KCB SOLUTIONS

THE HIGHEST STANDARD IN RF

Qualification Report

For

GaAs SPDT Switch Family

In 3MM QFN Package

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1.0 SUMMARY

This report is a culmination of all testing associated with KCB Solutions family of GaAs FET SPDT switches supplied in a hermetic 3 x 3 QFN microwave surface mount package with a frequency of operation from .02 to 6.0 GHz. It comprises reliability, radiation, electrostatic discharge, screening and quality conformance inspection. The family of devices that utilize the same die and package include KCB822, KCB301 and KS204. While individual aspects of the testing were performed on a specific member of the product family, the testing is applicable to the entire family. The results of all testing indicate that the KCB GaAs Switch in 3 x 3 mm QFN meets all process and product qualification requirements associated with high reliability and harsh environment applications.

2.0 APPLICABLE DOCUMENTS

MIL-PRF-38535	General Specification for Integrated Circuits Manufacturing
MIL-STD-883	Test Method Standard, Microcircuits

3.0 RELIABILITY TESTING/FAILURE RATE ESTIMATION

Reliability testing has been performed on the MMIC employed in the realization of the switch. Below is a discussion of the methodology used to predict the reliability of the device as well as the results of the prediction.

3.1 ACCELERATION FACTOR

Temperature acceleration for semiconductor failure mechanisms is typically calculated using the Arrhenius equation:

$$AF_T = e^{\left[\frac{E_a}{k}\left(\frac{1}{T_U}-\frac{1}{T_S}\right)\right]}$$

Where:

AF_T = Temperature acceleration factor
E_a = Activation energy in eV
k = Boltzmann's constant (8.617×10^5 eV/°K)
T_u = Temperature at normal use conditions in °K
T_s = Temperature at accelerated stress conditions in °K

In the absence of an experimentally validated voltage acceleration model, the following model is used:

$$AF_v = e^{[\gamma_V \times (V_s - V_u)]}$$

Where:

AF_V = Voltage acceleration factor
γ_V = Voltage acceleration constant in (1/V)
V_S = Stress voltage
V_U = Use voltage

If the dominant failure mechanism is determined to be accelerated by voltage as well as temperature, then the total acceleration is the product of the temperature and voltage acceleration factors, $AF = AF_T \times AF_V$.

3.2 FAILURE RATE CALCULATIONS

Average failure rates at specific use conditions are estimated using an exponential time-to-failure distribution. The upper confidence bound of the failure rate is estimated from the failure statistics and from the chi-squared distribution, described by the following equation:

$$\lambda = \frac{\chi^2(\alpha, df) \times 10^9}{2 \times N}$$

Where:

λ = failure rate in FITs (failures in 1 billion hours)
N = device operating hours at equivalent use conditions = (ss x AF x t)
SS = sample size
AF = the total acceleration factor
t = stress time in hours

χ^2 = chi-squared value
α = the chi-squared confidence interval
df = degrees of freedom (2r + 2)
r = number of observed failures

Failure rate calculations for data shown within this report are determined for 70°C and 55°C ambient temperatures at the 90% confidence level. Chi-square values at 60% and 90% confidence intervals are provided in the table below.

Chi-Squared Distribution		
r	χ^2 at 60% Confidence	χ^2 at 90% Confidence
0	1.833	4.605
1	4.045	7.779
2	6.211	10.645
3	8.351	13.362
4	10.473	15.987
5	12.584	18.549

Another common measure of reliability for non-repairable systems is mean time to failure (MTTF). MTTF is the average of the times to failure for members of the population.1 For a population with exponentially distributed times to failure (that is, $f(t) = \lambda e^{-\lambda t}$),

$$MTTF = \int_0^\infty t\lambda e^{-\lambda t} dt = \frac{1}{\lambda}$$

Where l is the failure rate as defined previously. For semiconductor devices, MTTF is often expressed in million device hours.

3.3 FAILURE RATE ESTIMATES FOR SPDT SWITCH

Model parameters used:

N = device operating hours at equivalent use conditions (70°C) = 6.7E+06
r = number of failures = 0
α = 0.1 (90% confidence)
E_a = 1.3 eV
T_s = 398 °K (125 °C)

				Failures in Time (FIT) @ Temperature		MTTF, Million Hours @ Temperature	
SS	t	r	Device Hours	70°C	55°C	70°C	55°C
77	1000	0	77000	69	9.2	1.45E+07	1.08E+08

The above estimates can be used as a basis for reliability prediction with a high level of confidence in high reliability applications.

4.0 RADIATION TESTING

4.1 DOSIMETRY SCHEDULE AND RESULTS

The SPDT switch was irradiated with the below schedule:

Irradiation Schedule/Dose Levels			
Dose Rate Rad(Si)/sec	**hr:min:sec**	**Incremental Dose Rad(Si)**	**Cumulative Dose Rad(Si)**
160+/-3.6%	0:10:44	103,440	103,040
	0:16:16	154,560	257,600
	0:26:50	257,600	515,200
	0:53:40	515,200	1,030,400

The Irradiation Schedule/Dose Levels are based on the dosimetry map generated by the test laboratory. The average dose rate is corrected for radiological decay and used to calculate the exposure time for the requested dose levels. The test specimens were exposed in an enclosed Pb/Al container to minimize dose enhancement effects.

4.2 ELECTRICAL TEST RESULTS AND CONCLUSION

Five samples were subjected to the above dosimetry schedule. Small signal test parameters were measured prior to dosing and upon completion of each interval in the table. The final test results were compared against the pre-dosing and interim results. In all cases the drift in electrical performance was negligible and within the measurement error of the test setup. The results conclude that the device is capable of withstanding a minimum of 1000Krad (Si) of total ionizing dose radiation without significant change in electrical performance.

5.0 ELECTROSTATIC DISCHARGE TESTING AND RATING

KCB subjected 9 devices to ESD Sensitivity Classification testing in accordance with MIL-STD-883, Method 3015.The devices were separated into three groups with each group of 3 subjected to increasing voltage levels of 100, 250 and 500V respectively. The 100V and 250V groups passed subsequent electrical testing, however, two failures were discovered from the group subjected to 500V discharge. The results of the testing lead to an ESD classification of 1B> 250V. Detailed electrical test results are available upon request.

6.0 SCREENING

KCB has performed screening testing in accordance with MIL-PRF-38535 per the below table:

100 % Screening; Mil-PRF- 38535 Class S			
Seq #	WI#	Description	Comment
10	4001	Kit Pick	Record Receiver #'s.
20	4305	Die Visual	MIL-STD-883, Method 2010 Cond A
60	4302	Non-Destruct Bond Pull	100 % Per Mil-Std-883, Method 2023
70	4313	Pre- Cap Visual Inspection	Perform 100% Class S Per MIL-STD-883, method 2010 cond A
100	4402	Seal: Date Code___	Solder reflow: profile 5
140	4701	Temp Cycle	MIL-STD-883, method 1010, Cond C, 10 Cycles
150	7000-4702	Acceleration	MIL-STD-883, method 2001, Cond E, Y1, 30,000g's
160	7000-4703	PIND	MIL-STD-883, method 2020, Cond A
170	4501	Device Marking/Serialization	per KCB822 Data Sheet
175	4704	Radiographic	MIL-STD-883, Method 2012; 2 views Y2 & X2
180	4602	Pre- Burn in Electrical Test	Small Signal Only @25C
185	5101	Engineering Review	Engineering Review: Limits per IPS
190	4705	Burn-in Time In _____ Time Out_____	MIL-STD-883, Method 1015 320 hrs @ 125C
220	4602	Post B/I Electrical	Small Signal Only @25C Read and Record: measurements Per IPS are required to be taken within 96 hours after removal from the Burn-in test conditions
230	5102	Delta/"Out of Family" Calulations Calculate PDA_____%	per KCB822 Data Sheet
250	4602	Final Electrical	Small Signal Only @-55C per Product Spec
260	4602	Final Electrical	Small Signal Only @+125C per Product Spec
270	4603	Final Electrical	Electrical Test +25c; P1dB, Ip3, Switch Speed
280	5101	Engineering Review	Engineering Review: Limits per IPS
290	4706	Fine Leak	MIL-STD-883, Method 1014 Cond A. Package Volume = .004cm³
300	4707	Gross Leak	MIL-STD-883, Method 1014 Cond C
310	4602	Electrical Test	Small Signal Only @25C Function Test Only 100%
320	4309	External Visual	MIL-STD-883, Method 2009
340		Issue to QCI	Group B & D

The parts successfully completed screening; showing minimal variation through all screening steps. Test data and environmental test reports are available upon request.

7.0 QUALITY CONFORMANCE INSPECTION

KCB has performed quality conformance inspection in accordance with MIL-PRF-38535 Group B and D Testing per the below tables:

Group B Mil-STD 883 TM 5005 Class S Table IIa						
Seq #	WI#	Description	Qty Test	Qty Accept	Qty Reject	Comment
Group B Subgroup 2						
40	4313	Internal Visual Inpsection	2	2	0	2 units per AD
50	4302	Bond Strength	2	2	0	MIL-STD-883, Method 2011 Cond C , n=22
60	5101	Review Data	2	2	0	Record Destruct
70	4301	Die Sheer Strength	3	3	0	MIL-STD-883, Method 2019, 3 units
80	5101	Review Data	3	3	0	
Group B Subgroup 5						
Seq #	WI#	Description	Qty Test	Qty Accept	Qty Reject	Comment
30	4602	Pre B/I Electrical	45	45	0	Table 6 Small Signal Only @25C
40	4705	Steady State Operating Life	45	45	0	MIL-STD-883, Method 1005, 500 hrs @ 125c
50	4602	Interim Electrical	45	45	0	Table 6 Small Signal Only @25C Read and Record: measurements Per DS are required to be taken within 96 hours after removal from the Burn-in test conditions
60	4705	Steady State Operating Life	45	45	0	MIL-STD-883, Method 1005, 500 hrs @ 125c
70	4602	Post B/I Electrical	45	45	0	Small Signal Only @25C Read and Record: measurements Per Data Sheet are required to be taken within 96 hours after removal from the Burn-in test conditions
80	4602	Post B/I Electrical	45	45	0	Table 6 Small Signal Only @-55C per Product Spec
90	4602	Post B/I Electrical	45	45	0	Table 6 Small Signal Only @+125C per Product Spec
100	5101	Engineering Review	45	45	0	Engineering Review: Limits per data Sheet
Group B Subgroup 6						
Seq #	WI#	Description	Qty Test	Qty Accept	Qty Reject	Comment
30	4602	Electrical Test	15	15	0	Small Signal Only @25C
40	4701	Temp Cycle	15	15	0	MIL-STD-883, Method 1010 Cond C 100 cycles
50	7000-4702	Acceleration	15	15	0	MIL-STD-883, Method 2001 3000g's Y1
60	4706	Fine Leak	15	15	0	MIL-STD-883, Method 1014 Cond A
70	4707	Gross Leak	15	15	0	MIL-STD-883, Method 1014 Cond C
80	4602	Electrical Test	15	15	0	Small Signal Only @25C

Group D Mil-STD 883 TM 5005 Table IIa Class V						
Seq #	WI#	Description	Qty In	Qty Out	Qty Rej	Comment
Group D Subgroup 1						
10	4001	Material Release	15	15	0	From Flight WO#
20	4309	External Visual	15	15	0	MIL-STD-883, Method 2009
30	4809	Physical Dimensions	15	15	0	MIL-STD-883, Method 2016: Record Dimensions
40	5101	Review Data	15	15	0	Product Outline:
Group D Subgroup 3						
60	4602	Electrical Test	15	15	0	Small Signal Only @25C
70	7000-4808	Thermal Shock	15	15	0	MIL-STD-883, Method 1011 Cond B 15 cycles min
80	4701	Temp Cycle	15	15	0	MIL-STD-883, Method 1010 Cond C 100 cycles
90	7000-4709	Moisture Resistance	15	15	0	MIL-STD-883, Method 1004
100	4706	Fine Leak	15	15	0	MIL-STD-883, Method 1014 Cond A
105	4707	Gross Leak	15	15	0	MIL-STD-883, Method 1014 Cond C
110	4602	Electrical Test	15	15	0	Small Signal Only @25C
120	5101	Review Data	15	15	0	Per Electrical Table
Group D SubGroup 4						
20	4602	Electrical Test	15	15	0	Small Signal Only @25C
30	7000-4710	Mecahanical Shock	15	15	0	MIL-STD-883, Method 2002 Cond B
40	7000-4711	Vibration	15	15	0	MIL-STD-883, Method 2007 Cond A
50	7000-4702	Acceleration	15	15	0	MIL-STD-883, Method 2001 Cond E, Y1 orientation only
60	4706	Fine Leak	15	15	0	MIL-STD-883, Method 1014 Cond A
70	4707	Gross Leak	15	15	0	MIL-STD-883, Method 1014 Cond C
80	4602	Electrical Test	15	15	0	Small Signal Only @25C
90	5101	Review Data	15	15	0	Per Electrical Table
Group D Subgroup 5						
Seq #	WI#	Description	Qty In	Qty Out	Qty Rej	Comment
10	4001	Material Release	3	3	0	Electrical Rejects From Flight WO# acceptable
20	4309	External Visual	3	3	0	MIL-STD-883, Method 2009
30	7000-4814	Internal water vapor (RGA)	3	3	0	MIL-STD-883, Method 1018 5000ppm@100c
40	5101	Review Data	3	3	0	

The SPDT switch family completed all testing without incident. Electrical test results and environmental test reports are available upon request.