KCB SOLUTIONS

THE HIGHEST STANDARD IN RF

Qualification Report

For

GaAs 7-Bit Digital Step Attenuator Products

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Registered

Contents

1.0 SUMMARY

This report is a culmination of all testing associated with KCB Solutions family of GaAs FET 7-Bit Digital Step Attenuators supplied both leaded and leadless packages. It comprises reliability, radiation, electrostatic discharge, screening and quality conformance inspection. This report is applicable to the following products:

KCB831C, KCB831B, KCB831S	Seven-Bit Digital Attenuator in 32-lead package
KT103C, KT103B, KT103S	Seven-Bit Digital Attenuator in 5mm QFN package
KT104C, KT104B, KT104S	Seven-Bit Digital Attenuator in 32-lead package
KT105C, KT105H, KT105K	Seven-Bit Digital Attenuator w/Serial TTL Driver
KT109C, KT109H, KT109K	Seven-Bit Digital Attenuator w/Parallel TTL Driver

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 Digital Step Attenuator 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 attenuator. 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 x 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 x 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 85°C and 55°C ambient temperatures at the 90% confidence level.

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 DIGITAL ATTENUATOR

Model parameters used:

N	=	device operating hours at equivalent use conditions = Device stress hours x AF_T
χ^2	=	chi-squared value
α	=	the chi-squared confidence interval = 0.1 (90% confidence)
df	=	degrees of freedom (2r + 2)
r	=	number of failures = 0
E_a	=	activation energy = 1.3 eV
k	=	Boltzmann's constant (8.617 x 10^{-5} eV/°K)
T_U	=	use temperature = 85 °C, 55 °C
T_S	=	stress temperature = 398 °K (125 °C)

Results:

				Failures in Time (FIT) @ Temperature		MTTF, Hours @ Temperature	
SS	t	r	Device Hours	85°C	55°C	85°C	55°C
77	1000	0	77,000	434.5	9.2	2.30E+06	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 attenuator 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

Devices were subjected to ESD Sensitivity Classification testing in accordance with JESD22-A114. The devices were separated into groups with each group of 3 subjected to increasing voltage levels until one device in one group failed production testing. The results of the testing led to a HBM classification of 2, 2000V. Detailed electrical test results are available upon request.

6.0 SCREENING

KCB has performed screening testing of the GaAs attenuator die, CMOS driver die and bias components as part of a hybrid module incorporating the attenuator die. Testing was in accordance with MIL-PRF-38534, Class K per the below table:

100% Screening: MIL-PRF-38534, Class K

Seq #	WI #	Operation Description	Comment
10	4603	Electrical Test	Read and Record IAW datasheet
20	4701	Temp Cycle	Class K IAW MIL-STD-883, method 1010, Cond C, 10 Cycles
30	7000-4702	Acceleration	Class K IAW MIL-STD-883, method 2001, Y1, 3,000g's
40	7000-4703	PIND	Class K IAW MIL-STD-883, method 2020, Cond A accept IAW para 3.5
50	4501	Device Marking/Serialization	IAW datasheet
60	4704	Radiographic	MIL-STD-883, Method 2012; 2 views Y2 & X2
70	4603	Pre- B/I Electrical	Read and Record IAW datasheet
80	4705	Burn-In	MIL-STD-883, Method 1015, Cond A, Table I - T=160hrs Ta=125c
90	4603	Interim Electrical	Interim Burn-In +25c measurements IAW datasheet
100	4705	Burn-In	MIL-STD-883, Method 1015, Cond A, Table I - T=160hrs Ta=125c
110	4603	Post B/I Electrical	Post burn-in +25c measurements IAW Table II of the datasheet are required to be taken within 96 hours after removal from the Burn-in test conditions.
120	5102	Delta/"Out of Family" Calculations Calculate PDA_____%	See datasheet for Delta Limits
130	4603	Final Electrical	Min Temperature IAW Table II of datasheet
140	4603	Final Electrical	Max Temperature IAW Table II of datasheet
150	4818	Trim Leads	IAW Outline Drwg
160	4706	Fine Leak	MIL-STD-883, Method 1014 Cond A. Read and Record Empty chamber leak rate at beginning and end of lot.
170	4707	Gross Leak	MIL-STD-883, Method 1014 Cond C
180	4603	Electrical	Functional Test 100% IAW Table II of datasheet
190	4309	External Visual	MIL-STD-883, Method 2009 100% Dimensions on 3 units. Read & Record data on Phys Dim Checklist.
200		Issue to QCI	Group C

Note: All Methods IAW Mil-Std-883

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

7.0 DIE LEVEL QUALIFICATION TESTING

KCB has performed die level qualification testing as part of element evaluation in accordance with MIL-PRF-38534, Table C-II, Class K:

Element Evaluation of KCB831 Die IAW MIL-PRF-38534, Table C-II, Class K						
Seq #	WI	Description	Qty In	Qty Out	Qty Rej	Comment
10	4001	Material Release	20	20	0	QFN 4x4
20	4305	Die Visual	20	20	0	MIL-STD-883, Method 2010 Class S
30	4102	Hand Mount Epoxy	20	20	0	84.1LM1-NB
35	4810	Epoxy Cure	20	20	0	1.5 hrs @ 165 +/- 5 deg
40	4202	Ball Bond	20	20	0	.001 mil wire
50	4313	Visual Inspection	20	20	0	MIL-STD-883, Method 2010/2017
60	4603	Electrical Test	20	20	0	Functional
70	4406	Vacuum Bake	20	20	0	8hrs (min) @ 125c
80	4407	Seal: Date Code___	20	20	0	AuSn Reflow 100% Nitrogen
90		Electrical Test	20	20	0	Functional
Issue Qty 10 Subgroup 4						
100	4701	Temp Cycle	10	10	0	MIL-STD-883, Method 1010 Cond C
110	7000-4702	Acceleration	10	10	0	MIL-STD-883, Method 2001 3000g's Y1
120	4604	Pre -B/I Electrical	10	10	0	Read and Record: +25c
130	4705	Burn-in	10	10	0	HTRB 120 hrs @ 150c
140	4604	Interim Electrical	10	10	0	Read and Record: +25c
150	4705	Burn-in	10	10	0	HTRB 500 hrs @ 150c
160	4604	Post B/I Electrical	10	10	0	Read and Record: +25c
170	5101	Data Review	10	10	0	Calculate Delta
180	4604	Final Electrical	10	10	0	0c per Product Spec
190	4604	Final Electrical	10	10	0	+75c per Product Spec
200	4309	External Visual	10	10	0	MIL-STD-883, Method 2009
210		Report	10	10	0	
Issue Qty 5 Subgroup 5						
10	4001	Material Release	5	5	0	QFN 4x4
20	4102	Hand Mount Epoxy	5	5	0	84-1LM1-NB
25	4810	Epoxy Cure	5	5	0	1.5 hrs @ 165 +/- 5 deg
30	4202	Ball Bond	5	5	0	.001 Au Wire Bond
40	4313	Visual Inspection	5	5	0	MIL-STD-883, Method 2010/2017
50	4302	Wire Bond Evaluation	5	5	0	MIL-STD-883, Method 2011 (10 wires)
60	4306	Visual Inspection	5	5	0	Bond Lift
70	5101	Data Review	5	5	0	Verify Compliance
80		Report	5	5	0	
Issue Qty 5 Subgroup 6						
10	4001	Material Release	5	5	0	GaAs IC/ Carrier
20	4305	Die Visual	5	5	0	MIL-STD-883, Method 2010 Class S
70	7000-4817	SEM Analysis	5	5	0	MIL-STD-883, Method 2018
100	5101	Data Review	5	5	0	Verify Compliance
110		Report	5	5	0	

The microcircuit successfully completed all subgroups of element evaluation. Test data and environmental test reports are available upon request.

8.0 QUALITY CONFORMANCE INSPECTION

KCB has performed quality conformance inspection on the attenuator GaAs and CMOS driver die as well as all bias components at the hybrid level in accordance with MIL-PRF-38534 Group C Testing per the below tables:

Quality Conformance Inspection IAW MIL-PRF-38534, Class K						
Seq #	WI #	Operation Description	Qty In	Qty Out	Qty Rej	Comment
Issue to Group C Subgroup 1						
10	4001	Material Release	5	5	0	From Flight WO#
15		Resistance to Soldering Heat	5	5	0	MIL-STD-883, Method 2036
20	4309	External Visual	5	5	0	MIL-STD-883, Method 2009
30	4701	Temp Cycle	5	5	0	MIL-STD-883, Method 1010 Cond C 100 cycles
40	7000-4702	Acceleration	5	5	0	MIL-STD-883, Method 2001 3000g's Y1
50	4706	Fine Leak	5	5	0	MIL-STD-883, Method 1010
60	4707	Gross Leak	5	5	0	MIL-STD-883, Method 1014 Cond C
65	4309	Visual	5	5	0	MIL-STD-883, Method 1014 Cond A
70	4603	Electrical	5	5	0	IAW Datasheet, Read and Record +25c
80	5101	Data Review	5	5	0	QA Verify Compliance
Issue to Group C Ssubgroup 2						
10	4001	Material Release	5	5	0	From Flight WO#
15	4603	Pre Life Electrical	5	5	0	Pre life +25c measurements IAW Datasheet
20	4705	Life Testing	5	5	0	MIL-STD-883, 500 hrs @ 125c
30	4603	Interim Life Electrical	5	5	0	Post Life +25c measurements IAW Datasheet. Must be completed within 96 hours after removal from the life test conditions.
40	4705	Life Testing	5	5	0	MIL-STD-883, 500 hrs @ 125c
50	4603	Final Post Life Electrical	5	5	0	Post Life +25c measurements IAW Datasheet. Must be completed within 96 hours after removal from the life test conditions.
55	5102	Delta/"Out of Family" Calculations Calcuate PDA_____%	5	5	0	See Datasheet for Delta Limits
60	5101	Data Review	5	5	0	QA Verify Compliance
70		Report	5	5	0	Group C Testing
Issue to Group C Subgroup 3						
10	4001	Material Release	3	3	0	From Group C Subgroup 1
20	4309	External Visual	3	3	0	MIL-STD-883, Method 2009
40	7000-4814	RGA	3	3	0	MIL-STD-883, Method 1018
50	5101	Data Review	3	3	0	Internal Water vapor content
60		Report	3	3	0	Group C Testing
Issue to Group C Subgroup 4						
10	4001	Material Release	2	2	0	From Group C Subgroup 1
20	4809	Physical Dimensions	2	2	0	MIL-STD-883, Method 2016: Record Dimensions
30	5101	Data Review	2	2	0	QA Verify Compliance
40		De-Lid	2	2	0	Mechanical
50	4306	Internal Visual Inspection	2	2	0	MIL-STD-883, Method 2017, IAW Assembly Drawing
60	4302	Destruct Bond Pull	2	2	0	MIL-STD-883, Method 2011 Cond C
70	5101	Data Review	2	2	0	Record Destruct Bond Pull Data
80	4301	Die Sheer Strength Testing	2	2	0	MIL-STD-883, Method 2019
90	5101	Data Review	2	2	0	QA Verify Compliance
100	4901	Label and Hold Samples	2	2	0	Store samples for further review if necessary
110		Report	2	2	0	Group C Report
Note: All Methods per Mil-Std-883						

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