Faculty of Engineering & Technology
Electrical & Computer Engineering Department
Communications Lab

'ENEE4113'

Report#2

Experiment No.10

Amplitude Shift Keying (ASK)

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Abstract:

The objective of this experiment was to explore Amplitude Shift Keying (ASK) modulation. The study centered on two keying techniques, Hard and Soft, and assessed the effects of the modulation index in both time and frequency domains. The experiment entailed applying ASK modulation, followed by an analysis of the resulting signals using both time-domain and frequency-domain methods. The results offered valuable insights into the behavior of ASK modulation, the impact of different keying methods, and the influence of the modulation index. This understanding contributes to a more effective use of ASK modulation in communication systems.

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1. Theory

1.1 Amplitude Shift Keying Modulation (ASK)

In digital communication, different modulation techniques are used to transmit data or message to receiver over a communication channel . One such technique is Amplitude Shift Keying (ASK). It is a modulation technique that alters the amplitude of a carrier signal to transmit the information over channel. It is a modulation scheme having wide range of application in real world which includes radio, television, and digital data transmission[1].

Amplitude Shift Keying (ASK) is a digital modulation technique . It transmits the digital information by varying the amplitude of a carrier signal. In ASK, a high-amplitude carrier signal is used to represent a binary '1,' and a low-amplitude carrier signal represents a binary '0.'

It involves the superimposition of a carrier signal and a digital message signal. The carrier signal is often a high-frequency sinusoidal waveform, which serves as the carrier for the digital information. The binary message signal, consisting of '1's and '0's, is used to control the amplitude of the carrier signal. The resultant signal formed after the superimposition of message and carrier is transmitted over the communication channel[1].

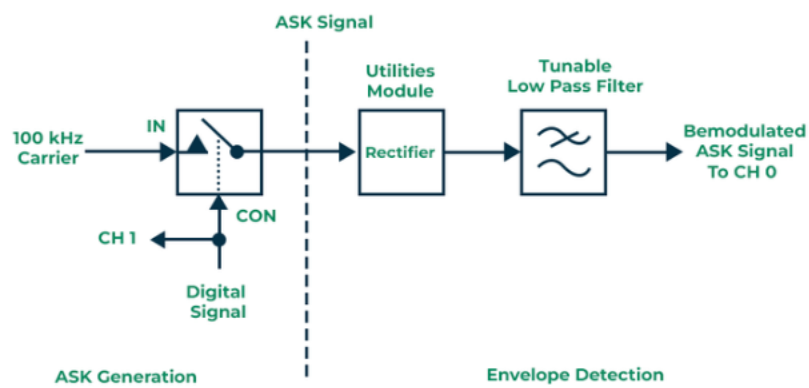

Figure 1circuit ASK diagram[1]

1.1.1Working[1]

- Carrier signal is chosen to be of very high frequency as compared to the message signal. It is usually a sinusoidal waveform.
- Message signal consists of a binary stream of data. In ASK the high amplitude is represented by '1' and low amplitude is represented by '0'.

- Modulated signal is generated as the resultant of the product of message signal and carrier signal(Modulation). If the message is represented by m(t), carrier as c(t) the the modulated waveform f(t)=m(t)*c(t) and this is transmitted over the communication channel.
- At receiver end, the modulated signal is demodulated to get the message binary stream(Demodulation). At receiver various mechanisms are used to recover the original message[1].

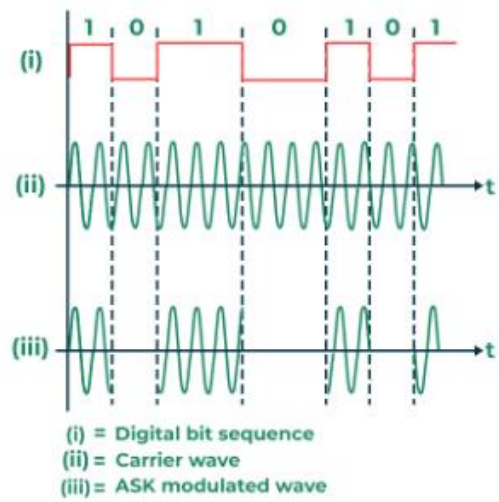

Figure 2ASK

There are two variants of ASK modulation and demodulation known as soft keying and hard keying:

- **Hard Keying:** The carrier wave is simply turned on and off to indicate the presence or absence of data.
- **Soft Keying:** It involves continuously varying the amplitude of the carrier wave to represent different binary values.

Soft keying offers more flexibility and potentially better performance in terms of data rates and noise immunity compared to hard keying.

1.1.2Advantage of Amplitude shift keying

- Its generation and detection are easy thus facilitate simple transmitter and receiver sections.

Disadvantages of Amplitude shift keying

- ASK technique is not suitable for high bit rate data transmission.
- Poor bandwidth efficiency.
- Highly susceptible to noise and other external factors.

1.2 ASK Modulator

In ASK modulation, a carrier wave (usually a sinusoidal wave) is modified in accordance with the digital message signal. The amplitude of the carrier signal is changed between two predefined values i.e. 0 and 1 to represent binary data[1].

The carrier wave is represented by continuous signal. The carrier's amplitude changes between two levels, particularly '0' and '1'. When the input data is '0', the amplitude might be lower, and when the input data is '1', the amplitude could be higher. The changes in amplitude effects the carrier signal in accordance with the digital signal. This modulation technique is simple but can be susceptible to noise and interference, which can affect the accuracy of the received data[1].

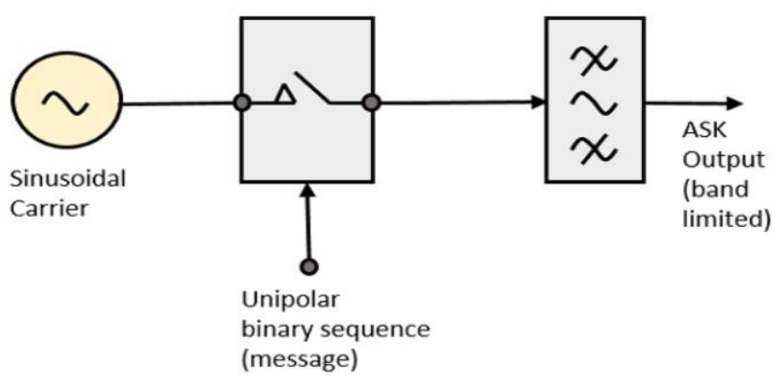

Figure 3ASK Block Diagram [3]

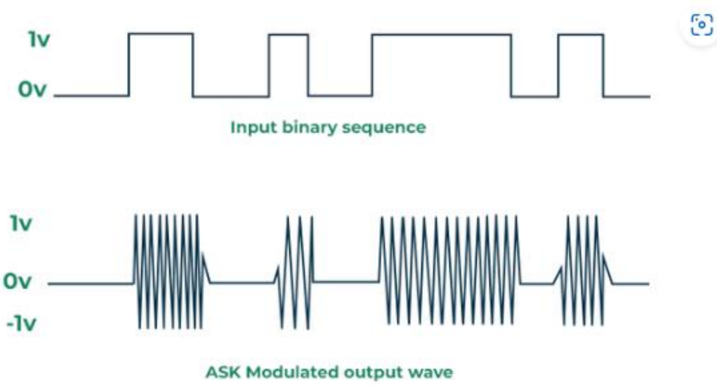

Figure 4: ASK MODULATION[1]

The carrier generator, sends a continuous high-frequency carrier. The binary sequence from the message signal makes the unipolar input to be either High or Low. The high signal closes the switch, allowing a carrier wave. Hence, the output will be the carrier signal at high input. When there is low input, the switch opens, allowing no voltage to appear. Hence, the output will be low. [3]

The band-limiting filter, shapes the pulse depending upon the amplitude and phase characteristics of the band-limiting filter or the pulse-shaping filter. [3]

1.2.1 Advantages OF MODULATION

There are various advantages of using ASK as a modulation technique[4].

- It is one of the simplest modulation techniques which makes it easy to implement in both analog and digital systems.
- It is a cost-effective modulation technique, which is one reason for its widespread use in various applications.
- It is compatible with various transmission media, including radio waves, optical fibers, and wired communication systems.
- It is efficient in terms of bandwidth utilization as it only requires two levels of amplitude i.e. 0 and 1[4].

1.2.2Disadvantages of modulation

- **Susceptibility to Noise:** ASK is more sensitive to noise and interference compared to other modulation techniques like Frequency Shift Keying (FSK) or Phase Shift Keying (PSK). Fluctuations in the amplitude caused by noise can lead to errors in data recovery at the receiver end [1].
- **Bandwidth Inefficiency:** ASK can be less bandwidth efficient compared to other modulation techniques. It requires more bandwidth because it uses changes in amplitude to encode data, which can limit the number of bits transmitted in a given bandwidth[4].
- **Power Inefficiency:** Transmitting signals at varying amplitudes requires more power compared to constant amplitude transmission. This can be a disadvantage in scenarios where power efficiency is critical.
- **Limited Data Rate:** ASK is generally limited in terms of achievable data rates compared to other modulation techniques. This limitation arises from the constraints on how fast the amplitude can be changed without distortion[1].
- **Signal-to-Noise Ratio Sensitivity:** ASK's performance is highly dependent on the signal-to-noise ratio (SNR). As the ratio between the signal power and noise power decreases, the accuracy and reliability of data transmission can be significantly affected.
- **Lack of Phase or Frequency Information:** ASK only utilizes changes in amplitude to represent data, unlike other modulation techniques that use phase or frequency changes. This limitation might make it more vulnerable to certain types of interference and distortions[1].

1.4ASK Applications

Modulation has an important role in communications. And amplitude shift keying applications are mentioned below. They are[1]:

- Low-frequency RF applications
- Home automation devices
- Industrial networks devices
- Wireless base stations[1]

- Tire pressuring monitoring systems

Thus, Ask (amplitude shift keying) is a digital modulation technique to increase the amplitude characteristics of the input binary signal. But its drawbacks make it so limited. And these drawbacks can be overcome by the other modulation technique which is FSK.

1.3 Amplitude Shift Keying Demodulation

Demodulation in Amplitude Shift Keying (ASK) involves extracting the original digital message signal from the modulated carrier wave. The process reverses the modulation applied to the carrier signal. The demodulation of ASK can be performed through various methods, such as envelope detection or coherent detection[1].

ASK detection is of two types:

- Coherent detection or synchronous demodulation
- Noncoherent detection or asynchronous demodulation [2]

1.3.1 Coherent ASK Detection

In this way of demodulation process, the carrier signal which we are using at the receiver stage is in the same phase with the carrier signal which we are using at the transmitter stage. It means the carrier signal at transmitter and receiver stages are the same values. This type of demodulation is called Synchronous ASK detection or coherent ASK detection[2].

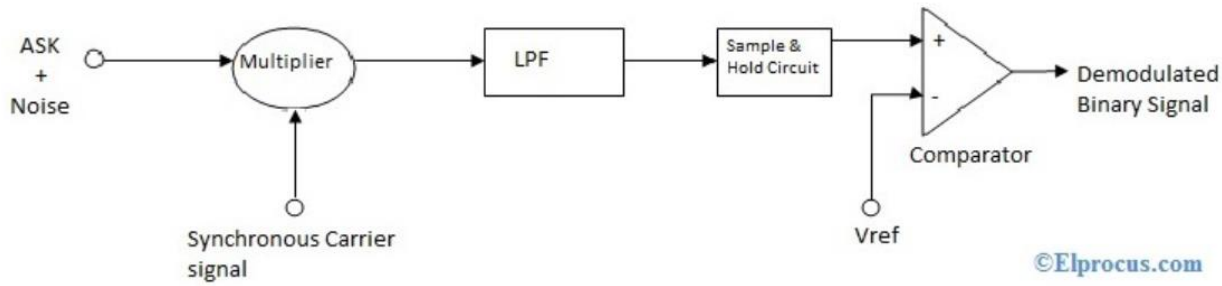

Figure 5: Coherent ASK Detection [2]

The receiver receives the ASK modulated waveform from the channel but here this modulated waveform is effected with noise signal because it is forwarded from the free space channel. So this, noise can be eliminated after [the multiplier] stage by the help of a [low pass filter]. Then it is forwarded from the sample and hold circuit for converting it into discrete signal form. Then at each interval, the discrete signal voltage is compared with the reference voltage (Vref) to reconstruct the original binary signal[2].

1.3.2 Noncoherent ASK Detection

In this, the only difference is the carrier signal which is using at the transmitter side and receiver side are not in the same phase with each other. By this reason, this detection is called as Non-coherent ASK detection (Asynchronous ASK detection). This demodulation process can be completed by using with square law device. The output signal which is generating from the square-law device can be forwarded through a low pass filter to reconstruct the original binary signal[2].

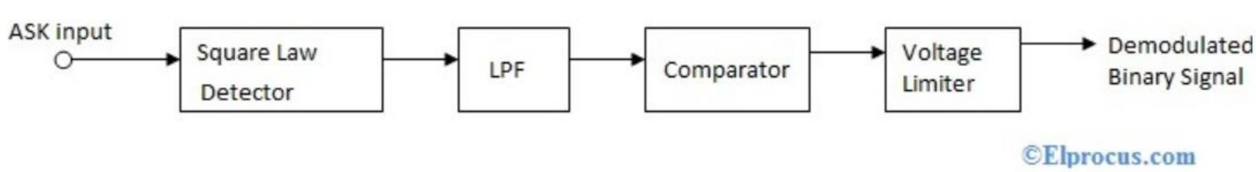

Figure 6Noncoherent ASK Detection[2]

Amplitude shift keying is an effective technique to increase the input amplitude characteristics in communications. But these ASK modulated waveforms are easily affected by noise. And this leads to amplitude variations. Due to this, there will be voltage fluctuations in the output waveforms. The second drawback of the ASK modulation technique is, it has low power efficiency. Because ASK requires the excessive bandwidth. It leads to power loss in the spectrum of ASK[2].

Whenever to modulate two input binary signals, amplitude shift keying modulation is not preferable. Because it has to take only one input only. So, to overcome this Quadrature Amplitude Shift Keying (ASK) is preferred. In this modulation technique, we can modulate two binary signals with two different carrier signals. Here, these two carrier signals are in opposite phase with 90degrees difference. Sin and cosine signals are used as carriers in quadrature amplitude shift keying. The advantage of this is, it uses effectively the bandwidth of the spectrum. It offers more power efficiency than the amplitude shift keying[2].

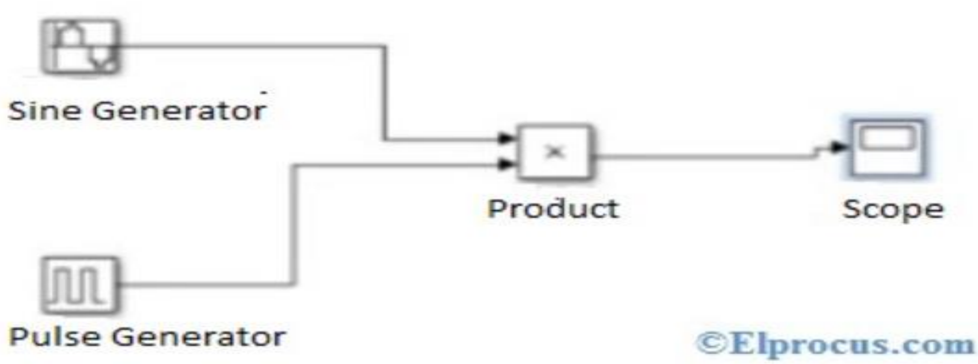

Figure 7amplitude-shift- keying-Matlab-Simulink[2]

Amplitude shift keying Matlab Simulink can be designed with Matlab tool. After initializing the tool, by following the proper steps we can draw the ASK circuit on the work area. By giving the proper signal values we can get the modulated output waveforms.[2]

1.2.3.Applications of ASK

Here comes a wide range of application of ASK

- ASK is commonly used in wireless communication systems, such as keyless entry systems, remote controls, and radio frequency identification (RFID) tags.
- In optical fiber communication, ASK is used to transmit digital data over long distances.
- ASK is often used in digital broadcasting, including television and radio transmissions, for transmitting audio and video signals[4].

- ASK can be used for low to medium data rate communication, such as in binary data transmission over short distances.
- ASK is used in medical telemetry systems for monitoring and transmitting patient data [4].

2.Procedure

2.1 **Part 1: Amplitude shift keying Modulation (Time domain)**

In this part, the kit setup shown in Figure 4 was connected in order to study the Amplitude Shift Keying Modulation in two keying methods the Hard and the Soft keying.

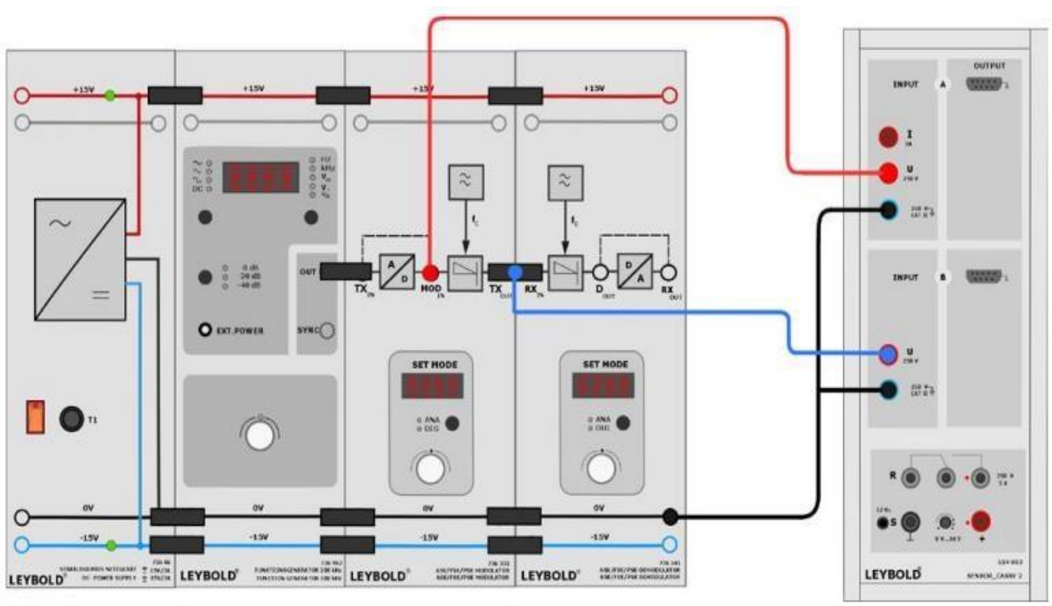

Figure 8ASK Modulation kit setup

- **Hard Keying**

When Modulation index = 100%

In this case, The function generator was configured to produce a square wave with a frequency of 1000 Hz, a peak-to-peak voltage of 10V, and a 50% duty cycle. The modulator mode was set to Digital (DIG), and Amplitude Shift Keying (ASK) with Hard keying and a 100%

modulation index was selected. Cassy sensors were initially connected to monitor the modulating signal and the unipolar square wave at the MODIN socket. After starting the measurement and capturing the output for five cycles, the sensors were reconnected to observe the ASK signal at the TXOUT output of the modulator. The second measurement displayed the amplitude-modulated waveform, highlighting the modulation effect on the square wave signal, with the resulting pattern showing the amplitude variation due to the modulation. Pictures of both outputs were taken for documentation and analysis.

The procedure was repeated with the Amplitude Shift Keying (ASK) mode set to Hard keying with a modulation index of 50% (A_21). After configuring the modulator, the measurement was started, and five cycles of the output were displayed and photographed. The observation revealed that the amplitude modulation reflected a 50% modulation index, showing a less pronounced variation in amplitude compared to the previous 100% modulation index. The coding method used in the experiment system was identified as Unipolar NRZ.

- Soft Keying

In this section, the same connection that was assembled in hard keying section was used.

The connections were maintained as they were for the hard keying part. The procedures were repeated with the modulator set to Amplitude Shift Keying (ASK) with Soft keying and a modulation index of 100% (A_12). The measurement was started, and five cycles of the output were displayed and photographed. The observed output showed the ASK signal with smooth amplitude variations due to the soft keying, which resulted in a more gradual transition in amplitude compared to hard keying.

Next, the modulation index was adjusted to 50% (A_22) while keeping the soft keying mode. The measurement was restarted, and five cycles of the output were again displayed and photographed. The output exhibited a softer amplitude modulation with a 50% modulation index, showing a less pronounced modulation depth compared to the 100% modulation index but still with smooth transitions.

Detecting the comparator threshold

The same connections used in previous parts were maintained. The function generator was set to produce a DC signal with a voltage of 0V. Amplitude Shift Keying (ASK) was configured with hard keying and a modulation index of 100% (A_11). The measurement was started, and the DC value was slowly increased until the high level of the ASK signal appeared; a picture of the output was taken. The DC upper threshold value was recorded. Next, the DC value was decreased from 2.5V until the low level of the ASK signal was observed; another picture of the output was taken, and the DC lower threshold value was noted.

Part 2: Amplitude Shift Keying Modulation (Frequency Domain)

The Cassy Lab was set to FFT mode by navigating to Settings > Calculator > FFT and selecting the appropriate input channel for FFT analysis. The same connections used in previous parts were retained. Cassy sensor UA1 was connected to the ASK signal at the output TXOUT of the modulator. The function generator was configured to produce a square wave with a frequency of 1000 Hz, a peak-to-peak voltage of 10V, and a 50% duty cycle. For hard keying, Amplitude Shift Keying (ASK) was set with a modulation index of 100% (A_11). The ASK signal spectrum was plotted using Cassy Lab, and a picture of the spectrum's impulses was taken after adjusting the x-axis range for clarity.

- Hard Keying

The Cassy Lab was set to FFT mode by navigating to Settings > Calculator > FFT and selecting the appropriate input channel. The same connections used previously were maintained. Cassy sensor UA1 was connected to the ASK signal at the output TXOUT of the modulator. The function generator was set to produce a square wave with a frequency of 1000 Hz, a peak-to-peak voltage of 10V, and a 50% duty cycle. For hard keying, Amplitude Shift Keying (ASK) was configured with a modulation index of 50% (A_21). The spectrum of the ASK signal was then plotted using Cassy Lab, and a picture of the spectrum's impulses was taken after adjusting the x-axis range to appropriately display the data.

- **Soft Keying**

The setup from the hard keying part was retained. The procedures were repeated with Amplitude Shift Keying (ASK) using soft keying with a modulation index of 100% (A_12). Cassy sensor UA1 was connected to the ASK signal at the output TXOUT of the modulator, and the function generator was configured as before. The ASK signal spectrum was plotted using Cassy Lab, and a picture of the impulses was taken after adjusting the x-axis range for clarity. Next, the modulation index was changed to 50% (A_22), and the same procedure was repeated. The spectrum of the ASK signal was plotted again, and a picture of the impulses was captured after adjusting the x-axis range.

Part 3: Amplitude shift keying Demodulation (Time and frequency domains)

Assemble the components as shown in the figure below:

The function generator was adjusted to output a square wave with a frequency of 1000 Hz, a peak-to-peak voltage of 10V, and a duty cycle of 50%. The modulator mode was set to Digital (DIG), and demodulation type (A) was chosen. Cassy sensor UA1 was linked to the bipolar square-wave signal at the TXIN input, while Cassy sensor UB1 was connected to the demodulated signal at the RXOUT output.

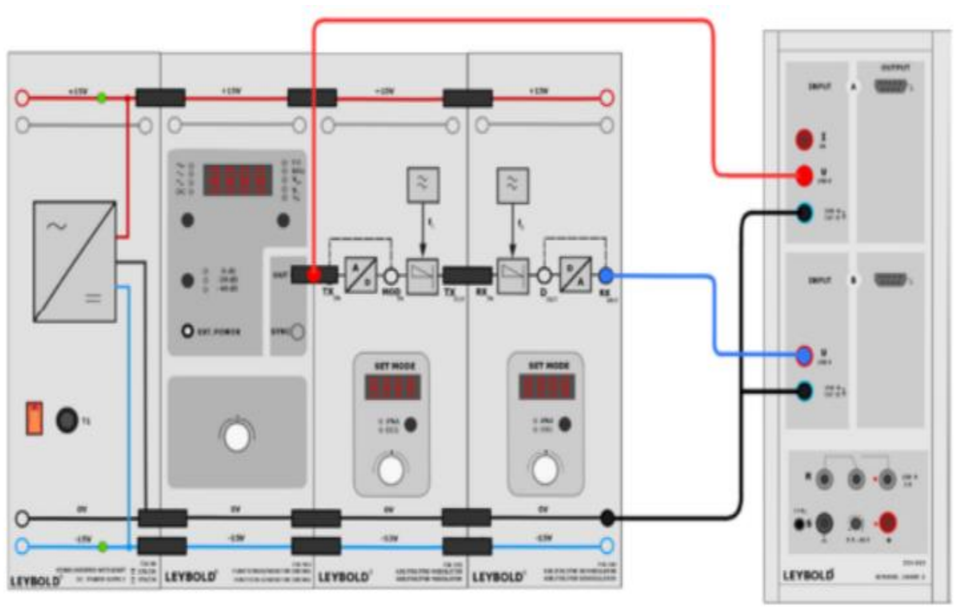

Figure 9(ASK) demodulation diagraim

To perform Amplitude Shift Keying (ASK) demodulation in both the time and frequency domains, the setup began with configuring the function generator to output a square wave with a frequency of 1000 Hz, a peak-to-peak voltage of 10V, and a 50% duty cycle. The demodulator mode was then set to Digital (DIG), and the demodulation type was selected as (A). Cassy sensor UA1 was connected to the bipolar message square-wave signal at the MODIN socket, while Cassy sensor UB1 was connected to the demodulated signal at the RXOUT output. This setup facilitated the analysis of the demodulated ASK signal's characteristics.

3.1Hard Keying:

To perform the demodulation of Amplitude Shift Keying (ASK) with hard keying, the modulator mode was initially set to Digital (DIG), and Amplitude Shift Keying with a modulation index of 100% (A_11) was selected. The measurement was then started, and five cycles of the output were displayed and photographed. Following this, the process was repeated with a modulation index of 50% (A_21). Five cycles of the output were again displayed and photographed. The success of the demodulation for each modulation index was evaluated based on the clarity and accuracy of the received signal.

3.2Soft Keying:

the same connections used for the hard keying part. The setup was then adjusted to Amplitude Shift Keying (ASK) with soft keying and a modulation index of 100% (A_12). The measurement was started, and five cycles of the output were displayed and captured in a photograph. The success of the demodulation process for ASK with 100% soft keying was evaluated based on the clarity of the output. Subsequently, the process was repeated with a modulation index of 50% (A_22), following the same steps. Five cycles of the output were again displayed and photographed, and the effectiveness of the demodulation for ASK with 50% soft keying was assessed.

3.Result & analasis

3.1 Part 1: Amplitude shift keying Modulation (Time domain)

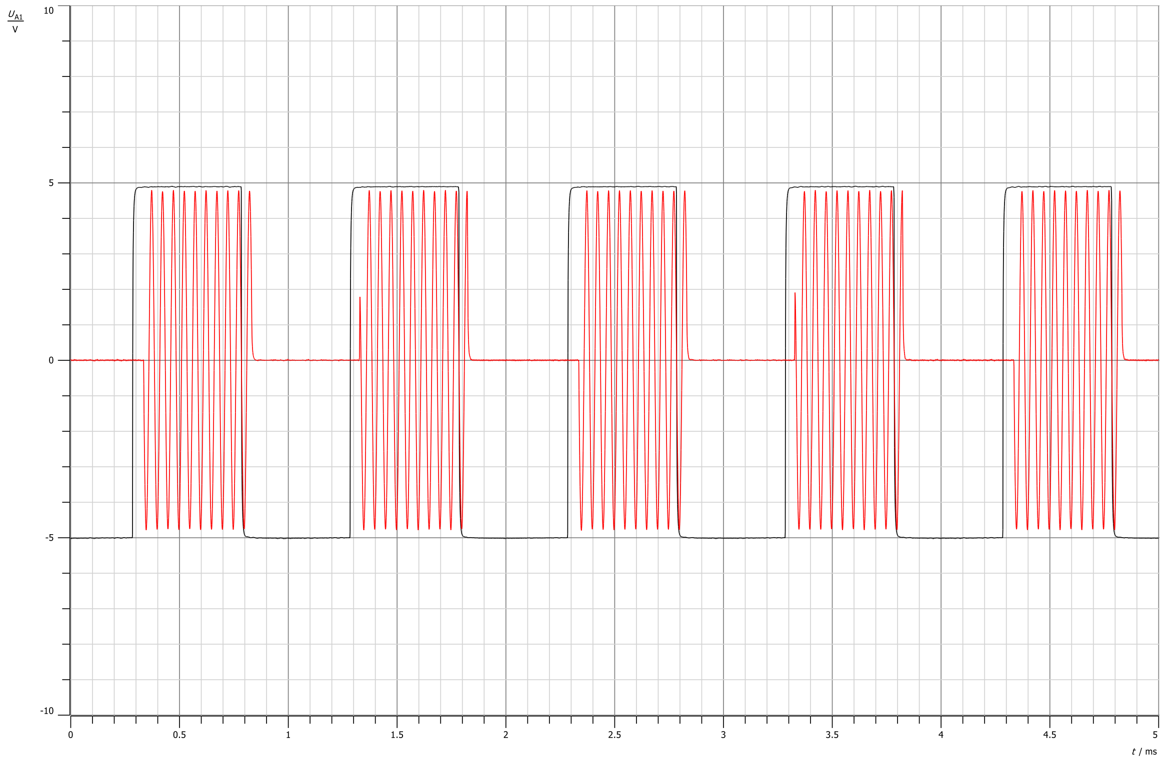

Figure 10The ASK modulated signal (Hard Keying) (MI=100%) and the unmodulated signal

The result of modulating binary data with Amplitude Shift Keying (ASK) using hard keying and a modulation index of 100% is an ASK-modulated signal. This signal displays amplitude fluctuations that correspond to the binary data being transmitted. When a high-level (logic 1) bit is sent, the amplitude of the ASK signal peaks. In contrast, when a low-level (logic 0) bit is transmitted, the amplitude falls to zero. These sudden amplitude shifts encode the digital data. ASK modulation efficiently conveys binary information by altering the amplitude of the carrier wave.

When Modulation index = 50%

In this case, the connections were unchanged from the previous configuration, but Amplitude Shift Keying (ASK) was set to hard keying with a modulation index of 50% (A_21). Figure 6 displays the characteristic curve of the ASK modulated signal with this modulation index, compared with the unmodulated signal.

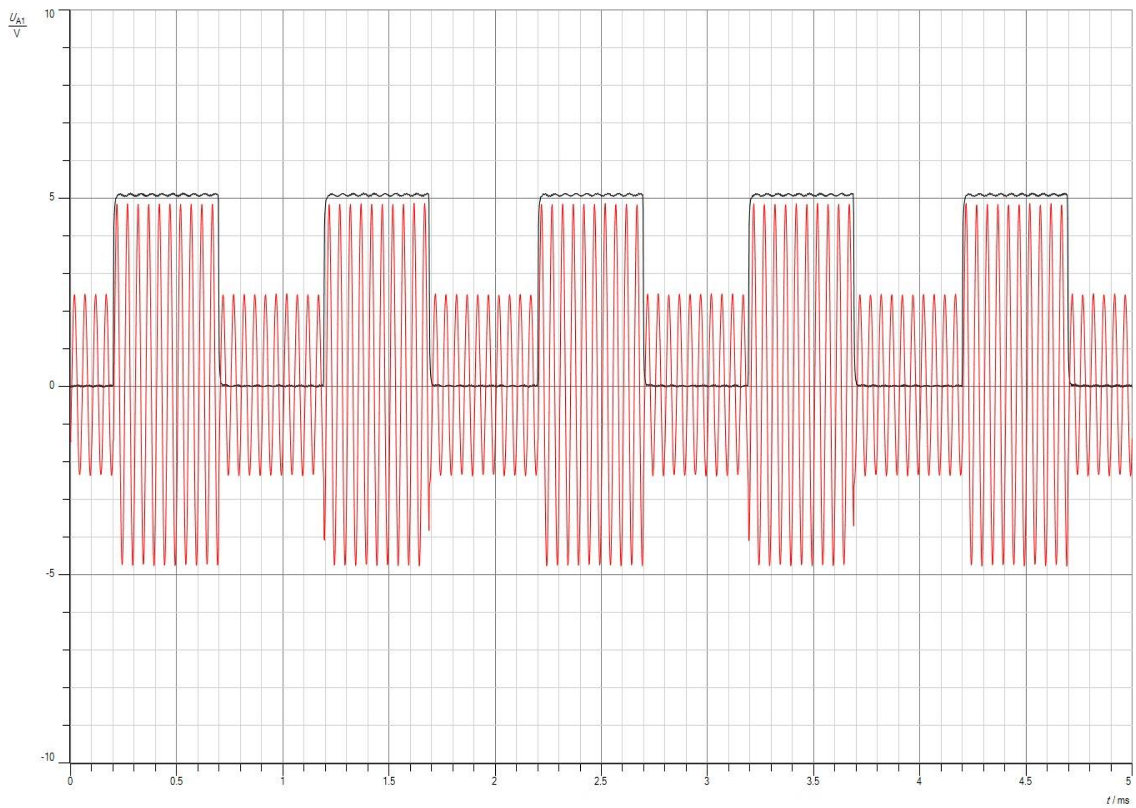

Figure 11: The ASK modulated signal (Hard Keying) (MI=50%) and the unmodulated signal

The output produced from modulating binary data with ASK (Hard Keying) at a modulation index of 50% is an ASK modulated signal. This signal displays amplitude variations that correspond to the binary data being transmitted. When a high-level (logic 1) binary signal is sent, the amplitude of the ASK signal reaches its peak. Conversely, when a low-level (logic 0) binary signal is transmitted, the amplitude drops to half of the high-level amplitude due to the modulation index being set at 50%. This modulation index means that the amplitude for a low-level signal is reduced to 0.5 times the amplitude of a high-level signal. This adjustment provides a sufficient amplitude difference to ensure accurate detection and decoding of binary data. Although the low-level amplitude does not drop to zero, the clear distinction between high and low levels is maintained. In both cases, the coding method employed is Unipolar Non-return to Zero.

- **Soft Keying**

  In this section, the same connection that was assembled in hard keying section was used.

When modulation index = 100%

Amplitude Shift Keying (ASK) using soft keying and a modulation index of 100% (A_12) was chosen for the modulation scheme. Figure bellow displays the characteristic curve of the ASK signal with this modulation index, alongside the unmodulated signal.

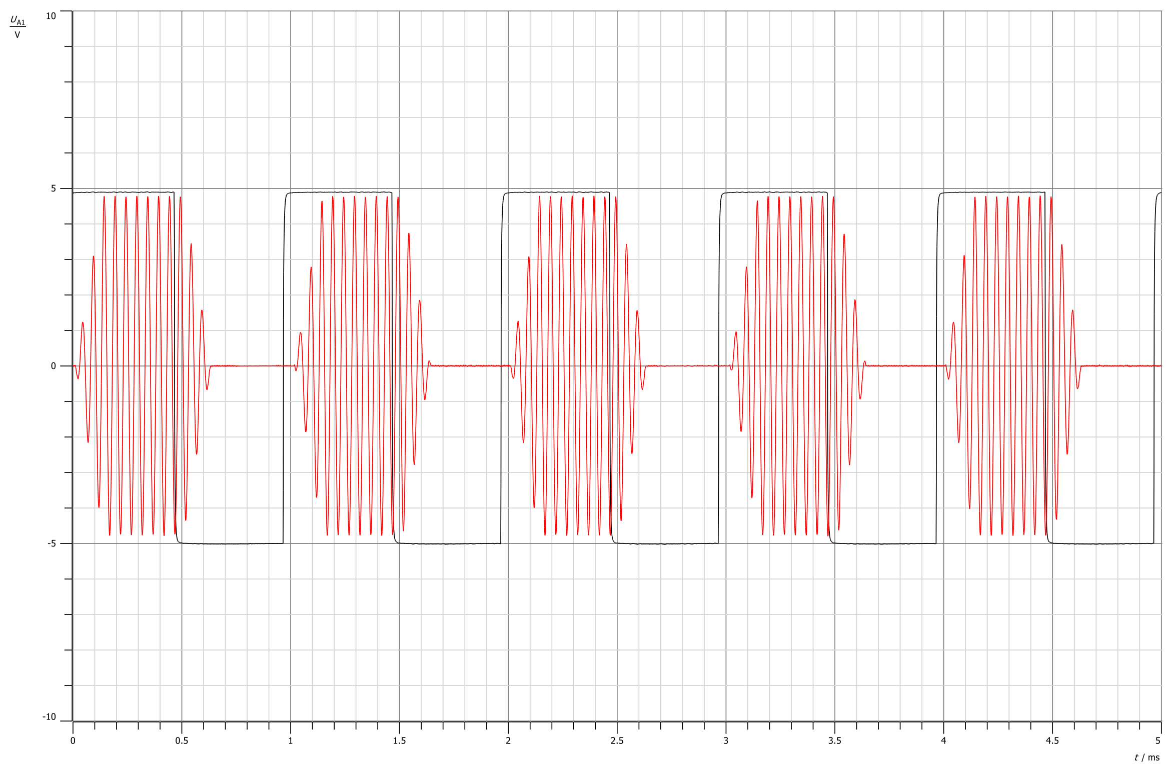

Figure 12The ASK modulated signal (Soft Keying) (MI=100%) and the unmodulated signal

In this modulation approach, the amplitude of the carrier signal is adjusted in response to the binary data being sent, with smooth amplitude transitions rather than abrupt changes. With a modulation index of 100%, the amplitude variations of the signal directly reflect the transmitted binary information. When transmitting a high-level (logic 1) bit, the amplitude of the ASK modulated signal peaks, while it drops to zero for a low-level (logic 0) bit. The result of using soft keying with a modulation index of 100% is a signal with gradual amplitude shifts between high and low levels.

- ***When modulation index = 50%***

Amplitude Shift Keying (ASK) using soft keying with a modulation index of 50% (A_22) was chosen for the modulation scheme. Figure 8 illustrates the characteristic curve of the ASK signal with this modulation index, compared to the unmodulated signal.

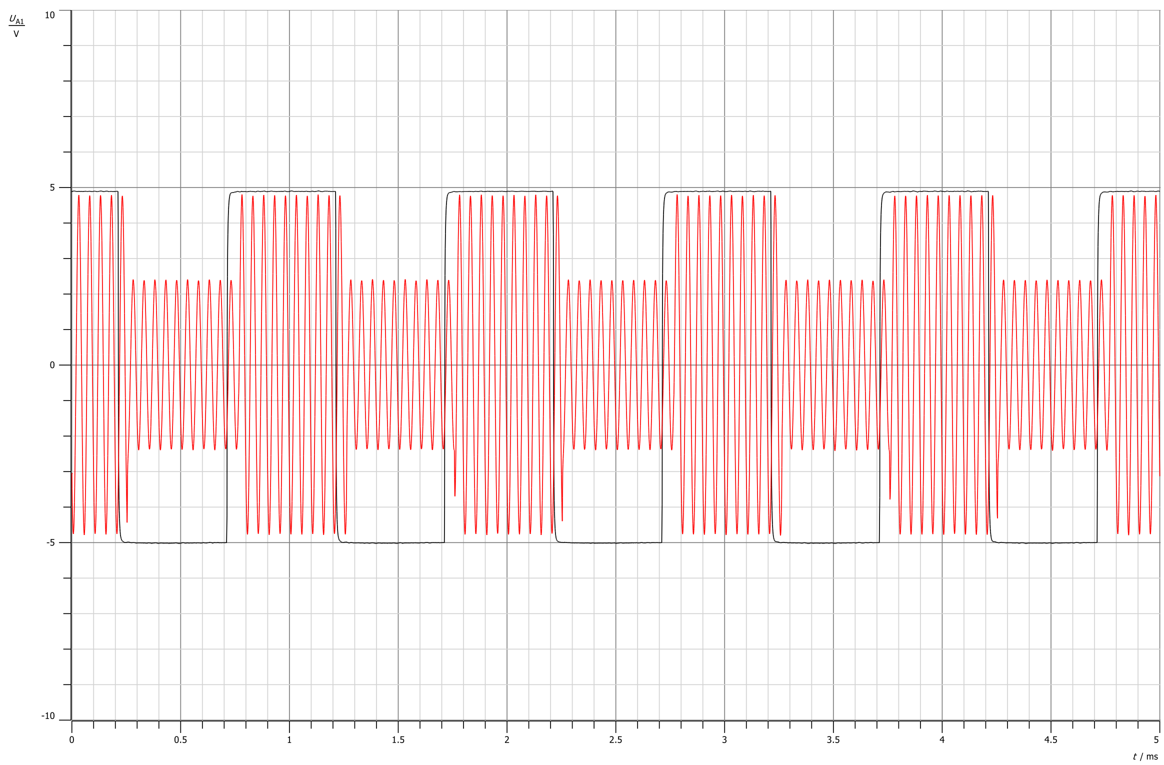

Figure 13The ASK modulated signal (Soft Keying) (MI=50%) and the unmodulated signal

In this modulation method, the amplitude of the carrier signal is adjusted according to the binary data being transmitted, using gradual amplitude changes instead of abrupt shifts. With a modulation index of 50%, the amplitude of the ASK modulated signal varies in response to the binary data, reaching its peak when transmitting a high-level (logic 1) bit and dropping to 0.5 when transmitting a low-level (logic 0) bit. This approach allows for smoother transitions between amplitude levels compared to sudden changes. The experiment revealed that both Amplitude Modulation (AM) and Amplitude Shift Keying (ASK) involve modulating a carrier signal by altering its amplitude to transmit information. AM continuously adjusts the carrier's amplitude in response to an analog signal, such as audio, creating a signal with varying amplitude. In contrast, ASK modifies the carrier’s amplitude based on binary data, using discrete levels to represent different binary states. Both techniques utilize amplitude changes to convey information, though they differ in how they achieve and represent these changes. information, but Amplitude Modulation (AM) and Amplitude Shift Keying (ASK) both modulate a carrier signal by varying its amplitude to transmit information, but they are suited to different applications. AM is typically employed for analog signals and creates sidebands to carry continuous variations of the signal, such as audio. In contrast, ASK is designed for digital signals, with distinct amplitude levels representing binary data.

In terms of keying techniques within ASK, hard keying and soft keying present distinct approaches. Hard keying is characterized by sudden and discrete changes in the carrier's amplitude, leading to sharp transitions and a wider bandwidth due to the presence of higher frequency components. On the other hand, soft keying involves smooth, gradual transitions in amplitude, which results in a more continuous waveform and a narrower bandwidth by reducing high-frequency components and limiting spectral spreading. The choice between hard and soft keying techniques notably affects the signal's bandwidth and susceptibility to interference.

Feature	**Hard Keying**	**Soft Keying**
Bandwidth	Wider bandwidth due to abrupt amplitude transitions, which introduce higher frequency components and greater spectral spreading.	Narrower bandwidth due to gradual amplitude transitions, which minimize high-frequency components and reduce spectral spreading.

- **Detecting the comparator threshold**

The measurements determined the thresholds necessary for transitioning the ASK signal from high to low amplitude. The DC upper threshold value was established at which the ASK signal's high amplitude became apparent, while the DC lower threshold value was recorded where the signal dropped to its low amplitude state. The observations clearly delineated the points of transition between high and low amplitudes based on the DC voltage levels. This enabled precise definition of the signal’s amplitude range, which is crucial for accurate demodulation and decoding of the transmitted data. Specifically, the DC value was gradually increased until the ASK signal’s high level was detected at 2.7V (DC upper threshold), and then it was reduced from 2.7V until the signal’s low level appeared at 1.73V (DC lower threshold).These thresholds (upper and lower thresholds)

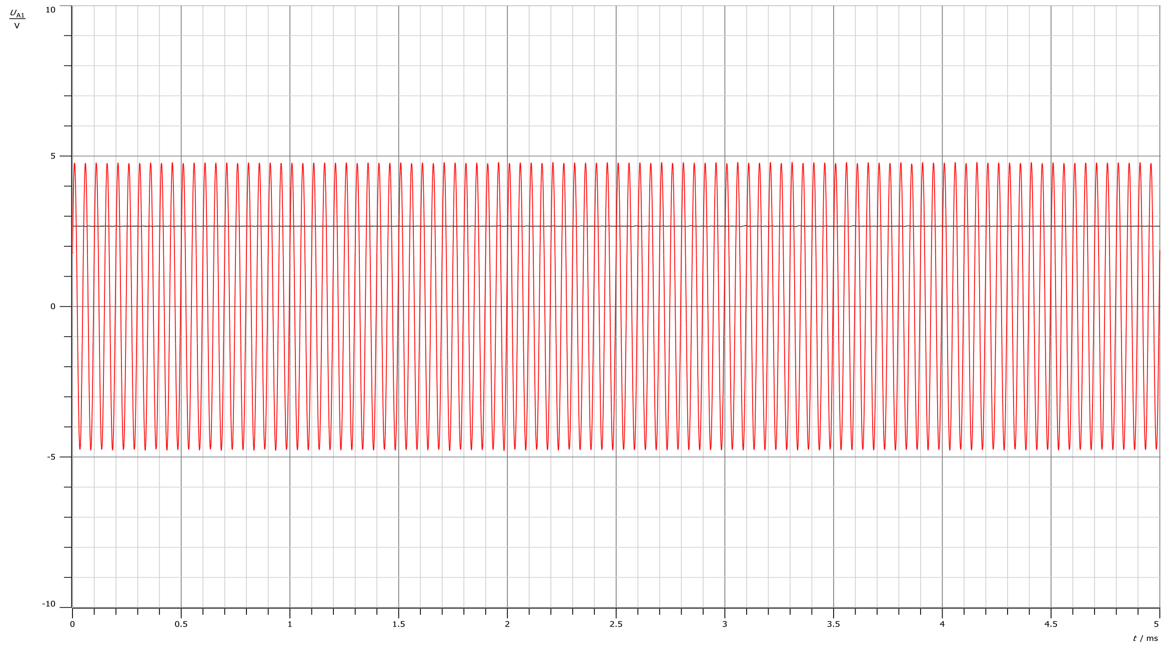

Figure 14the DC value was slowly increased until the high level of the ASK signal appeared at 2.7V

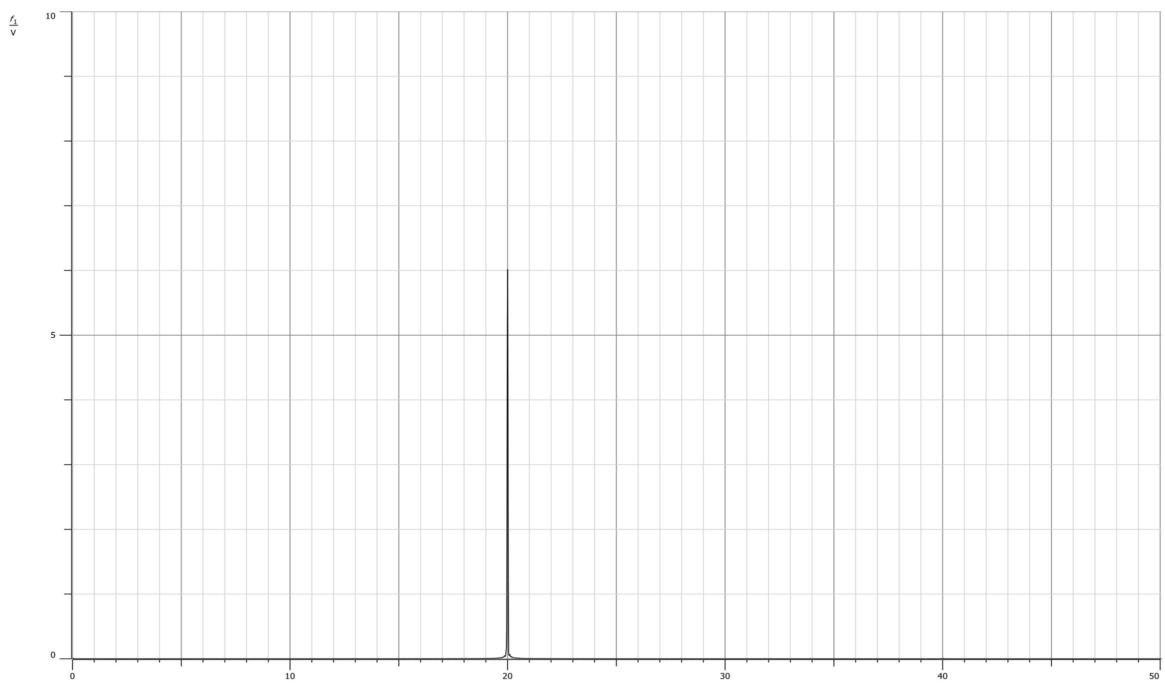

Figure 15 carrier

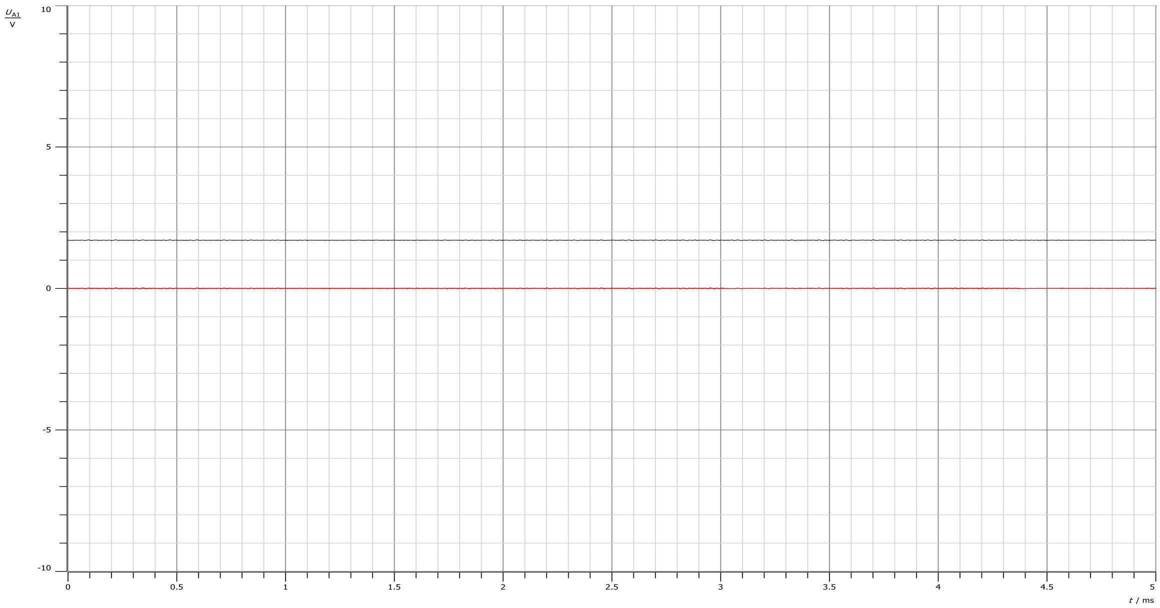

Figure 16the DC value was slowly reduced from 2.7V until the low level of the ASK appeared at 1.73V

Part 2: Amplitude Shift Keying Modulation (Frequency Domain)

The frequency domain analysis of the ASK signal using hard keying with a modulation index of 100% revealed a spectrum characterized by distinct impulses. The plot showed a prominent impulse at the carrier frequency, with additional impulses appearing at the harmonics of this frequency, attributable to the square wave modulation. The intervals between these impulses matched the anticipated harmonics of the square wave signal. This spectral behavior demonstrated that hard keying introduced notable frequency components at these harmonic frequencies, thus illustrating the typical frequency domain characteristics of the ASK signal.

- **Hard Keying**

- ***When Modulation Index = 100%***

  In this section, Amplitude Shift Keying (ASK) with hard keying and a modulation index of 100% (A_11) was selected as the modulation scheme. Figure bellow as shows the spectrum of the ASK modulated signal (Hard Keying) with modulation index = 100%.

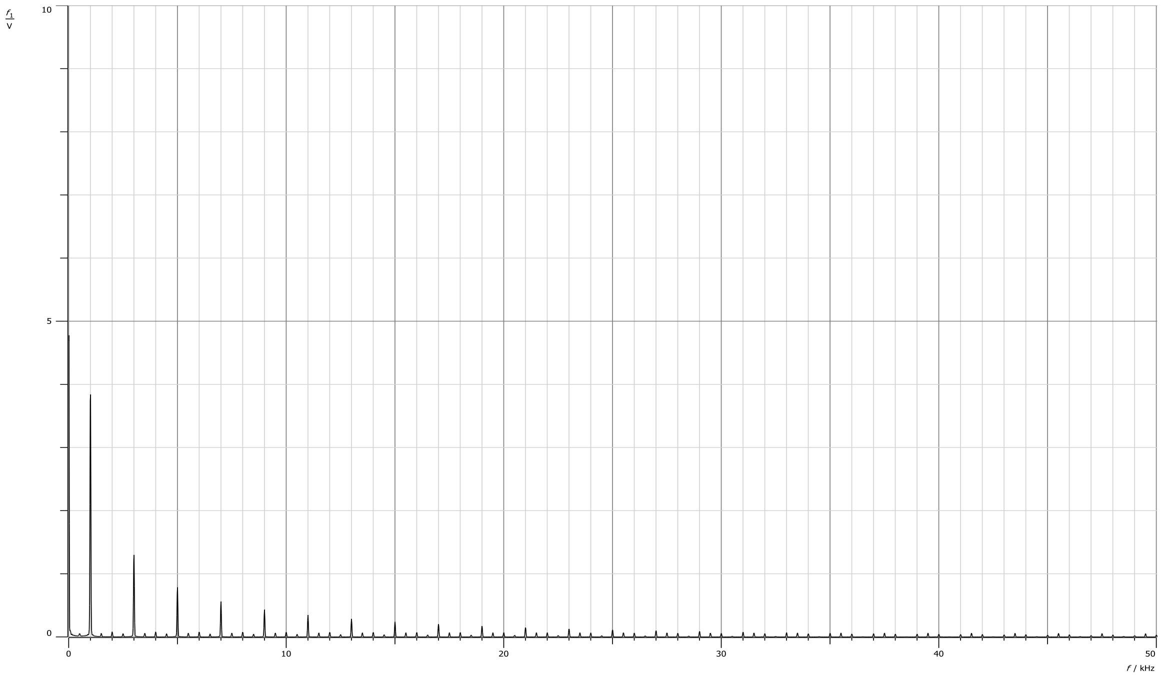

Figure 17 The spectrum of the ASK modulated signal (Hard Keying) (MI=100%)

In Amplitude Shift Keying (ASK) modulation with hard keying and a modulation index of 100%, the carrier signal experiences sharp transitions between two amplitude levels to encode binary data. The resulting spectrum of the modulated signal features distinct impulses spaced at intervals corresponding to the carrier frequency. These impulses reflect the carrier signal's presence and its amplitude changes, with higher amplitudes denoting a high-level state and lower amplitudes indicating a low-level state.

- ***When Modulation Index = 50%***

The spectrum of the ASK signal with hard keying and a modulation index of 50% displayed distinct impulses at both the carrier frequency and its harmonics. Compared to the 100% modulation index, the side impulse amplitudes were notably lower. While the carrier frequency remained strong, the harmonic components showed diminished amplitudes due to the reduced modulation depth. This decrease in side impulse amplitudes reflected the lower modulation index, which resulted in less pronounced spectral spreading. The amplitude of the side impulses inversely correlates with the modulation index: as the modulation index decreases, so does the amplitude of the side impulses. This highlights the direct link between modulation depth and the intensity of spectral components.

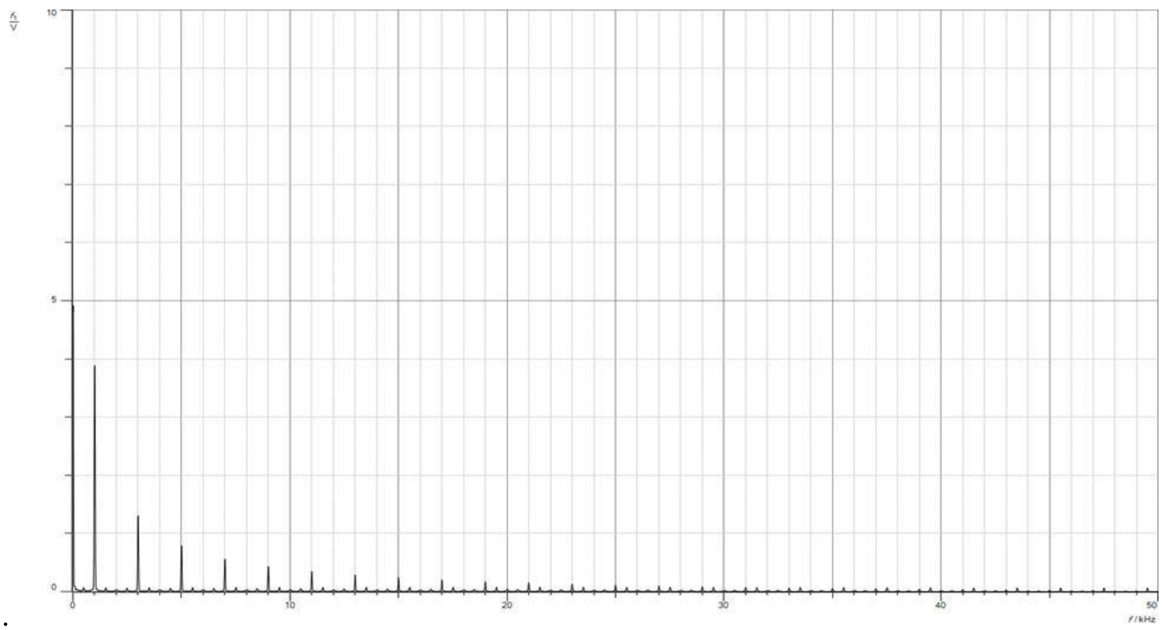

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Figure 18The spectrum of the ASK modulated signal (Hard Keying) (MI=50%)

In Amplitude Shift Keying (ASK) modulation using hard keying with a 50% modulation index, the carrier signal experiences sudden changes in amplitude to encode binary data, producing a spectrum characterized by discrete impulses around the carrier frequency. Impulses with higher amplitude signify the high-level state, while those with lower amplitude denote the low-level state. A lower modulation index causes these impulses to be spaced further apart. The amplitude of the side impulses is proportionate to the modulation index: a higher modulation index leads to larger side impulse amplitudes, whereas a lower modulation index results in smaller side impulse amplitudes.

- **Soft Keying**

  - ***When Modulation Index = 100%***

    In this section, Amplitude Shift Keying (ASK) with soft keying and a modulation index of 100% (A_12) was selected as the modulation scheme. Figure 11 shows the spectrum of the ASK modulated signal (Soft Keying) with modulation index = 100%.

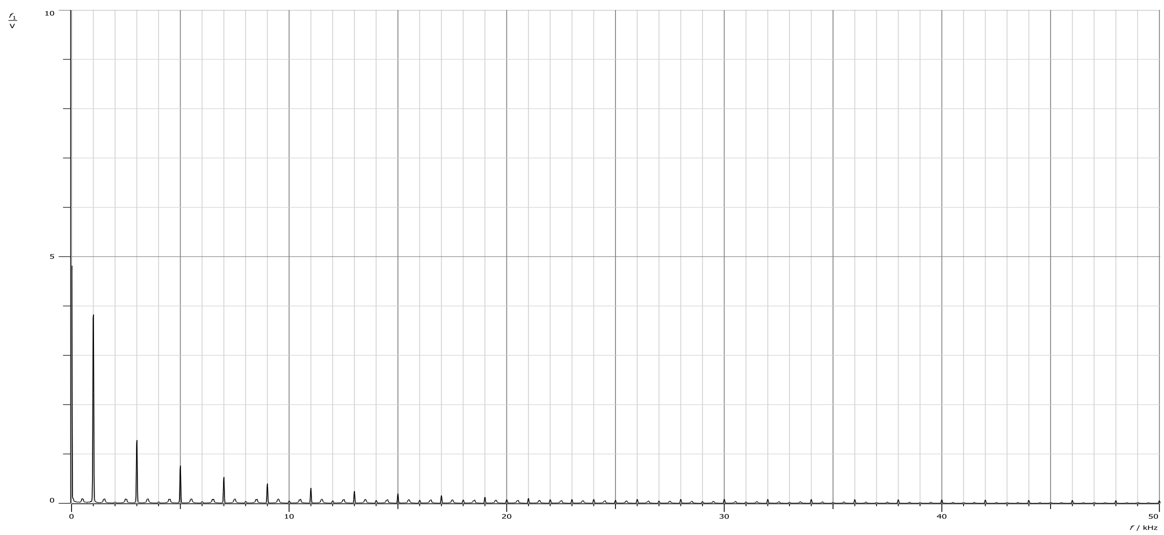

Figure 19The spectrum of the ASK modulated signal (Soft Keying) (MI=100%)

With soft keying and a 100% modulation index, the spectrum exhibited clear impulses around the carrier frequency, similar to the spectrum observed with hard keying but with more gradual transitions. The amplitude of the side impulses matched the modulation index, showing higher amplitudes for a 100% index and a more compact spectral distribution. The carrier signal was modulated smoothly throughout its amplitude range, leading to distinct and evenly spaced impulses at intervals that matched the carrier frequency. ASK modulation using soft keying with a 100% modulation index resulted in a distinct and well-separated spectrum, promoting effective transmission and reception of binary data.

- ***When Modulation Index = 50%***

  In this section, Amplitude Shift Keying (ASK) with soft keying and a modulation index of 50% (A_22) was selected as the modulation scheme. Figure 12 shows the spectrum of the ASK modulated signal (Soft Keying) with modulation index = 50%.

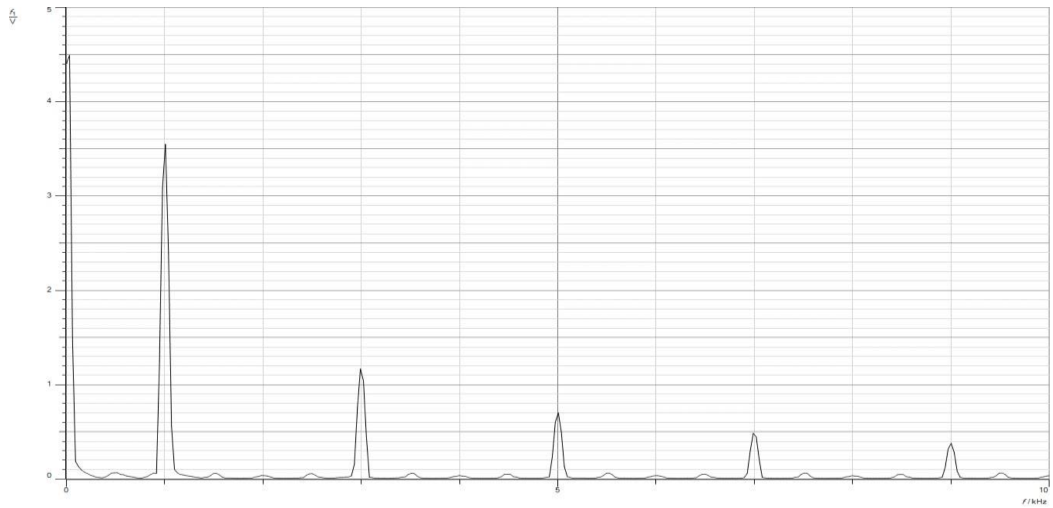
Figure 20The spectrum of the ASK modulated signal (Soft Keying) (MI=50%)

The carrier signal undergoes smooth modulation between different amplitude levels. The resulting spectral impulses exhibit separation centered around the carrier frequency, but with reduced amplitudes compared to higher modulation indices. In ASK modulation with soft keying at a 50% modulation index, the spectrum reveals distinctive features, albeit with notably lower amplitude and tighter impulse spacing compared to higher modulation indices.

- **The effect of changing the message signal amplitude on the spectrum**

In this section, the connection was the same as the previous sections, but the message signal amplitude was reduced to 1.5V (Vss=3V). Figure 13 shows the ASK modulated signal with amplitude 1.5V spectrum.

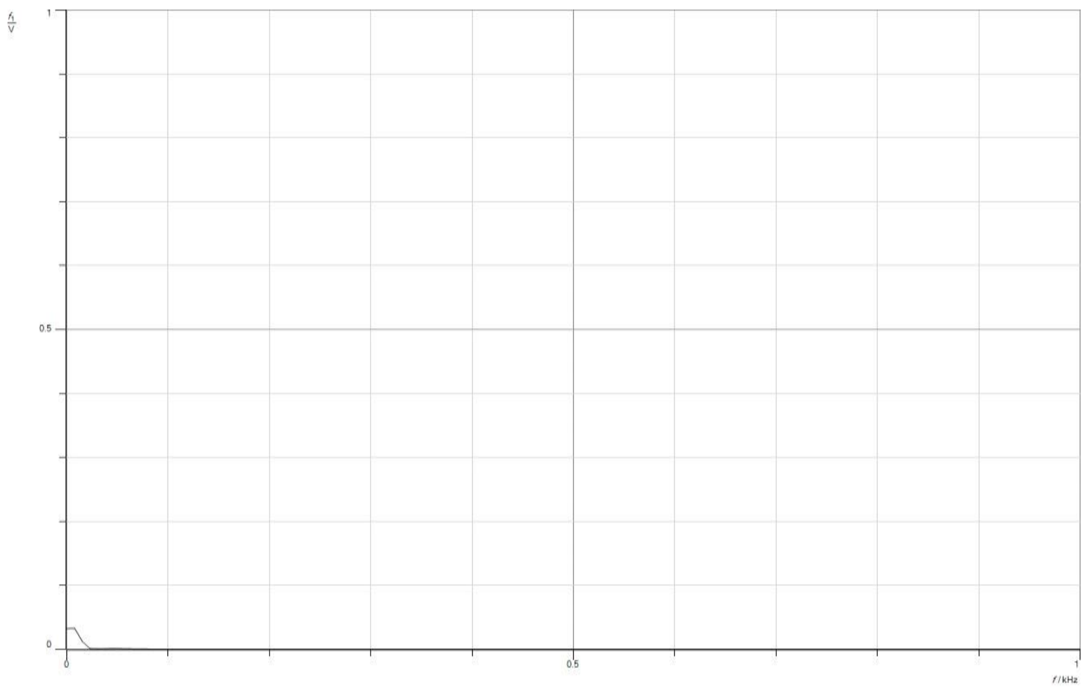

Figure 21ASK modulated signal with amplitude 1.5V spectrum

In Amplitude Shift Keying (ASK) modulation, altering the amplitude of the message signal directly impacts the modulated signal's spectrum. When the amplitude of the message signal is increased, the spectrum broadens, whereas a decrease in amplitude causes the spectrum to narrow. The amplitude changes of the carrier signal correspond directly to the variations in the message signal's amplitude, leading to wider or narrower side impulses in the spectrum.

- **The effect of changing the message signal frequency on the spectrum**

In this phase, the configuration was maintained as in previous setups. The function generator was set to generate a square wave with a frequency of 500 Hz, a peak-to-peak voltage of 10V, and a duty cycle of 50%. Cassy sensors UA1 and UB1 were linked to the unipolar square-wave signal at the MODIN port and to the ASK signal at the TXOUT terminal of the modulator, respectively. Figure 14 displays the spectrum of the ASK modulated signal with a frequency of 500 Hz.

When:A=11

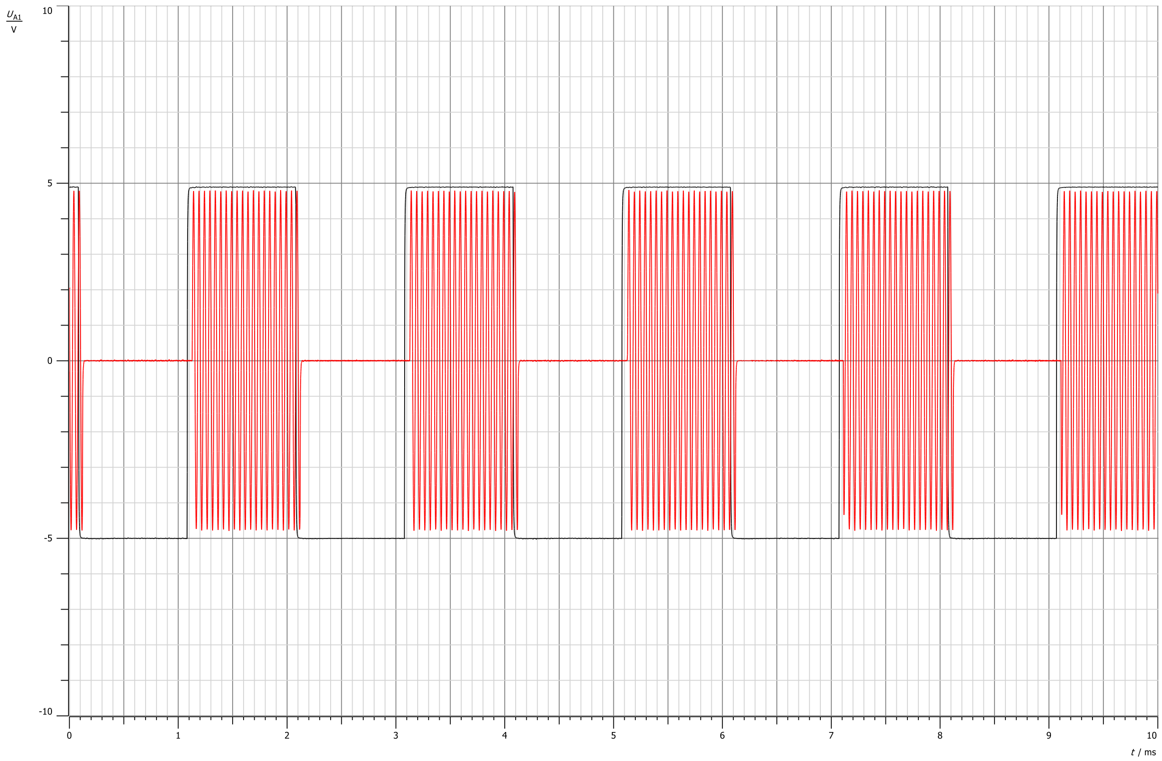

Figure 22 ASK modulated signal with a frequency of 500 Hz A =11 in time domain

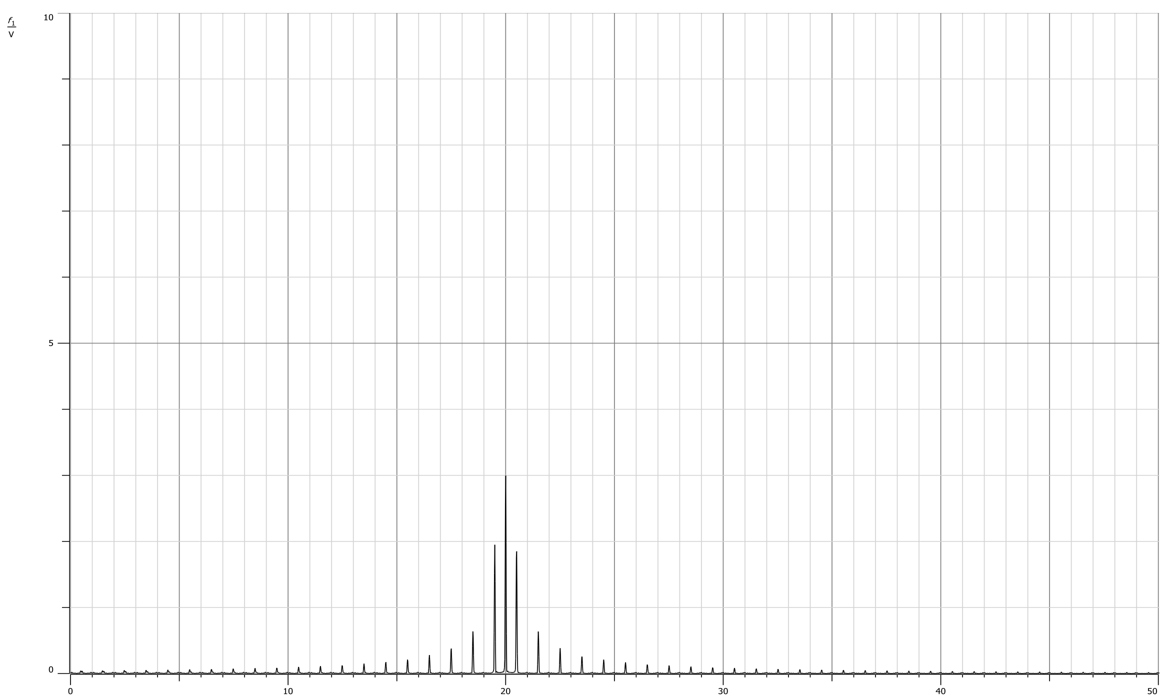

Figure 23ASK modulated signal with frequency 500Hz spectrum A =11

When A = 12

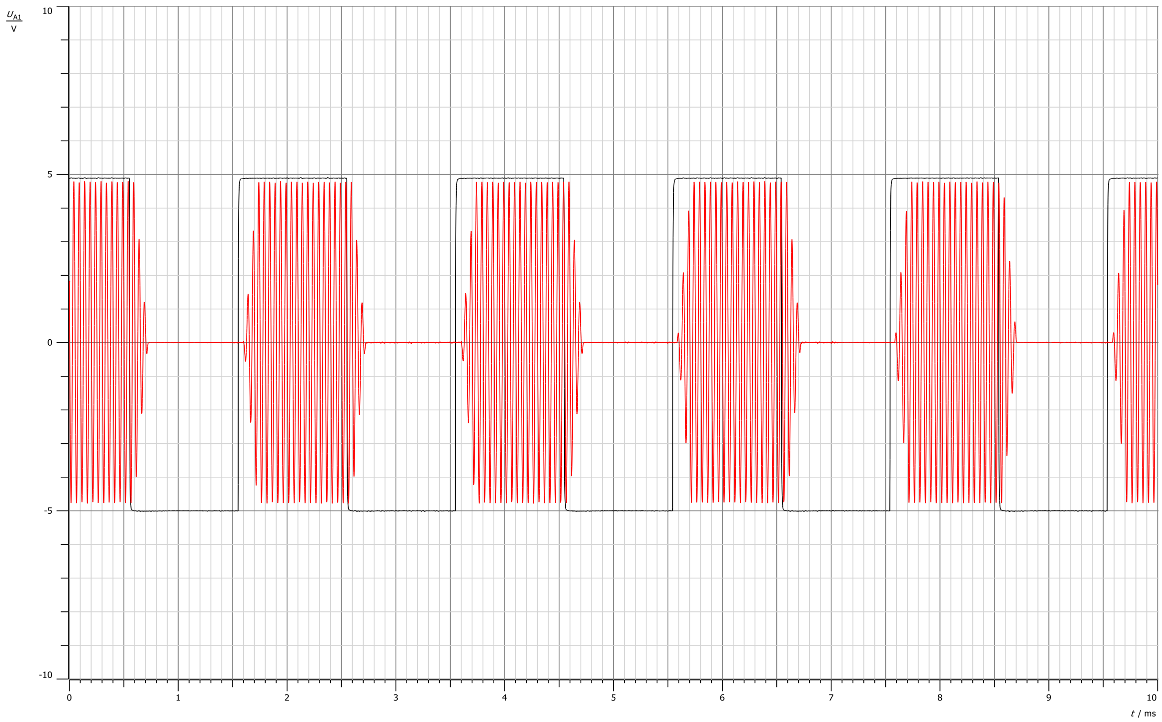

Figure 24ASK modulated signal with a frequency of 500 Hz A =12 in time domain

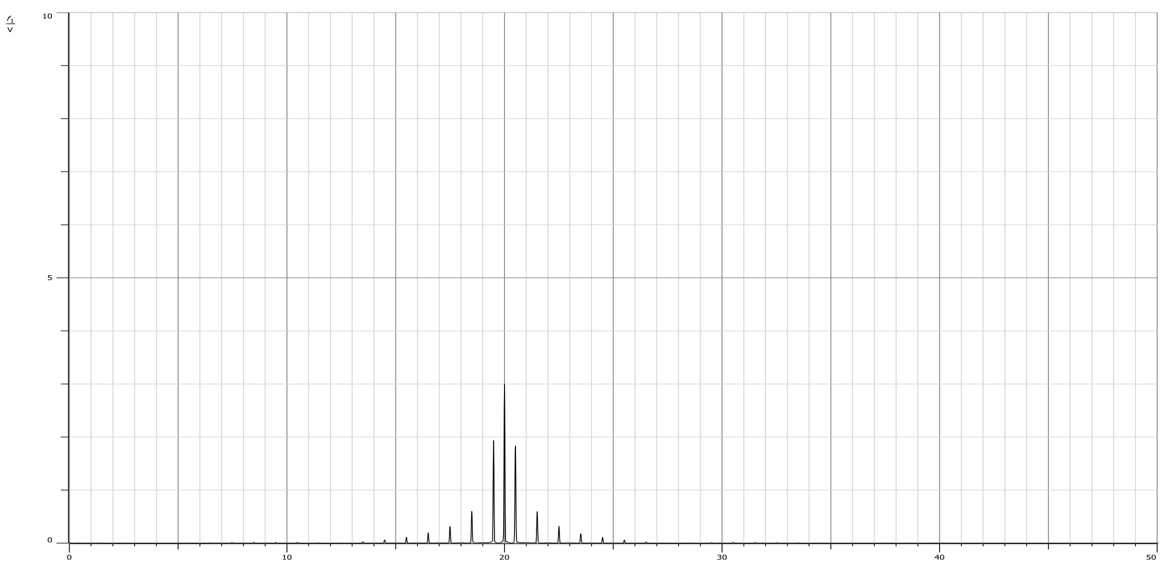

Figure 25:ASK modulated signal with frequency 500Hz spectrum A =12

In Amplitude Shift Keying (ASK) modulation, variations in the message signal's frequency directly influence the distribution of spectral components within the modulated signal's spectrum. As the message signal frequency rises, the spectral components become more widely dispersed. Conversely, a decrease in the message signal frequency results in a tighter packing of spectral components. Higher frequencies in the message signal lead to an expansion of the spectral components, whereas lower frequencies result in a more condensed spectrum.

- **The effect of changing the message signal duty cycle on the spectrum**

In this segment, the setup was kept identical to earlier configurations. The function generator was set to generate a square wave with a frequency of 1000 Hz, a peak-to-peak voltage of 10V, and a duty cycle of 10%. The duty cycle was varied to investigate its effect on the ASK spectrum. Figure bellow illustrates the spectrum of the ASK modulated signal with a duty cycle of 10%.

when A = 11.

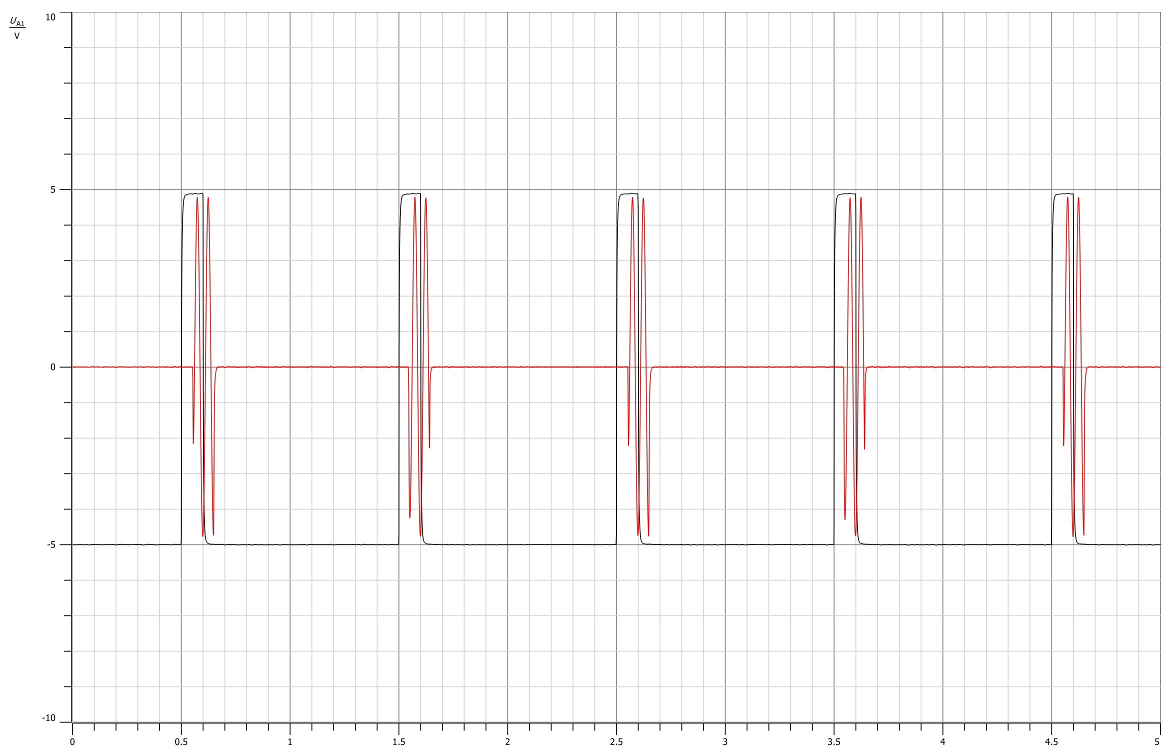

Figure 26 Freq = 1000 Hz, Vss = 10V, duty-cycle = 10% with A=11

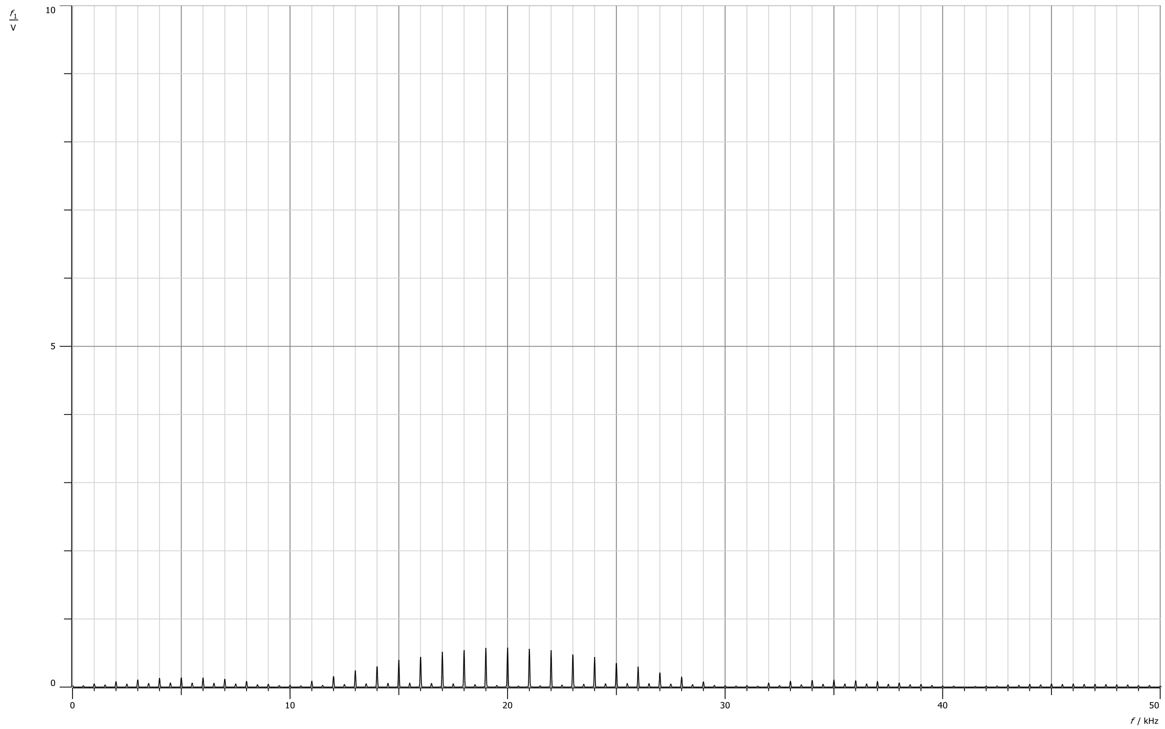

Figure 27:Freq = 1000 Hz, Vss = 10V, duty-cycle = 10% spectrum ASK modulation when A=11

When A =12

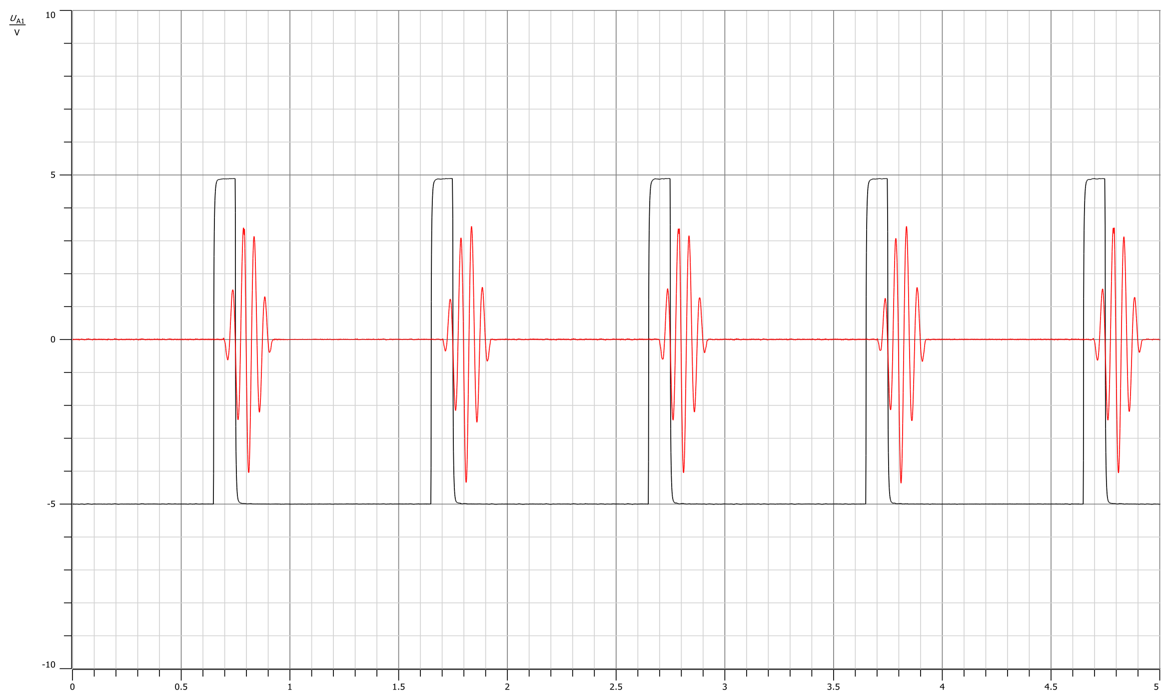

Figure 28Freq = 1000 Hz, Vss = 10V, duty-cycle = 10% A =12

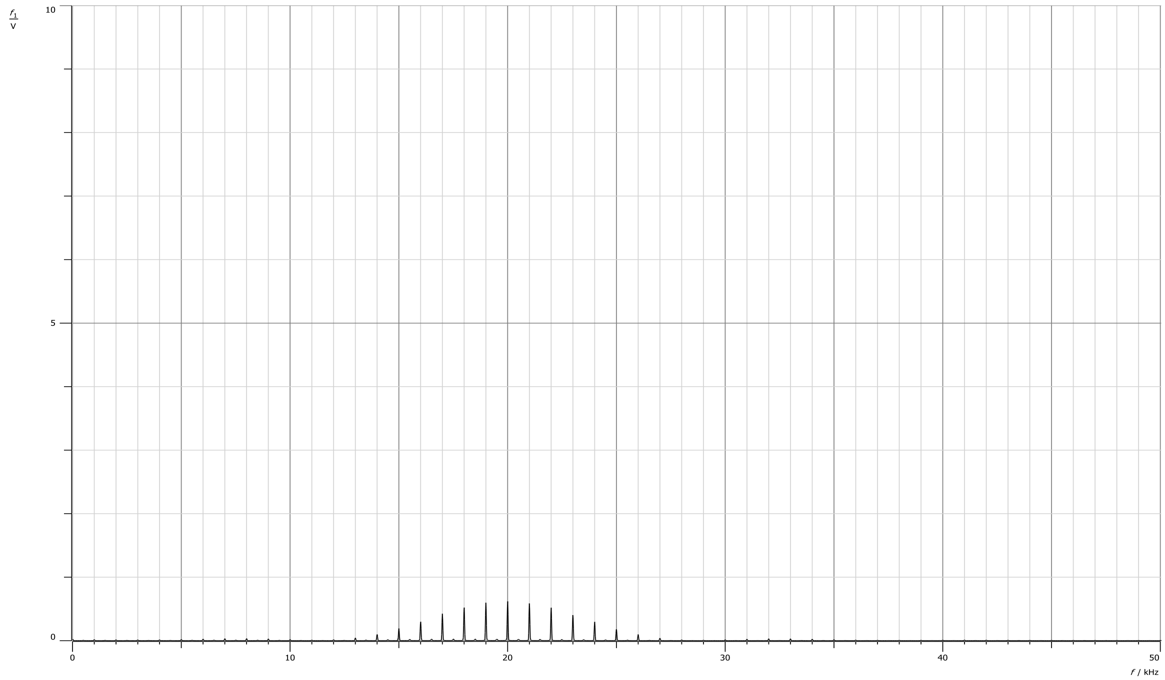

Figure 29Freq = 1000 Hz, Vss = 10V, duty-cycle = 10% spectrum ASK modulation when A=12

In Amplitude Shift Keying (ASK) modulation, adjusting the duty cycle of the message signal has a direct impact on the width of the modulated signal's spectrum. Increasing the duty cycle broadens the spectrum, while decreasing it narrows the spectrum. The range of frequency components within the spectrum is determined by the duration of the high-level phase of the message signal.

4.3 Part 3: Amplitude Shift Keying Demodulation (Time Domain)

4.3.1 Soft Keying

- ***When Modulation index = 100%***

  Amplitude Shift Keying (ASK) with soft keying and a modulation index of 100% (A_12) was selected as the modulation scheme. Figure shows the characteristic curve of the ASK unmodulated signal (Soft Keying) with modulation index = 100%, and the original signal.

  When A_11

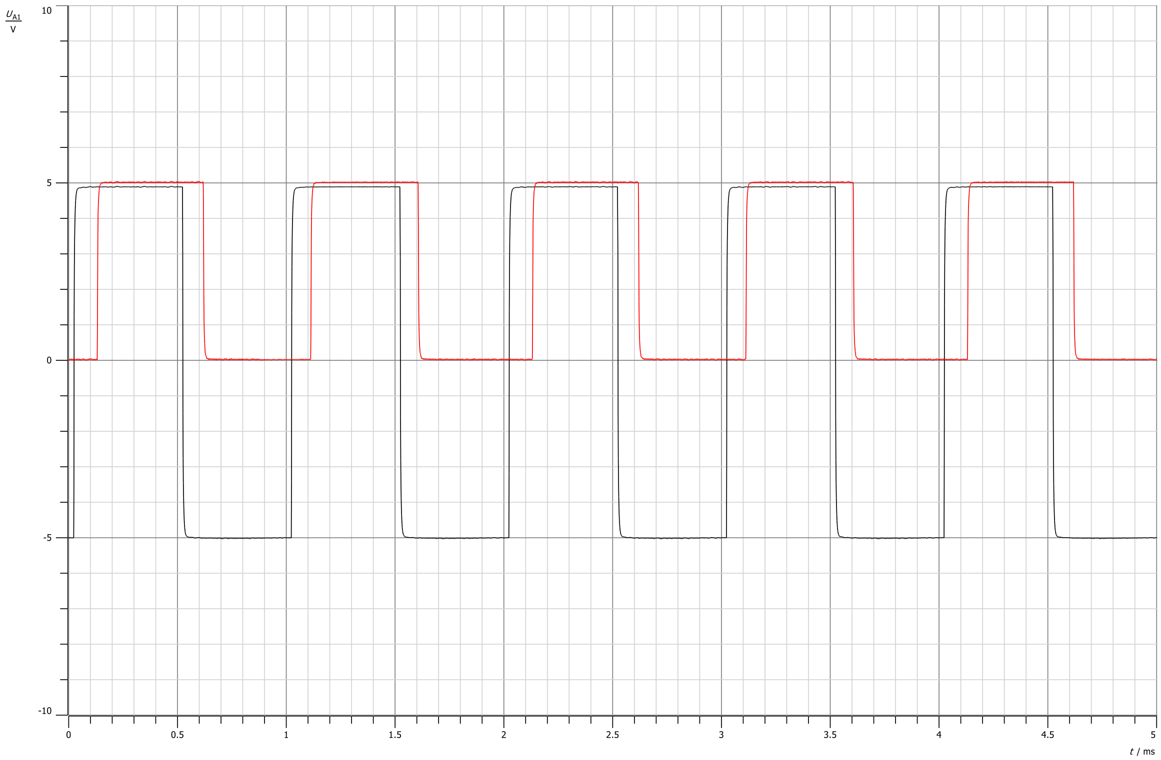

Figure 30ASK unmodulated signal (Soft Keying) (MI=100%) and the original signal

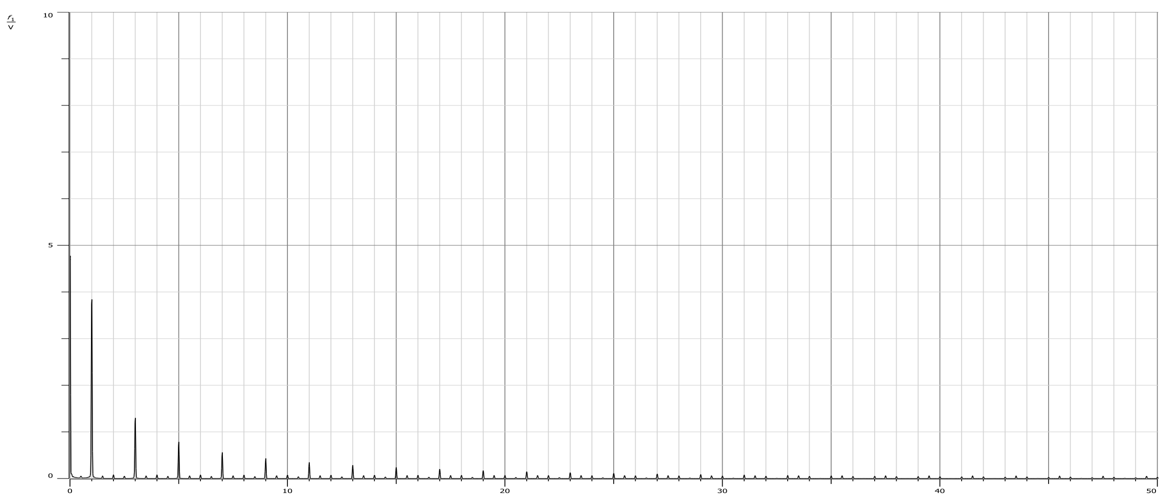

Figure 31ASK unmodulated spectrum (Soft Keying) (MI=100%) and the original signal

When A_12

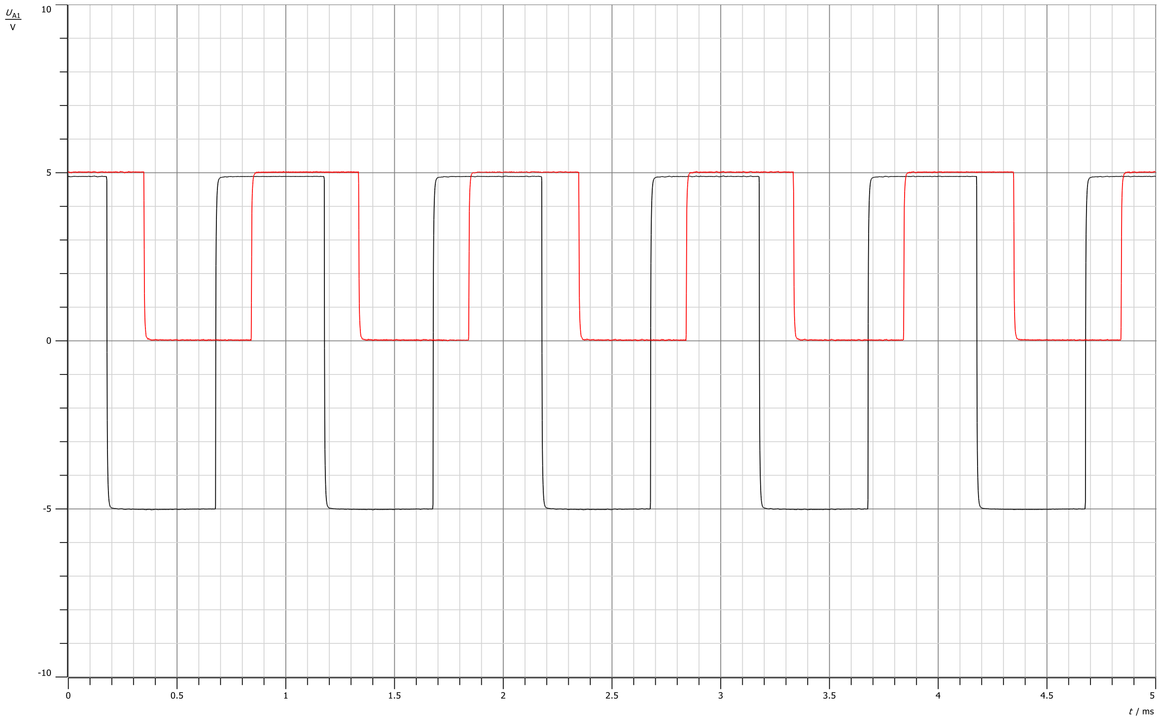

Figure 32 ASK unmodulated (Soft Keying) (MI=100%) and the original signal A_12

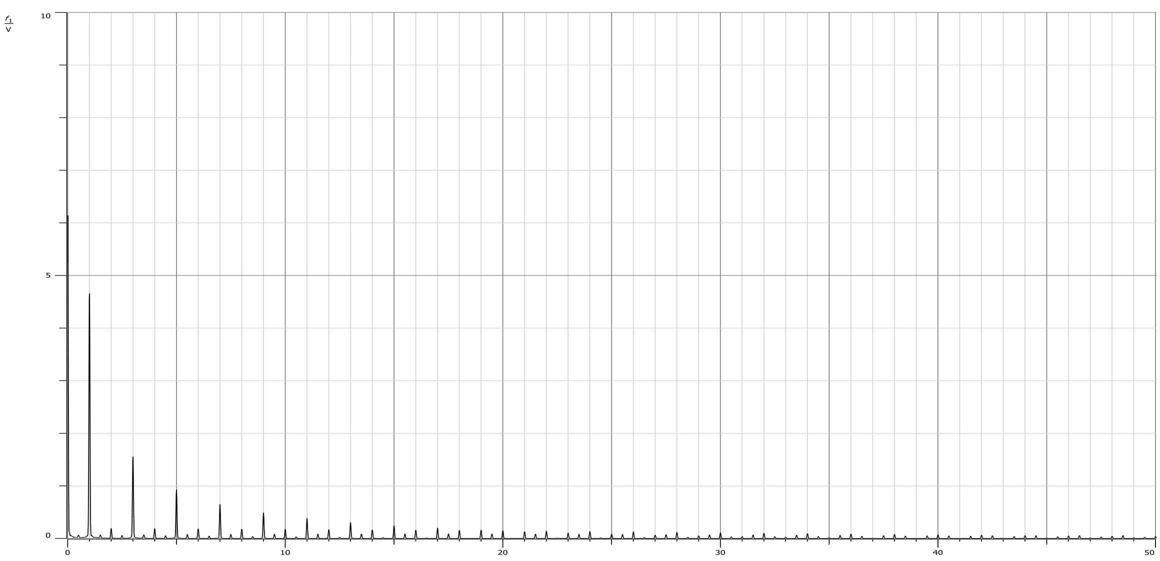

Figure 33ASK unmodulated SPECTRUM (Soft Keying) (MI=100%) and the original signal A_12

When A_21

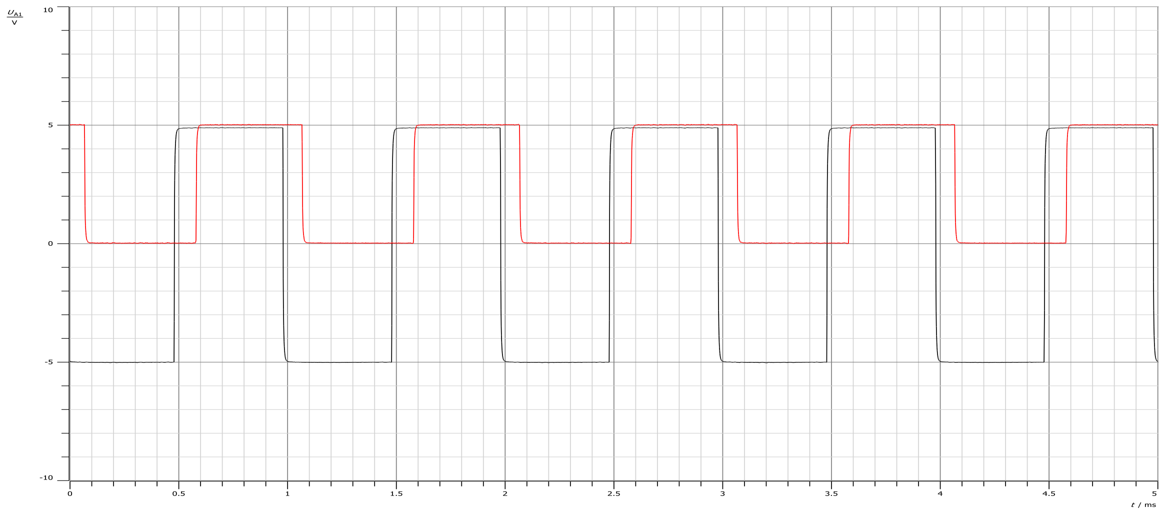

Figure 34 unmodulated ASK (Soft Keying) (MI=100%) and the original signal A_21

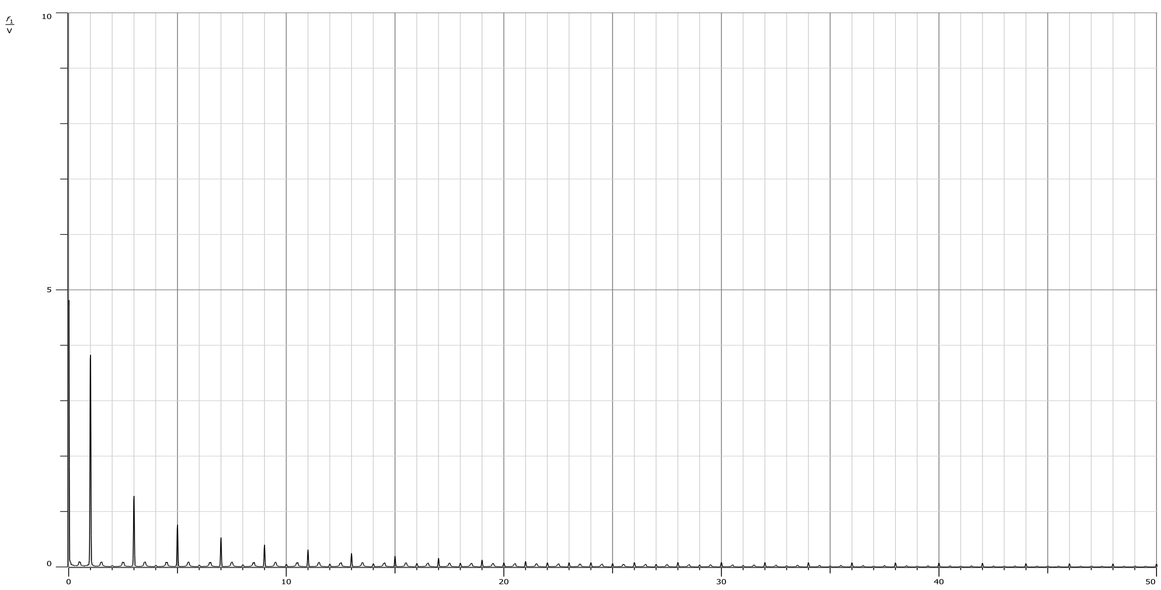

Figure 35 unmodulated SPECTRUM (Soft Keying) (MI=100%) and the original signal A_21

When A_22

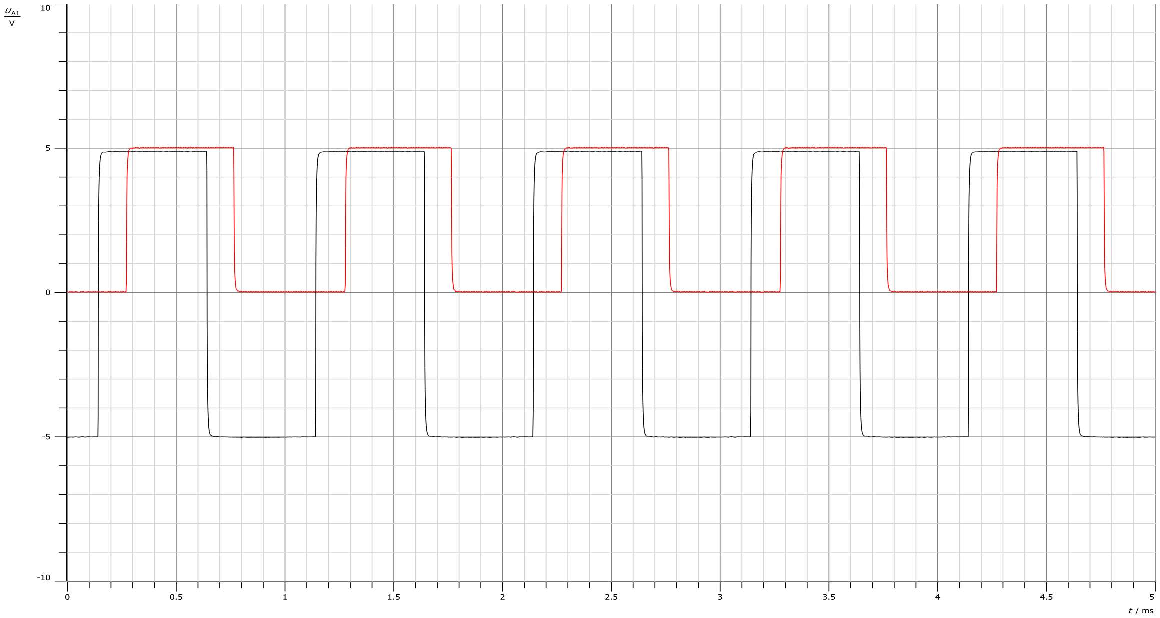

Figure 36 unmodulated ASK (Soft Keying) (MI=100%) and the original signal A_22

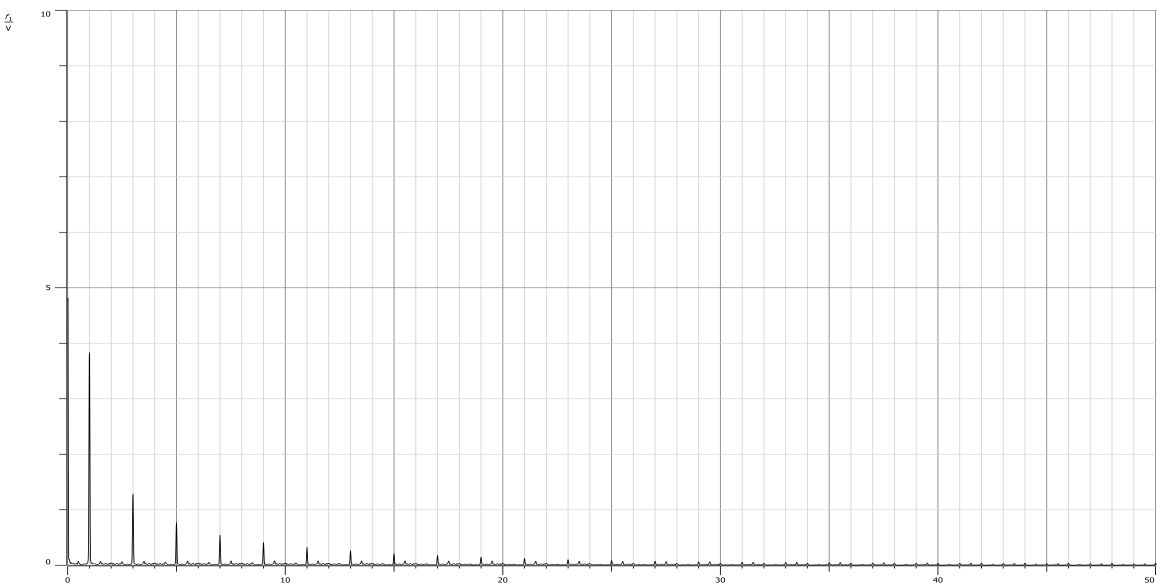

Figure 37 unmodulated SPECTRUM (Soft Keying) (MI=100%) and the original signal A_22

Demodulating ASK modulation with 100% or 50% soft keying may be more difficult than hard keying. The success of the demodulation process is determined by the demodulation methodology used, the SNR, and the use of appropriate signal processing procedures.

- **The effect of changing the message signal frequency on the demodulation**

• ***When signal's frequency = 500Hz***

In this section, the connection was the same as the previous sections, The function generator was set to generate a square wave signal with frequency = 500Hz, Vss =10V and duty cycle=50%. The Cassy sensors UA1 and UB1 was connected to the bipolar square-wave signal at socket TX_{IN} and to the ASK signal at the output RX_{OUT} of the demodulator respectively. Figure 21 shows the characteristic curve of the ASK demodulated signal with frequency 500Hz.

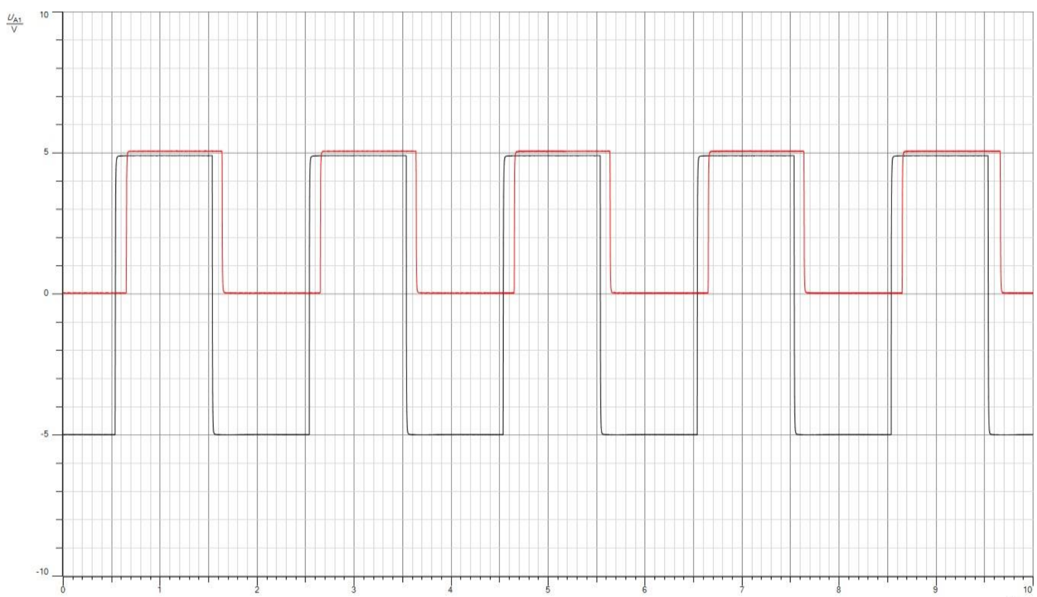

Figure 38ASK demodulated signal with frequency 500Hz

• ***When signal's frequency = 2000Hz***

In this section, the same connection of the previous section was used, but with frequency of 2000Hz. Figure 22 shows the characteristic curve of the ASK demodulated signal with frequency 2000Hz.

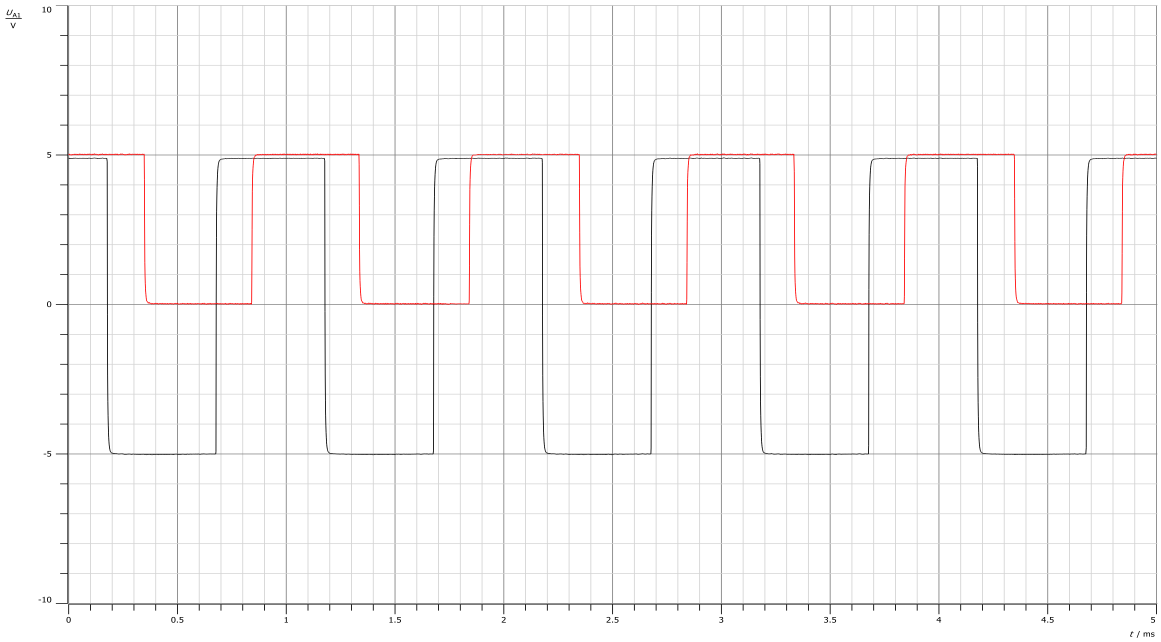

Figure 39: ASK demodulated signal with frequency 2000Hz

Changing the message signal frequency in ASK demodulation necessitates adjusting the demodulator's settings and filters to match the new frequency. The demodulator's bandwidth determines its capacity to correctly demodulate signals within a given frequency range. Sensitivity to amplitude variations and interference sensitivity may vary with frequency.

4.3.3Question

1. What is the main difference between the message signal and the demodulated signal?

The primary difference between the message signal and the demodulated signal is that the message signal is the original, unaltered signal containing the data, while the demodulated signal is the output after the modulation process, which has been processed to retrieve the original message. The demodulated signal often shows variations or distortions introduced during modulation, such as changes in amplitude or phase, which are not present in the original message signal.

2. What causes this difference? And does it consider as a disadvantage?

This difference is caused by the modulation and demodulation processes, which alter the message signal to enable transmission over a communication channel and then recover it. Modulation introduces changes to the signal's amplitude, frequency, or phase to encode information, while demodulation attempts to reverse these changes to retrieve the original message. These processes can introduce distortions or losses, which can be considered disadvantages if they lead to reduced signal quality or accuracy in data recovery.

3. Is there a time delay between the message and the demodulated signal? If so, what do you expect the reason behind it?

Yes, there is typically a time delay between the message and the demodulated signal. This delay occurs because the signal undergoes several stages of processing, including modulation, transmission, and demodulation, each of which introduces a processing time. Additionally, the inherent delay in electronic components and signal processing algorithms contributes to this time lag.

4. Is the time delay for the soft keying greater or smaller than that of the hard keying? Interpret your answer.

The time delay for soft keying is generally smaller than that for hard keying. Soft keying involves smoother transitions between amplitude levels, which can be processed more efficiently and with fewer abrupt changes, leading to quicker response times. In contrast, hard keying involves sudden, sharp changes in signal amplitude, which can cause additional processing delays due to the need to handle these abrupt transitions and their associated high-frequency components.

5. Does the modulation index affect the time delay between the message and the demodulated signal?

The modulation index can affect the time delay between the message and the demodulated signal. A higher modulation index typically results in more significant variations in the signal, which can introduce additional processing requirements and delays. Conversely, a lower modulation index often means smaller variations, which may lead to a more straightforward demodulation process and potentially reduced time delay.

As the duty cycle was increased, noticeable changes were observed in the demodulated signal. Lower duty cycles (e.g., 10%) resulted in narrower pulses in the output, while higher duty cycles led to wider pulses. This variation impacted the clarity and accuracy of the demodulated signal, with larger duty cycles generally providing a more distinct representation of the high and low states of the ASK signal.

What duty-cycle value can be considered as the best one? Why?

The optimal duty cycle value often depends on the specific application and the characteristics of the signal being transmitted. Typically, a duty cycle around 50% is considered ideal because it ensures that the signal has a balanced representation of high and low states, leading to clearer and more reliable demodulation. It provides sufficient time for both high and low levels, minimizing distortions and improving the accuracy of the demodulated signal.

Is there a difference between the smaller and greater duty-cycle values? Will they affect the low or high state of the ASK signal?

Yes, there is a difference between smaller and greater duty-cycle values. Smaller duty cycles (e.g., 10%) result in shorter high states and longer low states, which can lead to reduced signal clarity and increased difficulty in accurately demodulating the signal. Conversely, larger duty cycles (e.g., 50% or higher) provide more balanced high and low states, improving the visibility and accuracy of the ASK signal. These variations can affect the representation of both low and high states, potentially leading to inaccuracies in signal demodulation if not properly adjusted

4.Conclusion

this experiment aimed to explore Amplitude Shift Keying (ASK) modulation and its various aspects. By examining both Hard and Soft keying methods and evaluating the effects of the modulation index, the experiment provided valuable insights into the characteristics and behavior of ASK modulation. The practical construction and analysis of ASK-modulated signals, using both time and frequency domain techniques, enhanced our understanding of how the modulation index influences the amplitude and spectral properties of the signal. The results highlighted the differences between Hard and Soft keying methods, including their respective advantages and limitations. This experiment deepens our comprehension of ASK modulation, which is crucial for effective binary data transmission across different communication channels. The knowledge gained can contribute to the design and refinement of ASK modulation schemes, ensuring more efficient and reliable data transfer. Ultimately, this work advances our grasp of ASK modulation and its practical applications, supporting advancements in communication technology and improving data transmission systems.

5. References

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[3] Amplitude Shift Keying (tutorialspoint.com) at 18/8/2024 11:22 AM

[4] Amplitude Shift Keying - GeeksforGeeks at 18/8/2024 11:17 AM