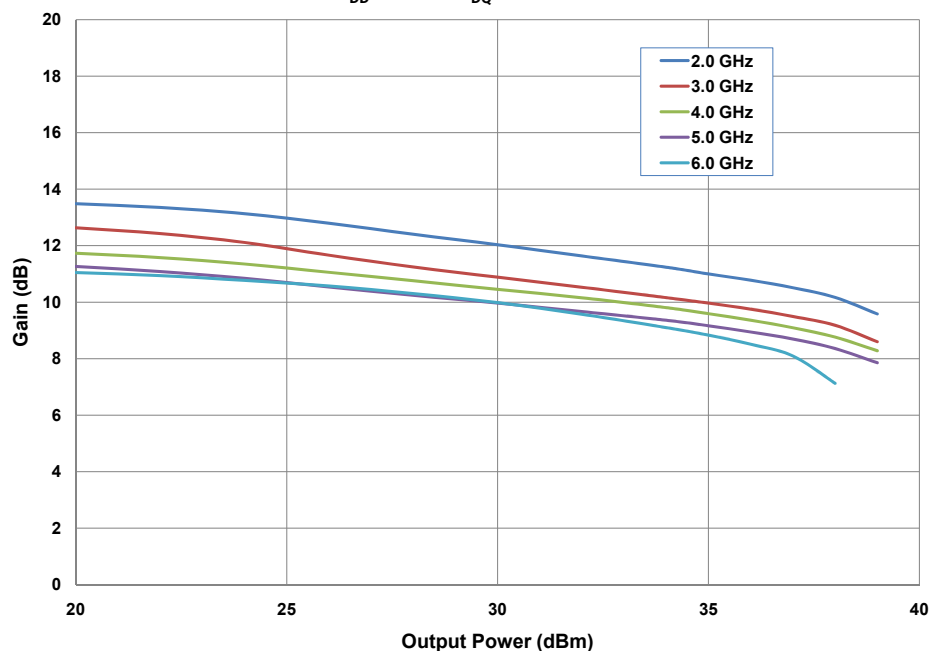
**Input & Output Return Losses vs Frequency at of the  
20 V of the CGH40006P in the CGH40006P-AMP**



## Typical Performance

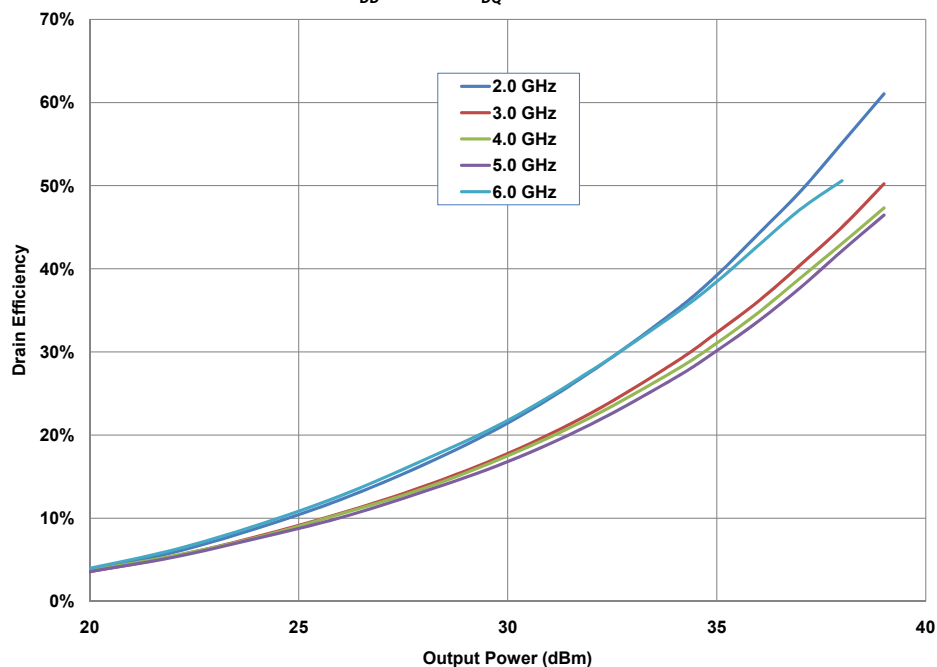
**Power Gain vs Output Power as a Function of Frequency  
of the CGH40006P in the CGH40006P-AMP**

$V_{DD} = 28\text{ V}$ ,  $I_{DQ} = 100\text{ mA}$



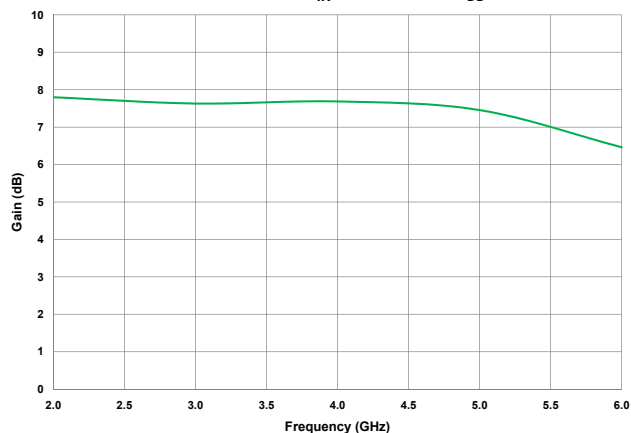
**Drain Efficiency vs Output Power as a Function of Frequency  
of the CGH40006P in the CGH40006P-AMP**

$V_{DD} = 28\text{ V}$ ,  $I_{DQ} = 100\text{ mA}$

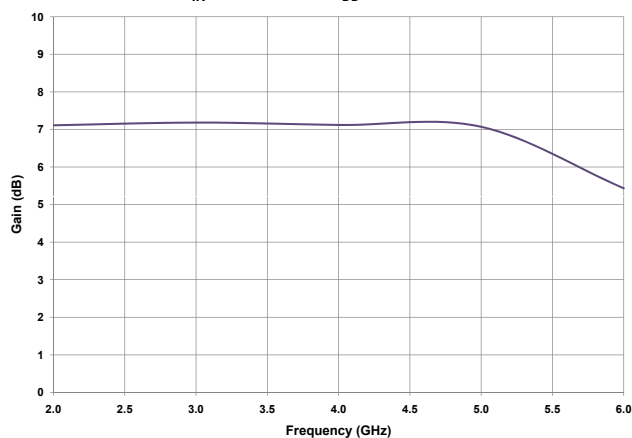


## Typical Performance

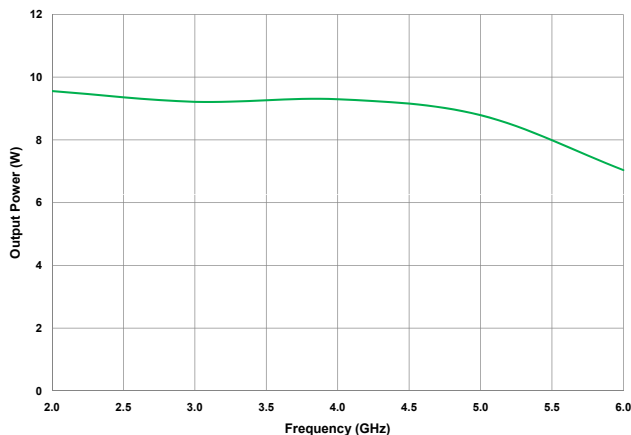
**Power Gain vs Frequency of the CGH40006P**  
in the CGH40006P-AMP at  $P_{IN} = 32 \text{ dBm}$ ,  $V_{DD} = 28 \text{ V}$



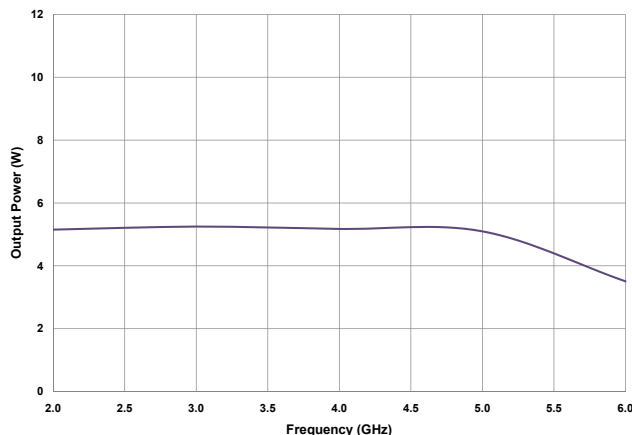
**Power Gain vs Frequency of the CGH40006P**  
in the CGH40006P-AMP at  $P_{IN} = 30 \text{ dBm}$ ,  $V_{DD} = 20 \text{ V}$



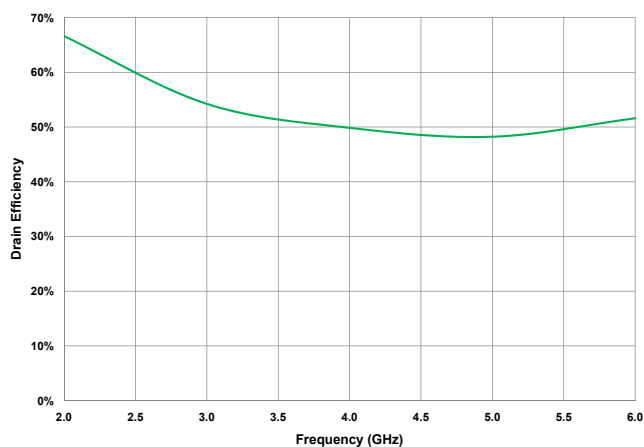
**Output Power vs Frequency of the CGH40006P**  
in the CGH40006P-AMP at  $P_{IN} = 32 \text{ dBm}$ ,  $V_{DD} = 28 \text{ V}$



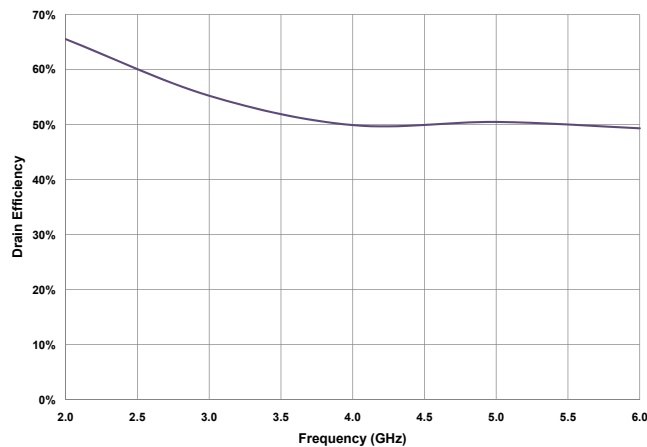
**Output Power vs Frequency of the CGH40006P**  
in the CGH40006P-AMP at  $P_{IN} = 30 \text{ dBm}$ ,  $V_{DD} = 20 \text{ V}$



**Drain Efficiency vs Frequency of the CGH40006P**  
in the CGH40006P-AMP at  $P_{IN} = 32 \text{ dBm}$ ,  $V_{DD} = 28 \text{ V}$

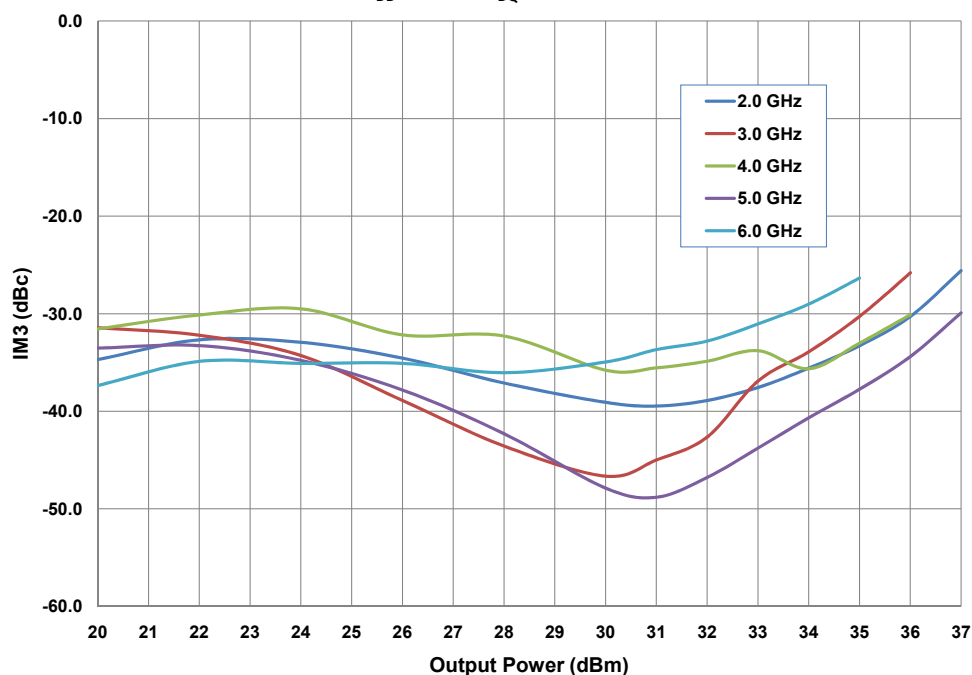


**Drain Efficiency vs Frequency of the CGH40006P**  
in the CGH40006P-AMP at  $P_{IN} = 30 \text{ dBm}$ ,  $V_{DD} = 20 \text{ V}$

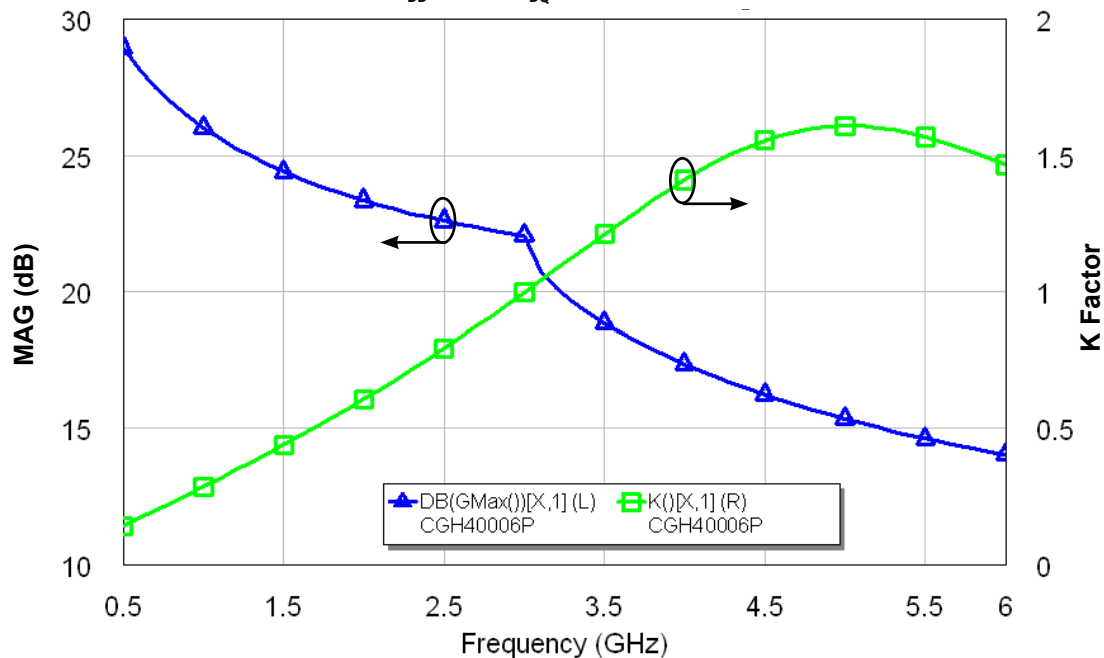


## Typical Performance

**Third Order Intermodulation Distortion vs Average Output Power  
as a Function of Frequency of the CGH40006P in the CGH40006P-AMP**  
 $V_{DD} = 28\text{ V}$ ,  $I_{DQ} = 60\text{ mA}$

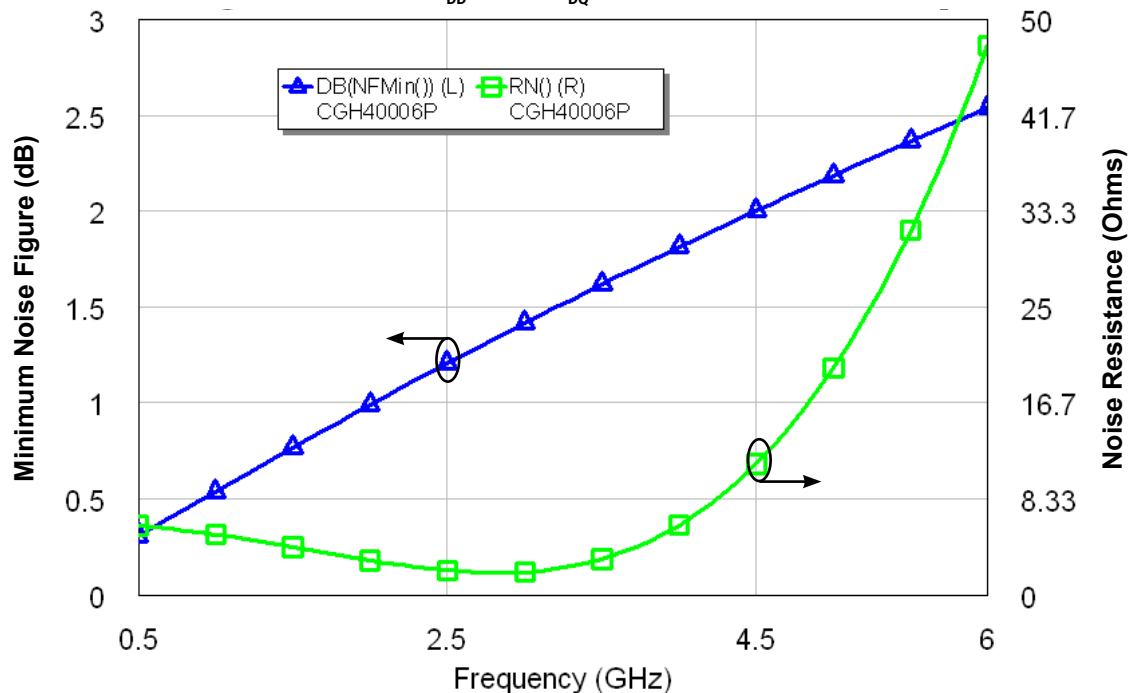


**Simulated Maximum Available Gain and K Factor of the CGH40006P**  
 $V_{DD} = 28\text{ V}$ ,  $I_{DQ} = 100\text{ mA}$



## Typical Noise Performance

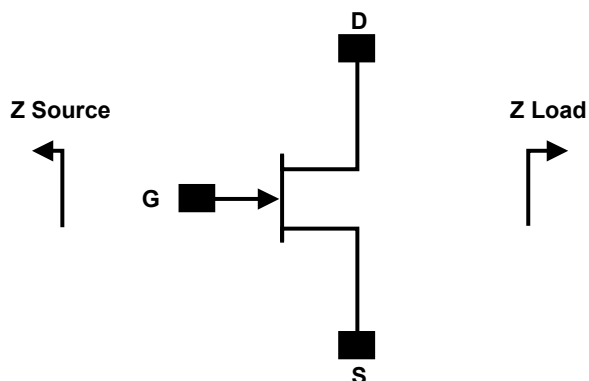
Simulated Minimum Noise Figure and Noise Resistance vs Frequency of the CGH40006P  
 $V_{DD} = 28\text{ V}$ ,  $I_{DQ} = 100\text{ mA}$



## Electrostatic Discharge (ESD) Classifications

| Parameter           | Symbol | Class      | Test Methodology    |
|---------------------|--------|------------|---------------------|
| Human Body Model    | HBM    | 1A > 250 V | JEDEC JESD22 A114-D |
| Charge Device Model | CDM    | 1 < 200 V  | JEDEC JESD22 C101-C |

## Source and Load Impedances



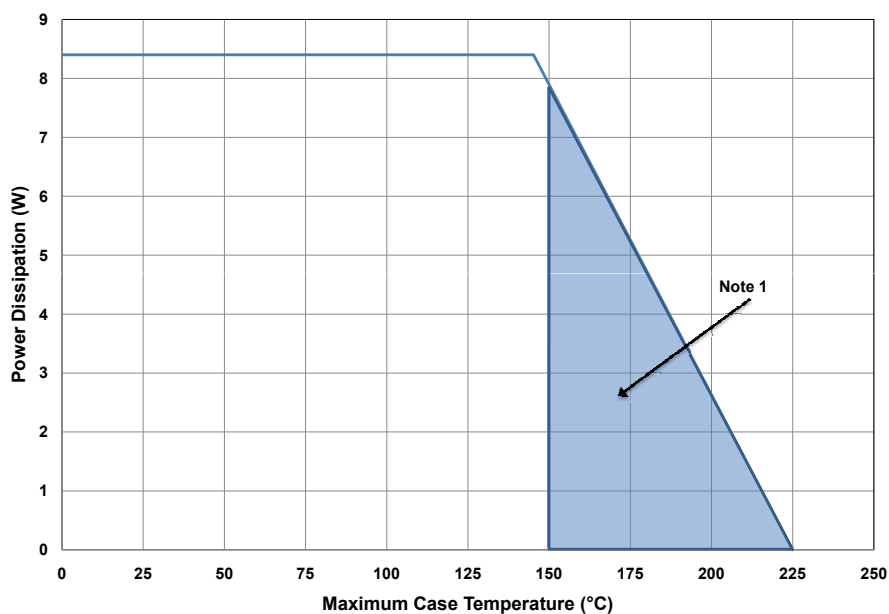
| Frequency (MHz) | Z Source        | Z Load          |
|-----------------|-----------------|-----------------|
| 1000            | $13.78 + j6.9$  | $61.5 + j47.4$  |
| 2000            | $4.78 + j1.78$  | $19.4 + j39.9$  |
| 3000            | $2.57 - j6.94$  | $12.57 + j23.1$ |
| 4000            | $3.54 - j14.86$ | $9.44 + j11.68$ |
| 5000            | $4.42 - j25.8$  | $9.78 + j4.85$  |
| 6000            | $7.1 - j42.7$   | $9.96 - j4.38$  |

Note 1.  $V_{DD} = 28V$ ,  $I_{DQ} = 100mA$  in the 440109 package.

Note 2. Optimized for power gain,  $P_{SAT}$  and PAE.

Note 3. When using this device at low frequency, series resistors should be used to maintain amplifier stability.

## CGH40006P Power Dissipation De-rating Curve



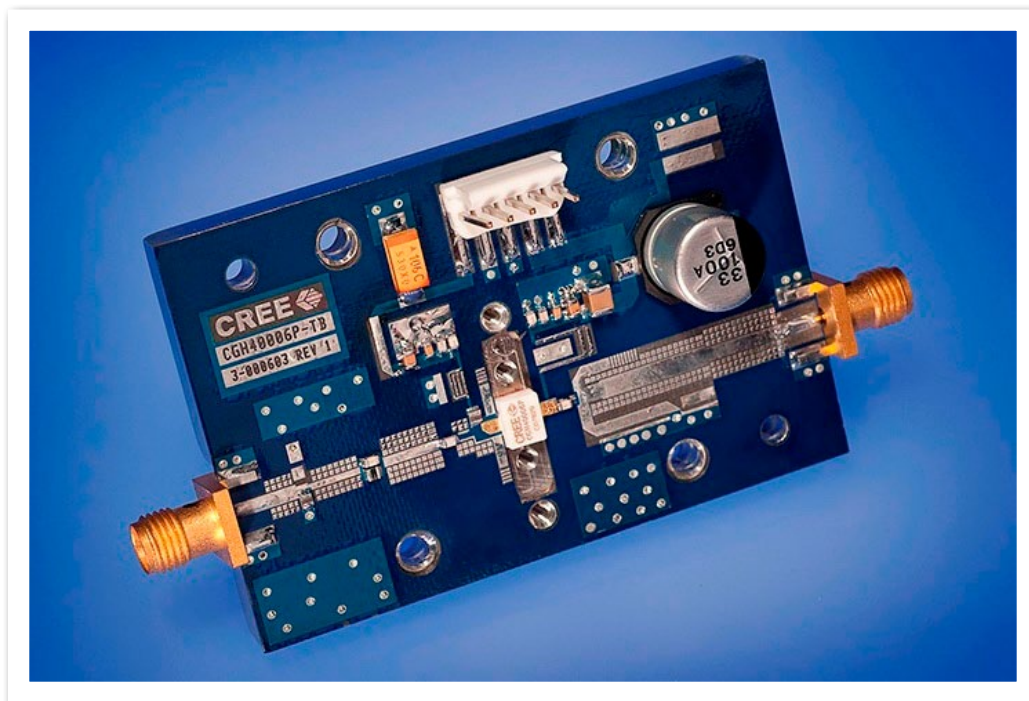
Note 1. Area exceeds Maximum Case Operating Temperature (See Page 2).



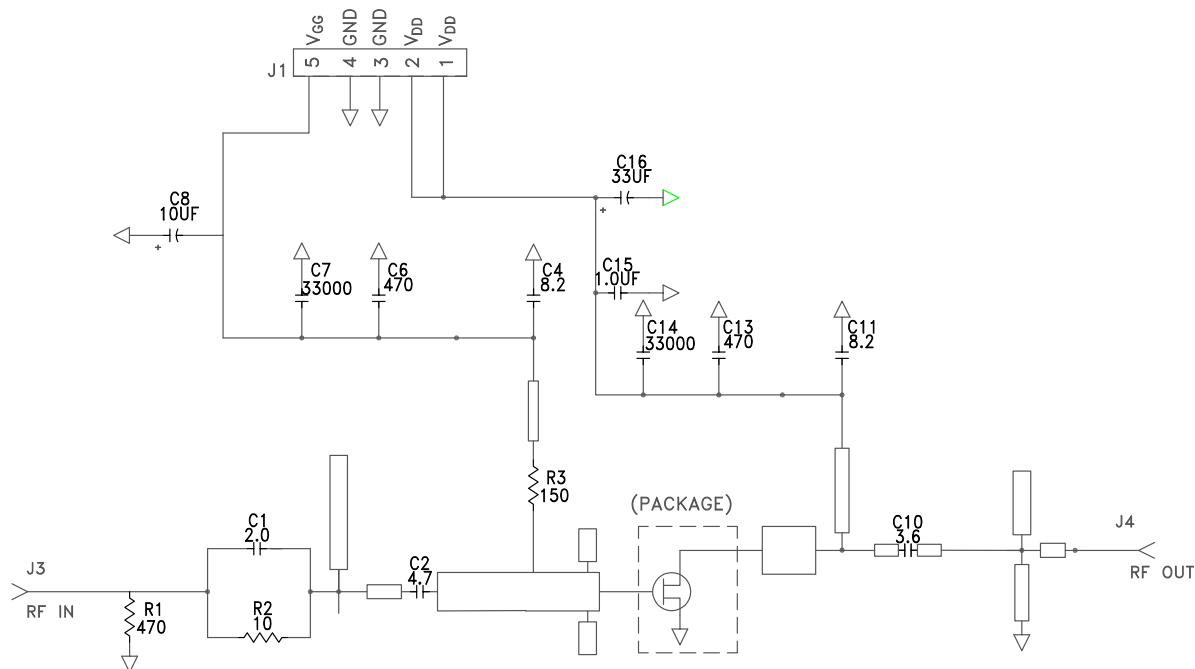
## CGH40006P-AMP Demonstration Amplifier Circuit Bill of Materials

| Designator | Description                                      | Qty |
|------------|--------------------------------------------------|-----|
| R1         | RES, AIN, 0505, 470 Ohms ( $\leq 5\%$ tolerance) | 1   |
| R2         | RES, AIN, 0505, 10 Ohms ( $\leq 5\%$ tolerance)  | 1   |
| R3         | RES, AIN, 0505, 150 Ohms ( $\leq 5\%$ tolerance) | 1   |
| C1         | CAP, 2.0 pF $\pm 0.1$ pF, 0603, ATC 600S         | 1   |
| C2         | CAP, 4.7 pF $\pm 0.1$ pF, 0603, ATC 600S         | 1   |
| C10        | CAP, 3.6 pF $\pm 0.1$ pF, 0603, ATC 600S         | 1   |
| C4,C11     | CAP, 8.2 pF $\pm 0.25$ , 0603, ATC 600S          | 2   |
| C6,C13     | CAP, 470 pF $\pm 5\%$ , 0603, 100 V              | 2   |
| C7,C14     | CAP, 33000 pF, CER, 100V, X7R, 0805              | 2   |
| C8         | CAP, 10 uF, 16V, SMT, TANTALUM                   | 1   |
| C15        | CAP, 1.0 uF $\pm 10\%$ , CER, 100V, X7R, 1210    | 1   |
| C16        | CAP, 33 uF, 100V, ELECT, FK, SMD                 | 1   |
| J3,J4      | CONN, SMA, STR, PANEL, JACK, RECP                | 2   |
| J1         | HEADER RT>PLZ .1CEN LK 5POS                      | 1   |
| -          | PCB, RO5880, 20 MIL                              | 1   |
| Q1         | CGH40006P                                        | 1   |

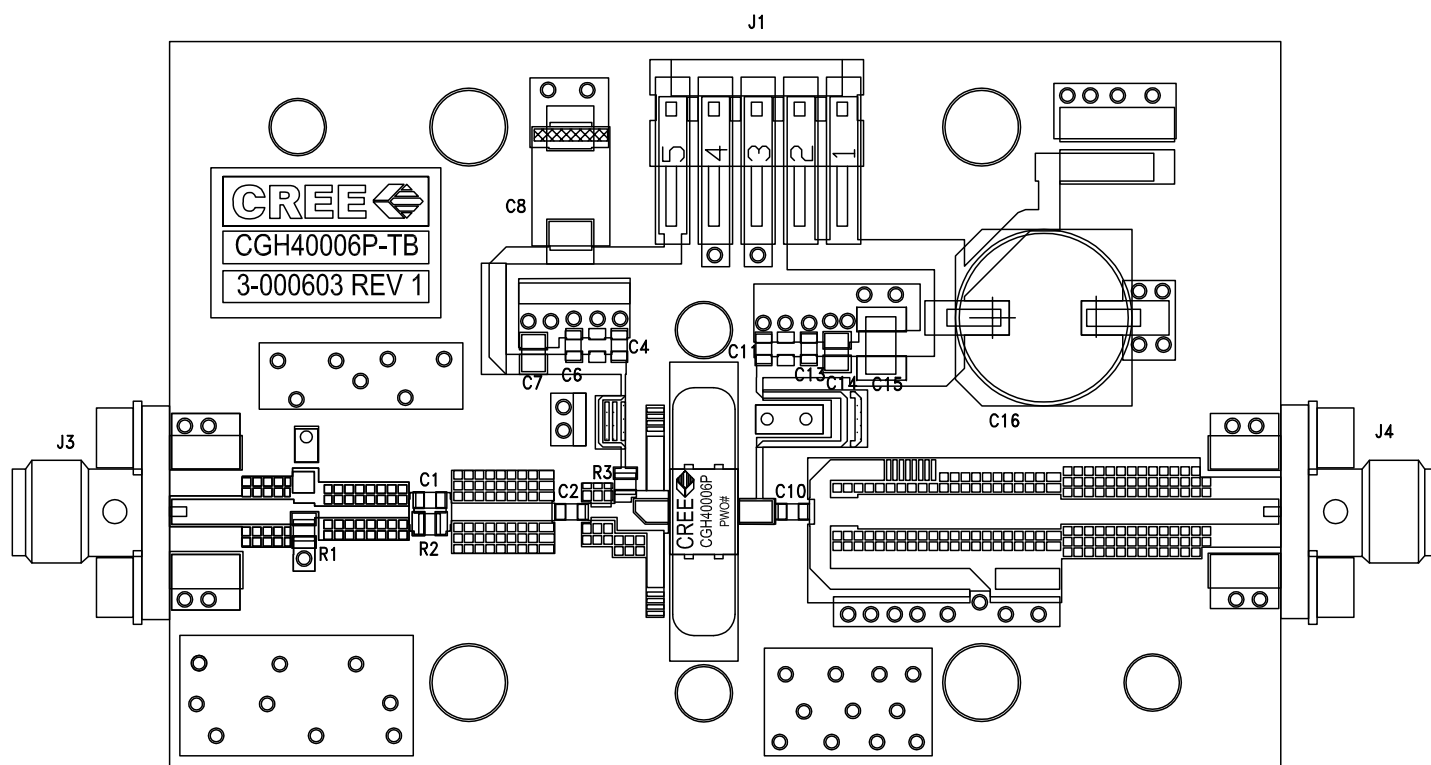
## CGH40006P-AMP Demonstration Amplifier Circuit



## CGH40006P-AMP Demonstration Amplifier Circuit Schematic



## CGH40006P-AMP Demonstration Amplifier Circuit Outline

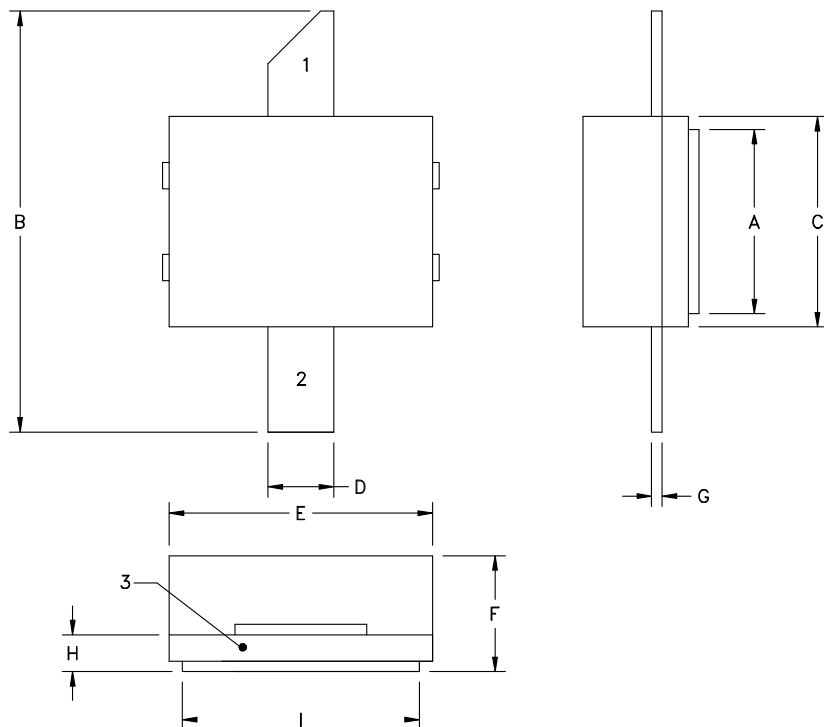


# **Typical Package S-Parameters for CGH40006P** **(Small Signal, $V_{DS} = 28\text{ V}$ , $I_{DQ} = 100\text{ mA}$ , angle in degrees)**

| Frequency | Mag S11 | Ang S11 | Mag S21 | Ang S21 | Mag S12 | Ang S12 | Mag S22 | Ang S22 |
|-----------|---------|---------|---------|---------|---------|---------|---------|---------|
| 500 MHz   | 0.905   | -96.56  | 18.30   | 120.62  | 0.023   | 35.87   | 0.456   | -52.76  |
| 600 MHz   | 0.889   | -107.98 | 16.39   | 113.31  | 0.025   | 29.63   | 0.429   | -58.98  |
| 700 MHz   | 0.877   | -117.55 | 14.76   | 106.99  | 0.026   | 24.39   | 0.408   | -64.31  |
| 800 MHz   | 0.867   | -125.66 | 13.37   | 101.43  | 0.027   | 19.92   | 0.393   | -68.96  |
| 900 MHz   | 0.860   | -132.61 | 12.19   | 96.46   | 0.028   | 16.05   | 0.381   | -73.11  |
| 1.0 GHz   | 0.854   | -138.66 | 11.18   | 91.94   | 0.028   | 12.66   | 0.374   | -76.87  |
| 1.1 GHz   | 0.849   | -143.98 | 10.31   | 87.79   | 0.028   | 9.64    | 0.368   | -80.34  |
| 1.2 GHz   | 0.845   | -148.73 | 9.56    | 83.92   | 0.028   | 6.92    | 0.366   | -83.57  |
| 1.3 GHz   | 0.842   | -153.01 | 8.90    | 80.29   | 0.028   | 4.46    | 0.365   | -86.61  |
| 1.4 GHz   | 0.839   | -156.90 | 8.33    | 76.84   | 0.028   | 2.22    | 0.365   | -89.49  |
| 1.5 GHz   | 0.837   | -160.49 | 7.82    | 73.56   | 0.028   | 0.15    | 0.367   | -92.24  |
| 1.6 GHz   | 0.835   | -163.81 | 7.37    | 70.40   | 0.028   | -1.75   | 0.369   | -94.88  |
| 1.7 GHz   | 0.833   | -166.92 | 6.96    | 67.36   | 0.028   | -3.51   | 0.373   | -97.43  |
| 1.8 GHz   | 0.832   | -169.85 | 6.60    | 64.41   | 0.028   | -5.15   | 0.376   | -99.88  |
| 1.9 GHz   | 0.830   | -172.62 | 6.27    | 61.54   | 0.028   | -6.67   | 0.381   | -102.27 |
| 2.0 GHz   | 0.829   | -175.27 | 5.98    | 58.74   | 0.028   | -8.08   | 0.386   | -104.58 |
| 2.1 GHz   | 0.828   | -177.81 | 5.71    | 56.00   | 0.028   | -9.40   | 0.391   | -106.84 |
| 2.2 GHz   | 0.827   | 179.75  | 5.46    | 53.32   | 0.027   | -10.61  | 0.396   | -109.04 |
| 2.3 GHz   | 0.826   | 177.38  | 5.24    | 50.68   | 0.027   | -11.73  | 0.401   | -111.19 |
| 2.4 GHz   | 0.825   | 175.07  | 5.03    | 48.09   | 0.027   | -12.77  | 0.407   | -113.29 |
| 2.5 GHz   | 0.824   | 172.82  | 4.84    | 45.53   | 0.027   | -13.71  | 0.412   | -115.36 |
| 2.6 GHz   | 0.823   | 170.61  | 4.67    | 43.00   | 0.026   | -14.57  | 0.418   | -117.38 |
| 2.7 GHz   | 0.821   | 168.44  | 4.51    | 40.50   | 0.026   | -15.34  | 0.423   | -119.36 |
| 2.8 GHz   | 0.820   | 166.30  | 4.36    | 38.02   | 0.026   | -16.02  | 0.428   | -121.32 |
| 2.9 GHz   | 0.819   | 164.18  | 4.22    | 35.57   | 0.026   | -16.62  | 0.434   | -123.24 |
| 3.0 GHz   | 0.818   | 162.08  | 4.09    | 33.13   | 0.026   | -17.13  | 0.439   | -125.13 |
| 3.2 GHz   | 0.816   | 157.91  | 3.85    | 28.31   | 0.025   | -17.89  | 0.449   | -128.84 |
| 3.4 GHz   | 0.813   | 153.76  | 3.65    | 23.53   | 0.025   | -18.30  | 0.458   | -132.46 |
| 3.6 GHz   | 0.810   | 149.58  | 3.47    | 18.78   | 0.025   | -18.38  | 0.467   | -136.00 |
| 3.8 GHz   | 0.807   | 145.35  | 3.31    | 14.05   | 0.024   | -18.13  | 0.474   | -139.48 |
| 4.0 GHz   | 0.804   | 141.05  | 3.18    | 9.32    | 0.024   | -17.60  | 0.481   | -142.91 |
| 4.2 GHz   | 0.801   | 136.66  | 3.05    | 4.57    | 0.024   | -16.82  | 0.488   | -146.30 |
| 4.4 GHz   | 0.797   | 132.15  | 2.94    | -0.20   | 0.025   | -15.89  | 0.493   | -149.67 |
| 4.6 GHz   | 0.793   | 127.50  | 2.85    | -5.01   | 0.025   | -14.87  | 0.497   | -153.02 |
| 4.8 GHz   | 0.789   | 122.70  | 2.76    | -9.86   | 0.026   | -13.89  | 0.500   | -156.37 |
| 5.0 GHz   | 0.785   | 117.72  | 2.68    | -14.79  | 0.027   | -13.04  | 0.503   | -159.74 |
| 5.2 GHz   | 0.780   | 112.55  | 2.62    | -19.78  | 0.029   | -12.42  | 0.504   | -163.14 |
| 5.4 GHz   | 0.776   | 107.17  | 2.55    | -24.86  | 0.030   | -12.13  | 0.505   | -166.59 |
| 5.6 GHz   | 0.772   | 101.58  | 2.50    | -30.03  | 0.032   | -12.22  | 0.504   | -170.10 |
| 5.8 GHz   | 0.768   | 95.76   | 2.44    | -35.30  | 0.035   | -12.75  | 0.503   | -173.70 |
| 6.0 GHz   | 0.764   | 89.70   | 2.40    | -40.69  | 0.037   | -13.73  | 0.501   | -177.41 |

To download the s-parameters in s2p format, go to the [CGH40006P Product Page](#) and click on the documentation tab.

## Product Dimensions CGH40006P (Package Type – 440109)



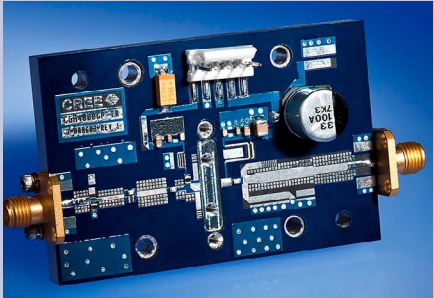
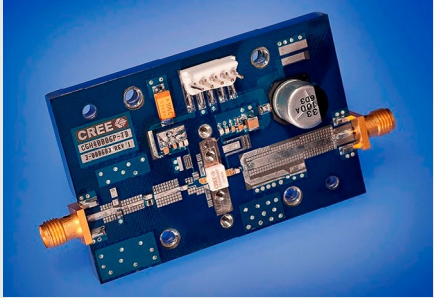
NOTES: (UNLESS OTHERWISE SPECIFIED)

1. INTERPRET DRAWING IN ACCORDANCE WITH ANSI Y14.5M-1982 DIMENSIONING AND TOLERANCING.
2. CONTROLLING DIMENSION: INCH.
3. ALL PLATED SURFACES ARE Ni/Au

| DIM | INCHES |      | MILLIMETERS |      |
|-----|--------|------|-------------|------|
|     | MIN    | MAX  | MIN         | MAX  |
| A   | .135   | .145 | 3.43        | 3.68 |
| B   | .315   | .325 | 8.00        | 8.26 |
| C   | .155   | .165 | 3.94        | 4.19 |
| D   | .045   | .055 | 1.14        | 1.40 |
| E   | .195   | .205 | 4.95        | 5.21 |
| F   | .090   | .110 | 2.29        | 2.79 |
| G   | .007   | .009 | .178        | 0.23 |
| H   | .026   | .030 | .660        | .762 |
| I   | .175   | .185 | 4.45        | 4.70 |

PIN 1. GATE  
PIN 2. DRAIN  
PIN 3. SOURCE

Product Ordering Information

| Order Number  | Description                        | Unit of Measure | Image                                                                                 |
|---------------|------------------------------------|-----------------|---------------------------------------------------------------------------------------|
| CGH40006P     | GaN HEMT                           | Each            |    |
| CGH40006P-TB  | Test board without GaN HEMT        | Each            |   |
| CGH40006P-AMP | Test board with GaN HEMT installed | Each            |  |

## Disclaimer

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