Automated Method for M-curve Signature Measurements of RR Devices and Modules

Nenad Pejovic, Vladimir Orlic, Miroslav Peric, Miloje Zecevic, and Svetlana Marcetic

Abstract **— In this paper we describe an automated method for testing the influence of selective fading on a radio-relay system and its vital modules in the form of M-curve signatures. Presented method is developed with a goal to make efficient measuremets of different RR devices generations, as well as to enable effective R&D of new RR equipment**.

Keywords **— Measurement automation, frequency-selective fading, M-curve signature, radio-relay devices.**

I. Introduction

FREQUENCY-SELECTIVE fading has a significant impact on the reliability and quality of medium- and high-capacity radio-relay (RR) links, and thus has to be taken into consideration in the course of RR connections planning process ([1],[2]), as well as development and testing of RR devices ([3],[4]). The robustness of RR devices against frequency-selective fading is commonly evaluated through laboratory measurements of „M-curve signatures“[5], based on employing simulators of frequency-selective propagation channels. These simulators are used for generation of frequency-selective fading with a given intensity ("notch depth") at a chosen frequency ("notch frequency"), with the goal to explore the limits of a two-dimensional space of notch depth/frequency values corresponding to operation of RR device at critical values of BER - Bit Error Rate ($>10^{-3}$ or $>10^{-6}$).

M-curve signature measurement of RR device represents in-detail investigation of device's performance within a huge number of propagation channel states – different fading levels appearing at frequencies that cover the complete IF bandwidth of a receiver. This means a large number of particular measurements, and in cases when RR devices with a selectable bitrate are targeted, this number is additionally multiplied by the number of different capacities that can be supported by a single device. Following the market demands, IMTEL Komunikacije A.D. has developed "Series B" RR devices with a software-selectable capacity (bitrate). Since M-curve signature measurements represent a standard procedure in laboratory tests, realization of frequency-selective fading simulator became unavoidable; as can be concluded from previous considerations, these simulators are necessarily supported by reliable automatic methods for control of curve signature measurement process. In this manner human resources are saved by eliminating a number of time-consuming measurements, laboratory measurements are kept at an appropriately high level of efficiency, and additionally – the possibility of error occurrence, as a result of operator's involvement, is eliminated.

N. Pejović is now with Meter and Control, Tršćanska 21, 11080 Zemun, Serbia (phone 381-64-2543660 e-mail: npejovic@sbb.rs).
V. Orlić is with IMTEL Komunikacije, Bul. Mihaila Pupina 165B, 11070 New Belgrade, Serbia (e-mail: cheggy@insimtel.com).
M. Perić, is with IMTEL Komunikacije, Bul. Mihaila Pupina 165B, 11070 Belgrade, Serbia (e-mail: micha@insimtel.com).
M. Zečević, is now with TTI Norte, Avda de los Castros 1, 39005 Santander, Spain (e-mail: mzecevic@ttinorte.es).
S. Marčetić, is now with Solutis, Ustanicka 64, Belgrade, Serbia (e-mail: svetlana.marcetic@solutis.rs).

II. Automation of Frequency-Selective Fading Simulator

Realization of frequency-selective fading simulator is based on a "simplified three-ray model" [1], with the possibility of operation in both minimum-phase and nonminimum-phase mode, and is intended for performance investigation of RR system having the intermediate frequency of 140MHz. Concept of the system is described in detail in [3], its structure is presented in Fig. 1, while the main technical characteristics of this device are given in Table 1.

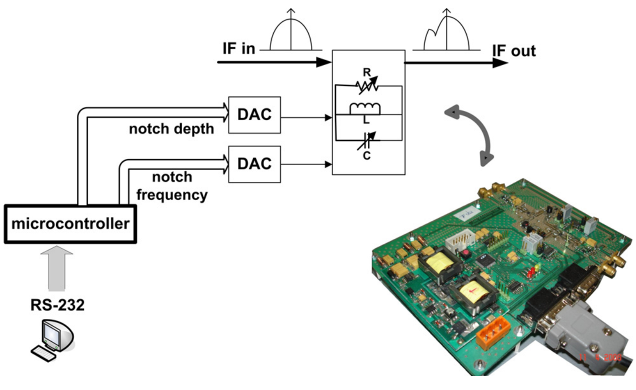

Fig. 1. Frequency-selective fading simulator [3].

A. Hardware for automated control

A fading simulator can be set in a desired configuration (notch depth, notch frequency, minimum/nonminimum phase mode) by providing the polarization voltages of appropriate values to voltage-controlled elements (varicap diode, JFET). Therefore, for automatic configuration of the circuit that defines functionality of this device, it is necessary to provide these two voltages with adequate values, which can be achieved by using a microcontroller and D/A converters, supported by amplifiers for covering the whole range of polarization voltages' values (all values of notch frequencies and depths in both operating modes). For this purpose the Silabs C8051F121 microcontroller is used, with integrated D/A converters, and with values of digital outputs that correspond to particular configurations of fading simulator pre-programmed in memory of a microcontroller.

TABLE 1: MAIN TECH. CHARACTERISTICS OF SIMULATOR.

Notch center frequencies	125 – 155MHz
Notch depth range	0dB - 40dB
Fixed attenuation	8dB
Freq. selection resolution	1 MHz
Freq. selection accuracy	< 0.1 MHz
Notch depth selection resolution	0.5 dB
Notch depth selection accuracy	< 0.2 dB
Power supply voltage	48V
PC interface	RS-232

In order to set the simulator in desired configuration, the user has to send an appropriate request to the microcontroller; this can be done by using a PC, via RS-232 interface. The computer controls and monitors operation of the microcontroller by providing it with configuration attributes, and the whole process is being guided by computer software developed especially for this purpose.

B. *Software for automatic control*

PC Software for controlling the simulator provides a user interface that enables setting the parameters for the measurement. Software performs control of both fading simulator and digital transmission analyzer via RS-232 ports. In the main window of the application (Fig. 2.), the user can define the ports to be used for connecting the devices. It supports digital transmission analyzers MOTS28SK[6] and MOTS AVR834[7]. The main role of the software is to monitor BER measured by the analyzer and to detect loss of synchronization or BER exceeding 1e-3 for each measuring point. In cases when loss of synchronization occurs, software reconfigures the transmission analyzer for the necessary number of iterations.

Since each simulator board requires different calibration voltages, the operator has to select an appropriate Excel table with calibration data for a specific board, which is then used by software during the measurement. User interface also enables the user to select the type of fading (minimum-phase/nonminimum-phase mode) and frequency range for the measurement. Depending on a desired precision level and measurement speed, the user can also select a measurement step for frequency, notch depth and waiting time for transmission analyzer synchronization.

In addition to automatic measurement, there is a possibility to set the simulator into one specific state of frequency and notch depth. This option is mainly used during calibration of the simulator board.

During M-curve signature measurements, software monitors the state of the simulator and digital transmission analyzer and shows the progress of the measurement to the user. After measurement finishes, it draws M-curve on display and saves numeric values in a file on the hard drive of the computer.

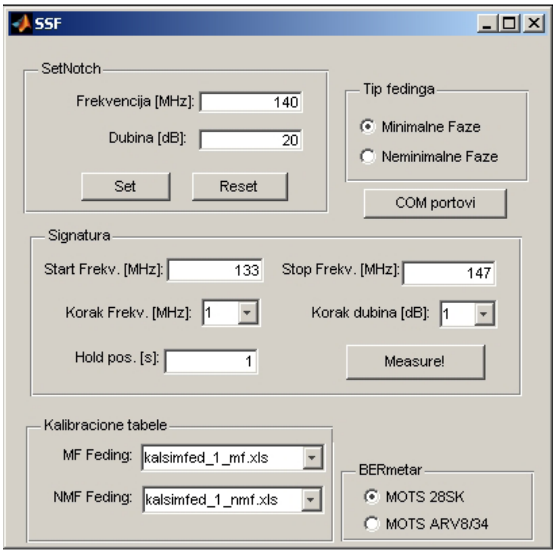

Fig. 2. Main window of the control application.

III. IMPLEMENTATION OF MEASUREMENT METHODS

The concept of the simulator enables the measurements of Radio-Relay systems and their subsystems (modules). It also enables measurements of the different generations of Radio-Relay devices, thanks to the appropriate selection of intermediate frequency (IF) value. Main guidelines during the development of measurement method were to minimize measurement equipment and to unify interfaces between PC and instruments used. On the other hand, we needed a flexible method which would include different generations of RR devices and modules. As a result, we adopted a solution that uses only instruments with RS-232 interface in order to simplify both software and hardware architecture. We decided to support different digital transmission analyzers in order to enable measurements of devices with different data interfaces and bitrates.

Figures 3 and 4 show block diagrams of methods for RR devices' M-curve measurements during laboratory testing. It is important to note that with some extra equipment and minimal modifications the same method can be used for other measurements in the process of final control of RR devices.

A. *Measurement of "Series B" RR devices*

Fig. 3 shows measurement method for IMTEL Komunikacije "Series B" RR devices. The computer driven digital transmission analyzer MOTS28SK sends a pseudo-random sequence to the E1 tributary (2.048kbit/s). InDoor Unit (IDU) contains 16xE1 multiplexer and sends a framed HDB3 signal to the OutDoor Unit (ODU) which performs modulation and transmits the signal at a desired radio band. Transmitter and receiver units are connected via coaxial cables and isolated with a 60dB attenuator which simulates a non-selective path attenuation. Received signal is then downconverted and it leaves ODU receiver at the intermediate frequency (IF) of 140MHz. This signal enters the computer-driven fading simulator which causes a frequency-selectable attenuation and in that manner simulates selective fading. A degraded signal is sent to Indoor Unit which performs demodulation and demultiplexing. Simulator is also equipped with a DC bias enabling Outdoor unit to be powered through the same coaxial cable as IF signal. HDB3 coded signal at 35Mbit/s for transmitter and ASK modulated signal on 50MHz for signalization purposes also pass through the fading simulator. After demodulation and demultiplexing in IDU, received E1 tributary is checked for errors with a digital transmission analyzer. The degree of degradation due to selective fading is being explored on the basis of BER measurement, by using a digital transmission analyzer.

B. Measurements of the "Series A" RR devices

„Series A" RR devices are much more complicated in construction and have mutually different structures, depending on bitrate. For this generation, we had to implement automatic measurement of the 17xE1 type of RR device. For this measurement (Fig. 4) one extra clock-signal operating at 2208kHz is necessary, which is routed from IDU 17x2.

For investigation of BER, we used MOTSARV834 equipped with E3 interface. Within the concept of „Series A" devices, demodulator is placed at ODU. A fading simulator is placed between the 2nd downconverter (1GHz-140MHz) and IF base band unit (IF BB) that performs demodulation. After demodulation, E3 tributary from base band unit can be directly connected with a digital transmission analyzer for measuring BER. If the device is equipped with an equalizer, we connect a transmission analyzer to its output, as shown in Fig. 4.

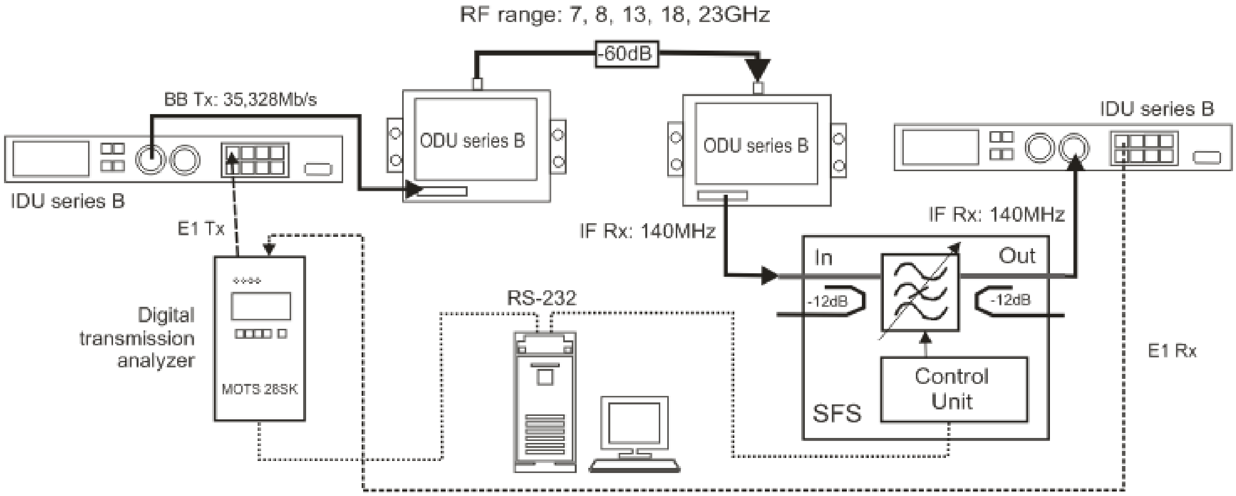

Fig. 3. Method for M-curve signature measurements of IMTEL Komunikacije A.D. "Series B" RR devices (software-selectable bitrate).

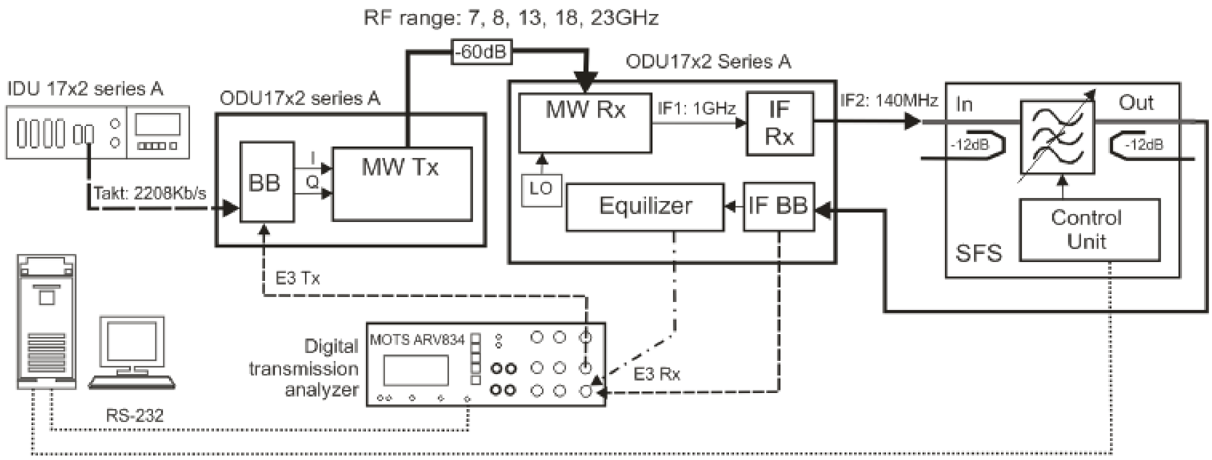

Fig. 4. Method for M-curve signature measurements of IMTEL Komunikacije A.D. "Series A" RR devices (17xE1 bitrate).

C. *Measurements of RR modules*

Fig. 5 shows method for testing RR modules of „Series A“ devices. Method for testing „Series B“ modules is even more simplified, since in this method it is not necessary to use clock source at 2208kHz.

Digital transmission analyzer MOTS ARV834 is used for sending a pseudo-random sequence which enters BB unit. BB unit converts signal to a binary code, and divides it, in order to form I and Q branch. The shaped signal is then brought to IQ modulator which forms a modulated signal at 140MHz. This signal passes through a fading simulator, just like in previous examples. Signal from a simulator goes into IF BB unit which performs demodulation and, optionally, equalization. Signal is then coded with the HDB3 code and forwarded to a digital transmission analyzer. Besides demodulator testing, this method is useful for testing equalizer functionality, as well.

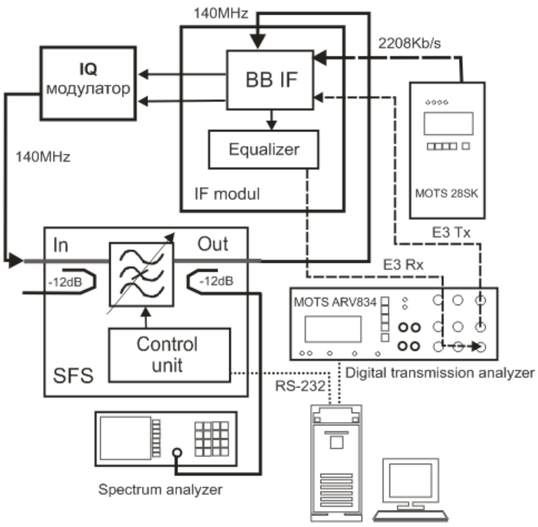

Fig. 5. Measuring of BBIF module.

During all described measurements it is very useful to monitor spectrum of the signal and to visualize the level of present degradations. This is possible thanks to monitor couplers on both input and output ports of the simulator, that are used for connecting a spectrum analyzer. In this manner, signal can be monitored without disturbing the measurement process.

IV. Conclusion

Operations controlled by software during M-curve signature measurements are very simple: along with instruments' control, only some basic computations are being performed. That is why a measurement process is not considered as resource-consuming, and a typical signature measurement includes investigation of several hundreds of different simulator states (propagation channel characteristics) that last around 20 minutes, approximately. At the end of the measurement, results are being displayed graphically (Fig. 6) and stored in a computer memory. Created measurement methods can be used in a very wide range of laboratory tests, and support the possibility of performance investigation for future generations of RR devices.

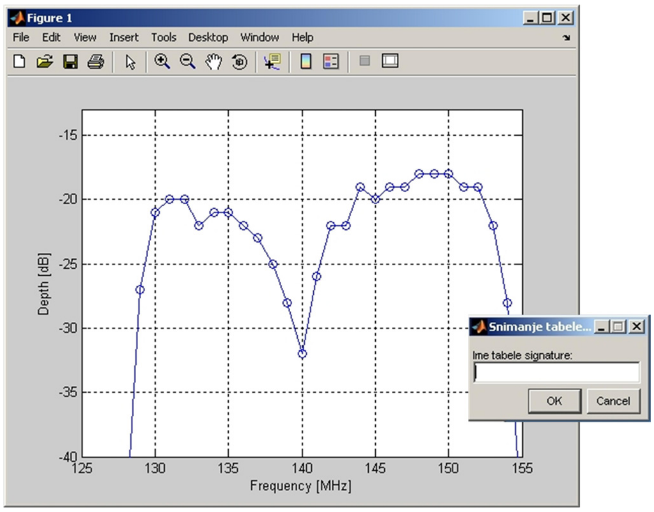

Fig. 6. M-curve signature displayed at the end of measurement.

References

[1] F. Ivanek, editor: Terrestrial *Digital Microwave Communications*, Artech House, 1989

[2] Rec. ITU-R F.1093-1

[3] V. Orlic, M. Peric, M. Zecevic: "Exploring and Improving the Performance of Radio-Relay System Under Frequency-Selective Fading Channel" , *ICEST 2008*, Nis 2008.

[4] M. Peric, D. Peric, M. Stojanovic: „Simulation and laboratory measurement of impact of selective fading on radio-relay device's performance“, *TELFOR 2003*, in Serbian.

[5] J. Liebetreu, 802.16sc-99/13 Dispersive Fade Margin: A Physical Layer Performance Metric

[6] Digital transmission analyzer MOTS 2/8/SK: user guide and measurement methods, IMTEL Komunikacije A.D., Belgrade, 2002, in Serbian

[7] Digital transmission analyzer MOTS ARV8/34: user guide and measurement methods, IMTEL Komunikacije A.D., Belgrade, 2006, in Serbian.