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Analysis of Different Pilot Patterns in Various Channels for DVB-T2

PRAMOD MOVVA[1], A KRISHNA CHAITANYA[2]

M.Tech Student, Department of ECE, Bapatla Engineering College, Bapatla, Andhra Pradesh, India[1]

Assistant Professor, Department of ECE, Bapatla Engineering College, Bapatla, Andhra Pradesh, India[2]

Abstract: This paper deals with an analysis of different pilot patterns in different real channels in order to test pilot patterns, compare them and determine in which conditions and scenarios their use is more appropriated. Simulations demonstrate that there is an optimum scattered pilot pattern for a specific channel condition, so an opportunity to choose the optimum pilot pattern to adjust to varying channel conditions dynamically is possible.

Keywords: DVB, Channel models, COFDM, LDPC

I. INTRODUCTION

The world nowadays is in the middle of a digital to analog TV transition where digital transmission technology is substituting completely the analog television. This is because digital transmission has many advantages in terms of spectral efficiency, flexibility and robustness which make it especially attractive over analog transmission. DVB-T2 is a new DVB European-based consortium standard and extension of DVB-T standard: ETSI EN 302 755 (April 2008), pushed by BBC for the broadcast transmission of digital terrestrial television. DVB-T2 provides higher data rates, better FEC (similar to DVB-S2), better mobile reception capability.

Like its predecessor, DVB-T2 uses OFDM (orthogonal frequency division multiplex) modulation with a large number of subcarriers delivering a robust signal, and offers a range of different modes, making it a very flexible standard. DVB-T2 uses the same error correction coding as used in DVB-S2 and DVB-C2: LDPC (Low Density Parity Check) Coding combined with BCH (Bose-Chaudhuri-Hocquengham) coding, offering a very robust signal. The Number of carriers, guard interval sizes and pilot signals can be adjusted, so that the overheads can be optimised for any target transmission channel. This system transmits compressed digital audio, video and other data over an MPEG-2 stream, using COFDM modulation.

II. DVB-T2 STANDARD

The DVB-T2 transmission system constitutes three different systems i.e, Input processing, Frame builder and OFDM generation. The functional block diagram of these three systems of DVB-T2 transmission system is shown in Figure-1.

Multiple MPEG-2 transport streams or multiple generic streams are provided as input. The Input-processor, which is not part of the T2 system, separates the services into the T2 system inputs which are carried in individual Physical Layer Pipes (PLPs). The Mode adaptation and stream adaptation module, which operate separately on the contents of each PLP, form the baseband frames. The baseband frames shall be processed by the FEC coding subsystem for the FEC frames, in which the outer coder is BCH and the inner coder is LDPC. The FEC frame is then mapped to a coded and modulated FEC block by the Map bits onto constellations module.

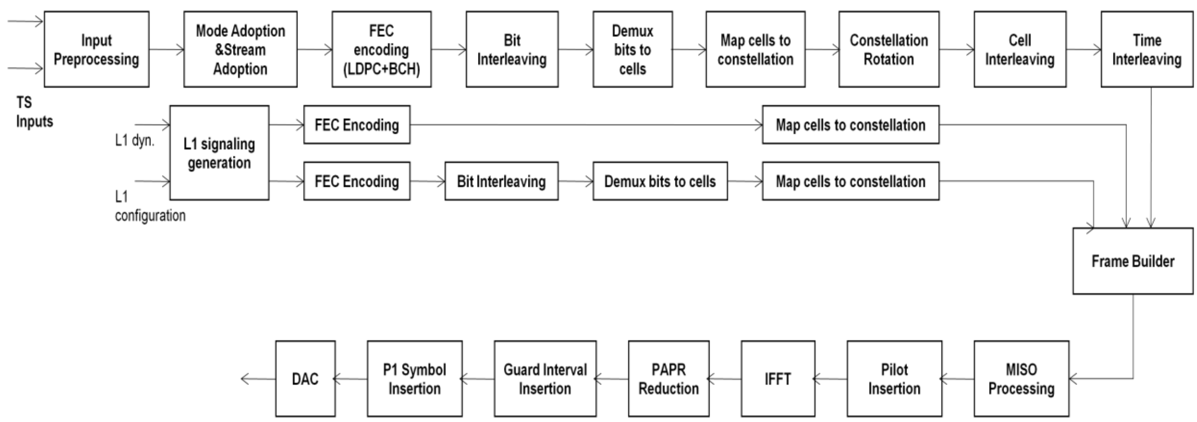

Figure-1: The functional block diagram of DVB-T2 transmission system

The T2 system also provides an optional module, Constellation Rotation and Cyclic Q Delay to further increase the ruggedness. The layer 1 (L1) signaling, which consists of P1 signaling data, L1-pre signaling data and L1-post signaling data, provides the receiver with a means to access physical layer pipes within the T2-frames.L1-dyn signaling and L1 configuration signal shall perform the FEC encoding and Mapping respectively. The function of the frame builder is to assemble the cells produced by time interleavers for each of the PLPs and the cells of the modulated L1 signaling data into arrays of active OFDM cells corresponding to each of the OFDM symbols which make up the overall frame structure. The lower part of the functional block diagram constitutes the OFDM Generation component part, which includes an optional MISO module, pilot insertion and dummy tone reservation module, IFFT module, an optional PAPR reduction module, guard interval insertion module and P1 symbol insertion module. In this paper, we mainly focus on the pilot insertion and IFFT modules, different pilot patterns and different pilot aided channel estimation are investigated.

Compared with DVB-T, DVB-T2 system extends the range of Fast Fourier Transform (FFT) sizes of OFDM, together with an increased range of guard intervals (GIs), to provide significantly improved bandwidths efficiency. DVB-T2 also extends the range of reference signals—scattered pilots (SPs) and continual pilots (CPs)—to allow an optimum choice to be selected for any given channel.

III. PILOT PATTERNS IN DVB-T2

Today's most popular digital wireless systems–WLAN, digital terrestrial broadcast systems, 4G cellular networks, etc. – are all based on OFDM. In OFDM a large number of closely spaced orthogonal carriers are used to carry data on several parallel channels. A smaller number of the carriers are allocated to pilot tones which, among other things, can be used to estimate the channel. The transmission protocol describes when and with what phase positions the pilot tones are transmitted. Based on that information the receiver can continuously estimate the quality of the channel over all frequencies.

Of the different kinds of pilots such as continual, scattered, P2 and frame-closing pilots, only the scattered pilots can be changed, so only they are considered.

In DVB-T2, eight different pilot patterns are available, PP1 to PP8. As certain patterns are more suited to particular channel types than others, the range in pilot patterns gives the network planner more freedom to match the transmission mode and pilot pattern to the intended transmission channel or payload requirement. An overview of the modes is provided in Table-1.

Table-1: Parameters defining the scattered pilot patterns

Pilot pattern	**Separation of pilot bearing carriers (D_X)**	**No.of symbols forming one scattered pilot sequence (D_Y)**
PP1	3	4
PP2	6	2
PP3	6	4
PP4	12	2
PP5	12	4
PP6	24	2
PP7	24	4
PP8	6	16

When determining which pilot pattern to use the following main factors should be considered:

Doppler performance: Patterns with a rapid repeat cycle (i.e. Dy=2) in which the pilots repeat every second OFDM symbol, provide the better Doppler performance. For networks where Doppler is a dominant factor, such as mobile and portable, patterns 2, 4 or 6 should be considered as they have the smallest Dy value.

Capacity: The least dense patterns, i.e. those with the greatest distance between pilots, in both time (Dy) and frequency (Dx), provide the greatest payload as fewer carriers are used for pilots, and subsequently more are available to carry data.

FFT Size and Guard Interval: Only a subset of pilot patterns is permitted for every FFT size and Guard Interval combination - these are shown in **Table-2**. The Table is valid only for SISO (Single Input Single Output) of DVB-T2. A different Table applies to MISO (Multiple Input Single Output) in **Table-3**.

Table-2: Scattered pilot pattern to be used for each allowed combination of FFT size and guard interval in SISO mode

FFT size	**Guard interval**						
	1/128	**1/32**	**1/16**	**19/256**	**1/8**	**19/128**	**¼**
32K	PP7	PP4 PP6	PP2 PP8 PP4	PP2 PP8 PP4	PP2 PP8	PP2 PP8	NA
16K	PP7	PP7 PP4 PP6	PP2 PP8 PP4 PP5	PP2 PP8 PP4 PP5	PP2 PP3 PP8	PP2 PP3 PP8	PP1 PP8
8K	PP7	PP7 PP4	PP8 PP4 PP5	PP8 PP4 PP5	PP2 PP3 PP8	PP2 PP3 PP8	PP1 PP8
4K, 2K	NA	PP7 PP4	PP4 PP5	NA	PP2 PP3	NA	PP1
1K	NA	NA	PP4 PP5	NA	PP2 PP3	NA	PP1

Table-3: Scattered pilot pattern to be used for each allowed combination of FFT size and guard interval in MISO mode

FFT size	**Guard interval**						
	1/128	**1/32**	**1/16**	**19/256**	**1/8**	**19/128**	**1/4**
32K	PP8 PP4 PP6	PP8 PP4	PP2 PP8	PP2 PP8	NA	NA	NA
16K	PP8 PP4 PP5	PP8 PP4 PP5	PP3 PP8	PP3 PP8	PP1 PP8	PP1 PP8	NA
8K	PP8 PP4 PP5	PP8 PP4 PP5	PP3 PP8	PP3 PP8	PP1 PP8	PP1 PP8	NA
4K, 2K	NA	PP4 PP5	PP3	NA	PP1	NA	NA
1K	NA	NA	PP3	NA	PP1	NA	NA

The small distance (Dx) of the pilots in PP1 proves this pattern as most robust against inter-symbol interference, whereas PP6 and PP7 are most vulnerable to it.

PP8 - Receiver Capability: Pilot pattern 8 requires the receiver to employ a channel equalization strategy that is

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fundamentally different to the others—PP8 channel estimation is based on the data rather than the pilots. No receivers are known to have incorporated this mode, largely due to the additional complexity required in the receiver. Therefore before settling on this pattern, receivers intended for the service should be confirmed to support it. Furthermore PP8 has some limitations over the others that should be considered. PLPs are not supported in PP8, and time interleaving should not be used—the latter means that the vastly improved impulse resilience of DVB-T2, a significantly important benefit, cannot be realized.

IV. CHANNELS MODELS

The profile of received signal can be obtained from that of the transmitted signal if we have a model of the medium between the two. This model of the medium is called channel model. The estimation of the channel is done using the following three channel models namely, Additive White Gaussian Noise (AWGN), Rayleigh and Rician.

Rayleigh channel model should normally be used for planning portable outdoor and portable indoor reception. Here a static Rayleigh channel is used by using a maximum Doppler shift of 0 is used. Due to the static nature of this channel model it should be regarded as a 'best case' when planning for portable reception and should be used when the receiver is stationary. Because at low Doppler frequency the time interleaving in DVB-T2 is less effective, this is often considered to be a worst case for a DVB-T2 receiver. Rayleigh channel with high Doppler frequency is not suitable for mobile reception in DVB-T2. A profile particularly designed for mobile reception is DVB-T2-Lite.

Rician channel is used for planning fixed rooftop reception where there is predominantly a single direct signal and smaller amplitude reflections. The Rician K-factor specifies the ratio of specular-to-diffuse power for a direct line-of-sight path. The ratio is expressed linearly, not in dB. For Rician fading, the K-factor is typically between 1 and 10.

Gaussian channel (AWGN) is characterised by a single wanted signal with no channel perturbations where only Gaussian noise is present. It is the least demanding channel and is normally used only as a reference, not in practical network planning.

V. SIMULATION RESULTS

In this section, we demonstrate the performance of different scattered in different channel models. Bit error rate and information transmission rate are taken into account to compare the different pilot pattern schemes.

It is obvious that pilot patterns with more pilot symbols and more intensive spacing performs better. Thus by comparing the pilot patterns with guard intervals (GI) ¼, 1/8, 1/16, 1/32 it is suggested that Pilot Pattern PP7 with GI 1/32 in Rayleigh channel, shown in Figure-2 and Pilot Pattern PP8 with GI 1/16 in Rician channel, shown in Figure-3 gives better BER performance.

In Rayleigh channel, pilot patterns PP2, PP3 and PP8 perform will with GI 1/8 and in Rician channel, pilot patterns PP1 and PP8 are also perform will with GI 1/32.

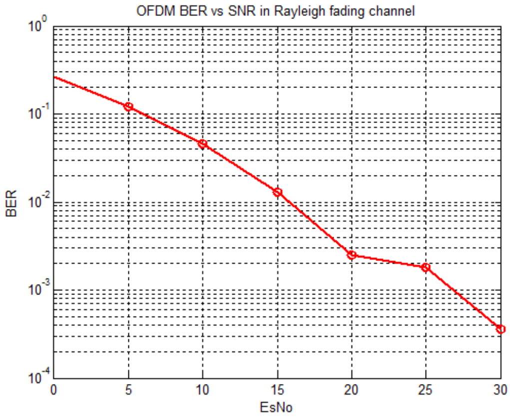

Figure-2: Pilot Pattern PP7 with GI 1/32 in Rayleigh channel

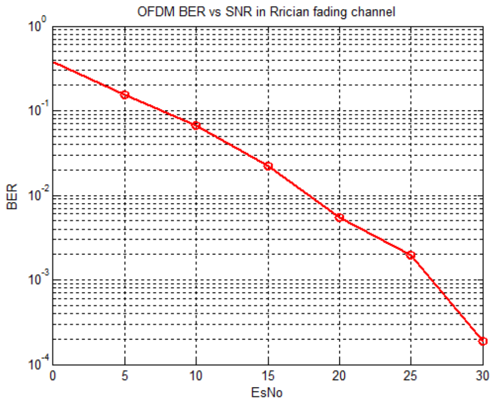

Figure-3: Pilot Pattern PP8 with GI 1/16 in Rician channel

VI. CONCLUSION

In this paper, a full review of the second generation of digital video broadcasting is given. Different types of scattered pilot patterns which are allowed to use in DVB-T2 are analyzed evaluated and compared in both bit error rate and information transmission rate aspects through Rayleigh and Rician channel models. Simulations demonstrate that there is an optimum scattered pilot pattern for a specific channel condition and it provides us an opportunity to choose the optimum pilot pattern.

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