

## Reliability Data Sheet

### Description

The AFEM-9040 is a multiband multimode module that includes PAs, duplexers, ANT switch, and coupler. This module supports GMSK and 8-PSK modulation schemes, UMTS/LTE bands 1, 2/25, 3, 4, 34, and 39, and CDMA BC1. The AFEM-9040 is designed to support ET (envelope tracking) for FDD bands and APT (average power tracking) operation for TDD bands, and the part can support CA (carrier aggregation) for B1+B3.

Input and output terminals are internally matched to 50 Ω. The power amplifier is manufactured on an advanced InGaP HBT technology offering state-of-the-art reliability, temperature stability, and ruggedness. This module is housed in a cost-effective, extremely small and thin 5.5 mm x 7.7 mm package.

### Reliability Prediction Model

Failure rate predictions are based on HTOL test results. The prediction uses an exponential cumulative failure function (constant failure rate) as the reliability prediction model to predict failure rate and mean time to failure (MTTF) at various temperatures as shown in Table 2. The wear-out mechanisms are therefore not considered. The Arrhenius temperature de-rating equation is used. We assume no failure mechanism change between stresses and use conditions. Bias and temperature are alterable stresses and must be considered with the thermal resistance of the devices when determining the stress condition. The failure rate will have a direct relationship to the life stress. The failure rate prediction was calculated using activation energy of 1.33eV as a conservative estimate. Confidence intervals are based upon the chi-squared prediction method associated with exponential distribution.

**Table 1 Life Prediction: Demonstrated Performance**

Test Name	Stress Condition	Total Units Tested	Total Device Hours	No. of Failed Units
High Temperature Operating Life	T <sub>junction</sub> = 150 °C	75	37800 hrs	0/75

**Table 2 Estimated for Various Channel Temperatures**

Channel Temp (°C)	Point Typical Performance MTTF (yrs/failure) <sup>a</sup>	90% Confidence MTTF (yrs)	Point Typical Performance FIT	90% Confidence FIT
150	4.31	1.87	26455.03	60978.84
125	42.67	18.51	2673.76	6163.02
100	573.97	249.01	198.75	458.12
85	3249.79	1409.89	35.10	80.91
60	82706.38	35881.29	1.38	3.18

- a. Point typical MTTF is simply the total device hours divided by the number of failures. Since no failures were observed, the point estimate is calculated under the assumption that one unit failed. FIT rates shown are relatively high due to the limited device hours at product release.

**Table 3 Environmental Test Results**

Stress	Conditions	Duration	Failures/Number Tested
High Temperature Storage	Ta = 150 °C JESD22-A103	504 hours	0/75
Unbiased Highly Accelerated Temperature and Humidity Stress	130 °C/85%RH, 205kPa, No Bias JESD22-A118	96 hours	0/75
Temperature Cycling	Cond.B: -55 °C/+125 °C, 15 min Dwell, Air to Air JESD22-A104	700 cycles	0/75

**Table 4 Operating Life Tests Results**

Stress	Conditions	Duration	Failures/Number Tested
High Temperature Operating Life (HTOL)	T <sub>j</sub> = 150 °C, VBATT = 3.4 V, Vcc = 0.5 V ~ 4.2 V, Vgsm = 3.5 V RFFE PA CNTRL = HPM Middle frequency, maximum Pout into 50 Ω JESD22-A108	504 hrs	0/75
Temperature Humidity with Bias (THB)	Ta = 85 °C/85%RH VBATT = 4.8 V, Vcc = 4.2 V, Vgsm = 4.35 V RFFE PA CNTRL = Power down mode RF ports into 50 Ω JESD22-A101	504 hrs	0/75

**Table 5 Mechanical Tests Information**

Stress	Conditions	Duration	Failures/Number Tested
Drop Test	Peak acceleration: 1500Gs. Pulse duration: 0.5-ms half-sine pulse. JESD22-B111	30 drops	0/60
Cycle Bending Test	Amplitude 1.0 mm, total displacement 2.0 mm. Bending rate 80 mm per min	5x	0/30
Shear Test	Force = 10N for 60 sec, 4 sides separately IEC60068-2-21	60 sec/side	0/30
Bending Test	Bending up to 5 mm with 1 mm increment. Maintained in bend state for 5 ± 1 sec for every 1 mm increment IEC60068-2-21	5 mm	0/30

**Table 6 Thermal Resistance Information**

Stress	Product	Theta Jc
Thermal Resistance UMTS HB	Vbatt = 3.7 V, Vcc = 3.4 V; RFFE PA CNTRL = B1 (HPM) APT	14.9 °C/W
Thermal Resistance UMTS HB	Vbatt = 3.7 V, Vcc = 3.4 V; REEF PA CNTRL = B3 (HPM) APT	8.1 °C/W
Thermal Resistance GSM HB	Vbatt = Vgsm = 3.5 V; RFFE PA CNTRL = GMSK_HB (HPM)	31.7 °C/W

**Table 7 ESD Ratings**

<b>ESD Test</b>	<b>Reference</b>	<b>Results</b>
Human Body Model (Non FBAR)	JS-001	1000 V (Class 1C)
Human Body Model (FBAR)	JS-001	250 V (Class 1A)
Charge Device Model (Non FBAR)	JESD22-C101	500 V (Class C2a)
Charge Device Model (FBAR)	JESD22-C101	250 V (Class C1)

## **HBM**

Class 0A is ESD voltage level <125 V, Class 0B is voltage level between 125 V and 250 V, Class 1A is voltage level between 250 V and 500 V, Class 1B is voltage level between 500 V and 1000 V, Class 1C is voltage level between 1000 V and 2000 V, Class 2 is voltage level between 2000 V and 4000 V, Class 3A is voltage level between 4000 V and 8000 V, Class 3B is voltage level  $\geq$ 8000 V.

## **CDM**

Class C0a <125 V, Class C0b 125 to <250 V, Class C1 250 to <500 V, Class C2a 500 to <750 V, Class C2b 750 to <1000 V, Class C3 >1000 V.

## **Moisture Sensitivity Classification: Level 3**

Preconditioning per JESD22-A113-D Level 3 was performed on all devices prior to reliability testing except ESD and mechanical tests.

MSL3 Preconditioning (JESD22-A113D): 125 °C HTSL for 24 hrs + 60 °C/60%RH for 40 hrs + 3X PbFree Reflow, 260 °C peak.

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pub-005539 – February 26, 2016

