

REPORT ITU-R BT.2139

Diversity reception of digital terrestrial television broadcasting signals

(2008)

1 Abstract

Diversity reception of digital terrestrial television broadcast signals offers substantial improvement in coverage of television services. Planning parameters for mobile reception can be found in Recommendation ITU-R BT.1368-7. The use of diversity receivers is increasing. The results of tests performed in Italy and Japan with mobile reception of digital terrestrial television can be found in this Report.

Part 1 of this Report presents mobile diversity case reception field test regarding present DVB-T. It presents the results of a study carried out by RaiWay on the possibility to receive present digital terrestrial television (DTT) broadcasting (64-QAM, FEC 2/3) in vehicular mobility conditions. Herein is proposed a receiving system capable of properly managing and possibly solving the typical problems concerning the reception of DTT broadcastings in vehicular environments and are outlined the results of a comparison between the performances achieved in several field tests by the proposed receiving system and a reference single antenna professional receiver.

Part 2 of this Report presents mobile reception with four-branch space diversity for ISDB-T. Mobile reception of digital terrestrial broadcasting carrying a digital high definition television (HDTV) signal was successful with four-branch space diversity. The effect of 4-branch diversity reception in a moving vehicle for a 64-QAM-OFDM signal was experimentally investigated by using prototype hardware. Field-based experiments showed evidence of a drastic improvement in reception performance and a reduction in the required minimum field strength as compared to that obtained using single dipole antenna.

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Part 1

Digital terrestrial television: Mobile diversity case reception field test regarding present DVB-T

1 Scope

Verify in a field test, the possibility to receive in vehicular mobility mode the DVB-T emissions broadcasted by the already on air networks, which has been developed and implemented to ensure fixed antenna reception through a complex system of reception.

DVB-T mobile reception can easily achieve at least three major advantages with respect to DVB-H broadcastings:

- seamless use of already existing network infrastructures (no need to further capex);
- remarkably higher reception quality, both in terms of screen resolution and of available bit-rate, compared to the reception quality currently available or expected by DVB-H broadcastings, allowing therefore to install high-quality display up to large-sized screen on board of vehicles (cars, vans, coaches, tramway cabs, trains, ...);
- availability for the end user of a wide range of subscription-free contents.

We assumed that this type of mobile DVB-T reception can be achievable by the use of “diversity” receivers with carriers coherent sum (CCS) system.

2 Introduction

Presently, broadcasted TV emissions in DVB-T standard allow Italian operators to cover the majority of the population resident in urban and rural areas. The network planning carried out by all DVB-T operators was targeted to guarantee the so-called “fixed antenna reception”, that is to say by means of a rooftop antenna. Also because of the Italian law constraints concerning electromagnetic pollution, said network planning considered the so-called “indoor reception” (without the use of external antennas) as a far secondary priority, and mobile reception was not included in the scope of work. In this market scenario the DVB-H standard was developed to the scope of allowing an adequate-quality mobile reception of a large number of programmes to be displayed on stand-alone portable receivers approximately sized as mobile phones or PDA, capable of a battery life adequate to the enjoyment of the broadcasted services. The DVB-H Standard practically requires a QPSK or 16-QAM modulation. This limits the available bandwidth per single programme, and in order to broadcast several programmes in the same channel it is commonly accepted to limit the screen resolution of each programme according to the typical resolution performance of the screen generally available on handheld equipments (CIF or similar). Such a compromise can be considered as adequate for pedestrian mobile reception, but limits the achievable performance in the case of vehicular mobile reception (vehicles, bus in city or intercity service, trains...), where larger displays are typically implemented. It is here useful to point out that vehicular reception can take advantage of the on-board electrical power plugs, and therefore any concern about battery duration is superseded.

3 Carriers coherent sum diversity receiver system

A diversity system commonly implies the employment of a receiving system whose main characteristic is the redundancy of some or all of the functional parts included in it. Each of the redounded part is in all capable to carry out its own task independently from the concerned “twin”,

and from an overall point of view we can say the redundancy allows to choose dynamically, moment by moment, the part which is offering the best performances. In short, the concept of diversity implies the concept of “choose of the best receiving condition”. The CCS diversity system represents a remarkable step ahead, and it can be adopted thanks to the COFDM modulation used in DVB-T standard. In the CCS case the RF system is completely redounded: Each of the two different antennas is connected to one receiver. Each receiver demodulates the carrier mask of the received signal. The two receivers are linked through a data bus by which receiver A “sends” to receiver B the carrier mask of the received signal. An appropriate circuit allows to re-synchronize (coherent) the two carrier masks to add, carrier by carrier, the amplitude of each pair of matching carriers (sum in phase of carriers amplitude, sum in power of the noise). The idea of “choose” here is definitely replaced by the idea of “merge”: even in case of two received signals, each of them is not lockable by the receiver, it could happen (and it happens!) that a signal, whose carrier content is the sum of the carrier content on each of the received signals, can be perfectly locked and decoded. This receiving mode can be usefully adopted in mobile reception. Our field test testifies the correct operation in vehicular mobility conditions of the CCS receiver under test. Given to the “consumer” nature of CCS receivers nowadays available in the market, it is not yet possible to carry out quantitative objective measurements on the reception quality in vehicular mobility conditions, because of consumer receivers supply no indication on the necessary data to determine the objective quality of reception.

4 Test development

Our field test has been developed in four consequent steps:

Step 1: Choice of the test vehicle and of the best receiving antenna system.

Step 2: Analysis of the available instruments (directly by RaiWay and with the cooperation of Rohde & Schwarz Italia) and choice of the data measurement and storage system.

Step 3: Reference vehicle implementation and field test.

Step 4: Analysis of the acquired data.

4.1 Choice of the test vehicle and of the best receiving antenna system

Among the various mobile laboratories in our fleet we chose the medium van Volkswagen Transporter. This vehicle has a footprint like a SW car, but a height like a SUV. This allowed us to use a single vehicle to carry out field tests referable to the majority of the vehicles potential target of such a receiving system. The choice of the receiving antennas has been carried out among consumer level models easy available on the market. One of the goals of this test was to verify whether it is possible to achieve the desired receiving performances by means of a receiving system whose size and costs allows the end user to easily install it on common vehicles, both as factory equipment and after-market one. Some field tests pointed out that the simplest and less visible receiving system, with two pre-amplified film antennas located on the windshield and on the rear window of the vehicle, can allow adequate receiving performance on commercial CCS diversity receivers. As a plus, this double antenna system is practically invisible. The use of one pre-amplified film antenna and one stylus antenna placed on top of the vehicle (a more invasive solution indeed) caused no significant advantages.

4.2 Analysis of available instruments (directly by RaiWay and with the cooperation of Rohde & Schwarz Italia) and the choice of data measurement and storage system

Scope of this test is the evaluation of the advantages that a CCS receiving system can offer in vehicular reception of existing DVB-T broadcastings compared to a single antenna receiver. As previously stated, no measurement instrument capable to perform quality reception

measurements in mobility conditions is currently available in the market. Should said instruments appear on the market it will be possible to improve Recommendation ITU-R BT.1735. Therefore our job pursued the way to compare the performance difference between said two receiving systems in everyday conditions. To this scope, RaiWay took advantage of the cooperation with Rohde & Schwarz Italia. As a start, we had to select a reference single antenna receiver; it was strictly requested to select a receiver designed to mobile use. Some high-end measurement instruments, designed to laboratory (stationary) use, revealed themselves definitely not adequate to our purposes, because they lose any signal locking as far as the vehicle speed exceeded 10-20 km/h. To ensure a conservative comparison, the choice of the reference single antenna receiver led us to a professional Rohde & Schwarz TSM-DVB equipment, with ASI out. This receiver, designed for the mobility use, is a diversity receiver with selection of the best received signal (no CCS), but when connected to just one antenna it performs as a single antenna receiver. The choice of the CCS receiver led us to an MB international prototype, not yet on the market, with both decoded video and ASI outs. The ASI out is a rare feature on consumer receivers, but it is a must for us. In fact, the advantages that the CCS configuration can offer affect the “reconstruction” of the carrier mask, while the subsequent MPEG-2 decoding must have no contribution to a trustable comparison between the considered receiving systems. We therefore had to include homogenous MPEG-2 decoding stadiums in our test bed. The ASI out of the two receivers were thus connected to two professional MPEG-2 decoder Rohde & Schwarz DVMD.

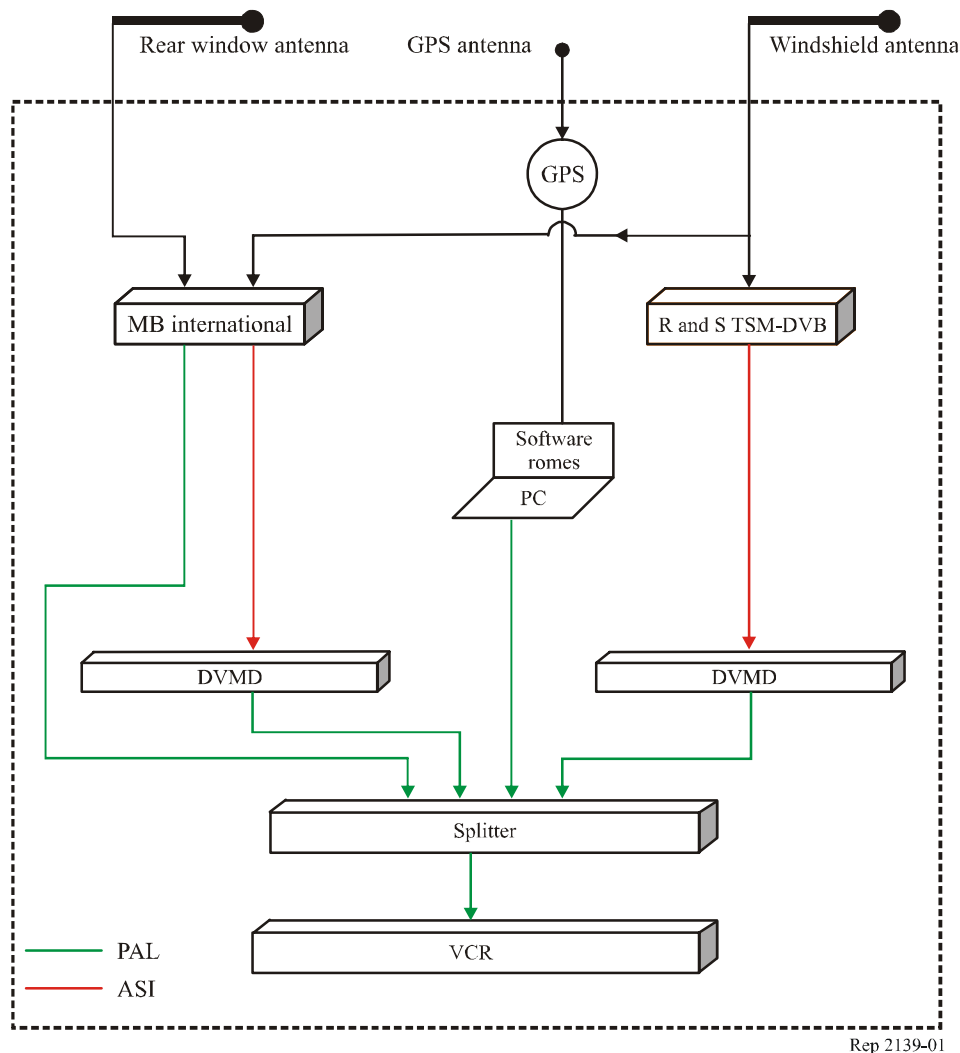
4.3 Reference vehicle implementation and field test

The Volkswagen Transporter was equipped with all the items and instruments described above. Further, to allow an immediate comparison between the two receiving systems the video out of each DVMD was connected to a four-way video splitter; the remaining two inputs were connected to the decoded video out of the CCS receiver, in order to compare the performance of the CCS receiver inner decoder Vs. the reference decoder (R&S DVMD), and to the video out of a laptop computer, connected to a GPS receiver and running a Rohde & Schwarz software (ROMES), capable to display on a background map the present position, heading and speed of the vehicle. The four-in-one splitter out was connected to a video recorder for the recording and the subsequent analysis. The complete connection diagram can be found in Fig. 1. Then we determined four reference paths where to perform our field test. Along these paths one can find the most common receiving conditions of urban, suburban, rural and highway routes. Since our receiving systems did not include the automatic search for alternate frequencies, said reference paths had furthermore to allow an adequate coverage by the same DTT signal on the same frequency. The selected paths are:

- Path 1:* Monza – Dalmine and back along the highway A4; it is an average speed journey (due to traffic congestion) but characterized by frequent obstacles in fast movement across the transmitter line of sight (the vehicles on adjacent tracks and on the opposite tracks) which cause rapid and continuous changes of near reflection conditions.
- Path 2:* Monza – Sesto Calende and back along the A4, the A8 and the A26 highways; it is a high speed journey (thus compliant with the 130 km/h Italian speed limit) with some passages in earth trench.
- Path 3:* A circular route along an urban Milan city ring; medium average speed (70 km/h speed limit in some parts, 50 km/h in the rest), wide roads surrounded by 5/7 storey buildings, one tramway overhead power line in the centre of the track, intense but flowing traffic.
- Path 4:* A route in the historical centre of Milan; crowded traffic, narrow roads surrounded by high buildings (no direct beam, pure Ricean channel).

For all of the four paths we set the receivers on channel 64, on which the so-called RAI “MUX A” is radiated from the sites of Valcava (mountain site at the borders between the province of Lecco and Bergamo) and from the mountain site of Campo dei Fiori (Varese), operating in SFN with two other systems in Lombardy, with 64-QAM modulation and 2/3 FEC. The field tests were carried out during September and October 2006.

FIGURE 1
Test bed connection diagram



4.4 Analysis of the acquired data

We have herein to testify that the performances shown in this field test by the single antenna receiver have no reference to the proper performances of the diversity receiver Rohde & Schwarz TSM-DVB; the performances shown in this field test refer only to the case of the same professional receiver in a mobile environment, but under the specific conditions in which just one of the two inlets of the diversity receiver is connected to a receiving antenna. Said receiver is composed by two independent receivers and one logic of selection; therefore if connected to a single receiving antenna it performs just in the same way of a single antenna receiver of similar capabilities and quality.