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High Security Adaptive BCH Code Discrete Wavelet Transform Copyright Protection

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***Abstract*—In this research, we analyze the audio watermarking system by combining adaptive wavelet with SVD in various BCH Codes. The host audio signal is embedded by a watermark signal in the form of an image signal accompanied by several attacks on the watermarking system. The results show that ODG and SNR values for DWT level 1 are higher than level 3, that can reach ODG for BCH code 15,11,1 level 1 = -0.58 and BCH code 15,7,2 level 1 = -0.68 on LSC attack type; SNR for BCH code 15,11,1 level 1 = 32.6 dB and BCH code 15,7,2 level 1 = 31 dB on LPF attack type. While for watermark image BER parameter, the result of the research shows that BER level 1 is worse than level 3, and BCH code 15,7,2 has better BER values than those of BCH code 15,11,1. In our system, we have high security watermark image at BCH 15,7,2 level 3 where the BER value is the lowest among other parameters.**

Keywords—Audio Watermarking; BCH Code; DWT; SVD

I. INTRODUCTION

Audio watermarking is a process of inserting information into a host audio signal in a certain way that is difficult to extract by unauthorized person(s). Watermarking is being increasingly needed and given the rapid information tranfers over the internet. Therefore the protection methods are demanded to fulfill the multimedia copyright including image, audio, and video files [1].

Some research in audio watermarking has been conducted in various methods, such as time domain method audio watermarking [2], temporal domain [3], DCT domain [4], DWT domain [5-8], combination of DWT and SVD method [6-7, 13], BCH code [9, 13], and SVD method [10-12].

In this research, we extend our previous work [13] regrading audio watermarking system using multilevel wavelet BCH code method based on SVD system with the aim to improve the security. For security purpose, we use bit error rate (BER) value. For other parameters such as audio perceptual quality is presented in objective difference grade (ODG) and signal to noise ratio (SNR) parameters. BCH code used in this paper is BCH code 15,11,1 and 15,7,2. We compare both the BCH codes in the combined wavelet and SVD method.

II. THEORETICAL REVIEW

A. Audio Watermarking

Audio watermarking is a data embedding-extracting technique commonly used for the purposes of copyright protection of an audio content. Watermarks can be embedded directly into an audio signal in time domain, or after being transformed to another domain by changing the value of parameters in certain samples. This insertion process is carried out in such a way that the watermark (in this study using the image signal) does not impair the quality of the audio signal and can also withstand attacks aimed at removing the embedded watermark. The general block diagram for an audio watermarking system can be seen in Fig.1.

There are two main processes in an audio watermarking system, namely the process of embedding and extraction. The embedding process defines algorithms on how to embed each bit of the watermark image into the host signal (audio signal). On the other hand, the extraction process defines the algorithm to determine the value of each bit of the watermark image based on the audio signal that has been embedded by the watermark and some other parameters. The algorithm in these two processes distinguishes an audio watermarking system from one another.

B. Wavelet Domain

Wavelet is a domain of a signal obtained by using a function of $\psi(x)$. This function can generate values from the signal samples in the wavelet domain by scaling and shifting related parameters [5]. Signals that have been transformed to the wavelet domain will be divided into two new signals, ie signals at high frequencies and at low frequencies [6]. The signal at low frequency is called as approximation and at high frequency is called as detail. Using the wavelet transform, a signal can be transformed to a wavelet domain with a certain decomposition level. This decomposition level determines the frequency band accuracy of the resulting wavelet transforms. In general, this decomposition process can be seen in the Fig.2. In general, to transform a discrete signal from the time domain to the wavelet domain we can use 3 transformation methods i.e. DWT, LWT, and SWT.

C. Discrete Wavelet Transormation (DWT)

DWT is a method of transformation in wavelet domains that are often used on some watermarking audio systems as in [6-8]. When a signal is transformed using the DWT method, the signal will down sample each decomposition level by 2 times. Block diagram of the DWT method can be seen in Fig.3.

D. Singular Value Decomposition (SVD)

SVD has often been used as a method of highly effective matrix decomposition on some watermarking audio systems

[6]. SVD is applied by using initial preprocessing matrix for watermark image embedding. This decomposition function can be formulated as follows:

$$M = USV^T \qquad (1)$$

Assuming M is an initial matrix before the transformation of size m x n, U is a unitary matrix of squares of size m x m, S is a diagonal matrix of size m x n with each matrix element being a non-negative real number, and V is a unitary matrix of size n x n. In the watermarking audio system, the watermark image will be inserted into the S matrix.

E. BCH (Bose-Chaudhuri-Hocquenghem) Code

BCH Code [10] is one of the correcting code error variations that are constructed based on the polynomial equation. There are many variations of BCH Code coding that can be used. Some examples of BCH Code variations are code 7,4,1, 15,11,1, 15,5,3, etc. Each number in each BCH Code variation has the message encoding length meaning, message length before encoding, and the ability of bit correction. The better the bit correction capability of the coding variation of BCH code is used, the more number of redundancy bits are inserted. As an example for coding variation 15,11,1 is only inserted 4 (11 bit messages into 15 bit code words) redundancy bit on message and has error correction ability as much as 1 bit. However, for the 15.5.3 coding variation has 10 redundant bits inserted in the original message, but has 3 bit error correction capabilities.

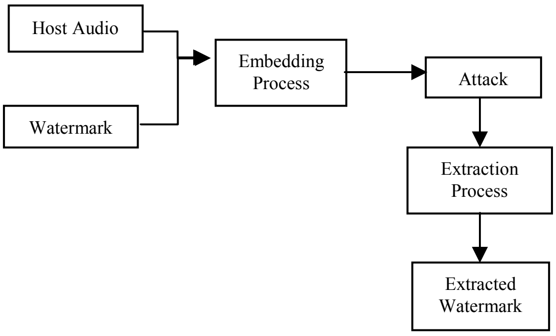

Fig.1. Audio Watermarking System

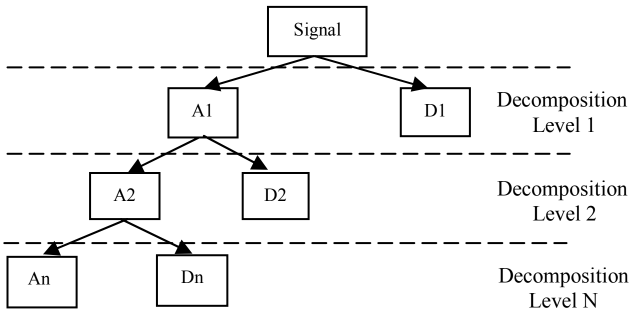

Fig.2. Wavelet Transformation Decomposition Process

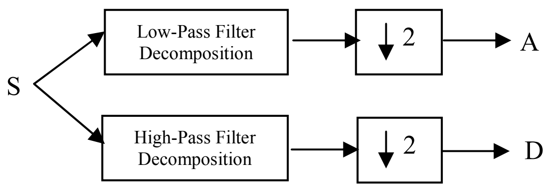

Fig.3. DWT Method

III. SYSTEM MODEL

Audio watermarking system is designed to be two main sub-systems: embedding and extracting processes.

A. Watermark Embedding

This process aims to embed a watermark image into the audio host. In detail, watermark embedding process is shown in Fig. 4.

B. Watermark Extraction

Extraction process aims to extract the watermark image from the audio host. In detail, watermark extraction process is shown in Fig. 5.

IV. EXPERIMENTAL RESULTS

In this research, we have experiment in the audio watermarking system with details as follows: audio host duration of 10 seconds with a sampling frequency of 44100 Hz. The watermark image is in black and white with the size of 65 x 65 pixels. Each audio segment is sampled in 512 samples. The embedding process is performed in the high frequency band. We form a square matrix, 4 samples are taken to form a 2 x 2 matrix. This work is extended experiment from [15]. This analysis is conducted to determine the quality of the audio watermarking system assuming an audio file embedded by a watermark image given a particular signal processing attack in order to damage the embedded watermark image. There are 4 attack types tested in this analysis.

A. Low Pass Filter (LPF) Attack

In our audio watermarking system, watermark image is embedded in the high frequency band by passing audio signal to the LPF with a cut-off frequency of 15 KHz. With LPF attack, in quantization spacing 0.1, perceptual performance of watermarking audio ODG (Fig. 6) for BCH code 15,11,1: level 1 is -0.68 and level 3 is -1.33; while for BCH code 15,7,2: level 1 is -0.82 and level 3 is -1,94. For SNR values (Fig. 7) BCH code 15,11,1 shows results of level 1 = 32.6 dB and level 3 = 29 dB; while BCH code 15,7,2 has SNR of level 1 is 31 dB and level 3 is 26.6 dB. BER performances (Fig. 8) of BCH code 15,7,2 are much better than BCH code 15,11,1 and also wavelet level 3 is much better than level 1. In our system, we have high security watermark image at BCH 15,7,2 level 3 where the BER value is the lowest among other parameters. The trade off for high security, we will have lower SNR and ODG values.

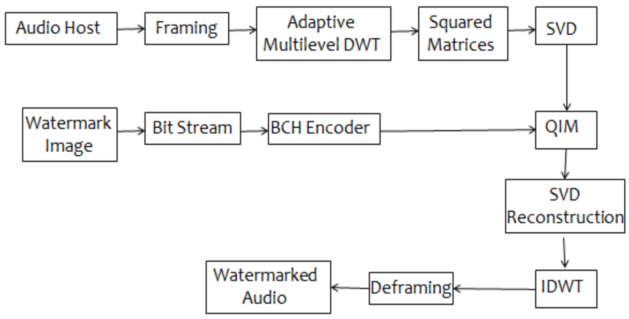

Fig.4. Wavelet Transformation Decomposition Process

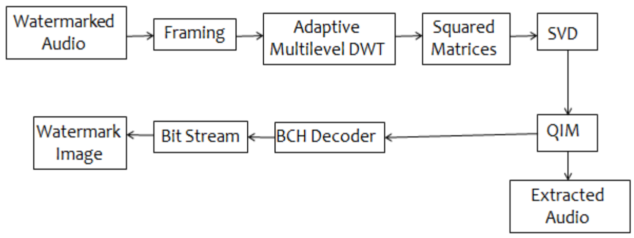

Fig.5. Wavelet Transformation Decomposition Process

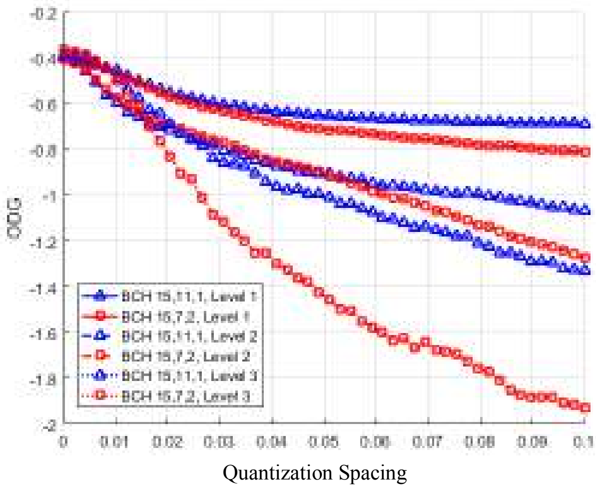

Fig. 6. ODG With LPF Attack

B. Noise Addition

In this analysis, the audio with watermark inserted will be given AWGN (Additive White Gaussian Noise) of -20 dB. The performances of the watermarking system can be seen in Fig. 9 – Fig. 11. With noise attack, on quantization spacing 0.1, perceptual performance of watermarking audio ODG (Fig. 9) for BCH code 15,11,1 level 1 = -2.1 and level 3 = -2.74; while BCH code 15,7,2 level 1 is -2.26 and level 3 is -3.32. SNR performances can be seen in Fig. 10, where BCH code 15,11,1 has level 1 = 29 dB and level 3 = 28.2 dB and BCH code 15,7,2 has level 1 = 27.2 dB and level 3 = 26.4 dB. While the performance of BER is shown in Fig. 11, where BCH code 15,7,2 has better value than BCH code 15,11,1. In our system, we have high security watermark image at BCH 15,7,2 level 3 where the BER value is the lowest among other parameters. The trade off for high security, we will have lower SNR and ODG values.

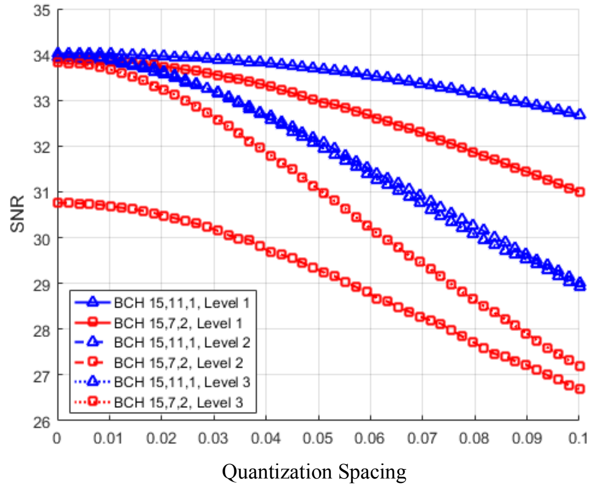

Fig. 7. SNR With LPF Attack

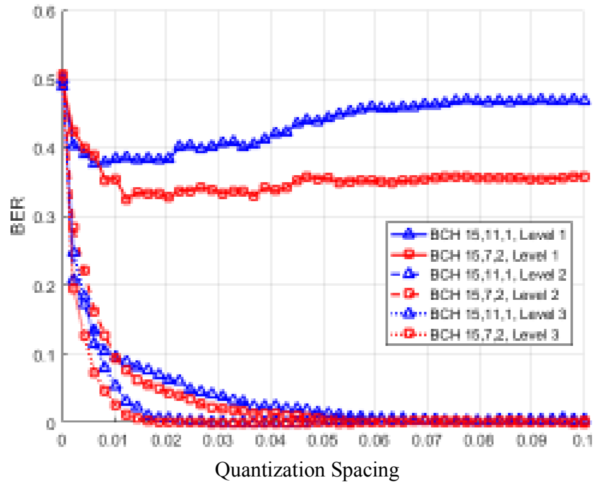

Fig. 8. BER With LPF Attack

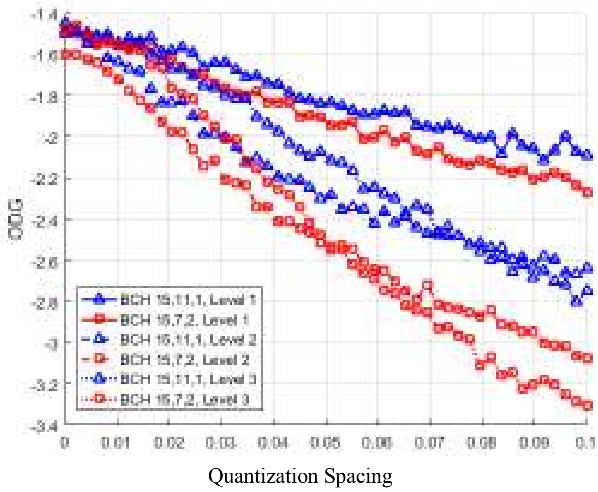

Fig. 9. ODG With Noise Attack

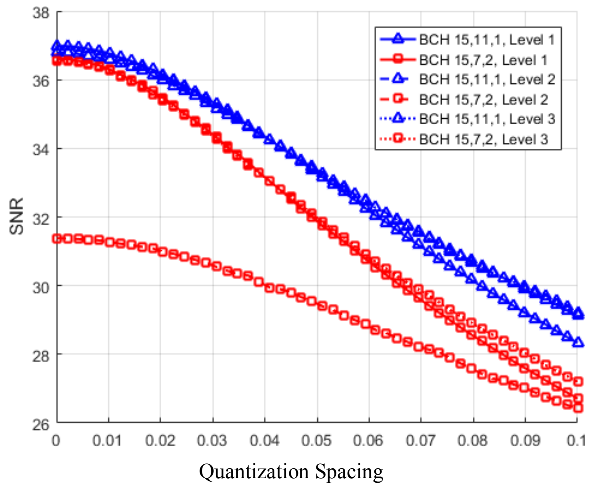

Fig. 10. SNR With Noise Attack

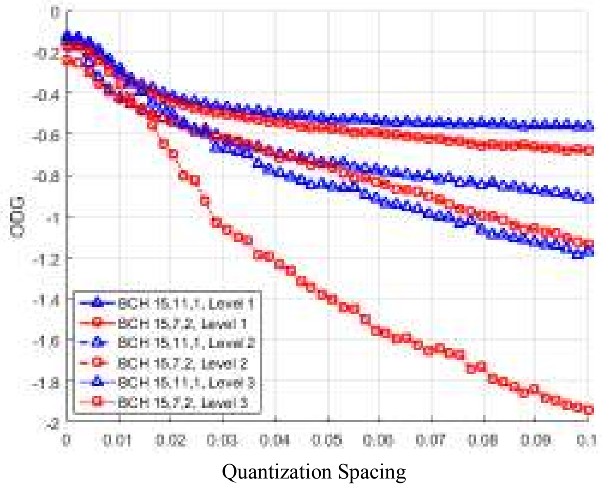

Fig. 12 ODG With MP3 Compressing Attack

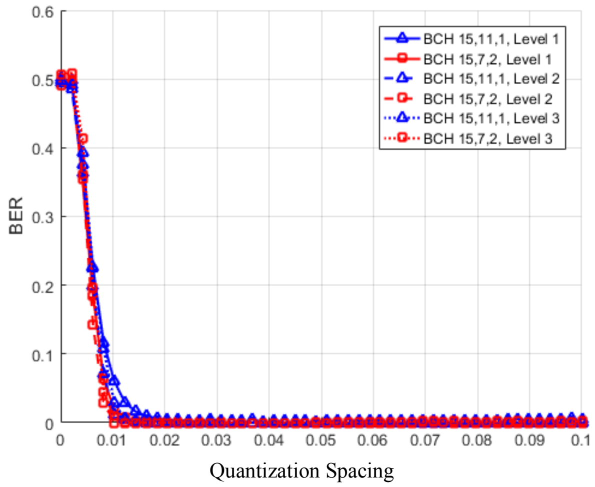

Fig. 11. BER With Noise Attack

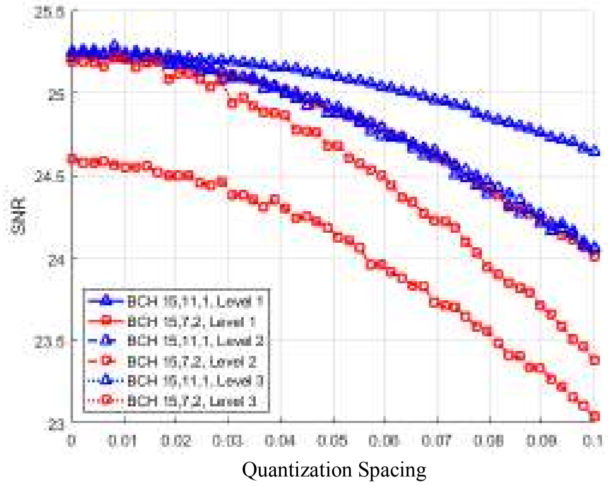

Fig. 13. SNR With MP3 Compressing Attack

C. MPEG Layer-3 (MP3) Compression

MP3 compression attack is an attack in audio file compression system based on psychoacoustics filters. In this experiment we use MP3 compression rate of 128 Kbps. In the presence of MP3 compression attack, on a quantization spacing of 0.1, the perceptual performance of an audio watermarking of ODG is in Fig. 12, where BCH code 15,11,1 level 1 = -0.58 and level 3 = -1.2; while BCH code 15,7,2 level 1 is -0.7 and level 3 is -1.95. SNR performances are shown in Fig. 13, where BCH code 15,11,1 level 1 = 24.7 dB and level 3 = 24.1 dB, and BCH code 15,7,2 level 1 is 24 dB and level 3 is 23 dB. While the performance of the BER is shown in Fig. 14, where BCH code 15,7,2 has better performance than BCH code 15,11,1 and wavelet level 3 has better BER value than level 1. In our system, we have high security watermark image at BCH 15,7,2 level 3 where the BER value is the lowest among other parameters. The tradeoff for high security, we will have lower SNR and ODG values.

D. Linear Speed Change (LSC)

LSC attack is an attack that works by changing the speed or tempo of audio files which also affects the pitch change of the audio file. Fig. 15 – Fig. 17 show the experiment result for ODG, SNR and BER.

From the figures, at 0.1 quantization spacing, the perceptual performance of the watermarking audio of ODG (Fig. 15) for BCH code 15,11,1 level 1 = -0.58 and level 3 = -1.02, while BCH code 15,7,2 level 1 is -0.68 and level 3 is -1.52. SNR values can be seen in Fig. 16, where BCH code 15,11,1 level 1 = 33 dB and level 3 = 31 dB and BCH code 15,7,2 level 1 is 29 dB and level 3 is 27 dB. BER values for walelet level 2 and 3 have approximately the same values and much better values than that of in the level 1 for both BCH codes (Fig. 17). In our system, we have high security watermark image at BCH 15,7,2 level 3 where the BER value is the lowest among other parameters. The trade off for high security, we will have lower SNR and ODG values.

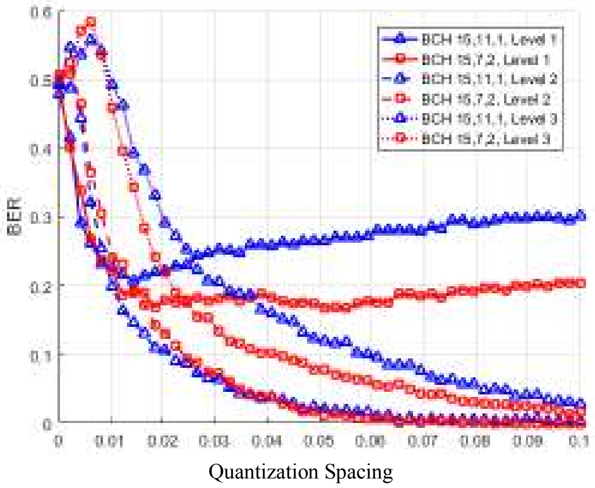

Fig. 14. BER With MP3 Compressing Attack

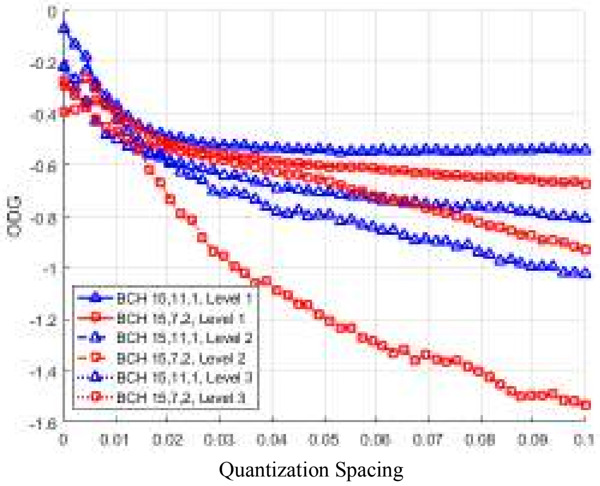

Fig. 15. ODG With LSC Attack

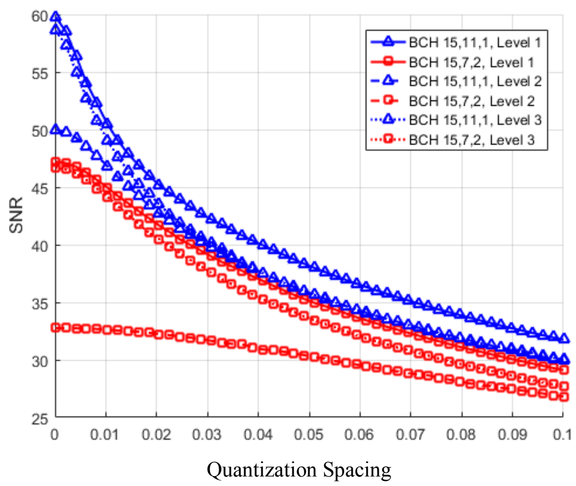

Fig. 16. SNR With LSC Attack

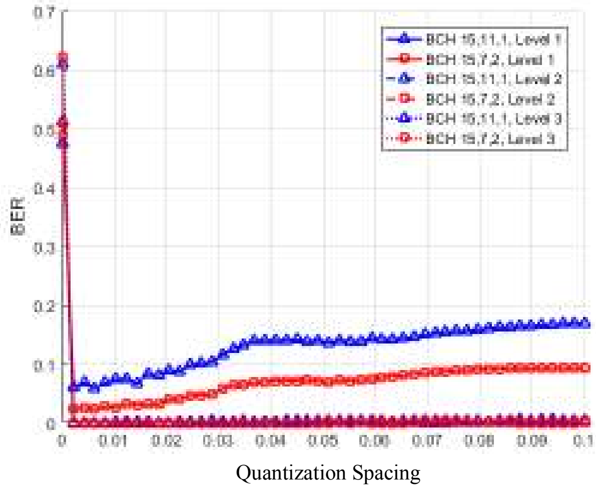

Fig. 17 BER With LSC Attack

V. CONCLUSION

In this research, the perceptual quality of audio parameters: ODG, SNR and BER has been analized with various attacks and DWT level at quantization spacing of 0.1 for both BCH codes of 15,11,1 and 15,7,2. For ODG and SNR values for DWT level 1 are higher than level 3, that can reach ODG for BCH code 15,11,1 level 1 = -0.58 and BCH code 15,7,2 level 1 = -0.68 on LSC attack type; SNR for BCH code 15,11,1 level 1 = 32.6 dB and BCH code 15,7,2 level 1 = 31 dB on LPF attack type. While for watermark image BER parameter, the result of the research shows that BER level 1 is worse than level 3, and BCH code 15,7,2 has better BER values than those of BCH code 15,11,1. In our system, we have high security watermark image at BCH 15,7,2 level 3 where the BER value is the lowest among other parameters. The trade off for high security, we will have lower SNR and ODG values.

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