**深 圳 大 学 实 验 报 告**

**课程名称： 现代通信原理**

**实验项目名称： 实验五**

**学院： 电子与信息工程学院**

**专业： 电子信息工程**

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**实验时间： 2023.03.30-2023.04.06**

**实验报告提交时间： 2023年4月6日**

**教务部制**

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| **实验目的与要求：**  微信截图_20230507233016 |
| **内容和步骤：**   1. **Plot the unipolar RZ waveform, the bipolar NRZ waveform of the sequence**   For each symbol, we define its Tb=1s. In order to plot the waveform, we next define Fs=100 for each symbol that is N\_sample=100 as shown in the following figure.  At the beginning, we first analyse and review some basic concept. The “unipolar” refers to the signal that only has one polarity of voltage level(+/0). Instead, “bipolar” refers to the signal that has both two polarity of voltage level(+/-). In addition, “RZ” means that in a symbol duration, no matter the symbol has polarity or not, waveform should return to zero at the end. Instead, “NRZ” means that in a symbol duration, the waveform always keep the voltage the same as the polarity of symbol. In order words, not return to zero at the end.  In order to plot the complete waveform, we should determine the basic unit of upipolar RZ waveform when the current symbol is high level, that is half of high level and half of low level during one symbol period. Also, for bipolar NRZ waveform when the current symbol is high level, its basic unit is all the high level during one symbol period.  For generating the complete signal waveform, we convert each binary symbol to its corresponding waveform according to its targeted code pattern. All the related codes are shown in the following figure.  微信截图_20230508001236  In the experiment, we generate a random sequence with length=8 that is “01011111”. Then we convert this binary sequence to bipolar NRZ waveform and unipolar RZ waveform. As mentioned in the above, we define its Tb=1s and Fs=100 for each symbol. The plotted unipolar RZ waveform and biploar NRZ waveform are shown in the following two figure. According to theoretical analysis, the two waveform is correct.  微信截图_20230508000749  微信截图_20230508000755   1. **Write a function to generate the differential code and HDB3 code.** 2. **The differential code**   The following figure shows the definition of the differential code, that is when 1 appears, voltage jumps, when 0 appears, voltage doesn’t change. What’ more, we observe that the differential code is bipolar NRZ waveform.  微信截图_20230508152622  Here we write a different\_code() function to generate the differential code. In the experiment, we give the initial voltage level is “+”. According to the principle, if the current symbol is ‘+1’, jump the voltage; if the current symbol is ‘0’, no jump the voltage. We use a variable pre\_voltage to record the previous state of voltage level. All the related codes are shown in the following figure.  微信截图_20230508155010  In the experiment, we generate a random sequence with length=8 that is “01011111” to verify the correctness of our program as shown in the following figure and plot the differential encoded result.  微信截图_20230508152758  The differential encoded waveform is shown in the following figure. The waveform is the same as theoretical result.  微信截图_20230508000804   1. **HDB3 code**   The following figure shows the process of generating the HDB3 code. In order to convert to it, the process includes totally five steps. First, we should convert binary sequence into AMI code. Second, check continuous 0s and replace by 000V. Third, check the number of 1 between the adjacent V to replace 000V by B00V. Next, determine the polarity. In specific, V has the same polarity as that of the first previous non-zero code. The polarities of 1s and Bs satisfy the polarity alternatively inverse rule. Finally, we replace B and V to 1 and obtain the HDB3 code.  微信截图_20230508152509  When it comes to AMI code, its definition is 1 in the message symbols are converted to +1 and -1 alternatively, and 0 in the message symbols keep 0.  In the experiment, we wrote a hdb3\_code() function to generate the HDB3 code. In the step 1, in order to alternatively converted to +1 and -1, we define a variable “number1” to record the number of existed 1. If mod(number1, 2) is 0, the sign of current 1 is “+”; otherwise, the sign of current 1 is ‘-’. In addition, we display the AMI encoded result to verify the correctness of the result. The coded are shown in the following figure.  微信截图_20230508152936  In step 2, we define a variable “count0” to record the number of existed 0. If count0 reaches to 4, replace the current symbol with “V” and recount count0. The codes are shown in the following figure.  微信截图_20230508152958  In step 3, we first record the position of V and then check the number of o for the adjacent V. We define a variable “number1” to record the number of 1 between two adjacent V. If mod(number1, 2) is 0, replace V to B. Here we use 2 represents V and 3 represent B. The codes are shown in the following figure.  微信截图_20230508153019  微信截图_20230508153031  Finally, we decide the polarity. First, we set the first 1 to ‘-1’. Then we define sign1 to record the current polarity of 1 and B and signv to record the current polarity of V. The codes are shown in the following figure.  微信截图_20230508153048  微信截图_20230508153055  At last, we use kron() function as shown in the following figure to repeat the voltage in order to achieve sample condition and plot the waveform. (“we define its Tb=1s and Fs=100 for each symbol”)  微信截图_20230412095329  In the experiment, in order to verify the correctness of our program we generate a binary sequence that is used in the class slides “100001000011000011”. And in the class, we analysis its theoretical coded result. The codes are shown in the following figure.  微信截图_20230508152805  Through the hdb3\_code() function we wrote, its HDB3 encoded result is shown in the following figure.  微信截图_20230508000815  Additionally, I display the AMI encoded result and HDB3 encoded result to directly observe the result as shown in the following figure. Compared to the theoretical result in the class slides (AMI is -1 0 0 0 0 +1 0 0 0 0 -1 +1 0 0 0 0 -1 +1 and HDB3 is -1 0 0 0–1 +1 0 0 0 +1 -1 +1 -1 0 0–1 +1 -1), our result is the same as it which indicates that the success of our program function.  微信截图_20230508000845  微信截图_20230508000837   1. **Assume that we use triangular pulse to represent 1 while a zero level to represent 0, where 1 and 0 appear with equal probabilities, find the theoretic power density and try to plot the curve.**   The formulation of Pb(f) is shown in the following figure. We get to know that Pb(f) consists of Pu(f) and Pv(f). So we partial present Pu(f) and Pv(f) that we can plot the Pb(f).  微信截图_20230508152721  In the experiment, we define the fb=1 and plot the Pb(f) in the range of m=[-10,10]. Then, we determine the FFT of g(t) that is FFT of triangular pulse G(t) and substitute it to the formulation. Then plot the theoretic power density curve. The codes are shown in the following figure.  微信截图_20230508152817  微信截图_20230508152824  The theoretic power density curve is shown in the following figure when fb=1 and m=[-10:10].  微信截图_20230508000825 |
| **实验结论：**   1. In a unipolar RZ waveform, only the positive half of the pulse is used to represent the signal. The negative half of the pulse is not used, and the signal stays at the reference level during this time. This is different from bipolar RZ, where both positive and negative halves of the pulse are used to represent the signal. 2. In a bipolar NRZ waveform, both the positive and negative halves of the pulse are used to represent the signal. The positive and negative voltages represent 1 and 0, respectively. 3. In the differential coding, the data is represented as a difference between two consecutive signal levels, rather than an absolute value. This helps in reducing the effect of noise and interference that may affect the absolute values of the signal. 4. In HDB3, the substitution code is used to maintain the same density of ones and zeros in the encoded signal, while ensuring that there are no more than three consecutive zeros in the signal. This helps to maintain the synchronisation of the receiver with the transmitted signal, and to reduce the effect of noise and interference. 5. The General expression of the frequency spectrum of the baseband digital signal consists of continuous spectrum and discrete spectrum.   微信截图_20230508165023 |
| **指导教师批阅意见：**    **成绩评定：**  **指导教师签字：**  **年 月 日** |
| **备注：** |

注：1、报告内的项目或内容设置，可根据实际情况加以调整和补充。

2、教师批改学生实验报告时间应在学生提交实验报告时间后10日内。