

Application Note

**Simulation of DVB-T Channel
for
Antenna Diversity
Reception**

Products:

TV Test Transmitter

R&S SFQ

7BM06_0E

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1 Introduction

DVB-T can be used for stationary, portable and – using the diversity technique – also mobile reception. Stationary reception via a Gaussian channel and a fixed Yagi antenna on the roof usually poses no problems. This is different with portable reception, for example on a park bench, if there are moving objects in the vicinity of the receiver that has been put up for optimal reception. These may be persons or any kind of vehicles that – while passing by the receiver - generate different types of reflections. With mobile reception, for example when driving on a motorway, poor receiving conditions have the most detrimental effect [1].

Receiving conditions can be considerably improved by employing several antennas, a technique that is referred to as antenna diversity. This application note discusses the improvements that can be achieved with antenna diversity and explains how to simulate a DVB-T channel with the required characteristics by means of TV Test Transmitter R&S SFQ.

2 Antenna Diversity Reception

Measurements in DVB-T networks have shown – both for indoor and outdoor reception – that dips of several 10 dB of the receive field strength can be largely compensated for by varying the antenna position in the range of about a quarter of a wavelength of the DVB-T (Rayleigh or Rice) channel.

Therefore, if at least two antennas set up at a spacing of about half a wavelength from each other are available simultaneously for the reception of DVB-T signals, receive conditions can be optimized by switching to the appropriate antenna in each case. A diversity receiver therefore has the following basic design:

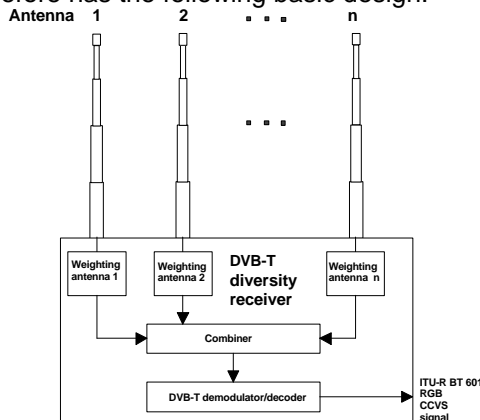


Fig. 1 Diversity receiver with n antennas

Normally, two antennas (for the UHF range only) are installed at a distance of 20 cm to 30 cm from each other. Studies have shown that, with this configuration, dips in field strength can be substantially reduced both for portable and mobile reception.

Selective antenna switching is the operating mode that offers the lowest gain, however, as power from only one antenna is utilized at a time. Greater efficiency is achieved by employing a configuration with two complete demodulators and a special technique known as maximum ratio combining (MRC):

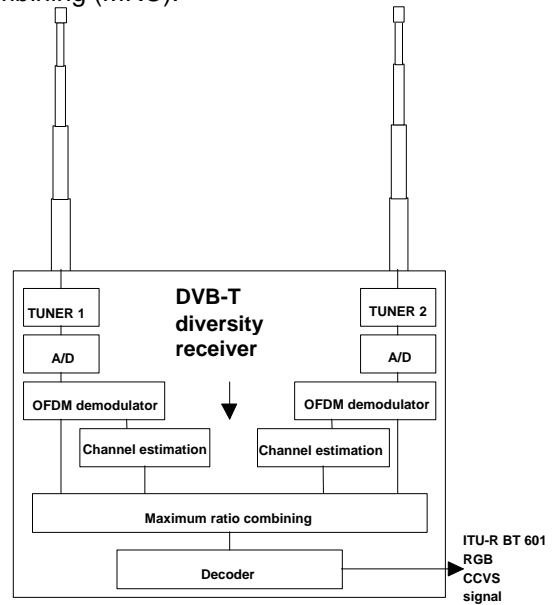


Fig. 2 MRC receiver with two antennas

Each antenna signal is taken via a tuner and an A/D converter to an OFDM demodulator. The pilots of the DVB-T signal are weighted with factors calculated in channel estimation, and then amplitude- and phase-corrected and added up in the MRC block. The carriers between the pilots are determined by way of interpolation using filters that cover several symbols and pilots in the symbols, and then likewise amplitude- and phase-corrected and added up.

The gain obtained with this configuration is sufficient to enable mobile reception throughout the UHF range up to 130 km/h (channel 69) and 230 km/h (channel 21), that is in the 8k mode with 16QAM, puncturing to 1/2 code rate, and with a guard interval of 1/4, yielding a data rate of 9.9529 Mbit/s. This is verified by simulations and measurements using the test setup described below within the framework of MOTIVATE.

The simulation of receive conditions with two independent channels – corresponding to the two antennas used in the diversity mode – is indispensable for measuring diversity receivers.

3 Simulation of Antenna Diversity Reception with Two TV Test Transmitters R&S SFQ

Simulation of antenna diversity reception is explained in the following by means of the block diagram of TV Test Transmitter R&S SFQ.

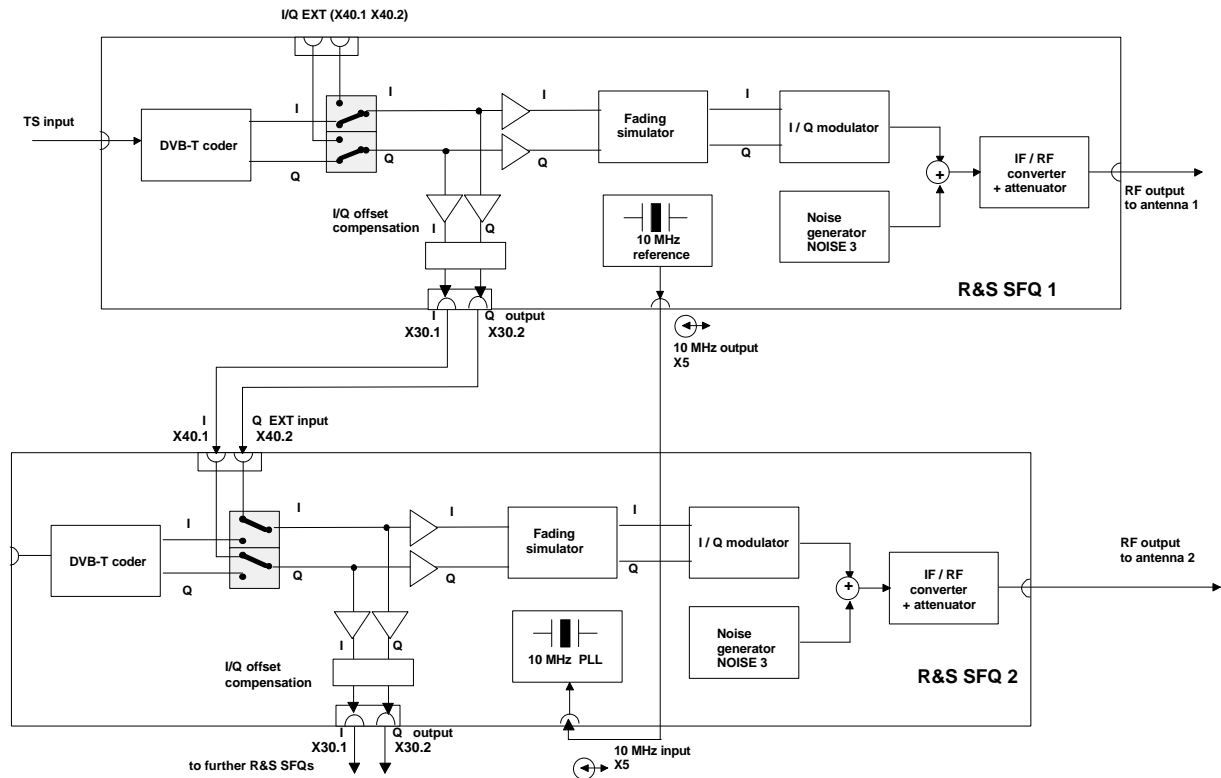


Fig. 3 Simulation of antenna diversity reception with two antennas by means of two R&S SFQs

The transport stream data present at the input of the R&S SFQ 1 is processed in the DVB-T coder and applied to the subsequent buffer amplifiers as analog I and Q signals. From the buffer amplifiers, the I and Q signals are routed via two paths:

On the first path, the signals are taken to the R&S SFQ 1 fading simulator and the I/Q modulator, to whose output signal noise from the R&S SFQ 1 noise generator option can be added. The modulated signal is converted to the RF and applied to antenna 1.

On the second path, the I and Q signals are taken to the R&S SFQ 1 rear panel and then applied to the I and Q EXT inputs (X40.1 and X40.2) of the R&S SFQ 2.

These inputs are activated by selecting I/Q EXTERNAL modulation on the R&S SFQ 2.

The I and Q signals processed in the R&S SFQ 2 are therefore identical to those in the R&S SFQ 1, and the I and Q paths of the R&S SFQ 2 are identical to those of the R&S SFQ 1.

With this configuration it is ensured that the RF outputs of the two R&S SFQs carry uncorrelated superimposed noise and uncorrelated fading profiles as in real diversity reception.

The analog BNC connectors (X30.1 and X30.2) for the output of the I and Q signals on the rear of the R&S SFQ 1 as well as the associated cables are available as an option (Cable Set for Diversity R&S SFQ-Z5). To fit this option, the R&S SFQ-B5 Noise Generator option, model 2072.7579.03 (NOISE 2) or 2072.7579.04 (NOISE 3), must be installed.

The R&S SFQ-Z5 option cannot be installed together with the R&S SFQ-B14 option.

For RF synchronization, the R&S SFQ 1 supplies a 10 MHz reference signal from connector X5 to the 10 MHz reference input (likewise X5) of the R&S SFQ 2. The synthesizers of the R&S SFQ 1 and the R&S SFQ 2 are thus synchronized. When on the R&S SFQ 2 the same RF frequency is selected as on the R&S SFQ 1, the converter of the R&S SFQ 2 feeds antenna 2 with a signal appropriate for diversity reception. The fading simulators of the R&S SFQ 1 and the R&S SFQ 2 can be set independently of each other. To each of the two antenna paths, fading profiles and uncorrelated noise can be added as required for the diversity receiver measurements to be performed.

4 Multiple Antenna Diversity

Diversity reception with more than two antennas increases reliability of reception. Several R&S SFQs can be cascaded to yield an n antenna diversity configuration, see Fig. 3. This requires n-1 R&S SFQs fitted with the R&S SFQ-Z5 option and a distribution amplifier for the 10 MHz master reference.

5 Settings and Adjustments on R&S SFQ 1 and R&S SFQ 2

Definition of terms:

Master M = R&S SFQ 1

with I/Q output to
NOISE 2/NOISE 3

Slave S = R&S SFQ 2

with I/Q derived from M

1) M and S:

Connect I/Q outputs of M to I/Q inputs of S.
Connect 10 MHz reference output of M to 10 MHz reference input of S.

M:

SETUP\PRESET\10MHZ REF. to
INTERNAL

S:

SETUP\PRESET\10MHZ REF. to
EXTERNAL

2) S:

Select I/Q EXTERNAL modulation, and in this mode, set I/Q INPUT SIGNAL to DVB-T FROM R&S SFQ (= 6.5 dB).

3) M:

HOME/MODULATION/F3 = CAL I/Q ONCE

Calibrates only the I/Q coder and thus also optimally adjusts the residual carrier suppression of M (to typ. >25 dB).

4) M:

SETUP\SERVICE/DIVERSITY OFFSET
Allow for approx. one hour warm-up time for S, then change the I and Q values as follows:

Connect the RF output of S to a TV Test Receiver R&S EFA model 40/43 and adjust for maximum residual carrier suppression as follows:

Switch M and S to the 2k mode, central carrier (852) only. Minimize the residual carrier of S by varying the I values for the amplitude of the constellation diagram of S and the Q values for the phase of the constellation diagram of S, using the DIVERSITY OFFSET function of M in both cases. Check the residual carrier suppression (>25 dB) on the R&S EFA by means of the COFDM parameter function. Switch M and S to the desired mode (8k or 2k).

5) M:

SETUP\SERVICE\CODER/DVB-T
CARRIER = ON

Adjust C/N by means of a spectrum analyzer.

Settings on R&S SFQ 1 (master):

RF = 150 MHz to 300 MHz, C/N = 0 dB
(NOISE = OFF).

Settings on spectrum analyzer:

detector = RMS, sweep = 10 s,
resolution 1 dB/div, span = 10 MHz.

Measure in lower third of screen, place display line on DVB-T spectrum and store display line. Then switch to CARRIER = OFF and NOISE = ON to check whether the DVB-T spectrum and the noise spectrum have the same level. If necessary, adjust with NOISE SHIFT. Switch back to CARRIER = ON.

This is the most accurate, but also the most time-consuming method of checking the noise level.

If the R&S SFQ-B5 Noise Generator option is fitted (model 2072.7579.03 (NOISE 2) or model 2072.7579.04 (NOISE 3)), adjustment is much easier: C/N is adjusted automatically on pressing the NOISE CAL softkey.

6) S:

SETUP\SERVICE\CODER/DVB-T
CARRIER = ON

Set RF LEVEL to same value as on M.

Correct DVB-T spectrum so that it matches the stored display line, using EDIT CORRECTION in the I/Q EXTERNAL/I/Q INPUT SIGNAL menu, then switch to CARRIER = OFF and NOISE ON (C/N = 0 dB) to check whether the DVB-T spectrum and the noise spectrum have the same level. If necessary, adjust with NOISE SHIFT. Switch back to CARRIER = ON.
M and S:
Switch to NOISE = OFF or set required C/N.

Reference
1 Fading, Channel Simulation with DVB
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7) M and S:

Select fading profiles for R&S SFQ 1 and R&S SFQ 2.