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ANALYSIS OF THE IMPACT OF DISTORTION ON SOUND RECORDINGS AS ANTI-FORENSIC ACTIVITIES

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ABSTRACT
Anti-forensics on audio is aimed at complicating investigations on audio forensics, on sound recordings. Sound recordings can be altered or manipulated in various ways as well as the provision of distortion effects on sound recordings. Effect such distortions will make it difficult for investigators to find out the owner of the original voice. Analysis of distortion effects on sound recordings for anti-forensic activities, has not been widely carried out. Distortion can be an effective anti-forensic technique because the sound produced will be noisy, making it difficult for investigators to conduct investigations. In this study, testing was carried out using 3 types of distortion, namely Hard Clipping, Hard Overdrive and Odd Harmonics. To find out the extent to which the three types of distortions make it difficult to identify the owner of the original sound, the variables that affect each type of distortion are set at low, medium, and high levels. Formant values from the original and distorted sound samples were compared for later analysis using the Anova One-Way approach to show whether the original sound was identical and the other three voices were distorted. The test was carried out using 10 sound samples. From the results of the anova analysis, it is known that the types of Distortion of Hard Clipping and Odd Harmonics with variables at high levels can manipulate sound recordings, making it difficult to recognize the authenticity of a sound recording. Unlike the case with the type of Distortion of Hard Overdrive with variable level high – low and Hard Clipping and Odd Harmonics with variable level low – medium, it proves that sound recordings can still be identified.

I. INTRODUCTION

THE term anti-forensics has become a staple for digital researchers. The term is not new, but there is no clear definition [1]. Forensics is the specialized scientific analysis of anti-forensic behavior as evidence in court. Since 2008, audio recordings have been admissible as valid evidence in Indonesian courts [2]. Using multimedia voice recording technology, evidence is often found at crime scenes in the form of voice recorders with voice recordings of people's conversations. Different dictaphones found at crime scenes can be compared to determine if the recording device belongs to the same person [3]. These digital voice recordings are part of the evidence that needs to be verified for authenticity, as their use in the courtroom is so large and growing [4]. Forensic speech comparison (FVC) usually refers to comparing recordings of a perpetrator with those of a suspect for the purpose of assisting investigative agencies or courts in identifying the identity of the speaker [5]. Records can be used as evidence in both criminal and civil cases.

Along with the times in this modern era, technology has become important in supporting human activities. Technology as a human creation has a positive side and a negative side [6]. But basically, technology is neutral, meaning that positive or negative impacts arise depending on the intended use. One of the significant technological developments is the change from physical data storage to digital data. Storage data that has changed include data in the form of images, video and sound. Changes in data storage also affect tools for recording data. The audio recorder also underwent a change from an analog phonograph recorder to a digital recorder that was not shaped like a recorder [7]. From several previous studies, voice manipulation has been carried out to change the identity of the original voice with various anti-forensic methods such as the use of a voice changer with a telephone effect conducted by A.B Baskoro [8] in 2020, the use of a voice changer with the effects of aliens, robots and zombies conducted by Rusydi Umar [9] in 2019, increasing 20% audio speed conducted by Yasep Azzery [10] in 2020 and the use of MDCT audio conducted by Tao B [11] in 2020.

In a study conducted by A.B Baskoro [8], the voice changer method with telephone effects was able to manipulate

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the authenticity of the voice with an average value of 63.4% and 61.4%, respectively. In a study conducted by Rusydi Umar [9] using a voice changer method with robotic, alien and zombie effects as well as a study conducted by Tao B [11] using the MDCT audio method to manipulate the authenticity of the voice. However, both studies did not use the ANOVA method as an analysis in identifying authenticity in sound recordings. Yasep Azzery [10] conducted a study of manipulating sound recordings by increasing the audio speed by 20%. By analyzing the pitch, formant, and spectrogram using the ANOVA approach, it can be concluded that the sound of the manipulated evidence recording and the recorded voice of the subject as a comparison are not identical.

Based on previous research, this study manipulates sound recordings using different types of distortion effects, namely hard clipping, hard overdrive and odd harmonics. Giving a distortion effect to manipulate sound recordings has not been much researched. So that the results of the effectiveness of the distortion in this sound recording will be compared with the anti-forensic methods that have been studied previously. To complete this research, ANOVA analysis was used to determine the similarities between the original sound recording and the distorted sound recording.

The problem raised in this study is the extent to which the effects of distortion can complicate the process of identifying the authenticity of sound. Another problem is that of some types of distortions, there are distortions that make the sound recording still recognizable and some that are already unrecognizable. The solution given by the researchers was to make an experiment by distorting a sample of sound recordings and analyzed the results using anova to see the effectiveness of each type of distortion in changing the authenticity of a sound recording.

Digital voice forensics uses voice recognition technology that compares two voices: evidence voice (unknown pattern) and comparison voice (known pattern). Its implementation uses several measurable metrics to determine the similarity between evidentiary sounds and a suspect's voice [12]. These metrics include pitch, one of the sound components that describe the intonation of pronunciation. Formants, in turn, are indicators of the articulation and accent of sound pronunciation and are spectrogram indicators of the energy of sound pronunciation. The three indicators have their own function without weakening each other [13]. In this study, digital audio forensic analysis based on formant metrics was performed. In carrying out the analysis process, several supporting applications were used to process the sound shape data numerically using the PRAAT application and then using Excel using a one-factor ANOVA approach. Statistically calculate and determine similarity between samples with evidence of sound was stocked [14].

II. RESEARCH METHOD

The flow of the system diagram will be depicted through the diagram in figure 1:

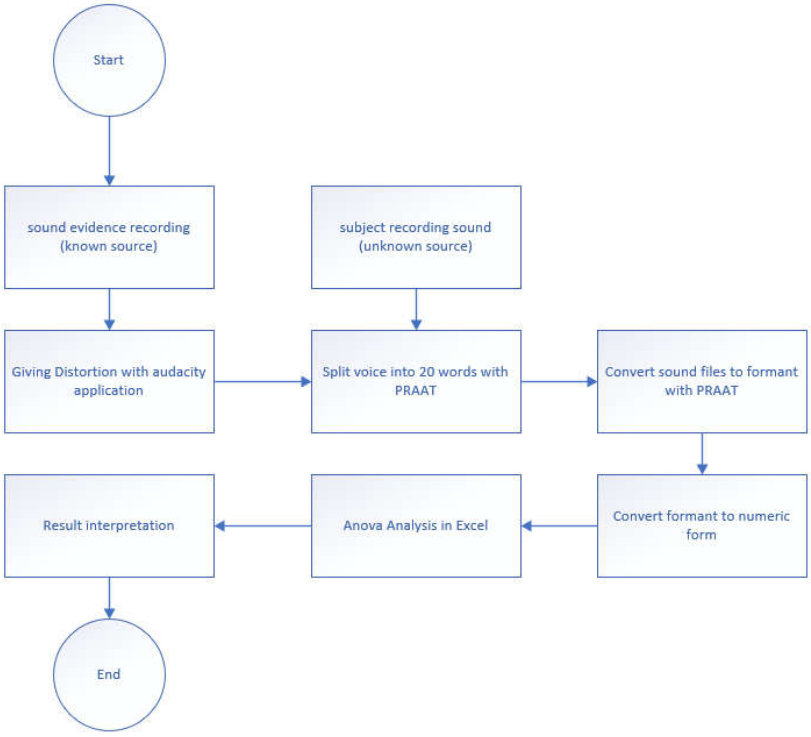

Figure 1. System Diagram Flow

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In figure 1 explains the flow of the system built in this study with the following description:

A. Sound Recording Collection

At this stage, 10 samples of votes were collected consisting of 10 people. For the reference script used as a source of words for the sound-making process, there are 24 words. With sentences: "Gedung TULT atau Telkom University Landmark Tower menjadi gedung perkuliahan tertinggi di wilayah Jawa Barat serta merupakan smart building dan mengusung konsep go green."

B. Giving Distortion to Sound Recording Samples

At this stage, manipulation of the sound recording is carried out by giving a distortion effect. This distortion is done using the audacity application. The distortion effect was given to 10 sound samples that had been collected previously. For the type of distortion used in this study, 3 types are used, namely, Hard Clipping distortion, Hard Overdrive distortion and Odd Harmonic distortion. Of the 3 types of distortion, 3 tests were carried out for each type of distortion by adjusting the control parameters contained in the audacity application. The explanation of the 3 types of distortion used and the control parameters are explained as follows:

1) Hard Clipping Distortion

Hard clipping distortion is clipping that occurs when the amplitude of an audio signal becomes too high for the circuit to generate it. The peaks of the waveform were "clipped" and flattened out like a square wave. This clipping adds high frequency tones to the signal and can make the sound a little fuzzier or even richer and denser [15].

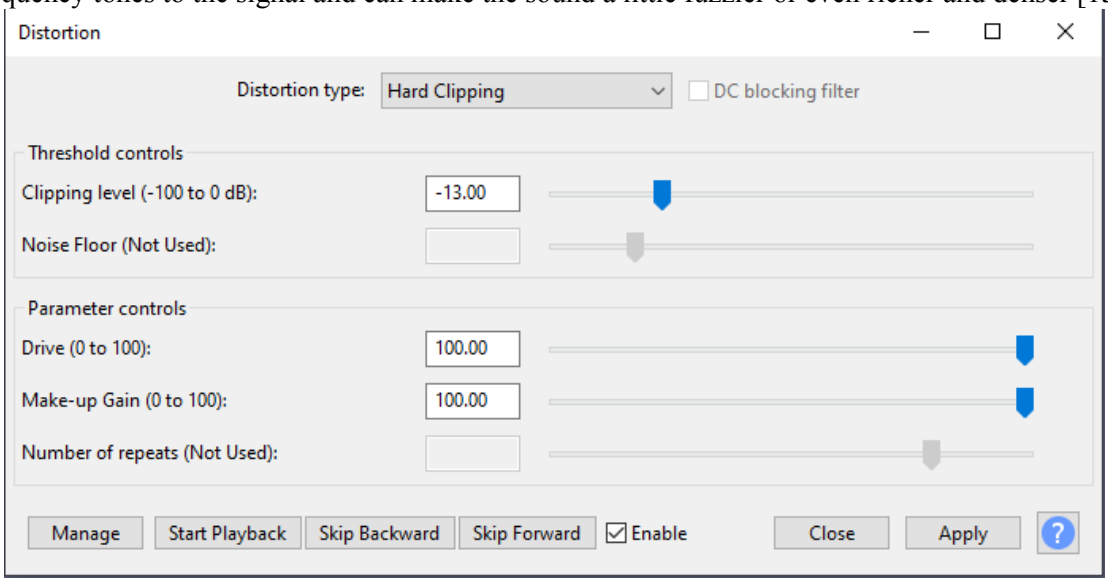

Figure 2. Control parameters of hard clipping distortion

Parameters of controls on hard clipping:

A. Clipping level (-100 to 0 dB): the peak of the wave will be cut from this level.

B. Drive (0 to 100): When set to greater than 0, the waveform amplifies this number (dB) before being truncated.

C. Make-up Gain (0 to 100): When set greater than 0, the output of the effect is amplified.

2) Hard Overdrive Distortion

Hard Overdrive Distortion is distortion with a continuous smooth curve. This type of overdrive is the "loudest" and produces the highest harmonics [15].

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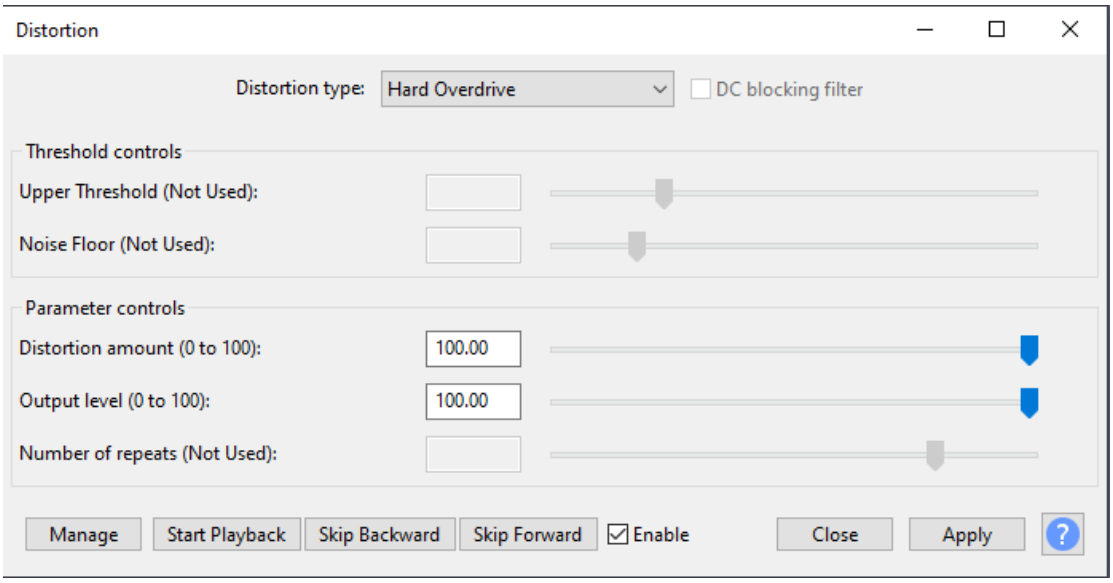

Figure 3. Control parameters hard overdrive distortion

Parameters controls on the hard overdrive:

A. Distortion amount (0 to 100): The number/strength of distortion.

B. Output level (0 to 100): Output level adjustment. When set to 0 the output will be silent.

3) Odd Harmonic Distortion

Odd harmonic distortion is the "odd" harmonics that have odd frequencies many times higher than the fundamental frequency. With this type of distortion, the effect is mild even with full application. Applying the "Distort" algorithm multiple times produces a stronger effect [16]. This can be achieved by setting the "Repeat" slider above 0. Applied only once, each frequency component of the sound gains a harmonic three times its original frequency [15].

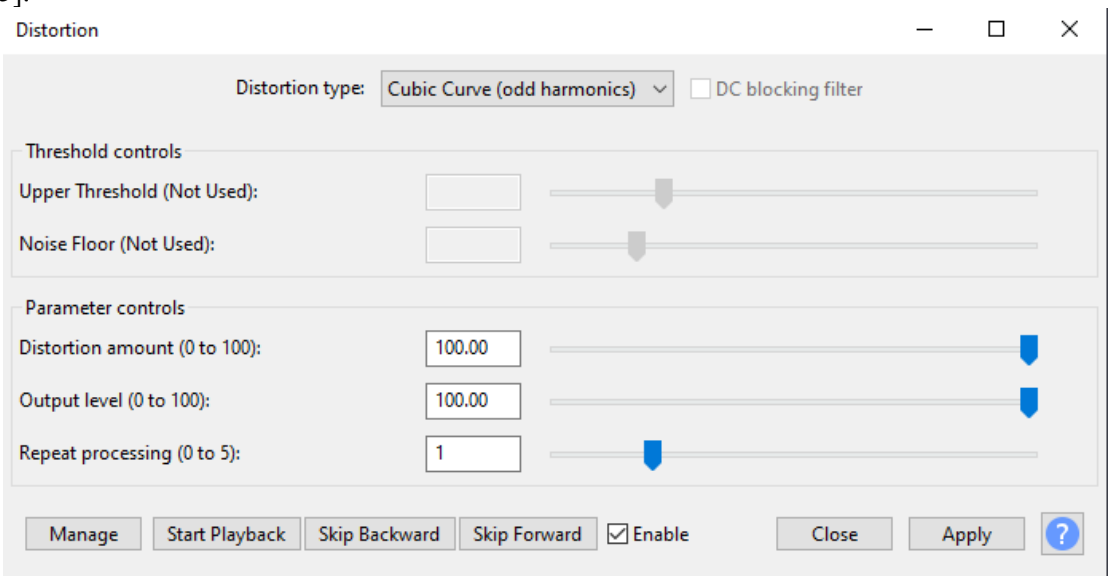

Figure 4. Parameter control odd harmonic distortion

Parameters controls on odd harmonics:

A. Distortion amount (0 to 100): The number/strength of distortion.

B. Output level (0 to 100): Output level adjustment. When set to 0 the output will be silent.

C. Repeat processing (0 to 5): The number of repetitions of the distortion algorithm. If it is set to 0 the effect is applied only once.

C. Sound Splitting Into 20 Words

At this stage, the separation of the subject's voice in the form of sentences into words is carried out because for the formant analysis process, the similarity of each word spoken will be measured so that the results obtained are more detailed. This process is carried out using the PRAAT application which can read and partition audio files

and then save them in .wav format.

D. Convert Sound Files to Formant

Sound files that have been partitioned because they are still in audio format or .wav must be converted in formant form because this research method uses formant parameters in the sound comparison. This process is carried out using the PRAAT application.

E. Convert Formant to Numerical Form

After obtaining the formant file, to facilitate the analysis process in the next stage, the formant data is converted into tabulan or numeric form using the PRAAT application. This conversion will result in 3 formants for each word in each subject.

F. Anova Analysis on Excel

This stage is the process of comparing the original recorded sound and the distorted record sound based on a numerical formant. In this Anova method, it shows the degree of difference in the value of the data group from each formant of the evidence sound and the voice of the comparison subject which is characterized by a comparison of ratios of F, F critical, and probability values (*P* - value).

G. Interpretation of Analysis Results

After processing the data from the Excel application, the results of each word of each subject will be seen that have been compared with the formant perpetrator. The results will then be rewritten so that they can be better understood.

H. Hardware and Software Specification

TABLE I
HARDWARE AND SOFTWARE SPECIFICATION

Personal Computer Hardware	
Hardware	**Detail**
CPU	Intel(R) Core(TM) i7-10700K CPU @3.50GHz
GPU	NVIDIA GeForce RTX 3060 6GB
RAM	16GB DDR4, 2993 Mhz
Internal Storage	1 TB
Operating System	Windows 10 Home
Software	**Detail**
Tools	- Audacity - Praat - Microsoft Excel

Table 1 above explains the hardware and software used in this study. It can be seen in table 1, personal computers are used to support the overall work of this research, starting from the splitting of words until the anova analysis process in excel. For the software used, there is Audacity which is used to change the format of sound recordings into the form of WAV files and provide a distortion effect to the sample sound recording of evidence. Praat is used to divide the word voice recording into 20 which will then be analyzed. Microsoft Excel used for a one-way anova analysis approach process to identify similarities between the original sound recording and the sound recording that has been distorted.

I. Dataset

TABLE II
DATASET

No.	**Type**	**Detail**
1.	Audio	10 files voice record 1 original voice recording (.wav) 3 voice recordings with hard clipping distortion (.wav) 3 voice recordings with hard overdrive distortion (.wav) 3 voice recordings with odd harmonics distortion (.wav)

Table 2 above describes the dataset used in this study. The dataset used is in the form of audio files of voice recordings in WAV format, totaling 10 audio files from each subject. With details of 1 original sound recording file, 3 hard clipping distortion sound recording files with low - high range, 3 hard overdrive distortion sound recording files with low - high range, 3 odd harmonics distortion sound recording files with low - high range. So that from the 10 subjects used in this study, a total of 100 voice samples were analyzed.

J. *Audio Distortion*

Distortion is generally the intention to change something from its real, natural, or original state. Audio distortion is the erroneous reproduction of an audio signal caused by changes in the original signal's waveform. Distorting a waveform changes its frequency, often making the sound "harsh" [15]. For the various types of distortions in the audio, there are three types, namely:

1) Clipping distortion

Clipping distortion is when the top and bottom edges of the signal wave are clipped so that the resulting shape resembles a straight line. Examples of distortion from this method are soft clipping and hard clipping. Soft clipping and hard clipping have the same meaning, the difference is in the soft type itself, the cut above and below the signal wave is not too "straight", and the sound produced is still soft unlike hard clipping [15].

2) Overdrive distortion

Compared to all types of distortion, overdrive distortion is the mildest type of distortion because the waveform change due to overdrive distortion is not that different from the original signal waveform. Examples of this method of distortion include soft overdrive and hard overdrive [15].

3) Harmonic distortion

Harmonic distortion is distortion based on integer multiples of the fundamental frequency. Examples of distortion by this method are even and odd harmonics . Even harmonics have even frequencies that are many times higher than the fundamental frequency. For example, a tone has a fundamental frequency of 440 Hz and is multiplied by even multiples such as 880 Hz, 1760 Hz, and odd harmonics with odd frequencies many times higher than the fundamental frequency. For example, the fundamental frequency of a tone is 440 Hz, and odd multiples give 1320 Hz, 2200 Hz, and so on [15].

K. *Formant Analysis*

Formants are filters, or resonant frequencies from the vocal tract (articulator), that relay and filter the output of meaningful words. In general, the frequency of formants is not limited however, to identify a person there are 3 formants analyzed, namely Formant 1 (F1), Formant 2 (F2) and Formant 3 (F3) [14].

The purpose of analyzing formants is to determine the complex natural frequencies of vowels present during sound generation. Once you know the vowel composition, you can calculate the frequency. Formant analysis usually begins by converting the speech signal into a shorter speech spectrum to reduce interference that can impair speech intelligibility [14].

L. *Analysis of Variance (ANOVA)*

Analysis of variance calculates formant 1, formant 2, formant 3, and formant 4 values based on the robust statistics of the evidence and the votes of the comparators [17]. The ANOVA method is part of a spreadsheet tool that helps find probability values from two or more data samples that have been classified or grouped. The Anova method expresses the degree of difference between data set values of each formant of evidence speech and comparison speech as a ratio of F, F critical, and probability (*P* - value) values. The ratio F is the ratio of the two mean squared values. The calculation of the ratio F comes from dividing the mean square and the mean square error [18]. F Critical is the value used to determine the significance of groups of variables. Critical F-value obtained from the F-distribution table. The *P* – value is the size of the observed odds (probability) from the test statistic. *P* - value is taken from degrees of freedom and F value. ANOVA uses an error rate of 0.05 because the probability value of getting a correct decision for each individual comparison is 0.95. Therefore, when the analysis of this method is completed, the detection accuracy is 95% [17, 19, 20].

III. RESULT & DISCUSSION

A. *Test Result*

In this section, the test results of the three types of distortions used in this study are described by making 3 different types of tests based on the control parameters that have been set.

1) Hard Clipping Distortion

TABLE III
TEST RESULTS WITH HARD CLIPPING DISTORTION

Subject	Testing Range	Class	Tested Words	Anova Analysis	Decision
Anas	Range Low	Identical	20	20	Identical
		Not Identical		0	
	Range Medium	Identical	20	20	Identical
		Not Identical		0	
	Range High	Identical	20	0	Not Identical
		Not Identical		20	
Aria	Range Low	Identical	20	20	Identical
		Not Identical		0	
	Range Medium	Identical	20	19	Identical
		Not Identical		1	
	Range High	Identical	20	0	Not identical
		Not Identical		20	
Iqbal	Range Low	Identical	20	19	Identical
		Not Identical		1	
	Range Medium	Identical	20	19	Identical
		Not identical		1	
	Range High	Identical	20	0	Not identical
		Not identical		20	
Nopal	Range Low	Identical	20	20	Identical
		Not Identical		0	
	Range Medium	Identical	20	18	Identical
		Not Identical		2	
	Range High	Identical	20	1	Not Identical
		Not Identical		19	
Rafly	Range Low	Identical	20	18	Identical
		Not Identical		2	
	Range Medium	Identical	20	19	Identical
		Not Identical		1	
	Range High	Identical	20	1	Not Identical
		Not Identical		19	
Owen	Range Low	Identical	20	18	Identical
		Not Identical		2	
	Range Medium	Identical	20	16	Identical
		Not Identical		4	
	Range High	Identical	20	1	Not Identical
		Not Identical		19	
Argon	Range Low	Identical	20	19	Identical
		Not Identical		1	
	Range Medium	Identical	20	17	Identical
		Not Identical		3	
	Range High	Identical	20	0	Not Identical
		Not Identical		20	
Thoriq	Range Low	Identical	20	19	Identical
		Not Identical		1	
	Range Medium	Identical	20	18	Identical
		Not Identical		2	

	Range High	Identical	20	2	Not Identical
		Not Identical		18	
Putra	Range Low	Identical	20	17	Identical
		Not Identical		3	
	Range Medium	Identical	20	19	Identical
		Not Identical		1	
	Range High	Identical	20	3	Not Identical
		Not Identical		17	
Faisal	Range Low	Identical	20	19	Identical
		Not Identical		1	
	Range Medium	Identical	20	19	Identical
		Not Identical		1	
	Range High	Identical	20	4	Not Identical
		Not Identical		16	

2) Hard Overdrive Distortion

TABLE IV
TEST RESULTS WITH HARD OVERDRIVE DISTORTION

Subject	Testing Range	Class	Tested Words	Anova Analysis	Decision
Anas	Range Low	Identical	20	19	Identical
		Not Identical		1	
	Range Medium	Identical	20	19	Identical
		Not Identical		1	
	Range High	Identical	20	17	Identical
		Not Identical		3	
Aria	Range Low	Identical	20	18	Identical
		Not Identical		2	
	Range Medium	Identical	20	19	Identical
		Not Identical		1	
	Range High	Identical	20	17	Identical
		Not Identical		3	
Iqbal	Range Low	Identical	20	19	Identical
		Not Identical		1	
	Range Medium	Identical	20	19	Identical
		Not identical		1	
	Range High	Identical	20	17	Identical
		Not identical		3	
Nopal	Range Low	Identical	20	19	Identical
		Not Identical		1	
	Range Medium	Identical	20	18	Identical
		Not Identical		2	
	Range High	Identical	20	16	Identical
		Not Identical		4	
Rafly	Range Low	Identical	20	19	Identical
		Not Identical		1	
	Range Medium	Identical	20	19	Identical
		Not Identical		1	
	Range High	Identical	20	17	Identical
		Not Identical		3	
Owen	Range Low	Identical	20	18	Identical
		Not Identical		2	

	Range Medium	Identical	20	18	Identical
		Not Identical		2	
	Range High	Identical	20	17	Identical
		Not Identical		3	
Argon	Range Low	Identical	20	16	Identical
		Not Identical		4	
	Range Medium	Identical	20	16	Identical
		Not Identical		4	
	Range High	Identical	20	12	Identical
		Not Identical		6	
Thoriq	Range Low	Identical	20	19	Identical
		Not Identical		1	
	Range Medium	Identical	20	17	Identical
		Not Identical		3	
	Range High	Identical	20	16	Identical
		Not Identical		4	
Putra	Range Low	Identical	20	18	Identical
		Not Identical		2	
	Range Medium	Identical	20	17	Identical
		Not Identical		3	
	Range High	Identical	20	17	Identical
		Not Identical		3	
Faisal	Range Low	Identical	20	17	Identical
		Not Identical		3	
	Range Medium	Identical	20	16	Identical
		Not Identical		4	
	Range High	Identical	20	16	Identical
		Not Identical		4	

3) Odd Harmonics Distortion

TABLE V
TEST RESULTS WITH ODD HARMONIC DISTORTION

Subject	Testing Range	Class	Tested Words	Anova Analysis	Decision
Anas	Range Low	Identical	20	20	Identical
		Not Identical		0	
	Range Medium	Identical	20	20	Identical
		Not Identical		0	
	Range High	Identical	20	0	Not Identical
		Not Identical		20	
Aria	Range Low	Identical	20	19	Identical
		Not Identical		1	
	Range Medium	Identical	20	20	Identical
		Not Identical		0	
	Range High	Identical	20	1	Not Identical
		Not Identical		19	
Iqbal	Range Low	Identical	20	19	Identical
		Not Identical		1	
	Range Medium	Identical	20	19	Identical
		Not identical		1	
	Range High	Identical	20	2	Not Identical

		Not identical		18	
Nopal	Range Low	Identical	20	19	Identical
		Not Identical		1	
	Range Medium	Identical	20	19	Identical
		Not Identical		1	
	Range High	Identical	20	0	Not Identical
		Not Identical		20	
Rafly	Range Low	Identical	20	18	Identical
		Not Identical		2	
	Range Medium	Identical	20	19	Identical
		Not Identical		1	
	Range High	Identical	20	1	Not Identical
		Not Identical		19	
Owen	Range Low	Identical	20	17	Identical
		Not Identical		3	
	Range Medium	Identical	20	15	Identical
		Not Identical		5	
	Range High	Identical	20	2	Not Identical
		Not Identical		18	
Argon	Range Low	Identical	20	19	Identical
		Not Identical		1	
	Range Medium	Identical	20	16	Identical
		Not Identical		4	
	Range High	Identical	20	0	Not Identical
		Not Identical		20	
Thoriq	Range Low	Identical	20	16	Identical
		Not Identical		4	
	Range Medium	Identical	20	15	Identical
		Not Identical		5	
	Range High	Identical	20	3	Not Identical
		Not Identical		17	
Putra	Range Low	Identical	20	19	Identical
		Not Identical		1	
	Range Medium	Identical	20	19	Identical
		Not Identical		1	
	Range High	Identical	20	2	Not Identical
		Not Identical		18	
Faisal	Range Low	Identical	20	20	Identical
		Not Identical		0	
	Range Medium	Identical	20	13	Identical
		Not Identical		7	
	Range High	Identical	20	8	Not Identical
		Not Identical		12	

B. Analysis of Test Results

1) Analysis of Hard Clipping Distortion Results

In the test results of Hard Clipping Distortion with 3 different test ranges, different decision results were obtained. When the sound sample is tested with a low range, with a control clipping level parameter (-13.00 dB); Drives (25); Make-up Gain (25). After being analyzed with anova, identical results were obtained. When the sound sample is tested with a medium range, with a control clipping level parameter (-14.00 dB); Drive (55); Make-up Gain (60). After being analyzed with anova, identical results were obtained. When the sound sample is tested with a high

range, with a control clipping level parameter (-40.00 dB); Drive (95); Make-up Gain (100). After being analyzed with anova, the results were not identical.

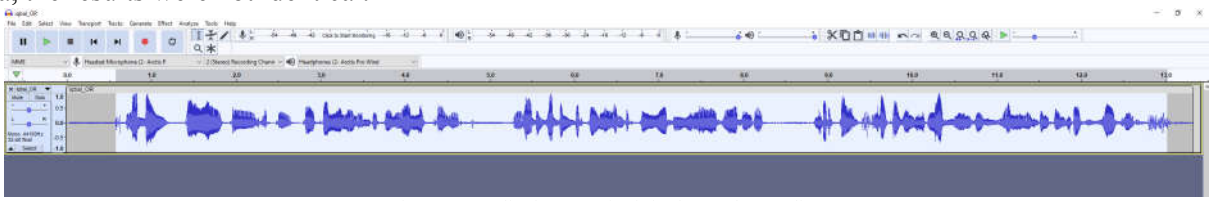

Figure 5. Audio frames of original sound recording

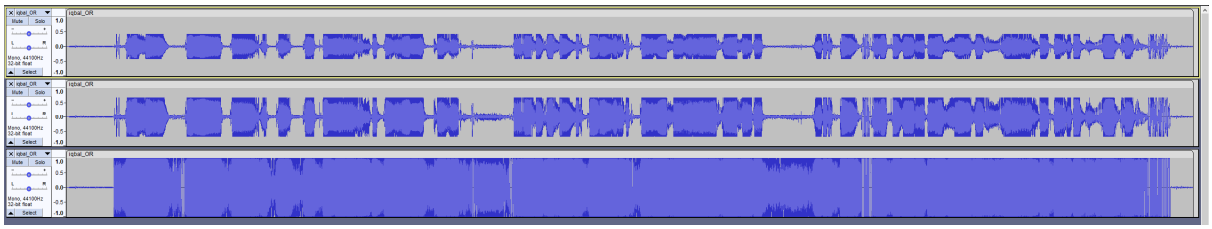

Figure 6. Audio frames of sound recordings that have been distorted by hard clipping in the low – high range

In figures 5 and 6, the shape of the frames in the original and already distorted sound recordings has differences. The higher the range parameter control applied, the larger or changed the resulting audio frame will be.

2) Analysis of Hard Overdrive Distortion Results

In the test results of Hard Overdrive Distortion with 3 different test ranges, different decision results were obtained. When the sound sample is tested with a range low, with a parameter of Distortion amount (25); Output level (25). After being analyzed with anova, identical results were obtained. When the sound sample is tested with a medium range, with control parameter Distortion amount (55); Output level (60). After being analyzed with anova, identical results were obtained. When the sound sample is tested with a high range, with control parameter Distortion amount (95); Output level (100). After being analyzed with anova, identical results were obtained.

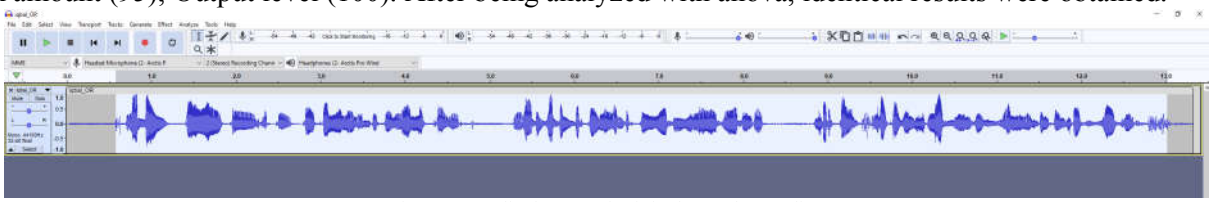

Figure 7. Audio frames of original sound recording

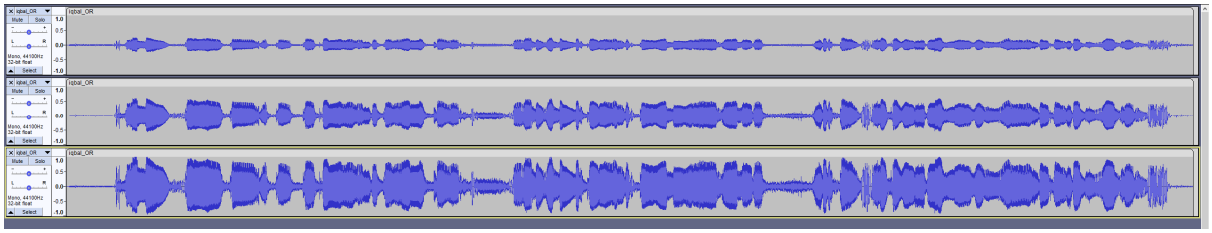

Figure 8. Audio frames of voice recordings that have been distorted by hard overdrive in the low – high range

In figures 7 and 8, the shape of the frames in the original and already distorted sound recordings has differences. The higher the range parameter control applied, the larger or changed the resulting audio frame will be.

3) Analysis of Odd Harmonics Distortion Results

In the odd harmonic distortion test results with 3 different test ranges, different decision results were obtained. When the sound sample is tested with a low range, with a distortion amount parameter (25); Output level (25); Repeat processing (1). After being analyzed with anova, identical results were obtained. When the sound sample is tested with a medium range, with a control parameter Distortion amount (60); Output level (60); Repeat processing (1). After being analyzed with anova, identical results were obtained. When the sound sample is tested with a range high, with control parameter Distortion amount (95); Output level (100); Repeat processing (3). After being analyzed with anova, the results were not identical.

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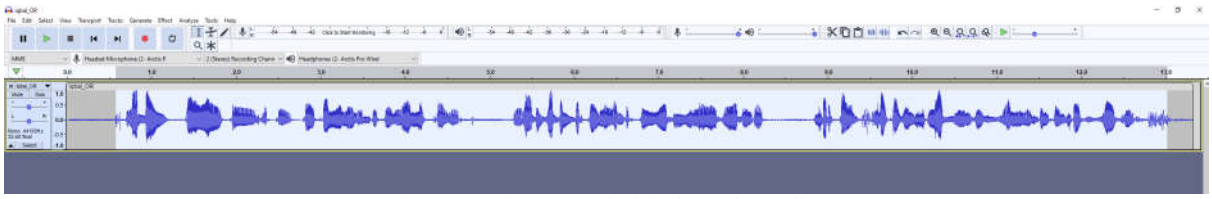

Figure 9. Audio frames of original sound recording

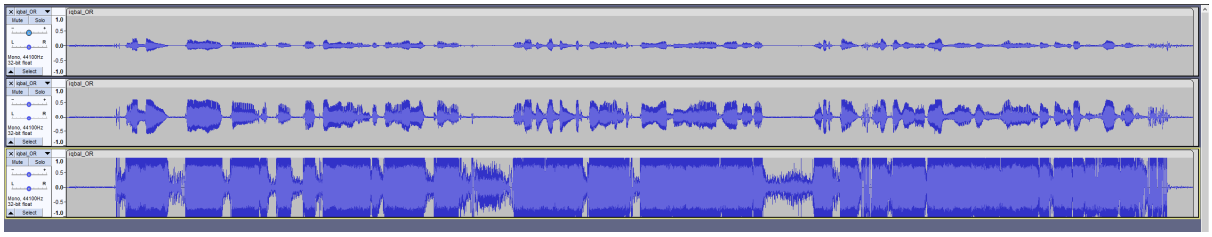

Figure 10. Audio frames of sound recordings that have been distorted odd harmonics in the low – high range

In figures 9 and 10, the shape of the frame on the original and already distorted sound recordings has differences. The higher the range parameter control applied, the larger or changed the resulting audio frame will be.

4) Analysis of Anova Approach Results

TABLE VI
EXAMPLE OF FORMANT CALCULATION RESULTS

Sample 1

Word	Telkom			
Parameter	Formant Value	*P* – Value	Formant Critical Value	Description
Formant 1	1.086745791	0.299521302	3.929011718	Accepted
Formant 2	0.438177568	0.509413345	3.929011718	Accepted
Formant 3	5.556438204	0.020214177	3.929011718	Rejected
Description	OK			

In table 6, we can see the ANOVA values of F1(formant 1), F2(formant 2) and F3(formant 3). *P* - values can be used to easily determine whether voice recording comparisons are identical. *P* - Value required value must be greater than or equal to 0.5. Another way is to compare the values of F and F critical. If the value of F is less than F critical, it can be shown that the two data sets compared and analyzed using the ANOVA technique are similar. It is sufficient to examine the values of F1 and F2 in a formant ANOVA analysis to draw conclusions. This is because there are more distinct speaker tone frequencies at the two formant frequency values [21].

5) Analysis of Percentage Results of Each Type of Distortion

a) Results Of Hard Clipping Distortion

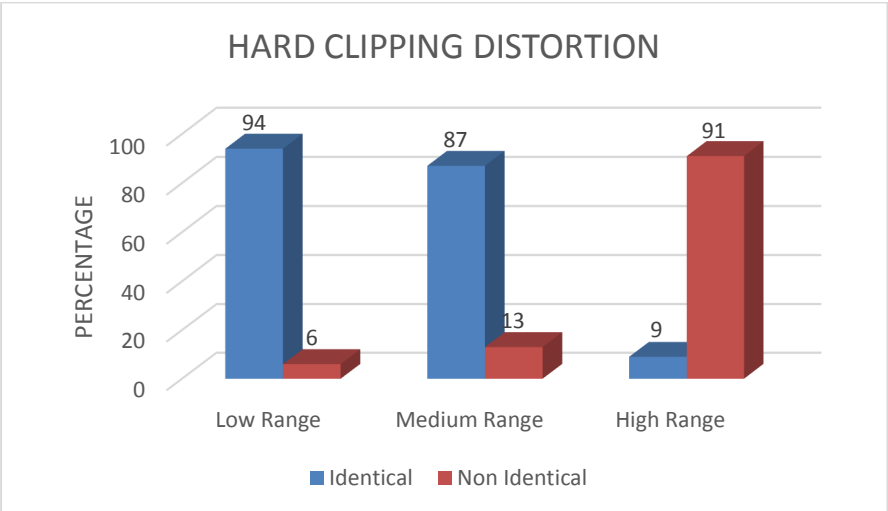

Figure 11. Percentage of results from hard clipping distortion

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In figure 11 showing the test results of hard clipping distortion on 10 subjects that have been analyzed through anova, it is concluded that in high range testing, it was obtained a percentage of 91% for non-identical results, so that with these results it can be difficult to identify authenticity in sound recordings. Unlike the test in the low-medium range, a percentage of 94% and 87% was obtained for identical results, so that with these results the sound that has been distorted can still be recognized for its authenticity.

b) Results of Hard Overdrive Distortion

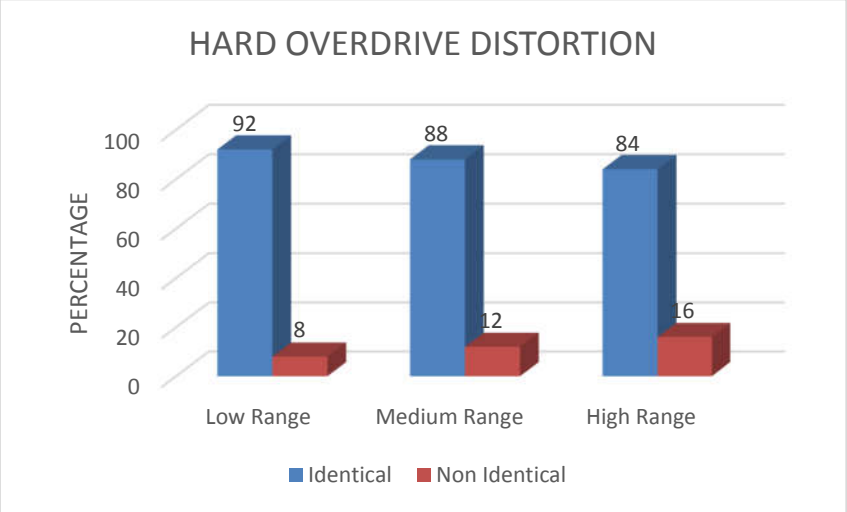

Figure 12. Percentage of results from hard overdrive distortion

In figure 12 showing the test results of hard overdrive distortion on 10 subjects that have been analyzed through anova, it is concluded that in the low - high range test, it gets percentages of 92%, 88%, and 84% for identical results, so that with these results the sound that has been distorted can still be recognized for authenticity.

c) Results of Odd Harmonics Distortion

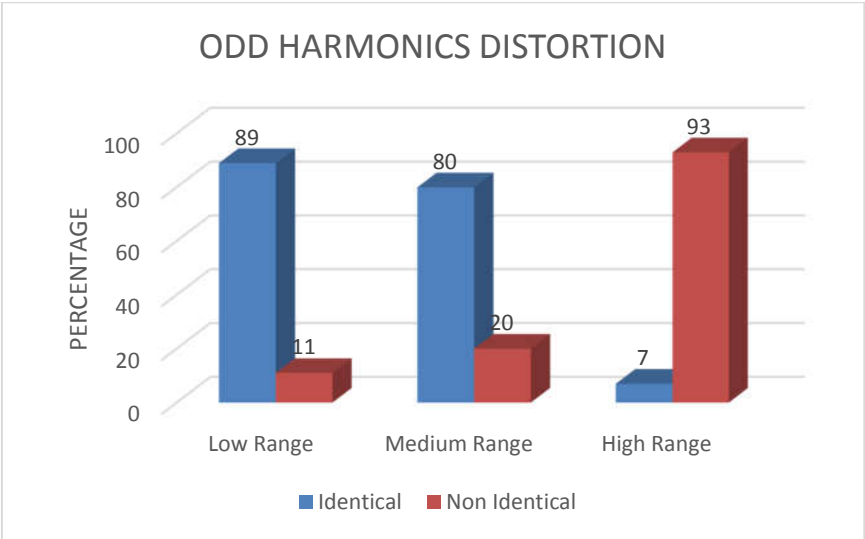

Figure 13. Percentage of results from odd harmonics distortion

In figure 13 showing the test results of odd harmonic distortion in 10 subjects that have been analyzed through anova, it is concluded that in high range testing, it was obtained a percentage of 93% for non-identical results, so that with these results it can be difficult to identify authenticity in sound recordings. In contrast to testing in the low-medium range, percentages of 89% and 80% were obtained for identical results, so that with these results the distorted sound can still be recognized for its authenticity.

From the analysis of the percentage results of each type of distortion tested, it was obtained the type of distortion that has a high percentage in manipulating sound, namely the type of hard clipping distortion and odd harmonics with a high range that produces an average value of 92%. From the results of the average value that has been obtained, it can be compared with the test results from previous studies using the voice changer method, MDCT audio and increasing audio speed that the percentage of effectiveness in manipulating sound produced from the

effects of hard clipping distortion and odd harmonics with a high range is greater than the anti-forensic method that has been used in previous studies.

IV. CONCLUSION

Based on the purpose of this study, which is to find out how far the impact of distortion effects on sound recordings as part of anti-forensic activities, it can be concluded that from the three types of distortions used in this study, they get types of distortions that are effective in manipulating the authenticity of sound recordings and types of distortions that can still be recognized for their authenticity. From the test results in this study, the types of Distortions of Hard Clipping and Odd Harmonics with controls range high parameters can manipulate sound recordings with a percentage of 91% and 93%, respectively, making it difficult to recognize the authenticity of a sound recording. Unlike the case with the type of Hard Overdrive distortion with controls range parameters high – low and Hard Clipping and Odd Harmonics with low – medium controls parameters, with percentages of 92%, 88%, and 84% respectively for hard overdrive then a percentage of 94% and 87% for hard clipping, respectively, and a percentage of 89% and 80% for odd harmonics, respectively, that the results of the Anova analysis prove that sound recordings can still be identified. With the use of the Anova method in analyzing formants in this study, the recognition accuracy rate reached 95%. For further work, it is quite possible to use other audio data processing applications, as is the case with Audacity. Because, by using other audio data processing applications, it can find variations of other audio effects and different control parameter variables.

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