ISO/IEC JTC 1/SC 29/WG 1 **N 3083**

Date: 2003-10-27

ISO/IEC JTC1/SC29/WG1
(ITU-T SG8)

Coding of Still Pictures

JBIG	JPEG
Joint Bi-level Image Experts Group	Joint Photographic Experts Group

TITLE: **Transmission of JPEG 2000 images over a DRM system: error patterns and modelisation of DRM channels**

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PROJECT: **JPEG 2000 part 11**

STATUS:

REQUESTED ACTION: **To be presented at WG1 JPWL intermediate meeting in Lausanne, November 2003**

DISTRIBUTION: **WG1 web pages**

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Transmission of JPEG 2000 images over a DRM system: error patterns and modelisation of DRM channels [1]

1. Introduction

The Digital Radio Mondiale (DRM) system [1] is a digital radio system for digital transmissions in the broadcasting bands. Designed to be used at any frequency below 30 MHz, *i.e.* for the long wave, medium wave and short wave broadcasting bands, and consequently with variable channel constraints and propagation conditions throughout these bands, this system is made to re-use the existing AM broadcasting frequencies and bandwidth across the globe. Offering near-FM quality sound, and coupled with multimedia capabilities, DRM aims at revitalising the old AM broadcasting bands.

Among the non-audio services foreseen for DRM, it is proposed [2] to consider the transmission of program related data services such as JPEG 2000 [3] images that could illustrate the audio transmitted, provide extra information or services to the user. In order to adapt the transmission characteristics (in particular in terms of robustness) of JPEG 2000 images over the DRM channels, it was consequently proposed by THALES Communications team to provide reference error patterns for various use cases.

Considering firstly that DRM is a broadcasting system, hence that the emitter can not rely on any return information on the quality of the received information at the receivers side, and will not provide retransmissions of badly received data, and secondly that DRM channels are bursty by nature, *i.e.* reaching at some time bit error rates much higher than those acceptable for JPEG 2000 transmissions, the use of JPWL tools in JPEG 2000 transmissions over DRM channels is highly recommended to ensure that the transmission is successful.

The purpose of this contribution is to provide error patterns representative for DRM system as well as a simple model of the corresponding channels for allowing to test the JPWL error detection and correction tools, among which the EPB marker introduced in [4].

2. DRM simulator

A DRM Simulator was developed by THALES Communications that emulates data transmission over DRM with respect to specification ETSI ES 201 980.

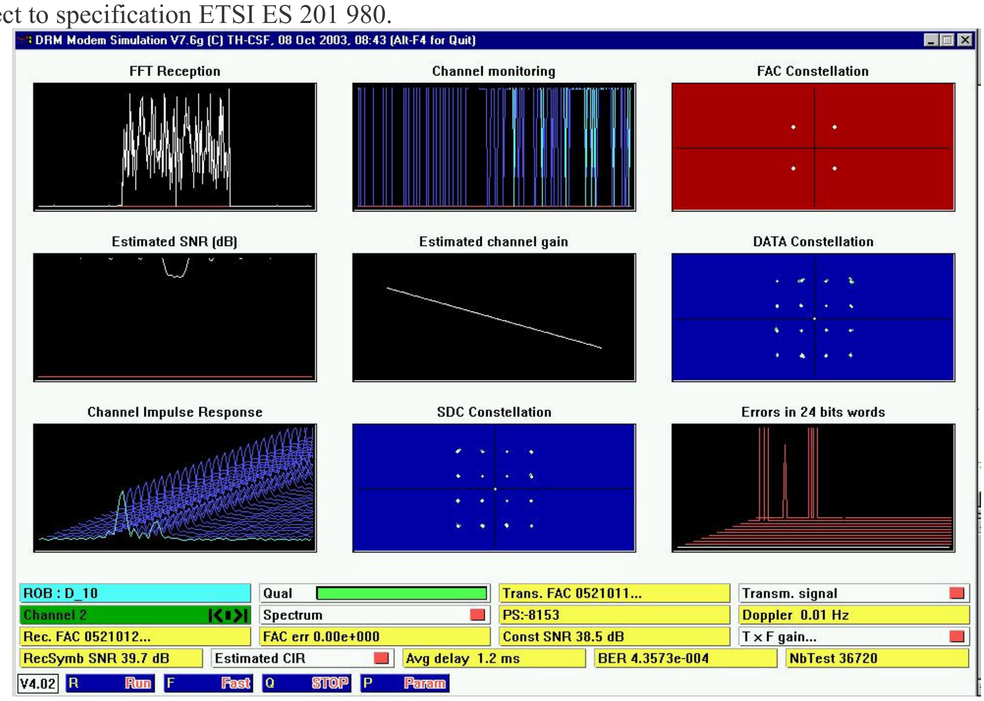

Figure 1 - Snapshot of DRM Simulator.

[1] This work was supported by the European Commission through the European project 2KAN (IST-2001-34096).
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Its role is to emulate the data transmission over the MSC (Main Service Channel), the information on services localisation and MSC data decoding being determined by the FAC (Fast Access Channel) and SDC (Service Description Channel). Its main parameters are:

- spectrum occupancy
- data constellation (MSC)
- coding rate
- robustness mode
- channel profile
- interleaving mode

As illustrated by Figure 1, the simulator takes those inputs to simulate the transmission of data over a DRM channel. The received SDC, FAC and DATA (MSC) constellations are shown, and the binary error rate (BER) over the input data is derived automatically

3. Considered use cases and corresponding settings

The use cases were defined by considering DRM requirements and currently considered as foreseen future modes, while keeping in mind that the mean bit error rate of interest for tests of JPEG 2000 images transmission were between 10^{-2} and 10^{-4}. Note that image data being transmitted over the Main Service Channel (MSC), which is the channel carrying the data for both audio and data services of the DRM system, only this channel is considered in the error measurements presented here, and that the error pattern generated corresponds only to said MSC.

Considering a transmission, the parameters for this transmission are of two kinds: first signal bandwidth parameters, restricted in DRM case to the definition of the spectrum occupancy, and then for any value of this signal bandwidth parameter, transmission efficiency related parameters which are defined to allow a trade off between the useful bit rate and the resistance to noise, multipath and Doppler effect. These parameters are the constellation type, the coding rate, the OFDM parameter set, and finally source coding modes.

In the measurements presented here, the parameters chosen are as follows:

1/ spectrum occupancy (*Spec-occ)*

The current channel widths for radio broadcasting below 30 MHz are 9 kHz and 10 kHz. The DRM system was built to be used whether within these nominal bandwidths, or within half these bandwidths in order to allow simulcasting of digital data and analogue AM signals, or within twice these bandwidths to provide for larger transmission capacity.

Aiming at providing services for the future, we chose in harmony with actually foreseen services to restrict our set of patterns to the two most interesting cases, namely a spectrum occupancy of 10kHz or 20 kHz, corresponding to the specification modes 3 and 5.

Spectrum occupancy	Channel bandwidh kKhz)
3	10 kHz
5	20 kHz

2/ Constellation (*Const)*

The 16-QAM MSC constellation was chosen based on fields measurements carried within DRM group and first perspectives of use described by system evaluators within THALES.

3/ Coding rate (*R)*

Two coding rates are achievable for DRM system by definition for 16-QAM constellation : R=0.5 and R=0.625. Those two rates were consequently considered.

Coding mode	Coding rate
0	0.5
1	0.625

4/ Robustness mode (*Robustness)*

The different robustness modes defined by the DRM specification correspond to different OFDM parameter sets, defined for different transmission conditions to provide various robustness modes for the signal. There are four of them in the specification, of which the two more likely were considered, namely:

Robustness mode	Typical propagation conditions
B mode "SKY"	Time and frequency selective channels, with long delay spread
C mode "ROBUST"	as robustness mode B, but with higher Doppler spread

<u>5/ Transmission conditions : channel profiles (*Channel)*</u>

The channels considered in DRM specification are the LF, MF and HF broadcast radio transmission channels. In principle, all three of them are multipath channels because the surface of the earth and the ionosphere are involved in the mechanism of electromagnetic wave propagation.

The specification has been considering six different models of such channels, from very easy ones to very hard ones. For now, two of those channels were selected according to their representativity in terms of resulting impact and behaviour for the three channels to establish the error patterns, as explained below:

Channel name and number	Resulting impact/behaviour		
	Good	Typical/moderate	Bad
Channel 1 "AWGN"	LF, MF, HF	LF	
Channel 2 "Rice with delay"		MF, HF	

Other patterns can be generated with other channels later, or on demand if necessary.

<u>6/ Interleaving type (*Interleaving*)</u>

Two types of interleaving are proposed at the frame level: whether long interleaving i.e. interleaving over five super audio frames, whose impact is to create a delay of 5*400ms=2s or interleaving over only the considered frame. Considering this delay as acceptable, only the long interleaving case was considered.

<u>7/ Source coding</u>

For now, only EEP mode was considered

From those parameters defining the signal bandwidth, the protection mode and the error correction codes rates, it is possible to establish a table of the available total bit rates (see DRM specification Annex H).

16-QAM modulation				
EEP SM				
Robustness mode	spectrum occupancy			
	3		5	
	R=0.5	R=0.625	R=0.5	R=0.625
SKY (B)	11.7 kbit/s	14.6 kbit/s	23.8 kbit/s	29.8 kbit/s
ROBUST (C)	9.2 kbit/s	11.5 kbit/s	19.3 kbit/s	24.1 kbit/s

4. Simulation results: error patterns

The corresponding binary error patterns are given in a zip archive with the following denomination:
pattern_*RobustnessChannel_Spec-occ_Const_R*_meanBER.bin

```
pattern_B1_10khz_16QAM_R0.5_1.8_10-1.bin
pattern_B1_10khz_16QAM_R0.5_2.9_10-5.bin
pattern_B1_10khz_16QAM_R0.5_4_10-3.bin
pattern_B1_10khz_16QAM_R0.5_8.1_10-4.bin
pattern_B1_10khz_16QAM_R0.625_1.8_10-1.bin
pattern_B1_10khz_16QAM_R0.625_2.3_10-3.bin
pattern_B1_10khz_16QAM_R0.625_2.9_10-4.bin
pattern_B1_10khz_16QAM_R0.625_5.1_10-2.bin
pattern_B1_10khz_16QAM_R0.625_7_10-3.bin
pattern_B1_20khz_16QAM_R0.5_1.4_10-2.bin
pattern_B1_20khz_16QAM_R0.5_2.6_10-3.bin
pattern_B1_20khz_16QAM_R0.5_4.1_10-4.bin
pattern_B1_20khz_16QAM_R0.625_1.4_10-2.bin
pattern_B1_20khz_16QAM_R0.625_2.1_10-4.bin
pattern_B1_20khz_16QAM_R0.625_3.4_10-3.bin
pattern_B1_20khz_16QAM_R0.625_8.4_10-4.bin
pattern_B2_10khz_16QAM_R0.5_1.6_10-3.bin
pattern_B2_10khz_16QAM_R0.5_2.9_10-2.bin
pattern_B2_10khz_16QAM_R0.5_3.1_10-4.bin
pattern_B2_10khz_16QAM_R0.5_7.1_10-3.bin
pattern_B2_10khz_16QAM_R0.625_1.1_10-2.bin
pattern_B2_10khz_16QAM_R0.625_1.6_10-3.bin
pattern_B2_10khz_16QAM_R0.625_2.2_10-2.bin
pattern_B2_10khz_16QAM_R0.625_5.5_10-3.bin
pattern_B2_10khz_16QAM_R0.625_8.3_10-4.bin
pattern_B2_20khz_16QAM_R0.5_1_10-3.bin
pattern_B2_20khz_16QAM_R0.5_2.3_10-4.bin
pattern_B2_20khz_16QAM_R0.5_2.6_10-2.bin
pattern_B2_20khz_16QAM_R0.5_5.2_10-3.bin
pattern_B2_20khz_16QAM_R0.625_2.9_10-3.bin
pattern_B2_20khz_16QAM_R0.625_2_10-2.bin
pattern_B2_20khz_16QAM_R0.625_5.6_10-4.bin
pattern_B2_20khz_16QAM_R0.625_8.2_10-2.bin
pattern_C1_10khz_16QAM_R0.5_2.7_10-2.bin
pattern_C1_10khz_16QAM_R0.5_4.5_10-3.bin
pattern_C1_10khz_16QAM_R0.5_7.2_10-4.bin
pattern_C1_10khz_16QAM_R0.5_9.5_10-5.bin
pattern_C1_10khz_16QAM_R0.625_1.6_10-2.bin
pattern_C1_10khz_16QAM_R0.625_1.9_10-4.bin
pattern_C1_10khz_16QAM_R0.625_4_10-3.bin
pattern_C1_10khz_16QAM_R0.625_8.4_10-4.bin
pattern_C1_20khz_16QAM_R0.5_1.4_10-2.bin
pattern_C1_20khz_16QAM_R0.5_1.8_10-5.bin
pattern_C1_20khz_16QAM_R0.5_1.9_10-3.bin
pattern_C1_20khz_16QAM_R0.5_2.3_10-4.bin
pattern_C1_20khz_16QAM_R0.625_1.7_10-3.bin
pattern_C1_20khz_16QAM_R0.625_3.5_10-4.bin
pattern_C1_20khz_16QAM_R0.625_3.6_10-2.bin
pattern_C1_20khz_16QAM_R0.625_8.5_10-5.bin
pattern_C2_10khz_16QAM_R0.5_1.7_10-2.bin
pattern_C2_10khz_16QAM_R0.5_2.1_10-3.bin
pattern_C2_10khz_16QAM_R0.5_4.4_10-4.bin
pattern_C2_10khz_16QAM_R0.5_5.8_10-3.bin
pattern_C2_10khz_16QAM_R0.625_1.4_10-2.bin
pattern_C2_10khz_16QAM_R0.625_4.1_10-3.bin
pattern_C2_10khz_16QAM_R0.625_7.1_10-3.bin
pattern_C2_10khz_16QAM_R0.625_8.6_10-2.bin
pattern_C2_20khz_16QAM_R0.5_2.2_10-2.bin
pattern_C2_20khz_16QAM_R0.5_3.5_10-3.bin
pattern_C2_20khz_16QAM_R0.625_1.1_10-2.bin
pattern_C2_20khz_16QAM_R0.625_2.6_10-2.bin
pattern_C2_20khz_16QAM_R0.625_8.7_10-3.bin
```

5. Modelisation of the DRM channel

Although the existence of the DRM simulator allows us to determine the impact of a "real" channel by comparison with the impact of a simple AWGN one, the fact that it is proprietary doesn't meet the foreseen requirements of having whether 2KAN project partners, or any other person interested in testing their JPEG 2000 implementation share its use. As a consequence, the patterns generated as explained in the previous sections were provided and uploaded on the JPEG website. Still, the use of traces is often perceived as clumsy, uneasy to handle and often unsatisfying. That is why people often are more willing to use stochastic error models, which can be parameterised from real data, obtained by field or simulation measurements. This is the case for instance for 802.11 channels as in [5] where packet level is considered, or in [6] where the study is also carried out at the physical layer, i.e. at bit level.

Following this approach, we have used the measurements of the DRM transmission to develop a wireless link error model. Based on the observation of the error patterns, the choice was made to select the classical model of Gilbert-Elliot [7][8], which is moreover the model considered in the JPWL environment.

5.1. Gilbert-Elliot model

The Gilbert-Elliot model introduces two states denoted by "Good" and "Bad" which allow to represent the bursty nature of the channel. In practice, after every bit transmission, the new channel state is determined according to a two-state bit time-homogeneous Markov chain, as illustrated in Figure 2. For each state, bit errors occur independently with respective bit error rates e_g and e_b.

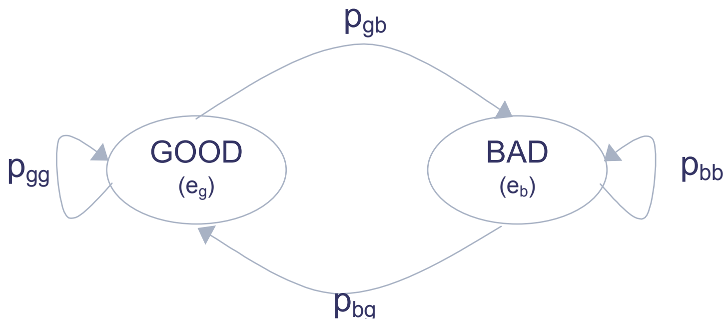

Figure 2- The Gilbert-Elliot model.

The transition matrix is determined by the four possible transitions, of respective probabilities p_{gg}, p_{gb}, p_{bb} and p_{bg}. In practice, this matrix is entirely determined by probabilities p_{gg} and p_{bb} as $p_{bg}+p_{bb}=1=p_{gb}+p_{gg}$.

It is also possible to derive the mean sojourn time in one state: the duration of being in one state is equal to the sum the time spent levelled by the probability to remain in that state:

For state GOOD: $$t_g = 1 + 1\times p_{gg} + 1\times p_{gg}^2 + \cdots + 1\times p_{gg}^i + \cdots = \frac{1}{1-p_{gg}} = \frac{1}{p_{gb}};$$

For state BAD: $$t_b = 1 + 1\times p_{bb} + 1\times p_{bb}^2 + \cdots + 1\times p_{bb}^i + \cdots = \frac{1}{1-p_{bb}} = \frac{1}{p_{bg}}.$$

It is possible as well to derive the average bit error rate e_{av} for the considered channel:

$$e_{av} = \frac{e_g \times \frac{1}{p_{gb}} + e_b \times \frac{1}{p_{bg}}}{\frac{1}{p_{gb}} + \frac{1}{p_{bg}}}.$$

5.2. Sequence indicators

In practice, it was observed in the obtained patterns but also in other settings such as 802.11 [6] that the bursty aspect of the channel could be simply represented by having as state GOOD an error-free state, leading to e_g=0, whereas state BAD corresponded to the observed error bursts over the channel.
Following this and method proposed within [6], we are introducing the concept of sequence indicators, which will help us to represent our error patterns and determine their statistics.
The pattern is divided into error free bursts (corresponding to GOOD state) and error bursts (corresponding to BAD state), where an error free burst of order k_0 is defined as a contiguous all-zero sub-sequence with a length of at least k_0. Conversely, an error burst of order k_0 is a sub-sequence with ones at its fringes within which at most k_0-1 consecutive zeros are allowed.
By definition, the sequence indicator for an error pattern of m bits which is segmented into p alternating error free bursts and error bursts is represented by the $(X_jY_jZ_j)_{j=1..p}$ 3p-uplet, where X_j is the length of the j^{th} error free burst, Y_j is the length of the j^{th} error burst and Z_j is the weight of this j^{th} error burst (the actual number of ones inside the error burst). This representation is illustrated in Figure 3.

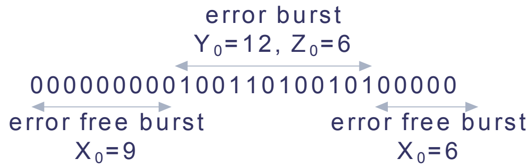

Figure 3 - Example of error pattern sub-division and sequence indicator representation.

Having determined the values of those $(X_jY_jZ_j)_{j=1..p}$, it is easy to derive some statistics over the considered pattern, namely the average error rate e_{av}, the mean sojourn times t_g and t_b in error free or error bursts:

$$e_{av} = \frac{\sum_{j=1}^{p} Z_j}{\sum_{j=1}^{p} \left(X_j + Y_j \right)} \quad ; \quad t_g = \hat{X} = \frac{1}{p}\sum_{j=1}^{p} X_j \quad ; \quad t_b = \hat{Y} = \frac{1}{p}\sum_{j=1}^{p} Y_j \; .$$

By definition of our Gilbert-Elliot model, we have consequently three parameters to determine: e_b, p_{gb} and p_{bg} and three equations at our disposal, which would lead us to an easy solving except that those three equations are dependant from variable p or equivalently from variable k_0.

6. Simulation results: Gilbert models

In practice indeed, when wanting to determine the representation of an error pattern by the sequence indicator introduced in previous section, one needs to determine the acceptable value of k_0. Conceptually, this means that we need to determine the average variation of the bursts sizes.
This was solved in our simulations by selecting the solution verifying the following conditions:

1. all our transmission chain being byte aligned, and the error patterns modelling the transmission up until the application layers, we suppose that k_0 is a multiple of 8 (in practice k_0 was also upper-bounded by 16385, which was the value considered in case the second condition was not met);
2. to ensure that detected state transitions corresponded to real change of burst nature and not to a solution were the systems transitioned at each '0' to GOOD, we imposes that the mean bit error rate over the BAD channel is upper-bounded by max(5*e_{av}, 0.01).

Naturally, such conditions could be extended or modified if deemed useful.
This results in the following parameters for the various channels proposed in section 4.

Pattern Name	e_{av}	e_b	p_{gb}	p_{bg}
pattern_B1_10khz_16QAM_R0.5_1.8_10-1	1.83e-01	5.33e-01	2.13e-02	4.07e-02
pattern_B1_10khz_16QAM_R0.5_2.9_10-5.bin	2.90e-05	9.39e-03	8.28e-06	2.68e-03
pattern_B1_10khz_16QAM_R0.5_4_10-3.bin	4.00e-03	1.97e-02	2.57e-04	1.01e-03
pattern_B1_10khz_16QAM_R0.5_8.1_10-4.bin	8.11e-04	9.97e-03	9.29e-05	1.05e-03
pattern_B1_10khz_16QAM_R0.625_1.8_10-1.bin	1.79e-01	5.41e-01	2.13e-02	4.31e-02
pattern_B1_10khz_16QAM_R0.625_2.3_10-3.bin	2.30e-03	1.17e-02	1.11e-04	4.43e-04
pattern_B1_10khz_16QAM_R0.625_2.9_10-4.bin	2.89e-04	1.00e-02	3.29e-05	1.11e-03
pattern_B1_10khz_16QAM_R0.625_5.1_10-2.bin	5.14e-02	2.48e-01	2.86e-03	1.09e-02
pattern_B1_10khz_16QAM_R0.625_7_10-3.bin	7.04e-03	3.52e-02	3.29e-04	1.31e-03
pattern_B1_20khz_16QAM_R0.5_1.4_10-2.bin	1.44e-02	7.07e-02	8.49e-04	3.33e-03
pattern_B1_20khz_16QAM_R0.5_2.6_10-3.bin	2.61e-03	1.30e-02	1.78e-04	7.09e-04
pattern_B1_20khz_16QAM_R0.5_4.1_10-4.bin	4.14e-04	1.00e-02	5.96e-05	1.38e-03
pattern_B1_20khz_16QAM_R0.625_1.4_10-2.bin	1.38e-02	6.77e-02	6.89e-04	2.71e-03

pattern_B1_20khz_16QAM_R0.625_2.1_10-4.bin	2.11e-04	9.92e-03	3.00e-05	1.38e-03
pattern_B1_20khz_16QAM_R0.625_3.4_10-3.bin	3.43e-03	1.71e-02	1.86e-04	7.43e-04
pattern_B1_20khz_16QAM_R0.625_8.4_10-4.bin	8.37e-04	9.99e-03	7.49e-05	8.19e-04
pattern_B2_10khz_16QAM_R0.5_1.6_10-3.bin	1.61e-03	1.45e-02	8.65e-06	6.93e-05
pattern_B2_10khz_16QAM_R0.5_2.9_10-2.bin	2.85e-02	1.42e-01	3.52e-04	1.40e-03
pattern_B2_10khz_16QAM_R0.5_3.1_10-4.bin	3.10e-04	1.00e-02	9.77e-06	3.06e-04
pattern_B2_10khz_16QAM_R0.5_7.1_10-3.bin	7.14e-03	3.56e-02	1.42e-05	5.64e-05
pattern_B2_10khz_16QAM_R0.625_1.1_10-2.bin	1.08e-02	7.29e-02	7.65e-06	4.39e-05
pattern_B2_10khz_16QAM_R0.625_1.6_10-3.bin	1.64e-03	2.46e-02	4.35e-06	6.09e-05
pattern_B2_10khz_16QAM_R0.625_2.2_10-2.bin	2.17e-02	1.08e-01	1.09e-05	4.37e-05
pattern_B2_10khz_16QAM_R0.625_5.5_10-3.bin	5.48e-03	5.17e-02	6.27e-06	5.28e-05
pattern_B2_10khz_16QAM_R0.625_8.3_10-4.bin	8.31e-04	1.59e-02	3.62e-06	6.56e-05
pattern_B2_20khz_16QAM_R0.5_1_10-3.bin	9.96e-04	9.95e-03	5.43e-06	4.88e-05
pattern_B2_20khz_16QAM_R0.5_2.3_10-4.bin	2.30e-04	9.92e-03	1.26e-05	5.33e-04
pattern_B2_20khz_16QAM_R0.5_2.6_10-2.bin	2.63e-02	1.31e-01	3.27e-04	1.30e-03
pattern_B2_20khz_16QAM_R0.5_5.2_10-3.bin	5.15e-03	2.58e-02	7.37e-06	2.95e-05
pattern_B2_20khz_16QAM_R0.625_2.9_10-3.bin	2.85e-03	3.28e-02	2.78e-06	2.92e-05
pattern_B2_20khz_16QAM_R0.625_2_10-2.bin	1.956e-02	9.77e-02	5.66e-06	2.26e-05
pattern_B2_20khz_16QAM_R0.625_5.6_10-4.bin	5.60e-04	1.16e-02	2.00e-06	3.93e-05
pattern_B2_20khz_16QAM_R0.625_8.2_10-2.bin	8.19e-02	3.85e-01	1.90e-03	7.03e-03
pattern_C1_10khz_16QAM_R0.5_2.7_10-2.bin	2.68e-02	1.33e-01	1.55e-03	6.18e-03
pattern_C1_10khz_16QAM_R0.5_4.5_10-3.bin	4.46e-03	2.22e-02	2.95e-04	1.17e-03
pattern_C1_10khz_16QAM_R0.5_7.2_10-4.bin	7.20e-04	9.89e-03	8.85e-05	1.13e-03
pattern_C1_10khz_16QAM_R0.5_9.5_10-5.bin	9.50e-05	9.94e-03	2.09e-05	2.17e-03
pattern_C1_10khz_16QAM_R0.625_1.6_10-2.bin	1.62e-02	7.96e-02	8.56e-04	3.35e-03
pattern_C1_10khz_16QAM_R0.625_1.9_10-4.bin	1.89e-04	9.90e-03	2.77e-05	1.42e-03
pattern_C1_10khz_16QAM_R0.625_4_10-3.bin	3.96e-03	1.98e-02	2.31e-04	9.21e-04
pattern_C1_10khz_16QAM_R0.625_8.4_10-4.bin	8.41e-04	9.99e-03	7.85e-05	8.54e-04
pattern_C1_20khz_16QAM_R0.5_1.4_10-2.bin	1.39e-02	6.91e-02	8.15e-04	3.23e-03
pattern_C1_20khz_16QAM_R0.5_1.8_10-5.bin	1.84e-05	8.70e-03	5.66e-06	2.67e-03
pattern_C1_20khz_16QAM_R0.5_1.9_10-3.bin	1.90e-03	9.94e-03	1.39e-04	5.88e-04
pattern_C1_20khz_16QAM_R0.5_2.3_10-4.bin	2.29e-04	9.98e-03	4.12e-05	1.76e-03
pattern_C1_20khz_16QAM_R0.625_1.7_10-3.bin	1.73e-03	1.00e-02	1.18e-04	5.66e-04
pattern_C1_20khz_16QAM_R0.625_3.5_10-4.bin	3.53e-04	9.97e-03	4.62e-05	1.26e-03
pattern_C1_20khz_16QAM_R0.625_3.6_10-2.bin	3.55e-02	1.77e-01	1.94e-03	7.72e-03
pattern_C1_20khz_16QAM_R0.625_8.5_10-5.bin	8.49e-05	9.94e-03	1.47e-05	1.71e-03
pattern_C2_10khz_16QAM_R0.5_1.7_10-2.bin	1.72e-02	8.58e-02	9.04e-05	3.61e-04
pattern_C2_10khz_16QAM_R0.5_2.1_10-3.bin	2.12e-03	1.84e-02	1.09e-05	8.37e-05
pattern_C2_10khz_16QAM_R0.5_4.4_10-4.bin	4.45e-04	9.73e-03	9.92e-06	2.07e-04
pattern_C2_10khz_16QAM_R0.5_5.8_10-3.bin	5.82e-03	3.14e-02	1.65e-05	7.25e-05
pattern_C2_10khz_16QAM_R0.625_1.4_10-2.bin	1.42e-02	8.15e-02	1.12e-05	5.31e-05
pattern_C2_10khz_16QAM_R0.625_4.1_10-3.bin	4.06e-03	4.19e-02	7.53e-06	7.02e-05
pattern_C2_10khz_16QAM_R0.625_7.1_10-3.bin	7.10e-03	5.83e-02	8.65e-06	6.24e-05
pattern_C2_10khz_16QAM_R0.625_8.6_10-2.bin	8.55e-02	4.21e-01	2.99e-03	1.17e-02
pattern_C2_20khz_16QAM_R0.5_2.2_10-2.bin	2.23e-02	1.11e-01	2.21e-04	8.80e-04
pattern_C2_20khz_16QAM_R0.5_3.5_10-3.bin	3.51e-03	2.08e-02	7.52e-06	3.71e-05
pattern_C2_20khz_16QAM_R0.625_1.1_10-2.bin	1.07e-02	6.40e-02	6.33e-06	3.16e-05
pattern_C2_20khz_16QAM_R0.625_2.6_10-2.bin	2.65e-02	1.32e-01	3.01e-05	1.20e-04
pattern_C2_20khz_16QAM_R0.625_8.7_10-3.bin	8.71e-03	5.99e-02	5.60e-06	3.30e-05

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Annex A Zip archive of patterns

See attached archive `patternsDRM.tgz`.