

Technical Report

Animation of VBOC2 GMGM Special Cases Waveforms ACF

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Abstract—The main purpose of this research is the animation of futuristic generalized multidimensional geolocation modulation (GMGM) waveforms.

Animation is defined as the technique, or the execution of an algorithm by means of a computer simulation, of photographing successive drawings, pictures, illustrations, representation, portrayal, delineation, depiction, composition, diagrams, study, outline, graphs, design, plans, plots, charts, or snap shots, or models to create an illusion of movement when the movie is shown as a sequence.

The focus on this paper is the description of the animation itself more than the analysis that results by utilizing the animation. I believe that the case can be made that *animation* may be seen as a very high qualitative and quantitative tool to bring into light insights, understanding, knowledge, verification of the ACF of the VBOC2 GMGM that a researcher, scientist, scholar, developer, engineer, expert may not be able to derive by other means.

Nevertheless, as seen in the content of this paper, *development of animation* in MATLAB requires significant amount of work, creativity, originality, and novelty to produce the *execution of animation* via a '*.avi', '*.mp4', or '*.mj2' files of the special cases on the VBOC2 GMGM.

Index Terms—Pulse generation, pulse amplitude modulation, pulse width modulation, multidimensional sequences, signal design, signal analysis, generalized functions, time analysis, animation, development, execution.

1 Introduction

The main objective of this paper is animation of $VBOC2(\alpha_1, \alpha_2)$ GMGM special cases waveforms ACF.

VBOC is a GMGM waveform of a Binary Offset Carrier (BOC) modulation, which is a GM of a Binary Phase-Shift Keying (or BPSK) modulation.

Definition: Animation is defined as the technique, or the execution of an algorithm by means of a computer simulation, of photographing successive drawings, pictures, illustrations, representation, portrayal, delineation, depiction, composition, diagrams, study, outline, graphs, design, plans, plots, charts, or snap shots, or models to create an illusion of movement when the movie is shown as a sequence.

One of the earliest descriptions of animation in the computation of the ACF comes from physical chemistry (Berne, Forster 1971, [1]). According to (Berne, Forster 1971, [1]) “*The computer output may be regarded as a dynamical movie of the manybody system and can be converted into a movie via computer animation techniques. This has been done by several investigators (Harp, Berne, Paskin, Rahman, and Fehder). Such sources are a particularly convenient way to present the enormous data so that the viewer can get some insight into the dynamical behavior of molecules in condensed media.*” Therefore, one should draw the conclusion that the earliest description of animation in the ACF was probably known by a very limited number of researchers, scholars, or scientists in the late 1960s.

One of the earliest descriptions of animation and BPSK signals is by Peter Banks of Stanford University in a National Administration Space Agency (NASA) report, (Banks 1986 pg. 2, [2]) “*in the area of video research, considerable progress has been made in the development of interfaces between the state-of-the-art Bosch FGS 4000 video graphics and animation system and the Evans and Sutherland PS 300 and the IRIS 2400 CAD/CAE systems.*” and (Banks 1986 pg. 40, [2]) “*The SM200A filter performance reduces this channel spacing to 7 times the symbol rate for versions using QPSK and 1.4 times the symbol rate for versions using BPSK. This can mean lower operating costs in many situations.*”

From the Naval Postgraduate School 1990 report of that contains the compilation of abstract thesis (Anon. 1990, [3]) we have three records of animation: (1) E.L. Pagenkopf, Lieutenant (LT), United States Navy (USN) “dynamic stall

analysis utilizing *interactive computer graphics*,” Mar. 1988; (2) F.E. Harris, LT, USN, “Preliminary work on the command and control workstation of the future,” June 1988; (3) T.W. Meier, LT, USN “Investigation into the use of texturing for real-time computer animation,” Dec. 1987. According to Pagenkopf, “*Flow field solutions in the form of pressure coefficient and stream function contour plots about an airfoil experiencing dynamic stall are plotted utilizing an IRIS 3000-series workstation and Graphical Animation System (GAS) software, developed by Sterling Software for NASA.*” According to Harris “*this initial display uses three resolutions to display large areas of Defense Mapping Agency Digital Terrain Elevation Data with near real time animation.*” And according to Meier “*... in this study an investigation into the use of texturing on the Silicon Graphics, Inc. IRIS for real-time computer animation.*”

In Zalesac, Huba, Mulbrandon, 1988 [4], [5] “3D dynamics of ionospheric plasma clouds” “*A combination of analytical models, 3D numerical simulations, and computer graphics/animation have enabled us to make significant progress in the understanding of ionospheric structuring processes important in the space-based tethered array antenna reliable operation of military systems.*” Also in Bracco, Davis, (1988, pg. 170, [4]) “Visualizing electronic warfare simulations,” “*This operator control extends to all aspects of the display including the size of the viewed area, the animation speed, and the highlighting or thinning of selected platforms.*”

I did find from Wikipedia’s “Convolution” article [6], [7] some very helpful *animations* and images which I considered very much consistent with my imagination of the description of the VBOC ACF and very helpful to develop the content of this masterpiece journal paper.

All eleven animation files are of the type “*.avi”, where “avi” stands for Audio Video Interleave (also Audio Video Interleaved), known by its initials AVI and the .avi filename extension is a multimedia container format introduced by Microsoft in November 1992 as part of its Video for Windows software [10]. AVI files can contain both audio and video data in a file container that allows synchronous audio-with-video playback. Like the DVD video format, AVI files support multiple streaming audio and video, although these features are seldom used [10].

Moreover, all of the eleven animation files are created using MATLAB 2018b [9]. In MATLAB 2018b [9] a developer can only write three types of video formats ‘avi’, ‘mp4’, or ‘mj2’.

Therefore, the case can be made that if one is looking for a very high quality deceptive tool then animation is the tool that needs to be exploited, explained, developed, implemented, and written about it.

The focus on this paper is the description of the animation itself more than the analysis that results by utilizing the animation, which was the focus of the Progrid 2019 journal paper [8].

I believe that the case can be made that *animation* may be seen as a very high qualitative and quantitative tool to bring into light insights, understanding, knowledge, verification of the ACF of the $VBOC2(\alpha_1, \alpha_2)$ GMGM that a researcher, scientist, scholar, developer, engineer, expert may not be able to derive by other means.

Nevertheless, as seen in the content of this paper, *development of animation* in MATLAB requires significant amount of work, creativity, originality, and novelty to produce the *execution of animation* via a '*.avi', '*.mp4', or '*.mj2' files of the special cases on the $VBOC2(\alpha_1, \alpha_2)$ GMGM.

This paper is organized as follows: The animation of the $VBOC1(\alpha)$ signal design is discussed next. The animation of the $VBOC2(\alpha_1, \alpha_2)$ signal design is discussed afterwards. Conclusion is given next and the paper is concluded with a list of references.

2 VBOC1(α) Signal Design Animation

In order to arrive at the animation of $VBOC2(m,n,\alpha)(t)$ ACF we will start our discussion with the simplest animation: the animation of the BPSK signal ACF.

2.1 Animation of BPSK Signal and ACF

Let us see how ACF $r(t)$ is obtained in animation. Since the animation is defined as the technique of successful drawings then the drawings considered for the purposes of deriving the analytical expression of the ACF should show the continuity of a state or transition or a case or a line or a segment; hence, the definition of case. *Case* is defined as a continuity of a flow of a state or a line or a segment of the ACF until a transition occurs to another case or line or a segment.

This animation is contained in the video file "VBOC1(1,1,1)=BPSK_ACF.avi" [11]. This is an "uncompressed video format" of size equal to 24.1 MB (25,362,000 bytes) and default (*seventy five percent*) quality.

If we were to use the video format of the type 'mp4' or 'avi'

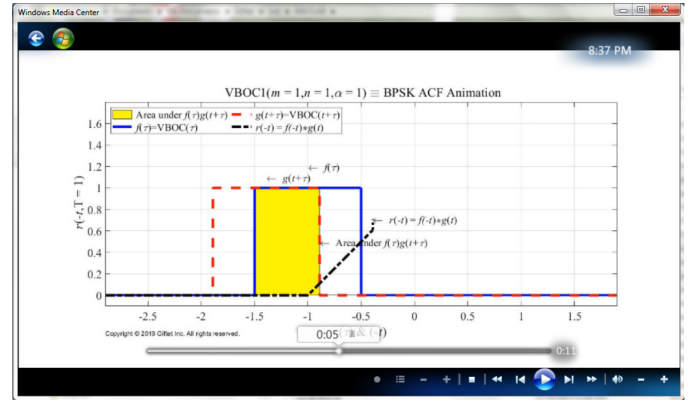


Fig. 1. A snapshot of the animation of the BPSK Signal and ACF as it is running in Windows Media Center.

with properties type of 'Motion JPEG AVI' with quality property value of *ninety five percent* then we would get then the total file size would be 669,934 or 671,718 bytes respectively. The super high quality value files can only be used in by Giftet Inc. for the purposes of giving presentations to business conferences, clients, etc.

The title of the animation is "VBOC1($m = 1, n = 1, \alpha = 1$) = BPSK ACF animation." The x/y axis label is " $(\tau)&(-t)$ " " $r(-t, T = 1)$ " and the range for the x/y axis is as follows: -2.9 to $1.9/-0.1$ to 1.8 . On the left upper corner the legend of functions is shown which contains four legends corresponding to four functions: (1) area under the product $f(\tau)g(t + \tau)$ which is shown with a rectangular filled solid yellow; (2) the function $f(\tau) = VBOC(\tau)$ which is equal to the $VBOC1(1,1,1)(\tau)$ is shown in solid blue and it is stationary; i.e., it does not move; (3) the function $g(\tau) = VBOC(t + \tau)$ which is equal to the $VBOC1(1,1,1)(t + \tau)$ is shown in dash red and it is shifting from left to right; i.e., it moves; (4) the function $r(-t) = f(-t) * g(t)$ which represents the normalized ACF rotated along the y axis whose computation is animated.

The function $f(\tau)$ from the animation is as follows:

$$f(\tau) = \begin{cases} 1 & -1.5 \leq \tau < -0.5 \\ 0 & \tau < -1.5 \cup \tau \geq 0.5 \end{cases} \quad (1)$$

So, what does the animation show? As the function $g(t + \tau)$ shifts from left to right the computation of the area function, $f(\tau)g(t + \tau)$, and of ACF, $r(-t)$, occur simultaneously. The entire animation duration is about eleven seconds. During this time about four seconds are spend for the actual integration of $f(\tau)$ and $g(t + \tau)$ the other seven seconds are spend on no overlap region.

It is very interested to note that the computation of the ACF is independent of the location of the right edge of the function $f(\tau)$, which is equal to $t_0 = -0.5$. One of the main reasons of

this animation is precisely to make this fact as visible as possible to the readers and/or viewers. Regardless of what is integrated, the output of animation of the ACF is always a first order equation in the form of a straight line.

The normalized ACF that is obtained from animation (see Fig. 1) is as follows

$$r(-t, T = 1) = \begin{cases} 1 - |t| & |t| \leq 1 \\ 0 & |t| > 1 \end{cases} \quad (2)$$

It is also very important to know that we have performed the animation of the function $r(-t, T = 1)$ not of the $r(t, T = 1)$ since these functions are numerically “identical” to each other; but, they are two different functions. There are two reasons for doing this. First, it is relatively much simpler to implement and follow the animation run from left to right as opposed to having parts of the animation run from left to right and part from right to left. Second, the delay between the actual point of the computation of the function $r(-t, T = 1)$ and right edge of the function $g(t + \tau)$ is exactly $t_0 = -0.5$ which is constant throughout the animation. If we were to implement and show the animation of the actual function $r(t, T = 1)$ then this delay would be variable. Hence, showing the animation of the function $r(-t, T = 1)$ results into a more intuitive, simple, and less confusing or distracting animation.

This concludes the discussion on the animation of BPSK Signal and ACF.

2.2 Animation of BOC(1,1) Signal and ACF

This animation is contained in the video file “VBOC1(1,1,0)=BOC(1,1)_ACF.avi” [12]. This is an “uncompressed video format” of size equal to 22.5 MB (23,600,504 bytes) and default (seventy five percent) quality.

The title of the animation is “VBOC1($m = 1, n = 1, \alpha = 0$) $\equiv$ BOC(1,1) ACF animation.” All the animation parameters discussed in Sect. 2.1 are exactly the same here with the expectation that the range for the y axis is from -1.1 to 1.8 .

The function $f(\tau)$ from the animation is as follows:

$$f(\tau) = \begin{cases} -1 & -1.5 \leq \tau < -1 \\ 1 & -1 \leq \tau < -0.5 \\ 0 & \tau < -1.5 \cup \tau \geq 0.5 \end{cases} \quad (3)$$

The normalized ACF that is obtained from animation (see Fig. 2) is as follows

$$r(-t, T = 1) = \begin{cases} 1 - 3|t| & |t| \leq 0.5 \\ 1 - |t| & 0.5 \leq |t| \leq 1 \\ 0 & |t| > 1 \end{cases} \quad (4)$$

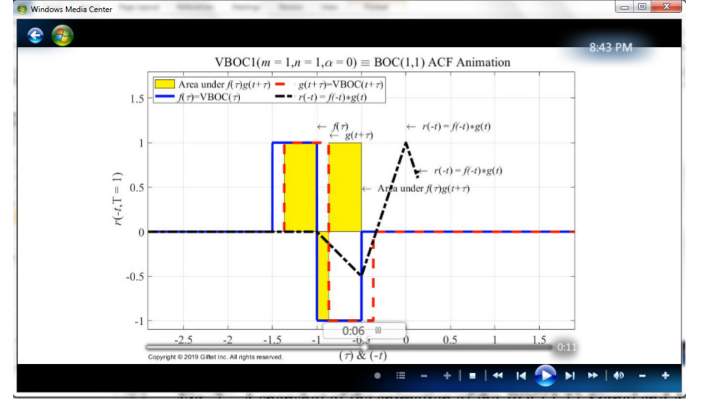


Fig. 2. A snapshot of the animation of the BOC(1,1) Signal and ACF as it is running in Windows Media Center.

The normalized ACF $r(-t, T = 1)$ has its maximum peak equal to one at the values of $t = 0$. Since the normalized ACF $r(-t, T = 1)$ is invariant of t_0 ; hence, the ACF peak by itself does not give any distance information; it is only useful to decode the signal.

This concludes the discussion on the animation of BOC(1,1) signal and ACF.

2.3 Animation of VBOC1(1,1,0.5) Signal and ACF

This animation is contained in the video file “VBOC1(1,1,0.5)_ACF.avi” [13]. This is an “uncompressed video format” of size equal to 21.9 MB (22,974,114 bytes) and default (seventy five percent) quality.

The title of the animation is “VBOC1($m = 1, n = 1, \alpha = 0.5$) ACF animation.” All the animation parameters discussed in Sect. 2.1 are exactly the same here with the expectation that the range for the y axis is from -1.1 to 1.8 and that in the video file “VBOC1(1,1,0.5)_ACF.avi” [13] the function $f(\tau)$ from the animation is as follows:

$$f(\tau) = \begin{cases} 1 & -1.5 \leq \tau < -0.75 \\ -1 & -0.75 \leq \tau < -0.5 \\ 0 & \tau < -1.5 \cup \tau \geq 0.5 \end{cases} \quad (5)$$

The normalized ACF that is obtained from animation (see Fig. 3) is as follows

$$r(-t, T = 1) = \begin{cases} 1 - 3|t| & 0 \leq |t| \leq 0.25 \\ 0.5 - |t| & 0.25 \leq |t| \leq 0.75 \\ 1 - |t| & 0.75 \leq |t| \leq 1 \\ 0 & |t| > 1 \end{cases} \quad (6)$$

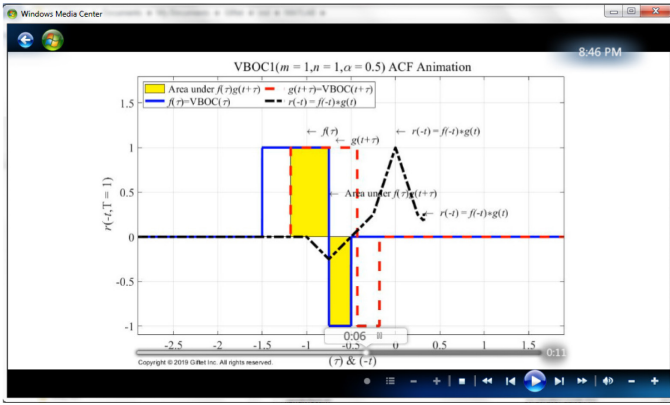


Fig. 3. A snapshot of the animation of the VBOC1(1,1,0.5) signal and ACF as it is running in Windows Media Center.

The normalized ACF $r(-t, T=1)$ has its maximum peak equal to one at the values of $t=0$. Since the normalized ACF $r(-t, T=1)$ is invariant of t_0 ; hence, the ACF peak by itself does not give any distance information; it is only useful to decode the signal.

This concludes the discussion on the animation of VBOC1(1,1,0.5) signal and ACF.

3 Animation of the VBOC2(α_1, α_2) Signal Design

Before we discuss the animation of the VBOC2(α_1, α_2) signal design let us first define the VBOC2($2,1,\alpha_1,\alpha_2$)(t) signal.

3.1 Animation of BPSK Signal and ACF

There are two scenarios from where one can obtain the BPSK signal from the signal VBOC2($2,1,\alpha_1,\alpha_2$)(t): one for BPSK(t) $\equiv$ VBOC2($2,1,\alpha_1=0,\alpha_2=0$)(t); and the other for BPSK(t) $\equiv$ VBOC2($2,1,\alpha_1=1,\alpha_2=1$)(t).

The first and second of the two animations are contained in the video file “VBOC2(2,1,0,0)=BPSK_ACF.avi” (see Fig. 4) [14] and “VBOC2(2,1,1,1)=BPSK_ACF.avi” (see Fig. 5) [15] respectively. These video files are of the “uncompressed video format” of size 20.5 MB (21,598,024 bytes) / 23.2 MB (24,400,104 bytes) and default (*seventy five percent*) quality.

The titles are “VBOC2($m=2, n=1, \alpha_1=0, \alpha_2=0$) $\equiv$ BPSK ACF animation” and “VBOC2($m=2, n=1, \alpha_1=1, \alpha_2=1$) $\equiv$ BPSK ACF animation” respectively.

Without repetition everything that was said in Sect. 2.1 is exactly what occurs in these two video files; the only difference in the video file “VBOC2(2,1,0,0)=BPSK_ACF.avi” [14] is the function $f(\tau)$ from the animation is as follows:

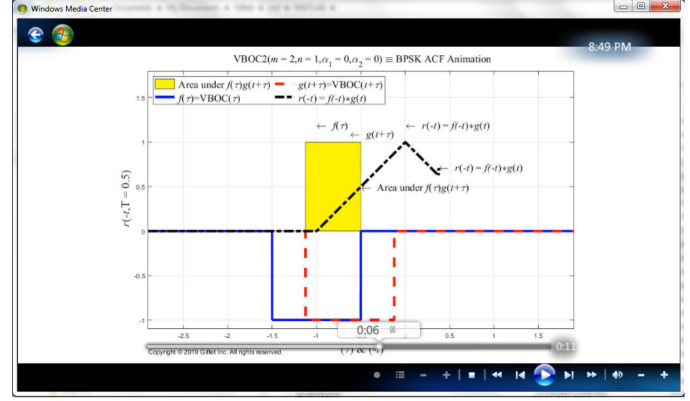


Fig. 4. A snapshot of the animation of the VBOC2(2,1,0,0) signal and ACF as it is running in Windows Media Center.

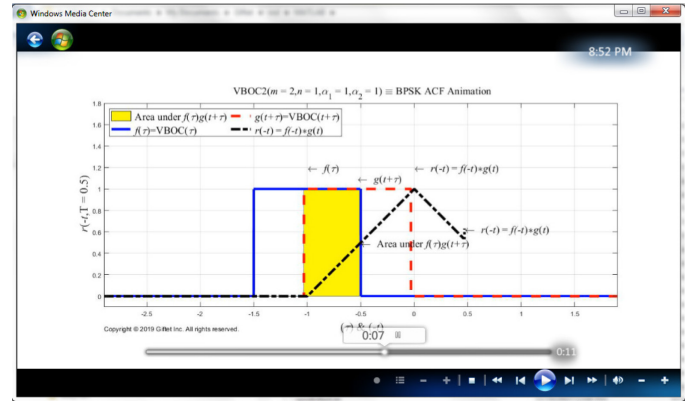


Fig. 5. A snapshot of the animation of the VBOC2(2,1,1,1) signal and ACF as it is running in Windows Media Center.

$$f(\tau) = \begin{cases} -1 & -1.5 \leq \tau < -0.5 \\ 0 & \tau < -1.5 \cup \tau \geq 0.5 \end{cases} \quad (7)$$

Since the function $f(\tau)$ (7) is equal to minus $f(\tau)$ in (1), the animation of the ACF does not change. Everything else is exactly the same. The ACF $r(-t, T=1)$ is exactly the same as in (2). Everything that was said in Sect. 2.1 can be said in this section as well.

This concludes the discussion on the animation of BPSK signal and ACF as a special case of VBOC2($2,1,\alpha_1,\alpha_2$)(t).

3.2 Animation of BOC(1,1) Signal and ACF

There are two scenarios from where one can obtain the BPSK signal from the signal VBOC2($2,1,\alpha_1,\alpha_2$)(t): one for BOC($1,1$)(t) $\equiv$ VBOC2($2,1,\alpha_1=0,\alpha_2=1$)(t); and the other for BOC($1,1$)(t) $\equiv$ VBOC2($2,1,\alpha_1=1,\alpha_2=0$)(t).

The first and second of the two animations are contained in the video file “VBOC2(2,1,0,1)=BOC(1,1)_ACF.avi” (see Fig. 6) [16] and “VBOC2(2,1,1,0)=BOC(1,1)_ACF.avi” (see Fig. 7) [17] respectively. These video files are of the “uncompressed video format” of size 21.5 MB (22,608,652 bytes) / 21.5 MB (22,595,604 bytes) and default (*seventy five percent*) quality.

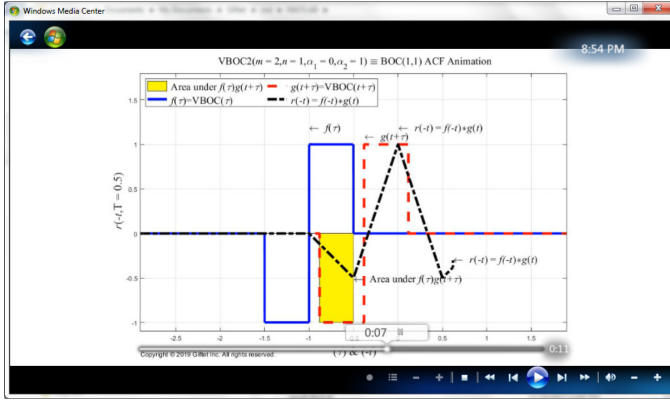


Fig. 6. A snapshot of the animation of the VBOC2(2,1,0,1) signal and ACF as it is running in Windows Media Center.

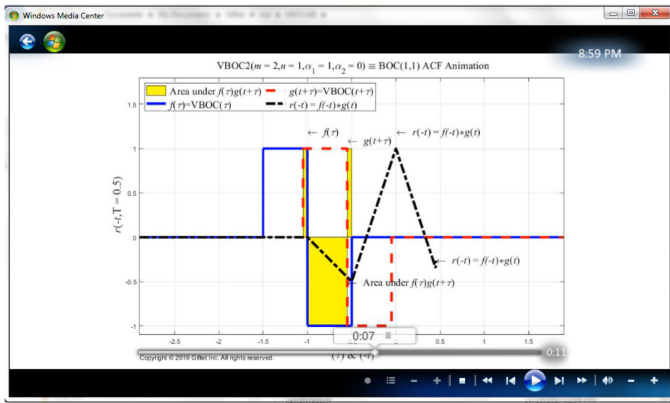


Fig. 7. A snapshot of the animation of the VBOC2(2,1,1,0) signal and ACF as it is running in Windows Media Center.

The titles of the animations are “VBOC2($m = 2, n = 1, \alpha_1 = 1, \alpha_2 = 0$) $\equiv$ BOC(1,1) ACF animation” and “VBOC2($m = 2, n = 1, \alpha_1 = 0, \alpha_2 = 1$) $\equiv$ BOC(1,1) ACF animation” respectively.

Without repetition everything that was said in Sect. 2.2 is exactly what occurs in these two video files; the only difference in the video file “VBOC2(2,1,0,1)=BOC(1,1)_ACF.avi” [16] are the range of y axis is from -1.1 to 1.8 and function $f(\tau)$ from the animation is as follows:

$$f(\tau) = \begin{cases} -1 & -1.5 \leq \tau < -1 \\ 1 & -1 \leq \tau < -0.5 \\ 0 & \tau < -1.5 \vee \tau \geq 0.5 \end{cases} \quad (8)$$

Since the function $f(\tau)$ (8) is equal to minus $f(\tau)$ in (2), the animation of the ACF does not change (see Fig. 6). Everything else is exactly the same. This concludes the discussion on the animation of BOC(1,1) signal and ACF.

3.3 Animation of VBOC1(1,1,0.5) Signal and ACF

There are two scenarios from where one can obtain the BPSK

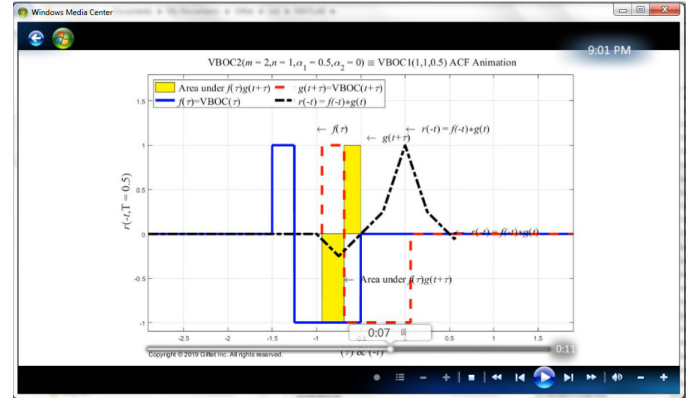


Fig. 8. A snapshot of the animation of the VBOC2(2,1,0.5,0) signal and ACF as it is running in Windows Media Center.

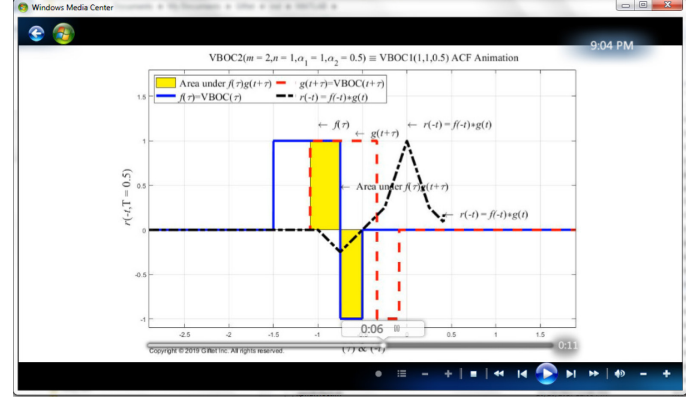


Fig. 9. A snapshot of the animation of the VBOC2(2,1,1,0.5) signal and ACF as it is running in Windows Media Center.

signal from the signal VBOC2($m=2, n=1, \alpha_1, \alpha_2$)(t): one for VBOC1($1,1,0.5$)(t) $\equiv$ VBOC2($2,1, \alpha_1=0.5, \alpha_2=0$)(t); and the other for VBOC1($1,1,0.5$)(t) $\equiv$ VBOC2($2,1, \alpha_1=1, \alpha_2=0.5$)(t)

The first animation can be obtained in the video file “VBOC2(2,1,0.5,0)=VBOC1(1,1,0.5)_ACF.avi,” which is shown in Fig. 8, [18] and the second one is titled and obtained from the “VBOC2(2,1,1,0.5)=VBOC1(1,1,0.5)_ACF.avi” file (see Fig. 9) [19]. These video files are of the “uncompressed video format” of size equal to 21.8 MB (22,910,600 bytes) / 21.5 MB (22,575,852 bytes) and default (*seventy five percent*) quality.

The titles of the animations are “VBOC2($m = 2, n = 1, \alpha_1 = 0.5, \alpha_2 = 0$) $\equiv$ VBOC1(1,1,0.5) ACF animation” and “VBOC2($m = 2, n = 1, \alpha_1 = 1, \alpha_2 = 0.5$) $\equiv$ VBOC1(1,1,0.5) ACF animation” respectively.

Without repetition everything that was said in Sect. 2.3 is exactly what occurs in these two video files; the only difference are the range of y axis is from -1.1 to 1.8 and that in “VBOC2(2,1,0.5,0)=VBOC1(1,1,0.5)_ACF.avi” [18] the function $f(\tau)$ from the animation is as follows:

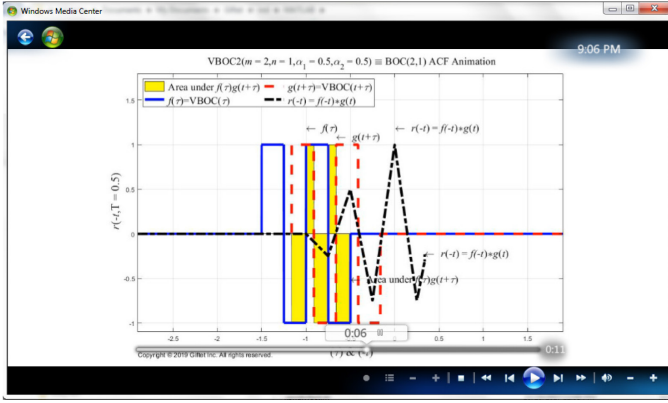


Fig. 10. A snapshot of the animation of the VBOC2(2,1,0.5,0.5) signal and ACF as it is running in Windows Media Center.

$$f(\tau) = \begin{cases} 1 & -1.5 \leq \tau < -1.25 \\ -1 & -1.25 \leq \tau < -0.5 \\ 0 & \tau < -1.5 \cup \tau \geq 0.5 \end{cases} \quad (9)$$

Since the function $f(\tau)$ (9) is rotated by 180° to obtain the function $f(\tau)$ in (5), the animation of the ACF does not change. Everything else is exactly the same. This concludes the discussion on the animation of VBOC1(1,1,0.5) signal and ACF.

3.4 Animation of BOC(2,1) Signal and ACF

This animation is contained in the video file “VBOC2(2,1,0.5,0.5)=BOC(2,1)_ACF.avi” (see Fig. 10) [20]. This is an “uncompressed video format” of the size 23.6 MB (24,807,868 bytes) and default (*seventy five percent*) quality. There is only one combination that BOC_(2,1)(t) can be obtained from VBOC2_(2,1, α_1,α_2)(t) that is only when $\alpha_1 = \alpha_2 = 0.5$.

The title of the animation is “VBOC2($m = 2, n = 1, \alpha_1 = 0.5, \alpha_2 = 0.5$) $\equiv$ BOC(2,1) ACF animation.”

The function $f(\tau)$ from the animation is as follows:

$$f(\tau) = \begin{cases} 1 & -1.5 \leq \tau < -1.25 \cup -1 \leq \tau < -0.75 \\ -1 & -1.25 \leq \tau < -1 \cup -0.75 \leq \tau < -0.5 \\ 0 & \tau < -1.5 \cup \tau \geq 0.5 \end{cases} \quad (10)$$

The maximum value of the $r(t)$ occurs at $t = 0$ which is the same as 1; so, the normalized autocorrelation function is as follows

$$r(-t, T = 0.5) = \begin{cases} 1 - 7|t| & 0 \leq |t| \leq 0.25 \\ -2 + 5|t| & 0.25 \leq |t| \leq 0.5 \\ 2 - 3|t| & 0.5 \leq |t| \leq 0.75 \\ -1 + |t| & 0.75 \leq |t| \leq 1 \\ 0 & |t| > 1 \end{cases} \quad (11)$$

This concludes the discussion on the animation of BOC(2,1) signal and ACF.

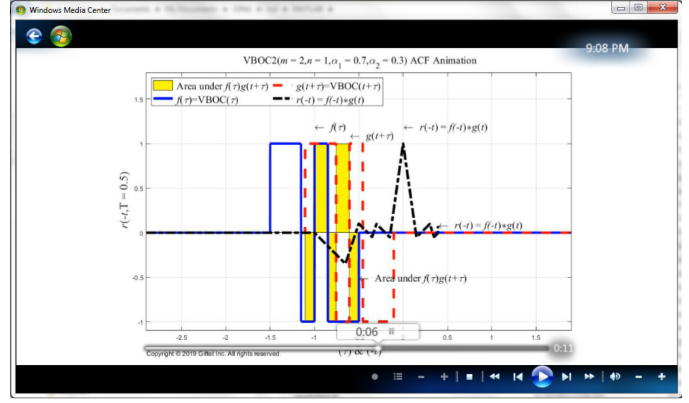


Fig. 11. A snapshot of the animation of the VBOC2(2,1,0.7,0.3) signal and ACF as it is running in Windows Media Center.

3.5 Animation of VBOC2(2,1,0.7,0.3) Signal and ACF

This animation is contained in the video file “VBOC2(2,1,0.7,0.3)_ACF.avi” (see Fig. 11) [21]. This is an “uncompressed video format” of the size 22.6 MB (23,781,200 bytes) and default (*seventy five percent*) quality. There is only one combination that VBOC2_(2,1,0.7,0.3)(t) can be obtained from VBOC2_(2,1, α_1,α_2)(t) that is only when $\alpha_1 = 0.7$ and $\alpha_2 = 0.3$.

The title of the animation is “VBOC2($m = 2, n = 1, \alpha_1 = 0.7, \alpha_2 = 0.7$) ACF animation.”

The function $f(\tau)$ from the animation is as follows:

$$f(\tau) = \begin{cases} 1 & -1.5 \leq \tau < -1.15 \cup -1 \leq \tau < -0.85 \\ -1 & -1.15 \leq \tau < -1 \cup -0.85 \leq \tau < -0.5 \\ 0 & \tau < -1.5 \cup \tau \geq 0.5 \end{cases} \quad (12)$$

The normalized ACF that is obtained from animation (see Fig. 21) is as follows

$$r(-t, T = 0.5) = \begin{cases} 1 - 7|t| & 0 \leq |t| \leq 0.15 \\ -0.2 + |t| & 0.15 \leq |t| < 0.3 \\ 1 - 3|t| & 0.3 \leq |t| \leq 0.35 \\ |t| - 0.4 & 0.35 \leq |t| \leq 0.5 \\ 1.6 - 3|t| & 0.5 \leq |t| \leq 0.65 \\ -1 + |t| & 0.65 \leq |t| \leq 1 \\ 0 & |t| > 1 \end{cases} \quad (13)$$

This concludes the discussion on the animation of VBOC2(2,1,0.7,0.3) signal and ACF.

4 Conclusions

This paper is the first complete discussion on the animation of eleven special cases of the ACF of VBOC1(1,1, α) and of VBOC2(2,1, α_1, α_2) GMGM, namely, three corresponding to

BPSK, three corresponding to BOC(1,1), three corresponding to VBOC1(1,1, $\alpha = 0.5$), one corresponding to BOC(2,1), and one VBOC2(2,1, $\alpha = 0.7, \beta_- = 0.3$).

These video files are of the “uncompressed video format” and default (*seventy five percent*) quality. The size of these video files is on the order of 20.5-24.1 MB. The duration of the animation is equal to eleven seconds.

It is clearly demonstrated both analytically and graphically (or by means of the animation) that the ACF of all these waveforms does not depend on the initial time offset, t_0 ; *the ACF peak by itself does not give any distance information; it is only useful to decode the signal.*

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