Development of Software for Measuring the Electrical Characteristics of the Information Storage Micromodule with Increased Radiation Resistance

R.S. Litvinenko, V.M. Matveev

Abstract*: Development of software for automation of electrical characteristics measurement plays an important role, because this approach contributes to a significant time reduction. This article discusses the development and application of software for the study of electrical characteristics of miniature data storage modules developed by 3D integration technology for aerospace applications. In outer space there are a number of problems affecting the functioning of microelectronic equipment, in particular - heavy charged particles (HCP) that can lead to both single failures and latch-up effect, which is critical for memory chips. Therefore, there is a need to check the electrical parameters, such as the response time of protection against HCP. The software is developed in LabVIEW and can be used in manual and automatic modes, what allows to improve the efficiency of the testing process. The full range of measurements can be done by one operator in a short period of time.

***Keywords* : 3D integration, micromodule, latch-up effect.**

I. INTRODUCTION

Information storage modules developed in the SMC "Technological centre" [1] are made by 3D integration technology and are intended for use in conditions of increased radiation exposure to the environment. Radiation resistance is implemented by using radition tolerant electronic components, memory reservation, correcting codes and latch-up protection chip. The specifics of the product require the development of software for measuring electrical characteristics in an automated mode.

Verification of electrical parameters occurs after the completion of all technological operations for the production of information storage micromodules. Characteristics to be confirmed: supply voltage, power consumption, access time, high level input voltage, low level input voltage, response time of protection against HCP (heavy charged particles), load capacity.

Since the measurement of the electrical characteristics of the micromodules can take a very long time, it was decided to create a specialized software.

Revised Manuscript Received on October 05, 2019.

R.S. Litvinenko, Science Manufacturing Complex "Technological centre", Moscow, Zelenograd, Russia.

V.M. Matveev, Science Manufacturing Complex "Technological centre", Moscow, Zelenograd, Russia.

II. METHODS

The basic components of the information storage micromodule is controller, NAND-Flash, as the most resistant to radiation [2,3], and the latch-up protection chip 1469TK035 made by SMC "Technological centre" working on the principle of limiting the current consumption [4]. Special attention is paid to latch-up effect counteraction, as this effect is the main cause of catastrophic failures of electronic devices under conditions of increased radiation exposure [5-7].

The software allows testing and control of the micromodule samples to detect defects in manufacturing. It provides measurements of electrical characteristics in automatic and manual modes, collection and storage of measurement data, generation and output of test result reports.

The following technical requirements are applied to the software:

- user interface with the ability to set parameters and measure characteristics in real time;
- connection external measuring equipment;
- option to save measurement results in a file;
- Windows 7/10 support.

During the project the stand for the study of the micromodule electrical characteristics was developed. The stand includes the following instrumentation:

- programmable power supply,
- personal computer,
- special measuring equipment.

Software was developed in LabVIEW environment to control the components of the stand. The developed software works with the control and measuring equipment through the interface GPIB, USB, RS-232. The program is able to work in manual and automatic modes.

The interface of the developed stand software is shown in figure 1. After the measurement of all electrical characteristics in different operation modes, specialized software creates a complete test protocol.

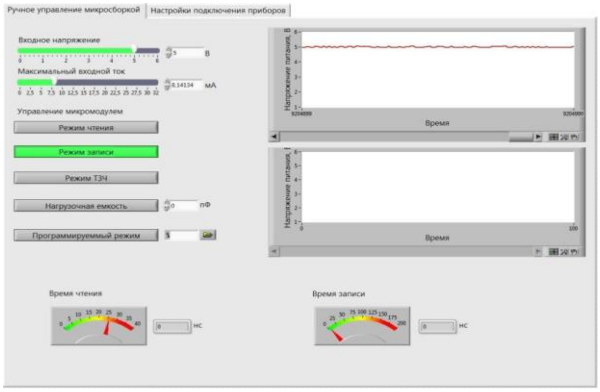

Figure 1 – User interface.

The measurement parameters can be configured: the value of the input voltage in the range from 0 to 32V with an accuracy of 0.01 V; the maximum switch current in the range from 0 to 10A with an accuracy of 0.01 A; the load Capacity is adjusted in the range: 0 – 100 pF.

Transmission of commands to the device is carried out by the string data type in ASCII encoding according to the VISA interface standard. The software operates with a programmable power source using the IEEE-488 GPIB digital interface. GPIB commands are always transmitted using the classic IEEE-488.1 protocol. The standard specifies the format of commands sent to the measuring equipment and the format and encoding of responses. The GPIB interface uses a byte-by-byte asynchronous data transfer scheme, that is, the entire bytes are sequentially transmitted over the bus at a rate determined by the slowest participant in the transmission. Messages are transmitted using strings that contain ASCII characters. The GPIB instrument interface trunk is a 24-wire parallel bus consisting of eight data lines, five bus control lines, three timing lines, and eight ground lines.

The following programs are also developed to work with the memory micromodule:

1) Software for data exchange between the data storage module and the PC.

The program allows exchanging data between the PC and the module controller. Data is exchanged via the USB interface.

2) Software of the module contact device.

The software allows loading the data exchange program into the information storage module for subsequent data exchange between the module and the PC.

The typical measuring algorithm:

- switch on the PC and the measuring equipment;
- initialize the software;
- connect the micromodule;
- check all connections;
- parameter setup in the user interface;
- start measuring program;
- save results.

All the necessary parameters for the measuring equipment are set by the software and the operator does not have to setup the hardware separately. This approach allows to reduce the measuring time and requirements to the operators qualification.

III. RESULTS

Thus, after connecting the control and measuring equipment to the interface, the results of the supply voltage and current consumption of micromodule sample at different temperatures were obtained. The results are presented in Table 1.

Table- I: Supply voltage and current consumption

T = -50 ºC			
Mode	Consumption current I (mA)		
	Vdd = +3.0V	Vdd = +3.3V	Vdd = +3.6V
1 write	35	36	35
2 read	36	37	36
3 erase	37	37	36
4 passive	0.01	0.01	0.01
T = +25 ºC			
Mode	Consumption current I (mA)		
	Vdd = +3.0V	Vdd = +3.3V	Vdd = +3.0V
1 write	34	35	35
2 read	36	35	35
3 erase	36	35	36
4 passive	0.01	0.01	0.015
T = +70 ºC			
Mode	Consumption current I (mA)		
	Vdd = +3.0V	Vdd = +3.3V	Vdd = +3.0V
1 write	35	36	35
2 read	35	36	35
3 erase	37	37	36
4 passive	0.015	0.02	0.02

The developed software allows working in manual mode to check the latch-up protection response time. The results are shown in Table 2.

Table- II: Latch-up protection response time.

Mode	Response time t (ms)		
	T = -50 ºC	T = +25 ºC	T = +70 ºC
C2= 10 nF	102	93	92
C2= 20 nF	208	194	197
C2= 30 nF	301	282	283
C2= 40 nF	449	395	402

The C2 trimming capacitor can be selected in the range of 10 to 40 nF depending on the specific operating conditions of the module and technical requirements. However, to ensure greater reliability of the module, it is necessary to choose the lowest value of the protection response time to prevent the growth of the latch-up effect [8, 9].

IV. CONCLUSIONS

The article presents the developed software for measuring the electrical characteristics of the information storage micromodules for onboard equipment of spacecraft with increased radiation resistance.

The software allows testing and control of manufactured samples to detect defects in the production. Automation of the measurement of electrical characteristics has significantly reduced the time of laboratory tests. Virtually the operator works only with the personal computer to obtain the full range of measuring results. The measuring time reduces not only by automation itself but also by lack of necessity to setup the hardware.

The software allows to check the following parameters: supply voltage, power consumption, access time, input voltage of high level, input voltage of low level, response time of latch-up protection, load capacity.

The obtained results correspond to electric characteristics of the components and the requirements in the field of application. Future work is aimed towards the series production and testing of the information storage micromodules and developing of the software for the automation of the interoperational control.

ACKNOWLEDGMENT

The work is carried out with the financial support of the Ministry of Education and Science of Russia under Agreement no. 14.574.21.0155 (unique identifier of applied research RFMEFI57417X0155). The work was carried out using the equipment of CCU “Functional testing and diagnostics of micro - and nanosystem technique" on the basis of SMC "Technological centre".

REFERENCES

1. R.S. Litvinenko, I.V. Prokofiev Development of the information storage micromodule for spacecrafts with latch-up effect protection // International journal of engineering and technology. 7 (4.7) (2018) 184-187.
2. Z.Wang, M. Karpovsky, A. Joshi Reliable MLC NAND Flash Memories Based on Non-Linear t-error Correcting Codes // Proceedings of International Conference on Dependable Systems and Networks. 2010.
3. Wang, X. Error Correction Codes and Signal Processing in Flash Memory/ X. Wang, G. Dong, L. Pan, R. Zhou // Ch.3 in «Flash Memories», Prof. Igor Stievano (Ed.), 2010.
4. V.V. Konyahin, A.N. Denisov, R.A. Fedorov, A.L. Vilson, S.S. Braghnikov, V.S. Konovalov, N.I. Malashevich, A.S. Roslyakov Chips for space equipment. Practical guide, under edition A.N. Saurov – M.: Technosphere, 2016. P. 388.
5. Holmes_Siedle A., Adams L. Handbook of Radiation Effects. N.Y.: Oxford university press, 1993. P. 479.
6. Messenger G.C., Ash M.S. Single Event Phenomena. N.Y.: Chapman&Hall, 1997. P. 368.
7. Heidi N. Becker, Tetsuo F. Miyahira, and Allan H. Johnston. Latent Damage in CMOS Devices from Single-Event Latchup // Jet Propulsion Laboratory, California Institute of Technology. Pasadena, California. 2002.
8. N.V. Kuznetsov, R.A. Nymmik, M.I. Panasyuk, E.N. Sosnovets, and M.V. Teltsov Detection and Prediction of Absorbed Radiation Doses from Solar Proton Fluxes onboard Orbital Stations // Space research. 2004. B. 42. N. 3.
9. Tararaksin A.S., Nigmatullin R.R., Savchenkov D.V., Solovyov S.A., Yanenko A.V. Single Event Latchup and Catastrophic Failure in CMOS Devices Investigation and Prevention Methods.: Institute for Design Problems in Microelectronics of Russian Academy of Sciences (IPPM RAS). 2012. P. 628-633.

AUTHORS PROFILE

R.S. Litvinenko, engineer-constructor in Science Manufacturing Complex "Technological centre", Moscow, Zelenograd since 2012. He has 7+ years of industry experience. He has got Master’s Degree in Moscow Institute of Electronic Technology. He has published more than 20 papers in International and National journals. His area of Interest is pressure and tactile sensing, microassemblies and 3D integration technologies.

V.M. Matveev engineer in Science Manufacturing Complex "Technological centre", Moscow, Zelenograd since 2017. He has 2+ years of industry experience. He has got Master’s Degree in Moscow Institute of Electronic Technology. He has published more than 10 papers in International and National journals. His area of Interest is magnetic sensing, microassemblies and 3D integration technologies.