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Components Engineering Section

RADIATION ANALYSIS REPORT NUMBER

RA 0082

Part Type : GaAs MMIC Amplifier

Type No. : CGY 40

Manufacturer : Siemens (G)

Project : Manufacturer Support

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Summary.

In order to give support to European companies working in the field of microwave components, a radiation test campaign has been carried out to investigate the sensitivty of microwave components to radiation.
More than 100 components have been measured, irradiated and measured again after irradiation.
Different technologies were available such as implanted and epitaxial technologies.
The testing included different kinds of processes such as GaAs, InP, N-off and N-on and different types of passive and active devices like capacitors, classical MESFETs, HEMTs and pseudomorphic HEMTs.
Two radiation levels have been applied: 200 krads and 600 krads.
Concerning the passive devices, we measured their value for different frequencies.
Concerning the active components, the analysis has been carried out in two different ways.
On the one hand, we studied some DC characteristics and especially :
- Idss: Drain to source current at Vgs=0 V and at a nominal value of Vds=2 or 3 V depending on the tested component.
- Vp: Pinch-off gate potential for a current of 1 mA per millimetre of gate width.
- gm2: Transconductance of the device measured at Idss/2.
- Igss: Leakage gate to source and drain (both to ground) current at Vgs=-1 V.

On the other hand, we made an RF analysis and we attached a particular importance to the S21 parameter (RF gain) of the devices.

For each type of component some of them have been kept for reference in order to control our measurement precision .
The error in measurement was recorded and compared to the variation that occurred in the values of irradiated components characteristics.

The following criterion was applied to the results:
- If the measured variation was less than twice the measurement error then the value was considered as a measurement error.
- If not, it was compared to variations authorised either by ESA/SCC Detail Specification or by the component's manufacturer itself.
  In case the variation was greater than this specificated limit then the value was attributed to irradiation degradation or even failure.

In the following each component's characteristics variation is analyzed and conclusions are drawn regarding this variation.

Note: all data and curves are not provided with this report, but are available from F. Garat.

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SIEMENS CGY40 MMIC AMPLIFIERS

I - Introduction

10 components were available:

- 2 have been kept for reference reserve.
- 4 have been submitted to 200 krads irradiation.
- 4 have been submitted to 600 krads irradiation.

Components were issued from the 3018/10 batch.
They had been mounted in ceramic stripline package for testing.

II - DC Analysis

II.1 - Siemens CGY40 Idss

Operating voltage range for CGY40 is 3 to 5.5 V, we measured Idss (maximum drain to source current at Vds=4.5 V.

The maximum measurement error (before and after irradiation) of the 2 control components is around 2.40% (2.36%).

Concerning the irradiated components, 2 component show Idss variations lower than the measurement error and are immediatly considered as not affected by irradiations.

The remaining components (6 out of 8) have variations lower than twice the error in measurement (between 1.04 times and 1.6 times the measurement error), we can consider that these variations are only due to measurement errors and not to drift or even to degradation.

In addition, we can check that all irradiated CGY40 exhibit Idss variations lower than 5 mA they are well below the 20 mA drift value authorised by the manufacturer in the CGY 40 data book and especially, all variations are well below the -10% drift usually allowed by manufacturers, (maximum Idss measured variation was 3.82%).

Notice: As far as all components are concerned, the variation was a slight decrease of Idss.

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CGY 40 Idss results table

S/N	Radiation Level	Idss in mA Before Irradiation	Idss in mA After Irradiation	Idss Variation in mA
89	200 krads	80.360	78.374	-1.986
90	200 krads	86.320	84.150	-2.170
91	200 krads	88.820	86.472	-2.348
92	200 krads	88.740	85.896	-2.844
93	600 krads	87.500	85.714	-1.786
94	600 krads	86.320	84.658	-1.662
95	600 krads	88.020	84.654	-3.366
96	600 krads	87.540	84.658	-2.882
Reserv1	0 krads	88.140	86.260	-1.880
Reserv2	0 krads	88.920	81.006	-1.914

II.2 Siemens CGY 40 gm2

gm2 is the device's transconductance measured at Idss/2.

We estimate a maximum measurement error around 0.90% (0.91%).
6 irradiated components out of 8 show a measurement variation inferior to this error and can be immediatly considered as not degraded.
2 other components show variations less than twice the measurement error (between 1.08 and 1.4 times the error); conclusion is drawn that their variations are due to measurement errors and not to drifts or even degradations.

Besides, all measured transconductances after irradiation show variations lower than +/- 1 mS, (maximum variation observed: 1.27%) it is far below to the 10% drift (about 8 mS) usually considered as a failure criteria by manufacturers.

Next page table show measured gm2 and observed variations for the Siemens CGY 40.

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CGY 40 gm2 results table

S/N	Radiation Level	gm2 in mS Before Irradiation	gm2 in mS After Irradiation	gm2 Variation in mS
89	200 krads	79.850	80.283	+0.433
90	200 krads	79.930	80.458	+0.528
91	200 krads	80.858	81.497	+0.639
92	200 krads	80.787	81.593	+0.806
93	600 krads	80.974	80.690	-0.284
94	600 krads	80.213	81.245	+1.032
95	600 krads	81.000	80.439	-0.561
96	600 krads	80.593	80.877	+0.284
Reserv1	0 krads	80.019	80.748	+0.729
Reserv2	0 krads	82.490	82.670	+0.180

II.3 Siemens CGY 40 Vp

We measured the 2 kept for reference components' pinch-off voltage, measurement error can be determined to be approximately 0.60% (0.61%)

No component appears to have variations lower than this value.
6 components out of 8 show variations lower than twice the recorded error in measurement (between 1.13 and 1.77 times the error) and pinch-off voltages can be considered as not degraded by 200 and 600 krads irradiations.

Finally, the remaining components (2 out of 8) show variations larger than twice the error in measurement (between 2.86 and 5.5 times the error).
Nevertheless, these variations are not large enough to be able to consider that 2 CGY 40 have been sensitive to irradiations.
Indeed, all Pinch-off voltages measured after irradiation (around -1.4 V) fit with usual manufacturers' specifications which consider that a drift is a failure if it is superior to 10% of the nominal Vp value. As far as this testing is concerned, maximum variation observed was 3.4%; it was not a failure criteria.

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CGY 40 Vp results table

S/N	Radiation Level	Vp in V Before Irradiation	Vp in V After Irradiation	Vp Variation in V
89	200 krads	-1.308	-1.299	+0.009
90	200 krads	-1.383	-1.373	+0.010
91	200 krads	-1.423	-1.409	+0.014
92	200 krads	-1.423	-1.410	+0.013
93	600 krads	-1.390	-1.405	-0.015
94	600 krads	-1.378	-1.368	+0.010
95	600 krads	-1.400	-1.360	+0.034
96	600 krads	-1.393	-1.369	+0.024
Reserv1	0 krads	-1.414	-1.412	+0.002
Reserv2	0 krads	-1.320	-1.312	+0.008

II.4 Siemens CGY 40 Igss

This measurement was easier for Siemens CGY 40 devices than with other Siemens tested devices because CGY 40 leakage currents are more important (about -0.2 μA).

We estimated the error in measurement to be 0.50%.

6 components out of 8 show a variation lower or nearly equal to this value. we even measured some CGY 40 Igss with a 0% variation before and after irradiation.

The remaining of components have variations lower than twice the error in measurement and can be considered as not affected by irradiations.

To conclude, we can notice that maximum variations are +/- 2 nA which is well below the drift value authorised by manufacturers: 5 μA/mm = 3 μA variations with Siemens CGY 40.

Next page table show measured CGY 40 leakage currents and their variation.

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CGY 40 Igss results table

S/N	Radiation Level	Igss in nA Before Irradiation	Igss in nA After Irradiation	Igss Variation in nA
89	200 krads	-195	-195	0
90	200 krads	-189	-188	+1
91	200 krads	-187	-187	0
92	200 krads	-192	-194	-2
93	600 krads	-193	-191	+2
94	600 krads	-193	-192	+1
95	600 krads	-194	-193	+1
96	600 krads	-189	-188	+1
Reserv1	0 krads	-192	-192	0
Reserv2	0 krads	-195	-194	+1

III - RF analysis

We studied the Siemens CGY 40 RF gain (S21 parameter) between 200 MHz and 4.2 GHz. The 85041A transistor test fixture from Hewlett Packard has been used to analyze the DC and RF characteristics.
In general, the measurement error for Sij can be estimated around 0.5%. 200 and 600 krads irradiated components show RF gain measured variations below this value which prove that the devices' performance are not affected by irradiation.
The gain maintains the same values of magnitude and phase before and after irradiation.
A typical value for CGY 40 gain at 1.6 GHz is calculated to be 9 dB before irradiation and we were still able to find this typical value after irradiation.
Having a quick look at other RF parameters (S11, S12 and S22) leads to the same conclusions: the Siemens CGY 40 high frequency parameters have not been affected by 200 and 600 krads irradiations.

IV - Conclusion

Other DC characteristics such as breakdown voltages, drain and source ohmic resistances, channel resistance were measured,no failure and no important drift were noted.

Therefore, this testing demonstrates that the Siemens CGY 40 is not sensitive to irradiation performed with a 3 MeV electron source up to 600 krads and possibly greater.