

# Command Console of Environmental Shielded TEM-chamber

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**Abstract**— The software implementation of command console for first-ever proposed environmental shielded TEM-chamber is presented. Searching of the hardware platform and development framework for the realization of command console is attended. Results of operation of the developed software for visualization and data transfer between command console and temperature control board of the environmental shielded TEM chamber are presented.

**Keywords**— environmental shielded TEM chamber; command console; software

## I. INTRODUCTION

Development trends in technologies of miniaturization of integrated circuits (IC) allow to increase the computational performance and decrease weight-size parameters of radio-electronic equipment (RE). Along with obvious advantages of technological development the issues of electromagnetic compatibility (EMC) arise. For example, an increase of component density and scale of integration, plus the increase in the operation speed of digital circuits and operating frequencies of analog circuits leads to an increase in RE susceptibility to radiated electromagnetic exposures [1].

For estimation of the reliability of RE there are different tests, including tests on climatic and electromagnetic exposures, which allows identifying the degradation processes of the electronic component base of devices. It's useful to note, what the change in operating conditions of RE may lead to degradation effects in semiconductors and dielectrics of the electronic component base, which in turn leads to changes in their technical characteristics. In this regard, for a more detailed studying of possible mechanisms of RE failures, it is necessary to perform joint testing on climatic and electromagnetic exposures, what allows to approximate tests to real operation conditions of RE. Joint testing is more actual for RE, which designed for operation in conditions of the space environment and in the Arctic and Antarctic regions, where RE undergoes in wide range changes of climatic conditions under the electromagnetic radiation [2].

For such test operation, the new environmental shielded TEM-chamber is being developed, which allows testing the IC and small RE on emissions and radiated susceptibility in the frequency range up to 2 GHz at a temperature of -50 to +150°C with humidity of air of 10 to 90%.

Construction of the environmental shielded TEM-cell consists of an environmental chamber (with heightened shielding effectiveness), inside which the TEM-cell is integrated. By heating or cooling of the surface of TEM-cell with a circulation of the air flow of a given humidity through it, the device under test is in the air of required temperature and humidity (Fig. 1) [4, 5].

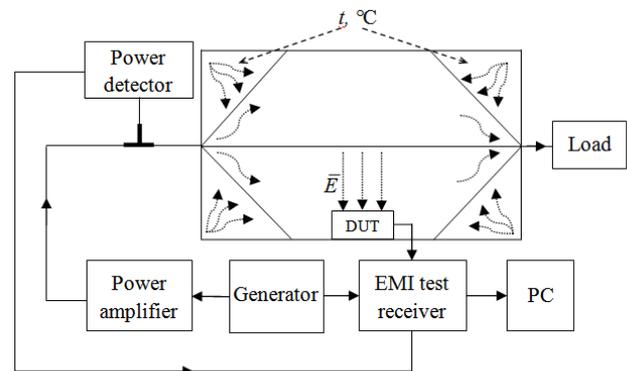


Fig. 1. Diagram of testing with electromagnetic and environmental excitations of device under test

Monitoring and maintaining of the preset temperature inside the TEM-cell realized by thermocontact and thermoair subsystems. Thermoair subsystem provides inflow and air circulation through the TEM-cell with the preset temperature and humidity of the air. Thermocontact subsystem provides preset temperature of TEM-cell's walls. On this moment the control board is designed, which realized this subsystems and synchronized their operation by a microcontroller (Fig. 2).

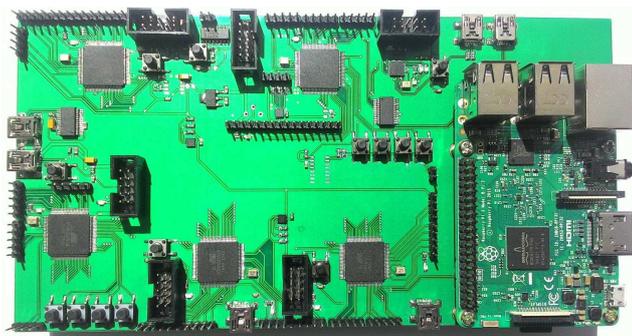


Fig. 2. Laboratory model of control board of environmental shielded TEM-chamber

For interaction between the operator of the chamber and control board, a command console is required that will allow the transfer of control commands to the control board, organize the visualization and transmission of data about conditions in TEM-cell to the client software on PC, and also perform diagnostic of the entire system as a whole.

The purpose of this paper is to present the results of the development of command console of environmental shielded TEM-chamber.

## II. FUNCTIONAL AREA OF COMMAND CONSOLE

Command console is the link between the control board and client software, which is installed on PC (Fig. 3). Data from the control board are transmitted to command console, in which the data about temperature, humidity and other parameters of the system are calculated and stored.



Fig. 3. Simplified block diagram of chamber control

The data from the temperature sensors come in the form of transactions, identifying an indication of the certain sensor, that is necessary for visualization of temperature field on TEM-cell surface during the operation cycle. Data transfer between command console and control board is organized by UART interface. The structure of data packet is described as follows: the first data item is an identifier of the microcontroller of the control board, the second data item identify data sensor, the third and fourth data items contain integer and fractional part of sensor value (Fig. 4). The structure of the data packet for humidity sensors is similar.

← 2 bytes →	← 5 bytes →	← 8 bytes →	← 8 bytes →
id_mc	id_tmp_snr	temp1	temp2

Fig. 4. Structure of data packet

After displaying information about the current climatic conditions inside the chamber, the operator sets the required temperature and humidity values, which are transmitted to

control board of environmental shielded TEM-chamber. In control board the pulse-width modulated signals are calculated for controlling the thermoair and thermocontact systems by proportional-integral differential regulators.

## III. DESIGN OF EVALUATION BOARD OF COMMAND CONSOLE

The following requirements are imposed on the command console: the presence of a touch panel for entering information and interfaces for data exchange between command console and client software on the PC. For a selection of a hardware platform, an overview of graphical debugging boards, most commonly used in embedded systems, was performed.

The following debug boards were considered: SAMA5D4 Xplained Ultra, EVE FT800 and Raspberry Pi B. The results of the comparison are tabulated in Table 1.

TABLE I. COMPARATIVE CHARACTERISTICS OF THE BOARD FOR COMMAND CONSOLE

Characteristics	Graphical boards		
	<i>EVE FT800</i>	<i>SAMA5D4</i>	<i>RASPBERRY PI</i>
Touch display	+	+	+
Interfaces	SPI, I2C, Audio	SPI, UART, USB, HDMI, I2C, GPIO, Ethernet	SPI, UART, I2C, GPIO, USB, HDMI, Ethernet, Audio
Frequency	48 MHz	500 MHz	700 MHz
Operating system	-	Own Linux kernel assembly	Linux, based on Debian
Architecture	FTDI	ARM Cortex-A5	ARM Cortex-A7
Programming environment	4D Workshop IDE	C/C++	C/C++, Python, Java

Initially, the EVE FT800 board was considered as a hardware basis of command console, which is widely used in embedded systems and automation for displaying of graphic information. But computing resources of this plate are not enough for the solution of the task. Debug plate SAMA5D4 Xplained Ultra (designed by Atmel) has not this flaw - plate has a wide range of interfaces and programmable I/O ports. However, the programming environment of the debug plate has a limited set of libraries and is poorly described in the technical literature, which makes it difficult to develop on this board. Concerning for realization of command console the Raspberry Pi B was chosen. The merits of this debug plate are high performance, operation system installation support and the existence of HDMI, USB, UART, SPI, I2C and GPIO interfaces. Therefore, this plate is the best (among the considered analogs) for implementing the command console with the possibility of upgrading and adding new functionality.

As a tool for developing of the graphical user interface (GUI-application), a cross-platform framework Qt was used

[6, 7]. The Qt development environment supports work with TCP/IP, UDP, COM and etc. interfaces and has the convenience of building a graphical interface. For the work with the serial port, the QtSerialPort module is responsible, which contains enough functionality for organizing the operation with COM-port: port configuration, reading / writing data to the port. The QtGui module contains classes of user interface elements.

Data transfer via the virtual serial port has the following feature. Since the size of the FIFO buffer of the serial port is 8 bytes, the transmitted sequence of  $N$  bytes may violate its integrity and at the receiving input it can be present as several smaller sequences. To solve this problem after receiving the first part of the package, the software is in the waiting of the next part and at the moment of its arrival "glues" it with the previous one. If the timeout is exceeded, the received packet is sent for parsing.

Development and debugging of the program source code was carried out on a PC under the Windows 10. Debugging of the transmission and parsing of data packets was carried out using a USB-UART converter. Before launching of the developed software on the hardware platform, the base libraries QtCore, QSerialPort, QtGui were installed.

The main window displays the current temperature and humidity data inside the TEM-cell. The interface of the main program window (Fig. 5) contains three tabs of the menu: the main screen (c), the temperature level (d) and humidity (e). At the moment, the main functions are realized: displaying/changing of temperature and humidity coefficient in the TEM-cell. For changing the temperature or humidity, in the corresponding console window, the required temperature or humidity value is set using the scrollbar. For a more precise adjustment of the adjustable value, 2 buttons (a) are provided. The changes take effect after confirmation by the operator by clicking on the corresponding button in the lower right corner of the graphical interface (b). The humidity level is adjusted in the same way in the corresponding program window.



Fig. 5. Temperature setting window

A keyboard PCB with a touch display of the command console was developed (Fig. 6). In addition, the buttons for shutting down the operation and for controlling the test table of the environmental shielded TEM-chamber are brought out.

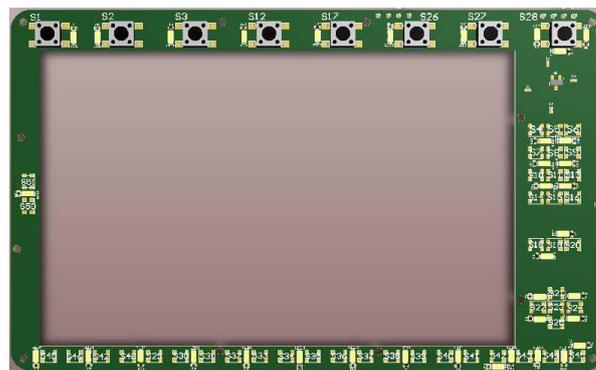


Fig. 6. PCB model of command console

The three-dimensional model of the final version of the command console in the case is shown in the Fig. 7.



Fig. 7. The three-dimensional model of the final version of the command console

#### IV. CONCLUSION

Thus, the command console was developed and the software of the console was debugged. As the remaining modules of the software-hardware complex will be developed, new functionality will be added to the software. In the future, it is planned to manufacture the console case and to assemble command console.

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