Mini Project I: General signal generator

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Introduction

The aim of this project is to implement a simple general signal generator using MATLAB software. The program can generate DC signals, ramp signals, general order polynomial signals, exponential signals, and sinusoidal signals. It can also perform many operations on these signals such as amplitude scaling, time reversal, time shifting, signal expansion, and signal compression.

Program Specifications

1. The program asks the user for the following parameters:
    a. Sampling frequency of the signal.
    b. Start and end of time scale.
    c. Number of breakpoints and their positions.

    For example, if the user enters the sampling frequency 10000 and he wants the signal to be defined from -2:0 as a DC signal and from 0:2 as ramp signal, then the number of breakpoints will be equal to 1 and its position is at time = 0. So, the user will enter these parameters as shown in figure 1.

```
Welcome To Our Program
Please, Enter The Following Specification.

 --------------------------------

Sampling Frequency >> 10000

 --------------------------------

Starting Of Time >> -2
Ending Of Time >> 2

 --------------------------------

Number Of Breakpoints >> 1
The Position of BreakPoint (1) is at t = 0

 --------------------------------
```

Figure 1

2. According to the number of breakpoints the program asks the user at each region to enter the specifications of the signal at this region Which are:
    a. DC signal: Amplitude.
    b. Ramp signal: slope – intercept.
    c. General order polynomial: Amplitude – power – intercept.
    d. Exponential signal: Amplitude – exponent.
    e. Sinusoidal signal: Amplitude – frequency – phase.

The user chooses which signal to be generated and enters the specification of each signal as shown in figures 2.1 and 2.2.

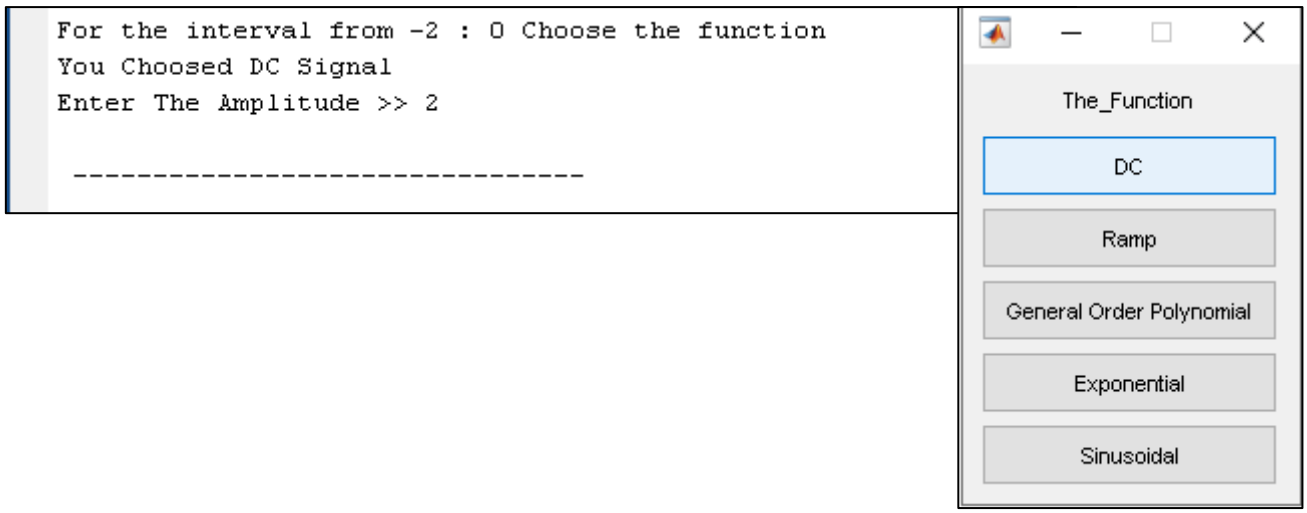


Figure 2.1

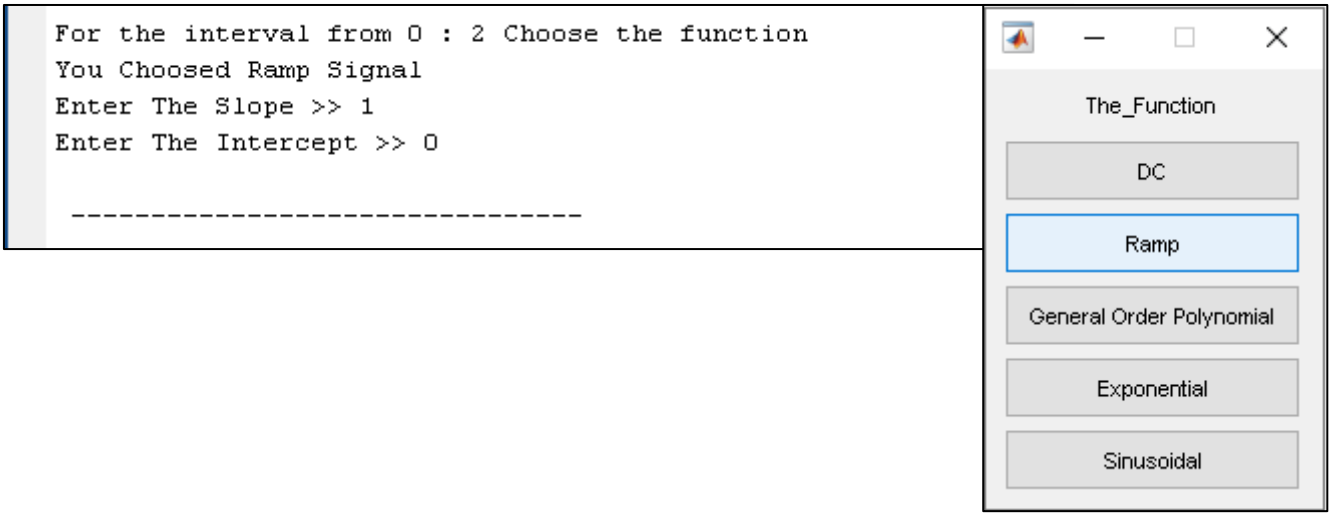


Figure 2.2

3. Display the resulting signal in time domain.

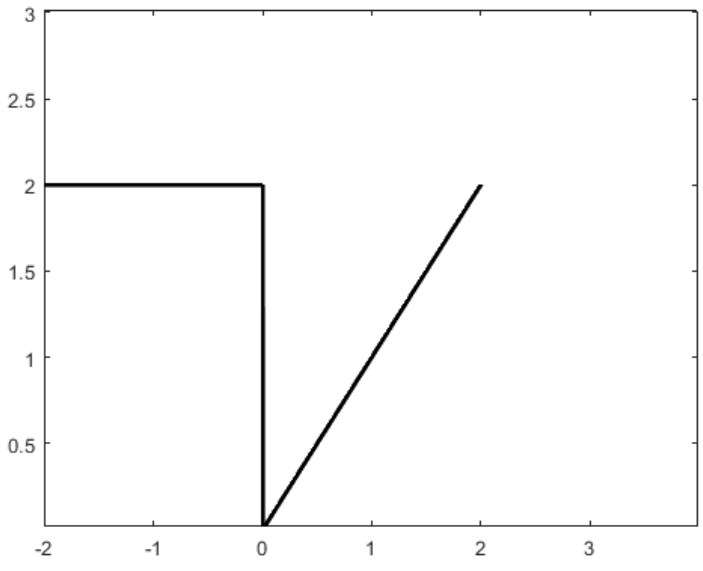


Figure 3

4. The program asks the user if he wants to perform any operation on the signal. The specifications of these operations are:
    a. Amplitude Scaling: The signal is multiplied by the scaling factor entered by the user.
    b. Time reversal: The signal is multiplied by -1
    c. Time Shift: The value of the shift is added to the initial and end of the time scale of the signal.
    d. Expanding the signal: The signal is multiplied by the expanding factor (must be >1)
    e. Compressing the signal: The signal is multiplied by the compressing factor (must be <1)
    f. None
5. Display the new signal in time domain.

Algorithm:

Algorithm of generating the signal:

1. The user enters the sampling frequency that stored in the variable ‘f’, the start and the end of time scale which stored in ‘T_intial’ and ‘T_final’, and the number of the breakpoints that stored in the variable ‘N’
2. The function ‘input()’ is used to get the data from the user.
3. The positions of the start, the end, and the breakpoints are stored in a vector named ‘Time’ using for loop then they are sorted using the function ‘sort( )’.
4. Using a for loop to specify the duration of each signal.

```
for i = 1 : 1 : length(Time) - 1
    Duration = Time(i+1) - Time(i);
    Number_of_Samples = Duration * f;
    t = linspace(Time(i), Time(i+1), Number_of_Samples);
    fprintf('For the interval from %d : %d Choose the function\n',Time(i), Time(i+1))
```

   this for loop is specified as follow:
   start = 1, step = 1, end = length of the vector ‘Time’ – 1, because the number of durations is less than the number of breakpoints by 1. For example, if the start = 0, end = 10, and there are 2 breakpoints at 3, 7. So there are 4 breakpoints but 3 durations from 0 to 3, from 3 to 7, and from 7 to 10.
5. The function ‘linspace( )’ is used in generating the time base signal. It takes the start of the duration, the end of the duration, and the number of samples.
6. Using switch-case statement to determine the kind of function for each duration and the specification of each function.
7. The function ‘menu( )’ displays a modal menu dialog box containing the text in "The_Function" and the choices specified by DC, Ramp, ...etc. It is used to return the number of the selected menu item which is used in the switch-case statement.

8. The functions are specified as follows:
    a. **DC Signal** is specified by its amplitude which is entered by the user and is generated by multiplying this amplitude by a ones vector.
    b. **Ramp Signal** is specified by the slope M and the intercept C which are entered by the user. The equation for ramp signal is $y = M * t + c$
    c. **General Order Polynomial Signal** is specified by the amplitude, the power, and the intercept. The equation is $y = A1 * x^{power} + A2 * x^{power-1} + \cdots + c$. A for loop is used to determine the constant of each term and its degree.
    d. **Exponential Signal** is specified by the amplitude and the exponent which are entered by the user. The equation is $y = A * \exp(exponent * t)$.
    e. **Sinusoidal Signal** is specified by the amplitude, the frequency and the phase shift(in radian) which are entered by the user. The equation is
$$y = A * \sin(2 * pi * freq * t - theta)$$
9. Concatenate all the functions in the full duration.
10. Using the function 'linspace( )' to generate the time base signal for the full duration.
11. Plot the signal using the function 'plot( )'.

Algorithm of operations on the generated signal:

12. The function 'menu( )' displays a modal menu dialog box containing the text in "Operation on The Signal" and the choices of the operations as Amplitude scaling, Time reversal,…etc . It is used to return the number of the selected menu item which is used in the switch-case statement.
13. Using switch-case statement to determine the operation required to be performed on the generated signal.
14. The user chooses the kind of operation required on the generated signal from the menu after that the switch-case statement the specification of each kind according to the user choice.

    a. **Amplitude scaling** if the user choose the first choice from the menu " Amplitude scaling" the switch case statement will activate "case 1" causing amplitude scaling to the signal by multiplying the signal by a constant value determined by the user then this amplitude scaling value is stored for later use.

    b. **Time reversal** if the user chooses the second choice from the menu Time reversal" the switch case statement will activate "case" causing Time reversal to the signal by multiplying the signal by "-1". the factor and Time and shift are affected by reversal to perform expansion and compression by redrawing the signal if expansion or compression was demanded by user later.

    c. **Time shift** if the user choose the third choice from the menu "Time shift " switch case will activate "case 3" causing time shift to the initial and final time of the signal by a constant value determined by the user. This value is stored in

Shift value as it may be used if expansion or compression operation was performed on this signal.

d. **Expanding the signal** if the user chooses the fourth choice from the menu "Expanding the signal" switch case statement will activate "case 4" causing expansion to the signal by multiplying the time of the signal by a constant determined by the user where" constant>1". All the previous operation done before this operation affect this operation where the use of some variable begin to appear like (shift, factor, amplitude, A_list, M_list , C_list , exponent_list , freq_list , theta_list, function_kind_list, L,P,Q , R ,S ,U). All the previous variables are used to redraw the signal to achieve multioperation functionality.

e. **Compressing the signal** if the user chooses the fifth choice from the menu "Expanding the signal" switch case statement will activate "case 5" causing compression to the signal by multiplying the time of the signal by a constant determined by the user where" constant<1". All the previous operation done before this operation affect this operation where the use of some variable begin to appear like (shift, factor, amplitude, A_list, M_list, C_list , exponent_list , freq_list , theta_list, function_kind_list, L,P,Q , R ,S ,U). All the previous variables are used to redraw the signal to achieve multioperation functionality.

f. **None** if the user choose the sixth choice from the menu the switch case will activate "case 6" where no operation will done on the signal causing flag to become "1".

15. **While loop** is used to allow the user to make multiple operations on the signal until the user choose "None" from the menu the while loop will stop and the signal after each operation will be plotted.

Note: the code refuses negative expanding or compressing value and it accept only number greater than 1 in case of expanding value and a number less than 1 but bigger than zero in case of compressing value.

Results

If the signal definition is as follow:

$$f(t) = \begin{cases} e^t, & 0 < t < 5 \\ 150, & 5 < t < 10 \\ t^2 - 30t + 225\,, & 10 < t < 15 \\ 5t - 5\,, & 15 < t < 20 \\ 95\sin(2\pi t \times 0.4 - 0)\,, & 20 < t < 25 \end{cases}$$

- The exponential signal is defined from 0:5 with amplitude = 1 and exponent = 1.
- The DC signal id defined from 5:10 with amplitude = 150.
- The polynomial signal is defined from 10:15 which is 2nd order with $A_2 = 1$, $A_1 = -30$, and intercept = 225.
- The ramp signal is defined from 15:20 with slope = 5 and intercept = -5.
- The sinusoidal signal is defined from 20:25 with amplitude = 95, frequency = 0.4, and phase shift = 0.

Then the output signal will be as shown in figure 4.

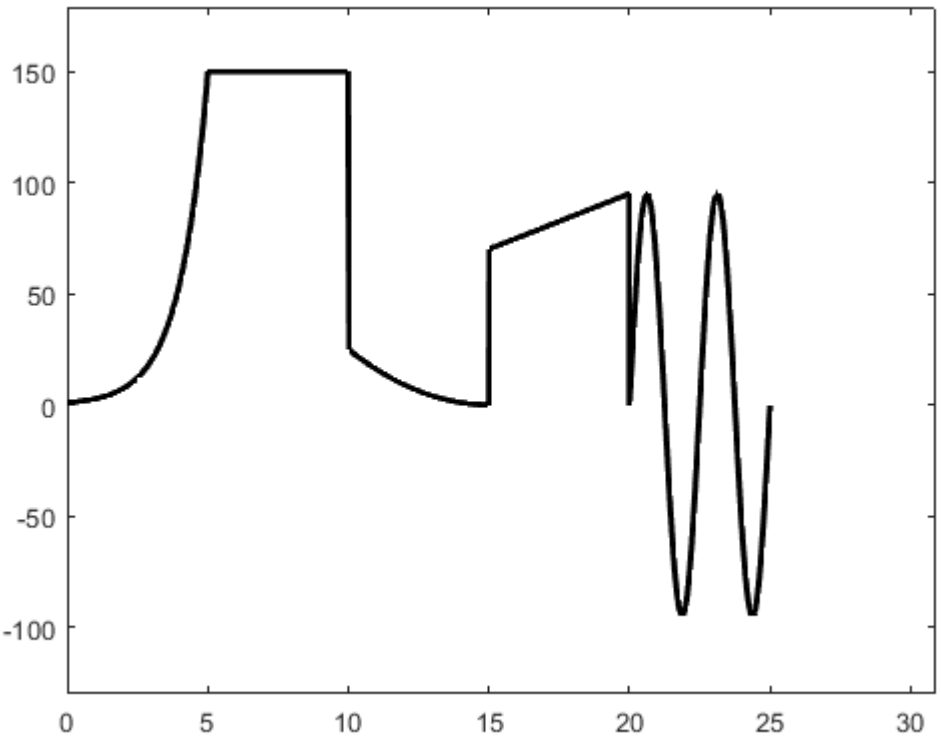


Figure 4

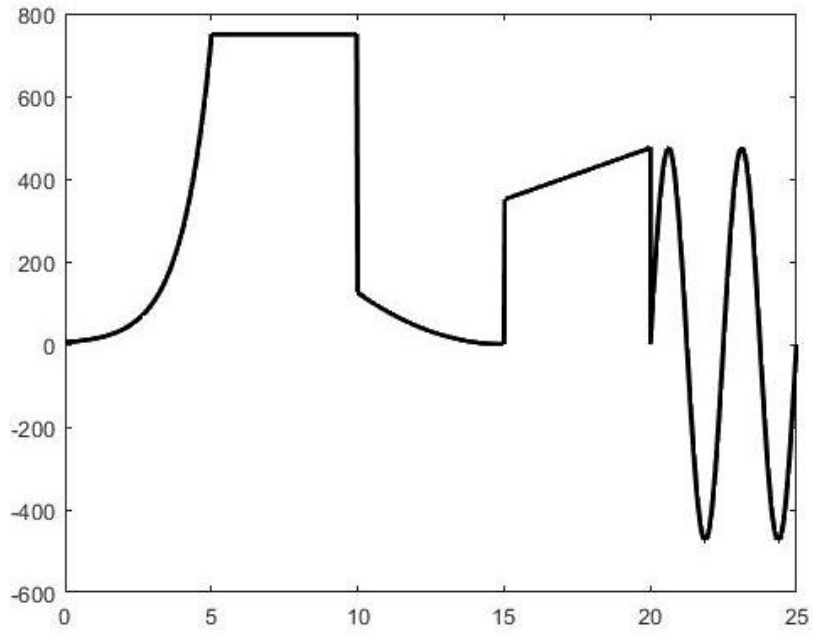
Testing the operations on this signal as follow:

a. Amplitude Scaling by 5 units.

```
Which Operation would you like to use ?
You chose Amplitude Scaling
Enter Amplitude Scaling Factor of new signal >> 5

Amplitude =

     5
```



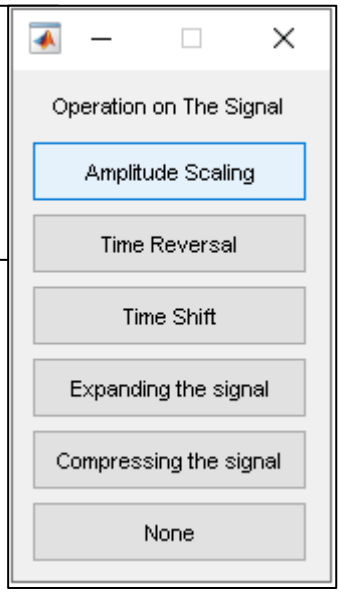
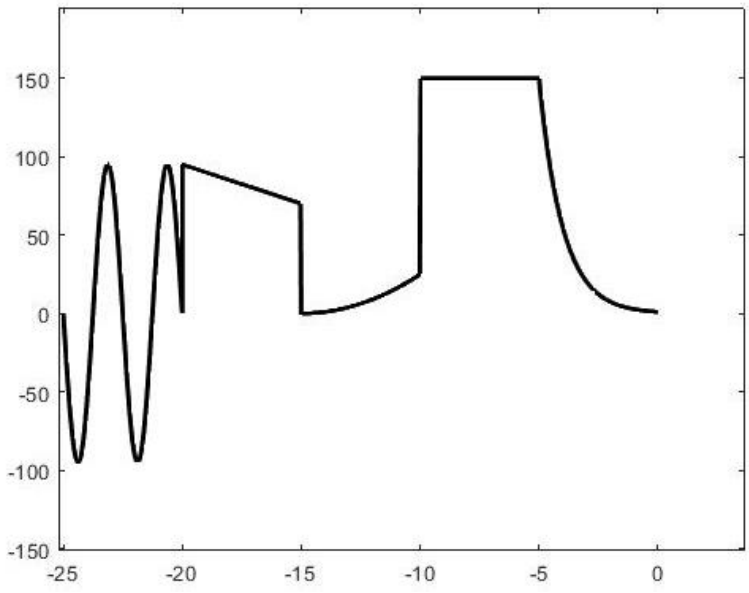


Figure 5

b. Time Reversing

```
Which Operation would you like to use ?
You chose Time Reversal
```



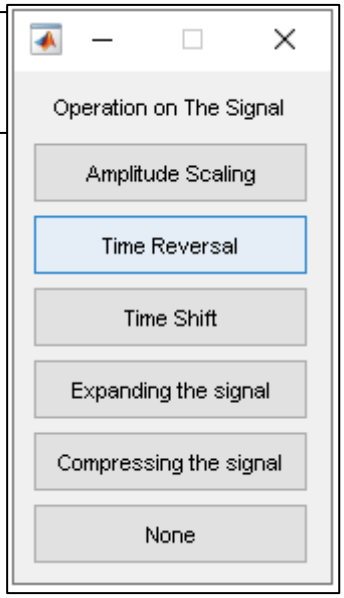


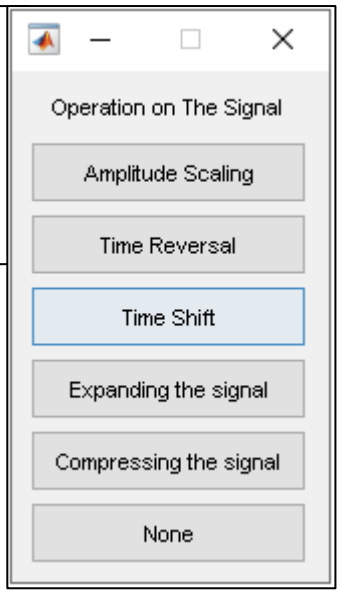
Figure 6

c. Time Shift by +5 (to the right)

```
Which Operation would you like to use ?
You chose Time Shift
Amount of shift in Time (+ve -> Right , -ve <- Left) >> +5

Shift_input =

     5
```



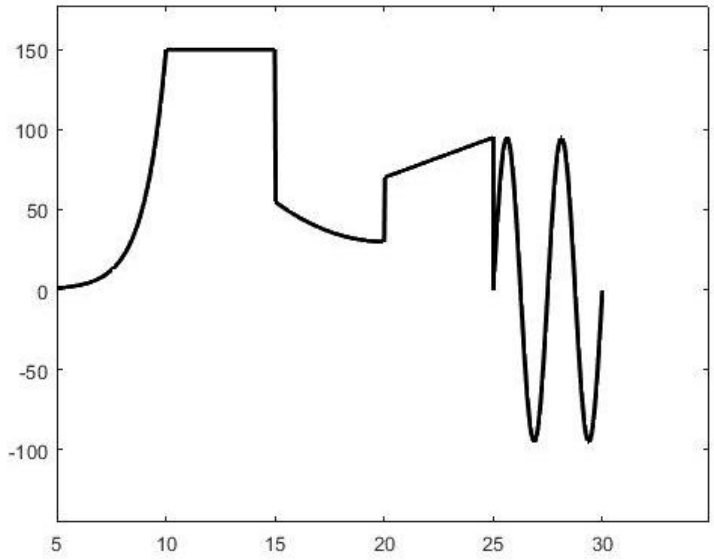


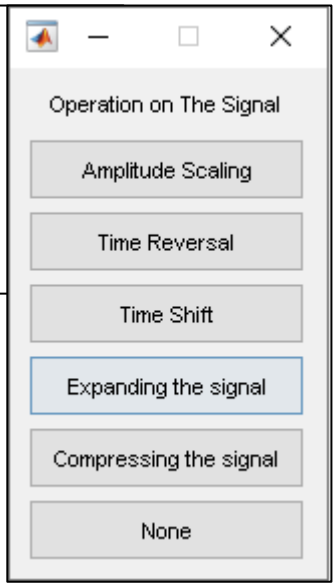
Figure 7

d. Expanding the signal by 5 (multiplying time scale by 5)

```
Which Operation would you like to use ?
You chose Expanding the Signal
Expanding Factor (Value > 1) >> 5

Factor =

     5
```



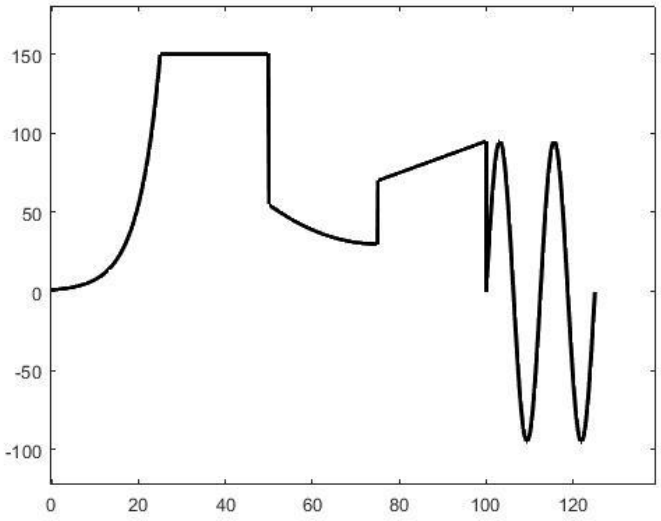
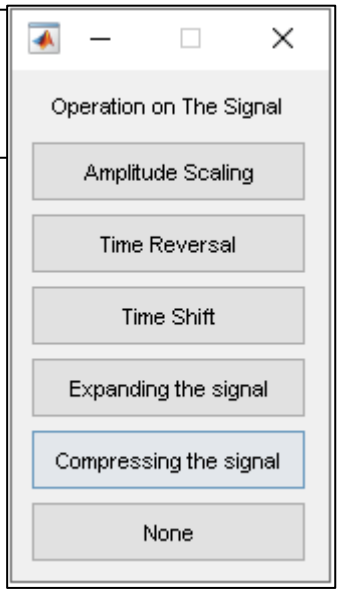


Figure 8

e. Compressing the signal by 5 (multiplying the time scale by 1/5)

```
Which Operation would you like to use ?
You chose Compressing the Signal
Compressing Factor (Value < 1) >> 1/5
```



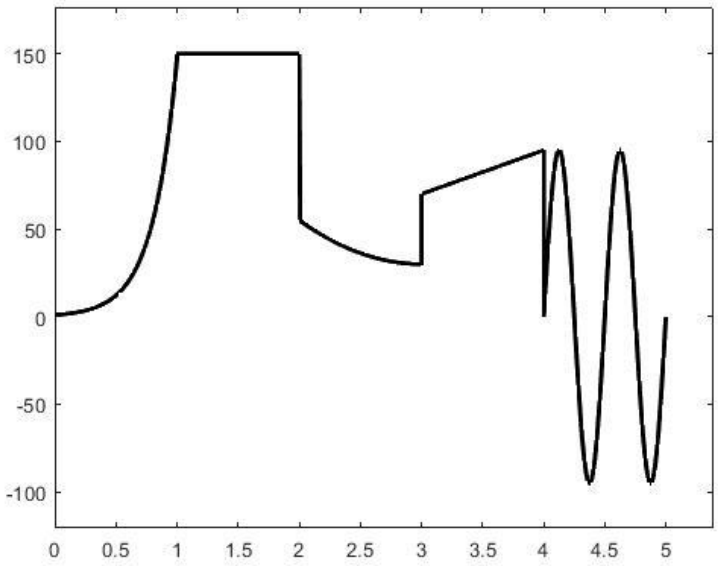


Figure 9

Conclusion:

The program is designed to generate function with demanded kind in each duration specified these kinds are DC Signal, Ramp Signal, General Polynomial Signal, Exponential Signal and Sinusoidal Signal. The program can also perform one or many operations on previously specified signal. These operations are Amplitude Scaling, Time reversal, Time Shifting, Expansion and Compression. The program terminates when user choose None. The program prints the required figure after each operation.