

# Up to 6 GHz Low Noise Silicon Bipolar Transistor Chip

## Technical Data

### AT-41400

#### Features

- **Low Noise Figure:**  
1.6 dB Typical at 2.0 GHz  
3.0 dB Typical at 4.0 GHz
- **High Associated Gain:**  
14.5 dB Typical at 2.0 GHz  
10.5 dB Typical at 4.0 GHz
- **High Gain-Bandwidth Product:**  
9.0 GHz Typical  $f_T$

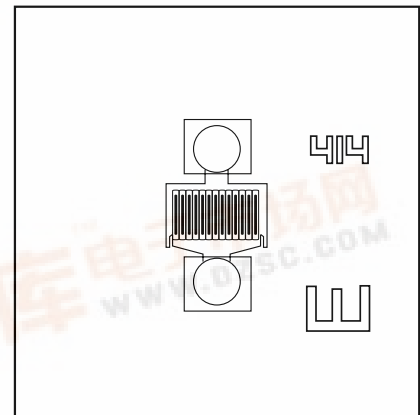
#### Description

Hewlett-Packard's AT-41400 is a general purpose NPN bipolar transistor chip that offers excellent high frequency performance. The 4 micron emitter-to-emitter pitch enables this transistor to be used in many different functions. The 14 emitter finger interdigitated geometry yields an intermediate sized transistor with impedances

that are easy to match for low noise and moderate power applications. This device is designed for use in low noise, wideband amplifier, mixer and oscillator applications in the VHF, UHF, and microwave frequencies. An optimum noise match near  $50\ \Omega$  at 1 GHz, makes this device easy to use as a low noise amplifier.

The AT-41400 bipolar transistor is fabricated using Hewlett-Packard's 10 GHz  $f_T$  Self-Aligned-Transistor (SAT) process. The die is nitride passivated for surface protection. Excellent device uniformity, performance and reliability are produced by the use of ion-implantation, self-alignment techniques, and gold metalization in the fabrication of this device.

#### Chip Outline



## AT-41400 Absolute Maximum Ratings

| Symbol    | Parameter                          | Units | Absolute Maximum <sup>[1]</sup> |
|-----------|------------------------------------|-------|---------------------------------|
| $V_{EBO}$ | Emitter-Base Voltage               | V     | 1.5                             |
| $V_{CBO}$ | Collector-Base Voltage             | V     | 20                              |
| $V_{CEO}$ | Collector-Emitter Voltage          | V     | 12                              |
| $I_C$     | Collector Current                  | mA    | 60                              |
| $P_T$     | Power Dissipation <sup>[2,3]</sup> | mW    | 500                             |
| $T_j$     | Junction Temperature               | °C    | 200                             |
| $T_{STG}$ | Storage Temperature                | °C    | -65 to 200                      |

### Thermal Resistance<sup>[2,4]</sup>:

$$\theta_{jc} = 95^{\circ}\text{C/W}$$

#### Notes:

1. Permanent damage may occur if any of these limits are exceeded.
2.  $T_{\text{MOUNTING SURFACE}} = 25^{\circ}\text{C}$ .
3. Derate at 10.5 mW/°C for  $T_{\text{MOUNTING SURFACE}} > 153^{\circ}\text{C}$ .
4. The small spot size of this technique results in a higher, though more accurate determination of  $\theta_{jc}$  than do alternate methods. See MEASUREMENTS section "Thermal Resistance" for more information.

## Part Number Ordering Information

| Part Number  | Devices Per Tray |
|--------------|------------------|
| AT-41400-GP4 | 100              |

**Note:** For more information, see "Tape and Reel Packaging for Semiconductor Devices".

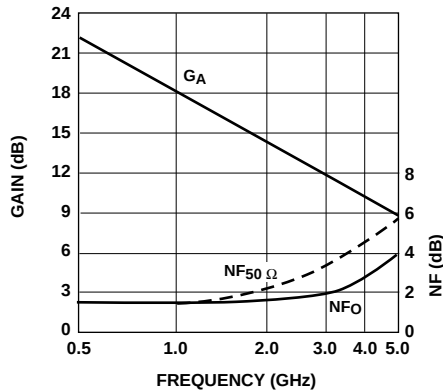
## Electrical Specifications, $T_A = 25^{\circ}\text{C}$

| Symbol            | Parameters and Test Conditions <sup>[1]</sup>                                                                                              | Units         | Min. | Typ.                 | Max. |
|-------------------|--------------------------------------------------------------------------------------------------------------------------------------------|---------------|------|----------------------|------|
| $ S_{21E} ^2$     | Insertion Power Gain; $V_{CE} = 8\text{ V}$ , $I_C = 25\text{ mA}$<br>$f = 2.0\text{ GHz}$<br>$f = 4.0\text{ GHz}$                         | dB            |      | 12.0<br>6.5          |      |
| $P_{1\text{ dB}}$ | Power Output @ 1 dB Gain Compression<br>$V_{CE} = 8\text{ V}$ , $I_C = 25\text{ mA}$<br>$f = 2.0\text{ GHz}$<br>$f = 4.0\text{ GHz}$       | dBm           |      | 19.0<br>18.5         |      |
| $G_{1\text{ dB}}$ | 1 dB Compressed Gain; $V_{CE} = 8\text{ V}$ , $I_C = 25\text{ mA}$<br>$f = 2.0\text{ GHz}$<br>$f = 4.0\text{ GHz}$                         | dB            |      | 15.0<br>10.5         |      |
| $NF_O$            | Optimum Noise Figure: $V_{CE} = 8\text{ V}$ , $I_C = 10\text{ mA}$<br>$f = 1.0\text{ GHz}$<br>$f = 2.0\text{ GHz}$<br>$f = 4.0\text{ GHz}$ | dB            |      | 1.3<br>1.6<br>3.0    |      |
| $G_A$             | Gain @ $NF_O$ ; $V_{CE} = 8\text{ V}$ , $I_C = 10\text{ mA}$<br>$f = 1.0\text{ GHz}$<br>$f = 2.0\text{ GHz}$<br>$f = 4.0\text{ GHz}$       | dB            |      | 18.5<br>14.5<br>10.5 |      |
| $f_T$             | Gain Bandwidth Product: $V_{CE} = 8\text{ V}$ , $I_C = 25\text{ mA}$                                                                       | GHz           |      | 9.0                  |      |
| $h_{FE}$          | Forward Current Transfer Ratio; $V_{CE} = 8\text{ V}$ , $I_C = 10\text{ mA}$                                                               | —             | 30   | 150                  | 300  |
| $I_{CBO}$         | Collector Cutoff Current; $V_{CB} = 8\text{ V}$                                                                                            | $\mu\text{A}$ |      |                      | 0.2  |
| $I_{EBO}$         | Emitter Cutoff Current; $V_{EB} = 1\text{ V}$                                                                                              | $\mu\text{A}$ |      |                      | 1.0  |
| $C_{CB}$          | Collector Base Capacitance <sup>[2]</sup> : $V_{CB} = 8\text{ V}$ , $f = 1\text{ MHz}$                                                     | pF            |      | 0.17                 |      |

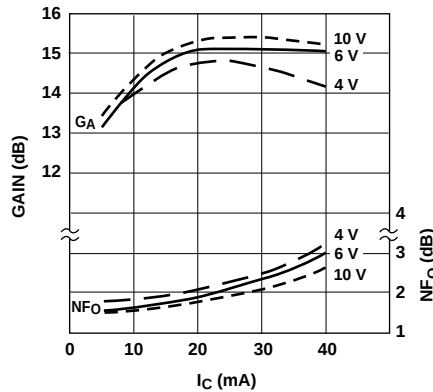
#### Notes:

1. RF performance is determined by packaging and testing 10 devices per wafer.
2. For this test, the emitter is grounded.

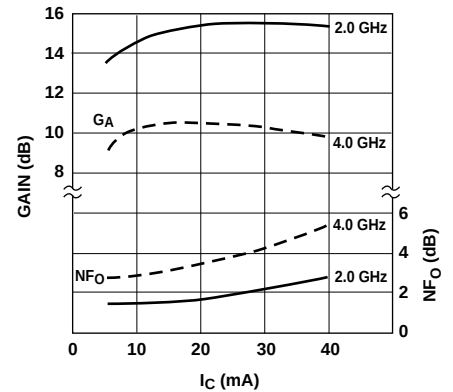
## AT-41400 Typical Performance, $T_A = 25^\circ\text{C}$



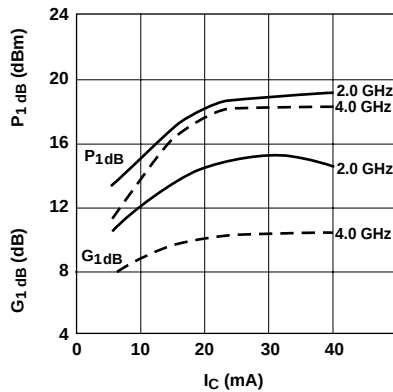
**Figure 1. Noise Figure and Associated Gain vs. Frequency.**  
 $V_{CE} = 8\text{ V}$ ,  $I_C = 10\text{ mA}$ .



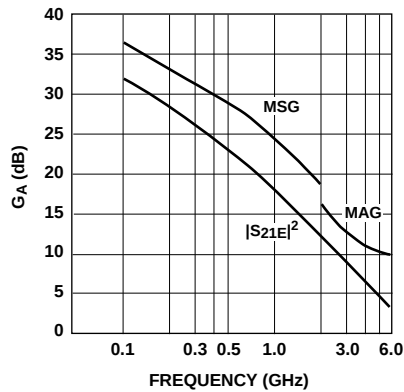
**Figure 2. Optimum Noise Figure and Associated Gain vs. Collector Current and Collector Voltage.  $f = 2.0\text{ GHz}$ .**



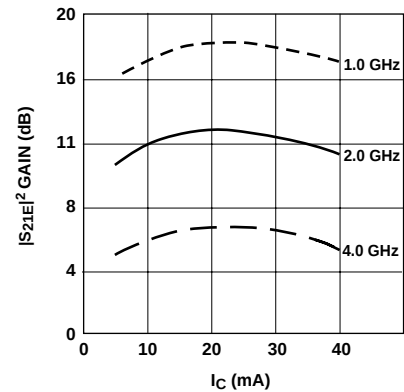
**Figure 3. Optimum Noise Figure and Associated Gain vs. Collector Current and Frequency.  $V_{CE} = 8\text{ V}$ .**



**Figure 4. Output Power and 1 dB Compressed Gain vs. Collector Current.  $V_{CE} = 8\text{ V}$ .**



**Figure 5. Insertion Power Gain, Maximum Available Gain and Maximum Stable Gain vs. Frequency.**  
 $V_{CE} = 8\text{ V}$ ,  $I_C = 25\text{ mA}$ .



**Figure 6. Insertion Power Gain vs. Collector Current and Frequency.  $V_{CE} = 8\text{ V}$ .**

**AT-41400 Typical Scattering Parameters,**  
Common Emitter,  $Z_O = 50\ \Omega$ ,  $T_A = 25^\circ\text{C}$ ,  $V_{CE} = 8\ \text{V}$ ,  $I_C = 10\ \text{mA}$

| Freq.<br>GHz | $S_{11}$ |      | dB   | $S_{21}$ |      | dB    | $S_{12}$ |      | $S_{22}$ |      |
|--------------|----------|------|------|----------|------|-------|----------|------|----------|------|
|              | Mag.     | Ang. |      | Mag.     | Ang. |       | Mag.     | Ang. | Mag.     | Ang. |
| 0.1          | .73      | -39  | 28.3 | 25.84    | 159  | -39.2 | .011     | 75   | .94      | -12  |
| 0.5          | .60      | -121 | 22.2 | 12.91    | 113  | -30.2 | .031     | 48   | .61      | -28  |
| 1.0          | .57      | -156 | 17.2 | 7.27     | 94   | -28.0 | .040     | 51   | .50      | -25  |
| 1.5          | .56      | -172 | 13.7 | 4.84     | 84   | -26.4 | .048     | 59   | .47      | -25  |
| 2.0          | .57      | 176  | 11.4 | 3.71     | 77   | -24.9 | .057     | 66   | .46      | -24  |
| 2.5          | .57      | 170  | 9.5  | 2.97     | 71   | -23.6 | .066     | 69   | .46      | -26  |
| 3.0          | .60      | 164  | 8.0  | 2.52     | 64   | -22.3 | .077     | 72   | .45      | -28  |
| 3.5          | .60      | 157  | 6.8  | 2.18     | 61   | -20.9 | .090     | 77   | .47      | -29  |
| 4.0          | .61      | 152  | 5.5  | 1.89     | 55   | -20.1 | .099     | 79   | .47      | -30  |
| 4.5          | .63      | 147  | 4.7  | 1.72     | 51   | -18.7 | .116     | 81   | .47      | -36  |
| 5.0          | .63      | 144  | 3.7  | 1.53     | 46   | -17.8 | .129     | 80   | .48      | -40  |
| 5.5          | .65      | 139  | 3.1  | 1.42     | 42   | -17.0 | .141     | 82   | .49      | -44  |
| 6.0          | .66      | 136  | 2.1  | 1.28     | 38   | -16.1 | .156     | 83   | .50      | -47  |

**AT-41400 Typical Scattering Parameters,**  
Common Emitter,  $Z_O = 50\ \Omega$ ,  $T_A = 25^\circ\text{C}$ ,  $V_{CE} = 8\ \text{V}$ ,  $I_C = 25\ \text{mA}$

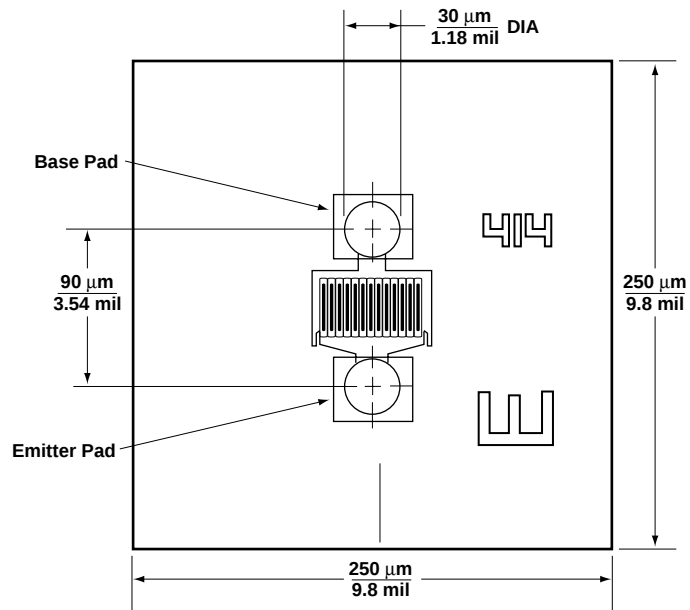
| Freq.<br>GHz | $S_{11}$ |      | dB   | $S_{21}$ |      | dB    | $S_{12}$ |      | $S_{22}$ |      |
|--------------|----------|------|------|----------|------|-------|----------|------|----------|------|
|              | Mag.     | Ang. |      | Mag.     | Ang. |       | Mag.     | Ang. | Mag.     | Ang. |
| 0.1          | .56      | -60  | 31.8 | 39.07    | 152  | -40.9 | .009     | 69   | .87      | -18  |
| 0.5          | .54      | -145 | 23.5 | 15.00    | 104  | -32.8 | .023     | 56   | .49      | -28  |
| 1.0          | .54      | -170 | 18.1 | 8.03     | 90   | -29.6 | .033     | 65   | .42      | -23  |
| 1.5          | .55      | 179  | 14.5 | 5.30     | 82   | -26.9 | .045     | 72   | .41      | -22  |
| 2.0          | .56      | 170  | 12.1 | 4.04     | 76   | -24.7 | .058     | 75   | .41      | -23  |
| 2.5          | .56      | 165  | 10.2 | 3.24     | 72   | -23.1 | .070     | 78   | .40      | -23  |
| 3.0          | .58      | 159  | 8.8  | 2.75     | 65   | -21.6 | .083     | 79   | .40      | -25  |
| 3.5          | .59      | 154  | 7.5  | 2.37     | 62   | -20.4 | .096     | 82   | .41      | -26  |
| 4.0          | .60      | 149  | 6.3  | 2.06     | 57   | -19.3 | .108     | 83   | .42      | -28  |
| 4.5          | .61      | 145  | 5.4  | 1.87     | 53   | -18.1 | .124     | 84   | .42      | -33  |
| 5.0          | .62      | 142  | 4.5  | 1.67     | 49   | -17.3 | .136     | 83   | .43      | -36  |
| 5.5          | .64      | 137  | 3.8  | 1.54     | 44   | -16.5 | .150     | 85   | .42      | -40  |
| 6.0          | .65      | 134  | 2.9  | 1.40     | 41   | -15.7 | .165     | 84   | .44      | -45  |

A model for this device is available in the DEVICE MODELS section.

**AT-41400 Noise Parameters:**  $V_{CE} = 8\ \text{V}$ ,  $I_C = 10\ \text{mA}$

| Freq.<br>GHz | $NF_O$<br>dB | $\Gamma_{opt}$ |      | $R_N/50$ |
|--------------|--------------|----------------|------|----------|
|              |              | Mag            | Ang  |          |
| 0.1          | 1.2          | .12            | 3    | 0.17     |
| 0.5          | 1.2          | .10            | 15   | 0.17     |
| 1.0          | 1.3          | .06            | 27   | 0.16     |
| 2.0          | 1.6          | .24            | 163  | 0.16     |
| 4.0          | 3.0          | .52            | -153 | 0.18     |

## AT-41400 Chip Dimensions



Note: Die thickness is 5 to 6 mil.