Testing of DVB-H Mobile Terminals Capability

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***Abstract**. This paper deals with the transmission of digital television to the DVB-H mobile terminals and interaction of DVB-H system with GSM/UMTS network. The mobile terminals testing approach is introduced including the testing transmission system in the laboratory of digital television and mobile communications at the Department of Radio Electronics, Brno University of Technology. This system can be used for efficient analysis in research and development of near future commercial DVB-H networks. The task of the DVB-H providers is to offer commercial mobile terminals capable to operate in DVB-H network with GSM/UMTS interactivity channel.*

Keywords

Mobile terminal testing, mobile terminal capability, interaction, DVB-H, GSM.

1. Introduction

Mobile radio networks allow robust point-to-point connections using relatively low data rates. Modulation methods, error protection levels and handover techniques are matched to the more difficult conditions of mobile transmission. Broadcast networks are unidirectional networks involving the point-to-multipoint distribution of identical content to a large number of subscribers at relatively high data rates. Content-on-demand is relatively rare. Predefined content is distributed to a large number of subscribers from a transmitter location or, more recently, through SFN (single frequency networks) [1].

The DVB-H (Digital Video Broadcasting – Handheld) standard is a specification for bringing television broadcast services to handheld mobile receivers. The purpose of the DVB-H standard is in convergence of mobile radio networks and broadcast networks [2]. If traffic volume is large enough, the downstream is mapped from a mobile radio network GSM/UMTS (Global System for Mobile Communication/ Universal Mobile Telecommunications System) to a broadcast network. For example, if only one subscriber requests a service via UMTS, this service will continue to be provided via UMTS in the downstream. However, if numerous subscribers request the same service at the same time, it is worthwhile to offer this service point-to-multipoint via a broadcast network.

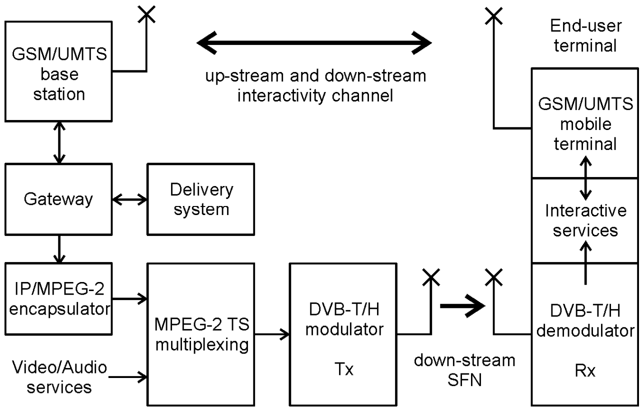

Fig. 1. System reference model with an interactivity channel through GSM/ UMTS network.

2. Digital Television with Interactivity Channel via GSM Network

The system reference model describes the concept of interactive services for DVB-T/H [3], [4].

Two channels are established between the user and the service provider. The network adapter provides connectivity between the service provider and the network while the interface unit connects the network to the end-user. Fig. 1 shows an adaptation of the reference architecture for DVB-H interactive services [5].

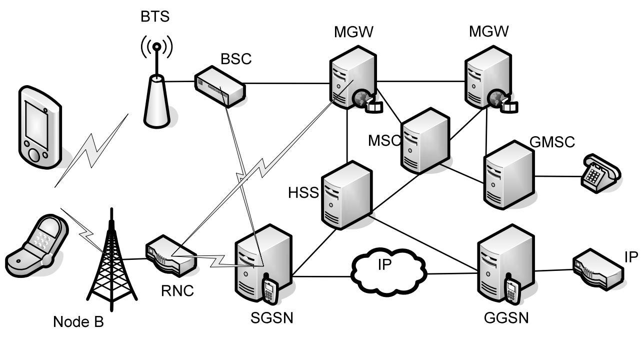

Fig. 2. Scheme of the complex 2G-3G mobile network topology.

The interactivity channel through the GSM (temporal development of DVB-H interactivity channel in the Czech Republic) provides a wireless bi-directional access technology connecting the user to the service provider.

The GSM wireless network may form a complete DVB-H interactivity channel or may be complemented by a further infrastructure such as PSTN (Public Switched Telephone Network) or ISDN (Integrated Service Digital Network) in order to provide a complete transmission path.

3. DVB-H Mobile Terminals Capability Testing

Mobile terminals tests vary depending on the stage of the product development (hardware/software), certification, production or service [6].

Temporal important property of the terminal is its behavior on operational procedures at the GSM network. These procedures can be divided at network procedures, such as location update, cell reselection and handover, incoming call and incoming SMS procedures, etc. Testing of the mobile terminal will inspect degradation of the presented video stream during above mentioned procedures. Degradation can be evaluated via count of video signal dropout, time of dropout, loss of signal and application terminating. Test setup enables measurement with different GSM signal strength in comparison to DVB-H signal.

Video quality measurements can be evaluated only in the subjective evaluation of the video stream dropouts during the incoming calls and other GSM procedures. The dropouts can be captured using the web camera record analysis and time reference of the GSM procedures.

Another important test should be the analog RF television channels interaction with the DVB-H service located in adjacent television channels. This test can be performed using the standard analog television broadcasting and laboratory DVB-H broadcasting.

4. Laboratory DVB-H Transmission System

The DVB-H test transmission system is placed in the laboratory of digital television and mobile communications at the Department of Radio Electronics, Brno University of Technology. Fig. 2 shows the illustrative setup of the test system used for measuring DVB-H network parameters and mobile terminals capabilities [7].

The transmitter side consists of the MPEG-2 TS generator with the DVB-H stream option (DVB-H test sequences and real sequence of the DVB-H broadcasting record) and DVB-T/H test transmitter with 2k, 4k and 8k mode, time-slicing, in-depth interleaver and MPE-FEC (Multi Protocol Encapsulation – Forward Error Correction) option. These are R&S DVRG generator with R&S DVB-H Library (MPEG-2 TS, multiplexing of H.264 AV streams) and R&S SFL-T test transmitter with DVB-T/H support (time slicing on/off, MPE-FEC on/off, 4k mode).

The reference side consists of the mobile terminal and reference test receiver with 2k, 4k, 8k mode support. The receiver MPEG-2 TS output is connected to the MPEG-2 TS analyzer (transmission errors check and statistics). Receivers are tested DVB-H mobile terminal (e.g. Samsung SGH-P910) and test receiver Kathrein MSK 33 with MPEG-2 TS output (power, BER and SNR measurements, spectrum and constellation analysis). The reference is R&S DVMD MPEG-2 TS analyzer, too (time slicing analysis, DVB tables and error priority statistics).

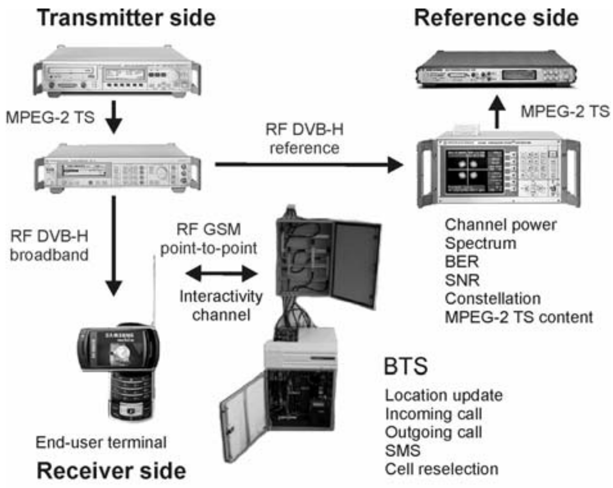

Fig. 3. Laboratory DVB-H testing transmission system with interactivity channel and network procedures via GSM.

The interactivity channel via GSM part of the testing system consists of T-Mobile CZ network picocell, which has two sectors. BTS is configured that each sector has another LAC (Location Area Code), so that Location Update procedure can be simulated.

5. Measurement Results

The experimental results will be described in this section. Experiments are divided into the two sections. The first section is about mobile terminal capabilities and the second section is about RF parts of the terminals.

The test setup was extended by the Rohde&Schwarz ROMES test system with TSM DVB receiver. This improvement allows measuring specific parameters due to the DVB-H in FFT mode 4k, which cannot be measured with Kathrein MSK 33. The ROMES system can measure the MER (Modulation Error Ratio) of the DVB-H in 4k mode.

Comparison of mobile terminal capability in RF front-end can be performed with RF measurements as:

- received channel power (as reference MSK 33),
- sensitivity of DVB-H receiver in UHF band (21 to 55) and VHF (56-69) TV channel (as reference MSK 33),
- channel BER before FEC (as reference MSK 33),

- interaction between GSM and DVB-H part of the mobile terminal for various GSM signal strength (using BTS).

5.1 Capabilities of the Terminals

The capabilities of the terminals are crucial for network operator due to parameters of the networks that can be used in. First of all, usage of different TV channels is mentioned. Due to RF signal coverage problem, lower frequency usage is better, but this implies to limitation of the antenna.

These channels were selected randomly from the IIIth, IVth and Vth television frequency band. Only the channel 538 MHz was used due to usage of the network operator in previous DVB-H pilot project and limitation of the only measured terminal (see Tab. 1).

DVB-H standard was developed for different types of modulation (see Tab. 2). Terminal should be accepting the modulation type change automatically, but only Terminal 2 was working correctly, other terminals must be changed manually. This means that TV viewer application must be restarted and it is very bad from user point of view.

DVB-H network will be configured as Single Frequency Network (SFN) with differences in settings of the OFDM signal and modulation properties. Let's say, that the automatic reconfiguration of the terminal is crucial.

The second parameter of the signal, which can change in different coverage area, is FFT mode (see Tab. 3). The DVB-H has implemented 4k network mode, but in experimental pilot project broadcasting 8k was used, too.

Combination of the code rate and guard interval is a limitation for the used transport stream bit rate (see Tab. 4). This is important for SFN network design and for number of TV channels in transmitted multiplex (see Tab. 5).

Each terminal is capable to work with all combinations of above mentioned parameters. This is good for DVB-H implementation and for service users.

Properties of the receivers can be verified via simulation of the RF baseband signal imperfections caused by transmitter. The terminals work correctly in this test case (see Tab. 6).

Channel	Terminal 1	Terminal 2	Terminal 3
210 MHz	—	—	—
474 MHz	—	X	—
538 MHz	X	X	X
594 MHz	—	X	—
618 MHz	—	X	—
706 MHz	—	X	—
754 MHz	—	—	—

Tab. 1. Available TV channels.

Modulation	Terminal 1	Terminal 2	Terminal 3
QPSK	X/M	X/A	X/M
16QAM	X/M	X/A	X/M
64QAM	X/M	X/A	X/M

Tab. 2. Modulation type.

FFT Mode	Terminal 1	Terminal 2	Terminal 3
2k	X/M	X/A	X/A
4k	X/M	X/A	X/A
8k	X/M	X/A	X/A

Tab. 3. Various FFT modes.

Code rate	Terminal 1	Terminal 2	Terminal 3
1/2	X	X	X
2/3	X	X	X
3/4	X	X	X

Tab. 4. Used code rates.

Guard interval	Terminal 1	Terminal 2	Terminal 3
1/32	X	X	X
1/16	X	X	X
1/8	X	X	X
1/4	X	X	X

Tab. 5. Guard intervals.

	Terminal 1	Terminal 2	Terminal 3
Phase error	± 10 %	± 10 %	± 10 %
IQ imbalance	± 25 %	± 25 %	± 25 %
Carrier Suppression	—	—	—

Tab. 6. Modulation imperfections.

	Terminal 1	Terminal 2	Terminal 3
MPE-FEC	X	X	X
Time Slicing	X	X	X
All OFF	X	X	X

Tab. 7. DVB-H specials.

DVB-H concept implements additional FEC coding, known as mentioned MPE-FEC and additional Time slicing for power saving of the terminal battery. Each terminal can operate with these improvements turned on/off (see Tab. 7).

Comparison of the DVB-H terminals provides possibilities to network operator for network optimization (FFT mode usage, modulation type and guard interval and code rate). These comparisons may be affected by terminal firmware, application versions and of course by the network configuration.

5.2 Measurement of the DVB-H Terminals RF Part

Measurement of the RF part was made via subjective comparison of video quality and reference measurement of power level with Kathrein MSK 33 reference receiver and test system ROMES. Objective measurement of the received power is not possible, because there is no system and test menu information accessible in terminals.

Comparison of all terminals was made only for television channel number C29, frequency 538 MHz (see Fig. 4 and 5). This frequency was used for the DVB-H pilot project in the Czech Republic and was supported by all three terminals. Presented results correspond to higher SNR requirements for 16QAM modulation.

Fig. 6 shows a comparison of RF part properties of the Terminal 2 for various TV channels. It's easy to see that RF part has lower sensitivity at a higher frequency. High order modulation format needs better SNR, so a dropout of TV signal occurs at higher signal strength.

The last test of mobile terminal properties was a simulation of the RF signal dropout and capabilities of an application to continue in video view. The short term dropout was 4 sec long and all terminals continued in receiving of the selected TV program from the DVB-H Transport Stream. The second dropout was 10 sec long and Terminal 2 started to scan for another channel. Terminal 1 and Terminal 3 needed to restart the TV application and tuned the channel.

5.3 Interaction between GSM and DVB-H

Interaction between GSM and DVB-H network is mentioned as a behavior of the DVB-H application in presence of GSM network procedures, such as incoming call, SMS receiving or Location Update procedure.

Interaction was evaluated in the laboratory test setup and picocell with two sectors of BTS with different BSC (Base Station Controller) with different LAI (Location Area Identification). So, the Location Update was occurred when a serving cell was changed. Incoming call and SMS were made via laboratory BTS.

The behavior of the terminal in presence of GSM Location update procedure was observed subjective. Terminal 1 lost the TV signal for 4 seconds (picture freeze), but restart of application was not needed. Terminal 2 had picture freeze only for one second. Terminal 3 had troubles with low sensitivity of the DVB-H receiver, so it can not be said if the dropout of the TV signal was caused by location update procedure or by low terminal sensitivity. The incoming call processed the Terminal 1 without termination of playing TV program on display.

Terminal 2 closed TV application and after call ending asked the user for the application restart if desired. The last Terminal 3 did not display a picture of the TV program during the call, but after call ending the TV application was automatically restored. Incoming SMS doesn't affect viewing of the TV in all terminals at all.

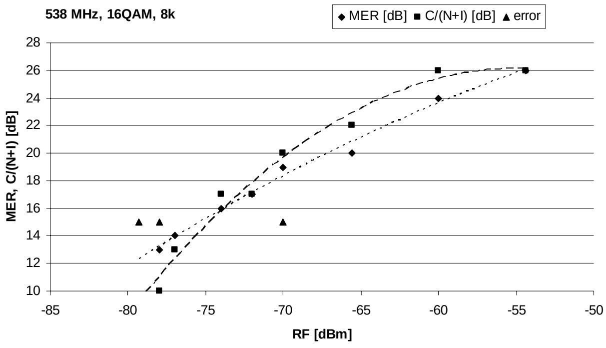

Fig. 4. RF part properties for 16-QAM modulation and 8k FFT mode, television channel C29 and all terminals.

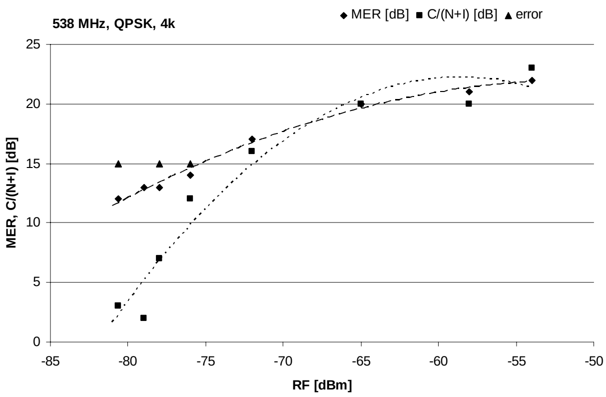

Fig. 5. RF part properties for QPSK modulation and 4k FFT mode, television channel C29 and all terminals.

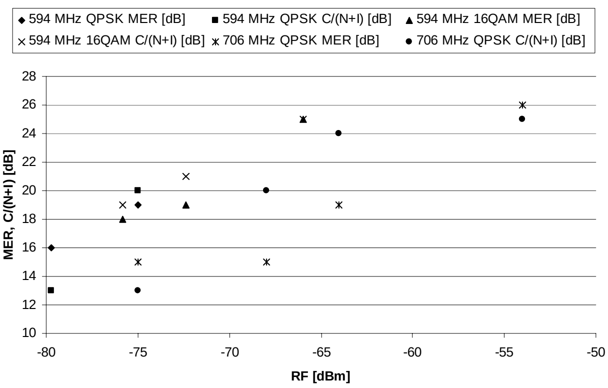

Fig. 6. RF part properties for Terminal 2 and various modulation and various FFT mode and changed television channel.

6. Conclusions

There is the successful DVB-H pilot project of the T-mobile CZ (the provider of GSM/UMTS mobile network) and the Czech Radiocommunications (the provider of DVB-T SFN network, www.cra.cz) companies made in autumn 2006 in the Czech Republic.

The near future plan is to reserve one commercial DVB-H program multiplex in SFN network for all three Czech mobile providers. Such multiplex will contain several LDTV (360 x 288 pixels) streams coded in H.264/MPEG-4 AVC and interactive services encapsulated into the MPEG-2 TS. The broadcast channel of DVB-H will be available via DVB-T SFN television transmitters. The interactivity channel will be available via GSM/UMTS network. It is obvious that before the commercial launch of the full interactive DVB-H in the Czech Republic the compatible and pre-tested mobile terminals must be available in the commercial market. Of course related optimal and effective configuration of the DVB-H network must be secured.

The comparison of mobile terminal capability in RF front-end can be performed with RF measurements as received channel power (as reference MSK-33), sensitivity of DVB-H receiver in UHF band (21-55) and (56-69) TV channel (as reference MSK-33), channel BER before FEC (as reference MSK-33), interaction between GSM and DVB-H part of the mobile terminal for various GSM signal strength (using laboratory BTS configuration).

Measurements and terminal capabilities evaluation showed that parameters of the terminals are similar. Main differences are in the RF part sensitivity. There is the worst case with Terminal 3, which needs power level higher than or equal to -76 dBm. This terminal has troubles with restart of the TV application after signal dropout and also has troubles with automatic changing of the receiver setup when signal parameters are changed.

At this point it must be notified that some errors or terminals incapabilities can be fixed by mobile terminals firmware update.

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