# Agilent AT-31011, AT-31033 Low Current, High Performance NPN Silicon Bipolar Transistor

## Data Sheet

### Features

- **High Performance Bipolar Transistor Optimized for Low Current, Low Voltage Operation**
- **900 MHz Performance:**
  AT-31011: 0.9 dB NF, 13 dB $G_A$
  AT-31033: 0.9 dB NF, 11 dB $G_A$
- **Characterized for End-Of-Life Battery Use (2.7 V)**
- **SOT-143 SMT Plastic Package**
- **Tape-And-Reel Packaging Option Available**
- **Lead-free Option Available**

### Description

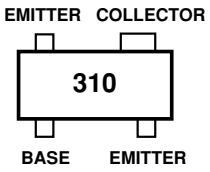
Agilent's AT-31011 and AT-31033 are high performance NPN bipolar transistors that have been optimized for operation at low voltages, making them ideal for use in battery powered applications in wireless markets. The AT-31033 uses the 3 lead SOT-23, while the AT-31011 places the same die in the higher performance 4 lead SOT-143. Both packages are industry standards compatible with high volume surface mount assembly techniques.

The 3.2 micron emitter-to-emitter pitch and reduced parasitic design of these transistors yields extremely high performance products that can perform a multiplicity of tasks. The 10 emitter finger interdigitated geometry yields an extremely fast transistor with low operating currents and reasonable impedances.

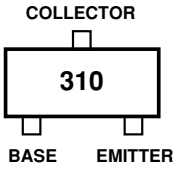
Optimized performance at 2.7 V makes these devices ideal for use in 900 MHz, 1.9 GHz, and 2.4 GHz battery operated systems as an LNA, gain stage, buffer, oscillator, or active mixer. Applications include cellular and PCS handsets as well as Industrial-Scientific-Medical systems. Typical amplifier designs at 900 MHz yield 1.3 dB noise figures with 11 dB or more associated gain at a 2.7 V, 1 mA bias. Moderate output power capability (+9 dBm $P_{1dB}$) coupled with an excellent noise figure yields high dynamic range for a microcurrent device. High gain capability at 1 V, 1 mA makes these devices a good fit for 900 MHz pager applications.

The AT-3 series bipolar transistors are fabricated using an optimized version of Agilent's 10 GHz $f_T$, 30 GHz $f_{max}$ Self-Aligned-Transistor (SAT) process. The die are 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 these devices.

### Outline Drawing




SOT-143 (AT-31011)




SOT-23 (AT-31033)

Agilent Technologies

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## AT-31011, AT-31033 Absolute Maximum Ratings

| Symbol | Parameter | Units | Absolute Maximum[1] |
|---|---|---|---|
| $V_{EBO}$ | Emitter-Base Voltage | V | 1.5 |
| $V_{CBO}$ | Collector-Base Voltage | V | 11 |
| $V_{CEO}$ | Collector-Emitter Voltage | V | 5.5 |
| $I_C$ | Collector Current | mA | 16 |
| $P_T$ | Power Dissipation[2,3] | mW | 150 |
| $T_j$ | Junction Temperature | °C | 150 |
| $T_{STG}$ | Storage Temperature | °C | -65 to 150 |

Thermal Resistance[2]:
$\theta_{jc} = 550°C/W$

**Notes:**
1. Operation of this device above any one of these parameters may cause permanent damage.
2. $T_{Mounting\ Surface} = 25°C$.
3. Derate at 1.82 mW/°C for $T_C > 67.5°C$.

## Electrical Specifications, $T_A = 25°C$

| Symbol | Parameters and Test Conditions | | Units | AT-31011 | | | AT-31033 | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Min | Typ | Max | Min | Typ | Max |
| NF | Noise Figure<br>$V_{CE} = 2.7$ V, $I_C = 1$ mA | f = 0.9 GHz | dB | | 0.9[1] | 1.2[1] | | 0.9[2] | 1.2[2] |
| $G_A$ | Associated Gain<br>$V_{CE} = 2.7$ V, $I_C = 1$ mA | f = 0.9 GHz | dB | 11[1] | 13[1] | | 9[2] | 11[2] | |
| $h_{FE}$ | Forward Current Transfer Ratio | $V_{CE} = 2.7$ V<br>$I_C = 1$ mA | - | 70 | | 300 | 70 | | 300 |
| $I_{CBO}$ | Collector Cutoff Current | $V_{CB} = 3$ V | µA | | 0.05 | 0.2 | | 0.05 | 0.2 |
| $I_{EBO}$ | Emitter Cutoff Current | $V_{EB} = 1$ V | µA | | 0.1 | 1.5 | | 0.1 | 1.5 |

**Notes:**
1. Test circuit B, Figure 1. Numbers reflect device performance de-embedded from circuit losses. Input loss = 0.4 dB; output loss = 0.4 dB.
2. Test circuit A, Figure 1. Numbers reflect device performance de-embedded from circuit losses. Input loss = 0.4 dB; output loss = 0.4 dB.

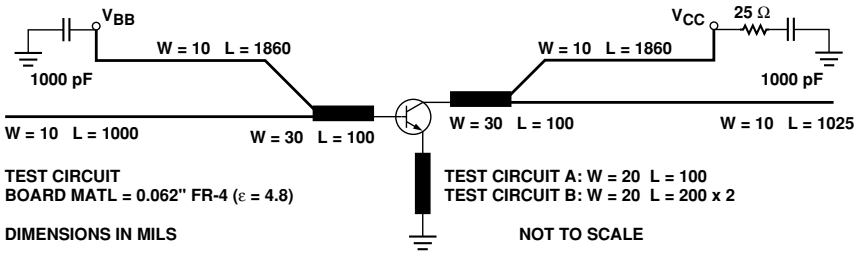


**Figure 1. Test Circuit for Noise Figure and Associated Gain. This Circuit is a Compromise Match Between Best Noise Figure, Best Gain, Stability, a Practical, Synthesizable Match, and a Circuit Capable of Matching Both the AT-305 and AT-310 Geometries.**

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## Characterization Information, $T_A$ = 25° C

| Symbol | Parameters and Test Conditions | Units | AT-31011 Typ | AT-31033 Typ |
|---|---|---|---|---|
| $P_{1dB}$ | Power at 1 dB Gain Compression (opt tuning)<br>$V_{CE}$ = 2.7 V, $I_C$ = 10 mA f = 0.9 GHz | dBm | 9 | 9 |
| $G_{1dB}$ | Gain at 1 dB Gain Compression (opt tuning)<br>$V_{CE}$ = 2.7 V, $I_C$ = 10 mA f = 0.9 GHz | dB | 15 | 13 |
| $IP_3$ | Output Third Order Intercept Point,<br>$V_{CE}$ = 2.7 V, $I_C$ = 10 mA (opt tuning) f = 0.9 GHz | dBm | 20 | 20 |
| $\|S_{21}\|_E^2$ | Gain in 50 Ω System; $V_{CE}$ = 2.7 V, $I_C$ = 1 mA f = 0.9 GHz | dB | 10 | 9 |
| $C_{CB}$ | Collector-Base Capacitance $V_{CB}$ = 3V, f = 1 MHz | pF | 0.04 | 0.04 |

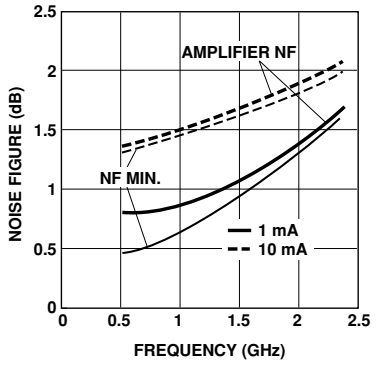


**Figure 2. AT-31011 and AT-31033 Minimum Noise Figure and Amplifier NF[1] vs. Frequency and Current at $V_{CE}$ = 2.7 V.**

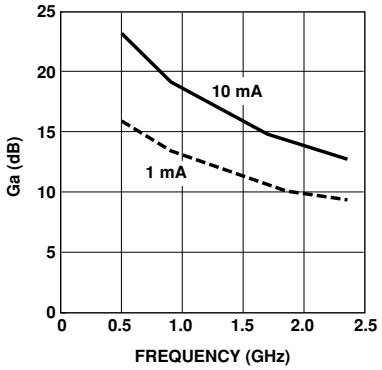


**Figure 3. AT-31011 Associated Gain at Optimum Noise Match vs. Frequency and Current at $V_{CE}$ = 2.7 V.**

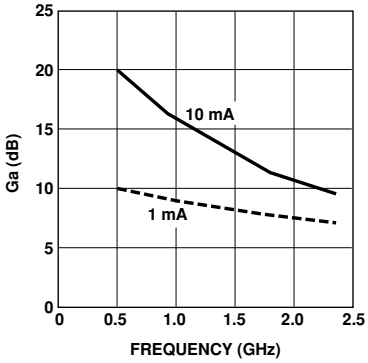


**Figure 4. AT-31033 Associated Gain at Optimum Noise Match vs. Frequency and Current at $V_{CE}$ = 2.7 V.**

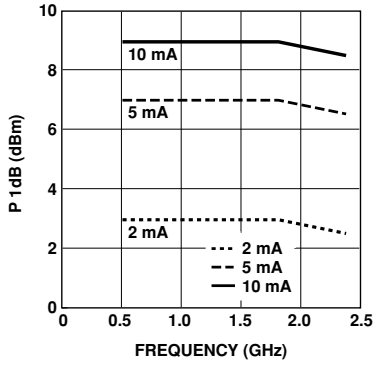


**Figure 5. AT-31011 and AT-31033 Power at 1 dB Gain Compression vs. Frequency and Current at $V_{CE}$ = 2.7 V.**

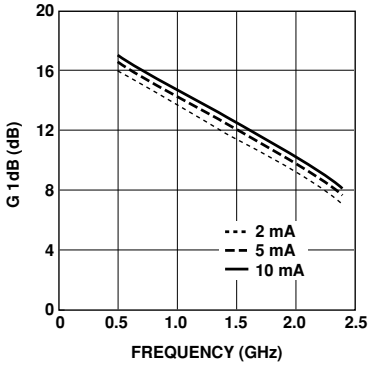


**Figure 6. AT-31011 1 dB Compressed Gain vs. Frequency and Current at $V_{CE}$ = 2.7 V.**

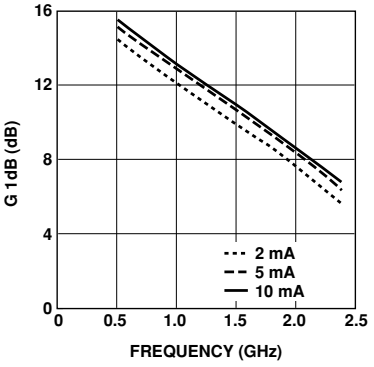


**Figure 7. AT-33033 1 dB Compressed Gain vs. Frequency and Current at $V_{CE}$ = 2.7 V.**

**Note:**

1. Amplifier NF represents the noise figure which can be expected in a real circuit representing reasonable reflection coefficients and including circuit losses.

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## AT-31011, AT-31033 Typical Performance

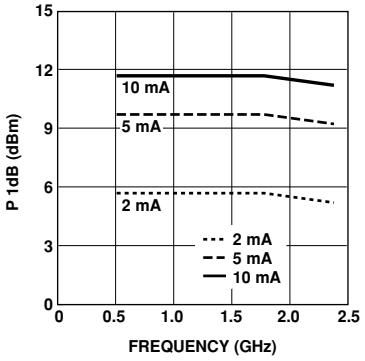


**Figure 8. AT-31011 and AT-31033 Power at 1 dB Gain Compression vs. Frequency and Current at $V_{CE}$ = 5 V.**

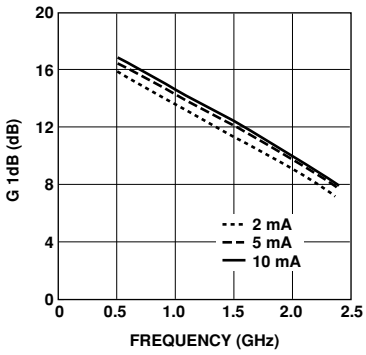


**Figure 9. AT-31011 1 dB Compressed Gain vs. Frequency and Current at $V_{CE}$ = 5 V.**

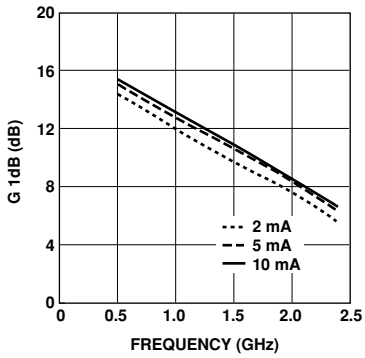


**Figure 10. AT-31033 1 dB Compressed Gain vs. Frequency and Current at $V_{CE}$ = 5 V.**

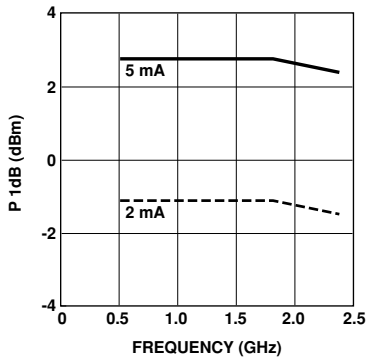


**Figure 11. AT-31011 and AT-31033 Power at 1 dB Gain Compression vs. Frequency and Current at $V_{CE}$ = 1 V.**

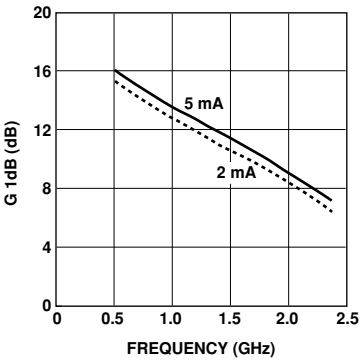


**Figure 12. AT-31011 1 dB Compressed Gain vs. Frequency and Current at $V_{CE}$ = 1 V.**

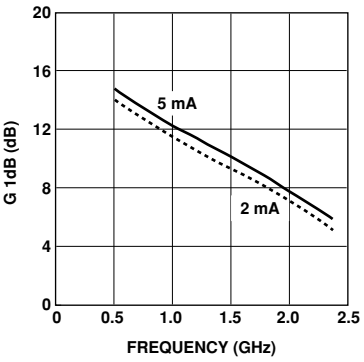


**Figure 13. AT-31033 1 dB Compressed Gain vs. Frequency and Current at $V_{CE}$ = 1 V.**

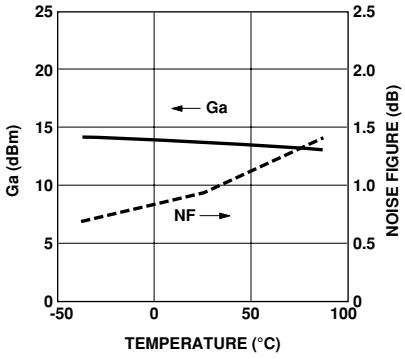


**Figure 14. AT-31011 Noise Figure and Associated Gain at $V_{CE}$ = 2.7 V, $I_C$ = 1 mA vs. Temperature in Test Circuit, Figure 1. (Circuit Losses De-embedded)**

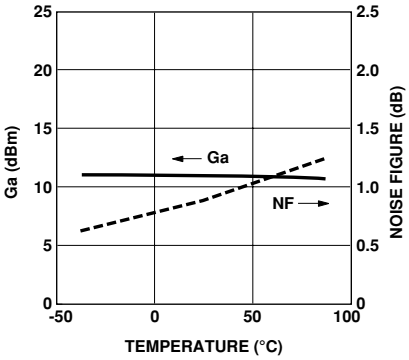


**Figure 15. AT-33033 Noise Figure and Associated Gain at $V_{CE}$ = 2.7 V, $I_C$ = 1 mA vs. Temperature in Test Circuit, Figure 1. (Circuit Losses De-embedded)**

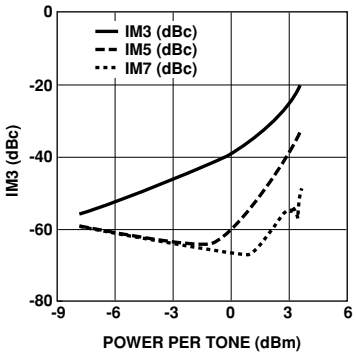


**Figure 16. AT-31011 and AT-33033 Intermodulation Products vs. Output Power at $V_{CE}$ = 2.7 V, $I_C$ = 10 mA, 900 MHz with Optimal Tuning.**

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## AT-31011 Typical Scattering Parameters, $V_{CE}$ = 1 V, $I_C$ = 1 mA, Common Emitter, $Z_O$ = 50 Ω

| Freq. GHz | $S_{11}$ Mag | $S_{11}$ Ang | $S_{21}$ dB | $S_{21}$ Mag | $S_{21}$ Ang | $S_{12}$ dB | $S_{12}$ Mag | $S_{12}$ Ang | $S_{22}$ Mag | $S_{22}$ Ang |
|---|---|---|---|---|---|---|---|---|---|---|
| 0.1 | 0.95 | -8 | 11.12 | 3.60 | 174 | -37.91 | 0.01 | 85 | 0.999 | -3 |
| 0.5 | 0.92 | -34 | 10.58 | 3.38 | 150 | -24.67 | 0.06 | 68 | 0.94 | -15 |
| 0.9 | 0.81 | -60 | 9.74 | 3.07 | 130 | -20.67 | 0.09 | 53 | 0.89 | -25 |
| 1.0 | 0.79 | -66 | 9.33 | 2.93 | 125 | -20.03 | 0.10 | 50 | 0.88 | -27 |
| 1.5 | 0.66 | -94 | 8.02 | 2.52 | 104 | -18.34 | 0.12 | 36 | 0.80 | -36 |
| 1.8 | 0.60 | -110 | 7.18 | 2.28 | 93 | -17.95 | 0.13 | 30 | 0.76 | -40 |
| 2.0 | 0.57 | -119 | 6.76 | 2.18 | 87 | -17.73 | 0.13 | 27 | 0.74 | -42 |
| 2.4 | 0.51 | -139 | 5.56 | 1.90 | 74 | -17.69 | 0.13 | 22 | 0.71 | -46 |
| 3.0 | 0.45 | -167 | 4.22 | 1.63 | 57 | -17.95 | 0.13 | 19 | 0.67 | -51 |
| 4.0 | 0.45 | 153 | 2.30 | 1.30 | 36 | -18.33 | 0.12 | 22 | 0.64 | -62 |
| 5.0 | 0.49 | 120 | 0.73 | 1.09 | 17 | -17.33 | 0.14 | 32 | 0.62 | -72 |

## AT-31011 Typical Noise Parameters,

Common Emitter, $Z_O$ = 50 Ω, 1 V, $I_C$ = 1 mA

| Freq GHz | $F_{min}$[1] dB | $\Gamma_{OPT}$ Mag | $\Gamma_{OPT}$ Ang | $R_n$ |
|---|---|---|---|---|
| 0.5[2] | 0.5 | 0.90 | 13 | 0.85 |
| 0.9 | 0.6 | 0.85 | 29 | 0.73 |
| 1.8 | 1.1 | 0.68 | 67 | 0.46 |
| 2.4 | 1.6 | 0.55 | 98 | 0.28 |

**Notes:**

1. Matching constraints may make $F_{min}$ values associated with high $|\Gamma_{OPT}|$ values unachievable in physical circuits. See Figure 2 for expected performance.
2. 0.5 GHz noise parameter values are extrapolated, not measured.

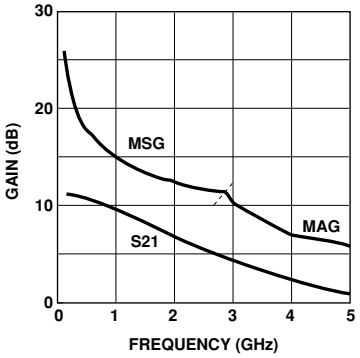


**Figure 17. AT-31011 Gains vs. Frequency at $V_{CE}$ = 1 V, $I_C$ = 1 mA.**

## AT-31033 Typical Scattering Parameters, $V_{CE}$ = 1 V, $I_C$ = 1 mA, Common Emitter, $Z_O$ = 50 Ω

| Freq. GHz | $S_{11}$ Mag | $S_{11}$ Ang | $S_{21}$ dB | $S_{21}$ Mag | $S_{21}$ Ang | $S_{12}$ dB | $S_{12}$ Mag | $S_{12}$ Ang | $S_{22}$ Mag | $S_{22}$ Ang |
|---|---|---|---|---|---|---|---|---|---|---|
| 0.1 | 0.94 | -7 | 11.16 | 3.61 | 173 | -35.95 | 0.02 | 85 | 0.999 | -3 |
| 0.5 | 0.87 | -34 | 10.37 | 3.30 | 144 | -22.84 | 0.07 | 68 | 0.92 | -17 |
| 0.9 | 0.70 | -58 | 9.17 | 2.87 | 121 | -19.06 | 0.11 | 56 | 0.85 | -27 |
| 1.0 | 0.66 | -64 | 8.69 | 2.72 | 115 | -18.49 | 0.12 | 53 | 0.83 | -29 |
| 1.5 | 0.46 | -90 | 7.11 | 2.27 | 92 | -16.94 | 0.14 | 45 | 0.74 | -37 |
| 1.8 | 0.36 | -106 | 6.16 | 2.03 | 81 | -16.40 | 0.15 | 43 | 0.70 | -40 |
| 2.0 | 0.31 | -117 | 5.66 | 1.92 | 74 | -16.06 | 0.16 | 42 | 0.68 | -42 |
| 2.4 | 0.22 | -143 | 4.48 | 1.67 | 62 | -15.50 | 0.17 | 42 | 0.66 | -45 |
| 3.0 | 0.16 | 166 | 3.19 | 1.44 | 46 | -14.34 | 0.19 | 44 | 0.63 | -50 |
| 4.0 | 0.23 | 101 | 1.39 | 1.17 | 25 | -11.85 | 0.26 | 46 | 0.60 | -62 |
| 5.0 | 0.33 | 67 | 0.05 | 1.01 | 9 | -9.11 | 0.35 | 41 | 0.56 | -77 |

## AT-31033 Typical Noise Parameters,

Common Emitter, $Z_O$ = 50 Ω, 1 V, $I_C$ = 1 mA

| Freq GHz | $F_{min}$[1] dB | $\Gamma_{OPT}$ Mag | $\Gamma_{OPT}$ Ang | $R_n$ |
|---|---|---|---|---|
| 0.5[2] | 0.5 | 0.90 | 12 | 0.70 |
| 0.9 | 0.6 | 0.82 | 28 | 0.60 |
| 1.8 | 1.1 | 0.57 | 68 | 0.38 |
| 2.4 | 1.6 | 0.41 | 100 | 0.22 |

**Notes:**

1. Matching constraints may make $F_{min}$ values associated with high $|\Gamma_{OPT}|$ values unachievable in physical circuits. See Figure 2 for expected performance.
2. 0.5 GHz noise parameter values are extrapolated, not measured.

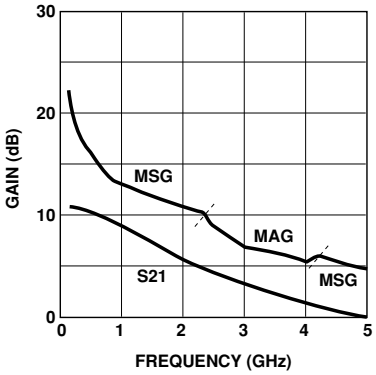


**Figure 18. AT-31033 Gains vs. Frequency at $V_{CE}$ = 1 V, $I_C$ = 1 mA.**

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## AT-31011 Typical Scattering Parameters, $V_{CE}$ = 2.7 V, $I_C$ = 1 mA, Common Emitter, $Z_O$ = 50 Ω

| Freq. GHz | $S_{11}$ Mag | $S_{11}$ Ang | $S_{21}$ dB | $S_{21}$ Mag | $S_{21}$ Ang | $S_{12}$ dB | $S_{12}$ Mag | $S_{12}$ Ang | $S_{22}$ Mag | $S_{22}$ Ang |
|---|---|---|---|---|---|---|---|---|---|---|
| 0.1 | 0.96 | -7 | 11.11 | 3.59 | 174 | -39.92 | 0.01 | 86 | 0.999 | -2 |
| 0.5 | 0.93 | -32 | 10.66 | 3.41 | 152 | -26.43 | 0.05 | 69 | 0.95 | -13 |
| 0.9 | 0.83 | -56 | 9.90 | 3.13 | 132 | -22.32 | 0.08 | 55 | 0.91 | -22 |
| 1.0 | 0.81 | -61 | 9.53 | 2.99 | 128 | -21.66 | 0.08 | 53 | 0.90 | -24 |
| 1.5 | 0.68 | -89 | 8.32 | 2.61 | 107 | -19.90 | 0.10 | 40 | 0.84 | -32 |
| 1.8 | 0.62 | -104 | 7.52 | 2.38 | 96 | -19.46 | 0.11 | 34 | 0.80 | -36 |
| 2.0 | 0.58 | -113 | 7.15 | 2.28 | 90 | -19.24 | 0.11 | 31 | 0.78 | -38 |
| 2.4 | 0.52 | -133 | 5.98 | 1.99 | 77 | -19.15 | 0.11 | 27 | 0.75 | -42 |
| 3.0 | 0.45 | -160 | 4.65 | 1.71 | 61 | -19.37 | 0.11 | 25 | 0.72 | -46 |
| 4.0 | 0.43 | 158 | 2.75 | 1.37 | 39 | -19.60 | 0.10 | 29 | 0.69 | -56 |
| 5.0 | 0.46 | 123 | 1.16 | 1.14 | 20 | -18.16 | 0.12 | 41 | 0.68 | -66 |

## AT-31011 Typical Noise Parameters,

Common Emitter, $Z_O$ = 50 Ω, 2.7 V, $I_C$ = 1 mA

| Freq GHz | $F_{min}$[1] dB | $\Gamma_{OPT}$ Mag | $\Gamma_{OPT}$ Ang | $R_n$ |
|---|---|---|---|---|
| 0.5[2] | 0.5 | 0.92 | 13 | 0.85 |
| 0.9 | 0.6 | 0.85 | 29 | 0.73 |
| 1.8 | 1.1 | 0.68 | 67 | 0.46 |
| 2.4 | 1.6 | 0.55 | 98 | 0.28 |

**Notes:**
1. Matching constraints may make $F_{min}$ values associated with high $|\Gamma_{OPT}|$ values unachievable in physical circuits. See Figure 2 for expected performance.
2. 0.5 GHz noise parameter values are extrapolated, not measured.

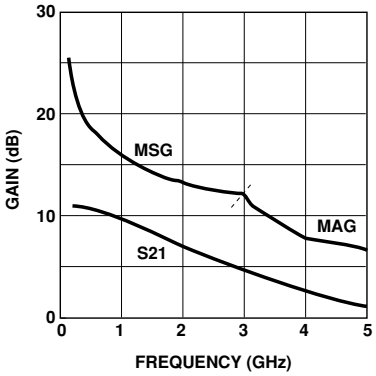


**Figure 19. AT-31011 Gains vs. Frequency at $V_{CE}$ = 2.7 V, $I_C$ = 1 mA.**

## AT-31033 Typical Scattering Parameters, $V_{CE}$ = 2.7 V, $I_C$ = 1 mA, Common Emitter, $Z_O$ = 50 Ω

| Freq. GHz | $S_{11}$ Mag | $S_{11}$ Ang | $S_{21}$ dB | $S_{21}$ Mag | $S_{21}$ Ang | $S_{12}$ dB | $S_{12}$ Mag | $S_{12}$ Ang | $S_{22}$ Mag | $S_{22}$ Ang |
|---|---|---|---|---|---|---|---|---|---|---|
| 0.1 | 0.94 | -7 | 11.07 | 3.58 | 173 | -37.44 | 0.01 | 86 | 0.999 | -3 |
| 0.5 | 0.89 | -32 | 10.35 | 3.29 | 146 | -24.11 | 0.06 | 70 | 0.94 | -15 |
| 0.9 | 0.72 | -54 | 9.27 | 2.91 | 123 | -20.27 | 0.10 | 58 | 0.87 | -25 |
| 1.0 | 0.69 | -59 | 8.80 | 2.76 | 118 | -19.65 | 0.10 | 56 | 0.86 | -26 |
| 1.5 | 0.48 | -83 | 7.32 | 2.32 | 95 | -18.01 | 0.13 | 48 | 0.78 | -33 |
| 1.8 | 0.38 | -97 | 6.39 | 2.09 | 84 | -17.43 | 0.13 | 46 | 0.74 | -36 |
| 2.0 | 0.33 | -107 | 5.91 | 1.97 | 77 | -17.07 | 0.14 | 45 | 0.72 | -38 |
| 2.4 | 0.23 | -130 | 4.73 | 1.72 | 65 | -16.46 | 0.15 | 46 | 0.70 | -41 |
| 3.0 | 0.14 | -178 | 3.43 | 1.48 | 49 | -15.25 | 0.17 | 48 | 0.67 | -46 |
| 4.0 | 0.19 | 103 | 1.62 | 1.21 | 28 | -12.62 | 0.23 | 51 | 0.65 | -57 |
| 5.0 | 0.30 | 67 | 0.25 | 1.03 | 12 | -9.72 | 0.33 | 47 | 0.63 | -71 |

## AT-31033 Typical Noise Parameters,

Common Emitter, $Z_O$ = 50 Ω, 2.7 V, $I_C$ = 1 mA

| Freq GHz | $F_{min}$[1] dB | $\Gamma_{OPT}$ Mag | $\Gamma_{OPT}$ Ang | $R_n$ |
|---|---|---|---|---|
| 0.5[2] | 0.5 | 0.90 | 12 | 0.70 |
| 0.9 | 0.6 | 0.82 | 28 | 0.60 |
| 1.8 | 1.1 | 0.57 | 68 | 0.38 |
| 2.4 | 1.6 | 0.41 | 100 | 0.22 |

**Notes:**
1. Matching constraints may make $F_{min}$ values associated with high $|\Gamma_{OPT}|$ values unachievable in physical circuits. See Figure 2 for expected performance.
2. 0.5 GHz noise parameter values are extrapolated, not measured.

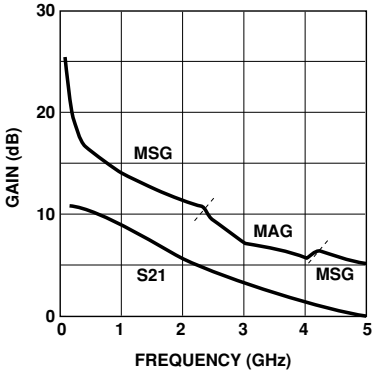


**Figure 20. AT-31033 Gains vs. Frequency at $V_{CE}$ = 2.7 V, $I_C$ = 1 mA.**

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## AT-31011 Typical Scattering Parameters, $V_{CE}$ = 2.7 V, $I_C$ = 10 mA, Common Emitter, $Z_O$ = 50 Ω

| Freq. GHz | $S_{11}$ Mag | $S_{11}$ Ang | $S_{21}$ dB | $S_{21}$ Mag | $S_{21}$ Ang | $S_{12}$ dB | $S_{12}$ Mag | $S_{12}$ Ang | $S_{22}$ Mag | $S_{22}$ Ang |
|---|---|---|---|---|---|---|---|---|---|---|
| 0.1 | 0.74 | -23 | 27.42 | 23.49 | 161 | -41.00 | 0.01 | 77 | 0.95 | -9 |
| 0.5 | 0.46 | -85 | 22.65 | 13.57 | 116 | -30.64 | 0.03 | 59 | 0.68 | -24 |
| 0.9 | 0.32 | -121 | 18.73 | 8.64 | 97 | -27.55 | 0.04 | 59 | 0.59 | -27 |
| 1.0 | 0.30 | -128 | 17.91 | 7.86 | 93 | -27.05 | 0.04 | 59 | 0.58 | -27 |
| 1.5 | 0.25 | -161 | 14.77 | 5.48 | 79 | -24.48 | 0.06 | 61 | 0.55 | -30 |
| 1.8 | 0.25 | -177 | 13.29 | 4.62 | 72 | -23.26 | 0.07 | 61 | 0.54 | -32 |
| 2.0 | 0.24 | 174 | 12.42 | 4.18 | 68 | -22.51 | 0.07 | 61 | 0.53 | -33 |
| 2.4 | 0.25 | 157 | 10.97 | 3.54 | 60 | -21.12 | 0.09 | 59 | 0.53 | -36 |
| 3.0 | 0.27 | 138 | 9.11 | 2.86 | 49 | -19.31 | 0.11 | 58 | 0.52 | -40 |
| 4.0 | 0.31 | 113 | 6.86 | 2.20 | 33 | -16.88 | 0.14 | 54 | 0.51 | -50 |
| 5.0 | 0.37 | 94 | 5.19 | 1.82 | 17 | -14.75 | 0.18 | 48 | 0.50 | -59 |

## AT-31011 Typical Noise Parameters,

Common Emitter, $Z_O$ = 50 Ω, 2.7 V, $I_C$ = 10 mA

| Freq GHz | $F_{min}$[1] dB | $\Gamma_{OPT}$ Mag | $\Gamma_{OPT}$ Ang | $R_n$ |
|---|---|---|---|---|
| 0.5[2] | 1.3 | 0.45 | 11 | 0.55 |
| 0.9 | 1.4 | 0.37 | 33 | 0.46 |
| 1.8 | 1.7 | 0.25 | 86 | 0.29 |
| 2.4 | 2.0 | 0.18 | 129 | 0.18 |

**Notes:**
1. Matching constraints may make $F_{min}$ values associated with high $|\Gamma_{OPT}|$ values unachievable in physical circuits. See Figure 2 for expected performance.
2. 0.5 GHz noise parameter values are extrapolated, not measured.

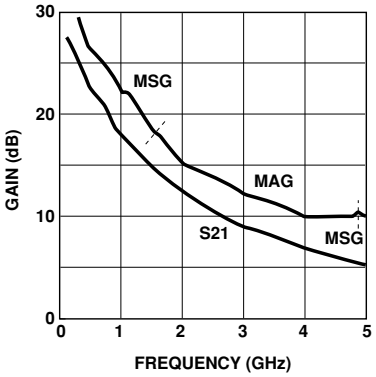


**Figure 21. AT-31011 Gains vs. Frequency at $V_{CE}$ = 2.7 V, $I_C$ = 10 mA.**

## AT-31033 Typical Scattering Parameters, $V_{CE}$ = 2.7 V, $I_C$ = 10 mA, Common Emitter, $Z_O$ = 50 Ω

| Freq. GHz | $S_{11}$ Mag | $S_{11}$ Ang | $S_{21}$ dB | $S_{21}$ Mag | $S_{21}$ Ang | $S_{12}$ dB | $S_{12}$ Mag | $S_{12}$ Ang | $S_{22}$ Mag | $S_{22}$ Ang |
|---|---|---|---|---|---|---|---|---|---|---|
| 0.1 | 0.72 | -21 | 26.80 | 21.87 | 154 | -38.46 | 0.01 | 80 | 0.92 | -10 |
| 0.5 | 0.33 | -49 | 19.93 | 9.92 | 106 | -27.31 | 0.04 | 73 | 0.66 | -20 |
| 0.9 | 0.19 | -47 | 15.51 | 5.96 | 88 | -22.90 | 0.07 | 72 | 0.61 | -22 |
| 1.0 | 0.17 | -46 | 14.66 | 5.41 | 85 | -22.03 | 0.08 | 72 | 0.60 | -23 |
| 1.5 | 0.11 | -28 | 11.44 | 3.73 | 72 | -18.74 | 0.12 | 69 | 0.59 | -27 |
| 1.8 | 0.10 | -14 | 9.99 | 3.16 | 66 | -17.26 | 0.14 | 67 | 0.58 | -30 |
| 2.0 | 0.10 | -6 | 9.15 | 2.87 | 62 | -16.40 | 0.15 | 65 | 0.58 | -32 |
| 2.4 | 0.10 | 9 | 7.78 | 2.45 | 54 | -14.88 | 0.18 | 62 | 0.57 | -35 |
| 3.0 | 0.12 | 23 | 6.16 | 2.03 | 43 | -12.99 | 0.22 | 57 | 0.55 | -41 |
| 4.0 | 0.15 | 34 | 4.30 | 1.64 | 27 | -10.49 | 0.30 | 48 | 0.52 | -53 |
| 5.0 | 0.20 | 36 | 3.01 | 1.41 | 12 | -8.53 | 0.37 | 38 | 0.48 | -65 |

## AT-31033 Typical Noise Parameters,

Common Emitter, $Z_O$ = 50 Ω, 2.7 V, $I_C$ = 10 mA

| Freq GHz | $F_{min}$[1] dB | $\Gamma_{OPT}$ Mag | $\Gamma_{OPT}$ Ang | $R_n$ |
|---|---|---|---|---|
| 0.5[2] | 1.3 | 0.42 | 10 | 0.38 |
| 0.9 | 1.4 | 0.31 | 30 | 0.34 |
| 1.8 | 1.7 | 0.16 | 80 | 0.23 |
| 2.4 | 2.0 | 0.08 | 118 | 0.17 |

**Notes:**
1. Matching constraints may make $F_{min}$ values associated with high $|\Gamma_{OPT}|$ values unachievable in physical circuits. See Figure 2 for expected performance.
2. 0.5 GHz noise parameter values are extrapolated, not measured.

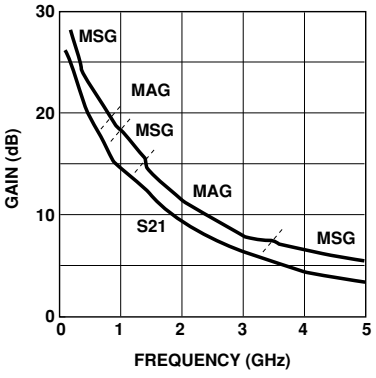


**Figure 22. AT-31033 Gains vs. Frequency at $V_{CE}$ = 2.7 V, $I_C$ = 10 mA.**

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## AT-31011 Typical Scattering Parameters, $V_{CE}$ = 5 V, $I_C$ = 1 mA, Common Emitter, $Z_O$ = 50 Ω

| Freq. GHz | $S_{11}$ Mag | $S_{11}$ Ang | $S_{21}$ dB | $S_{21}$ Mag | $S_{21}$ Ang | $S_{12}$ dB | $S_{12}$ Mag | $S_{12}$ Ang | $S_{22}$ Mag | $S_{22}$ Ang |
|---|---|---|---|---|---|---|---|---|---|---|
| 0.1 | 0.96 | -7 | 11.10 | 3.59 | 174 | -40.35 | 0.01 | 84 | 0.999 | -2 |
| 0.5 | 0.94 | -31 | 10.67 | 3.41 | 153 | -26.95 | 0.04 | 69 | 0.96 | -13 |
| 0.9 | 0.83 | -54 | 9.93 | 3.14 | 133 | -22.80 | 0.07 | 56 | 0.92 | -22 |
| 1.0 | 0.81 | -60 | 9.57 | 3.01 | 129 | -22.18 | 0.08 | 53 | 0.91 | -23 |
| 1.5 | 0.68 | -86 | 8.41 | 2.63 | 108 | -20.33 | 0.10 | 41 | 0.85 | -31 |
| 1.8 | 0.62 | -101 | 7.62 | 2.40 | 97 | -19.85 | 0.10 | 35 | 0.81 | -35 |
| 2.0 | 0.58 | -110 | 7.27 | 2.31 | 91 | -19.64 | 0.10 | 32 | 0.79 | -37 |
| 2.4 | 0.52 | -129 | 6.10 | 2.02 | 78 | -19.50 | 0.11 | 28 | 0.76 | -41 |
| 3.0 | 0.44 | -157 | 4.78 | 1.73 | 62 | -19.68 | 0.10 | 26 | 0.73 | -45 |
| 4.0 | 0.42 | 161 | 2.90 | 1.40 | 40 | -19.86 | 0.10 | 31 | 0.70 | -55 |
| 5.0 | 0.45 | 125 | 1.33 | 1.17 | 21 | -18.35 | 0.12 | 43 | 0.70 | -65 |

## AT-31011 Typical Noise Parameters,

Common Emitter, $Z_O$ = 50 Ω, 5 V, $I_C$ = 1 mA

| Freq GHz | $F_{min}$[1] dB | $\Gamma_{OPT}$ Mag | $\Gamma_{OPT}$ Ang | $R_n$ |
|---|---|---|---|---|
| 0.5[2] | 0.5 | 0.92 | 13 | 0.85 |
| 0.9 | 0.6 | 0.85 | 29 | 0.73 |
| 1.8 | 1.1 | 0.68 | 67 | 0.46 |
| 2.4 | 1.6 | 0.55 | 98 | 0.28 |

**Notes:**
1. Matching constraints may make $F_{min}$ values associated with high $|\Gamma_{OPT}|$ values unachievable in physical circuits. See Figure 2 for expected performance.
2. 0.5 GHz noise parameter values are extrapolated, not measured.

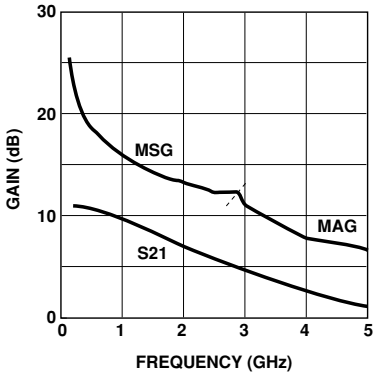


**Figure 23. AT-31011 Gains vs. Frequency at $V_{CE}$ = 5 V, $I_C$ = 1 mA.**

## AT-31033 Typical Scattering Parameters, $V_{CE}$ = 5 V, $I_C$ = 1 mA, Common Emitter, $Z_O$ = 50 Ω

| Freq. GHz | $S_{11}$ Mag | $S_{11}$ Ang | $S_{21}$ dB | $S_{21}$ Mag | $S_{21}$ Ang | $S_{12}$ dB | $S_{12}$ Mag | $S_{12}$ Ang | $S_{22}$ Mag | $S_{22}$ Ang |
|---|---|---|---|---|---|---|---|---|---|---|
| 0.1 | 0.95 | -7 | 10.93 | 3.52 | 173 | -37.78 | 0.01 | 85 | 0.999 | -3 |
| 0.5 | 0.89 | -31 | 10.24 | 3.25 | 147 | -24.43 | 0.06 | 70 | 0.94 | -15 |
| 0.9 | 0.73 | -52 | 9.20 | 2.88 | 124 | -20.49 | 0.09 | 59 | 0.88 | -24 |
| 1.0 | 0.70 | -57 | 8.75 | 2.74 | 119 | -19.91 | 0.10 | 57 | 0.87 | -26 |
| 1.5 | 0.49 | -80 | 7.30 | 2.32 | 96 | -18.15 | 0.12 | 49 | 0.79 | -32 |
| 1.8 | 0.39 | -93 | 6.41 | 2.09 | 85 | -17.54 | 0.13 | 47 | 0.75 | -36 |
| 2.0 | 0.34 | -102 | 5.93 | 1.98 | 78 | -17.19 | 0.14 | 46 | 0.73 | -37 |
| 2.4 | 0.23 | -122 | 4.77 | 1.73 | 66 | -16.55 | 0.15 | 46 | 0.71 | -40 |
| 3.0 | 0.13 | -166 | 3.49 | 1.49 | 50 | -15.35 | 0.17 | 49 | 0.68 | -45 |
| 4.0 | 0.17 | 107 | 1.71 | 1.22 | 29 | -12.83 | 0.23 | 51 | 0.66 | -56 |
| 5.0 | 0.28 | 68 | 0.32 | 1.04 | 12 | -9.96 | 0.32 | 48 | 0.64 | -69 |

## AT-31033 Typical Noise Parameters,

Common Emitter, $Z_O$ = 50 Ω, 5 V, $I_C$ = 1 mA

| Freq GHz | $F_{min}$[1] dB | $\Gamma_{OPT}$ Mag | $\Gamma_{OPT}$ Ang | $R_n$ |
|---|---|---|---|---|
| 0.5[2] | 0.5 | 0.90 | 12 | 0.70 |
| 0.9 | 0.6 | 0.82 | 28 | 0.60 |
| 1.8 | 1.1 | 0.57 | 68 | 0.38 |
| 2.4 | 1.6 | 0.41 | 100 | 0.22 |

**Notes:**
1. Matching constraints may make $F_{min}$ values associated with high $|\Gamma_{OPT}|$ values unachievable in physical circuits. See Figure 2 for expected performance.
2. 0.5 GHz noise parameter values are extrapolated, not measured.

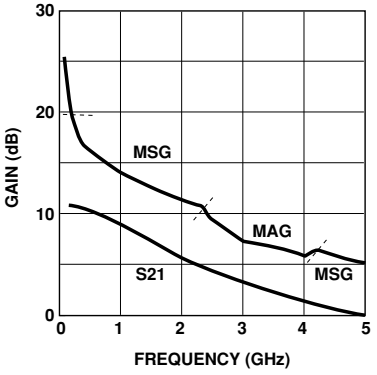


**Figure 24. AT-31033 Gains vs. Frequency at $V_{CE}$ = 5 V, $I_C$ = 1 mA.**

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## AT-31011 Typical Scattering Parameters, $V_{CE}$ = 5 V, $I_C$ = 10 mA, Common Emitter, $Z_O$ = 50 Ω

| Freq. GHz | $S_{11}$ Mag | $S_{11}$ Ang | $S_{21}$ dB | $S_{21}$ Mag | $S_{21}$ Ang | $S_{12}$ dB | $S_{12}$ Mag | $S_{12}$ Ang | $S_{22}$ Mag | $S_{22}$ Ang |
|---|---|---|---|---|---|---|---|---|---|---|
| 0.1 | 0.77 | -21 | 27.41 | 23.46 | 162 | -41.49 | 0.01 | 80 | 0.95 | -8 |
| 0.5 | 0.48 | -77 | 22.97 | 14.07 | 118 | -30.66 | 0.03 | 61 | 0.70 | -24 |
| 0.9 | 0.32 | -112 | 19.14 | 9.06 | 98 | -27.77 | 0.04 | 59 | 0.61 | -27 |
| 1.0 | 0.30 | -119 | 18.34 | 8.26 | 95 | -27.11 | 0.04 | 60 | 0.59 | -27 |
| 1.5 | 0.23 | -151 | 15.23 | 5.78 | 80 | -24.56 | 0.06 | 60 | 0.56 | -29 |
| 1.8 | 0.22 | -168 | 13.75 | 4.87 | 73 | -23.37 | 0.07 | 60 | 0.55 | -31 |
| 2.0 | 0.21 | -178 | 12.91 | 4.42 | 69 | -22.62 | 0.07 | 60 | 0.55 | -32 |
| 2.4 | 0.21 | 163 | 11.46 | 3.74 | 61 | -21.25 | 0.09 | 59 | 0.54 | -36 |
| 3.0 | 0.23 | 142 | 9.60 | 3.02 | 50 | -19.45 | 0.11 | 58 | 0.53 | -39 |
| 4.0 | 0.27 | 116 | 7.36 | 2.33 | 34 | -17.08 | 0.14 | 54 | 0.52 | -48 |
| 5.0 | 0.33 | 96 | 5.70 | 1.93 | 19 | -14.97 | 0.18 | 48 | 0.51 | -58 |

## AT-31011 Typical Noise Parameters,

Common Emitter, $Z_O$ = 50 Ω, 5 V, $I_C$ = 10 mA

| Freq GHz | $F_{min}$[1] dB | $\Gamma_{OPT}$ Mag | $\Gamma_{OPT}$ Ang | $R_n$ |
|---|---|---|---|---|
| 0.5[2] | 1.3 | 0.45 | 11 | 0.55 |
| 0.9 | 1.4 | 0.37 | 33 | 0.46 |
| 1.8 | 1.7 | 0.25 | 86 | 0.29 |
| 2.4 | 2.0 | 0.18 | 129 | 0.18 |

**Notes:**
1. Matching constraints may make $F_{min}$ values associated with high $|\Gamma_{OPT}|$ values unachievable in physical circuits. See Figure 2 for expected performance.
2. 0.5 GHz noise parameter values are extrapolated, not measured.

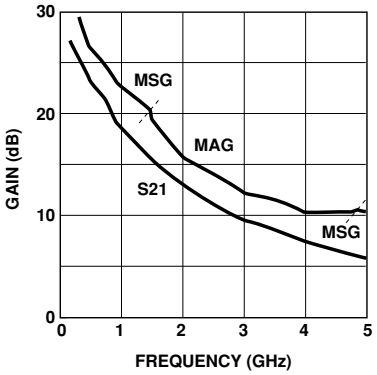


**Figure 25. AT-31011 Gains vs. Frequency at $V_{CE}$ = 5 V, $I_C$ = 10 mA.**

## AT-31033 Typical Scattering Parameters, $V_{CE}$ = 5 V, $I_C$ = 10 mA, Common Emitter, $Z_O$ = 50 Ω

| Freq. GHz | $S_{11}$ Mag | $S_{11}$ Ang | $S_{21}$ dB | $S_{21}$ Mag | $S_{21}$ Ang | $S_{12}$ dB | $S_{12}$ Mag | $S_{12}$ Ang | $S_{22}$ Mag | $S_{22}$ Ang |
|---|---|---|---|---|---|---|---|---|---|---|
| 0.1 | 0.75 | -19 | 26.79 | 21.84 | 155 | -38.82 | 0.01 | 79 | 0.92 | -10 |
| 0.5 | 0.37 | -45 | 20.17 | 10.20 | 107 | -27.39 | 0.04 | 73 | 0.67 | -20 |
| 0.9 | 0.23 | -42 | 15.79 | 6.16 | 90 | -23.00 | 0.07 | 72 | 0.62 | -22 |
| 1.0 | 0.21 | -42 | 14.94 | 5.58 | 86 | -22.11 | 0.08 | 72 | 0.61 | -23 |
| 1.5 | 0.15 | -30 | 11.75 | 3.87 | 73 | -18.86 | 0.11 | 69 | 0.60 | -27 |
| 1.8 | 0.14 | -21 | 10.30 | 3.27 | 67 | -17.37 | 0.14 | 66 | 0.59 | -29 |
| 2.0 | 0.13 | -17 | 9.47 | 2.97 | 63 | -16.51 | 0.15 | 65 | 0.58 | -31 |
| 2.4 | 0.13 | -7 | 8.08 | 2.54 | 55 | -15.00 | 0.18 | 62 | 0.57 | -35 |
| 3.0 | 0.13 | 3 | 6.47 | 2.11 | 45 | -13.14 | 0.22 | 57 | 0.56 | -41 |
| 4.0 | 0.14 | 19 | 4.61 | 1.7 | 29 | -10.67 | 0.29 | 48 | 0.53 | -52 |
| 5.0 | 0.18 | 28 | 3.33 | 1.47 | 14 | -8.73 | 0.37 | 38 | 0.49 | -64 |

## AT-31033 Typical Noise Parameters,

Common Emitter, $Z_O$ = 50 Ω, 5 V, $I_C$ = 10 mA

| Freq GHz | $F_{min}$[1] dB | $\Gamma_{OPT}$ Mag | $\Gamma_{OPT}$ Ang | $R_n$ - |
|---|---|---|---|---|
| 0.5[2] | 1.3 | 0.42 | 10 | 0.38 |
| 0.9 | 1.4 | 0.31 | 30 | 0.34 |
| 1.8 | 1.7 | 0.16 | 80 | 0.23 |
| 2.4 | 2.0 | 0.08 | 118 | 0.17 |

**Notes:**
1. Matching constraints may make $F_{min}$ values associated with high $|\Gamma_{OPT}|$ values unacheivable in physical circuits. See Figure 2 for expected performance.
2. 0.5 GHz noise parameter values are extrapolated, not measured.

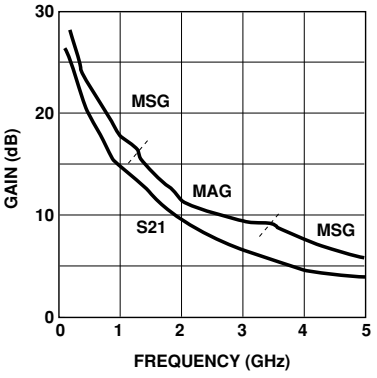


**Figure 26. AT-31033 Gains vs. Frequency at $V_{CE}$ = 5 V, $I_C$ = 10 mA.**

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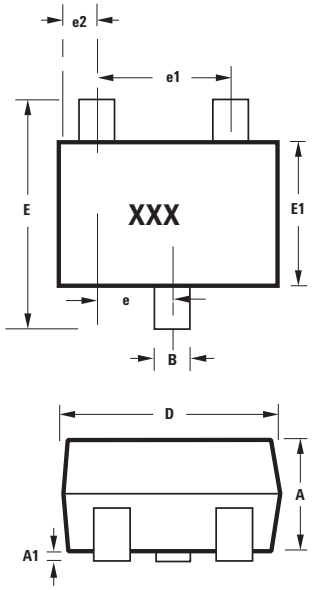
## Ordering Information

| Part Numbers | | No. of Devices | Comments |
|---|---|---|---|
| AT-31011-BLK | AT-31033-BLK | 100 | Bulk |
| AT-31011-BLKG | AT-31033-BLKG | 100 | Bulk |
| AT-31011-TR1 | AT-31033-TR1 | 3000 | 7" Reel |
| AT-31011-TR1G | AT-31033-TR1G | 3000 | 7" Reel |
| AT-31011-TR2 | AT-31033-TR2 | 10000 | 13" Reel |
| AT-31011-TR2G | AT-31033-TR2G | 10000 | 13" Reel |

**Note:** Order part number with a "G" suffix if lead-free option is desired.

## Package Dimensions

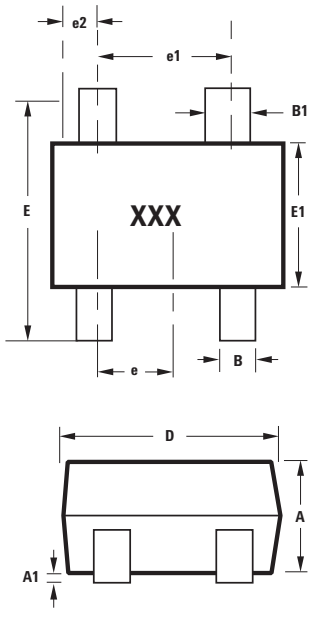
### SOT-23 Plastic Package




Notes:
XXX-package marking
Drawings are not to scale

| SYMBOL | DIMENSIONS (mm) MIN. | MAX. |
|---|---|---|
| A | 0.79 | 1.20 |
| A1 | 0.000 | 0.100 |
| B | 0.37 | 0.54 |
| C | 0.086 | 0.152 |
| D | 2.73 | 3.13 |
| E1 | 1.15 | 1.50 |
| e | 0.89 | 1.02 |
| e1 | 1.78 | 2.04 |
| e2 | 0.45 | 0.60 |
| E | 2.10 | 2.70 |
| L | 0.45 | 0.69 |

### SOT-143 Plastic Package




Notes:
XXX-package marking
Drawings are not to scale

| SYMBOL | DIMENSIONS (mm) MIN. | MAX. |
|---|---|---|
| A | 0.79 | 1.097 |
| A1 | 0.013 | 0.10 |
| B | 0.36 | 0.54 |
| B1 | 0.76 | 0.92 |
| C | 0.086 | 0.152 |
| D | 2.80 | 3.06 |
| E1 | 1.20 | 1.40 |
| e | 0.89 | 1.02 |
| e1 | 1.78 | 2.04 |
| e2 | 0.45 | 0.60 |
| E | 2.10 | 2.65 |
| L | 0.45 | 0.69 |

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