# Agilent AT-32011, AT-32033 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-32011: 1 dB NF, 14 dB $G_A$
  AT-32033: 1 dB NF, 12.5 dB $G_A$
- **Characterized for End-Of-Life Battery Use (2.7 V)**
- **SOT-23 and SOT-143 SMT Plastic Packages**
- **Tape-And-Reel Packaging Option Available**
- **Lead-free Option Available**

### Description

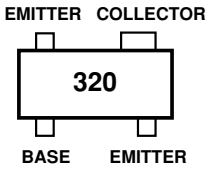
Agilent's AT-32011 and AT-32033 are high performance NPN bipolar transistors that have been optimized for maximum $f_t$ at low voltage operation, making them ideal for use in battery powered applications in wireless markets. The AT-32033 uses the 3 lead SOT-23, while the AT-32011 places the same die in the higher performance 4 lead SOT-143. Both packages are industry standard, and 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 20 emitter finger interdigitated geometry yields an easy to match to and extremely fast transistor with moderate power, low noise resistance, and low operating currents.

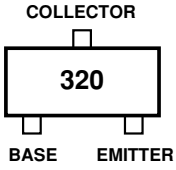
Optimized performance at 2.7 V makes these devices ideal for use in 900 MHz, 1.8 GHz, and 2.4 GHz battery operated systems as an LNA, gain stage, buffer, oscillator, or active mixer. Typical amplifier designs at 900 MHz yield 1.2 dB noise figures with 12 dB or more associated gain at a 2.7 V, 2 mA bias, with noise performance being relatively insensitive to input match. High gain capability at 1 V, 1 mA makes these devices a good fit for 900 MHz pager applications. Voltage breakdowns are high enough for use at 5 volts.

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-32011)




SOT-23 (AT-32033)

Agilent Technologies

## AT-32011, AT-32033 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 | 32 |
| $P_T$ | Power Dissipation[2, 3] | mW | 200 |
| $T_j$ | 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 $T_C$ > 40°C.

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

| | | | AT-32011 | | | AT-32033 | | |
|---|---|---|---|---|---|---|---|---|
| Symbol | Parameters and Test Conditions | Units | Min. | Typ. | Max. | Min. | Typ. | Max. |
| NF | Noise Figure<br>$V_{CE}$ = 2.7 V, $I_C$ = 2 mA f = 0.9 GHz | dB | | 1.0[1] | 1.3[1] | | 1.0[2] | 1.3[2] |
| $G_A$ | Associated Gain<br>$V_{CE}$ = 2.7 V, $I_C$ = 2 mA f = 0.9 GHz | dB | 12.5[1] | 14[1] | | 11[2] | 12.5[2] | |
| $h_{FE}$ | Forward Current Transfer Ratio<br>$V_{CE}$ = 2.7 V, $I_C$ = 2 mA | – | 70 | | 300 | 70 | | 300 |
| $I_{CBO}$ | Collector Cutoff Current<br>$V_{CB}$ = 3 V | µA | | | 0.2 | | | 0.2 |
| $I_{EBO}$ | Emitter Cutoff Current<br>$V_{EB}$ = 1 V | µA | | | 1.5 | | | 1.5 |

**Notes:**
1. Test circuit A, Figure 1. Numbers reflect device performance de-embedded from circuit losses. Input loss = 0.3 dB; output loss = 0.3 dB.
2. Test circuit B, Figure 1. Numbers reflect device performance de-embedded from circuit losses. Input loss = 0.3 dB; output loss = 0.3 dB.

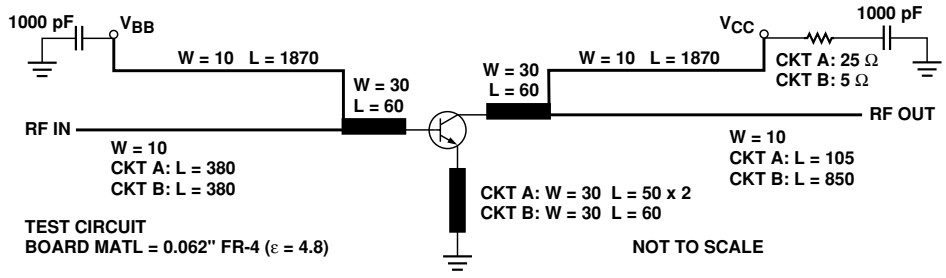



**Figure 1. Test Circuit for Noise Figure and Associated Gain.**
**This circuit is a compromise match between best noise figure, best gain, stability, and a practical synthesizable match.**

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

| Symbol | Parameters and Test Conditions | Units | AT-32011 Typ. | AT-32033 Typ. |
|---|---|---|---|---|
| $P_{1dB}$ | Power at 1 dB Gain Compression (opt tuning)<br>$V_{CE}$ = 2.7 V, $I_C$ = 20 mA f = 0.9 GHz | dBm | 13 | 13 |
| $G_{1dB}$ | Gain at 1 dB Gain Compression (opt tuning)<br>$V_{CE}$ = 2.7 V, $I_C$ = 20 mA f = 0.9 GHz | dB | 16.5 | 15 |
| $IP_3$ | Output Third Order Intercept Point (opt tuning)<br>$V_{CE}$ = 2.7 V, $I_C$ = 20 mA f = 0.9 GHz | dBm | 24 | 24 |
| $\|S_{21}\|_E^2$ | Gain in 50 Ω System<br>$V_{CE}$ = 2.7 V, $I_C$ = 2 mA f = 0.9 GHz | dB | 13 | 11.5 |

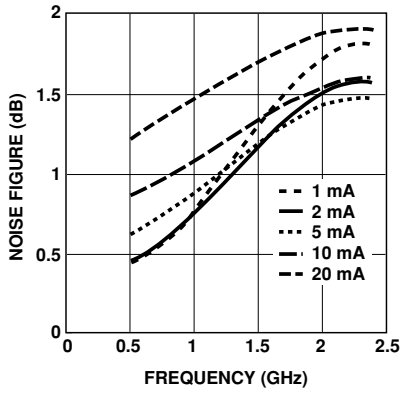



**Figure 2. AT-32011 and AT-32033 Minimum Noise Figure vs. Frequency and Current at $V_{CE}$ = 2.7 V.**

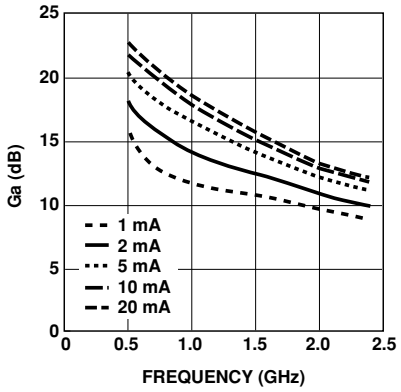



**Figure 3. AT-32011 Associated Gain at Optimum Noise Match vs. Frequency and Current at $V_{CE}$ = 2.7 V.**

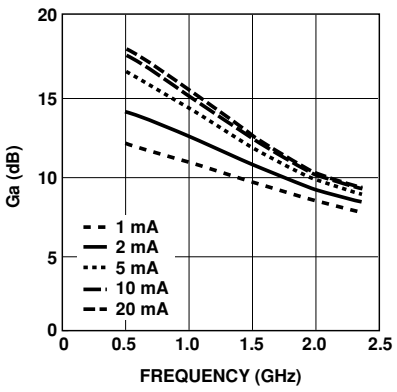



**Figure 4. AT-32033 Associated Gain at Optimum Noise Match vs. Frequency and Current at $V_{CE}$ = 2.7 V.**

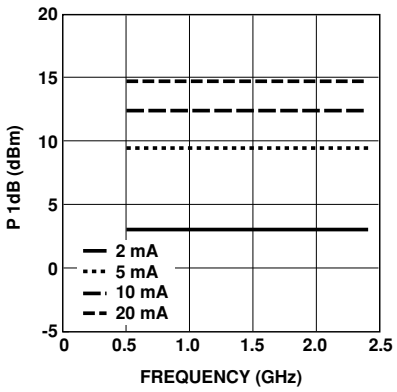



**Figure 5. AT-32011 and AT-32033 Power at 1 dB Gain Compression vs. Frequency and Current at $V_{CE}$ = 2.7 V.**

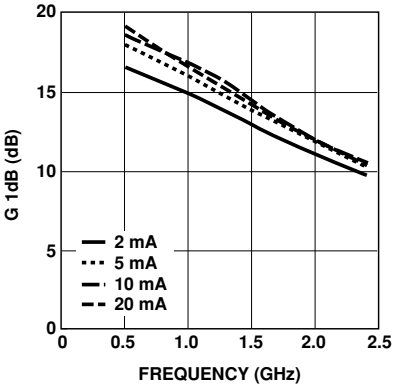



**Figure 6. AT-32011 1 dB Compressed Gain vs. Frequency and Current at $V_{CE}$ = 2.7 V.**

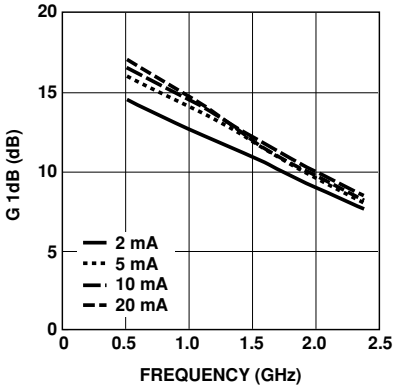



**Figure 7. AT-32033 1 dB Compressed Gain vs. Frequency and Current at $V_{CE}$ = 2.7 V.**

## AT-32011, AT-32033 Typical Performance

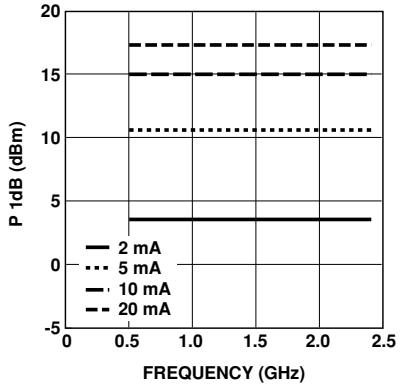



**Figure 8. AT-32011 and AT-32033 Power at 1 dB Gain Compression vs. Frequency and Current at $V_{CE}$ = 5 V.**

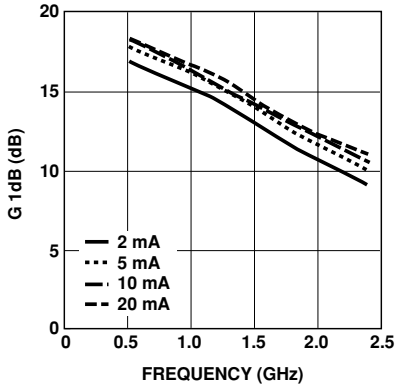



**Figure 9. AT-32011 1 dB Compressed Gain vs. Frequency and Current at $V_{CE}$ = 5 V.**

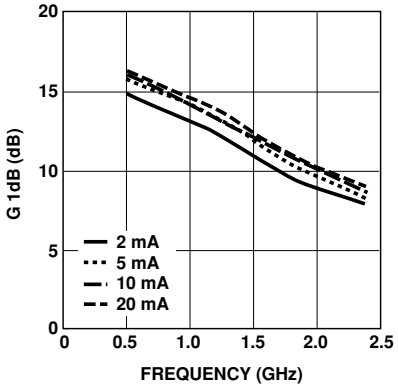



**Figure 10. AT-32033 1 dB Compressed Gain vs. Frequency and Current at $V_{CE}$ = 5 V.**

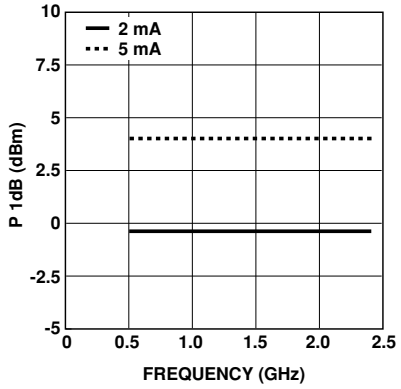



**Figure 11. AT-32011 and AT-32033 Power at 1 dB Gain Compression vs. Frequency and Current at $V_{CE}$ = 1 V.**

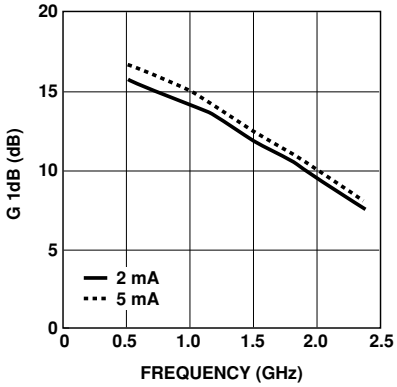



**Figure 12. AT-32011 1 dB Compressed Gain vs. Frequency and Current at $V_{CE}$ = 1 V.**

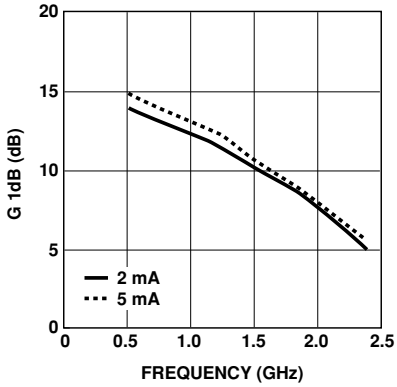



**Figure 13. AT-32033 1 dB Compressed Gain vs. Frequency and Current at $V_{CE}$ = 1 V.**

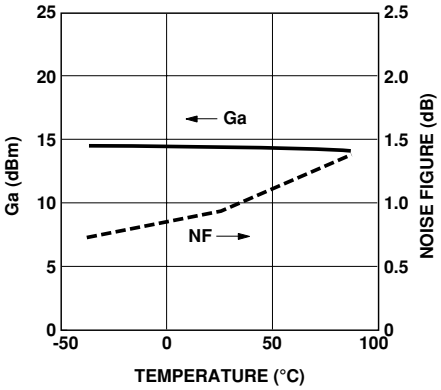



**Figure 14. AT-32011 Noise Figure and Associated Gain at $V_{CE}$ = 2.7 V, $I_C$ = 2 mA vs. Temperature in Test Circuit, Figure 1. (Circuit Losses De-embedded).**

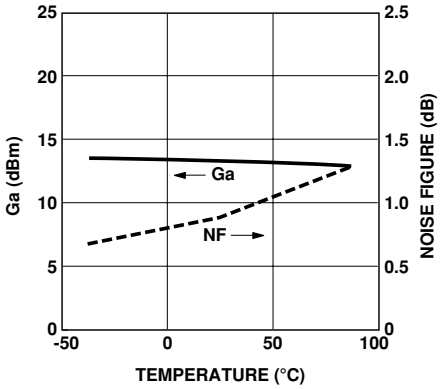



**Figure 15. AT-32033 Noise Figure and Associated Gain at $V_{CE}$ = 2.7 V, $I_C$ = 2 mA vs. Temperature in Test Circuit, Figure 1. (Circuit Losses De-embedded).**

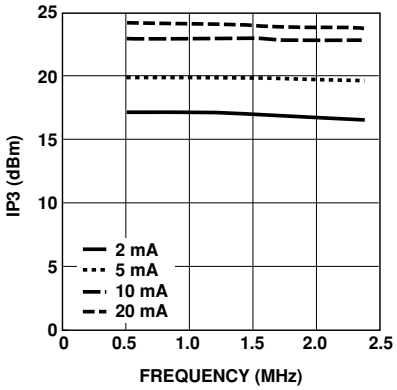



**Figure 16. AT-32011 and AT-32033 Third Order Intercept vs. Frequency and Bias at $V_{CE}$ = 2.7 V, with Optimal Tuning.**

## AT-32011 Typical Scattering Parameters, Common Emitter, Zo = 50 Ω $V_{CE}$ = 1 V, $I_C$ = 1 mA

| Freq. | $S_{11}$ | | $S_{21}$ | | | $S_{12}$ | | | $S_{22}$ | |
|---|---|---|---|---|---|---|---|---|---|---|
| GHz | Mag | Ang | dB | Mag | Ang | dB | Mag | Ang | Mag | Ang |
| 0.1 | 0.97 | -11 | 11.09 | 3.59 | 172 | -33.55 | 0.021 | 83 | 0.99 | -5 |
| 0.5 | 0.88 | -52 | 10.13 | 3.21 | 141 | -20.85 | 0.091 | 59 | 0.92 | -21 |
| 0.9 | 0.78 | -86 | 8.67 | 2.71 | 117 | -17.62 | 0.132 | 41 | 0.82 | -32 |
| 1.0 | 0.75 | -94 | 8.35 | 2.62 | 112 | -17.27 | 0.137 | 37 | 0.79 | -35 |
| 1.5 | 0.67 | -127 | 6.35 | 2.08 | 89 | -16.30 | 0.153 | 23 | 0.71 | -45 |
| 1.8 | 0.63 | -144 | 5.25 | 1.83 | 77 | -16.28 | 0.154 | 16 | 0.67 | -50 |
| 2.0 | 0.61 | -155 | 4.75 | 1.73 | 70 | -16.42 | 0.151 | 13 | 0.65 | -53 |
| 2.4 | 0.59 | -175 | 3.48 | 1.49 | 57 | -16.86 | 0.144 | 9 | 0.62 | -59 |
| 3.0 | 0.59 | 157 | 1.77 | 1.23 | 40 | -17.89 | 0.128 | 8 | 0.61 | -68 |
| 4.0 | 0.63 | 120 | -0.39 | 0.96 | 18 | -18.40 | 0.120 | 23 | 0.59 | -84 |
| 5.0 | 0.69 | 94 | -2.39 | 0.76 | 0 | -15.60 | 0.166 | 35 | 0.59 | -104 |

## AT-32011 Typical Noise Parameters,

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

| Freq. | $F_{min}$ | $\Gamma_{opt}$ | | $R_n$ |
|---|---|---|---|---|
| GHz | dB | Mag | Ang | – |
| 0.5[1] | 0.42 | 0.79 | 26 | 0.44 |
| 0.9 | 0.71 | 0.70 | 54 | 0.35 |
| 1.8 | 1.37 | 0.53 | 119 | 0.18 |
| 2.4 | 1.80 | 0.55 | 158 | 0.08 |

**Note:**
1. 0.5 GHz noise parameter values are extrapolated, not measured.

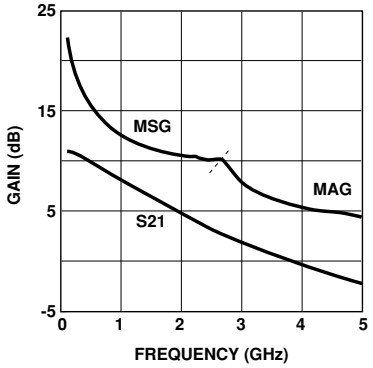



**Figure 17. AT-32011 Gains vs. Frequency at $V_{CE}$ = 1 V, $I_C$ = 1 mA.**

## AT-32033 Typical Scattering Parameters, Common Emitter, Zo = 50 Ω $V_{CE}$ = 1 V, $I_C$ = 1 mA

| Freq. | $S_{11}$ | | $S_{21}$ | | | $S_{12}$ | | | $S_{22}$ | |
|---|---|---|---|---|---|---|---|---|---|---|
| GHz | Mag | Ang | dB | Mag | Ang | dB | Mag | Ang | Mag | Ang |
| 0.1 | 0.97 | -11 | 11.09 | 3.58 | 170 | -32.75 | 0.023 | 83 | 0.99 | -5 |
| 0.5 | 0.81 | -52 | 9.88 | 3.12 | 134 | -20.30 | 0.097 | 60 | 0.90 | -22 |
| 0.9 | 0.61 | -87 | 8.07 | 2.53 | 107 | -17.57 | 0.132 | 46 | 0.78 | -33 |
| 1.0 | 0.56 | -95 | 7.65 | 2.41 | 101 | -17.24 | 0.137 | 44 | 0.76 | -35 |
| 1.5 | 0.41 | -136 | 5.43 | 1.87 | 77 | -16.61 | 0.148 | 39 | 0.68 | -42 |
| 1.8 | 0.36 | -160 | 4.30 | 1.64 | 66 | -16.36 | 0.152 | 41 | 0.65 | -46 |
| 2.0 | 0.34 | -177 | 3.74 | 1.54 | 59 | -16.05 | 0.158 | 44 | 0.63 | -49 |
| 2.4 | 0.34 | 154 | 2.49 | 1.33 | 47 | -15.10 | 0.176 | 49 | 0.61 | -55 |
| 3.0 | 0.38 | 119 | 0.96 | 1.12 | 32 | -12.77 | 0.230 | 55 | 0.59 | -65 |
| 4.0 | 0.46 | 81 | -0.84 | 0.91 | 15 | -8.68 | 0.368 | 50 | 0.56 | -87 |
| 5.0 | 0.51 | 56 | -1.90 | 0.80 | 5 | -5.68 | 0.520 | 37 | 0.51 | -114 |

## AT-32033 Typical Noise Parameters,

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

| Freq. | $F_{min}$ | $\Gamma_{opt}$ | | $R_n$ |
|---|---|---|---|---|
| GHz | dB | Mag | Ang | – |
| 0.5[1] | 0.42 | 0.87 | 25 | 0.48 |
| 0.9 | 0.71 | 0.73 | 55 | 0.34 |
| 1.8 | 1.37 | 0.42 | 143 | 0.11 |
| 2.4 | 1.80 | 0.50 | -162 | 0.07 |

**Note:**
1. 0.5 GHz noise parameter values are extrapolated, not measured.

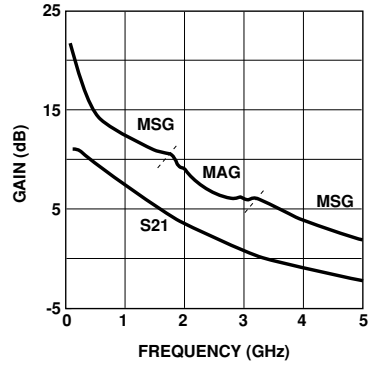



**Figure 18. AT-32033 Gains vs. Frequency at $V_{CE}$ = 1 V, $I_C$ = 1 mA.**

## AT-32011 Typical Scattering Parameters, Common Emitter, Zo = 50 Ω $V_{CE}$ = 2.7 V, $I_C$ = 2 mA

| Freq. | $S_{11}$ | | $S_{21}$ | | | $S_{12}$ | | | $S_{22}$ | |
|---|---|---|---|---|---|---|---|---|---|---|
| GHz | Mag | Ang | dB | Mag | Ang | dB | Mag | Ang | Mag | Ang |
| 0.1 | 0.94 | -13 | 16.67 | 6.81 | 170 | -35.25 | 0.017 | 82 | 0.99 | -6 |
| 0.5 | 0.80 | -60 | 15.10 | 5.69 | 136 | -23.07 | 0.070 | 57 | 0.86 | -24 |
| 0.9 | 0.67 | -97 | 12.97 | 4.45 | 112 | -20.34 | 0.096 | 41 | 0.73 | -35 |
| 1.0 | 0.64 | -104 | 12.48 | 4.21 | 107 | -20.05 | 0.099 | 39 | 0.70 | -37 |
| 1.5 | 0.55 | -137 | 10.04 | 3.18 | 86 | -19.21 | 0.110 | 30 | 0.61 | -45 |
| 1.8 | 0.51 | -154 | 8.77 | 2.75 | 76 | -19.04 | 0.112 | 28 | 0.58 | -49 |
| 2.0 | 0.50 | -165 | 8.13 | 2.55 | 70 | -18.99 | 0.112 | 27 | 0.56 | -52 |
| 2.4 | 0.48 | 176 | 6.75 | 2.18 | 58 | -18.84 | 0.114 | 27 | 0.54 | -57 |
| 3.0 | 0.49 | 150 | 4.97 | 1.77 | 43 | -18.52 | 0.119 | 30 | 0.52 | -64 |
| 4.0 | 0.54 | 116 | 2.73 | 1.37 | 22 | -16.98 | 0.142 | 36 | 0.50 | -77 |
| 5.0 | 0.61 | 92 | 0.83 | 1.10 | 4 | -14.50 | 0.188 | 37 | 0.50 | -95 |

## AT-32011 Typical Noise Parameters,

Common Emitter, Zo = 50 Ω, 2.7 V, $I_C$ = 2 mA

| Freq. | $F_{min}$ | $\Gamma_{opt}$ | | $R_n$ |
|---|---|---|---|---|
| GHz | dB | Mag | Ang | – |
| 0.5[1] | 0.57 | 0.69 | 22 | 0.30 |
| 0.9 | 0.78 | 0.60 | 51 | 0.25 |
| 1.8 | 1.25 | 0.42 | 117 | 0.14 |
| 2.4 | 1.57 | 0.44 | 159 | 0.08 |

**Note:**
1. 0.5 GHz noise parameter values are extrapolated, not measured.

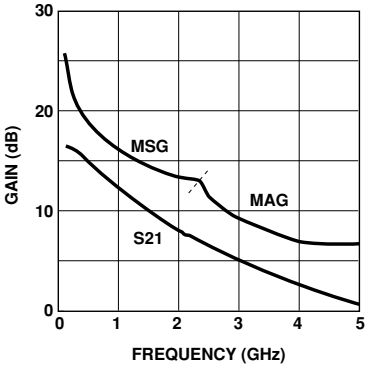



**Figure 19. AT-32011 Gains vs. Frequency at $V_{CE}$ = 2.7 V, $I_C$ = 2 mA.**

## AT-32033 Typical Scattering Parameters, Common Emitter, Zo = 50 Ω $V_{CE}$ = 2.7 V, $I_C$ = 2 mA

| Freq. | $S_{11}$ | | $S_{21}$ | | | $S_{12}$ | | | $S_{22}$ | |
|---|---|---|---|---|---|---|---|---|---|---|
| GHz | Mag | Ang | dB | Mag | Ang | dB | Mag | Ang | Mag | Ang |
| 0.1 | 0.93 | -13 | 16.61 | 6.77 | 167 | -34.89 | 0.018 | 82 | 0.99 | -6 |
| 0.5 | 0.68 | -56 | 14.29 | 5.18 | 127 | -23.10 | 0.070 | 61 | 0.83 | -22 |
| 0.9 | 0.44 | -86 | 11.48 | 3.75 | 101 | -20.35 | 0.096 | 55 | 0.71 | -30 |
| 1.0 | 0.39 | -93 | 10.88 | 3.50 | 96 | -19.91 | 0.101 | 54 | 0.70 | -31 |
| 1.5 | 0.23 | -129 | 8.16 | 2.56 | 76 | -17.99 | 0.126 | 55 | 0.64 | -36 |
| 1.8 | 0.18 | -156 | 6.89 | 2.21 | 66 | -16.89 | 0.143 | 57 | 0.62 | -39 |
| 2.0 | 0.16 | -176 | 6.19 | 2.04 | 60 | -16.14 | 0.156 | 57 | 0.61 | -42 |
| 2.4 | 0.17 | 146 | 4.91 | 1.76 | 50 | -14.70 | 0.184 | 58 | 0.60 | -47 |
| 3.0 | 0.22 | 108 | 3.35 | 1.47 | 36 | -12.51 | 0.237 | 57 | 0.58 | -56 |
| 4.0 | 0.32 | 76 | 1.51 | 1.19 | 18 | -9.19 | 0.347 | 51 | 0.55 | -73 |
| 5.0 | 0.40 | 56 | 0.17 | 1.02 | 4 | -6.54 | 0.471 | 40 | 0.51 | -95 |

## AT-32033 Typical Noise Parameters,

Common Emitter, Zo = 50 Ω, 2.7 V, $I_C$ = 2 mA

| Freq. | $F_{min}$ | $\Gamma_{opt}$ | | $R_n$ |
|---|---|---|---|---|
| GHz | dB | Mag | Ang | – |
| 0.5[1] | 0.57 | 0.77 | 15 | 0.36 |
| 0.9 | 0.78 | 0.63 | 49 | 0.28 |
| 1.8 | 1.25 | 0.32 | 136 | 0.10 |
| 2.4 | 1.57 | 0.40 | -159 | 0.08 |

**Note:**
1. 0.5 GHz noise parameter values are extrapolated, not measured.

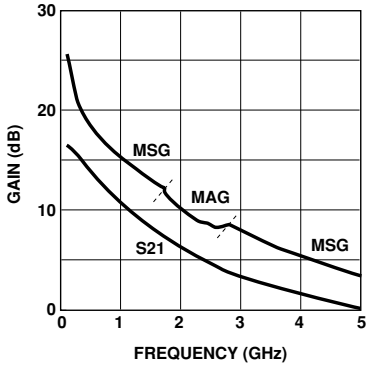



**Figure 20. AT-32033 Gains vs. Frequency at $V_{CE}$ = 2.7 V, $I_C$ = 2 mA.**

## AT-32011 Typical Scattering Parameters, Common Emitter, Zo = 50 Ω $V_{CE}$ = 2.7 V, $I_C$ = 20 mA

| Freq. | $S_{11}$ | | $S_{21}$ | | | $S_{12}$ | | | $S_{22}$ | |
|---|---|---|---|---|---|---|---|---|---|---|
| GHz | Mag | Ang | dB | Mag | Ang | dB | Mag | Ang | Mag | Ang |
| 0.1 | 0.52 | -49 | 31.08 | 35.79 | 149 | -37.78 | 0.013 | 72 | 0.83 | -22 |
| 0.5 | 0.36 | -138 | 22.96 | 14.06 | 102 | -28.93 | 0.036 | 62 | 0.40 | -42 |
| 0.9 | 0.34 | -168 | 18.33 | 8.25 | 86 | -25.15 | 0.055 | 64 | 0.31 | -42 |
| 1.0 | 0.34 | -174 | 17.46 | 7.47 | 83 | -24.41 | 0.060 | 64 | 0.30 | -42 |
| 1.5 | 0.34 | 165 | 14.13 | 5.09 | 71 | -21.35 | 0.086 | 63 | 0.28 | -45 |
| 1.8 | 0.34 | 155 | 12.61 | 4.27 | 64 | -19.92 | 0.101 | 61 | 0.28 | -49 |
| 2.0 | 0.35 | 148 | 11.74 | 3.86 | 60 | -19.08 | 0.111 | 60 | 0.27 | -52 |
| 2.4 | 0.36 | 136 | 10.23 | 3.25 | 52 | -17.60 | 0.132 | 57 | 0.27 | -58 |
| 3.0 | 0.39 | 120 | 8.38 | 2.62 | 40 | -15.86 | 0.161 | 51 | 0.26 | -67 |
| 4.0 | 0.45 | 98 | 6.00 | 2.00 | 23 | -13.68 | 0.207 | 42 | 0.24 | -84 |
| 5.0 | 0.52 | 82 | 4.25 | 1.63 | 7 | -11.93 | 0.253 | 32 | 0.23 | -106 |

## AT-32011 Typical Noise Parameters,

Common Emitter, Zo = 50 Ω, 2.7 V, $I_C$ = 20 mA

| Freq. | $F_{min}$ | $\Gamma_{opt}$ | | $R_n$ |
|---|---|---|---|---|
| GHz | dB | Mag | Ang | – |
| 0.5[1] | 1.39 | 0.15 | 65 | 0.16 |
| 0.9 | 1.51 | 0.14 | 105 | 0.13 |
| 1.8 | 1.78 | 0.28 | -164 | 0.12 |
| 2.4 | 1.96 | 0.40 | -142 | 0.13 |

**Note:**
1. 0.5 GHz noise parameter values are extrapolated, not measured.

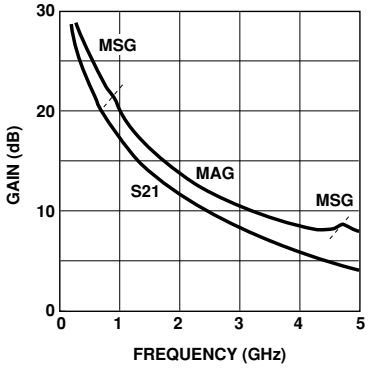



**Figure 21. AT-32011 Gains vs. Frequency at $V_{CE}$ = 2.7 V, $I_C$ = 20 mA.**

## AT-32033 Typical Scattering Parameters, Common Emitter, Zo = 50 Ω $V_{CE}$ = 2.7 V, $I_C$ = 20 mA

| Freq. | $S_{11}$ | | $S_{21}$ | | | $S_{12}$ | | | $S_{22}$ | |
|---|---|---|---|---|---|---|---|---|---|---|
| GHz | Mag | Ang | dB | Mag | Ang | dB | Mag | Ang | Mag | Ang |
| 0.1 | 0.50 | -35 | 29.84 | 31.03 | 137 | -37.08 | 0.014 | 77 | 0.79 | -18 |
| 0.5 | 0.16 | -52 | 19.58 | 9.53 | 94 | -25.35 | 0.054 | 77 | 0.53 | -20 |
| 0.9 | 0.08 | -36 | 14.81 | 5.50 | 81 | -20.63 | 0.093 | 75 | 0.50 | -24 |
| 1.0 | 0.07 | -31 | 13.96 | 4.99 | 78 | -19.66 | 0.104 | 74 | 0.50 | -25 |
| 1.5 | 0.06 | 12 | 10.71 | 3.43 | 66 | -16.31 | 0.153 | 69 | 0.49 | -31 |
| 1.8 | 0.07 | 31 | 9.31 | 2.92 | 60 | -14.75 | 0.183 | 66 | 0.48 | -35 |
| 2.0 | 0.08 | 40 | 8.50 | 2.66 | 56 | -13.85 | 0.203 | 63 | 0.47 | -38 |
| 2.4 | 0.11 | 48 | 7.16 | 2.28 | 48 | -12.32 | 0.242 | 59 | 0.46 | -44 |
| 3.0 | 0.15 | 53 | 5.62 | 1.91 | 37 | -10.49 | 0.299 | 52 | 0.43 | -54 |
| 4.0 | 0.21 | 52 | 3.86 | 1.56 | 20 | -8.11 | 0.393 | 41 | 0.39 | -71 |
| 5.0 | 0.26 | 48 | 2.61 | 1.35 | 6 | -6.34 | 0.482 | 29 | 0.33 | -91 |

## AT-32033 Typical Noise Parameters,

Common Emitter, Zo = 50 Ω, 2.7 V, $I_C$ = 20 mA

| Freq. | $F_{min}$ | $\Gamma_{opt}$ | | $R_n$ |
|---|---|---|---|---|
| GHz | dB | Mag | Ang | – |
| 0.5[1] | 1.39 | 0.15 | 45 | 0.28 |
| 0.9 | 1.51 | 0.12 | 100 | 0.22 |
| 1.8 | 1.78 | 0.28 | -135 | 0.14 |
| 2.4 | 1.96 | 0.46 | -107 | 0.22 |

**Note:**
1. 0.5 GHz noise parameter values are extrapolated, not measured.

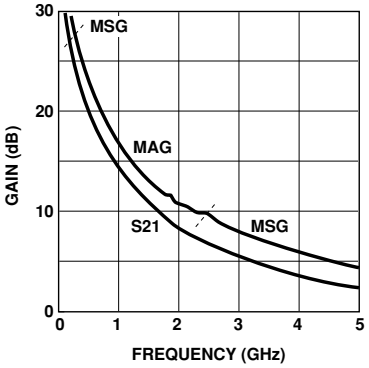



**Figure 22. AT-32033 Gains vs. Frequency at $V_{CE}$ = 2.7 V, $I_C$ = 20 mA.**

## AT-32011 Typical Scattering Parameters, Common Emitter, Zo = 50 Ω

$V_{CE}$ = 5 V, $I_C$ = 2 mA

| Freq. | $S_{11}$ | | $S_{21}$ | | | $S_{12}$ | | | $S_{22}$ | |
|---|---|---|---|---|---|---|---|---|---|---|
| GHz | Mag | Ang | dB | Mag | Ang | dB | Mag | Ang | Mag | Ang |
| 0.1 | 0.95 | -13 | 16.65 | 6.80 | 170 | -35.84 | 0.016 | 82 | 0.99 | -6 |
| 0.5 | 0.81 | -57 | 15.18 | 5.74 | 137 | -23.56 | 0.066 | 58 | 0.87 | -23 |
| 0.9 | 0.68 | -93 | 13.16 | 4.55 | 113 | -20.72 | 0.092 | 43 | 0.74 | -34 |
| 1.0 | 0.64 | -100 | 12.69 | 4.31 | 109 | -20.42 | 0.095 | 40 | 0.72 | -36 |
| 1.5 | 0.55 | -133 | 10.31 | 3.28 | 88 | -19.49 | 0.106 | 32 | 0.63 | -43 |
| 1.8 | 0.51 | -150 | 9.05 | 2.84 | 78 | -19.29 | 0.109 | 29 | 0.60 | -47 |
| 2.0 | 0.49 | -161 | 8.43 | 2.64 | 71 | -19.22 | 0.109 | 28 | 0.58 | -50 |
| 2.4 | 0.47 | 180 | 7.06 | 2.25 | 60 | -19.03 | 0.112 | 29 | 0.55 | -55 |
| 3.0 | 0.47 | 153 | 5.29 | 1.84 | 45 | -18.72 | 0.116 | 31 | 0.54 | -62 |
| 4.0 | 0.52 | 118 | 3.07 | 1.42 | 24 | -17.19 | 0.138 | 37 | 0.52 | -75 |
| 5.0 | 0.59 | 94 | 1.17 | 1.14 | 6 | -14.73 | 0.183 | 38 | 0.51 | -92 |

## AT-32011 Typical Noise Parameters,

Common Emitter, Zo = 50 Ω, 2.7 V, $I_C$ = 2 mA

| Freq. | $F_{min}$ | $\Gamma_{opt}$ | | $R_n$ |
|---|---|---|---|---|
| GHz | dB | Mag | Ang | – |
| 0.5[1] | 0.52 | 0.73 | 20 | 0.34 |
| 0.9 | 0.75 | 0.63 | 49 | 0.28 |
| 1.8 | 1.26 | 0.44 | 111 | 0.16 |
| 2.4 | 1.60 | 0.45 | 153 | 0.09 |

**Note:**
1. 0.5 GHz noise parameter values are extrapolated, not measured.

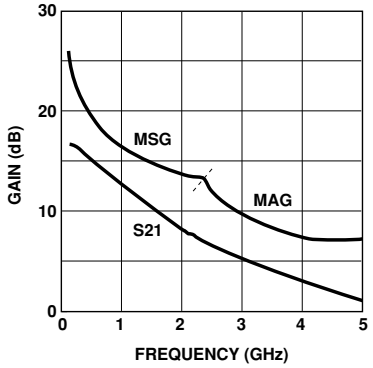



**Figure 23. AT-32011 Gains vs. Frequency at $V_{CE}$ = 5 V, $I_C$ = 2 mA.**

## AT-32033 Typical Scattering Parameters, Common Emitter, Zo = 50 Ω

$V_{CE}$ = 5 V, $I_C$ = 2 mA

| Freq. | $S_{11}$ | | $S_{21}$ | | | $S_{12}$ | | | $S_{22}$ | |
|---|---|---|---|---|---|---|---|---|---|---|
| GHz | Mag | Ang | dB | Mag | Ang | dB | Mag | Ang | Mag | Ang |
| 0.1 | 0.94 | -13 | 16.56 | 6.73 | 167 | -35.39 | 0.017 | 82 | 0.99 | -5 |
| 0.5 | 0.69 | -54 | 14.34 | 5.21 | 128 | -23.74 | 0.065 | 62 | 0.85 | -21 |
| 0.9 | 0.45 | -82 | 11.62 | 3.81 | 102 | -20.92 | 0.090 | 56 | 0.73 | -28 |
| 1.0 | 0.40 | -89 | 11.03 | 3.56 | 98 | -20.35 | 0.096 | 55 | 0.72 | -30 |
| 1.5 | 0.23 | -121 | 8.33 | 2.61 | 77 | -18.49 | 0.119 | 56 | 0.66 | -35 |
| 1.8 | 0.17 | -147 | 7.04 | 2.25 | 68 | -17.39 | 0.135 | 58 | 0.65 | -37 |
| 2.0 | 0.15 | -167 | 6.36 | 2.08 | 62 | -16.59 | 0.148 | 59 | 0.63 | -40 |
| 2.4 | 0.14 | 151 | 5.06 | 1.79 | 51 | -15.14 | 0.175 | 60 | 0.62 | -44 |
| 3.0 | 0.20 | 109 | 3.52 | 1.50 | 37 | -12.92 | 0.226 | 59 | 0.61 | -53 |
| 4.0 | 0.31 | 76 | 1.66 | 1.21 | 19 | -9.55 | 0.333 | 53 | 0.59 | -70 |
| 5.0 | 0.38 | 55 | 0.26 | 1.03 | 5 | -6.80 | 0.457 | 42 | 0.55 | -90 |

## AT-32033 Typical Noise Parameters,

Common Emitter, Zo = 50 Ω, 5 V, $I_C$ = 2 mA

| Freq. | $F_{min}$ | $\Gamma_{opt}$ | | $R_n$ |
|---|---|---|---|---|
| GHz | dB | Mag | Ang | – |
| 0.5[1] | 0.52 | 0.79 | 15 | 0.42 |
| 0.9 | 0.75 | 0.65 | 48 | 0.30 |
| 1.8 | 1.26 | 0.33 | 127 | 0.11 |
| 2.4 | 1.60 | 0.39 | -166 | 0.07 |

**Note:**
1. 0.5 GHz noise parameter values are extrapolated, not measured.

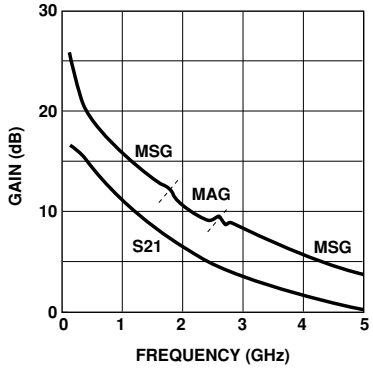



**Figure 24. AT-32033 Gains vs. Frequency at $V_{CE}$ = 5 V, $I_C$ = 2 mA.**

## AT-32011 Typical Scattering Parameters, Common Emitter, Zo = 50 Ω $V_{CE}$ = 5 V, $I_C$ = 20 mA

| Freq. | $S_{11}$ | | $S_{21}$ | | | $S_{12}$ | | | $S_{22}$ | |
|---|---|---|---|---|---|---|---|---|---|---|
| GHz | Mag | Ang | dB | Mag | Ang | dB | Mag | Ang | Mag | Ang |
| 0.1 | 0.58 | -43 | 31.28 | 36.64 | 151 | -38.13 | 0.012 | 72 | 0.83 | -21 |
| 0.5 | 0.35 | -128 | 23.51 | 14.99 | 103 | -29.05 | 0.035 | 62 | 0.42 | -40 |
| 0.9 | 0.31 | -161 | 18.93 | 8.84 | 87 | -25.30 | 0.054 | 64 | 0.33 | -40 |
| 1.0 | 0.30 | -167 | 18.06 | 8.00 | 84 | -24.57 | 0.059 | 64 | 0.32 | -40 |
| 1.5 | 0.29 | 170 | 14.74 | 5.46 | 72 | -21.50 | 0.084 | 63 | 0.30 | -44 |
| 1.8 | 0.30 | 158 | 13.22 | 4.58 | 65 | -20.06 | 0.099 | 61 | 0.29 | -47 |
| 2.0 | 0.30 | 151 | 12.35 | 4.15 | 61 | -19.23 | 0.109 | 60 | 0.29 | -50 |
| 2.4 | 0.32 | 138 | 10.85 | 3.49 | 53 | -17.77 | 0.129 | 57 | 0.28 | -56 |
| 3.0 | 0.35 | 121 | 8.99 | 2.82 | 42 | -16.03 | 0.158 | 52 | 0.27 | -64 |
| 4.0 | 0.41 | 98 | 6.64 | 2.15 | 25 | -13.85 | 0.203 | 42 | 0.25 | -80 |
| 5.0 | 0.48 | 83 | 4.90 | 1.76 | 9 | -12.12 | 0.248 | 33 | 0.24 | -100 |

## AT-32011 Typical Noise Parameters,

Common Emitter, Zo = 50 Ω, 5 V, $I_C$ = 20 mA

| Freq. | $F_{min}$ | $\Gamma_{opt}$ | | $R_n$ |
|---|---|---|---|---|
| GHz | dB | Mag | Ang | – |
| 0.5[1] | 1.38 | 0.18 | 50 | 0.20 |
| 0.9 | 1.50 | 0.15 | 88 | 0.16 |
| 1.8 | 1.78 | 0.23 | 176 | 0.13 |
| 2.4 | 1.96 | 0.34 | -156 | 0.12 |

**Note:**
1. 0.5 GHz noise parameter values are extrapolated, not measured.

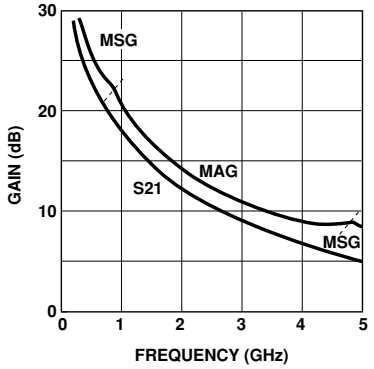



**Figure 25. AT-32011 Gains vs. Frequency at $V_{CE}$ = 5 V, $I_C$ = 20 mA.**

## AT-32033 Typical Scattering Parameters, Common Emitter, Zo = 50 Ω $V_{CE}$ = 5 V, $I_C$ = 20 mA

| Freq. | $S_{11}$ | | $S_{21}$ | | | $S_{12}$ | | | $S_{22}$ | |
|---|---|---|---|---|---|---|---|---|---|---|
| GHz | Mag | Ang | dB | Mag | Ang | dB | Mag | Ang | Mag | Ang |
| 0.1 | 0.55 | -31 | 30.00 | 31.61 | 138 | -37.72 | 0.013 | 78 | 0.81 | -16 |
| 0.5 | 0.20 | -44 | 19.91 | 9.90 | 95 | -25.85 | 0.051 | 77 | 0.56 | -19 |
| 0.9 | 0.13 | -31 | 15.15 | 5.72 | 82 | -21.01 | 0.089 | 75 | 0.53 | -22 |
| 1.0 | 0.12 | -28 | 14.30 | 5.19 | 79 | -20.18 | 0.098 | 74 | 0.53 | -23 |
| 1.5 | 0.10 | -7 | 11.03 | 3.56 | 68 | -16.77 | 0.145 | 69 | 0.52 | -30 |
| 1.8 | 0.09 | 5 | 9.63 | 3.03 | 61 | -15.19 | 0.174 | 66 | 0.51 | -33 |
| 2.0 | 0.10 | 13 | 8.82 | 2.76 | 57 | -14.33 | 0.192 | 64 | 0.50 | -36 |
| 2.4 | 0.11 | 25 | 7.49 | 2.37 | 50 | -12.77 | 0.230 | 60 | 0.49 | -42 |
| 3.0 | 0.13 | 36 | 5.93 | 1.98 | 39 | -10.90 | 0.285 | 54 | 0.47 | -51 |
| 4.0 | 0.18 | 42 | 4.19 | 1.62 | 23 | -8.50 | 0.376 | 43 | 0.42 | -67 |
| 5.0 | 0.22 | 43 | 2.98 | 1.41 | 8 | -6.65 | 0.465 | 31 | 0.37 | -86 |

## AT-32033 Typical Noise Parameters,

Common Emitter, Zo = 50 Ω, 5 V, $I_C$ = 20 mA

| Freq. | $F_{min}$ | $\Gamma_{opt}$ | | $R_n$ |
|---|---|---|---|---|
| GHz | dB | Mag | Ang | – |
| 0.5[1] | 1.38 | 0.25 | 35 | 0.30 |
| 0.9 | 1.50 | 0.19 | 85 | 0.23 |
| 1.8 | 1.78 | 0.21 | -150 | 0.14 |
| 2.4 | 1.96 | 0.39 | -114 | 0.19 |

**Note:**
1. 0.5 GHz noise parameter values are extrapolated, not measured.

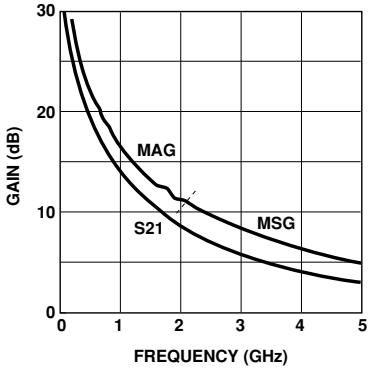



**Figure 26. AT-32033 Gains vs. Frequency at $V_{CE}$ = 5 V, $I_C$ = 20 mA.**

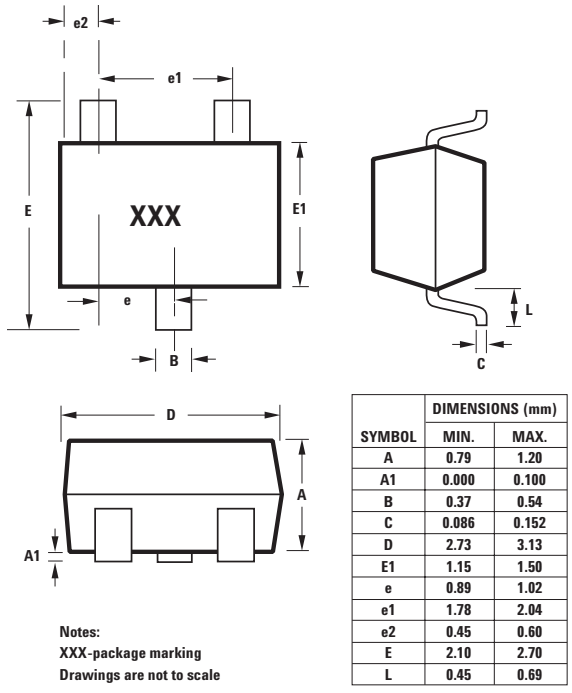
## Ordering Information

| Part Numbers | | No. of Devices | Comments |
|---|---|---|---|
| AT-32011-BLK | AT-32033-BLK | 100 | Bulk |
| AT-32011-BLKG | AT-32033-BLKG | 100 | Bulk |
| AT-32011-TR1 | AT-32033-TR1 | 3000 | 7" Reel |
| AT-32011-TR1G | AT-32033-TR1G | 3000 | 7" Reel |
| AT-32011-TR2 | AT-32033-TR2 | 10000 | 13" Reel |
| AT-32011-TR2G | AT-32033-TR2G | 10000 | 13" Reel |

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

## Package Dimensions

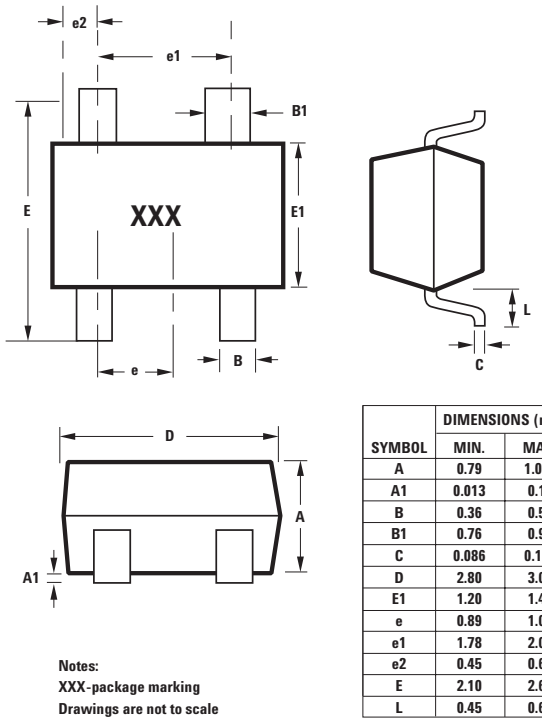
### SOT-23 Plastic Package




| 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 |

Notes:
XXX-package marking
Drawings are not to scale

### SOT-143 Plastic Package




| 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 |

Notes:
XXX-package marking
Drawings are not to scale

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