Application Note

AH101 Temperature Effects on Reliability

The Communications Edge ™

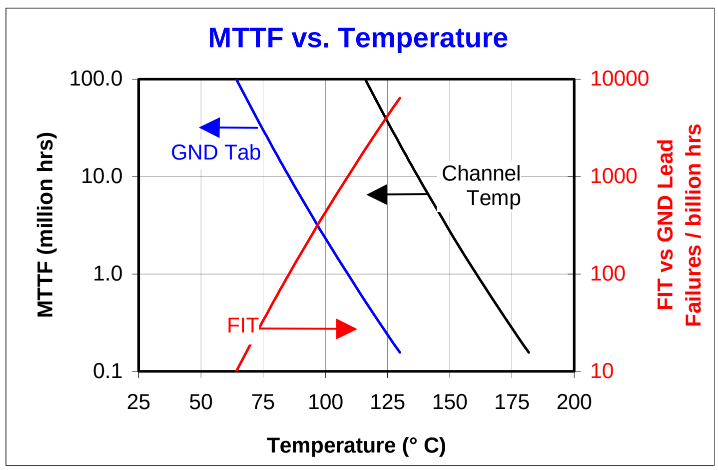
Product Information

The AH101 is a GaAs MESFET MMIC amplifier based on GaAs processes and technology that have been incorporated into WJ's products for more than 15 years. Extensive life testing and field history of our GaAs products have demonstrated excellent robustness and reliability. In general, WJ GaAs MMIC products are capable of operating reliably at channel temperatures up to +175° C based on accelerated lifetest measurements of small-signal linear parameters like gain and input/output match. Biased lifetests performed at 250° C channel temperature have shown no failures after 1000 hours of operation.

Long-term aging behavior of two-tone third-order output intercept (3OIP) performance, a non-linear characteristic, has not been as extensively studied as the small-signal linear parameters. As a result, WJ Communications opted to take a conservative position in specifying the maximum operating temperature of the AH101. To support the reliability of the AH101 under lifetime and stress conditions, a qualification of the AH101 contains an Accelerated Biased Humidity (HAST, +130°C, 85% RH, 33 psi) test and a High Temperature Operating Lifetime (HTOL) test under a biased condition at +125° C ground tab temperature. As shown in the AH101 & AH102 Qualification Report, we have reported no failures with over 7,488 device hours for HAST and one failure on 78,000 device hours for HTOL.

Currently, the maximum recommended operating temperature is +85° C (referenced to the GND lead of the device) which insures that the maximum channel temperature at worst case power conditions will never be above a safe **+137° C**, when operated at the recommended bias of +9 V. The maximum recommended operating temperature insures a MTTF (mean time to failure) rating of 10.5 million hours. The channel temperature can be calculated using the temperature rise due to power dissipation of the device, e.g. ground tab temperature (85° C) + voltage (9 V) x current consumption (230 mA max) x thermal resistance (25° C/W) = 137° C. The calculation is conservative because as the temperature of the channel increases in the device, the current consumption of the device typically decreases. A 10% reduction is typical with a temperature increase from 25° C to 85° C at the ground lead temperature. Using the activation energy of 1.5 eV, the following MTTF estimates have been calculated from the Arrhenius function [1]:

GND Lead Temp. (°C)	Channel Temp. (°C)	MTTF (million hours)	FIT per billion hours
50	102	553	2
60	112	165	6
70	122	53.6	19
80	132	17.7	57
85	137	10.5	96
90	142	6.27	196
95	147	3.80	263
100	152	2.33	428
105	157	1.45	690
110	162	0.91	1100



As can be seen from the MTTF values above, the predicted failure rate is still above 1 million hours, even at operating temperatures up to +110° C (corresponding to channel temperatures of +162° C). Also note that these MTTF estimates are a lower bound as the accelerated testing never resulted in 50% failures.

[1] [1] $MTTF = A^* e^{(Ea/kT)}$ Where: $A = 3.71 \times 10^{-12}$ (hrs) (Pre-exponential Factor)
Ea = 1.5 (eV) (Activation Energy)
k = 8.617 x 10-5 (eV/ºC) (Boltzmann's Constant)